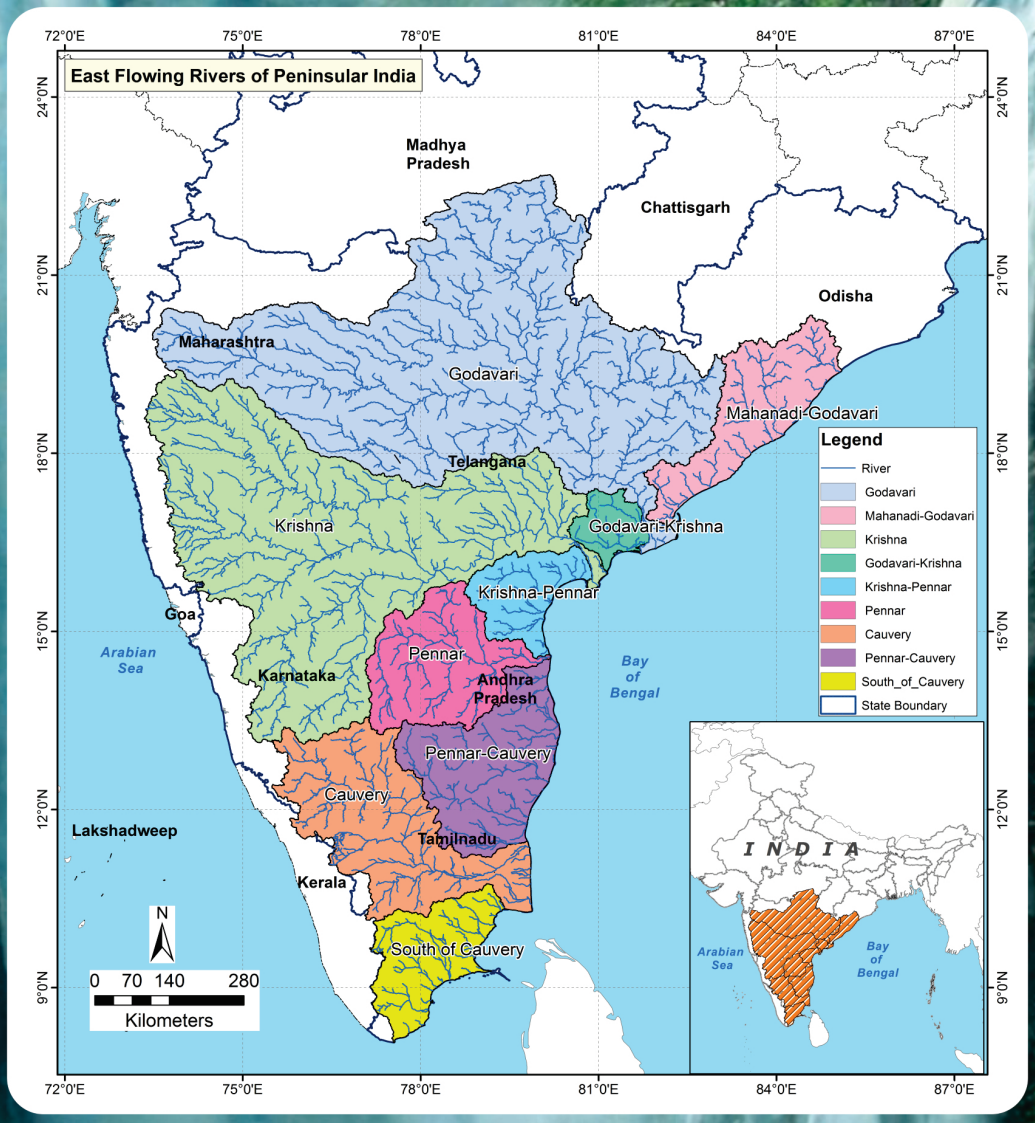
सत्यमेव जयते

Government of India
Ministry of Power
Central Electricity Authority

BASIN-WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN INDIA
EAST FLOWING RIVERS OF PENINSULAR INDIA
(LARGE HYDROELECTRIC PROJECTS EXCLUDING PUMPED STORAGE)



VOLUME-I

January-2021

प्रकाश मस्के
अध्यक्ष तथा पदेन सचिव भारत सरकार
Prakash Mhaske
Chairperson & Ex-officio Secretary
to the Government of India

सत्यमेव जयते

केन्द्रीय विद्युत प्राधिकरण
विद्युत मंत्रालय
सेवा भवन, आर. के. पुरम
नई दिल्ली–110066
Central Electricity Authority
Ministry of Power
Sewa Bhawan, R. K. Puram
New Delhi-110066

FOREWORD

India, being one of the fastest growing economy on the Globe, needs to develop adequate, sustainable, economic, reliable and power system friendly energy sources for meeting rising demand as well as for future energy security. Harnessing potential Hydro power is important not only as a vital source of renewable electricity but also as most flexible resource, to play a crucial role in optimum utilisation of other renewable energy as well as conventional energy sources.

With an objective of identification of exploitable hydro potential and taking up the development of it in a systematic manner Central Electricity Authority (CEA) took up a study namely "Reassessment of Hydroelectric Potential in the country" in March' 2017. Under this comprehensive study, the reassessment of hydroelectric potential for all the six basins namely Ganga, Indus, Brahmaputra, West Flowing and East Flowing Rivers of Peninsular India and Central Indian River has been taken up.

This document on " East Flowing Rivers of Peninsular India" contains details of the basin characteristics along with status of hydro power development in the basin and basin states It will facilitate developers / States in taking advance action and in preparation of detailed project reports based on adequate investigations, in a phased manner, which would eliminate the causes of delay in the implementation of hydroelectric projects.

I am confident that this document will be useful in effective hydro development planning and speedy development of hydro projects in the Country.

(PRAKASH MHASKE)

6 Jan 2021

दूरभाष / Telephone: 011-26102583, 26732222, फैक्स / Fax: 011-26109212, ईमेल / Email: chair@nic.in, वेबसाइट / Website: www.cea.nic.in

दिनेश चन्द्रा
सदस्य
तथा पदेन अपर सचिव
भारत सरकार
DINESH CHANDRA
MEMBER &
EX-OFFICIO ADDL. SECRETARY
TO THE GOVERNMENT OF INDIA

दूरभाष (का.) Telephone (O) : 26732701
टेलिफैक्स Telefax : 26172942
केन्द्रीय विद्युत प्राधिकरण
सेवा भवन, आर. के. पुरम,
नई दिल्ली - 110066
CENTRAL ELECTRICITY AUTHORITY
SEWA BHAWAN, R.K. PURAM
NEW DELHI - 110066

PREFACE

The first systematic Hydroelectric Survey of India was undertaken by Central Water & Power Commission (CW&PC) during 1953-59. According to this survey, hydroelectric potential of the country was assessed as about 42,000 MW. This very first attempt of country's hydroelectric potential assessment was extremely useful for hydro planning in the country for about three decades.

During this long period, however, there had been major changes and important developments. Hence, the need was felt by the Central Electricity Authority for a second exercise to reassess the country's hydroelectric potential and accordingly, the Authority undertook the study in 1978 and completed it in 1987. As per this study, the Hydroelectric Power Potential of the country was estimated as 1,45,320 MW consisting of hydroelectric schemes having installed capacity above 25 MW.

Again, after three decades, fresh Basin wise reassessment of Hydroelectric Power Potential has been carried out to arrive at realistic exploitable potential taking into consideration updated high resolution Survey of India maps, hydrological data, hydro-meteorological data, ecological data, new norms relating to environmental flows, free flow stretch, inter-state issues & tribunal awards etc.

I hope that this re-assessment of hydroelectric potential would prove useful not only in assigning proper priorities in investigation and construction of hydro power projects but also help in placing the hydro developmental efforts in proper perspective.

(Dinesh Chandra)

प्रदीप कुमार शुक्ल
मुख्य अभियंता
PARDEEP KUMAR SHUKLA
CHIEF ENGINEER

सत्मेव जयते

दुरभाष (का.) Telephone (O) : 26732773
टेलिफैक्स Telefax : 26109610
केन्द्रीय विद्युत प्राधिकरण
सेवा भवन, आर. के. पुरम,
नई दिल्ली-110066
CENTRAL ELECTRICITY AUTHORITY
SEWA BHAWAN, R.K. PURAM
NEW DELHI - 110066

ACKNOWLEDGEMENT

The "Reassessment of Hydroelectric Potential in the country" involves preparation of Basin Reports for all the six basins namely Ganga, Indus, Brahmaputra, West Flowing and East Flowing Rivers of Peninsular India and Central Indian River System.

The present report of East Flowing Rivers of Peninsular India (EFR) Basin is being brought out in two volumes. The volume-I contains the general description of the study, the methodology adopted, Project Profiles and Environmental aspects of Projects while volume-II contains Hydrological & Power Potential Studies. The work has been carried out by CEA in association with WAPCOS Limited and periodical monitoring of the work along with getting inputs from CWC, MOEF & CC, GSI, SOI and NRSC. I am grateful to following officers of these Organizations for their co-operation and assistance in accomplishing this important and difficult task:

CWC

1. Dr.R.K.Gupta, Member (D&R)
2. Shri C. Lal, Chief Engineer (Hydrology)
3. Sh. S.K.Sinha, Director (Hydrology)

MOEF&CC

1. Dr.S.Kerketta, Director (IA)
2. Sh. Manmeet Singh, Consultant

GSI

1. Dr. Saibal Ghosh , Director
2. Sh. Dharmendra Kumar, Sr. Geologist

SOI

1. Sh. D.N. Pathak, Director

NRSC

1. Dr. V.V. Rao, Director
2. Dr. V.M. Chowdhary, Scientist 'SG'

I express my sincere thanks to Shri J.S. Bawa, Chief Engineer (HPP&I), CEA for providing support and guidance in completing this complex task in a highly systematic way. I am also thankful to Officers/ Staff of HEPR Division, CEA and WAPCOS who have rendered active assistance in the study and preparation of the reports. The work could not have been possible without their sincere and sustained effort.

I am also thankful to all the officers of concerned State Governments /CPSUs/SPSUs and private developers for providing information regarding their hydro projects in the EFR Basin.

(Pradeep Kumar Shukla)

CONTENTS

S.No.	Table of Contents	Page No.
	Volume-I	
	Abbreviations	1
	Members of the Monitoring Committee	3
	Chapter-1: Introduction	
1.0	Background	5
1.1	Objectives of Reassessment study	7
1.2	Need for Reassessment Study	8
1.3	General Methodology	9
1.4	Data Layers – Sources & Uses	13
1.5	East Flowing Rivers of Peninsular India (EFR) Basin	14
1.6	Hydroelectric Projects (above 25 MW) in EFR Basin as per 1978-87 studies	18
1.7	Hydroelectric Projects (above 25 MW) in EFR Basin and their status (Present Study)	19
1.8	Hydroelectric Projects in EFR Basin having Environmental/ Forest Issues	26
1.9	Hydroelectric Projects in EFR Basin having Inter-State Issues	27
1.9.1	International Treaties and Interstate Tribunals on rivers of EFR Basin	33
1.9.1.1	Cauvery Water Disputes Tribunal (June 1990)	34
1.9.1.2	Godavari Water Disputes Tribunal (April 1969)	41
1.9.1.3	Krishna Water Disputes Tribunal	42
1.9.1.4	Vansadhara Water Disputes Tribunal	43
1.10	Hydroelectric Projects (above 25 MW) in EFR Basin having no major constraints which have been taken up for further studies	46
1.11	Hydroelectric Projects in EFR Basin Projects not feasible	47
1.12	Final Outcome of Reassessment studies	48
	A. Hydro Potential at a glance in EFR Basin	48
	B. State wise Hydro Potential at a glance in EFR Basin	48
	Annexure I	52
	Annexure II	56

S.No.	Table of Contents	Page No.
	Annexure III	60
	Annexure IV	66
	Chapter-2: Sub-Basins	
2.1	**Godavari Sub-Basin**	73
2.1.1	Physiographic status of Godavari Sub-Basin	76
2.1.2	River Profile	87
2.1.2.1	Godavari River	87
2.1.2.2	Pranitha River	91
2.1.2.3	Indravati River	95
2.1.2.4	Sabari River	99
2.2	**Krishna Sub-Basin**	102
2.2.1	Physiographic status of Krishna Sub-Basin	104
2.2.2	River Profile	114
2.2.2.1	Krishna River	114
2.2.2.2	Indrayani River	118
2.2.2.3	Tungabhadra River	121
2.3	**Cauvery Sub-Basin**	124
2.3.1	Physiographic status of Cauvery Sub-Basin	126
2.3.2	River Profile	138
2.3.2.1	Cauvery River	138
2.3.2.2	Bhavani River	142
2.4	**South of Cauvery Sub-Basin**	146
2.4.1	Physiographic status of South of Cauvery Sub-Basin	146
2.4.2	River Profile	154
2.4.2.1	Suruli River	154
2.4.2.2	Thamirabarani River	157

S.No.	Table of Contents	Page No.
	Chapter-3: Project Profiles of Projects except those taken up for further studies	
A	**Projects In Operation**	
3.1	Bhandardara St-II Hydroelectric Project	161
3.2	Pench Hydroelectric Project	167
3.3	Pochampad Hydroelectric Project	171
3.4	Upper Indravati Hydroelectric Project	175
3.5	Upper Kolab Hydroelectric Project	179
3.6	Machkund Hydroelectric Project	183
3.7	Balimela Hydroelectric Project	189
3.8	Upper Sileru I & II Hydroelectric Project	193
3.9	Lower Sileru Hydroelectric Project	197
3.10	Bhivpuri Hydroelectric Project	201
3.11	Khopoli Hydroelectric Project	205
3.12	Bhira Hydroelectric Project	211
3.13	Koyna DPH Hydroelectric Project	215
3.14	Koyna St. I & II Hydroelectric Project	219
3.15	Koyna St. III Hydroelectric Project	223
3.16	Koyna St. IV Hydroelectric Project	227
3.17	Ghatprabha Hydroelectric Project	231
3.18	Almatti Hydroelectric Project	235
3.19	Priyadarshini Jurala Hydroelectric Project	239
3.20	Lower Jurala Hydroelectric Project	245
3.21	Srisailam Hydroelectric Project	249
3.22	Nagarjunasagar RBC & Ext Hydroelectric Project	255
3.23	Nagarjunasagar TPD Hydroelectric Project	259
3.24	Nagarjunasagar LBC Hydroelectric Project	263
3.25	Nagarjunasagar Hydroelectric Project	267
3.26	T B Dam Hydroelectric Project	273

S.No.	Table of Contents	Page No.
3.27	Hampi Hydroelectric Project	277
3.28	Munirabad Hydroelectric Project	283
3.29	Bhadra Hydroelectric Project	287
3.30	Pulichintala Hydroelectric Project	291
3.31	Mettur Dam Hydroelectric Project	295
3.32	Mettur Tunnel Hydroelectric Project	301
3.33	Lower Mettur-I Hydroelectric Project	307
3.34	Lower Mettur-II Hydroelectric Project	311
3.35	Lower Mettur-III Hydroelectric Project	315
3.36	Lower Mettur-IV Hydroelectric Project	319
3.37	Bhavani Kattalai Barrage-I Hydroelectric Project	323
3.38	Bhavani Kattalai Barrage-II Hydroelectric Project	327
3.39	Bhavani Kattalai Barrage-III Hydroelectric Project	331
3.40	Pykara Hydroelectric Project	335
3.41	Pykara Ultimate Hydroelectric Project	341
3.42	Kundah-I Hydroelectric Project	347
3.43	Kundah-II Hydroelectric Project	353
3.44	Kundah-III Hydroelectric Project	357
3.45	Kundah-IV Hydroelectric Project	363
3.46	Kundah-V Hydroelectric Project	367
3.47	Parson's Valley Hydroelectric Project	371
3.48	Shivasamudram Hydroelectric Project	377
3.49	Moyar Hydroelectric Project	383
3.50	Suruliyar Hydroelectric Project	387
3.51	Papanasam Hydroelectric Project	393
B	**Project Under Construction**	
3.52	Polavaram Hydroelectric Project	399
C	**Project Concurred/ Approved By State Governments**	
3.53	Matnar Hydroelectric Project	403

S.No.	Table of Contents	Page No.
D	**Projects having Environmental/ Forest Issues**	
3.54	Nugur-II Hydroelectric Project	407
3.55	Bhopalpatnam Hydroelectric Project	411
3.56	Lower Moyar Hydroelectric Project	415
E	**Projects having Inter-State Issues**	
3.57	Middle Kolab Hydroelectric Project	417
3.58	Lower Kolab Hydroelectric Project	423
3.59	Sivasamudram Hydroelectric Project	427
3.60	Mekadatu Hydroelectric Project	431
3.61	Rasimanal Hydroelectric Project	435
3.62	Hogenekkal Hydroelectric Project	439
3.63	Nellithorai Hydroelectric Project	443
3.64	Mananthavady Hydroelectric Project	445
	Chapter-4: Environmental Aspects	
4.1	General	449
4.2	Protected Areas	449
4.3	Assessment of Projects	451
4.3.1	Godavari Sub-Basin	451
4.3.2	Krishna Sub-Basin	460
4.3.3	Cauvery Sub-Basin	461
4.3.4	South of Cauvery Sub-Basin	463
4.4	Ecological Aspects	463
4.4.1	Flora	463
4.4.2	Fauna	468
4.4.2.1	Mammals	468
4.4.2.2	Reptiles	469
4.4.2.3	Amphibians	469
4.4.2.4	Avi-fauna	469
4.4.2.5	Butterflies	470

S.No.	Table of Contents	Page No.
4.4.2.6	Fish & Fisheries	471
4.5	Environmental Flows	471
	Annexure V	487
	Annexure VI	497
	Annexure VII	499
	Annexure VIII	501
	Annexure IX	502
	Annexure X	509
	Annexure XI	511
Volume-II		
	Chapter-5: Hydrological Studies	
5.0	General	517
5.1	Tupakulagudem Hydroelectric Project	522
5.2	Dummugudem Hydroelectric Project	547
5.3	Bodhghat Hydroelectric Project	567
5.4	Kutru-I Hydroelectric Project	588
5.5	Kutru-II Hydroelectric Project	608
5.6	Nugur-I Hydroelectric Project	627
5.7	Kotri Hydroelectric Project	649
5.8	Wainganga Hydroelectric Project	668
5.9	Samda Hydroelectric Project	689
5.10	Kunghara Hydroelectric Project	709
5.11	Pranhita Hydroelectric Project	729
5.12	Balimela Hydroelectric Project	750
5.13	Konta Hydroelectric Project	767
5.14	Tamankal Hydroelectric Project	792
5.15	Jaldurg Hydroelectric Project	818
	Chapter-6: Power Potential Studies	
6.0	Introduction	851

S.No.	Table of Contents	Page No.
6.1	Tupakulagudem Hydroelectric Project	851
6.2	Dummugudem Hydroelectric Project	865
6.3	Bodhghat Hydroelectric Project	873
6.4	Kutru-I Hydroelectric Project	881
6.5	Kutru-II Hydroelectric Project	888
6.6	Nugur-I Hydroelectric Project	898
6.7	Kotri Hydroelectric Project	906
6.8	Wainganga Hydroelectric Project	915
6.9	Samda Hydroelectric Project	923
6.10	Kunghara Hydroelectric Project	932
6.11	Pranhita Hydroelectric Project	940
6.12	Balimela Hydroelectric Project	947
6.13	Konta Hydroelectric Project	954
6.14	Tamankal Hydroelectric Project	964
6.15	Jaldurg Hydroelectric Project	969
6.16	Possibility of developing Hydroelectric Projects having environmental issues with adjustment of project components	975
	Chapter-7: Project Profiles of Projects Taken for Further Studies	
7.1	Tupakulagudem Hydroelectric Project	977
7.2	Dummugudem Hydroelectric Project	981
7.3	Bodhghat Hydroelectric Project	985
7.4	Kutru-I Hydroelectric Project	989
7.5	Kutru-II Hydroelectric Project	991
7.6	Nugur-I Hydroelectric Project	995
7.7	Kotri Hydroelectric Project	999
7.8	Wainganga Hydroelectric Project	1003
7.9	Samda Hydroelectric Project	1007
7.10	Kunghara Hydroelectric Project	1011
7.11	Pranhita Hydroelectric Project	1015

S.No.	Table of Contents	Page No.
7.12	Balimela Hydroelectric Project	1019
7.13	Konta Hydroelectric Project	1021
7.14	Tamankal Hydroelectric Project	1023
7.15	Jaldurg Hydroelectric Project	1027
	Chapter-8	
8.1	Exploration of river profiles for identifying new potential sites for Hydroelectric Projects development	1031
8.2	Outcome of river profile exploration	1088

LIST OF FIGURES

Figure No.	Details	Page No.
Figure 1.1	River basins of India	6
Figure 1.2	General Methodology	11
Figure 1.3	Catchment Delineation Process	13
Figure 1.4	Sub-Basins of East Flowing Rivers of Peninsular India	17
Figure 1.5	Hydroelectric Projects in East Flowing Rivers of Peninsular India Basin	22
Figure 2.1	Hydroelectric Projects in Godavari sub-basin	81
Figure 2.2	Topographical (Elevation Data) Map of Godavari sub-basin	82
Figure 2.3	Ecologically Sensitive Area Map of Godavari sub-basin	83
Figure 2.4	Geological Map of Godavari sub-basin	84
Figure 2.5	Seismic Map of Godavari sub-basin	85
Figure 2.6	CWC Gauge Discharge sites & IMD Rain Gauge sites of Godavari sub-basin	86
Figure 2.7	Hydroelectric Project on Godavari River	89
Figure 2.8	Geological Features of Godavari River	90
Figure 2.9	Hydroelectric Project on Pranhita River	93
Figure 2.10	Geological Features of Pranhita River	94
Figure 2.11	Hydroelectric Project on Indravati River	97
Figure 2.12	Geological Features of Indravati River	98
Figure 2.13	Hydroelectric Project on Sabari River	100

Figure No.	Details	Page No.
Figure 2-14	Geological Features of Sabari River	101
Figure 2.15	Hydroelectric Projects in Krishna sub-basin	108
Figure 2.16	Topographical (Elevation Data) Map of Krishna sub-basin	109
Figure 2.17	Ecologically Sensitive Area Map of Krishna sub-basin	110
Figure 2.18	Geological Map of Krishna sub-basin	111
Figure 2.19	Seismic Map of Krishna sub-basin	112
Figure 2.20	CWC Gauge Discharge sites & IMD Rain Gauge sites of Krishna sub-basin	113
Figure 2.21	Hydroelectric Project on Krishna River	116
Figure 2.22	Geological Features of Krishna River	117
Figure 2.23	Hydroelectric Project on Indrayani River	119
Figure 2.24	Geological Features of Indrayani River	120
Figure 2.25	Hydroelectric Project on Tungbhadra River	122
Figure 2.26	Geological Features of Tungbhadra River	123
Figure 2.27	Hydroelectric Projects in Cauvery sub-basin	132
Figure 2.28	Topographical (Elevation Data) Map of Cauvery sub-basin	133
Figure 2.29	Ecologically Sensitive Area Map of Cauvery sub-basin	134
Figure 2.30	Geological Map of Cauvery sub-basin	135
Figure 2.31	Seismic Map of Cauvery sub-basin	136
Figure 2.32	CWC Gauge Discharge sites & IMD Rain Gauge sites of Cauvery sub-basin	137
Figure 2.33	Hydroelectric Project on Cauvery River	140
Figure 2.34	Geological Features of Cauvery River	141
Figure 2.35	Hydroelectric Project on Bhavani River	144
Figure 2.36	Geological Features of Bhavani River	145
Figure 2.37	Hydroelectric Projects in South of Cauvery sub-basin	148
Figure 2.38	Topographical (Elevation Data) Map of South of Cauvery sub-basin	149
Figure 2.39	Ecologically Sensitive Area Map of South of Cauvery sub-basin	150

Figure No.	Details	Page No.
Figure 2.40	Geological Map of South of Cauvery sub-basin	151
Figure 2.41	Seismic Map of South of Cauvery sub-basin	152
Figure 2.42	CWC Gauge Discharge sites & IMD Rain Gauge sites of South of Cauvery sub-basin	153
Figure 2.43	Hydroelectric Project on Suruli River	155
Figure 2.44	Geological Features of Suruli River	156
Figure 2.45	Hydroelectric Project on Thamirabarani River	158
Figure 2.46	Geological Features of Thamirabarani River	159
Figure 4.1	Location of Dam site, Powerhouse Site of Dummugudem H.E. Project with respect to Kinnerasani and Eturnagram Eco-Sensitive	457
Figure 4.2	Location of Dam and Powerhouse Site of Nugur- II H.E. Project with respect to Indravati National Park	458
Figure 4.3	Location of Dam and Powerhouse Site of Bhopalapatnam H.E. Project with respect to Indravati National Park	458
Figure 4.4	Location of Dam and Powerhouse Site of Nugur-I H.E. Project with respect to Indravati National Park	459
Figure 4.5	Location of Dam and Powerhouse Site of Kunghara H.E. Project with respect to Chaprala Wildlife Sanctuary	459
Figure 4.6	Location of Dam and powerhouse site of Lower Moyar H.E. Project, Nilgiri, Tamil Nadu	463
Figure 5.1	Specific Flow at Polavaram	524
Figure 5.2	Specific Flow at Koida	524
Figure 5.3	Specific Flow at Perur	524
Figure 5.4	Specific Flow at Somanpally	525
Figure 5.5	Specific Flow at Mancherial	525
Figure 5.6	Specific Flow at all sites	525
Figure 5.7	Koida-Flood frequency estimates by different methods	528
Figure 5.8	Pathagudem-Flood frequency estimates by different methods	529
Figure 5.9	Mancherial-Flood frequency estimates by different methods	529
Figure 5.10	Perur-Flood frequency estimates by different methods	529
Figure 5.11	Polavaram-Flood frequency estimates by different methods	530
Figure 5.12	Flood frequency estimate at Tupakulagudem barrage site	531
Figure 5.13	Diagram of the Godavari river system showing Raingauge stations	544

Figure No.	Details	Page No.
Figure 5.14	Diagram of the Godavari river system showing Isohyetal map of Normal rainfall	545
Figure 5.15	Diagram the Godavari river system showing Gauge and Discharge stations	546
Figure 5.16	Catchment Area of Project and Locations of Dam and G&D site	548
Figure 5.17	IMD Grid Rainfall Data for Dummugudem Project site and G&D site	550
Figure 5.18	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Perur G&D site	554
Figure 5.19	Plot of runoff coefficient at Perur G&D Site	555
Figure 5.20	EAC curve of Dummugudem Dam	562
Figure 5.21	Catchment Area of Project and Locations of Dam and G&D site	569
Figure 5.22	IMD Grid Rainfall Data for Bodhghat Project site and G&D site	571
Figure 5.23	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site	575
Figure 5.24	Plot of Runoff Coefficient at G&D site	576
Figure 5.25	EAC curve of Bodhghat Dam	583
Figure 5.26	Catchment Area of Project and Locations of Dam and G&D site	589
Figure 5.27	IMD Grid Rainfall Data for Kutru-I Project site and G&D site	591
Figure 5.28	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site	595
Figure 5.29	Plot of Runoff Coefficient at G&D site	596
Figure 5.30	EAC curve of Kutru-I Dam	603
Figure 5.31	Catchment Area of Project and Locations of Dam and G&D site	609
Figure 5.32	IMD Grid Rainfall Data for Kutru-II Project site and G&D site	611
Figure 5.33	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site	615
Figure 5.34	Plot of Runoff Coefficient at G&D site	616
Figure 5.35	EAC curve of Kutru-II Dam	623
Figure 5.36	Catchment Area of Project and Locations of Dam and G&D site	629
Figure 5.37	IMD Grid Rainfall Data for Nugur-I Project site and G&D site	631
Figure 5.38	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tumnar G&D site	635

Figure No.	Details	Page No.
Figure 5.39	Plot of Runoff Coefficient at G&D site	636
Figure 5.40	Daily Rainfall-Runoff Correlation at Tumnar G&D Site	637
Figure 5.41	EAC curve of Nugur-I Dam	645
Figure 5.42	Catchment Area of Project and Locations of Dam and G&D site	650
Figure 5.43	IMD Grid Rainfall Data for Kotri Project site and G&D site	652
Figure 5.44	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tumnar G&D site	656
Figure 5.45	Plot of Runoff coefficient at G&D site	657
Figure 5.46	EAC curve of Kotri Dam	664
Figure 5.47	Catchment Area of Project and Locations of Dam and G&D site	670
Figure 5.48	IMD Grid Rainfall Data for Wainganga Project site and G&D site	672
Figure 5.49	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site	676
Figure 5.50	Plot of Runoff Coefficient at G&D site	677
Figure 5.51	EAC curve of Wainganga Dam	684
Figure 5.52	Catchment Area of Project and Locations of Dam and G&D site	691
Figure 5.53	IMD Grid Rainfall Data for Samda Project site and G&D site	693
Figure 5.54	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site	697
Figure 5.55	Plot of Runoff Coefficient at G&D site	698
Figure 5.56	EAC curve of Samda Dam	705
Figure 5.57	Catchment Area of Project and Locations of Dam and G&D site	711
Figure 5.58	IMD Grid Rainfall Data for Kunghara Project site and G&D site	713
Figure 5.59	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site	717
Figure 5.60	Plot of Runoff Coefficient at G&D site	718
Figure 5.61	EAC curve of Kunghara Dam	725
Figure 5.62	Catchment Area of Project and Locations of Dam and G&D site	731
Figure 5.63	IMD Grid Rainfall Data for Pranhita Project site and G&D site	733
Figure 5.64	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tekra G&D site	737
Figure 5.65	Plot of Runoff coefficient at the G&D	738

Figure No.	Details	Page No.
Figure 5.66	EAC curve of Pranhita Dam	745
Figure 5.67	Catchment Area of the Project and Locations of Dam Site	751
Figure 5.68	IMD Grid Rainfall Data for Balimela Project site	753
Figure 5.69	Comparison of Annual Rainfall and Annual Runoff in mm at Balimela Dam site	756
Figure 5.70	EAC curve of Balimela Dam	763
Figure 5.71	Catchment Area of Project and Locations of Dam and G&D site	768
Figure 5.72	IMD Grid Rainfall Data for Konta Project site and G&D site	770
Figure 5.73	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tekra G&D site	775
Figure 5.74	Plot of Runoff coefficient at the G&D	776
Figure 5.75	EAC curve of Sabari Dam	785
Figure 5.76	EAC curve of Sileru Dam	786
Figure 5.77	Catchment Area of Project Locations of Dams and G&D site	794
Figure 5.78	IMD GRID Rainfall Data for Project site and Dam site	796
Figure 5.79	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Huvinhedgi G&D site	801
Figure 5.80	Plot of Runoff Coefficient at G&D Site	802
Figure 5.81	Plot of Runoff Coefficient at Narayanpur Dam site	802
Figure 5.82	EAC curve of Tamankal Dam	813
Figure 5.83	Catchment Area of Project and Locations of Dam site	820
Figure 5.84	IMD GRID Rainfall Data for Jaldurg Diversion Site & Dam site	822
Figure 5.85	Plot of Monthly Rainfall (mm) and Monthly Runoff (mm) at Huvinhedgi G&D site	829
Figure 5.86	Plot of Runoff Coefficient at G&D Site	829
Figure 5.87	Plot of Runoff Coefficient at Narayanpur Dam site	830
Figure 5.88	EAC curve of Jaldurg Diversion	845

ABBREVIATIONS

Abbreviation	Expanded Form
CEA	Central Electricity Authority
CPSU	Central Public Sector Undertaking
CWC	Central Water Commission
DEM	Digital Elevation Model
G&D Sites	Gauge and Discharge Sites
HEC-GeoHMS	Hydrologic Engineering Center's Geospatial Hydrologic Modeling System
GIS	Geographic Information System
GSI	Geological Survey of India
NCS	National Centre for Seismology
IUCN	International Union for Conservation of Nature
IWPA	Indian Wildlife Protection Act
H.E. Project	Hydroelectric Project
IC	Installed Capacity
PFR	Pre-Feasibility Report
DPR	Detailed Project Report
S&I	Survey & Investigation
IMD	India Meteorological Department
LULC	Land Use Land Cover
Mcum	Million Cubic Meter
MoEF & CC	Ministry of Environment, Forest and Climate Change
ESZ	Eco-Sensitive Zone
WGS	World Geodetic System
MW	Mega Watt
NRSC	National Remote Sensing Centre
SOI	Survey of India
Sq.km	Square Kilometer
R & R	Resettlement & Rehabilitation
SRTM	Shuttle Radar Topography Mission

Abbreviation	Expanded Form
UID	Unique Identification
UTM	Universal Transverse Mercator
EFR	East Flowing Rivers of Peninsular India Basin
WRIS	Water Resources Information System
NWDA	National Water Development Agency
MPPGCL	Madhya Pradesh Power Generation Company Limited
OHPCL	Odisha Hydro Power Corporation Ltd.
CSPGCL	Chhattisgarh State Power Generation Company Ltd.
APGENCO	Andhra Pradesh Power Generation Cooperation Ltd.
TANGEDCO	Tamil Nadu Generation and Distribution Corporation Limited
TSGENCO	Telangana State Power Generation Corporation Limited
KPCL	Karnataka Power Corporation Limited
KSEB	Kerala State Electricity Board
MAHAGENCO	Maharashtra State Power Generation Company Limited

Definition of various status/categories of Project Stage is given in **Table 1.1**

Status/ Categories		Definition
In Operation		Hydroelectric Projects in Operation
Under Construction		Hydroelectric Projects under Construction
Concurred	CEA Concurred	Hydroelectric Projects Concurred/Approved by CEA
	State Concurred	Hydroelectric Projects Concurred/Approved by State Agencies
DPR Returned for Re-submission		Hydroelectric Projects under DPR stage but returned for Re-submission
Under Examination		Hydroelectric Projects under Examination in CEA/MoWR
S & I		Hydroelectric Projects under Survey & Investigation
PFR		Hydroelectric Projects under PFR stage
Balance		Hydroelectric Projects other than above categories
Large Hydroelectric Projects		Hydroelectric Projects having installed capacity above 25 MW
Small Hydroelectric Projects		Hydroelectric Projects having installed capacity 25 MW or below 25 MW

Table 1.1

MEMBERS OF THE MONITORING COMMITTEE

The work of "Basin Wise Reassessment of Hydroelectric Potential in the country" was taken up by Central Electricity Authority (CEA) through M/s WAPCOS Ltd. (Executing Agency). For carrying out the work, a monitoring committee was constituted under the Chairmanship of Chairperson, Central Electricity Authority (CEA) for monthly review & monitoring of executing agency's work.

The committee comprised of representatives from following organizations:-

1. CENTRAL ELECTRICITY AUTHORITY (CEA)
2. CENTRAL WATER COMMISSION (CWC)
3. SURVEY OF INDIA (SOI)
4. GEOLOGICAL SURVEY OF INDIA (GSI)
5. MINISTRY OF ENVIRONMENT, FOREST AND CLIMATE CHANGE (MoEF & CC)
6. NATIONAL REMOTE SENSING CENTRE (NRSC), INDIAN SPACE RESEARCH ORGANIZATION (ISRO)

The committee met every month and reviewed the progress of the work and provided valuable guidance.

UNDER GUIDANCE RECEIVED FROM MEMBERS OF MONITORING COMMITTEE

Listed below are some of the valuable suggestions provided by the members of the monitoring committee which have been incorporated suitably:

a) Ministry of Environment, Forest and Climate Change (MoEF & CC) guided that the approach to be followed by WAPCOS for present study may be submitted for approval in the form of approach paper. The same was prepared and submitted to Ministry of Environment, Forest and Climate Change (MoEF & CC) and was approved after few modifications.

b) Ministry of Environment, Forest and Climate Change (MoEF & CC) guided that while shortlisting the projects for further studies the projects which are located in either in draft notified stage or in buffer zone can be taken up for studies. Only the projects planned inside the core area of ESZ are not be studied further.

c) Ministry of Environment, Forest and Climate Change (MoEF & CC) enquired about the environmental flows to be released. It was clarified that

these flows are as per the Ministry of Environment, Forest and Climate Change (MoEF & CC) norms.

d) The source of information for preparation of map layout to be indicated in the layout itself.

e) In case of L-section of rivers both vertical as well as horizontal scales using scale legend must be shown.

f) It was suggested that geological map of India may be obtained from Geological Survey Of India (GSI) Kolkata for use in detailed study of the project.

g) Geological Survey Of India (GSI) guided that as Open source maps from Survey of India (SOI), DEM data of different type and resolution such as SRTM, Carto-Sat etc. are being used for topographical studies which has global datum (WGS 1984). Therefore, datum based correction should be done on all these data.

h) The legend being used in the preparation of various maps should be same as the legend provided by the source organization.

i) The various range of elevations in topographical maps should be defined in legends by different colours (sufficient number of elevation ranges).

j) It was advised that Land use/ Land cover of 1:50000 generated by NRSC available on INDIA-WRIS may be used for present studies.

k) It was desired that an approach paper for hydrological studies may be submitted for approval to CWC and the same was prepared with different methodologies for different cases & was approved with few modifications.

l) Central Water Commission (CWC) suggested WAPCOS to use rainfall data in case of availability of short term data at the project location for development of rainfall-runoff model and extension of run-off series and computation of water availability.

CHAPTER-1

INTRODUCTION

1.0 Background:

India is endowed with enormous economically exploitable and viable hydroelectric potential. The first systematic hydroelectric potential Survey of India was undertaken by erstwhile Central Water & Power Commission (CW& PC) during 1953-59. According to this survey, Hydroelectric potential of the country was assessed as about 42 Million kW from a total of about 250 Projects. Subsequently, the studies for Reassessment of Hydroelectric Potential (1978-87) were undertaken by Central Electricity Authority (CEA). As per the Reassessment study completed by Central Electricity Authority (CEA) in 1987, the Hydroelectric Power Potential of the country was estimated as about 84 million KW at 60% load factor (with probable installed capacity of 1,48,701 MW) from a total of 845 nos. projects. The above comprised 592 Hydroelectric Projects (above 25 MW) aggregating to installed capacity of 145320 MW. The basin-wise Hydroelectric power potential of the country as per, the Reassessment studies carried out by CEA in 1987 is as shown in **Table 1.2** along with all six (6) river basins of India are shown in **Figure 1.1**:

River Basin	Total		Above 25 MW	
	No. of Projects	Probable Installed Capacity (MW)	No. of Projects	Probable Installed Capacity (MW)
Indus	190	33832	126	33028
Brahmaputra	226	66065	183	65400
Ganga	142	20711	111	20252
Central Indian River System	53	4152	26	3868
West Flowing Rivers of Southern India	94	9430	60	8997
East Flowing Rivers of Southern India	140	14511	86	13775
Total	**845**	**148701**	**592**	**145320**

Table 1.2

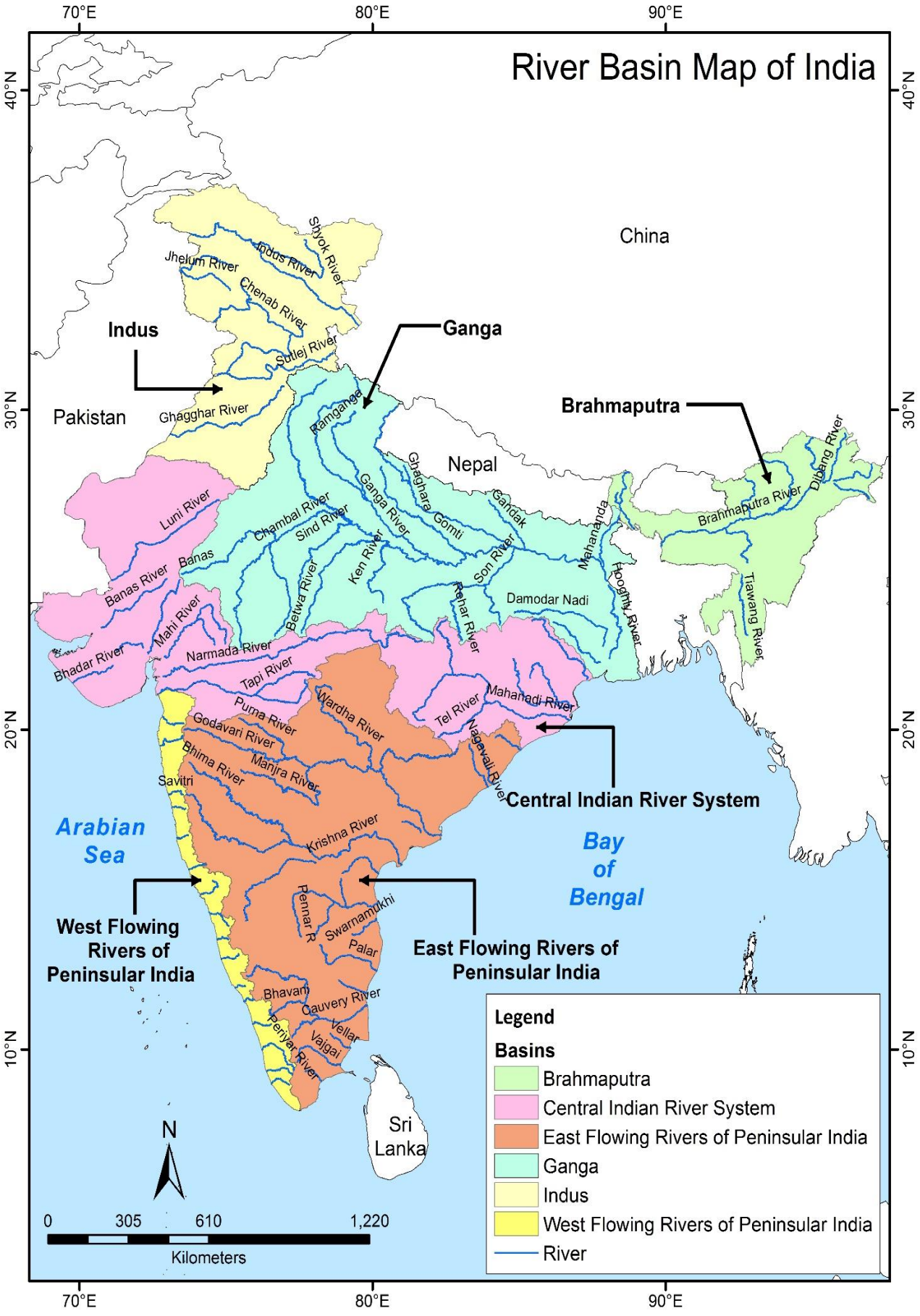


Figure 1.1 River Basins of India

1.1 Objectives of Reassessment study:

The basin wise reassessment of hydro potential would help in achieving the following objectives:

- The opportunity to optimize the river cascade system.
- Identify the most viable projects to develop first.
- Reduce the duplication of various studies, particularly hydrology, sedimentation, regional geological issues, seismic studies and power evacuation studies. This would make an important contribution in reducing the long implementation period for the projects.
- Coordinated development of power evacuation system.
- Optimize construction and use of road network in a coordinated way.
- Provide systematic approach and improvement in implementation & monitoring of environmental & social aspects.

Under Section-8(1) of the Electricity Act, 2003- any generating company intending to set up a hydro generating station shall prepare and submit to the Authority for its concurrence, a Project estimated to involve a capital expenditure exceeding such sum, as may be fixed by the Central Government, from time to time, by notification. Further, under Section 8(2) of the Electricity Act, 2003- the Authority shall before concurring in any Project submitted to it, have particular regard to, whether or not in its opinion,

(a) The proposed river-works will prejudice the prospects for the best ultimate development of the river or its tributaries for power generation, consistent with the requirements of drinking water, irrigation, navigation, flood control, or other public purposes and for this purpose the Authority shall satisfy itself.

(b) Further, after consultation with the State Government, the Central Government or such other agencies as it may deem appropriate, that an adequate study has been made for the optimum location of dams and other river-works.

(c) The proposed Project meets the norms regarding dam design and safety.

A basin-wise reassessment study is therefore important as it would be helpful to fulfill the statutory responsibility of Central Electricity Authority (CEA) under Section 8(2) of the Electricity Act, 2003.

1.2 Need For Reassessment Study:

In the Reassessment studies carried out earlier, the land use, submergence, environmental & ecological issues were assigned only broad consideration. Due to increasing consciousness of these issues and fresh guidelines and notifications issued by Ministry of Environment, Forest and Climate Change (MoEF & CC) all these aspects have been comprehensively studied to arrive at realistic assessment of hydroelectric potential. The requirement of environment flows has been considered as per guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Therefore hydroelectric projects identified as a result of the present studies would not have environmental concerns.

Hydrological study forms backbone of any power potential assessment study. The earlier reassessment studies were completed in 1987. Ever since, additional hydrological data to the tune of more than 30 years has become available and also tremendous climate change could have a significant impact on the reassessment of the power potential. The projects identified earlier did not take into consideration various inter-state issues, agreements and tribunal awards. These have been taken into consideration to have a more realistic assessment of the available potential.

The review has been necessitated further due to availability of additional hydrological ,topographical and other data (of higher spatial & temporal resolutions) about upstream and downstream water uses as in last three decades many hydro projects have been developed or are under various stages of development projects. Information and data on present /future irrigation development & other consummative uses both upstream & downstream of diversion/dam sites is an essential input for assessment of hydro potential. NWDA studies, which have compiled inputs for existing, ongoing & proposed projects and consumptive uses of various river basins of the country, along with inputs/Data from various State Authorities have provided a realistic basis for Reassessment of Hydro Potential.

Further higher resolution satellite imageries from NRSC and taking into consideration the ground realities like geological & submergence aspects , project parameters of many projects identified from earlier study(1978-87) necessitated modification along with relocation of site to minimize the R&R aspects.

The SOI "s latest maps of 1:50,000 having contour intervals of 10m to 20m (wherever available) have resulted in more accurate features of project details like Dam, barrage, water conductor system, location of power house, Switchyard etc. (in earlier study, maps of SOI used were 1:2,50,000& 1:50,000 scale with contour intervals of 40 m and 20 m respectively).

1.3 General Methodology:

Reassessment studies of Hydro Power Potential (Basin Wise) have been carried out taking into consideration:

- Updated Hydrological and Hydro-Meteorological data
- Ecological Data
- New Norms of Environmental flow & Free flow stretch
- Inter-State Issues and Tribunal awards.

River Basin maps have been studied in detail along its entire length to review all possible projects including existing projects, Projects under construction, Projects under DPR Stage and all new Potential projects with Potential above 25 MW. All projects identified in the previous assessment studies (1978-87) have been reviewed.

If any component of the project falls in notified protected area viz National Parks, Wildlife Sanctuaries, Eco Sensitive zones etc then the development of the project should be as per the guidelines of the respective protected area.

The Basin and Sub-Basin boundaries have been demarcated using the topographical data (SRTM 30M) of the river basin. Sub-basin wise topographical contours have been generated at 20 m interval using GIS techniques and contour values have been checked at critical locations with the available SOI Open Series Topographical Map Sheet. The longitudinal profile has been prepared for the various rivers of each sub-basin. The existing & proposed hydroelectric project locations have been overlaid on sub-basin boundaries and contributing areas have been estimated to the Project locations.

In the next stage, various hydro-meteorological, geological, ecological and seismological data set pertaining to a particular basin/Sub-basin have been reviewed. All the layers have been overlaid in GIS and schematic maps have been developed.

The Data have been digitized by GIS and longitudinal profiles of rivers have been prepared/ developed using DEM data (SRTM 30M of USGS). SRTM source details are given below:

Projection	Geographic
Horizontal Datum	WGS84
Vertical Datum	EGM96 (Earth Gravitational Model1996)
Vertical Units	Meters
Spatial Resolution	1 arc-second for global coverage(~30meters) 3 arc-second for global coverage (~90meters)
Raster Size	1 degree tiles
C-band wavelength	5.6 cm

The L Section of all major rivers and tributaries have been prepared with an objective to explore possibility of identifying a new potential site for hydroelectric project and longitudinal sections are analyzed for any major fall/drop within a short distance for possible utilization as water head along the course of river/tributary.

Any site where sufficient Head is available with adequate hydrology, that site can be further explored as potential site for hydro power project development. As the scope of studies start for projects with minimum capacity above 25 MW, if any site is found to have head of 60 meter & above than its Hydrology for minimum 10 cumecs of flow is checked for leading the potential of 25 MW peaking operation for four hours in a day. Any such site found is to be considered for hydrology and power potential studies.

Hydrology and Power Potential studies are to be carried out for all projects under planned category. The planning studies are to be revisited from civil component planning angle in an optimized manner. All projects already planned and newly found potential projects would be finally led to the potential of a particular basin.

Based on the above methodology the potential of each & every basin in the country would be assessed with reports prepared for individual basin wise. General methodology has been represented in following **Figure 1.2**.

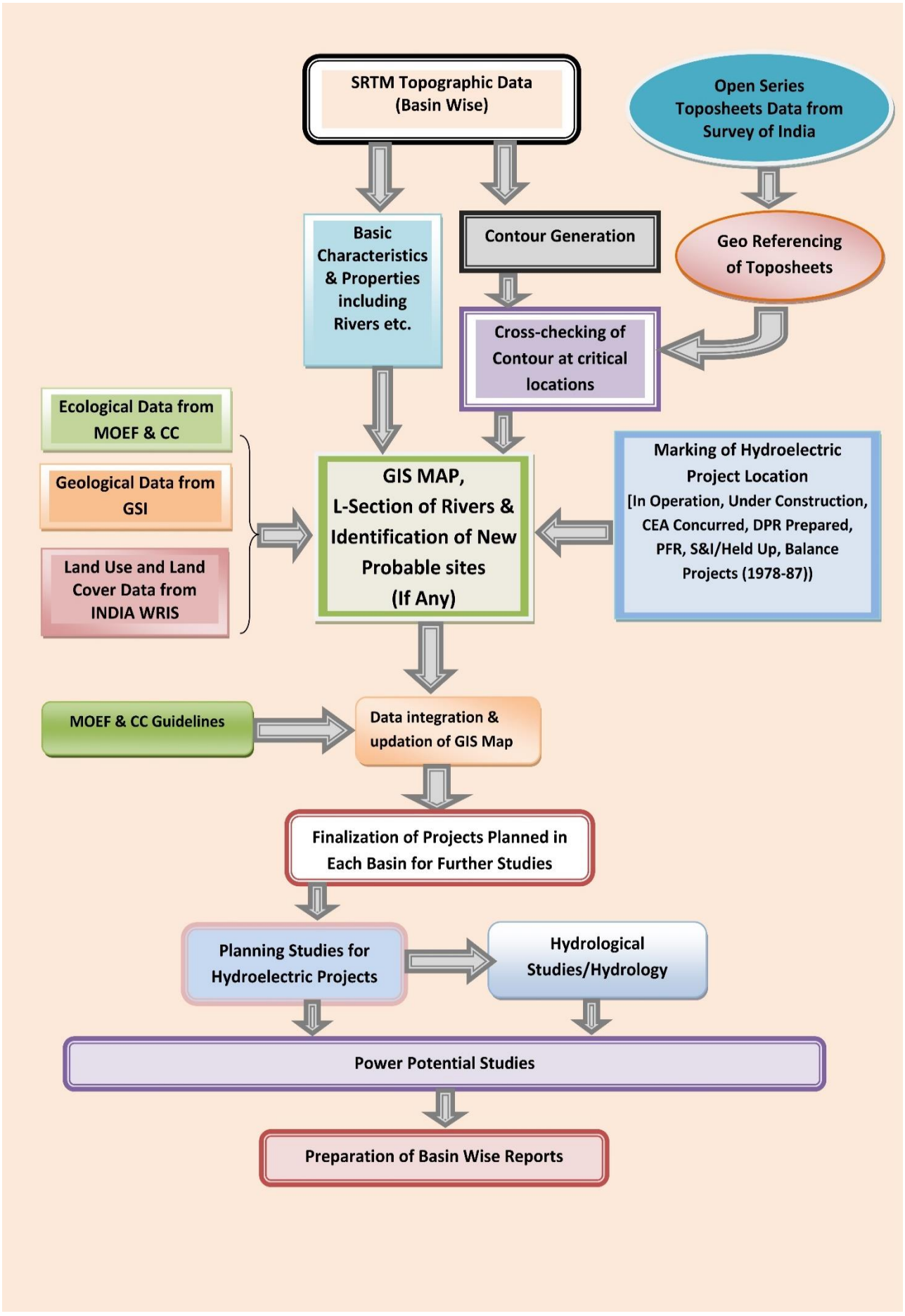


Figure 1.2 General Methodology

Steps for generating basin and sub-basin boundaries:

To develop basin and sub-basin boundaries, catchment area and drainage network for entire country has been digitized by GIS taking into consideration DEM data (SRTM 30M of USGS). With the help of drainage network, which are delineated in the above process, the sub-basin boundary has been developed by merging the corresponding catchment area. Basin boundary has been finalized by merging corresponding sub-basin boundaries.

Steps for generating L-section of river:

To develop the L-section of all rivers having hydroelectric potential, the DEM has been extracted for each sub-basin using sub-basin boundary. This is followed by re-projection of DEM from geographic to UTM projection system using WGS 1984 datum. Next step is to run the fill process to fill sinks of DEM. Flow direction grid is generated using fill DEM. This is followed by generation of flow accumulation grid using flow direction grid. Using flow accumulation grid, stream grid is generated. Next step is stream segmentation to create a grid of stream segments with unique identification. Inputs for this process are flow direction and stream definition grid.

Above step is followed by catchment grid delineation to create the grid in which each cell carries a value, which indicates to which catchment the cell belongs. Inputs for this process are stream link and flow direction grid files. Catchment polygon is generated using catchment delineation grid. Stream link grid is converted to a drainage line feature class (in shape format). Inputs for this process are flow direction and stream link grid files. To generate the aggregated upstream catchments, drainage lines and catchment polygons have been used.

Catchment delineation for the project will be carried out using HEC-GeoHMS with the help of ArcGIS.

A terrain model is used as an input to derive eight additional datasets that collectively describe the drainage pattern of the watershed and allows for stream and sub-basin delineation. The first six datasets are grid layers that represent the flow direction, flow accumulation, stream definition, stream segmentation, stream link and watershed delineation. The next two datasets are vector layers of the watersheds and streams.

The depression-less DEM is created by filling the depressions or pits by increasing the elevation of the pit cells to the level of the surrounding terrain. The pits are often considered as errors in the DEM due to re-sampling and interpolating the grid.

The hydrologically corrected DEM is used as the starting point for delineating Sub-basins and river reaches.

The flow chart shown in **Figure 1.3** shows the catchment delineation process in Arc-GIS software.

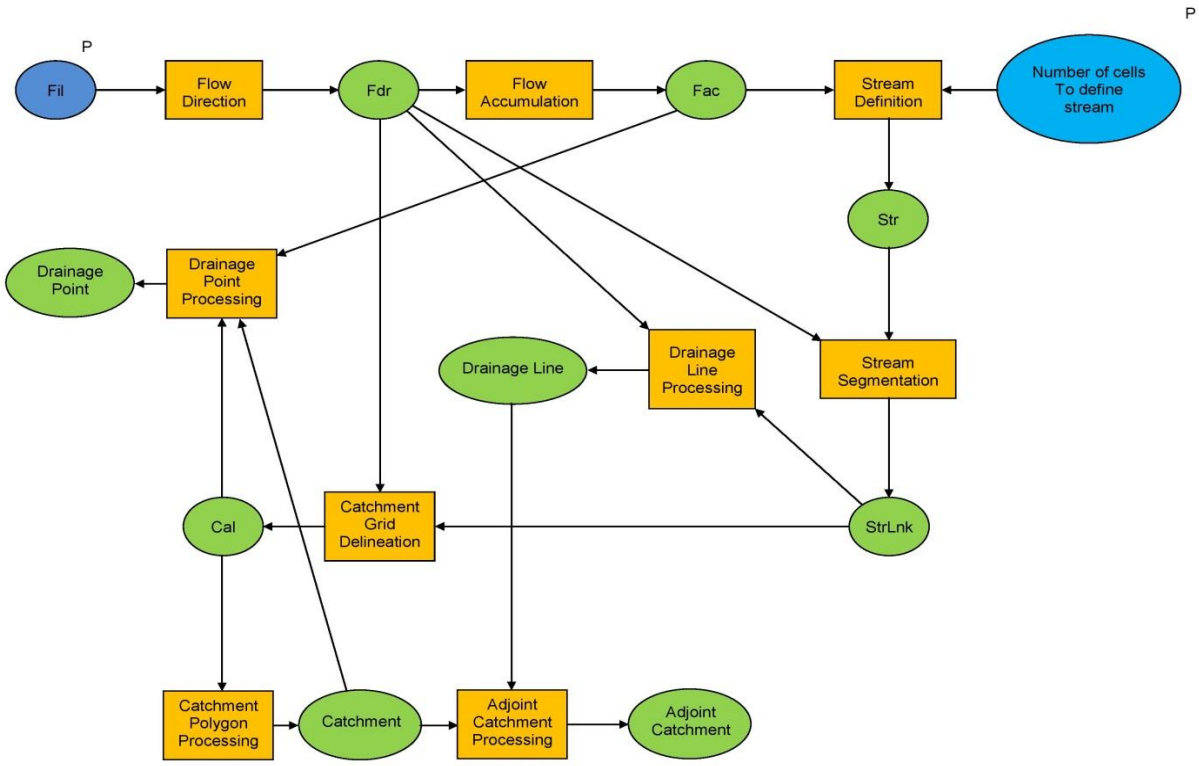


Figure 1.3 Catchment Delineation Process

1.4 Data Layers- Sources & Uses :

The various data layers used for carrying out the studies for Basin wise Reassessment of Hydroelectric potential are shown in **Table 1.3**:

S.No.	Data Layers	Uses	Sources
1	SRTM 30 m	Basin and River Identification	United States Geological Survey (USGS)
		Contour Generation	
		Plotting L-Section	
2	Toposheet (Open series)	Validation of Contours and Rectification	Survey of India (SOI)

S.No.	Data Layers	Uses	Sources
3	Land Use/ Land Cover	Distribution of Land Use & Land cover in the Basin	India-WRIS
4	Geology	Regional Geology of Sub Basin	Geological Survey of India (GSI)
5	Ecologically Sensitive Areas	Identification of Ecological zones, Wild life Sanctuary and Reserve Forest in Sub Basin	Ministry of Environment, Forest and Climate Change (MOEF & CC)
6	G&D Sites	Locations of Gauge-Discharge sites across the rivers	Central Water Commission (CWC)
7	Rain/Gauge Stations	Locations of IMD rain gauge in the Sub Basin	India Meteorological Department (IMD)
8	Dams and Barrages	Location of existing and proposed Dams and Hydroelectric Projects	India-WRIS, State Govt. Departments / Authorities

Table 1.3

1.5 East Flowing Rivers of Peninsular India (EFR) Basin :

Indian River system has been divided into six major river basins for reassessment studies i.e. Indus, Ganga, Brahmaputra, Central Indian River System, East Flowing Rivers of Peninsular India and West Flowing rivers of Peninsular India Basin.

The East Flowing Rivers of Peninsular India (EFR) basin extends over an area of about 9 lakh sq. kms and covers areas drained by East Flowing Rivers south of Mahanadi downwards upto Kanyakumari. The major rivers of the East Flowing River basin are Godavari, Krishna, Pennar, Cauvery, Paleru, Ponnaiyar, Vaigai and Thamirabarani and their principal tributaries. The East Flowing rivers of Peninsular India covers areas in the states of Maharashtra, Karnataka, Madhya Pradesh, Chhattisgarh, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Kerala and Pondicherry.

The East Flowing Rivers of Peninsular India basin has total of Nine-sub basin namely Godavari, Krishna, Cauvery, South of Cauvery, Mahanadi-Godavari, Godavari-Krishna, Krishna-Pennar, Pennar and Pennar-Cauvery. Various thematic maps of these sub basins are represented in detail in their subsequent sections.

Following map **(Figure1.4)** shows the various sub basins of East Flowing river system of India with colour code and their boundaries marked on it.
The Sub-basins namely Mahanadi-Godavari, Godavari-Krishna, Krishna-Pennar, Pennar and Pennar-Cauvery, which were mentioned in the previous (1978-87)

study are presently not being considered for detail study as no hydroelectric project (above 25 MW) has been identified in these sub-basins.

One of the sub-basin namely Cauvery-Kanyakumari (as per reassessment study of CEA conducted in 1978-87) has been renamed as South of Cauvery sub basin.

Therefore for present detailed studies, East Flowing River of Peninsular India basin has been divided into Four (4) sub basins namely.

1. Godavari Sub-Basin
2. Krishna Sub-Basin
3. Cauvery Sub-Basin
4. South of Cauvery Sub-Basin

Most of the rivers in the East Flowing River System have their origin in the Eastern slopes of Western Ghats and traverse their course through the plains of Deccan plateau and after passing through the Eastern Ghats drain into the Bay of Bengal. Some of the small rivers originating at low elevations below Cauvery join the sea near Kanyakumari. The drainage area of the East Flowing Rivers lies in the States of Maharashtra, Karnataka, Madhya Pradesh, Chhattisgarh, Odisha, Andhra Pradesh, Telangana, Tamil Nadu, Kerala and the Union Territory Pondicherry. The topography of the river system can be divided into three main divisions, i.e., high hill ranges of Western Ghats, Central Plateau and Deltaic plains in the east of Ghats.

In addition to the major rivers, the river system also constitutes numerous other small independent rivers which have their origin in low hills of Eastern Ghats flowing down with gentle slopes towards the Bay of Bengal. The initial course of the rivers of East flowing river system comprises rolling and undulating country and series of ridges and valleys between the low hills except the deltaic areas which are generally plains.

The river run-off in the eastern rivers is mainly due to south-west monsoon season which accounts for 80-85% of the total precipitation although north-east part of this river system near Odisha coast, receives some rain due to north-east monsoon season. The rivers are generally perennial with large variation in the river flows during monsoon and non-monsoon periods. The river basins, because of large variation in river flows during the year, are generally suitable for storage type projects.

Some of the rivers which originate in comparatively lower elevations of the coastal plains and flow down independently to drain into the sea have unfavorable topography for economic potential development. It is, however, observed that the upper reaches of the Godavari, Krishna and Cauvery in the vicinity of Western Ghats have possibilities for inter basin diversion. These possibilities, although generally attractive for hydro power development, involve inter-State aspects such as restriction in utilization of water for power generation/irrigation and other water use etc. It is also observed that in almost entire river system of the East flowing Rivers, greater attention has been paid to the development of major /medium/minor irrigation projects with exploitation of hydro potential as secondary consideration. On this account as well as on account of inter-State agreements between different participating States in connection with water utilization for irrigation and other purposes, the possibilities of development of hydroelectric power potential by providing storage type projects have been effected substantially. The present studies take into consideration available data regarding utilization of water by various Large existing and under construction irrigation/multi-purpose projects.

In East Flowing Rivers of Peninsular India Basin, there were 86 large hydroelectric projects as per previous hydro potential study carried out by CEA in 1978-87 with a total Probable Installed Capacity of 13775 MW. In that study, four projects namely Bhandardara II, Parson's Valley (Kundah 6), Upper Bhavani (Kundah 5) and Pillur (Kundah 4) were developed with capacity below 25 MW but presently Bhandardara II (34 MW), Parson's Valley (Kundah 6) (30 MW), Upper Bhavani (Kundah 5) (40MW) and Pillur (Kundah 4) (100MW) are operating with capacity above 25 MW. In addition to it, 1 project namely Nellithorai was identified with installed capacity below 25 MW but presently Nellithorai (50 MW) is proposed with capacity above 25 MW.

Three new projects have been identified subsequent to earlier study namely Nagarjunasagar TPD (50 MW), Lower Jurala (240MW) and Middle Kolab (315 MW).

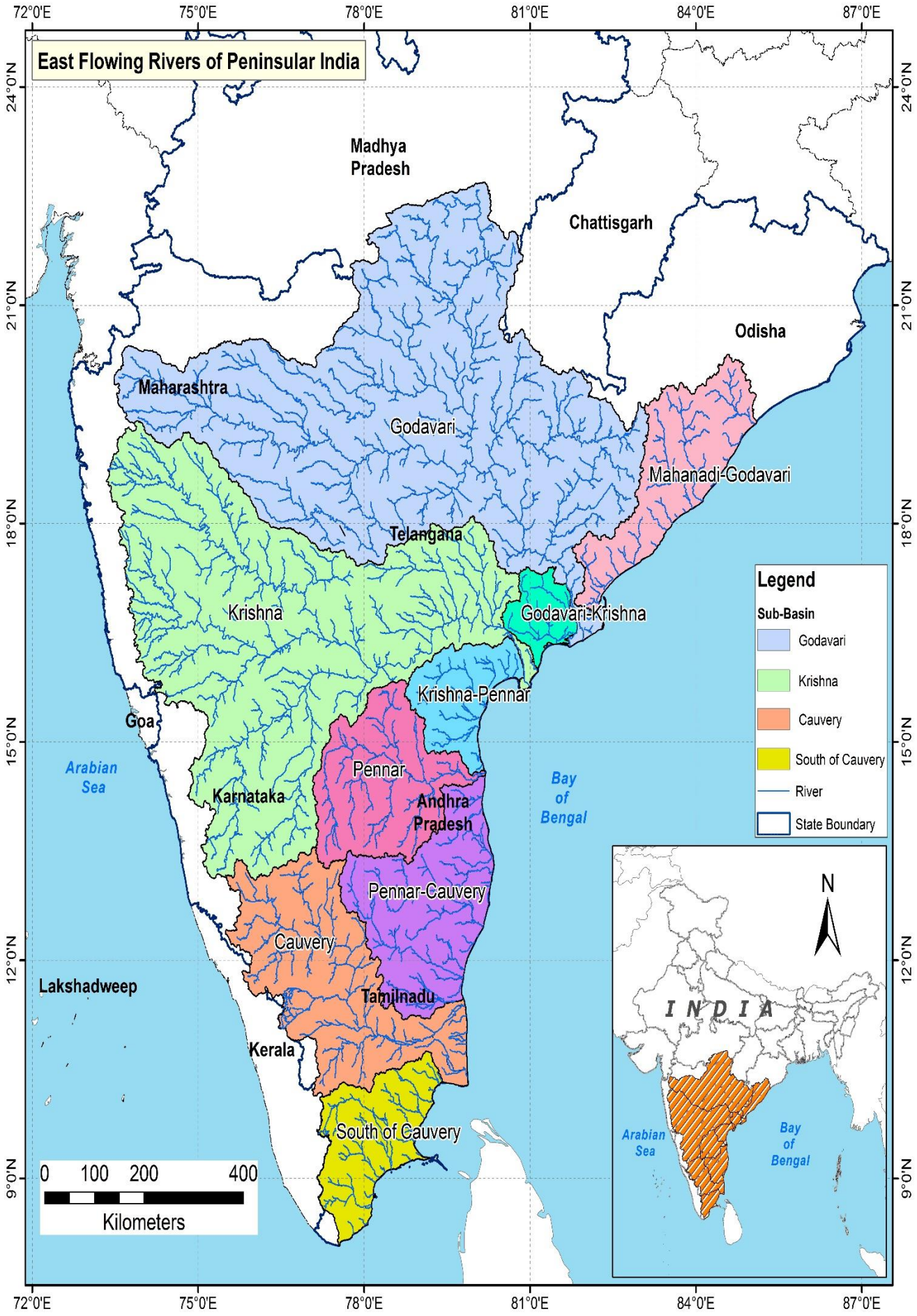


Figure 1.4 Sub-Basins of East Flowing Rivers of Peninsular India

1.6 Hydroelectric Projects (above 25MW) in EFR Basin as per 1978-87 studies :

As per studies for "Reassessment of Hydroelectric Potential of the country" conducted during 1978-87, East Flowing Rivers of Peninsular India Basin has been divided into 9 sub-basins. Projects above 25 MW could not be identified in Mahanadi & Godavari, Godavari & Krishna, Krishna & Penner, Penner and Penner & Cauvery Sub basins. 140 nos. of projects were identified in the 4 sub-basin with total probable installed capacity of 14511 MW. Out of which, 86 nos. of projects were above 25 MW with total installed capacity of 13775 MW. The sub-basin wise summary of Hydroelectric Projects (above 25 MW) identified in East Flowing River of Peninsular India basin is shown in **Table-1.4:**

S. No.	Sub-Basin	No. of Projects	I.C (MW)
1	Godavari	31	7413
2	Krishna	31	4357
3	Cauvery	22	1944
4	Cauvery-Kanyakumari	2	61
	TOTAL	**86**	**13775**

Table 1.4

The state wise summary of 86 nos. of these Projects is shown in **Table 1.5**:

S. No.	State	Number of Projects	I.C (MW)
1	Odisha	4	1645
2	Madhya Pradesh	9	1868
3	Maharashtra	22	3192
4	Andhra Pradesh	18	4360
5	Karnataka	18	1445
6	Tamil Nadu	14	1065
7	Kerala	1	200
Total		**86**	**13775**

Table 1.5

The State wise detailed list of Hydroelectric Projects (above 25 MW) as per 1978-87 studies identified in EFR Basin is given in ***Annexure-I***.

1.7 Hydroelectric Projects (above 25 MW) in EFR Basin and their status (Present Study) :

- There were 86 large projects in East Flowing Rivers of Peninsular India basin as per previous hydro potential carried out by CEA in 1978-87 with a total Probable Installed Capacity of 13775 MW.
- In the present hydropotential, out of these projects identified in the earlier study, 8 projects namely Donkarayi Canal, Shivpuri, Varna, Lower Bhavani, Shimsha PH I, Shimsha PH II, Pathri and Kumbhi II are developed with capacity less than 25 MW whereas 2 projects namely Ghargaon and Arkavathi are developed as irrigational projects.
- 2 projects namely Sahasrakund-I and Patharpunj are proposed to be developed as projects having capacity below 25MW and 4 projects namely Kadvi, Kasari I, Kumbhi-I and Hiryankeshi –II were identified as above 25MW projects as per reassessment study carried out by Central Electricity Authority (CEA) in 1978-87 but as per PFR studies these projects are proposed with capacity below 25MW.
- 1 project namely Pondugala hydroelectric project is abandoned in view of Pulichintala project was contemplated whereas 2 project namely Krishnarajsagar and Tungabhadra HLC are developed as multipurpose project with the purpose of irrigation and power generation below 25 MW.

  1 project namely Singareddi is not included as there was submergence issue with Dummugudem hydroelectric project.

  Therefore all these projects are not included in the present study.
- 4 projects namely Bhandardara II, Parson's Valley (Kundah 6), Upper Bhavani (Kundah 5) and Pillur (Kundah 4) were below 25MW as per reassessment study carried out by Central Electricity Authority (CEA) in 1978-87 but now these projects are developed with capacity above 25MW.
- 1 project namely Nellithorai was identified as a project having capacity below 25MW and was proposed to be developed having capacity above 25MW. Earlier, 2 projects namely Bhavani Kattalai and Lower Mettur were identified as single projects respectively but now Bhavani Kattalai is being considered in three stages namely Bhavani Kattalai Barrage-I, Bhavani Kattalai Barrage-II & Bhavani Kattalai Barrage-III and Lower Mettur is being considered in four stages namely Lower Mettur- I, Lower Mettur- II , Lower Mettur-III and Lower Mettur-IV .

- In addition, 3 new projects namely Nagarjunasagar TPD, Lower Jurala (In Operation Projects) and Middle Kolab (DPR Returned for Re-submission) have been identified subsequent to earlier study.

Therefore, at present, 79 large Hydroelectric Projects with a total probable Installed Capacity of 14779.40 MW are in East Flowing Rivers of Peninsular India (EFR) Basin. These Projects are also marked in **Figure 1.5** and their details are shown in ***Annexure III***.

The state wise comparison of Projects according to previous hydro potential (1978-87) and present hydro potential is shown in **Table 1.6**.

S. No.	State	Previous Hydro Potential (1978-87)		Present Hydro Potential	
		No. of Projects	I.C (MW)	No. of Projects	I.C (MW)
1	Odisha	4	1645	6	2330
2	Madhya Pradesh	9	1868	-	-
3	Maharashtra	22	3192	13	2944
4	Andhra Pradesh	18	4360	7	2596
5	Karnataka	18	1445	11	1828.2
6	Tamil Nadu	14	1065	24	1920.2
7	Kerala	1	200	1	225
8	Chhattisgarh	-	-	9	1634
9	Telangana	-	-	8	1302
Total		**86**	**13775**	**79**	**14779.4**

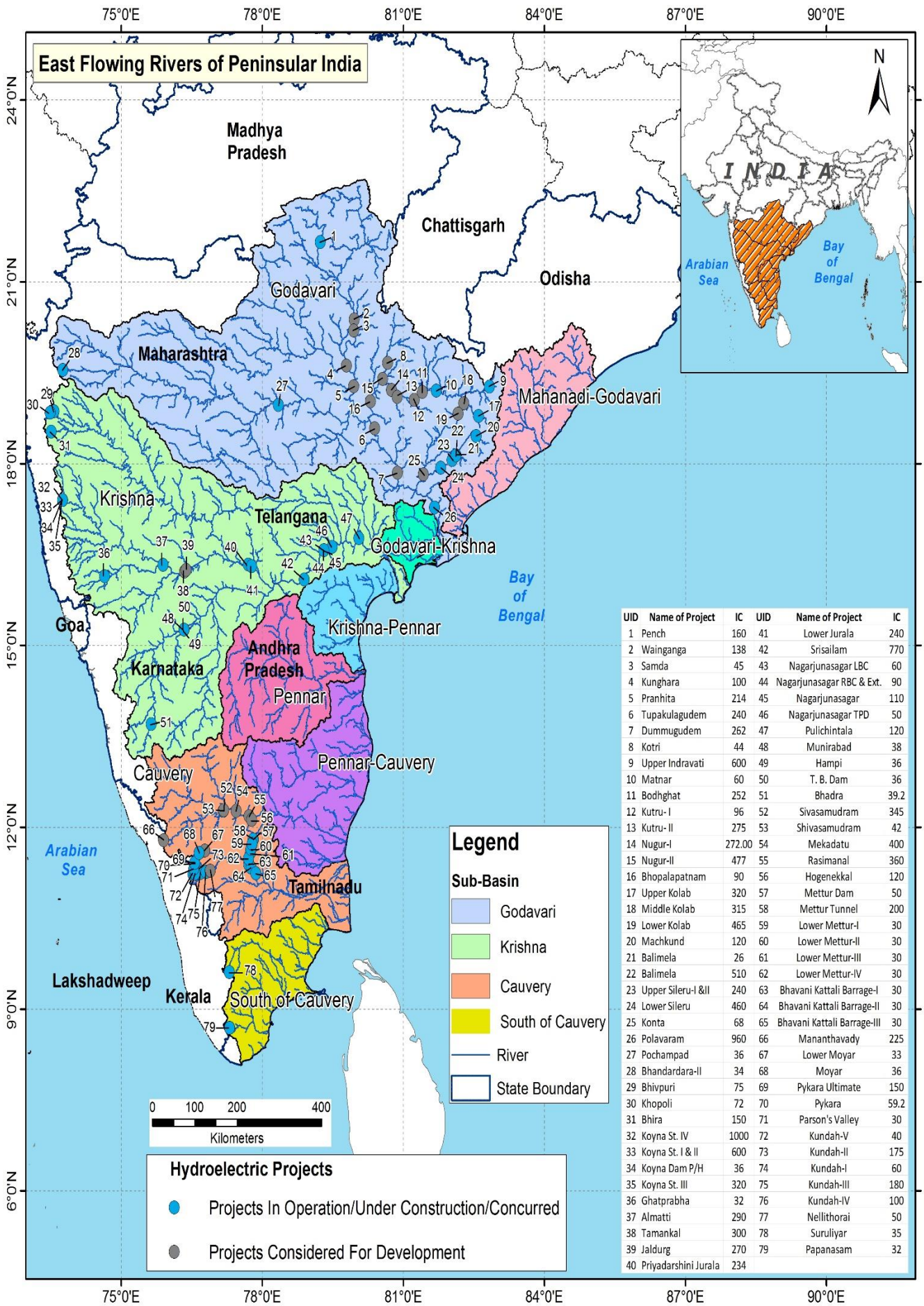
Table 1.6

The details of these projects are given in ***Annexure IV.***

The sub-basin wise comparison of Projects according to previous hydro potential (1978-87) and present hydro potential is shown in **Table 1.7**.

S. No.	Sub-Basin	Previous Hydro Potential (1978-87)		Present Hydro Potential	
		No. of Projects	I.C (MW)	No. of Projects	I.C (MW)
1	Godavari	31	7413	28	6879
2	Krishna	31	4357	23	4968.2
3	Cauvery	22	1944	26	2865.2
4	South of Cauvery	2	61	2	67
Total		**86**	**13775**	**79**	**14779.4**

Table 1.7



UID	Name of Project	IC	UID	Name of Project	IC
1	Pench	160	41	Lower Jurala	240
2	Wainganga	138	42	Srisailam	770
3	Samda	45	43	Nagarjunasagar LBC	60
4	Kunghara	100	44	Nagarjunasagar RBC & Ext.	90
5	Pranhita	214	45	Nagarjunasagar	110
6	Tupakulagudem	240	46	Nagarjunasagar TPD	50
7	Dummugudem	262	47	Pulichintala	120
8	Kotri	44	48	Munirabad	38
9	Upper Indravati	600	49	Hampi	36
10	Matnar	60	50	T. B. Dam	36
11	Bodhghat	252	51	Bhadra	39.2
12	Kutru- I	96	52	Sivasamudram	345
13	Kutru- II	275	53	Shivasamudram	42
14	Nugur-I	272.00	54	Mekadatu	400
15	Nugur-II	477	55	Rasimanal	360
16	Bhopalapatnam	90	56	Hogenekkal	120
17	Upper Kolab	320	57	Mettur Dam	50
18	Middle Kolab	315	58	Mettur Tunnel	200
19	Lower Kolab	465	59	Lower Mettur-I	30
20	Machkund	120	60	Lower Mettur-II	30
21	Balimela	26	61	Lower Mettur-III	30
22	Balimela	510	62	Lower Mettur-IV	30
23	Upper Sileru-I &II	240	63	Bhavani Kattali Barrage-I	30
24	Lower Sileru	460	64	Bhavani Kattali Barrage-II	30
25	Konta	68	65	Bhavani Kattali Barrage-III	30
26	Polavaram	960	66	Mananthavady	225
27	Pochampad	36	67	Lower Moyar	33
28	Bhandardara-II	34	68	Moyar	36
29	Bhivpuri	75	69	Pykara Ultimate	150
30	Khopoli	72	70	Pykara	59.2
31	Bhira	150	71	Parson's Valley	30
32	Koyna St. IV	1000	72	Kundah-V	40
33	Koyna St. I & II	600	73	Kundah-II	175
34	Koyna Dam P/H	36	74	Kundah-I	60
35	Koyna St. III	320	75	Kundah-III	180
36	Ghatprabha	32	76	Kundah-IV	100
37	Almatti	290	77	Nellithorai	50
38	Tamankal	300	78	Suruliyar	35
39	Jaldurg	270	79	Papanasam	32
40	Priyadarshini Jurala	234			

Figure 1.5 Hydroelectric Projects in East Flowing Rivers of Peninsular India Basin

The state wise summary of 79 nos. of Hydroelectric Projects is given in **Table 1.8**

State	Total Projects		Projects In Operation		Projects Under Construction		Projects Concurred by CEA/Approved by State Govt.		Projects under Planning/ DPR Preparation *	
	Nos.	I.C (MW)	Nos.	I.C (MW)	Nos.	I.C (MW)	Nos.	I.C (MW)	Nos.	I.C (MW)
Odisha	6	2330	4	1550	-	-	-	-	2	780
Maharashtra	13	2944	9	2447	-	-	-	-	4	497
Andhra Pradesh	7	2596	5	1610	1	960	-	-	1	26
Karnataka	11	1828.2	7	513.2	-	-	-	-	4	1315
Tamil Nadu	24	1920.2	20	1357.2	-	-	-	-	4	563
Kerala	1	225	-	-	-	-	-	-	1	225
Chhattisgarh	9	1634	-	-	-	-	1	60	8	1574
Telangana	8	1302	6	800	-	-	-	-	2	502
Total	**79**	**14779.4**	**51**	**8277.4**	**1**	**960**	**1**	**60**	**26**	**5482**

Table 1.8

*** Installed capacity in the above column obtained after carrying out the power potential studies.**

State wise detailed list of 26 nos. of Projects (Projects under Planning/ DPR Preparation) is given in **Table 1.9**

S. No.	Status	Total		Projects having Environmental/ Forest Issues (Section 1.8)		Projects having Inter-state Issues (Section 1.9)		Projects considered for further studies* (Section 1.10)			
								Projects not feasible (Section 1.11)			
		Nos. of Project	I.C (MW)	Nos. of Project	I.C (MW)	Nos. of Project	I.C (MW)	Nos. of Project	I.C (MW)	Nos. of Project	I.C (MW)
Odisha											
1	PFR	1	465	-	-	1	465	-	-	-	-
2	DPR Returned for Re-submission	1	315	-	-	1	315	-	-	-	-
	Sub Total	**2**	**780**	-	-	**2**	**780**	-	-	-	-
Maharashtra											
1	PFR	4	497	-	-	-	-	-	-	4	497
	Sub Total	**4**	**497**	-	-	-	-	-	-	**4**	**497**
Andhra Pradesh											
1	Balance	1	26	-	-	-	-	-	-	1	26
	Sub Total	**1**	**26**	-	-	-	-	-	-	**1**	**26**
Karnataka											
1	PFR	1	300	-	-	-	-	1	300	-	-
2	Balance	1	270	-	-	-	-	1	270	-	-
3	DPR Returned for Re-submission	2	745	-	-	2	745	-	-	-	-
	Sub Total	**4**	**1315**	**-**	**-**	**2**	**745**	**2**	**570**	-	-

S. No.	Status	Total		Projects having Environmental/ Forest Issues (Section 1.8)		Projects having Inter-state Issues (Section 1.9)		Projects considered for further studies* (Section 1.10)			
								Projects not feasible (Section 1.11)		Nos. of Project	I.C (MW)
		Nos. of Project	I.C (MW)	Nos. of Project	I.C (MW)	Nos. of Project	I.C (MW)	Nos. of Project	I.C (MW)		
Kerala											
1	DPR Returned for Re-submission	1	225	**-**	**-**	1	225	-	-	-	-
	Sub Total	**1**	**225**	**-**	**-**	**1**	**225**	-	-	-	-
Tamil Nadu											
1	Balance	1	33	1	33	-	-	-	-	**-**	**-**
2	DPR Returned for Re-submission	3	530	-	-	3	530	-	-	**-**	**-**
	Sub Total	**4**	**563**	**1**	**33**	**3**	**530**	-	-	**-**	**-**
Chhattisgarh											
1	PFR	7	1506	2	567	-	-	-	-	5	939
2	Balance	1	68	-	-	-	-	-	-	1	68
	Sub Total	**8**	**1574**	**2**	**567**	-	-	-	-	**6**	**1007**
Telangana											
1	DPR Returned for Re-submission	1	262	-	-	-	-	-	-	1	262
2	Under S&I	1	240	-	-	-	-	-	-	1	240
	Sub Total	**2**	**502**	-	-	**-**	**-**	-	-	**2**	**502**
Grand Total		**26**	**5482**	**3**	**600**	**8**	**2280**	**2**	**570**	**13**	**2032**

Table 1.9

*** Installed capacity in the above column obtained after carrying out the power potential studies.**

1.8 Hydroelectric Projects in EFR Basin having Environmental/ Forest Issues :

In East Flowing Rivers of Peninsular India River Basin, out of 79 nos. of Projects, 3 nos. of Projects have not been considered for further studies due to environmental/ forest issues and their details are given in **Table 1.10:**

S. No.	Name of Project	I.C (MW)	Sub- Basin	River	State	Status	Environmental Issues
1	Lower Moyar	33	Cauvery	Moyar	Tamil Nadu	Balance	• The pickup dam site of Lower Moyar is located on the boundary of Bandipur Wildlife Sanctuary (protected Area) • The Forebay dam is located of the project is located 4.1 km away from Bandipur Wildlife Sanctuary (protected Area). • The Powerhouse site is located 0.5 km inside Bandipur Wildlife Sanctuary (protected Area)
2	Nugur-II	477	Godavari	Indravati	Chhattisgarh	PFR	• The dam and powerhouse site of Nugur II HEP is situated on the boundary of Indravati National Park (Protected Area)
3	Bhopalpatnam	90	Godavari	Indravati	Chhattisgarh	PFR	• The dam and powerhouse sites of Bhopalapatnam HEP are located on boundary of the Indravati National Park (Protected Area).
Total		**600**					

Table 1.10

1.9 Hydroelectric Projects in EFR Basin having Inter-State Issues :

In East Flowing Rivers of Peninsular India River Basin, out of 79 nos. of Projects, 8 nos. of Projects have not been considered for further studies due to inter-state issues or disputes and their details are given in **Table 1.11:**

S. No.	Name of Project	I.C (MW)	Sub-Basin	River	State	Status
1	Middle Kolab	315	Godavari	Kerajodi Nallah	Odisha	DPR Returned for Re-submission
2	Lower Kolab*	465	Godavari	Kolab	Odisha	PFR
3	Sivasamudram	345	Cauvery	Cauvery	Karnataka	DPR Returned for Re-submission
4	Mekadatu	400	Cauvery	Cauvery	Karnataka	DPR Returned for Re-submission
5	Rasimanal	360	Cauvery	Cauvery	Tamil Nadu	DPR Returned for Re-submission
6	Hogenekkal	120	Cauvery	Cauvery	Tamil Nadu	DPR Returned for Re-submission
7	Nellithorai	50	Cauvery	Bhavani	Tamil Nadu	DPR Returned for Re-submission
8	Mananthavady	225	Cauvery	Mananthavady	Kerala	DPR Returned for Re-submission
Total		**2280**				

Table 1.11

* **Lower Kolab is located at the Downstream of Middle Kolab which is Under Interstate issue. As the outflows of Middle Kolab would be taken as inflows for Lower Kolab, therefore Lower Kolab could be taken up for further study only after the resolution of Middle Kolab Interstate Issue.**

Their current status is given below:

Nellithorai Inter-state Issue:

a) Sanctioned by planning commission in 1974 at an estimated cost of Rs 10.04 crores.

b) Concurrence not issued by Central Electricity Authority (CEA) due to objection received from Govt. of Kerala.

Hogenekkal & Rasimanal Inter-state Issue:

a) Returned in February, 1997.

b) In the Core Group Meeting taken by Secretary (Power) on 27.10.2004, it was agreed by GOK and GOTN that Sivasamudram (in Karnataka) and Hogenekkal (in TN) should be taken up simultaneously in the first phase and remaining two projects viz. Mekadatu (in Karnataka) and Rasimanal (in TN) in the next phase.

c) In the Core Group Meeting taken by Secretary (Power) on 21.06.2006, it was agreed that execution of these four projects through NHPC would be most viable proposition. It was decided that representatives of both the Govts. would take up the matter with their respective Govts. and seek their approval and thereafter necessary agreement will be signed between NHPC and the two State Govts. Consent by both the State Govts. was to be communicated to MOP by 31.07.2006. Tripartite agreement between Govt. of Tamil Nadu, Govt. of Karnataka and NHPC was to be signed. However, in June, 2007 the State of Karnataka informed that Sivasamudram and Mekadatu will be executed by Karnataka in State Sector.

d) TNEB informed in April, 2009 that Tamil Nadu has given its concurrence to MOP's draft tripartite agreement and sent it to MOP, GOI on 15.12.2008. Tamil Nadu insists the execution of the projects by neutral agency under Govt. of India. Final award of Cauvery Water Dispute Tribunal (CWDT) is yet to be notified in the Gazette of Govt. of India, as the case has been filed in the Supreme Court of India.

e) Subsequently, a meeting was held on 08.07.2009 under the chairmanship of Secretary (Power) to discuss the pending issue of development of Hydroelectric Projects in Cauvery Basin. Secretary (Power) expressed that Sivasamudaram being a Run of River Project with in the territory of Karnataka, Tamil Nadu should not have any objection to the development of the Project by the State Government. He further opined that there should not be any problem in taking up Sivasamudram Project by the State of Karnataka provided there is joint mechanism for monitoring the water level/releases of water to Tamil Nadu. He suggested that the Central Water Commission (CWC) could act as an observer in this regard and directed that the Govt.of Karnataka would provide/share all the

technical details of the Project to/with Tamil Nadu. Both the States Governments were advised to consult Central Electricity Authority (CEA) and Central Water Commission (CWC) before finalization of designing of the Project.

f) As regards other projects located in Tamil Nadu but whose submergence area partly falls in Karnataka, it was suggested that the two Governments need to arrive at an arrangement for power sharing.

Mekadatu Inter-state Issue:

a) Preliminary report of Stage-I was returned in 10/1996.

b) Sharing of Cauvery water awarded by Cauvery Water Dispute Tribunal (CWDT).

c) With the consent of GOTN and GOK, NHPC took up S&I and preparation of DPR.

d) In the Core Group Meeting taken by secretary (Power) on 27.10.2004, it was agreed by GOK and GOTN that Sivasamudram (Karnataka) and Hogenekkal (T.N.) should be taken up simultaneously in the first phase and remaining two projects viz. Mekadatu and Rasimanal in the next phase.

e) In the Core Group Meeting taken by Secretary (Power) on 21.06.2006, it was agreed that execution of these four projects through NHPC would be most viable proposition. It was decided that representatives of both the Govts. would take up the matter with their respective Govts. and seek their approval and thereafter necessary agreement will be signed between NHPC and the two State Govts. Consent by both the State Govts. was to be communicated to MOP by 31.07.2006. The State of Karnataka in June, 2007 informed that Sivasamudram and Mekadatu will be executed by them in State sector.

f) Karnataka Power Corporation Limited (KPCL) informed in April, 2009 that the tribunal award is with Supreme Court.

g) Subsequently, a meeting was held on 08.07.2009 under the chairmanship of Secretary (Power) to discuss the pending issue of development of Hydroelectric Projects in Cauvery Basin. Secretary (Power) expressed that Sivasamudram being a Run of River Project with in the territory of Karnataka, Tamil Nadu should not have any objection to the development of the Project by the State Government. He further opined that there

should not be any problem in taking up Sivasamudram Project by the State of Karnataka provided there is joint mechanism for monitoring the water level/releases of water to Tamil Nadu. He suggested that the Central Water Commission (CWC) could act as an observer in this regard and directed that the Govt. of Karnataka would provide/share all the technical details of the Project to/with Tamil Nadu. Both the States Government were advised to consult Central Electricity Authority (CEA) and Central Water Commission (CWC) before finalization of designing of the Project.

h) As regards other projects located in Tamil Nadu but whose submergence area partly falls in Karnataka, it was suggested the two Governments need to arrive at an arrangement for power sharing.

Sivasamudram Inter-state Issue:

a) Sharing of Cauvery water awarded by Cauvery Water Dispute Tribunal (CWDT).

b) With the consent of GOTN and GOK, NHPC took up S&I and preparation of DPR.

c) In the Core Group Meeting taken by secretary (Power) on 27.10.2004, it was agreed by GOK and GOTN that Sivasamudram (Karnataka) and Hogenekkal (TN) should be taken up simultaneously in the first phase and remaining two projects viz. Mekadatu (Karnataka) and Rasimanal (T.N.) in the next phase.

d) In the Core Group Meeting taken by Secretary (Power) on 21.06.2006, it was agreed that execution of these four projects through NHPC would be most viable proposition. It was decided that representatives of both the Govts. would take up the matter with their respective Govts. and seek their approval and thereafter necessary agreement will be signed between NHPC and the two State Govts. Consent by both the State Govts. was to be communicated to MOP by 31.07.2006. The State of Karnataka in June, 2007 informed that Sivasamudaram and Mekadatu will be executed by them in State sector.

e) Subsequently, a meeting was held on 08.07.2009 under the chairmanship of Secretary (Power) to discuss the pending issue of development of Hydroelectric Projects in Cauvery Basin. Secretary (Power) expressed that

Sivasamudaram being a Run of River Project with in the territory of Karnataka, Tamil Nadu should not have any objection to the development of the Project by the State Government. He further opined that there should not be any problem in taking up Sivasamudaram Project by the State of Karnataka provided there is joint mechanism for monitoring the water level/ releases of water to Tamil Nadu. He suggested that the Central Water Commission (CWC) could act as an observer in this regard and directed that the GOK would provide/share all the technical details of the Project to/with Tamil Nadu Both the States Government were advised to consult Central Electricity Authority (CEA) and Central Water Commission (CWC) before finalization of designing of the Project.

f) As regards other projects located in TN but whose submergence area partly falls in Karnataka, it was suggested the two Governments need to arrive at an arrangement for power sharing.

g) KPCL submitted revised DPR of Sivasamudaram Run of River Power Project (3x100+3x15=345 MW) in Cauvery Basin to Central Electricity Authority (CEA) vide their letter dated 30.03.2012. In the presentation meeting held in Central Electricity Authority (CEA) on 16.05.2012, it was decided in the meeting that due to non-resolution of Inter-State issues the DPR cannot be examined and the same is returned.

Mananthavady Inter-state Issue:

a) Earlier DPR with estimated cost of Rs 69.17 crores (1980 PL) returned in 07/1980.

b) Final award of Cauvery Water Dispute Tribunal (CWDT) stated that the scheme involves trans- basin diversion of water of Kabini, therefore it is not possible to allocate water for this project

c) Since the tribunal has ruled out trans basin transfer (from interstate rivers), this project remains as a non-starter

d) The final award of Cauvery Water Dispute Tribunal (CWDT) has been challenged by Kerala State before the Honorable Supreme Court of India.

Middle Kolab Inter-state Issue:

a) In the Detailed Project Report (DPR) of Middle Kolab Multipurpose Project of Odisha, observations of Water Resource Deprtment, Govt. of Chhattisgarh are as follows.: -

i) Rainfall data used in DPR of Middle Kolab Project are from the year 1966-67 to 2002-03, Rainfall data of the year from 2003-04 to 2016-17 has not been considered.

ii) Flow data of Indravati River and Joura Nalla for the year 2003-04 to 2016-17 has been considered. Since the control structures in Indravati River and Joura Nalla have been completed in June 2016, hence from the year 2002-03 to till completion of control structures and there after, difference occurred in flow data must be calculated.

iii) Since River Indravati, Joura Nalla and River Kolab (Shabari) are the life lines of both Odisha and Chhattisgarh State, hence it will appropriate to check/investigate the water availability and its use, by the Joint High Level Technical Committee of both the state.

iv) In the light of aforementioned observations, Joint Inter-State Agreement, Dated 11.07.1979 should be reviewed at high level.

b) After construction of first barrage under Middle Kolab Project, the quantity of water in River Kolab at boundary of Chhattisgarh and Odisha has become reduced, resulting following:-

i) Govt. of Chhattisgarh allocated 53.69 McuM/year water for Nagamar Steel Plant and 11.00 Mcum/year water for Slurry Pipe Project of N.D.M.C. from Kolab (Shabari) River , but due to reduced water availability in Kolab 9Shabari) River , it will not be possible to full fill the committed water demand of aforesaid industries.

ii) Total 53 cumecs flow of water, required for proposed 5 No's Hydro Electric Power Project in Kolab (Shabari) River will be affected.

iii) Before entering Kolab River in Sukuma Distt. Of Chhattisgarh State, its 2751.55 sq km catchment area used by the Odisha State resulting reduction of flow in Sukma Distt.

In the above context, the Govt. of Chhattisgarh is disagree with construction of Middle Kolab Project.

Lower Kolab Inter-state Issue:

Lower Kolab is located at the Downstream of Middle Kolab which is Under Interstate issue. As the outflows of Middle Kolab would be taken as inflows for Lower Kolab, therefore Lower Kolab could be taken up for further study only after the resolution of Middle Kolab Interstate Issue.

1.9.1 International Treaties and Interstate Tribunals on Rivers of EFR Basin :

A river traversing through two or more than two states is termed as an interstate river. Some of the large Indian River basins viz. the Indus, Ganga and Brahmaputra, all not only pass through various states of India, but also traverse through neighboring countries and are thus termed as International Rivers.

Development of water resources of inter-state rivers involves issues, like total utilizable water resources of the basin/ sub-basin and its water allocation, sharing of project cost & benefits, submergence aspects & ecological consideration among the basin states.

Therefore, development of water resources of inter-state rivers by any state needs co-operation among basin states within the legal framework. The constitutional provisions relevant to inter-state rivers, laws enacted by the Parliament, agreements reached by the basin states and awards of various Tribunals, etc. have to be taken into consideration.

Various inter-state agreements have been reached by the co-basin states amongst themselves for development of their share of water resources in the basin/co-basin. If some disputes persists, efforts made by the Central Govt. to resolve them through negotiations. If, a State Govt. makes a request regarding any water dispute and the Central Government is of the opinion that the water dispute cannot be settled by negotiations, then a water dispute tribunal is constituted for adjudication of the dispute.

The Tribunals after investigating the whole gamut of issues involved among the concerned basin states, award is given and notified by the Central Govt. of India. These awards are final and binding on the co-basin state.

The constitutional provisions/important notifications, international treaties, interstate agreements, awards etc. are published by Central Water commission (CWC) entitled “Legal Instruments on Rivers in India” in four volumes namely:

Vol. - I- Constitutional Provisions, Central laws and notifications.

Vol. - II- Awards of Interstate Water Disputes Tribunals.

Vol. - III- Agreements on Interstate Rivers

Vol. - IV- International Agreements and treaties.

While doing the detailed studies of Hydro-Power Potential in each basin, these publications are referred. However, it is pertinent to note that so far the

development of Hydro- Power is concerned, consumptive use of water is mainly limited to the evaporation loss from the reservoir created, which the basin states are able to manage within their state of total water allocated or as per Tribunal awards. The main inter-state issues related to hydroelectric projects are:

1. Submergence in the other state
2. Sharing of benefits & cost
3. Pattern of downstream releases, which needs to abide with the already agreed/existing irrigation and other demands of downstream state.

The overall Hydro-Power potential of a basin is assessed on the basis of topography, head available and the net water yield at various identified locations. The contents of the existing agreements between the state governments, tribunal awards, need for negotiation among the states and new agreements between states if needed has to be looked into while framing the PFR of the individual Projects.

1.9.1.1 Cauvery Water Disputes Tribunal (June 1990):

Cauvery is an inter-State basin having its origin Karnataka and flowing through Tamil Nadu and Puduchery before out falling in Bay of Bengal. The total catchment of the Cauvery basin is 81,155 sq.km of which the catchment of the river in Karnataka is about 34,273 sq. km that in Kerala is about 2,866 sq. km and the remaining area of 44,016 sq. km in Tamil Nadu and Puduchery.

1. Harangi and Hemavathi dams in Karnataka are constructed across Harangi and Hemavathi rivers which are the tributaries of river Cauvery. Downstream of these two dams Krishna Raja Sagar dam is constructed across main Cauvery in Karnataka. Kabini reservoir of Karnataka is constructed across river Kabini a tributary of Cauvery joining it d/s of Krishna Raja Sagar reservoir. Mettur dam is constructed across main stream of Cauvery in Tamil Nadu. Between the confluence of Kabini with Cauvery and Mettur dam, Central Water Commission has established two G&D sites on main Cauvery namely Kollegal and Billigundulu. Billigundulu G&D site is about 60 km u/s of Mettur dam where the Cauvery river forms its boundary with Karnataka and Tamil Nadu.
2. The Cauvery Water Disputes Tribunal (CWDT) was constituted by the Government of India on 2nd June 1990 to adjudicate the water dispute

regarding inter-state river Cauvery and the river valley thereof among the States of Tamil Nadu, Karnataka, Kerala and Puducherry.

3. The Cauvery Water Disputes Tribunal (CWDT) passed an Interim order on 25th June, 1991 directing the State of Karnataka to release Water from its reservoirs in Karnataka so as to ensure 205 Thousand Million Cubic Feet (TMC) of water into Mettur reservoir of Tamil Nadu in a water year (1st June to 31st May) with monthly and weekly stipulations.

4. In respect of a particular month the releases are to be made in four weeks in four equal installments. If in a particular week, it is not possible to release the required quantum of water, the said deficit shall be made good in the subsequent week. 6 TMC of water for Karaikal region of the Union Territory of Pondicherry will be delivered by the State of Tamil Nadu in a regulated manner.

5. Upon consideration of the said order, the Hon'ble President of India made a reference to the Supreme Court of India on 27th July,1991 under clause (1) of Article 143 of the Constitution of India for consideration and report among other on :-

    i. Whether the Order of the Tribunal constitutes a Report and a Decision within the meaning of Section 5 (2) of the Act; and

    ii. Whether the Order of the Tribunal is required to be published by the Central Government in order to make it effective;

6. The Supreme Court has given its opinion on 22nd November, 1991, among others on the above questions that;

    i. The order of the Tribunal dated June 25,1991 constitutes report and decision within the meaning of Section 5 (2) of the Inter State Water Disputes Act,1956;and

    ii. the said order is , therefore, required to be published by the Central Government in the official Gazette under section 6 of the Act in order to make it effective";

7. In view of this, the interim Order dated 25th June,1991 of CWDT was notified in the Gazette of India under Section 6 of ISRWD Act 1956 on 10th December, 1991 to make it effective and binding on the parties to the dispute and is required to be given effect to by them.

8. On 14th May, 1992, Government of Tamil Nadu filed an original suit No.1 of 1992 in the Supreme Court praying inter-alia to pass a decree of

mandatory injunction directing the Union of India to frame a scheme making provision for all matters necessary to give effect to the decisions of the Tribunal and to issue a notification thereof in official gazette. The Original suit no. 1/92 came up for hearing before a constitution bench of Supreme Court in 9th April, 1997. On the insistence of the Supreme Court, the Attorney General of India made a statement in the Court on 9th April, 1997 that the Union of India was agreeable to frame a scheme under Section 6A of the Inter State Water Disputes Act, 1956 for the effective implementation of the interim award of the Tribunal. After the hearing on 9th April, 1997, when the Supreme Court directed the Union Government to frame a scheme there have been regular hearings on 20th August, 1997, 30th September 1997, 11th November, 1997, 6th January, 1998, 31st March, 1998, 28th April, 1998 and 21st July, 1998 in the Supreme Court. In view of the above, under the provisions of Section 6A of the ISRWD Act, 1956, the Central Government notified a Scheme called Cauvery Water (implementation of the Interim Order of 1991 and all subsequent Related Orders of the Tribunal) Scheme, 1998 consisting of Cauvery River Authority (CRA) and Monitoring Committee (CMC). The Cauvery River Authority is headed by Hon'ble Prime Minister as Chairperson and Chief Ministers of the basin States as Members. Secretary, MoWR is Secretary to the Authority. The Monitoring Committee consists of Secretary, MoWR as Chairperson, Chief Secretaries and Chief Engineers of the basin States as Members and Chairman, Central Water Commission as Member. CE(IMO),CWC is Member Secretary of the Monitoring Committee. The Authority is required to give effect to the implementation of the Interim Order dated 25th June 1991 of the Tribunal and its related subsequent orders. So far CRA has held 7 meetings and CMC has held 32 meetings. 7th meeting of CRA was held on 19.9.2012. 32nd meeting of CMC was held on 10.1.2013 (in compliance to the Supreme Court Order dated 04.01.2013).

9. Cauvery water Disputes Tribunal (CWDT) gave its report and decision u/s 5(2) of the ISRWD Act,1956 on 5th February, 2007. The Central Govt and party States filed application for clarification/further guidance u/s 5 (3) of the above said Act. The Party States also filed Special Leave Petition (SLPs) against the above mentioned report and decision of the Tribunal before the

Hon'ble Supreme Court. Hon'ble Supreme Court on 07.05.2007 has granted Special Leave in the matter.

10. The Tribunal took up the petition of the parties for consideration on 10th July, 2007 and observed that party States have also filed Special Leave Petitions (SLPs) against the aforesaid decision of the Tribunal dated 5.2.2007 before the Hon'ble Supreme Court and the Hon'ble Supreme Court has also granted Special Leave Petition. In this background the applications under Section 5(3) of the said Act should be listed for orders after disposal of the appeal of the Supreme Court.

11. In view of this Union of India filed an application & affidavit for impleadment in the said SLPs vide letter dated 12.03.2008 citing that Section 11 of the ISRWD Act, 1956 reads that "neither Supreme Court nor any other Court shall have or exercise the jurisdiction in respect of any water dispute which may be referred to the Tribunal under the Act." The matter is under consideration of the Supreme Court.

12. Decision of CWDT has been challenged by party States of Tamil Nadu, Karnataka and Kerala before Hon'ble Supreme Court by filling Civil Appeals. Further, the party States have also sought clarification and explanation on the decision of Tribunal under Section 5(3) of ISRWD Act 1956. In the meanwhile, in the 31st meeting of CMC held on 7.12.2012, it had been mentioned that the Ministry of Water Resources would take steps to notify the final Award (decision) in the month of December 2012. In this meeting, the quantity of water which Tamil Nadu was to receive during the month of December, 2012 was determined (12 TMC).

13. In the order passed by Hon'ble Supreme Court on 04.01.2013, it has been indicated that Senior Counsel appearing for all the concerned States have stated that they do not have any objection to the final decision by CWDT being notified, without prejudice to their rights and contentions raised in the pending appeals. Hon'ble Supreme Court directed CMC to convene its meeting on or before 11th January 2013 and make appropriate orders regarding the requirement of water for the two states.

14. In pursuance to the above order, 32nd meeting of CMC was held on 10.01.2013. In this 32nd meeting of the CMC the object was to determine the water that Tamil Nadu should receive during the month of January, 2013 in terms of the Interim Award. It was decided that Karnataka should

regulate the release of water in such a manner so that Tamil Nadu receives 1.51 TMC during the month of January, 2013. All the States except Karnataka again reiterated that the award should be notified at the earliest. The Chief Secretary, Karnataka stated that he would receive orders of the Government on this issue and communicate the same to the CMC within the next two days, extended to one week later on. However, no official communication has been received as on date.

15. Against above decision, Tamil Nadu filed an application in Supreme Court praying that 12 TMC water is released forthwith by Karnataka to save its standing crops and meet drinking water requirements. But Karnataka argued during hearing on 29.1.2013 that it has got only that much water in its four reservoirs so as to fulfill its drinking water requirements during remaining four months i.e. February to May. Therefore there is no question of releasing any further water to Tamil Nadu.

16. Hearing of above case continued on 4th February 2013. Hon'ble Supreme Court on this day directed the Central Government to publish in official gazette the final decision given by CWDT dated February 5, 2007 as early as may be possible and in no case later than February 20 2013.Accordingly, MOWR has published the final decision dated 05.02.2013 of CWDT in official gazette on 19.02.2013.

17. As per Section 6(2) of Inter State River Water Disputes Act, 1956 "The decision of the Tribunal, after its publication in the Official Gazette by the Central Government under sub-section (1), shall have the same force as an order or decree of the Supreme Court". Further, Chapter 8, Machinery for implementation of Final Decision/Orders of the Tribunal mentions that "an Inter- State forum to be called "Cauvery Management Board" shall be established for the purpose of securing compliance and implementation of the final decision of the Cauvery Water Disputes Tribunal".

18. Meanwhile, an I.A. No. 5 of 2013 in Civil Appeal No. 2456 of 2007 was filed on 18th March, 2013 in the Supreme Court by Government of Tamil Nadu praying for a direction against the Union of India to constitute Cauvery Management Board as per the directions contained in the final Order/Award dated 5.02.2007. In this regard, an Affidavit dated 1st May, 2013 was filed on behalf of Ministry of Water Resources clearly stating that after publication of the decision of CWDT on 19.02.2013, the Ministry of

Water Resources has initiated action for constitution of Cauvery Management Board in consultation with concerned Ministries The Hon'ble Supreme Court, during the hearing of above I.A. No. 5 of 2013 on 10.05.2013, has directed to constitute a Supervisory Committee to implement final order dated 5.02.2007 of CWDT which was notified on 19.02.2013, as a purely pro tem measure. The Order dated 10.05.2013 of the Hon'ble Supreme Court inter-alia reads as under: **"...the follow up action pursuant to the Notification dated February 19, 2013 is under active consideration of the Central Government. Until that is done, some arrangement shall have to be made...**

19. A Supervisory Committee is constituted for implementation of the final order dated February 5, 2007 as notified vide Notification dated February 19, 2013. The Supervisory Committee shall consist of the Secretary, Union Ministry of Water Resources as Chairman and the Chief Secretaries of the respective States of Karnataka, Tamil Nadu, Kerala and Union Territory of Puducherry as Members."

- So far 8 meetings of this Committee have been held on 1.06.2013, 12.06.2013, 15.7.2013 and 8.11.2013, 28.9.2015, 12.9.2016, 19.9.2016 and 17.2.2017 at New Delhi.
- An I.A. No.12/2016 in I.A. No.10 in Civil Appeal No.2456/2007 between State of Karnataka Vs State of Tamil Nadu was filed in Hon'ble Supreme Court where Hon'ble Supreme Court directed "the learned Attorney General of India has submitted that the Union of India is prepared to facilitate so that the impasse between the two States can appositely melt. The learned Sr. Counsel appearing for the State of Karnataka, as suggested by the Attorney Gen. of India, shall be available for discussions with the competent authority of Union of India to be suggested by the Attorney Gen. of India. State of Tamil Nadu has also expressed his consent.
- As a follow-up to the Order dated 27.09.2016 of the Hon'ble Supreme Court in I.A No.12/2016 in I.A.No.10 in Civil Appeal No.2456/2007 (State of Karnataka & Ors. Vs. State of Tamil Nadu), this Ministry convened a meeting on 29.09.2016 of Karnataka and Tamil Nadu to resolve the present impasse on release of Cauvery water. The Ministry made sincere efforts to make both the States

converge to a consensus on release of Cauvery water. The Ministry communicated the outcome of this meeting to Hon'ble Supreme Court through learned Attorney General of India on 30.09.2016.

- With regard to constitution of Cauvery Management Board, the Attorney General of India clarified the legal position before the Hon'ble Supreme Court. During the hearing of the case in the Supreme Court on 04.10.2016, the Attorney General made his submission and the issue of constitution of Cauvery Management Board has been deferred for the time being. In the interim, on the advice of Attorney General of India, the Hon'ble Supreme Court directed to constitute a Technical Team to visit the Cauvery Basin area to assess the ground realities in the Basin. Accordingly, this Ministry constituted a High Level Technical Team comprising Shri G.S Jha, Chairman, CWC as Chairman, Shri S. Masood Hussain, Member, CWC, Shri R.K. Gupta, Chief Engineer, CWC, Chief Secretaries of Tamil Nadu and Karnataka and one Chief Engineer each from Tamil Nadu, Karnataka, Kerala and Puducherry as Members for assessing the ground realities. The team has submitted its report to the Hon'ble Supreme Court on 17.10.2016. Till then, Govt. of Karnataka was directed to release 2000 cuses of water.
- The matter came up for hearing in the Supreme Court on 18.10.2016, wherein report submitted by High Level Technical Team was taken on records and directed to list the matter for 19.10.2016.
- Hon'ble Supreme Court in its order dated 09.12.2016 directed that these Civil Appeals are maintainable and listed the matter for 15.12.2016 which was deferred to 04.01.2017 for further orders. The case was heard by the Hon'ble Supreme Court on 04.01.2017 and adjourned to 07.01.2017, however next hearing was listed on 21.3.2017. Hon'ble Supreme Court on 21.3.2017 has directed that the interim order passed on 4th January, 2017, to be continued till the next date of hearing on 11.07.2017.

1.9.1.2 Godavari Water Disputes Tribunal (April 1969) :

The Godavari Water Disputes Tribunal headed by Justice Bachawat was constituted by the Government in April, 1969 for adjudication of Inter-State Water Disputes regarding Godavari River.

While the adjudication proceedings were going on, several Inter-State agreements between the party States viz. Maharashtra, Andhra Pradesh, Odisha, Madhya Pradesh and Karnataka were reached during the year 1975. Subsequently, bilateral and tripartite agreements between the party States with regard to number of irrigation projects were also reached during the year 1978-79. The Tribunal took cognizance of all these agreements and having regard to the requests of the party States included them in the Final Award. The agreements in effect imply a series of Inter-State compacts in the sense that the party States are free to utilize flow of river Godavari or its tributaries upto certain specified points. For example, Maharashtra is free to utilise flow in Godavari upto Paithan, while the State of Andhra Pradesh is free to utilise the Godavari flows below Paithan. Similarly, the bilateral agreements also specify for sharing of water of certain tributaries of Godavari. The agreement also provides for construction of certain Inter-State projects such as Inchampalli and Polavaram with specified Full Reservoir Levels (FRL). The Tribunal gave its Award in July, 1980.

Constitution Award

* The agreement on Polavaram Project provides for diversion of 80 TMC of Godavari Water from Polavaram Project to Krishna River upstream of Vijayawada Anicut. The water thus diverted in Krishna will be shared as under

- Andhra Pradesh 45 TMC
- Karnataka & Maharashtra 35 TMC

* The Inchampalli Multipurpose Project will be a joint venture of Madhya Pradesh, Maharashtra and Andhra Pradesh to be executed and operated under the directions of a Tripartite Inter-State Control Board. The cost of storage, power and benefits will be shared by these States in agreed proportions. Andhra Pradesh is allowed to divert 85 TMC of waters from Inchampalli Reservoir for its use. The balance available water is to be used for power generation at Inchampalli Power House. After generation, the water can be used by Andhra Pradesh in any manner.

* As per the award any alteration, amendments or modification to any of the provision of the Tribunal can be made by agreement between the party States or by legislation of Parliament.

1.9.1.3 Krishna Water Disputes Tribunal :

There is no allocation of water for this Project under KWDT-I Award.

KWDT-II :

The Central Government vide Notification number S.O. 451(E) dated 02.04.2004 has constituted Krishna Water Disputes Tribunal (KWDT) for adjudicating dispute between the States of Maharashtra, Karnataka and erstwhile Andhra Pradesh under Section 4 of the Inter-State River Water Dispute (ISRWD) Act, 1956. The Tribunal has given its report and decision under Section 5(2) of the Act on 30.12.2010. The party States and the Central Government sought further clarification from the Tribunal under Section 5(3) of the Act. However, State of Andhra Pradesh (AP) filed in March, 2011 a Special Leave Petition (SLP (Civil) No. 10498/2011) before the Hon'ble Supreme Court against the States of Karnataka and Maharashtra under Article 139 of Constitution of India, challenging the decision of KWDT-II dated 30.12.2010 on various grounds. Later, in July 2011, State of AP also filed IA NO- 3 in above SLP before the Hon'ble Supreme Court. Tribunal in the mean-time has forwarded report on 29th November, 2013 under Section 5(3) of the ISRWD Act, 1956; recommending allocating of water amongst the States of Andhra Pradesh, Maharashtra and Karnataka. However, on account of stay by Supreme Court vide its order dated 16.09.2011, the award could not be published in the Official Gazette in terms of Section 6(1) of the ISRWD Act, 1956, yet.The matter of KWDT-II is still sub-judice before the Hon'ble Supreme Court. The Ministry vide its notification dated 15.05.2014 extended the tenure of the Tribunal for two years or until further order whichever is earlier with effect from 01.08.2014 in exercise of the powers conferred by the sub-Section 3 of Section 5 of the ISRWD Act, 1956 so as to address the Terms of Reference (TOR) specified in clauses (a) and (b) of the Section 89 of Andhra Pradesh Reorganization Act, 2014 (6 of 2014). Further, the term of the Tribunal has been extended twice for 1 year the latest vide Notification No. 2459(E) dated 31st July, 2017 w.e.f. 1.08.2017 and that the Tribunal is currently hearing the disputes on sensitive matters related to newly created State of Telangana and Andhra Pradesh.

1.9.1.4 Vansadhara Water Disputes Tribunal :

1. The State of Odisha in February 2006 sent a complaint to the Central Government under Section 3 of the Inter-State River Water Disputes (ISRWD) Act, 1956 regarding water disputes between the Government of Odisha and Government of Andhra Pradesh pertaining to Inter-State River Vansadhara for constitution of a Inter-State Water Disputes Tribunal for adjudication. The main grievance of the State of Odisha in the complaint sent to the Central Government is basically adverse effect of the executive action of Govt. of Andhra Pradesh in undertaking the construction of a canal taking off from the river Vansadhara called as flood flow canal at Katragada and failure of Govt. of Andhra Pradesh to implement the terms of inter-State agreement understanding etc. relating to use, distribution and control of waters of inter-State river Vansadhara and its valley. Basic contention of State of Odisha in the complaint is that the flood flow canal would result in drying up the existing river bed and consequent shifting of the river affecting ground water table. It has also raised the issue of scientific assessment of available water in Vansadhara at Katragada and Gotta Barrage and the basis for sharing the available water.
2. As per the provision of ISRWD Act, 1956, when any request under Section 3 is received from any State Government in respect of any water dispute and the Central Government is of opinion that the water dispute cannot be settled by negotiations, the Central government shall, within a period of not exceeding one year from the date of receipt of such request, by notification in the Official Gazette, constitute a Water Disputes Tribunal for the adjudication of the water dispute. Accordingly, Secretary (WR) convened an inter-State meeting on 24.4.2006 at New Delhi to explore the possibility of finding out negotiated settlement of the dispute. In the meeting, both the States agreed that yield of the river is to be shared between Odisha and Andhra Pradesh on 50 – 50 basis. Both States also agreed that CWC will reassess the yield of the Vansadhara basin by utilizing the yield series upto 2005 for which necessary utilization data shall be furnished by the concerned State Government expeditiously. Based on the conclusions reached in the meeting, Central Government is hopeful of finding the negotiated settlement of the

dispute. The effect of flood flow canal on the river region is being investigated through a model study in CWPRS.

3. In continuation of this process, another inter-State meeting at the level of Addl. Secretary (WR) was convened on 5th -6th December, 2006 in which the follow-up action taken on the decision of the previous Inter-State meeting was reviewed. Further, Addl. Secretary (WR) convened another inter-State meeting on 2nd March, 2007 to review the follow-up action on the conclusions reached in the meeting taken by him on 5th & 6th December, 2006. In the meeting, Addl. Secretary (WR) felt that it may be appropriate to request Secretary (WR) to call another meeting at the level of Chief Secretaries of State of Odisha and Andhra Pradesh in view of the divergent position stated by officials of respective States in an explicit manner.

4. Meanwhile, the W.P.(C)No.443 of 2006 filed by State of Odisha came up for hearing before the Hon'ble Supreme Court on 30th April, 2007. The Hon'ble Supreme Court was requested to adjourn the matter for a longer time so that the Central Government can once again try for a negotiated settlement and, therefore, the matter was adjourned. In view of that Secretary (WR) proposed meeting with the Chief Secretaries on 18.5.06 which was rescheduled to 15.6.07 and again to 5.7.07 due to inability expressed by Chief Secretary, Govt. of Odisha to attend the same. However the meeting finally could not be held as Chief Secretary, Govt. of Odisha expressed inability to attend the same as no useful purpose will be served in holding the meeting till Govt. of Andhra Pradesh stops construction of the project.

5. Further, an interstate meeting was taken by Chairman, CWC with the officers of CWC, CWPRS, Pune, the State of A.P. and Odisha on 17.12.07 to discuss the model studies requested in this regard. Another meeting was held on 22.1.08 to firm up additional studies required.

6. In the hearing dated 6.2.2009, the Hon'ble Supreme Court directed Central Government to constitute a water dispute tribunal.

7. With the approval of the Cabinet (dated 25.06.2009) Ministry of Water Resources has constituted Vansadhara Water Dispute Tribunal (VWDT) vide Notification Dt.24.2.2010. The Tribunal has its Head-Quarters at New Delhi.

8. The complaint of the Government of Odisha is now referred to a Tribunal constituted under Section 4 of the Act.

9. Subsequently, in pursuance of the order of the Hon'ble Supreme Court dated 13.12.2013, the Central Govt. vide Notification no S.O 778 (E) dated 14.3.2014 decided that the effective date of constitution of said tribunal shall be 17.9.12 for the purpose of computing period of three years for submission of report and decision by the Tribunal as per provisions of sub- section (2) of section 5 of ISRWD Act, 1956. Further, the Central Govt. vide notification dated 18.9.15 extended the period of submission of report and decision by the Tribunal for a further period of one year with effect from 17.9.2015. Subsequently, on request of the Tribunal, and as per proviso under Section 5(2) of the ISRWD Act, 1956, the Tribunal has been granted two extension of one year each viz. extension given for period of one year w.e.f. 17.09.2015 vide Notification No. S.O. 2581(E) dated 18.09.2015 and extension given for period of one year w.e.f. 17.09.2016 vide Notification No. S.O. 2971(E) dated 16.09.2016.

10. Hon'ble Tribunal delivered its judgment in the I.A. No. 1 of 2010 on 17th December,2013, allowing the Government of Andhra Pradesh to construct the Side Channel Weir along with the ancillary works as proposed and has, inter-alia, directed for constitution of a 3 member Supervisory Flow Management and Regulation Committee on River Vansadhara .

11. Govt. of Odisha has filed SLP No. 3392/2014 and stay application against interim order of VWDT dated 17.12.2013. Department of Legal Affairs was consulted in the matter on 15.09.2014 who inter alia advised that since, SLP and stay petition are sub-judice before Hon'ble Supreme Court, normally such step should be avoided by the Department which may hamper the result of the pending SLP in the Supreme Court.

12. The Tribunal has submitted its report to the Central Government under Section 5(2) of the ISRWD Act, 1956 on 13.09.2017.

1.10 Hydroelectric Projects (above 25 MW) in EFR Basin having no constraints which have been taken up for further studies :

In East Flowing Rivers of Peninsular India Basin, out of 79 nos. of projects, 51 nos. of projects are Under Operation, 1 no. of project is under Construction, 1 no. of project is under Concurred stage. Remaining 26 nos. of projects are under various categories viz. DPR Returned for Re-submission, PFR, Under S&I and Balance Projects. Out of these 26 no. of projects, 3 nos. of projects are having Environmental & Forest issues, 8 nos. of Projects are under Inter-state issues and remaining 15 nos. of projects are not having any constraints which are considered for further studies. The list of these 15 nos. of projects is given in **Table 1.12.**

S.No.	Sub-Basin	State	Name of Project	I.C (MW) Previous Hydro Potential (1978-87)	Status
1	Godavari	Telangana	Tupakulagudem	920	Under S&I
2		Telangana	Dummugudem	360	DPR Returned for Re-submission
3		Chhattisgarh	Bodhghat	295	PFR
4		Chhattisgarh	Kutru-I	100	PFR
5		Chhattisgarh	Kutru-II	155	PFR
6		Chhattisgarh	Nugur-I	160	PFR
7		Chhattisgarh	Kotri	70	PFR
8		Maharashtra	Wainganga	150	PFR
9		Maharashtra	Samda	95	PFR
10		Maharashtra	Kunghara	115	PFR
11		Maharashtra	Pranhita	310	PFR
12		Andhra Pradesh	Balimela	65	Balance
13		Chhattisgarh	Konta	65	Balance
14	Krishna	Karnataka	Tamankal	70	PFR
15		Karnataka	Jaldurg	270	Balance
Total				**3200**	

Table 1.12

1.11 Hydroelectric Projects in EFR Basin Projects not feasible :

In East Flowing Rivers of Peninsular India Basin, 15 nos. of projects are considered for further studies, out of which two projects namely Tamankal and Jaldurg may not be feasible due to commercially unviability.

In Tamankal Hydroelectric Project (300 MW), it is observed that generation is mainly being done in only three months of August, September and October in a year. For these three months, restricted energy for 300 MW operation is 165.94 MU at load factor of 15.36 whereas annual generation is 168.99 MU at annual load factor for of 6.43%. Similarly, for Jaldurg Hydroelectric Project (270 MW), generation happens mainly in the same three months at load factor of about 29.88%, whereas annual load factor is about 7.95%. The list of these 2 nos. of projects is given in **Table 1.13.**

S. No.	Sub-Basin	State	Project	I.C (MW)	Status
1	Krishna	Karnataka	Tamankal	300	PFR
2			Jaldurg	270	Balance
Total				**570**	

Table 1.13

1.12 Final Outcome of Reassesment study

A. Hydro Potential at a glance in EFR Basin

S.No.	Description	Nos.	Installed Capacity (MW)
I	**Previous Hydro Potential (1978-87 study)**	86	13775
II	**Present Exploited/ Exploitable Hydro Potential**	**65**	**11269.4**
	Breakup of Present Exploited/ Exploitable Hydro Potential		
	i. Projects In Operation	51	8277.4
	ii. Projects Under Construction	1	960
	iii. Projects Under Planning/ DPR Preparation Stage which can be taken up for further studies (above 25 MW)	13	2032
III	**Hydro Potential Unexploitable at Present**	**12**	**2940**
	Breakup of Hydro Potential Unexploitable at Present		
	i. Projects Concurred by CEA/State Govt. (Dropped because as per developer, project seems not viable with revised IC of 40MW)	1	60
	ii. Projects Under Planning/ DPR preparation stage		
	a) Projects in Ecologically Sensitive area	3	600
	b) Projects having interstate issues	8	2280
IV	**Projects Under Planning/DPR stage which are not feasible as energy generation only during 3 months (Aug-Oct)**	**2**	**570**
V	**Total Exploited/ Exploitable + Unexploitable Potential + Projects not feasible as energy generation only during 3 months (Aug-Oct)**	**79**	**14779.4**

Table 1.14

The details of these projects are given in ***Annexure II***.

B. State wise Hydro Potential at a glance in EFR Basin

S.No.	Description	Nos.	Installed Capacity (MW)
MAHARASHTRA			
I	**Previous Hydro Potential (1978-87 study)**	22	3192
II	**Present Exploited/ Exploitable Hydro Potential**	**13**	**2944**
	Breakup of Present Exploited/ Exploitable Hydro Potential		

S.No.	Description	Nos.	Installed Capacity (MW)
	i. Projects In Operation	9	2447
	ii. Projects Under Planning/ DPR Preparation Stage which can be taken up for further studies (above 25 MW)	4	497
CHHATTISGARH			
I	**Previous Hydro Potential (1978-87 study)**	9*	1868
II	**Present Exploited/ Exploitable Hydro Potential**	**6**	**1007**
	Breakup of Present Exploited/ Exploitable Hydro Potential		
	i. Projects Under Planning/ DPR Preparation Stage which can be taken up for further studies (above 25 MW)	6	1007
III	**Hydro Potential Unexploitable at Present**	**3**	**627**
	Breakup of Hydro Potential Unexploitable at Present		
	i. Projects Concurred by CEA/State Govt. (Dropped because as per developer, project seems not viable with revised IC of 40MW)	1	60
	ii. Projects Under Planning/ DPR Preparation stage		
	a) Projects in Ecologically Sensitive area/Indravati National park	2	567
IV	**Total Exploited/ Exploitable + Unexploitable Potential**	**9**	**1634**
ODISHA			
I	**Previous Hydro Potential (1978-87 study)**	4	1645
II	**Present Exploited/ Exploitable Hydro Potential**	**4**	**1550**
	Breakup of Present Exploited/ Exploitable Hydro Potential		
	i. Projects In Operation	4	1550
III	**Hydro Potential Unexploitable at Present**	**2**	**780**
	Breakup of Hydro Potential Unexploitable at Present		
	i. Projects Under Planning/ DPR Preparation stage		
	a) Projects having interstate issues	2	780
IV	**Total Exploited/ Exploitable + Unexploitable Potential**	**6**	**2330**

S.No.	Description	Nos.	Installed Capacity (MW)
TELANGANA			
I	**Present Exploited/ Exploitable Hydro Potential**	**8#**	**1302**
	Breakup of Present Exploited/ Exploitable Hydro Potential		
	i. Projects In Operation	6	800
	ii. Projects Under Planning/ DPR Preparation Stage which can be taken up for further studies (above 25 MW)	2	502
ANDHRA PRADESH			
I	**Previous Hydro Potential (1978-87 study)**	18	4360
II	**Present Exploited/ Exploitable Hydro Potential**	**7**	**2596**
	Breakup of Present Exploited/ Exploitable Hydro Potential		
	i. Projects In Operation	5	1610
	ii. Projects Under Construction	1	960
	iii. Projects Under Planning/ DPR Preparation Stage which can be taken up for further studies (above 25 MW)	1	26
KARNATAKA			
I	**Previous Hydro Potential (1978-87 study)**	18	1445
II	**Present Exploited/ Exploitable Hydro Potential**	**7**	**513.2**
	Breakup of Present Exploited/ Exploitable Hydro Potential		
	i. Projects In Operation	7	513.2
III	**Hydro Potential Unexploitable at Present**	**2**	**745**
	Breakup of Hydro Potential Unexploitable at Present		
	i. Projects Under Planning/ DPR Preparation stage		
	a) Projects having interstate issues	2	745
IV	**Projects Under Planning/DPR stage which are not feasible as energy generation only during 3 months (Aug-Oct)**	**2**	**570**
V	**Total Exploited/ Exploitable + Unexploitable Potential + Projects not feasible as energy generation only during 3 months (Aug-Oct)**	**11**	**1828.2**

S.No.	Description	Nos.	Installed Capacity (MW)
TAMIL NADU			
I	**Previous Hydro Potential (1978-87 study)**	14	1065
II	**Present Exploited/ Exploitable Hydro Potential**	**20**	**1357.2**
	Breakup of Present Exploited/ Exploitable Hydro Potential		
	i. Projects In Operation	20	1357.2
III	**Hydro Potential Unexploitable at Present**	**4**	**563**
	Breakup of Hydro Potential Unexploitable at Present		
	i. Projects Under Planning/ DPR Preparation stage		
	a) Projects in Ecologically Sensitive area/ Bandipur Wildlife Sanctuary	1	33
	b) Projects having interstate issues	3	530
IV	**Total Exploited/ Exploitable + Unexploitable Potential**	**24**	**1920.2**
KERALA			
I	**Previous Hydro Potential (1978-87 study)**	1	200
II	**Present Unexploitable Hydro Potential**	**1**	**225**
	Breakup of Hydro Potential Unexploitable at Present		
	i. Projects Under Planning/ DPR Preparation stage		
	a) Projects having interstate issues	1	225

Table 1.15

* In the Reassessment study these projects were identified in Madhya Pradesh before bifurcation of Chhattisgarh and Madhya Pradesh.

In the Reassessment study 7 projects (Pochampad, Priyadarshini Jurala, Nagarjunsagar, Nagarjunasagar LBC, Pulichintala, Dummugudem, Tupakulagudem) were identified in Andhra Pradesh before bifurcation of Andhra Pradesh and Telangana.

The details of these projects are given at ***Annexure III***.

Annexure I

Previous Study (1978-87)

The State wise detailed list of Hydroelectric Projects (above 25 MW)

S.No.	Name of Project	I.C (MW)	River	Status
ODISHA				
Godavari Sub-basin				
1	Upper Indravati	585	Indravati	Under Construction
2	Upper Kolab	280	Sabari	Under Construction
3	Lower Kolab	375	Sabari	Balance
4	Balimela	405	Balimela	In Operation
MADHYA PRADESH				
Godavari Sub-basin				
5	Konta	65	Sabari	Balance
6	Chitrakot	38	Indravati	Balance
7	Bodhghat	295	Indravati	Under Construction
8	Kutru-I	100	Indravati	Balance
9	Kutru-II	155	Indravati	Balance
10	Nugur-I	160	Indravati	Balance
11	Bhopalapatnam	715	Indravati	Balance
12	Nugur-II	270	Indravati	Balance
13	Kotri	70	Kotri	Balance
MAHARASHTRA				
Godavari Sub-basin				
14	Pench	85	Pench	In Operation
15	Pathri	40	Wainganga	Balance
16	Wainganga	150	Wainganga	Balance
17	Samda	95	Pranhita	Balance
18	Ghargaon	105	Pranhita	Balance
19	Kunghara	115	Pranhita	Balance
20	Pranhita	310	Pranhita	Balance
21	Sahasrakund I	29	Penganga	Balance

S.No.	Name of Project	I.C (MW)	River	Status
Krishna Sub-basin				
22	Bhivpuri	85	Andhra	In Operation
23	Khopoli	70	Ganga	In Operation
24	Bhira	215	Mula	In Operation
25	Koyna St-IV	350	Koyna	Under Construction
26	Koyna St-III	145	Koyna	In Operation
27	Koyna St-I & II	245	Koyna	In Operation
28	Koyna Dam PH	65	Koyna	In Operation
29	Patharpunj	29	Varna	Balance
30	Kadvi	215	Varna	Balance
31	Varna	27	Varna	Balance
32	Kasari I	215	Kasari	Balance
33	Kumbhi I	170	Pen Ganga	Balance
34	Kumbhi II	27	Pen Ganga	Balance
35	Hiranyakeshi II	405	Vedganga	Balance
ANDHRA PRADESH				
Godavari Sub-basin				
36	Pochampad	47	Godavari	Under Construction
37	Inchampalli	920	Godavari	Balance
38	Singareddi	250	Godavari	Balance
39	Dummagudem	360	Godavari	Balance
40	Machkund	205	Machkund	In Operation
41	Balimela	65	Sileru	Under Construction
42	Upper Sileru	150	Sileru	In Operation
43	Donkarai Canal	44	Sileru	In Operation
44	Lower Sileru	385	Sileru	In Operation
45	Polavaram	545	Godavari	Balance
Krishna Sub-basin				
46	Pulichintala	180	Krishna	Balance
47	Pondugala	95	Krishna	Balance

S.No.	Name of Project	I.C (MW)	River	Status
48	Nagarjunasagar LBC	42	Krishna	Under Construction
49	Nagarjunasagar Dam PH	115	Krishna	In Operation
50	Nagarjunasagar RBC	45	Krishna	In Operation
51	Srisailam	775	Krishna	In Operation, Under Construction
52	Tungbhadra HLC	32	Bhadra	Under Construction
53	Priyadarshini	105	Krishna	Balance
KARNATAKA				
Krishna Sub-basin				
54	Jaldurg	270	Krishna	Balance
55	Narayanpur	70	Krishna	Balance
56	Almatti	160	Krishna	Under Construction
57	Ghatprabha	41	Ghataprabha	Under Construction
58	Shivpur	26	Tungabhadra	In Operation
59	Munirabad	41	Tungabhadra	In Operation
60	Hampi	34	Tungabhadra	In Operation
61	Tungbhadra RBC	27	Tungabhadra	In Operation
62	Bhadra Dam PH	36	Bhadra	In Operation
Cauvery Sub-basin				
63	Krishnarajasagar	55	Cauvery	Balance
64	Sivasamudram	44	Cauvery	In Operation
65	Shimsa PH-I	31	Cauvery	In Operation
66	Cauvery PH-I	235	Cauvery	Balance
67	Shimsa PH-II	42	Shimsha	Balance
68	Arkavathi	42	Arkavathi	Balance
69	Cauvery PH-II	165	Cauvery	Balance
70	Cauvery PH-III	90	Cauvery	Balance
71	Cauvery PH-IV	36	Cauvery	Balance

S.No.	Name of Project	I.C (MW)	River	Status
TAMIL NADU				
Cauvery Sub-basin				
72	Mettur Dam PH	32	Cauvery	In Operation
73	Mettur Tunnel PH	100	Cauvery	In Operation
74	Lower Mettur	115	Cauvery	Under Construction
75	Bhawani Kattalai	115	Cauvery	Balance
76	Lower Bhavani	34	Bahavani	Under Construction
77	Lower Moyar	33	Moyar	Balance
78	Moyar	75	Moyar	In Operation
79	Pykara (Singara)	115	Moyar	In Operation
80	Pykara (Ultimate)	60	Moyar	Balance
81	Avalaanche Em'ld (Kundah 1)	70	Kundah	In Operation
82	Kundapallam (Kundah 2)	160	Kundah	In Operation
83	Pengumbahalla (Kundah 3)	95	Kundah	In Operation
Cauvery-Kanyakumari Sub-basin				
84	Suruliar	30	Suruliar	In Operation
85	Papanasam	31	Thamirabarani	In Operation
KERALA				
Cauvery Sub-basin				
86	Manthavady	200	Kabini	Balance
Total		**13775**		

Annexure II
Reassessment Study
Details of Hydroelectric Projects (above 25 MW) in EFR Basin

S.No.	Project Name	I.C. (MW)	State
PRESENT EXPLOITED/ EXPLOITABLE HYDRO POTENTIAL			
In Operation			
1	Bhandardara St- II	34	Maharashtra
2	Pench	160	Maharashtra
3	Pochampad	36	Telangana
4	Upper Indravati	600	Odisha
5	Upper Kolab	320	Odisha
6	Machkund	120	Odisha
7	Balimela	510	Odisha
8	Upper Sileru -I &II	240	Andhra pradesh
9	Lower Sileru	460	Andhra pradesh
10	Bhivpuri	75	Maharashtra
11	Khopoli	72	Maharashtra
12	Bhira	150	Maharashtra
13	Koyna Dam P/H	36	Maharashtra
14	Koyna St. I & II	600	Maharashtra
15	Koyna St. III	320	Maharashtra
16	Koyna St. IV	1000	Maharashtra
17	Ghataprabha	32	Karnataka
18	Almatti	290	Karnataka
19	Priyadarshini Jurala	234	Telangana
20	Lower Jurala	240	Telangana
21	Srisailam	770	Andhra Pradesh
22	Nagarjunasagar RBC & Ext	90	Andhra Pradesh
23	Nagarjunasagar TPD	50	Andhra Pradesh
24	Nagarjunasagar LBC	60	Telangana
25	Nagarjunsagar	110	Telangana
26	T B Dam	36	Karnataka
27	Hampi	36	Karnataka
28	Munirabad	38	Karnataka

S.No.	Project Name	I.C. (MW)	State
29	Bhadra	39.2	Karnataka
30	Pulichintala	120	Telangana
31	Mettur Dam	50	Tamil Nadu
32	Mettur Tunnel	200	Tamil Nadu
33	Lower Mettur-I	30	Tamil Nadu
34	Lower Mettur-II	30	Tamil Nadu
35	Lower Mettur-III	30	Tamil Nadu
36	Lower Mettur-IV	30	Tamil Nadu
37	Bhavani Kattalai Barrage -I	30	Tamil Nadu
38	Bhavani Kattalai Barrage -II	30	Tamil Nadu
39	Bhavani Kattalai Barrage -III	30	Tamil Nadu
40	Pykara	59.2	Tamil Nadu
41	Pykara Ultimate	150	Tamil Nadu
42	Kundah-I	60	Tamil Nadu
43	Kundah-II	175	Tamil Nadu
44	Kundah-III	180	Tamil Nadu
45	Kundah-IV	100	Tamil Nadu
46	Kundah-V	40	Tamil Nadu
47	Parson's valley	30	Tamil Nadu
48	Shivasamudram	42	Karnataka
49	Moyar	36	Tamil Nadu
50	Suruliar	35	Tamil Nadu
51	Papanasam	32	Tamil Nadu
	Sub Total	**8277.4**	
Under Construction			
1	Polavaram	960	Andhra Pradesh
	Sub Total	**960**	
Projects considered for further studies			
1	Tupakulagudem	240	Telangana
2	Dummugudem	262	Telangana
3	Bodhghat	252	Chhattisgarh
4	Kutru-I	96	Chhattisgarh

S.No.	Project Name	I.C. (MW)	State
5	Kutru-II	275	Chhattisgarh
6	Nugur-I	272	Chhattisgarh
7	Kotri	44	Chhattisgarh
8	Wainganga	138	Maharashtra
9	Samda	45	Maharashtra
10	Kunghara	100	Maharashtra
11	Pranhita	214	Maharashtra
12	Balimela	26	Andhra Pradesh
13	Konta	68	Chhattisgarh
	Sub Total	**2032**	
	Total (Exploited/ Exploitable Hydro Potential)	**11269.4**	
PRESENTLY UNEXPLOITABLE HYDRO POTENTIAL			
CEA/ State Concurred			
1	Matnar	60	Chhattisgarh
	Sub Total	**60**	
Projects In Ecologically Sensitive Area			
1	Lower Moyar	33	Tamil Nadu
2	Nugur-II	477	Chhattisgarh
3	Bhopalpatnam	90	Chhattisgarh
	Sub Total	**600**	
Projects Having Inter-State Issues			
1	Sivasamudram	345	Karnataka
2	Mekadatu	400	Karnataka
3	Hogenekkal	120	Tamil Nadu
4	Rasimanal	360	Tamil Nadu
5	Nellithorai	50	Tamil Nadu
6	Mananthavady	225	Kerala
7	Middle Kolab	315	Odisha
8	Lower Kolab	465	Odisha
	Sub Total	**2280**	
	Total (Unexploitable Hydro Potential)	**2940**	

S.No.	Project Name	I.C. (MW)	State
PROJECTS UNDER PLANNING/DPR STAGE WHICH ARE NOT FEASIBLE AS ENERGY GENERATION ONLY DURING 3 MONTHS (AUG-OCT)			
1	Tamankal	300	Karnataka
2	Jaldurg	270	Karnataka
	Sub Total	**570**	
	Grand Total (Exploited/ Exploitable + Unexploitable Hydro Potential+ Projects Not Feasible As Energy Generation Only During 3 Months (Aug-Oct))	**14779.4**	

Annexure III
Reassessment Study
The State wise detailed list of Hydroelectric Projects (above 25 MW)

S.No.	Name of Project	I.C (MW)	Annual/ Design Energy (MU)	River	Status	Remarks
ODISHA						
Godavari Sub-basin						
1	Upper Indravati	600	1962	Indravati	In Operation	Potential Exploited
2	Upper Kolab	320	832.2	Kolab	In Operation	Potential Exploited
3	Machkund	120	630	Machkund	In Operation	Potential Exploited
4	Balimela	510	1183	Sileru	In Operation	Potential Exploited
5	Middle Kolab	315	1059.83	Kerajodi Nallah	Interstate Issue between Odisha and Chhattisgarh	Potential Unexploitable at Present
6	Lower Kolab	465	845.86	Kolab	Interstate Issue (Could be taken up after resolution of interstate issue of Middle Kolab project)	Potential Unexploitable at Present
CHHATTISGARH						
Godavari Sub-basin						
7	Matnar	60	177.18	Indravati	Project seems not viable with revised IC of 40MW	Potential Unexploitable at Present
8	Bodhghat	252	664.74	Indravati	PFR	Potential Exploitable
9	Kutru-I	96	252.29	Indravati	PFR	Potential Exploitable
10	Kutru-II	275	870.16	Indravati	PFR	Potential Exploitable
11	Nugur-I	272	744.84	Indravati	PFR	Potential Exploitable
12	Kotri	44	142.66	Kotri	PFR	Potential Exploitable
13	Konta	68	234.02	Sabari	Balance	Potential Exploitable

S.No.	Name of Project	I.C (MW)	Annual/ Design Energy (MU)	River	Status	Remarks
14	Bhopalpatnam	90	723.12	Indravati	Dam and Powerhouse site located on boundary of the Indravati National Park (Protected Area)	Potential Unexploitable at Present
15	Nugur-II	477	961.33	Indravati	Dam and Powerhouse site located on boundary of the Indravati National Park (Protected Area)	Potential Unexploitable at Present
MAHARASHTRA						
Godavari Sub-basin						
16	Bhandardara St-II	34	36.26	Pravara	In Operation	Potential Exploited
17	Pench	160	315.36	Pench	In Operation	Potential Exploited
18	Wainganga	138	367.39	Wainganga	PFR	Potential Exploitable
19	Samda	45	157.76	Wainganga	PFR	Potential Exploitable
20	Kunghara	100	263.4	Wainganga	PFR	Potential Exploitable
21	Pranhita	214	575.23	Pranhita	PFR	Potential Exploitable
Krishna Sub-basin						
22	Bhivpuri	75	193.23	Andhra	In Operation	Potential Exploited
23	Khopoli	72	174.68	Indrayani	In Operation	Potential Exploited
24	Bhira	150	745	Neela& Mula	In Operation	Potential Exploited
25	Koyna Dam P/H	36	120	Koyna	In Operation	Potential Exploited
26	Koyna St. I & II	600	775	Koyna	In Operation	Potential Exploited
27	Koyna St. III	320	516	Koyna	In Operation	Potential Exploited
28	Koyna St. IV	1000	1711	Koyna	In Operation	Potential Exploited

S.No.	Name of Project	I.C (MW)	Annual/ Design Energy (MU)	River	Status	Remarks
ANDHRA PRADESH						
Godavari Sub-basin						
29	Upper Sileru -I&II	240	375	Sileru	In Operation	Potential Exploited
30	Lower Sileru	460	1050	Sileru	In Operation	Potential Exploited
31	Polavaram	960	2308.4	Godavari	Under Construction	Potential Exploitable
32	Balimela	26	67.27	Sileru	Balance	Potential Exploitable
Krishna Sub-basin						
33	Srisailam	770	1750	Krishna	In Operation	Potential Exploited
34	Nagarjunasagar RBC & Ext	90	292.54	Krishna	In Operation	Potential Exploited
35	Nagarjunasagar TPD	50	177	Krishna	In Operation	Potential Exploited
TELANGANA						
Godavari Sub-basin						
36	Pochampad	36	107.5	Godavari	In Operation	Potential Exploited
37	Dummugudem	262	690.06	Godavari	DPR Returned for Re-submission	Potential Exploitable
38	Tupakulagudem	240	317	Godavari	Under S&I	Potential Exploitable
Krishna Sub-basin						
39	Priyadarshini Jurala	234	404	Krishna	In Operation	Potential Exploited
40	Lower Jurala	240	534.34	Krishna	In Operation	Potential Exploited
41	Nagarjunasagar	110	992	Krishna	In Operation	Potential Exploited
42	Nagarjunasagar LBC	60	127.40	Krishna	In Operation	Potential Exploited
43	Pulichintala	120	219.49	Krishna	In Operation	Potential Exploited
KARNATAKA						
Krishna Sub-basin						
44	Almatti	290	483	Krishna	In Operation	Potential Exploited

S.No.	Name of Project	I.C (MW)	Annual/ Design Energy (MU)	River	Status	Remarks
45	Ghatprabha	32	86	Ghataprabha	In Operation	Potential Exploited
46	Bhadra	39.2	51	Bhadra	In Operation	Potential Exploited
47	Munirabad	38	76.5	Tungbhadra	In Operation	Potential Exploited
48	Hampi	36	70	Tungbhadra	In Operation	Potential Exploited
49	T B Dam	36	70	Tungbhadra	In Operation	Potential Exploited
50	Tamankal	300	168.99	Krishna	PFR	Projects not feasible as energy generation only during 3 months (Aug-Oct)
51	Jaldurg	270	188.08	Krishna	Balance	
Cauvery Sub-basin						
52	Shivasamudram	42	181.17	Cauvery	In Operation	Potential Exploited
53	Sivasamudram	345	1034	Cauvery	Interstate Issue between Kerala, Tamil Nadu and Karnataka	Potential Unexploitable at Present
54	Mekadatu	400	796	Cauvery	Interstate Issue between Kerala, Tamil Nadu and Karnataka	Potential Unexploitable at Present
TAMIL NADU						
Cauvery Sub-basin						
55	Kundah-I	60	218.36	Avalanche Stream	In Operation	Potential Exploited
56	Bhavani Kattalai Barrage -I	30	69.68	Cauvery	In Operation	Potential Exploited
57	Bhavani Kattalai Barrage -II	30	94	Cauvery	In Operation	Potential Exploited
58	Bhavani Kattalai Barrage -III	30	94	Cauvery	In Operation	Potential Exploited

S.No.	Name of Project	I.C (MW)	Annual/ Design Energy (MU)	River	Status	Remarks
59	Kundah-II	175	552.4	Kundah	In Operation	Potential Exploited
60	Lower Mettur-I	30	95	Cauvery	In Operation	Potential Exploited
61	Lower Mettur-II	30	99	Cauvery	In Operation	Potential Exploited
62	Lower Mettur-III	30	91	Cauvery	In Operation	Potential Exploited
63	Lower Mettur-IV	30	69	Cauvery	In Operation	Potential Exploited
64	Mettur Dam	50	82	Cauvery	In Operation	Potential Exploited
65	Mettur Tunnel	200	520	Cauvery	In Operation	Potential Exploited
66	Moyar	36	159.27	Moyar	In Operation	Potential Exploited
67	Parson's valley	30	57	Bhavani	In Operation	Potential Exploited
68	Kundah-III	180	346.84	Pegumbah allah	In Operation	Potential Exploited
69	Kundah-IV	100	143.66	Bhavani	In Operation	Potential Exploited
70	Pykara	59.2	352	Pykara	In Operation	Potential Exploited
71	Pykara Ultimate	150	332.42	Pykara	In Operation	Potential Exploited
72	Kundah-V	40	63.34	Bhavani	In Operation	Potential Exploited
73	Lower Moyar	33	126	Cauvery	Dam site located on boundary and Powerhouse site located inside Bandipur Wildlife Sanctuary (protected Area)	Potential Unexploitable at Present
74	Rasimanal	360	453	Cauvery	Interstate Issue between Kerala , Tamil Nadu and Karnataka	Potential Unexploitable at Present

S.No.	Name of Project	I.C (MW)	Annual/ Design Energy (MU)	River	Status	Remarks
75	Hogenekkal	120	183	Cauvery	Interstate Issue between Kerala, Tamil Nadu and Karnataka	Potential Unexploitable at Present
76	Nellithorai	50	41	Bhavani	Interstate Issue between Tamil Nadu & Kerala	Potential Unexploitable at Present
South of Cauvery Sub-basin						
77	Papanasam	32	280	Thamirabarani	In Operation	Potential Exploited
78	Suruliyar	35	306	Vaigai	In Operation	Potential Exploited
KERALA						
Cauvery Sub-basin						
79	Mananthavady	225	687	Mananthavady	Interstate Issue between Kerala, Tamil Nadu and Karnataka	Potential Unexploitable at Present
Total		**14779.40**				

Annexure IV

The state wise comparison of Projects according to previous hydro potential (1978-87) and present hydro potential

S.No.	Name of Project	Installed Capacity (MW)		Status	Remarks
		Previous Study (1978-87)	Reassessment Study		
ODISHA					
1	Upper Indravati	585	600	In Operation	Exploited
2	Upper Kolab	280	320	In Operation	Exploited
3	Machkund	205	120	In Operation	Exploited
4	Balimela	405	510	In Operation	Exploited
5	Middle Kolab	Not Identified	315	DPR Returned for Re-submission	Unexploitable
6	Lower Kolab	375	465	PFR	Unexploitable
	Sub Total	**1850**	**2330**		
CHHATTISGARH *					
7	Matnar (Chitrakot)	38	60	Concurred	Unexploitable
8	Bodhghat	295	252	PFR	Exploitable
9	Kutru-I	100	96	PFR	Exploitable
10	Kutru-II	155	275	PFR	Exploitable
11	Nugur-I	160	272	PFR	Exploitable
12	Kotri	70	44	PFR	Exploitable
13	Konta	65	68	Balance	Exploitable
14	Bhopalpatnam	715	90	PFR	Unexploitable
15	Nugur-II	270	477	PFR	Unexploitable
	Sub Total	**1868**	**1634**		
MAHARASHTRA					
16	Pathri @ (Gosikhurd)	40	<25	Balance	Developed below 25 MW
17	Ghargaon @	105	-	Balance	Developed as Irrigation Project

S.No.	Name of Project	Installed Capacity (MW)		Status	Remarks
		Previous Study (1978-87)	Reassessment Study		
18	Sahasrakund-I @	29	<25	Balance	Proposed below 25 MW
19	Patharpunj @	29	<25	Balance	Proposed below 25 MW
20	Kadvi @	215	<25	Balance	PFR below 25 MW
21	Varna @ (Warna)	27	<25	Balance	Developed below 25 MW
22	Kasari-I @	215	<25	Balance	PFR below 25 MW
23	Kumbhi-I @	170	<25	Balance	PFR below 25 MW
24	Kumbhi-II @ (Kumbhi)	27	<25	Balance	Developed below 25MW
25	Hiranyakeshi-II @	405	<25	Balance	PFR below 25 MW
26	Bhandardara St- II##	<25	34	In Operation	Exploited
27	Pench	85	160	In Operation	Exploited
28	Wainganga	150	138	PFR	Exploitable
29	Samda	95	45	PFR	Exploitable
30	Kunghara	115	100	PFR	Exploitable
31	Pranhita	310	214	PFR	Exploitable
32	Bhivpuri	85	75	In Operation	Exploited
33	Khopoli	70	72	In Operation	Exploited
34	Bhira	215	150	In Operation	Exploited
35	Koyna Dam P/H	65	36	In Operation	Exploited
36	Koyna St. I & II	245	600	In Operation	Exploited
37	Koyna St. III	145	320	In Operation	Exploited
38	Koyna St. IV	350	1000	In Operation	Exploited
	Sub Total	**3192**	**2944**		
ANDHRA PRADESH					
39	Singareddi @	250	-	Balance	Submergence issue
40	Donkarayi Canal @	44	<25	Balance	Developed below 25 MW
41	Tungabhadra HLC @	32	<25	Balance	Developed below 25 MW

S.No.	Name of Project	Installed Capacity (MW)		Status	Remarks
		Previous Study (1978-87)	Reassessment Study		
42	Upper Sileru -I &II (Upper Sileru)	150	240	In Operation	Exploited
43	Lower Sileru	385	460	In Operation	Exploited
44	Polavaram	545	960	Under Construction	Exploitable
45	Balimela	65	26	Balance	Exploitable
46	Srisailam	775	770	In Operation	Exploited
47	Nagarjunasagar RBC & Ext (Nagarjunasagar RBC)	45	90	In Operation	Exploited
48	Nagarjunasagar TPD	Not Identified	50	In Operation	Exploited
49	Pondugala @	95	-	PFR	Abandoned by State
	Sub Total	**2386**	**2596**		
TELANGANA#					
50	Pochampad	47	36	In Operation	Exploited
51	Dummugudem	360	262	DPR Returned for Re-submission	Exploitable
52	Tupakulagudem (Inchampalli)	920	240	Under S&I	Exploitable
53	Priyadarshini Jurala (Priyadarshini)	105	234	In Operation	Exploited
54	Lower Jurala	Not Identified	240	In Operation	Exploited
55	Nagarjunasagar (Nagarjunasagar Dam P/H)	115	110	In Operation	Exploited
56	Nagarjunasagar LBC	42	60	In Operation	Exploited
57	Pulichintala	180	120	In Operation	Exploited
	Sub Total	**1769**	**1302**		
KARNATAKA					
58	Shivpur @ (Shivapur Dam)	26	<25	Balance	Developed below 25 MW
59	Krishnarajsagar @	55	<25	Balance	Developed as MPP below 25 MW
60	Shimsha PH I @ (Shimsha)	31	<25	Balance	Developed below 25 MW

S.No.	Name of Project	Installed Capacity (MW)		Status	Remarks
		Previous Study (1978-87)	Reassessment Study		
61	Shimsha PH-II @ (Shimsha)	42	<25	Balance	Developed below 25 MW
62	Arkavathi @	42	-	Balance	Developed as Irrigation Project
63	Almatti	160	290	In Operation	Exploited
64	Ghataprabha	41	32	In Operation	Exploited
65	Bhadra (Bhadra Dam P/H)	36	39.2	In Operation	Exploited
66	Munirabad	41	38	In Operation	Exploited
67	Hampi	34	36	In Operation	Exploited
68	T B Dam (Tungabhadra RBC)	27	36	In Operation	Exploited
69	Tamankal (Narayanpur)	70	300	PFR	Projects not feasible as energy generation only during 3 months (Aug-Oct)
70	Jaldurg	270	270	Balance	
71	Shivasamudram	44	42	In Operation	Exploited
72	Sivasamudram (Cauvery PH I)	235	345	DPR Returned for Re-submission	Unexploitable
73	Mekadatu (Cauvery PH II)	165	400	DPR Returned for Re-submission	Unexploitable
	Sub Total	**1319**	**1828.2**		
TAMIL NADU					
74	Lower Bhavani @	34	<25	Balance	Developed below 25MW
75	Kundah-I (Avalanche Emerald (Kundah 1))	70	60	In Operation	Exploited
76	Bhavani Kattalai Barrage-I (Bhavani Kattalai)	115	30	In Operation	Exploited
77	Bhavani Kattalai Barrage-II (Bhavani Kattalai)		30	In Operation	Exploited

S.No.	Name of Project	Installed Capacity (MW)		Status	Remarks
		Previous Study (1978-87)	Reassessment Study		
78	Bhavani Kattalai Barrage-III (Bhavani Kattalai)		30	In Operation	Exploited
79	Kundah-II (Kundapallam (Kundah 2))	160	175	In Operation	Exploited
80	Lower Mettur-I (Lower Mettur)	115	30	In Operation	Exploited
81	Lower Mettur-II (Lower Mettur)		30	In Operation	Exploited
82	Lower Mettur-III (Lower Mettur)		30	In Operation	Exploited
83	Lower Mettur-IV (Lower Mettur)		30	In Operation	Exploited
84	Mettur Dam (Mettur Dam P/H)	32	50	In Operation	Exploited
85	Mettur Tunnel (Mettur Tunnel P/H)	100	200	In Operation	Exploited
86	Moyar	75	36	In Operation	Exploited
87	Parson's valley## (Parson's Valley (Kundah 6))	<25	30	In Operation	Exploited
88	Kundah-III (Pengumbahalla (Kundah 3))	95	180	In Operation	Exploited
89	Kundah-IV ## (Pillur (Kundah 4))	<25	100	In Operation	Exploited
90	Pykara (Pykara (Singara))	115	59.2	In Operation	Exploited
91	Pykara Ultimate	60	150	In Operation	Exploited
92	Kundah-V ## (Upper Bhavani (Kundah 5))	<25	40	In Operation	Exploited
93	Lower Moyar	33	33	Balance	Unexploitable
94	Rasimanal (Cauvery PH III)	90	360	DPR Returned for Re-submission	Unexploitable
95	Hogenekkal (Cauvery PH IV)	36	120	DPR Returned for Re-submission	Unexploitable

S.No.	Name of Project	Installed Capacity (MW)		Status	Remarks
		Previous Study (1978-87)	Reassessment Study		
96	Nellithorai ##	<25	50	DPR Returned for Re-submission	Unexploitable
97	Papanasam	31	32	In Operation	Exploited
98	Suruliyar	30	35	In Operation	Exploited
	Sub Total	**1191**	**1920.2**		
KERALA					
99	Mananthavady	200	225	DPR Returned for Re-submission	Unexploitable
	Sub Total	**200**	**225**		
	Grand Total	**13775**	**14779.4**		

* In the Reassessment study these projects were identified in Madhya Pradesh before bifurcation of Chhattisgarh and Madhya Pradesh.

In the Reassessment study these projects were identified in Andhra Pradesh before bifurcation of Andhra Pradesh and Telangana.

As per previous studies, 4 projects namely Parson's valley, Kundah IV, Kundah V & Nellithorai were developed/proposed below 25MW but now these projects are developed/Proposed above 25MW.

@ These projects are developed below 25 MW/ proposed to be developed below 25 MW/PFR below 25 MW/developed as Irrigation Project/ abandoned by State/ have submergence issue, therefore these projects are not included in the reassessment study.

CHAPTER-2

SUB-BASINS

2.1 GODAVARI SUB-BASIN

States Involved – Maharashtra, Andhra Pradesh, Madhya Pradesh, Chhattisgarh, Odisha, Telangana and Karnataka

The Godavari basin extends over states of Maharashtra, Telangana, Andhra Pradesh, Chhattisgarh and Odisha in addition to smaller parts in Madhya Pradesh, Karnataka and Union territory of Puducherry having a total area of 3,12,812 Sq.km with a maximum length and width of about 995 km and 583 km. It lies between 73°24' to 83°4' East Longitudes and 16°19' to 22°34' North Latitudes and accounts for nearly 9.5% of the total geographical area of the country.

The basin is bounded by Satmala hills, the Ajanta range and the Mahadeo hills on the north, by the Eastern Ghats on the south and the east and by the Western Ghats on the west. The Godavari River rises from Trimbakeshwar in the Nashik district of Maharashtra about 80 km from the Arabian Sea at an elevation of 1,067 m. The total length of Godavari from its origin to outfall into the Bay of Bengal is 1,465 km. About 64 km. from the origin, the Godavari is joined by Dharna, on its right bank and a short distance downstream the Kadana joins it from the left. The combined waters of the Pravara and Mula which rise in the hills of Akola join the river from left about 217 km. from the origin. About 338 km. from the origin, the river receives the combined waters from the Purna and Dudhna rivers and after a further 138 km. at the border of Maharashtra and Andhra Pradesh, the waters of the Manjira river joins it from the South. At this point, Godavari flows at an elevation of about 329 m. Godavari enters into Telangana in Nizamabad district at Kandakurthy where Manjira and Haridra Rivers joins Godavari and forms Triveni Sangamam. The river flows along the border between Nirmal and Mancherial districts in the north and Nizamabad, Jagityal, Peddapalli Ramagundam districts to its south. The river Pranhita, conveying the combined waters of Penganga, the Wardha and Wainganga, which drain Nagpur and southern slopes of the Satpura ranges, falls into Godavari about 306 km. below its confluence with the Manjira. The waters of the Indravati join the river Godavari 48 Km

downstream. The last major tributary is the Sabari, which joins the Godavari, 100 km. up-stream of Rajahmundry.

The largest tributary of the Godavari is the Pranhita with about 34.87% coverage of drainage area. The Pravara, Manjira and Maner are right bank tributaries covering about 16.14%, the Purna, Pranhita, Indravati and Sabari are important left bank tributaries, covering nearly 59.7% of the total catchment area of the basin. The Godavari in the upper, middle, and lower reaches make up for the balance 24.16%. The major part of basin is covered with agricultural land accounting to 59.57% of the total area and 3.6% of the basin is covered by water bodies. The basin spreads over 51 parliamentary constituencies (2009) comprising 21 of Maharashtra, 18 of Andhra Pradesh, 4 of Madhya Pradesh, 3 each of Chhattisgarh and Odisha and 1 each of Karnataka and Puducherry.

Topography-The Godavari basin is bounded on the north by the Satmala hills, on the south by the Ajanta range and the Mahadeo hills, on the east by the Eastern Ghats and on the west by the Western Ghats. Except for the hills forming the watershed around the basin, the entire drainage basin of the river comprises rolling and undulating country – a series of ridges and valleys interspersed with low hill ranges. The upper reaches of the Godavari drainage basin are occupied by the Deccan Traps containing minerals, hypersthene, augite, diopside, enstatite, magnetite, epidote, biotite, zircon, rutile, apatite and chlorite. The middle part of the basin is principally Archean granites and Dharwars composed of phyllites, quartzites, amphiboles and granites. The downstream part of the middle basin is occupied mainly by the Cuddapah and Vindhyan metasediments and rocks of the Gondwana group. The Cuddapahs and Vindhyan are quartzites, sandstones, shales, lime stones and conglomerates. The Gondwanas are principally detritals with some thick coal seams. The Eastern Ghats dominate the lower part of the drainage basin and are formed mainly from the Khondalites which include quartz- feldspar- garnet-sillimanite gneisses, quartzite, calc-granulites and charnockites. In the coastal region the tertiary Rajahmundry sandstones crop out.

The western edge of the basin is an almost unbroken line formed by the Sahyadri range of the Western Ghats from 600 to 2,100 m height. It has the heaviest rainfall and the dampest climate in the basin. Hardly 50 to 60 km east of the Ghats lie the sparsely cultivated and undulating plains of the Deccan, with a dry climate. The interior of the basin is a plateau, the greater part of

which is at an elevation of 300 to 600 m with its general slope eastwards. Great undulating plains, divided from each other by flat topped ranges of hills, are the chief characteristics of this plateau. The Eastern Ghats which form the eastern boundary of the peninsula are not well-defined or continuous as the Sahyadri range on the west. They rise from the plains of East Godavari and Visakhapatnam to the level of the table land of Jeypore. The northern boundary of the basin comprises a series of table-lands varying from 600 to 1,200 m in elevation, which have withstood the effect of ages of denudation better than the terrain to the north and south of them. To the south, lie great stretches of plain at an elevation of more than 300 m interspersed with and surrounded by hill ranges, some bare and rocky, but generally covered with forests and scrub jungles. The delta of Godavari consists of a wide belt of river borne alluvium formed by deposits at the mouth of the river over the ages. The process of silting at the mouth of the river is still continuing and the delta is gradually extending into the sea

Rainfall Pattern in the Basin-The Godavari basin receives its maximum rainfall during the Southwest monsoon season. The monsoon currents strike the West Coast of the peninsula from West and South-West, meet the Western Ghats or Sahyadri Range which present almost an uninterrupted barrier ranging from 600 m. to 2100 m. in height. Before surmounting this barrier the currents deposit most of their moisture on its windward side, and then sweep across the interior of the peninsula on the Easterly course. Rainfall is governed largely by the orography of the area, which leads to variation in the amount of precipitation. In crossing the Ghats, the monsoon wind loses a large part of its moisture. The monsoon currents follow the Eastward slope of the country from the crest of the Ghats, which form the watershed. Conditions in the interior are, therefore, somewhat unfavorable for heavy precipitation except in association with the depression from the Bay of Bengal. The north-east part of the Godavari basin also receives some rain in association with monsoon depressions, which move west-north-west across the Odisha coast.

The Godavari receives the water from a length of about 129 km. of the high rainfall zone in the Western Ghats. The annual rainfall varies from 1,000 to 3,000 mm in this reach. East of the Western Ghats, the rainfall decreases rapidly to less than 600 mm. There is a belt some distance East of the Western Ghats and in width varying from about 80 km. in the South to about 97 km. in the North with less than 600 mm, of normal annual rainfall. The belt which is

about 10,360 sq.km. in area, includes portions of Aurangabad and Ahmednagar districts of Maharashtra. After this area the rainfall again gradually increases to about 900 mm towards the East coast.

The months of January and February are almost dry in the Godavari basin, the rainfall during these two months being less than 15 mm. During the next three months, up to end of May, it varies from 20 mm to about 50 mm, in most parts of the basin. All parts of the basin receive the maximum rainfall in the period from June to September. The Godavari basin as a whole receives 84% of the annual rainfall on an average, during the Southwest monsoon season, which sets in mid-June and ends by mid-October. The Indravati and Pranhita sub-basins receive upto 86% and 88% of the annual rainfall during the same period due to influence of the cyclonic storms which predominantly pass through these sub-basins.

Large Hydroelectric Projects in this sub-basin are situated in Kolab, Machkund, Sileru, Indravati, Wainganga, Kotri, Pranhita and Pravara rivers.

Location of hydroelectric projects in Godavari sub-basin and their salient features is given in **Figure 2.1** and **Table 2.1** repectively.

2.1.1 Physiographic status of Godavari Sub-Basin

In Godavari sub-basin, the physiographic status of the study area is shown in various maps prepared on GIS platform and these maps are as follows:

1. Hydroelectric Projects in Godavari sub-basin (**Figure 2.1**)
2. Topographic(Elevation Data) Map (**Figure 2.2**)
3. Ecologically Sensitive Area Map (**Figure 2.3**)
4. Geological Map (**Figure 2.4**)
5. Seismic Map (**Figure 2.5**)
6. CWC Gauge Discharge Sites & IMD Rain Gauge Sites (**Figure 2.6**)

Table 2.1 Salient Features of Hydroelectric Projects in Godavari Sub-Basin .

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
1	Pochampad	Telangana	Nizambad	Godavari	36	Storage	2297.67	21.35	107.5	332.5	312.50	18°58' 07.8"N	78°20' 28.0"E	18°57' 59.9"N	78°20' 41.4"E	TSGENCO	In Operation
2a	Tupakulagudem (Barrage)	Telangana	Mulugu	Godavari	240	Storage	11535	8.3	317	83	69	18°35' 9.24"N	80°23' 35.57"E	18°33' 46.10"N	80°22' 53.40"E	TSGENCO	Under S&I
2b	Tupakulagudem (Forebay)											18°34' 28.20"N	80°22' 29.60"E				
3	Dummugudem	Telangana	Khamman	Godavari	262	RoR	438	11.5	690.06	60	45.72	17°52' 25.3"N	80°53' 07.6"E	17°52' 35.4"N	80°52' 42.8"E	APGENCO	DPR Returned for Re-submission
4	Polavaram	Andhra Pradesh	West Godavari	Godavari	960	Storage	2128.16	27	2308.41	45.72	13.64	17°17' 14.1"N	81°39' 48"E	17°17' 4.3"N	81°40' 8.8"E	APGENCO	Under Construction
5a	Bhandardara-II (Bhandardara Dam)	Maharashtra	Ahmadnagar	Pravara	34	RoR with Pondage	277.2	50	36.26	744.73	608	19°32' 50"N	73°45' 26"E	19° 33' 20"N	73° 48' 31" E	Dodson Lindblom	In Operation
5b	Bhandardara-II (Randha Pickup Weir)						1.42			668.35		19°32' 38.0"N	73°48' 09.1"E				
6	Pench #	Maharashtra	Nagpur	Pench	160	Storage	1088	150	315.36	490	327.5	21°39' 32.2"N	79° 13' 53.4"E	21° 39' 30"N	79°14'E	MPPGCL	In Operation
7	Wainganga	Maharashtra	Gadchiroli/ Chandrapur	Wain ganga	138	Storage	3366.69	25.15 (Max.)	367.39	222.4	198	20°23' 0"N	79°57' 35"E	20°23' 0"N	79°57' 35"E		PFR
8	Samda	Maharashtra	Gadchiroli/ Chandrapur	Wain ganga	45	RoR	15.41	11.01	157.76	197.5	186	20°11' 54"N	79° 56' 47"E	20°11' 54"N	79°56' 47"E		PFR
9	Kunghara	Maharashtra	Gadchiroli/ Chandrapur	Wain ganga	100	RoR	721.29	15.84	263.4	160	145	19° 37' 13"N	79°47' 30" E	19° 37' 13"N	79°47' 30" E		PFR

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
10	Pranhita	Maharashtra	Gadchiroli	Pranhita	214	Storage	140.76	31.19 (Max.)	575.23	144.5	113	19° 16' 52" N	79°56' 51" E	19° 16' 52" N	79° 56' 51" E		PFR
11	Kotri	Chhattisgarh	Bastar	Kotri	44	Storage	608.47	44.55 (Max.)	142.66	290	245	19°39' 48.8"N	80°40' 06.6"E	19°39' 48.8"N	80°40' 06.6"E		PFR
12a	Upper Indravati (Upper Indravati Dam	Odisha	Kalahandi	Indravati	600	Storage	1435.7	379	1962	642	263	19°16' 33.9" N	82°49' 47" E	19°25' 37.4" N	82° 51' 34"E	OHPC	In Operation
12b	Upper Indravati (Podagada Dam)											19°13' 49.7"N	82°48' 36.2"E				
12c	Upper Indravati (Kapur dam)											19°11' 47.3"N	82°46' 48.5"E				
12d	Upper Indravati (Muran Dam)											19°06' 20.7"N	82°45' 44.1"E				
13	Matnar	Chhattisgarh	Bastar	Indravati	60	RoR	26.15	57.75	177.18	532.5	466.5	19°12 ' 27"N	81°42' 15"E	19°10' 31.7"N	81°39' 35.9"E	CSPGCL	Concurred
14	Bodhghat	Chhattisgarh	Dantewada	Indravati	252	Storage	2198.93	99.08 (Max.)	664.74	456	350.6	19°11' 19.3"N	81°24' 08.0"E	19°09' 54.5"N	81°23' 29.9"E		PFR
15	Kutru-I	Chhattisgarh	Bastar	Indravati	96	Storage	129.66	29.7 (Max.)	252.29	347	317	19°3' 15" N	81°14'E	19° 3 15" N	81°14'E		PFR
16	Kutru-II	Chhattisgarh	Bastar	Indravati	275	Storage	1258.4	42.18 (Max.)	870.16	317	274.39	19°05' 54.97"N	80°53' 32.89"E	19°05' 54.97"N	80°53' 32.89"E		PFR
17	Nugur-I	Chhattisgarh	Dantewada	Indravati	272	Storage	140.76	30.24 (Max.)	744.84	273.7	243.15	19°13' 00"N	80°45' 00"E	19°13' 00"N	80° 45' 00"E		PFR
18	Nugur-II	Chhattisgarh	Dantewada	Indravati	477	Storage	2741.86	27.17	961.53	237	204	19°24'N	80°34' E	19°24' N	80°34' E		PFR
19	Bhopalapatnam	Chhattisgarh	Dantewada	Indravati	90	Storage	66	29.90	723.12	152.86	116	19°1' 48"N	80° 18' 16"E	19° 1' 48"N	80° 18' 16"E		PFR

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
20	Upper Kolab	Odisha	Koraput	Kolab	320	Storage	935	241.72	832.2	858	587.68	18° 47' 18'' N	82° 36' 02'' E	18°49' 53.9''N	82°35' 37.1''E	OHPC	In Operation
21a	Middle Kolab (Diversion Barrage)	Odisha	Koraput	Kerajodi Nallah/ Kolab River	315	Storage	135	252.7	1059.83	536.5	260	18°59' 55"N	82°17' 10"E	18°44' 35"N	82°08' 56"E	Govt of Odisha, Water Resource Dept	DPR Returned for Re-submission
21b	Middle Kolab (Kerajodi dam)									528		18°45' 37.3"N	82°10' 15.8"E				
22	Lower Kolab	Odisha	Koraput	Kolab	65	Storage	1947.42	252.1	845.86	506.9	257.2	18° 49' 40'' N	82° 09' 50'' E	18°43' 30"N	82°9' 30" E		PFR
23a	Machkund* (Jalaput Dam)	Odisha	Koraput	Machkund	120	Storage	892.24	245.36	630	838.2	510.84	18°27' 33.15"N	82°32' 54.49"E	18°30' 31.1"N	82°26' 30.1"E	APGENCO	In Operation
23b	Machkund* (Diversion Dam)											18°31' 57.2"N	82°27' 51.9"E				
24	Balimela	Odisha	Malkangiri	Sileru	510	Storage	2676.04	285.3	1183	462.7	162.33	18°8' 25'' N	82°7' 22''E	18°12' 26.7'' N	82°3' 37''E	OHPC	In Operation
25	Balimela	Andhra Pradesh		Sileru	26	Storage	888.03	33.71 (Max.)	67.27	462.1	411.5	18°08' 20.5"N	82°07' 20.5"E	18°08' 48.1"N	82°06' 43.5"E		Balance
26a	Upper Sileru -I & II (Guntawada Weir)	Andhra pradesh	Visakha patnam	Sileru	240	Storage	88	88.39	375	414.53	318.51	18°03' 34.9"N	82°02' 21.1"E	18°02' 13.99"N	82°01' 9.43"E	APGENCO	In Operation
26b	Upper Sileru -I & II (Forebay Embankment 1)											18°02' 57.2"N	82°01' 22.2"E				
26c	Upper Sileru -I & II (Forebay Embankment 2)											18°03' 06.3"N	82°01' 47.5"E				

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
27a	Lower Sileru (Donkarayi Dam)	Andhra pradesh	East Godavari	Sileru	460	Storage	375.17	188.97	1050	316.07	77.2	17°56' 03.8"N	81°47' 41.9"E	17°52' 12.88'' N	81°39' 33.50'' E	APGENCO	In Operation
27b	Lower Sileru (Left flank Saddle Dam)											17°55' 59.1"N	81°48' 39.0"E				
27c	Lower Sileru (Alimeru Vagu Pickup Dam)											17°53' 13.6"N	81°46' 29.3"E				
27d	Lower Sileru (Forebay Dam)						3.96			283.46		17°51' 54.6"N	81°42' 06.4"E				
28a	Konta (Peda Muduguru)	Chhattisgarh	Dantewada	Sabari/ Sileru	68	RoR	329.31	18.7	234.02	67	45.7	17°49' 36"N	81°25' 40.5"E	17°51' 0.6"N	81°24' 11.5"E		Balance
28b	Konta (Banigudam)									67		17°50' 31.37"N	81°23' 57.6"E				

 # Power is being shared in the ratio of 66.69:33.31 between Madhya Pradesh & Maharashtra

*** Power is being shared in the ratio of 70:30 between Andhra Pradesh & Odisha**

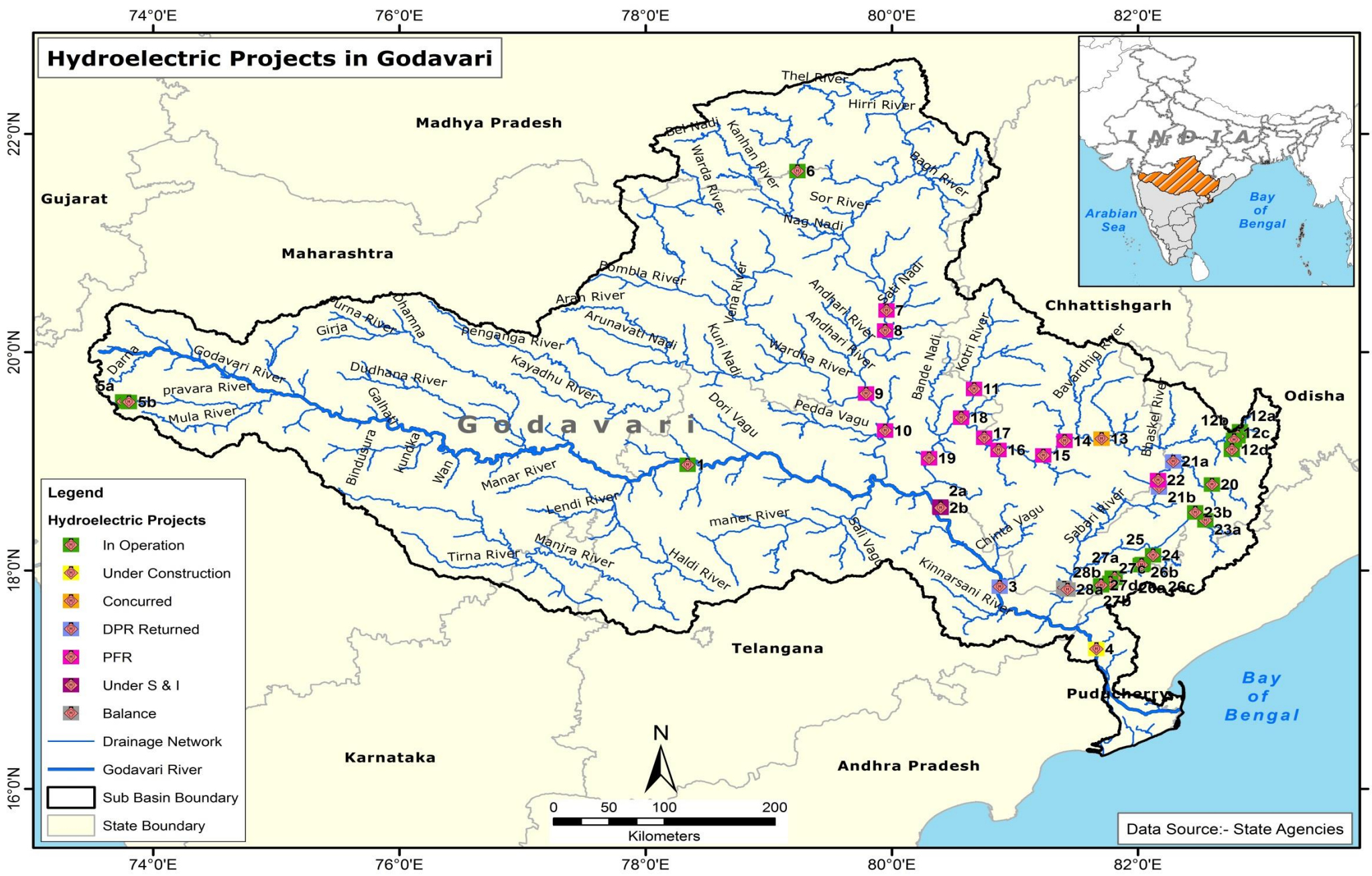


Figure 2.1 Hydroelectric Projects in Godavari Sub-Basin

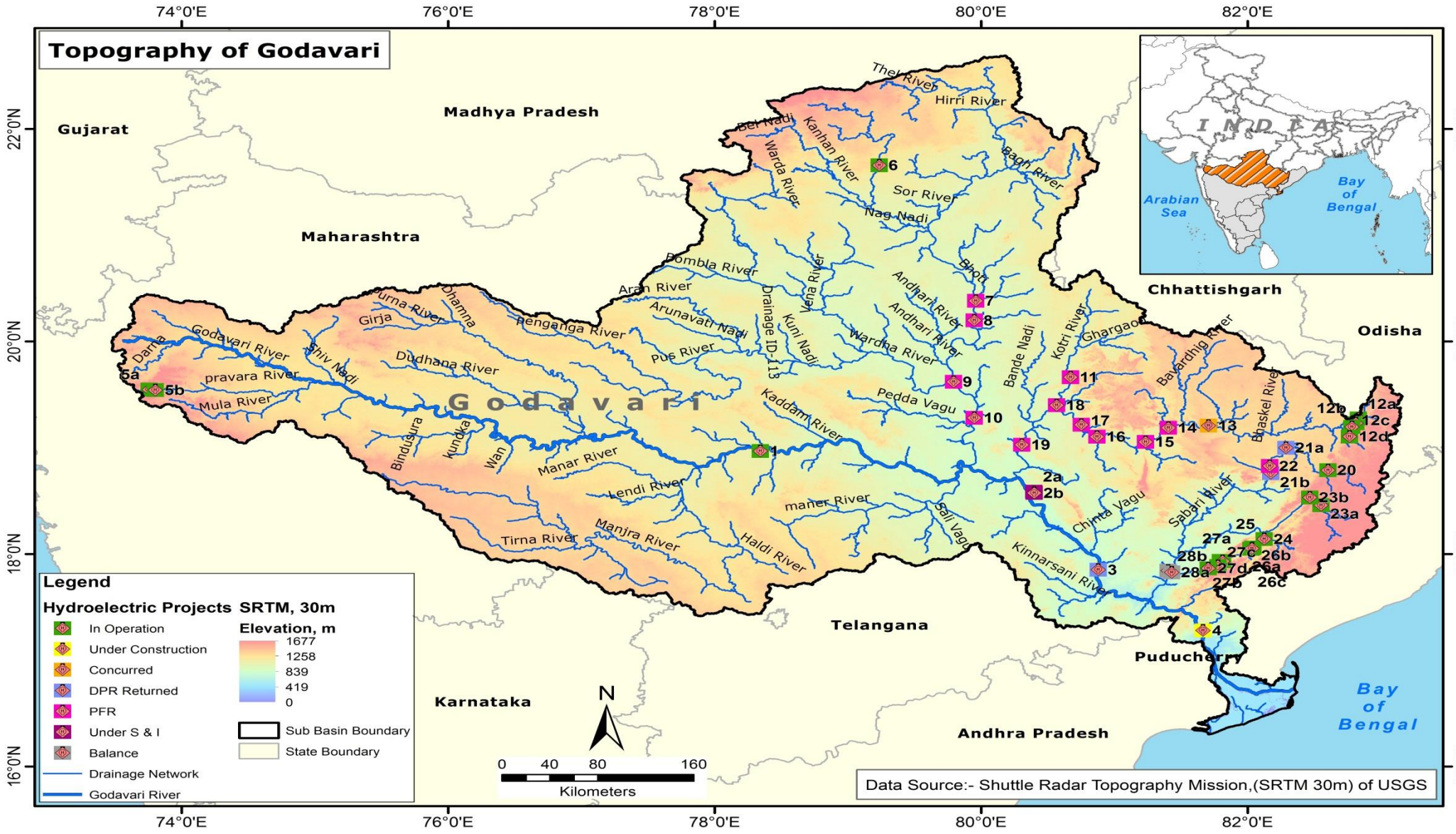


Figure 2.2 Topographical (Elevation Data) Map of Godavari Sub-Basin

The Resolution of this data is 1 arc-second (30 meters). The maximum elevation of this area is 1677 meter.

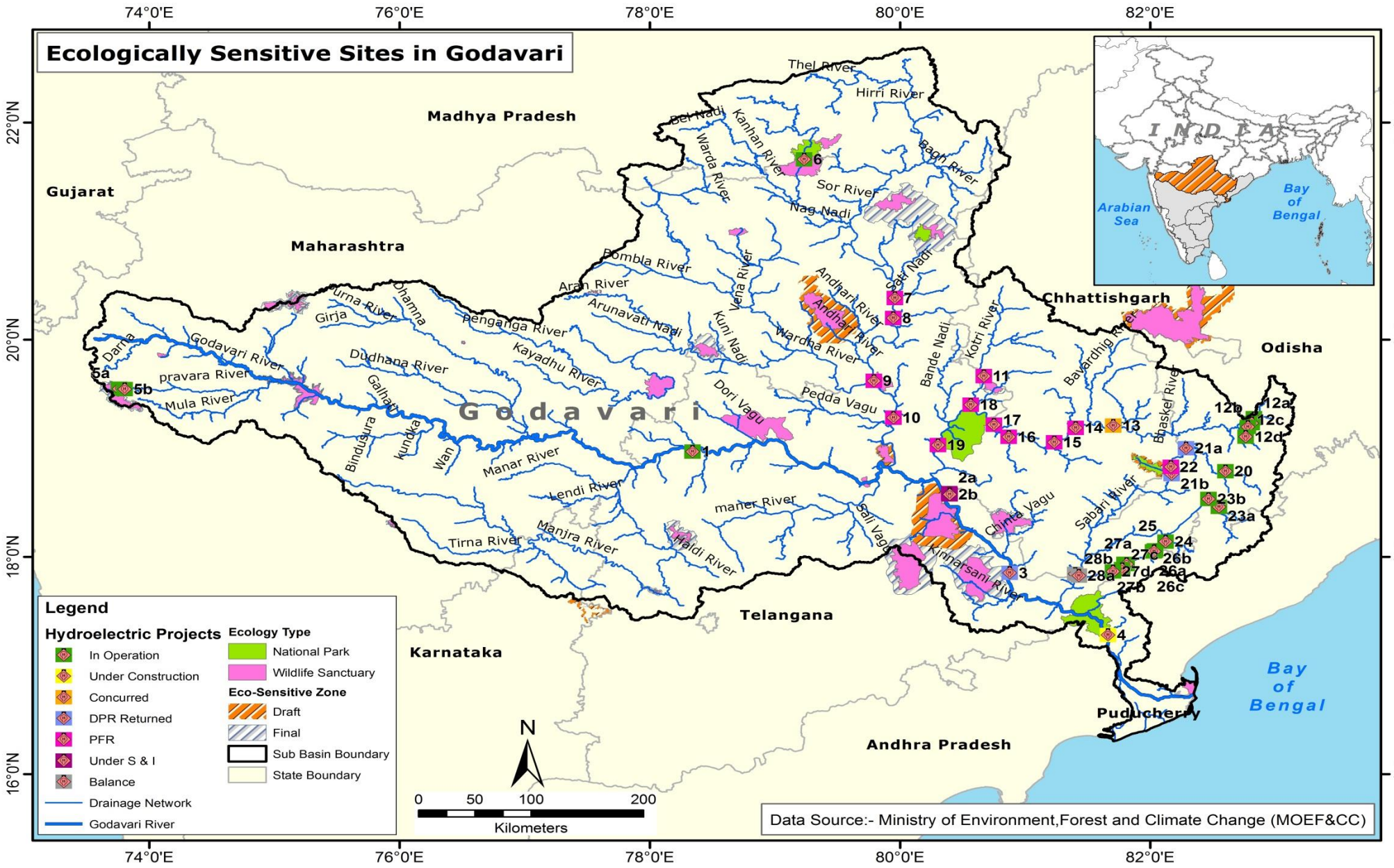


Figure 2.3 Ecologically Sensitive Area Map of Godavari Sub-Basin

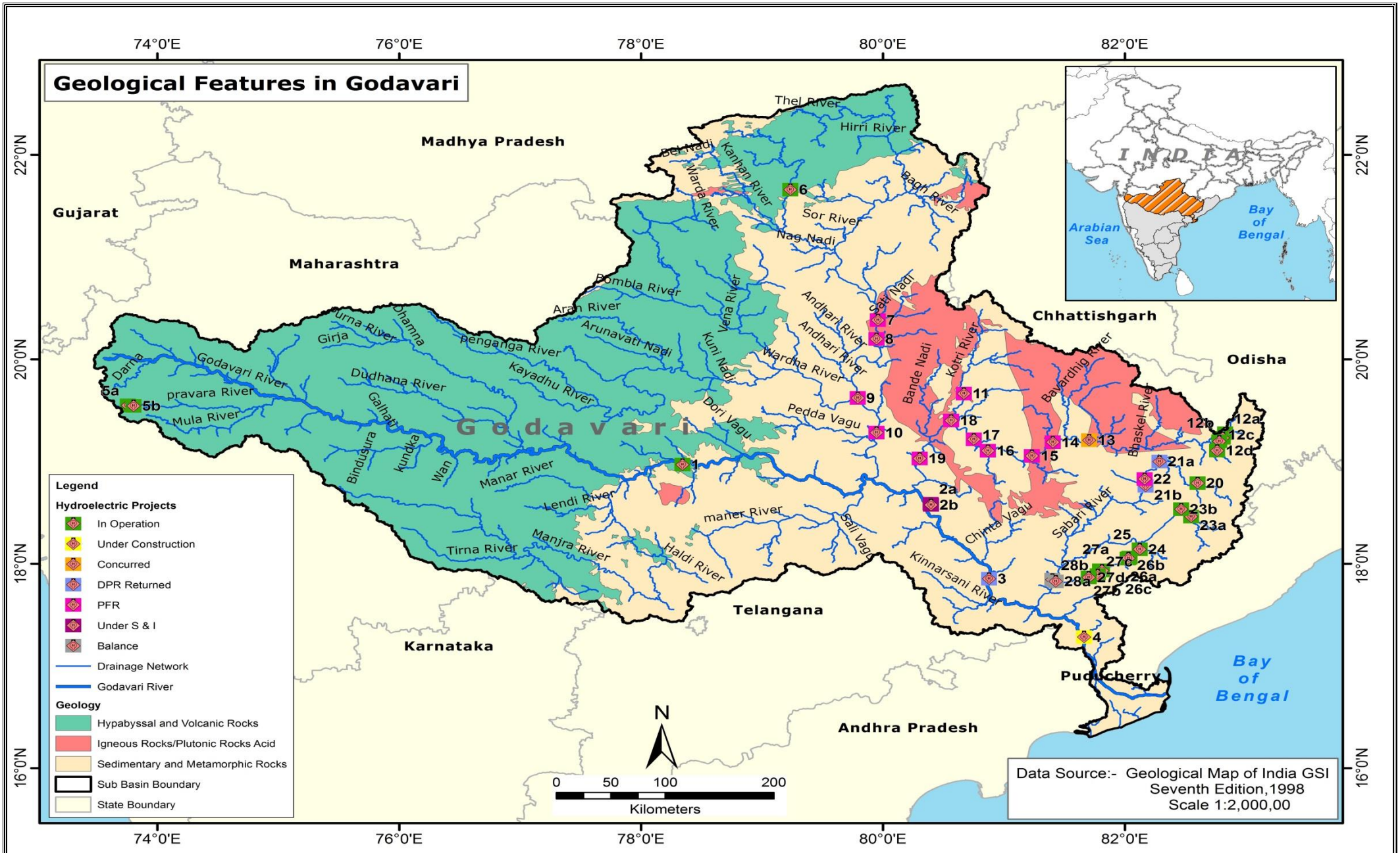


Figure 2.4 Geological Map of Godavari Sub-Basin

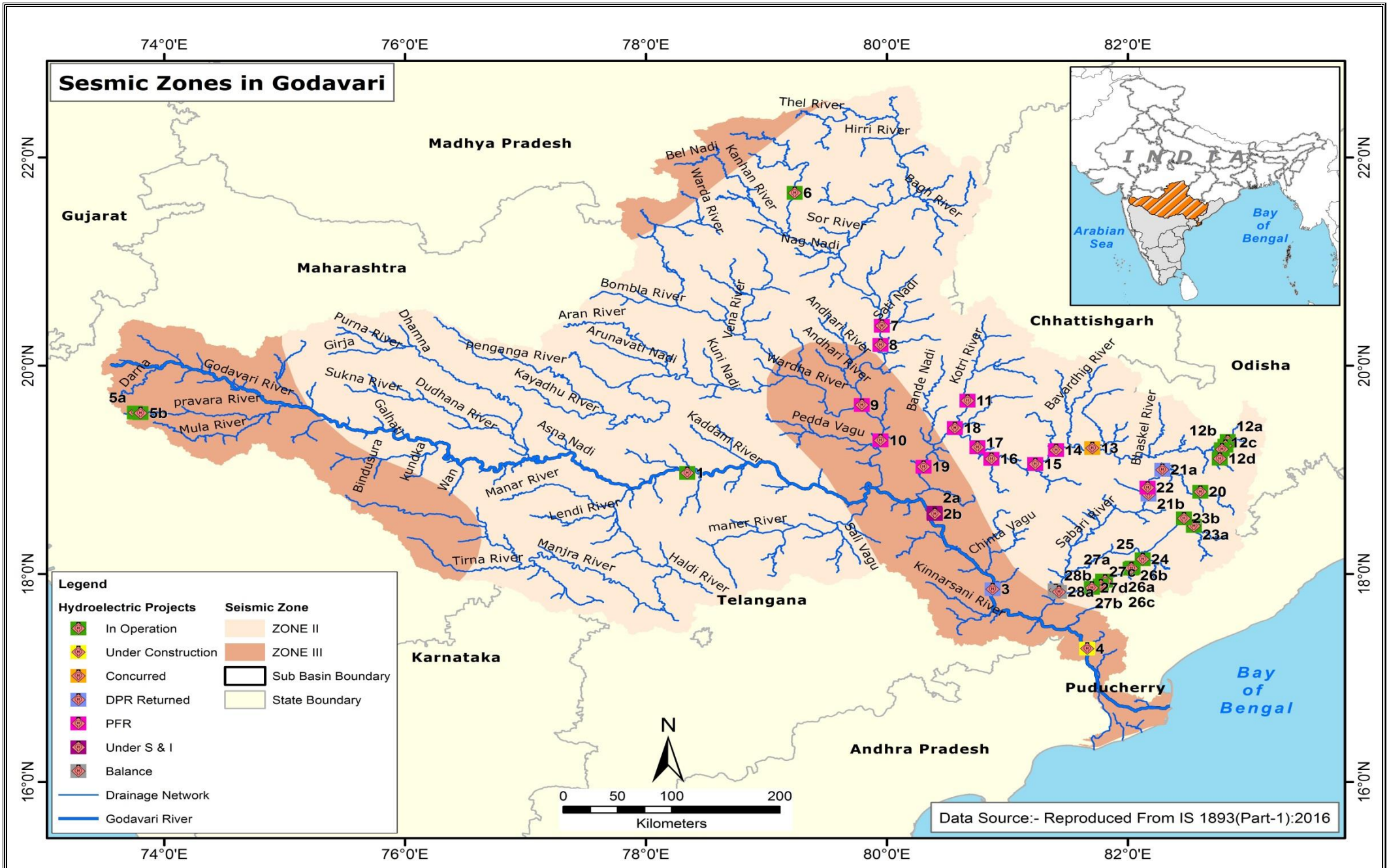


Figure 2.5 Seismic Map of Godavari Sub-Basin

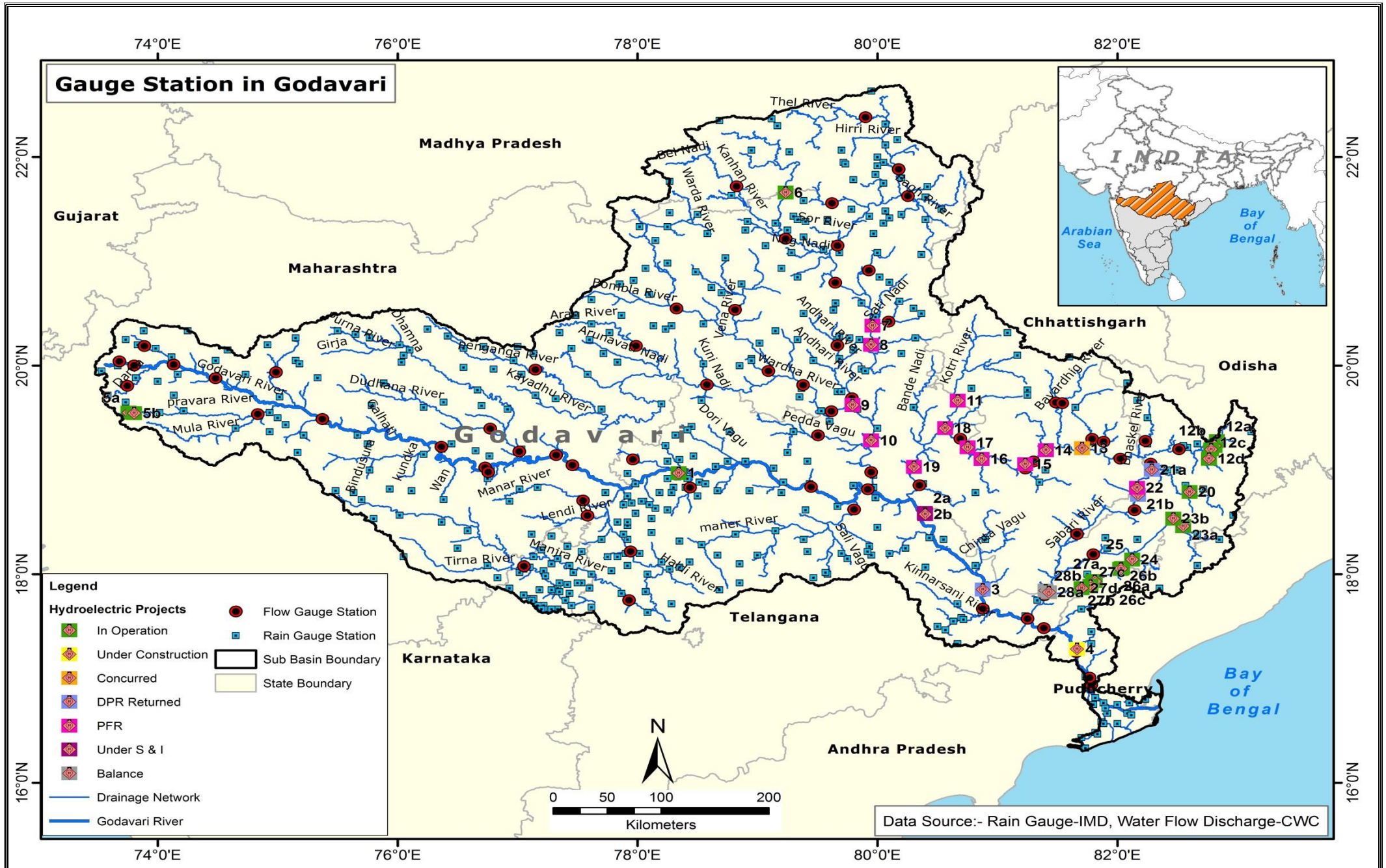


Figure 2.6 CWC Gauge Discharge Sites & IMD Rain Gauge Sites of Godavari Sub-Basin

2.1.2 RIVER PROFILE

2.1.2.1 GODAVARI RIVER

The Godavari flows across the Deccan plateau from western to Eastern Ghats. It originates in the Western Ghats of central India near Nashik in Maharashtra at an elevation of about 1143 m, 80 km from the Arabian Sea. It flows east for 1,465 kilometres having catchment in the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal. Within Nashik district, the river assumes a north-easterly course Gangapur Dam has been constructed across the river to create a reservoir which along with the Kashypi Dam provides potable water to Nashik, one of the largest cities located on its banks. The river as it emerges through the dam, some 8 km upstream from Nashik, flows on a rocky bed resulting in the formation of two significant waterfalls – the Gangapur waterfalls and the Someshwar Waterfalls, the latter, located at Someshwar and more popularly known as the Dudhsagar Waterfall. About 25 km below Nashik and about 68 km from the source, 1st important tributary Darna joins. A few kilometers after its influence with the Darna, the course of the Godavari turn decidedly towards south. At Nandur-Madhmeshwar, another large tributary Kadva joins Godavari considerable increases in the flows of the Godavari. After traversing through Nashik district enter at Ahmednagar District Kopargaon taluka. Within Ahmednagar the river quickly completes its short course, flowing alongside the town of Kopargaon and reaching Puntamba. Its course upto Purna taluka of Parbhani district is relatively non-significant where a major tributary of some name Purna joins Godavari. Further discharge in the neighboring district of Nanded Vishnupuri Dam has been constructed.

Godavari enters into Telangana in Nizamabad district at Kandakurthy where Manjira and Haridra River joins Godavari and forms Triveni Sangamam. The river flows along the border between Nirmal and Mancherial districts in the north and Nizamabad, Jagityal, Peddapalli Ramagundam districts to its south.

Within the state of Andhra Pradesh, it flows through hilly terrain of the Eastern Ghats known as the Papi hills which explains the narrowing of its bed, only to re-widen at Polavaram. Before crossing the Papi hills, it receives its last major tributary Sabari River on its left bank. Arma Konda or Jindhagada Peak (1,680 m above msl) located near Paderu is the highest peak in the Godavari river

basin as well as in Eastern Ghats. After traversing same distance, the Godavari splits into two branches which are called Vriddha Gautami (Gautami Godavari) and Vasishta Godavari. The Gautami branch again splits into two branches namely Gautami and Nilarevu. Similarly the Vasishta splits into two branches named Vasishta and Vainateya. These four branches join the Bay of Bengal at different places.

PRAVARA RIVER

Pravara approximately 208 km in length, is one of the major tributaries of river Godavari located in Maharashtra, India. Among the major tributaries, it is the only tributary which originates in the Western Ghats, akin to Godavari. Close to its origin, the river flows into the town of Bhandardara. Where Bhandardara Dam has been constructed across it, forming the Arthur Lake. The gates of the dam are periodically opened, to allow the flow drownstream, giving rise to the Umbrella Falls. After traversing a distance of 208 km from its origin, river Pravara join Godavari River at the place being known as Pravara Sangam.

List of the projects and their geographical locations on Godavari River & its tributaries /sub-tributaries (Pravara) is shown in **Figure 2.7** & **Figure 2.8.**

Map showing Hydroelectric Projects on Godavari River

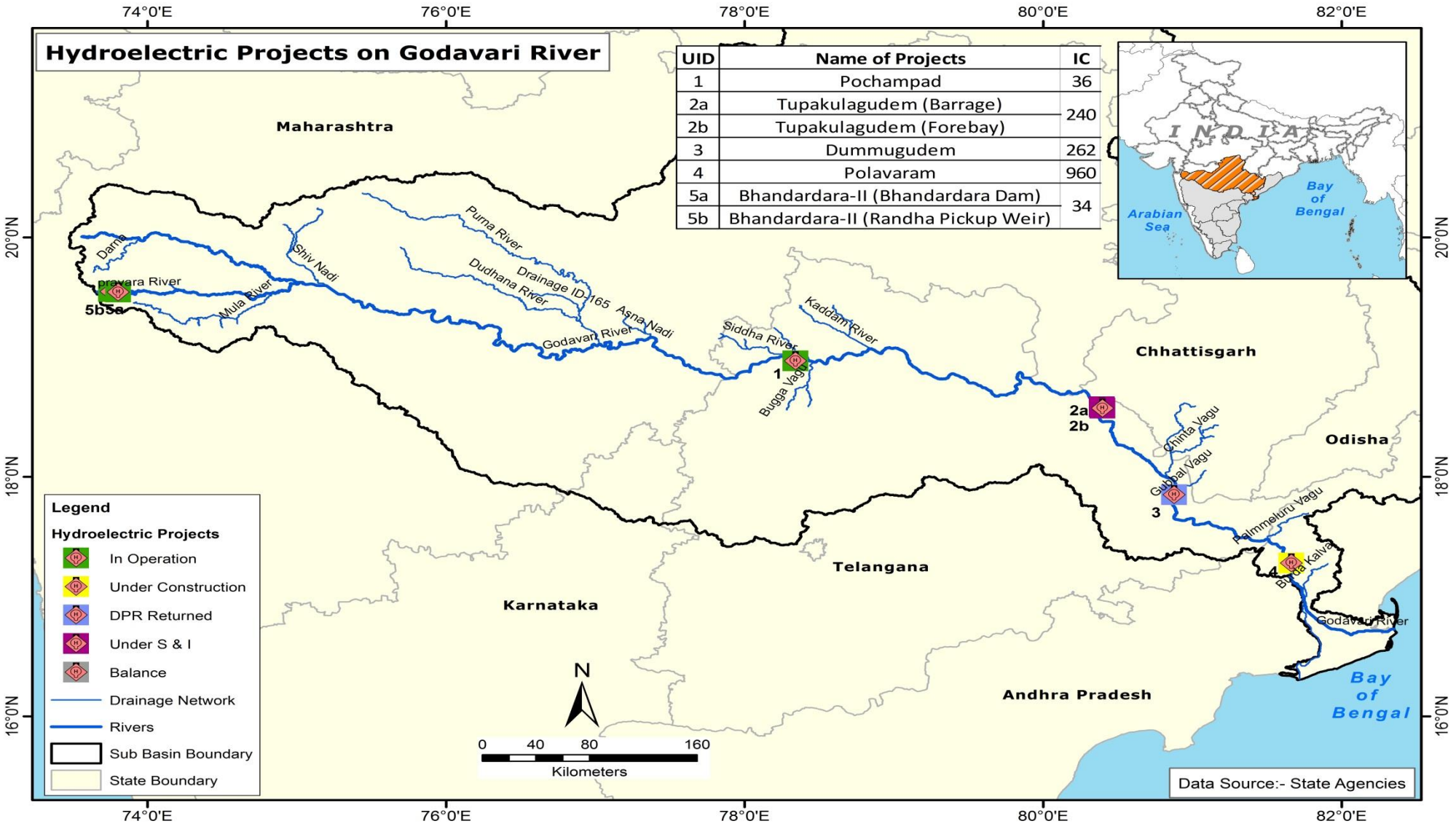


Figure 2.7

Map showing Geological Features of Godavari River

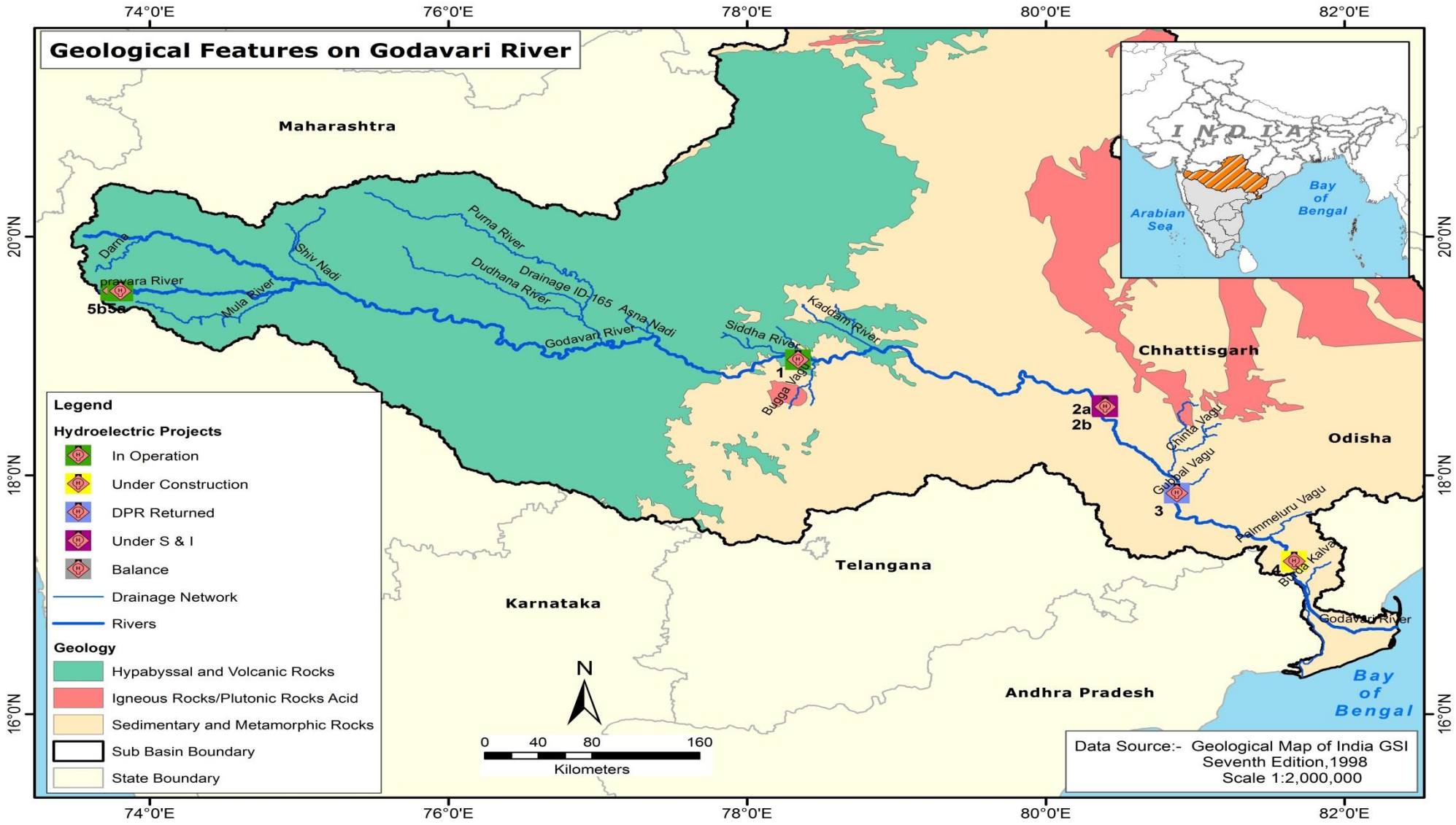


Figure 2.8

2.1.2.2 PRANHITA RIVER

Pranhita River is the largest tributary of Godavari River covering about 34% of its drainage basin. The drainage area of Pranhita mainly comprise of drainage of its three important branches namely Penganga River, Wardha River and Wainganga River. By virtue of its extensive network of tributaries, the river drains all of Vidarbha region in Maharashtra as well as the southern slopes of the Satpura Ranges. The river has a short course of 113 km, strictly adhering to the boundary between Gadchiroli district in Maharashtra and Adilabad district in Telangana. The direction of flow is southward unlike most rivers of the Deccan Plateau. Along its course the river is flanked by thick forest and harbors a rich biodiversity of flora and fauna. After completing its short journey the river empties itself into the Godavari River at 170 feet in Kaleswaram.

WAINGANGA RIVER

It originates about 12 km from the Sundara village of the Seoni district in the southern slopes of the Satpura Range of Madhya Pradesh. The river flows south through Madhya Pradesh and the Maharashtra states for roughly 579 km. Wainganga along with Wardha & Penganga are the major source of water of Pranhita which ultimately joins the Godavari River at Kaleshwaram, Telangana. The Wainganga River has extensive floodplains, characterized by sweeping graceful meanders, low alluvial flats and meander terraces. The northern part of river is covered by Mahadeo hills and Satpura ranges with an average elevation 625 m above sea level.

The Wainganga River during its course is joined by numerous tributaries on either bank and drains part of Madhya Pradesh and Maharashtra. The main tributaries of the Wainganga river meeting the river on left bank are the Thel, Thanwar, Bagh, Chulband, Garhavi, Khobragadi, and Kathani whereas Hirri, Chandan, Bawanthari, Mul and Kanhan drains into Wainganga on the right bank.

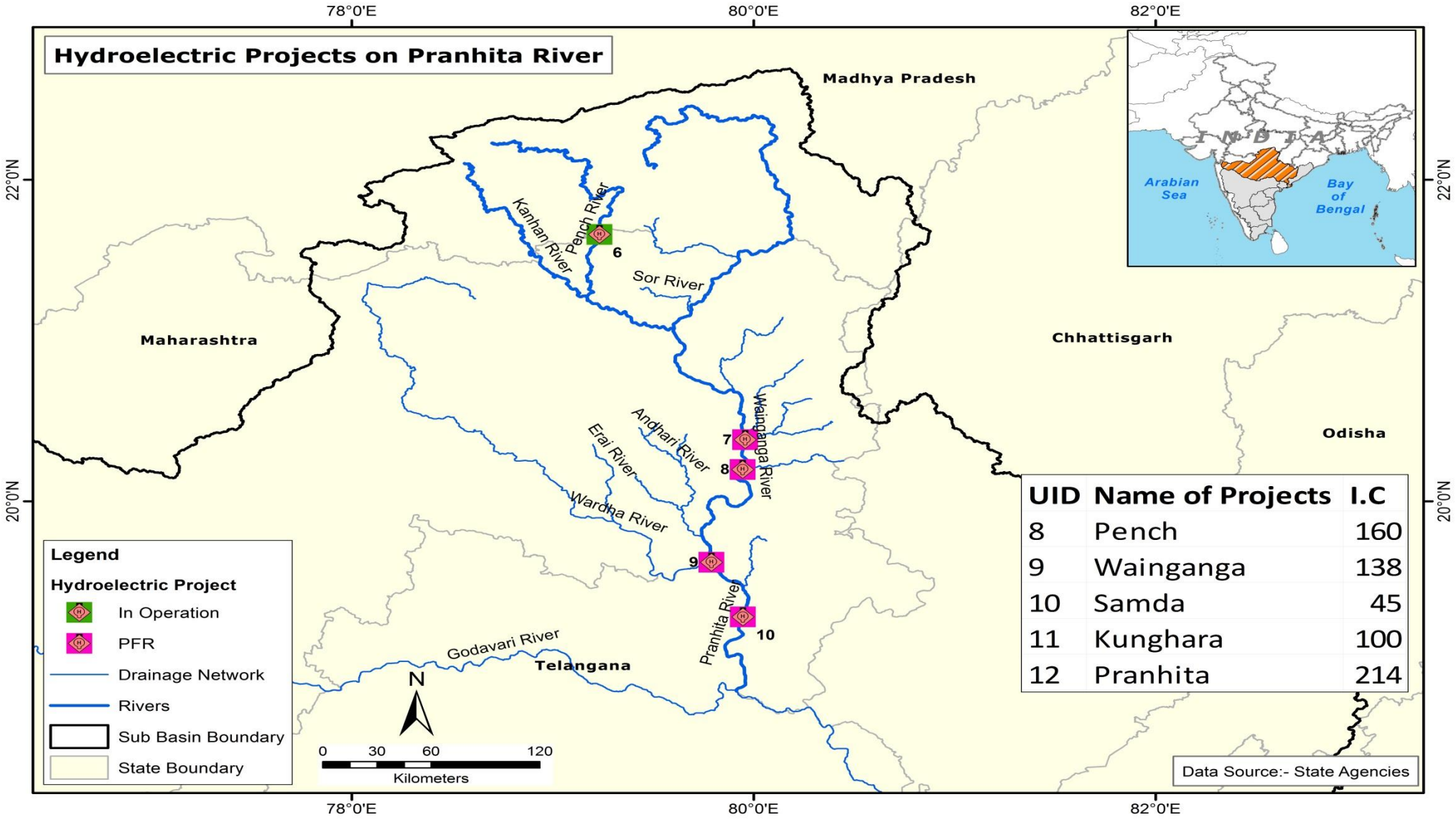
PENCH RIVER

One of the tributary of Kanhan River is Pench. Pench originates in the Chhindwara district of Madhya Pradesh and flows across Pench National Park, which is a reserve for the Tiger Project of India. The Pench River flowing through the center of the Reserve is usually dry by April, but a number of water pools, locally known as dohs, are found along the course of the river. The

hydroelectric Totladoh Dam on the Pench River was the first interstate project of Maharashtra. It is located in the Pench National Park. The next big dam is Pench Dam near just downstream of the Totladoh Dam, the town of Navegaon Khairy located in Parseoni Taluka.

List of the projects and their geographical locations on Pranhita River & its tributaries/sub-tributaries (Wainganga and Pench) is shown in **Figure 2.9** & **Figure 2.10**.

Map showing Hydroelectric Projects on Pranhita River



UID	Name of Projects	I.C
8	Pench	160
9	Wainganga	138
10	Samda	45
11	Kunghara	100
12	Pranhita	214

Figure 2.9

Map showing Geological Features of Pranhita River

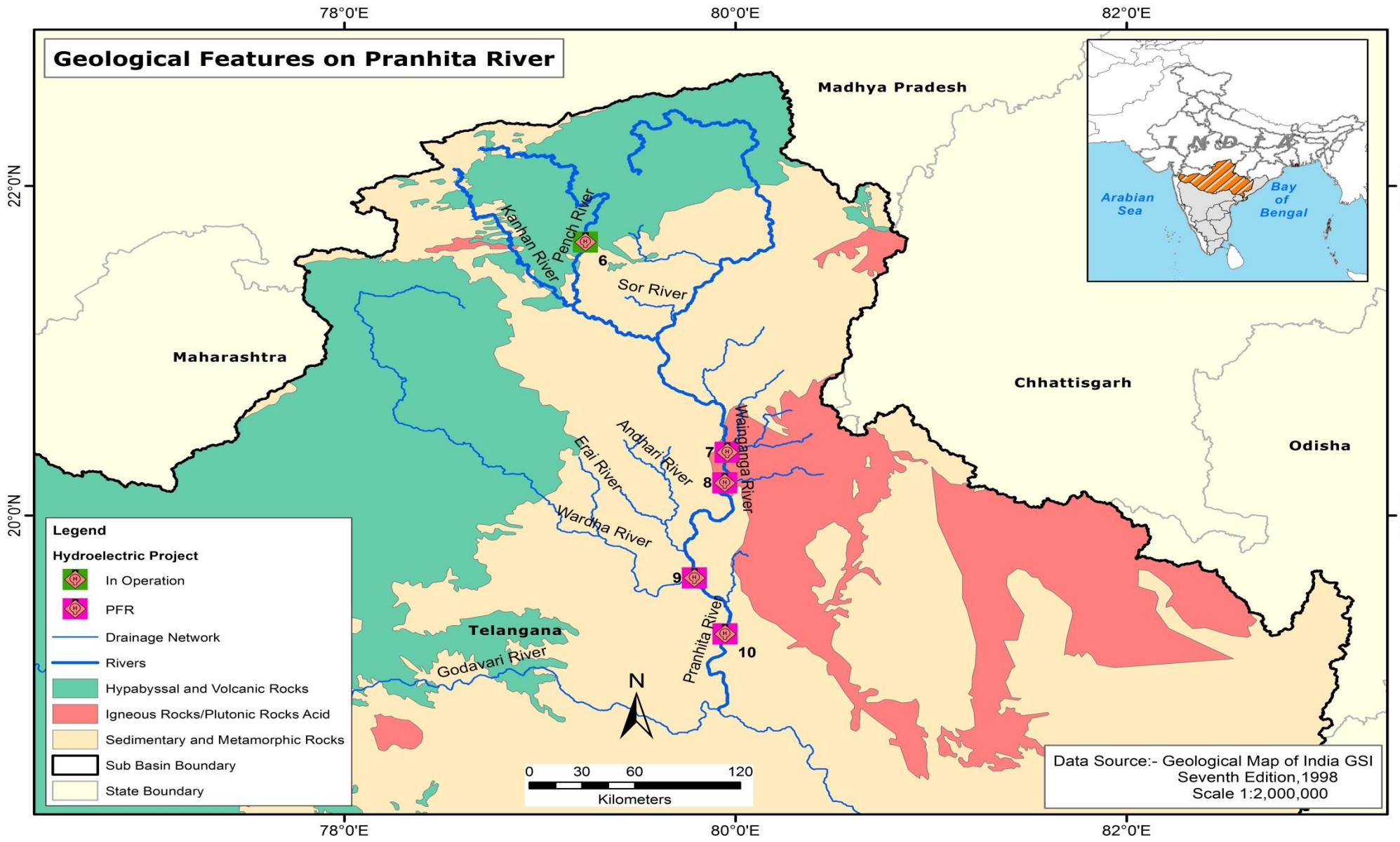


Figure 2.10

2.1.2.3 INDRAVATI RIVER

The river Indravati with sizable catchment of 41,960 sq.km is a major tributary of river Godavari. It rises at an elevation of 914 meters in the Kalahandi district of Odisha the river Indravati having total length of about 536 km flows about west-ward through the Kalahandi, Nabarangapur and Koraput districts for about 164 kilometers and after forming the boundary between Odisha and Chhattisgarh states for 9.5 kilometers, enters the Bastar district of Chhattisgarh. After flowing 233 kilometres in Chhattisgarh, it turns south and flows along the boundary of Chhattisgarh and Maharashtra for about 129 kilometers and joins Godavari River at the junction of the boundaries of Maharashtra, Chhattisgarh and Telangana states. Starting from the hills of Kalahandi, the river Indravati traverses a total length of about 85m. Thus during its total course the river drops by about 832.10 meters.

The major tributaries of river Indravati are Keshadhara Nalla, Kandabindha Nallah, Chandragiri Nalla, Golagar Nalla, Poragarh Nalla, Kapur Nallah, Muran River, Bangiri Nallah, Telengi Nallah, Parlijori Nallah, Turi Nallah, Chourijori Nallah, Damayanti Sayarh, Kora River, Modang River, Padrikundijori River, Jaura River and Bhaskel River. The important right bank tributaries of the Indravati are Bhaskal, Narangi, Boarding, Nibra, Kotri and Bandia. The important left bank tributary is Nandiraj. An important tributary whose potential could be utilized is Kotri, which is a northern tributary of Indravati River. The surplus water of Indravati River in Odisha is diverted to Sabari river (also known as Kolab River in Odisha) river via Jaura Nallah through which Indravati flood water naturally overflow.

KOLAB RIVER

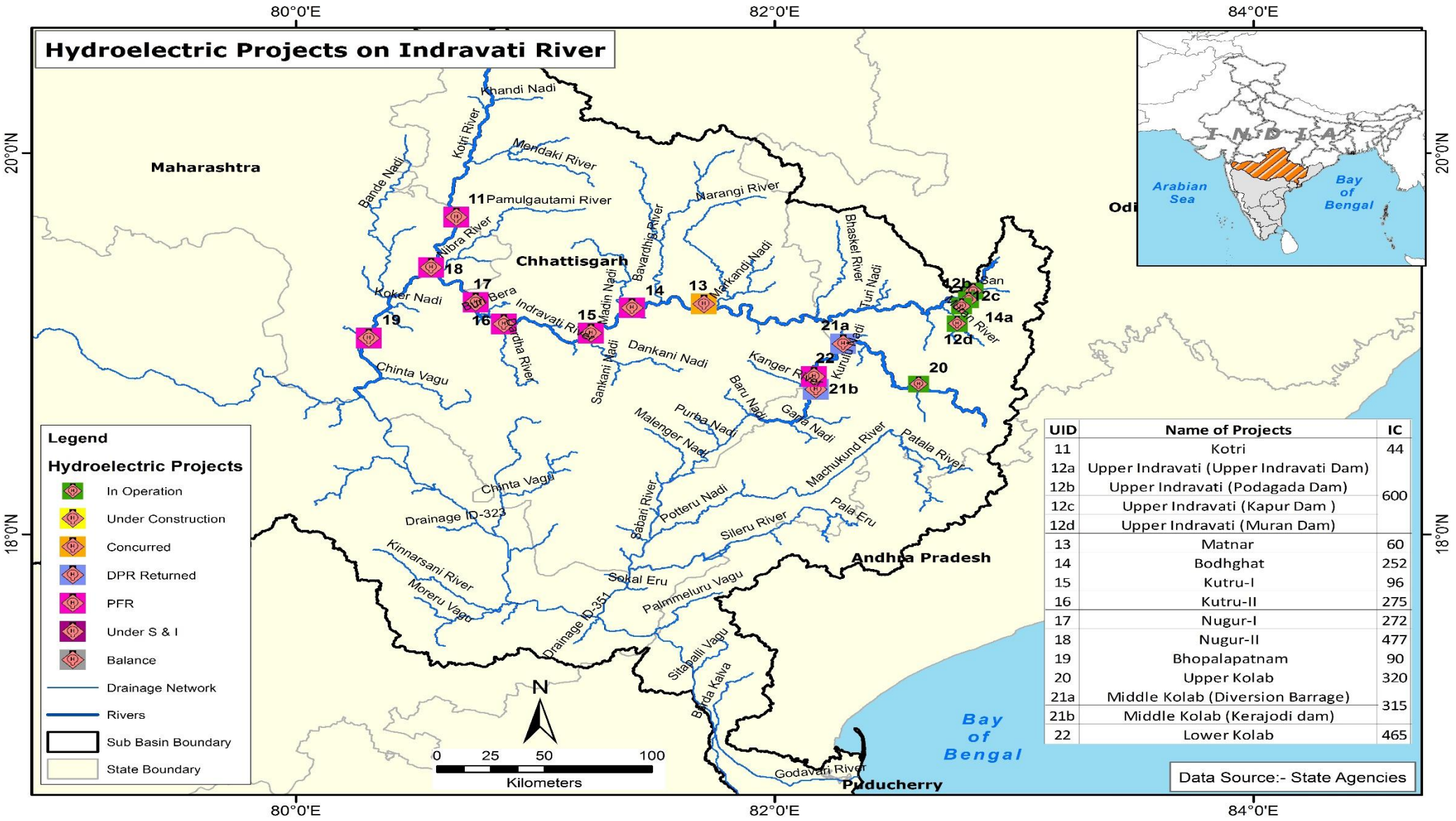
The river Kolab originates from the Sinkaran hills of the Eastern Ghats in Koraput districts at an elevation of 1372 m and after traversing for about 406 km finally joins the Godavari in Andhra Pradesh at an elevation of 25m. It is one of the main tributaries of Godavari and one of the major rivers of Odisha, the river covers a catchment area of 20400 sq kms. The prominent tributaries of Kolab are Karandi Nalla, Kerajodi, Guradi Nalla, Kangar Nallah, Garia, Dharmageda Nallah, JamNadi, Malengar River, Mulervagu Nallah, Potteru Vagu Nallah, Machhakund River, Sileru River. Upper Kolab Hydroelectric Project with Kolab dam constructed across river Kolab utilizes the potential of river Kolab to

generate power. Sileru River also known as Machkund joins Sabari River at tri-junction boundary point of Andhra Pradesh, Chhattisgarh and Odisha.

The huge availability of water and sustainable drop in the Kolab River provide fairly good scope for Hydro-Power Generation.

List of the projects and their geographical locations on Indravati River & its Tributaries /sub-tributaries (Kolab) is shown in **Figure 2.11** & **Figure 2.12**.

Map showing Hydroelectric Projects on Indravati River



UID	Name of Projects	IC
11	Kotri	44
12a	Upper Indravati (Upper Indravati Dam)	600
12b	Upper Indravati (Podagada Dam)	
12c	Upper Indravati (Kapur Dam)	
12d	Upper Indravati (Muran Dam)	
13	Matnar	60
14	Bodhghat	252
15	Kutru-I	96
16	Kutru-II	275
17	Nugur-I	272
18	Nugur-II	477
19	Bhopalapatnam	90
20	Upper Kolab	320
21a	Middle Kolab (Diversion Barrage)	315
21b	Middle Kolab (Kerajodi dam)	
22	Lower Kolab	465

Figure 2.11

Map showing Geological Features of Indravati River

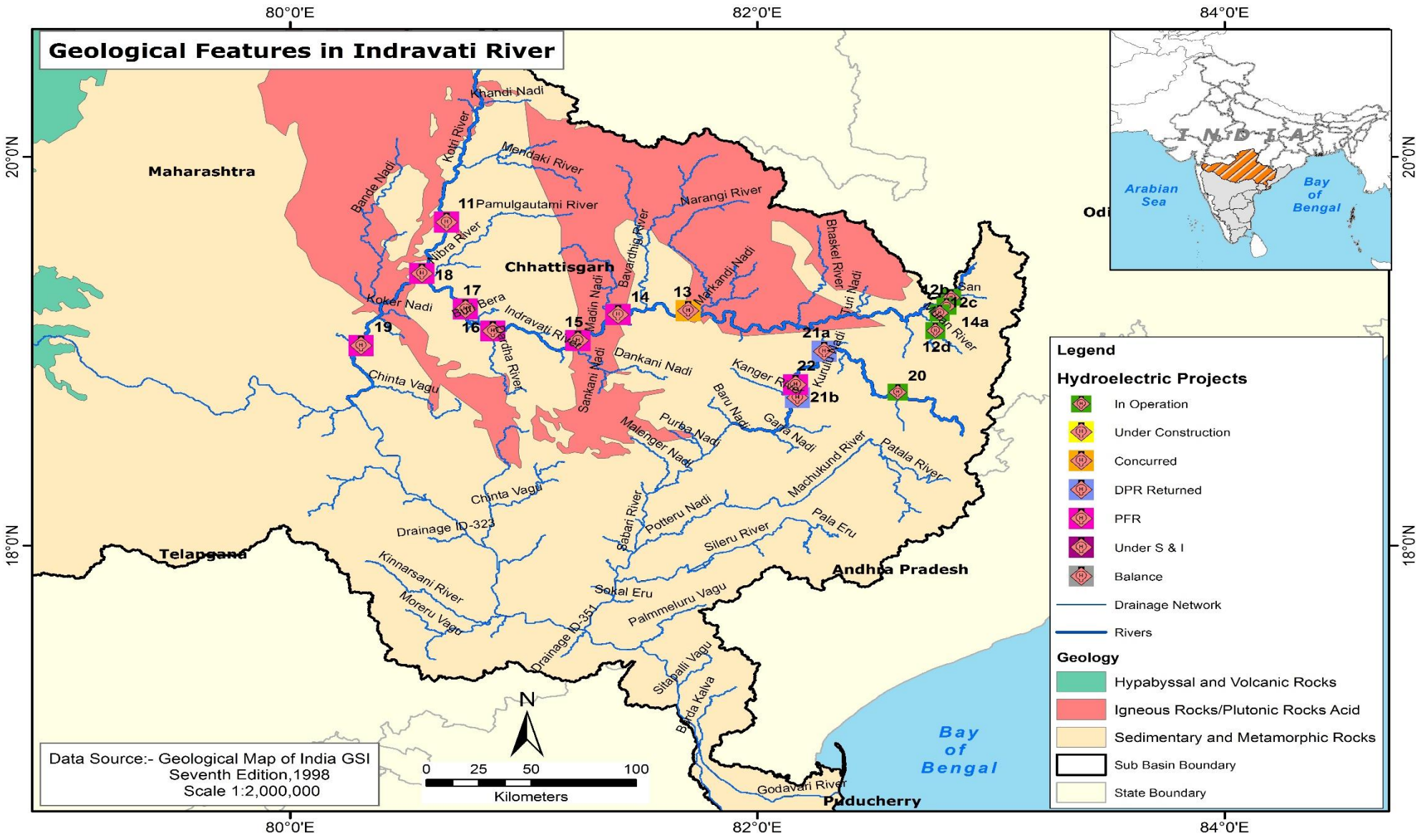


Figure 2.12

2.1.2.4 SABARI RIVER

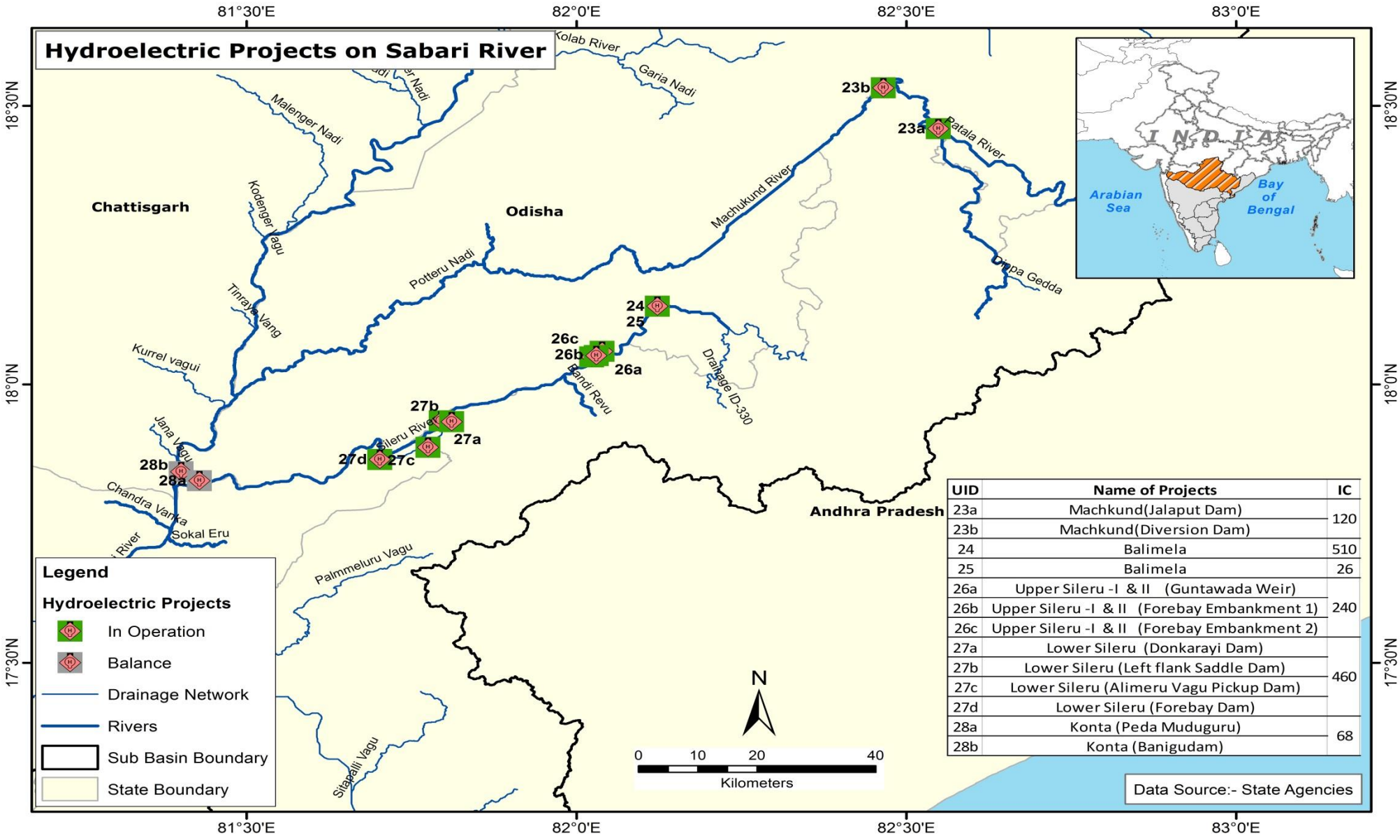
Sabari River is one of the main tributaries of Godavari. It originates from the western slopes of Eastern Ghats in Odisha state from Sinkaram hill ranges at 1370 m MSL. It is also known as Kolab River in Odisha. The Sabari river basin receives nearly 1250 mm annual average rainfall. It forms common boundary between Chhattisgarh and Odisha states and subsequently enters into Andhra Pradesh and joins River Godavari. The 200 km long stretch of the river forming boundary between Chhattisgarh and Odisha has a drop of 2.25 meters per km length on an average. This stretch of the river has substantial hydro electricity generation potential through cascade of medium head (< 20 m) barrages in series to minimize land submergence. Sileru River (known as Machkund in its upper reaches) is the major tributary of Sabari which joins Sabari River at tri-junction boundary point of Andhra Pradesh, Chhattisgarh and Odisha

SILERU RIVER

Machkund River also known as Sileru River (in Lower reaches) flow towards the Southern east central India. It rises in the Eastern Ghats in the north eastern part of Andhra Pradesh and then flow towards northern region. A dam known as Jalaput has been constructed on the border with the Odisha state. Power potential of the river is being tapped at Jalaput reservoir makes a sharp bend towards the southwestern region and form the border between Odisha and Andhra Pradesh. During the southern westward course, this river is in a parallel direction towards the mountain ranges in south east and its channel is at the elevation of 2000 to 3000 feet. This river flows for a total distance of 309 km before joining Sabari River beside Jalaput Reservoir, upper as well as lower courses of this river are prime sources of power in this region.

List of the projects and their geographical locations on Sabari River & its tributaries / sub-tributaries (Sileru) is shown in **Figure 2.13** & **Figure 2.14**.

Map showing Hydroelectric Projects on Sabari River



UID	Name of Projects	IC
23a	Machkund(Jalaput Dam)	120
23b	Machkund(Diversion Dam)	
24	Balimela	510
25	Balimela	26
26a	Upper Sileru -I & II (Guntawada Weir)	240
26b	Upper Sileru -I & II (Forebay Embankment 1)	
26c	Upper Sileru -I & II (Forebay Embankment 2)	
27a	Lower Sileru (Donkarayi Dam)	460
27b	Lower Sileru (Left flank Saddle Dam)	
27c	Lower Sileru (Alimeru Vagu Pickup Dam)	
27d	Lower Sileru (Forebay Dam)	
28a	Konta (Peda Muduguru)	68
28b	Konta (Banigudam)	

Figure 2.13

Map showing Geological Features of Sabari River

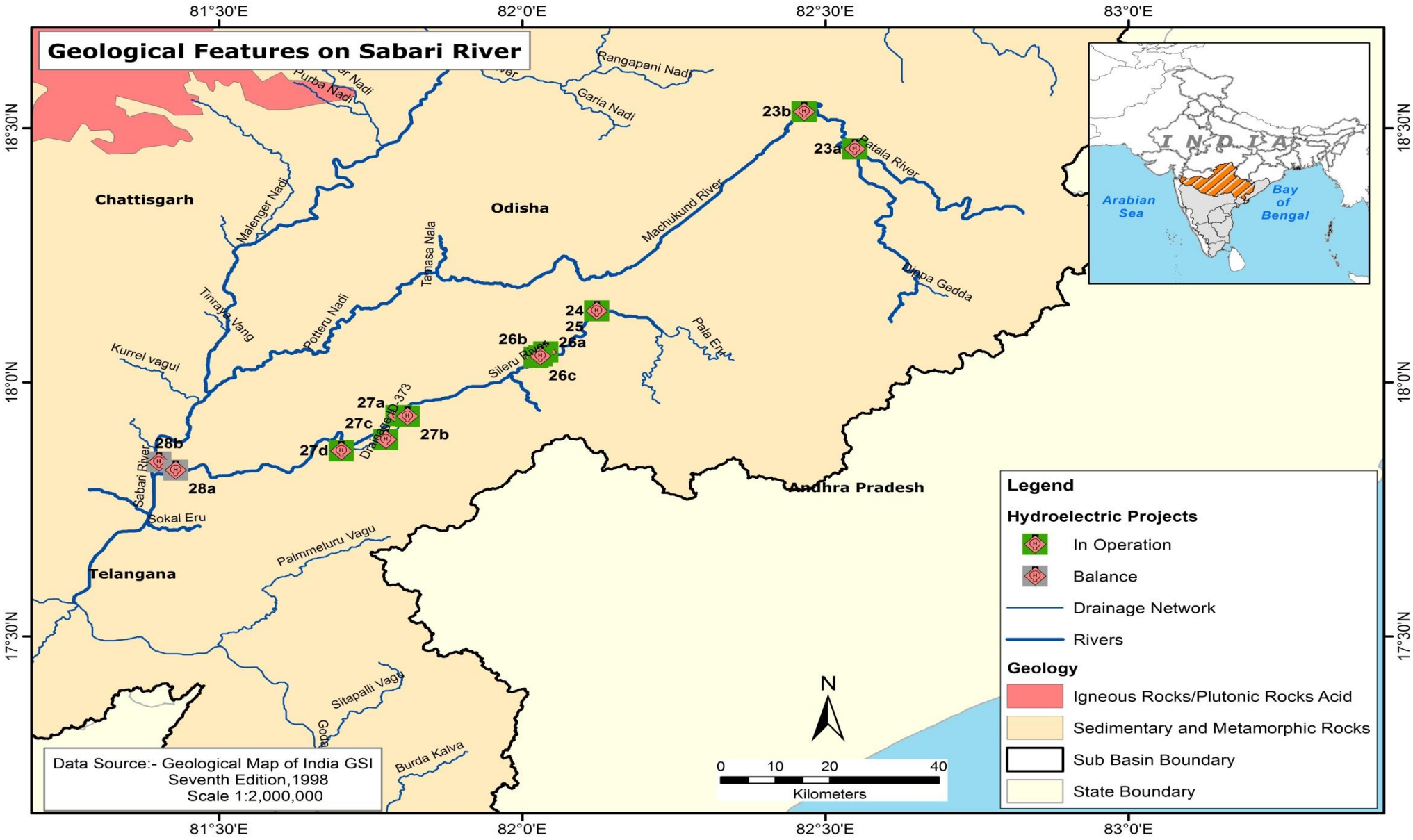


Figure 2.14

2.2 KRISHNA SUB-BASIN

State Involved – Maharashtra, Karnataka, Andhra Pradesh, Telangana

The Krishna Basin extends over Andhra Pradesh, Maharashtra, Karnataka and Telangana having a total area of 2,58,948 Sq.km which is nearly 8% of the total geographical area of the country. The basin has a maximum length and width of about 701 km and 672 km and lies between 73°17' to 81°9' east longitudes and 13°10' to 19°22' north latitudes. It is bounded by Balaghat range on the north, by the Eastern Ghats on the south and the east and by the Western Ghats on the west. The Krishna River rises from the Western Ghats near Jor village of Satara district of Maharashtra at an altitude of 1,337 m just north of Mahabaleshwar. The total length of river from origin to its outfall into the Bay of Bengal is 1,400 km. Its principal tributaries joining from right are Ghatprabha, Malprabha and Tungabhadra whereas those joining from left are the Bhima, Musi and Munneru. The major part of basin is covered with agricultural land accounting to 75.86% of the total area and 4.07% of the basin is covered by water bodies.

Topography -The western edge of the basin is an almost unbroken line formed by the Western Ghats whose height ranges from 600 m to 2100 m. It has the heaviest rainfall and the most humid climate in the basin. Hardly 50 to 60 km. east of the ghats lie the sparsely cultivated and undulating plains of the Deccan with a dry climate and poor rainfall.

The interior of the basin is a plateau, the greater part of which is at an elevation 300 to 600 m. Its general slope is eastwards. Great undulating plains, divided from each other by flat-topped ranges of hills are the main characteristics of this plateau. The hill-sides are marked by conspicuous, wide, terraces except in the southern part where the hills are frequently crowned with great 'tors' or rounded hummocks of bare rock, the result of constant weathering.

The Eastern Ghats which form the eastern boundary of the peninsula are by no means so well-defined or continuous as the Western Ghats. To the south of the Krishna, the Eastern Ghats comprise parallel ranges, which are the successive outcrops of an ancient series of stratified rocks.

Except for the hills forming the watershed around the basin, the entire drainage basin of the river comprise rolling and undulating country, a series of ridges and valleys interspersed with low hill ranges. Large flat

areas of the type seen in the Indo-Gangetic plains are scarce, except in the delta.

The delta of the Krishna formed by deposits at the mouth of the river over past ages consists of a wide belt of river-borne alluvium. The process of silt deposition at the mouth of the river is still continuing and the delta is gradually extending into the sea.

Climate- The Krishna basin has a tropical climate. The climate is dominated by the southwest monsoon season, which provides most of the precipitation for the basin. High flow in the river occurs during the months of August-November and the lean flow season is from April to May. Climate type ranges from per-humid through dry sub-humid in the west through semi-arid in the central and eastern parts of the basin. The south-central part of the basin is truly arid.

The region with its north-south elongation and typical arrangement of the major relief features, responds differently to the monsoon currents and thus exhibits sub-regional climate variations within this tropical monsoon zone. Western Ghats exert considerable influence as a climate barrier or rather a divide in the spatial distribution of climate attributes, the temperature, rainfall and relative humidity etc. Around the year, four distinct seasons occur in the basin. They are:

The cold weather 2)hot weather 3)south-west monsoon season 4)post monsoon season. The cold weather season from mid-October to mid-February is generally pleasant in the entire basin. The western and the north-eastern regions are colder than the rest of the basin. In the hot weather season, the heat is unbearable in the central, northern and eastern regions of the basin. It is comparatively pleasant in the western-most parts. The south-west monsoon season sets in by mid-June and ends by mid-October. During this period, the basin receives about 80% of its total annual rainfall. After the withdrawal of the south-west monsoon season in the middle of October, the weather clears up gradually and it is cool thereafter.

Rainfall- Like most other parts of India, the Krishna basin receives its maximum rainfall during the south-west monsoon season. The monsoon winds strike the west coast of the Indian peninsula from the west and south-west and strike the Western Ghats or the Sahyadri Range, which present an almost uninterrupted barrier ranging from 610 m to 2,134 m in height.

The average annual rainfall in the Krishna basin for the period of 1969 to 2004 is 859 mm. The south-west monsoon season sets in the middle of June and withdraws by the middle of October. About 90% of annual rainfall is received during the Monsoon period, of which more than 70% occurs during July, August and September.

Large Hydroelectric Projects in this sub-basin are situated in Andhra, Indrayani, Neela & Mulla, Koyna, Ghatprabha, Bhadra and Tungabhadra rivers.

Location of Hydroelectric project in Krishna sub-basin and their salient features are given in **Figure 2.15** and **Table 2.2** respectively.

2.2.1 Physiographic status of Krishna Sub-Basin

In Krishna sub-basin, the physiographic status of the study area is shown in various maps prepared on GIS platform and these maps are as follows:

1. Hydroelectric Projects in Krishna sub-basin (**Figure 2.15**)
2. Topographic (Elevation Data) Map (**Figure 2.16**)
3. Ecologically Sensitive Area Map (**Figure 2.17**)
4. Geological Map (**Figure 2.18**)
5. Seismic Map (**Figure 2.19**)
6. CWC Gauge Discharge Sites & IMD Rain Gauge Sites (**Figure 2.20**)

Table 2.2 Salient Features of Hydroelectric Project in Krishna Sub-Basin.

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
1	Almatti	Karnataka	Bagalkot	Krishna	290	Storage	3139	U1-24.09 U-2 TO6: 26.6	483	519.6	492.25	16°19' 48"N	75°53' 10.7"E	16°19' 40" N	75°53' 9"E	KPCL	In Operation
2a	Tamankal # (Narayanpur)	Karnataka	Raichur	Krishna	300	Storage	113.23	87.14 (Max.)	168.99	492.25	402.12	16°13' 28.5"N	76°20' 39.7"E	16°14' 40.5"N	76°25' 08.5"E		PFR
2b	Tamankal# (Narayanpur Forebay)											16°14' 37.4"N	76°25' 00.5"E				
3a	Jaldurg# (Jaldurg Diversion)	Karnataka	Raichur	Krishna	270	RoR	177.34	75.57	188.08	466	381	16°14' 46.7"N	76°22' 53.6"E	16°18.6' N	76°39.3'E		Balance
3b	Jaldurg# (Diversion1)											16°12' 35.23"N	76°29' 1.46"E				
3c	Jaldurg# (Diversion2)											16°14' 25.98"N	76°31' 43.34"E				
3d	Jaldurg# (Diversion3)											16°15' 30.29"N	76°32' 55.60"E				
3e	Jaldurg# (Diversion 4)											16°17' 1.37"N	76°34' 53.05"E				
3e	Jaldurg# (Diversion 5)											16°17' 36.97"N	76°36' 28.82"E				
4	Priyadarshini Jurala	Telangana	Jogulamba Gadwal	Krishna	234	RoR	192.27	18.87	404	318.51	299.6	16°19' 58.3"N	77°42' 13.1"E	16°19' 58.3"N	77°42' 13.1"E	TSGENCO	In Operation
5	Lower Jurala	Telangana	Kalwakurthy	Krishna	240	RoR	8.49	20	534.34	299	271.7	16°18' 28.1"N	77°46' 18.6"E	16°18' 46.1"N	77°46' 38.1"E	TSGENCO	In Operation

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
6	Srisailam	Andhra Pradesh	Kurnool	Krishna	770	Storage	5289.15	91.44	1750	269.75	163	16°05' 12.4"N	78°53' 47.7"E	16°05' 19.12"N	78°54' 4.87"E	APGENCO	In Operation
7	Nagarjunasagar LBC	Telangana	Nalkonda	Krishna	60	Storage	3020.27	24.8	127.4	179.83	155.76	16°34' 32.8"N	79°18' 42.9"E	16°39' 51.6"N	79°16' 55.0"E	TSGENCO	In Operation
8	Nagarjunasagar	Telangana	Nalgonda	Krishna	110	Storage	5733.95	93	992	179.8	73.15	16°34' 32.8"N	79°18' 42.9"E	16°34' 40.7"N	79°18' 50.4"E	TSGENCO	In Operation
9	Nagarjunasagar RBC & Ext	Andhra Pradesh	Guntur	Krishna	90	Storage	4074.79	25	292.54	179.83	147.50	16°34' 32.8"N	79°18' 42.9"E	16°34' 11.1"N	79°18' 40.8"E	APGENCO	In Operation
10	Nagarjunasagar TPD	Andhra Pradesh	Guntur	Krishna	50	RoR	29.55	21.19	177	75.5	71	16°37' 35.71" N	79°29' 26.09"E	16°37' 33.78"N	79°29' 27.71"E	APGENCO	In Operation
11	Pulichintala	Telangana	Suryapet	Krishna	120	Storage	983	24	219.49	53.34	27.86	16°46' 16.1"N	80°03' 20.4"E	16°46' 25.6"N	80°03' 10.2"E	TSGENCO	In Operation
12	Bhivpuri	Maharashtra	Raigad	Andhra	75	Conventional Dam	352.64	531	193.23	667.17	133	18° 51' 54.58"N	73° 34' 8.51"E	18°56' 10.9"N	73°27' 09.9"E	TATA Power	In Operation
13a	Khopoli (Kundli Dam)	Maharashtra	Raigad	Indrayani	72	Storage	6.34	512.8	174.68	652	83.1	18°50' 42.7"N	73°29' 10.2"E	18°46' 55.8"N	73°21' 15.5"E	TATA Power	In Operation
13b	Khopoli (Shirwata Dam)						197.28			656.84		18°48' 53.6"N	73°28' 50.4"E				
13c	Khopoli (Walwahn Dam)						72.12			635.2		18°45' 54.3" N	73°25' 32.7"E				
13d	Khopoli (Lonavala Dam)						11.52			625.46		18°44' 30.8"N	73°24' 17.9"E				
13e	Khopoli (Forebay)											18°44' 59.47"N	73°22' 12.60"E				
14	Bhira	Maharashtra	Raigad	Neela & Mula	150	Conventional Dam	522.76	480	745	607.1	93	18° 31′ 37.8″ N	73° 30′ 39.4″ E	18°27' 17.7"N	73°23' 27.8"E	TATA Power	In Operation
15	Koyna St. I & II	Maharashtra	Ratnagiri	Koyna	600	Storage	2860.88	StI-475 StII-490	775	650.07	135.4	17°24' 3.6"N	73°45' 1.4"E	17°26' 32.3"N	73°41' 19.8"E	MSPGCL	In Operation
16	Koyna Dam P/H	Maharashtra	Satara	Koyna	36	Storage	2860.88	59	120	650.07	591.07	17°24' 8.57"N	73°45' 5.46"E	17°24'6. 85"N	73°45' 1.34"E	MSPGCL	In Operation

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
17b	Koyna St. III (Kolkewadi Dam)	Maharashtra	Ratnagiri	water discharged from units(St-I, II & IV)	320	RoR with storage	11.22	109.7	516	136.05	15	17°28' 22.8"N	73°38' 37.7"E	17°28' 22.8"N	73°38' 37.7"E	MSPGCL	In Operation
17a	Koyna St. III (Koyna dam)						2860.88			650.07		17°24' 8.57"N	73°45' 5.46"E				
18	Koyna St. IV	Maharashtra	Ratnagiri	Koyna	1000	Storage	2860.88	500	1711	650.07	135.4	17°24' 8.57"N	73°45' 5.46"E	17°27' 38.9"N	73°41' 00.2"E	MSPGCL	In Operation
19	Ghataprabha	Karnataka	Belgaum	Ghatprabha	32	Storage	1387	32	86	662.94	630.9	16°08'35.7"N	74°38' 34.3"E	16°08' 31.9"N	74°38' 41.2"E	KPCL	In Operation
20	Bhadra	Karnataka	Chikka magaluru	Bhadra	39.2	Storage	1783.96	RB= 49.39, LBC= 43.75, RBC= 21.18	51	657.76	RB= 608.37 ,LBC= 614.01 ,RBC= 636.58	13°42' 4.84" N	75°38' 11.78"E	13°42' 02.90"N	75°38' 14.63"E	KPCL	In Operation
21	Munirabad	Karnataka	Bellary	Tungabhadra	38	Storage	2775.05	23.47	76.5	497.73	474.26	15°15' 59.7"N	76°19' 43.2" E	15°15' 59.7"N	76°19' 43.5"E	KPCL	In Operation
22a	Hampi * (Tungabhadra Dam)	Karnataka	Bellary	Tungabhadra	36	Storage	2831.67	36.73	70	497.74	426.72	15°15'48.9"N	76°20' 01.6"E	15°18' 58"N	76°29' 50"E	APGENCO	In Operation
22b	Hampi * (Forebay)						0.74			463.3		15°18' 45.7"N	76°29' 22"E				
23	T B Dam*	Karnataka	Bellary	Tungabhadra	36	Storage	2831.67	26.82	70	497.74	470.92	15°15' 50.1"N	76°19' 059.1"E	15°14' 41"N	76°20' 17.4"E	APGENCO	In Operation

*** Power is being shared in the ratio of 80:20 between Andhra Pradesh & Karnataka**

 # These project may not be feasible due to commercial unviability. In Tamankal Hydroelectric Project (300 MW), it is observed that generation is mainly being done in only three months of August, September and October in a year. For these three months, restricted energy for 300 MW operation is 165.94 MU at load factor of 15.36 whereas annual generation is 168.99 MU at annual load factor for of 6.43%. Similarly, for Jaldurg Hydroelectric Project (270 MW), generation happens mainly in the same three months at load factor of about 29.88%, whereas annual load factor is about 7.95% .

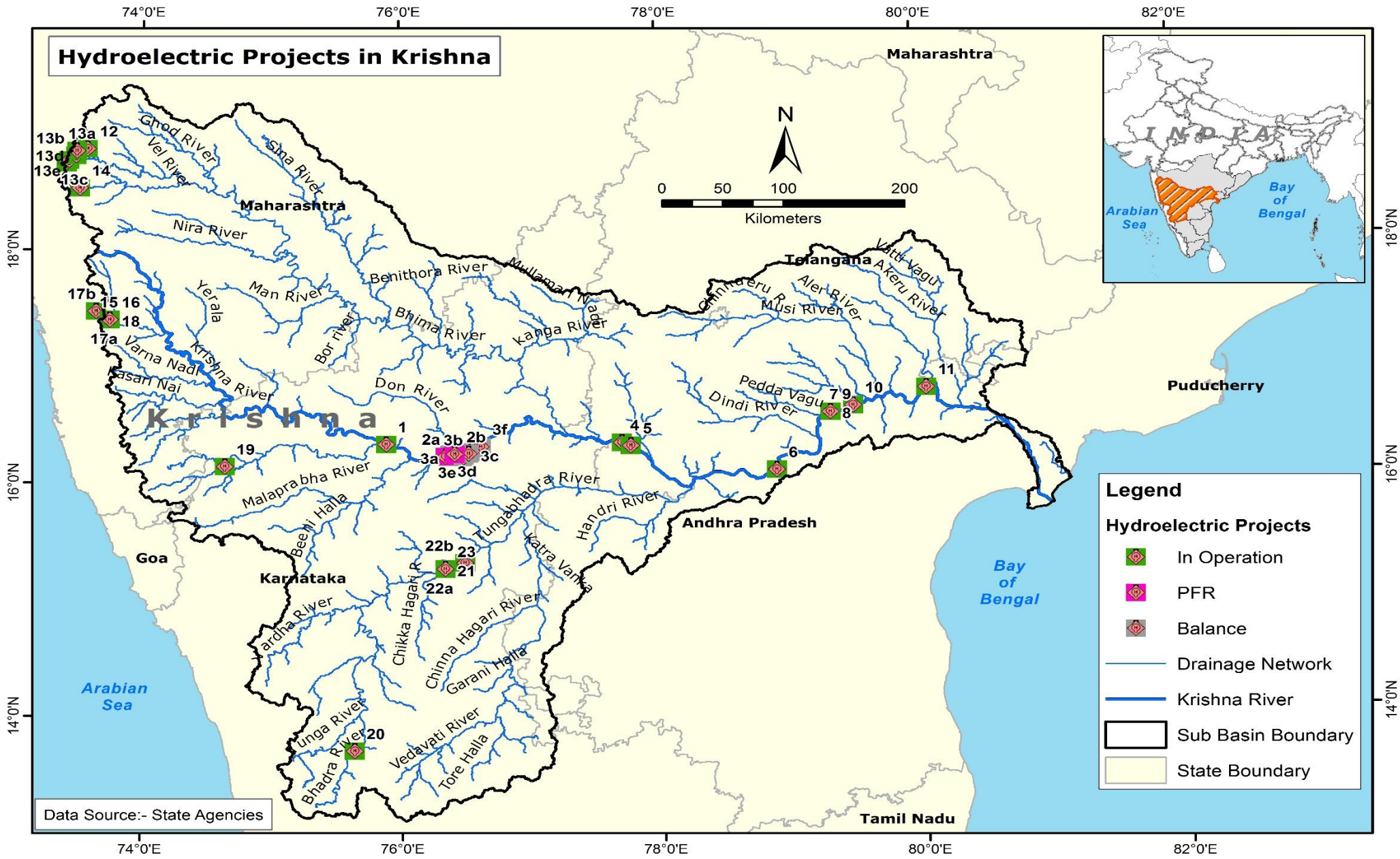


Figure 2.15 Hydroelectric Project in Krishna Sub-Basin

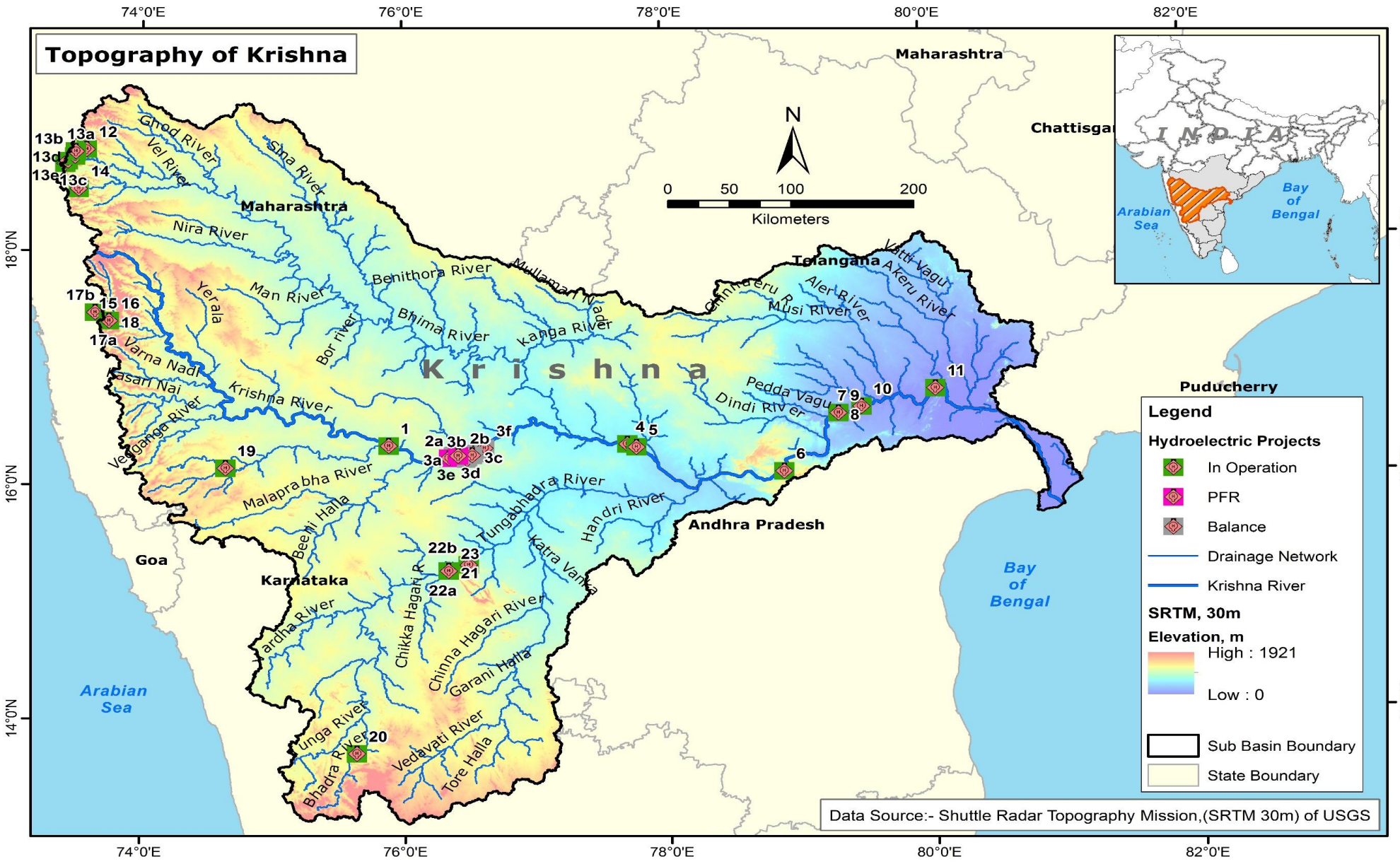


Figure 2.16 Topographical (Elevation Data) Map of Krishna Sub-Basin

The resolution of this data is 1 arc-second (30 meters). The maximum elevation of this area is 1921 meter.

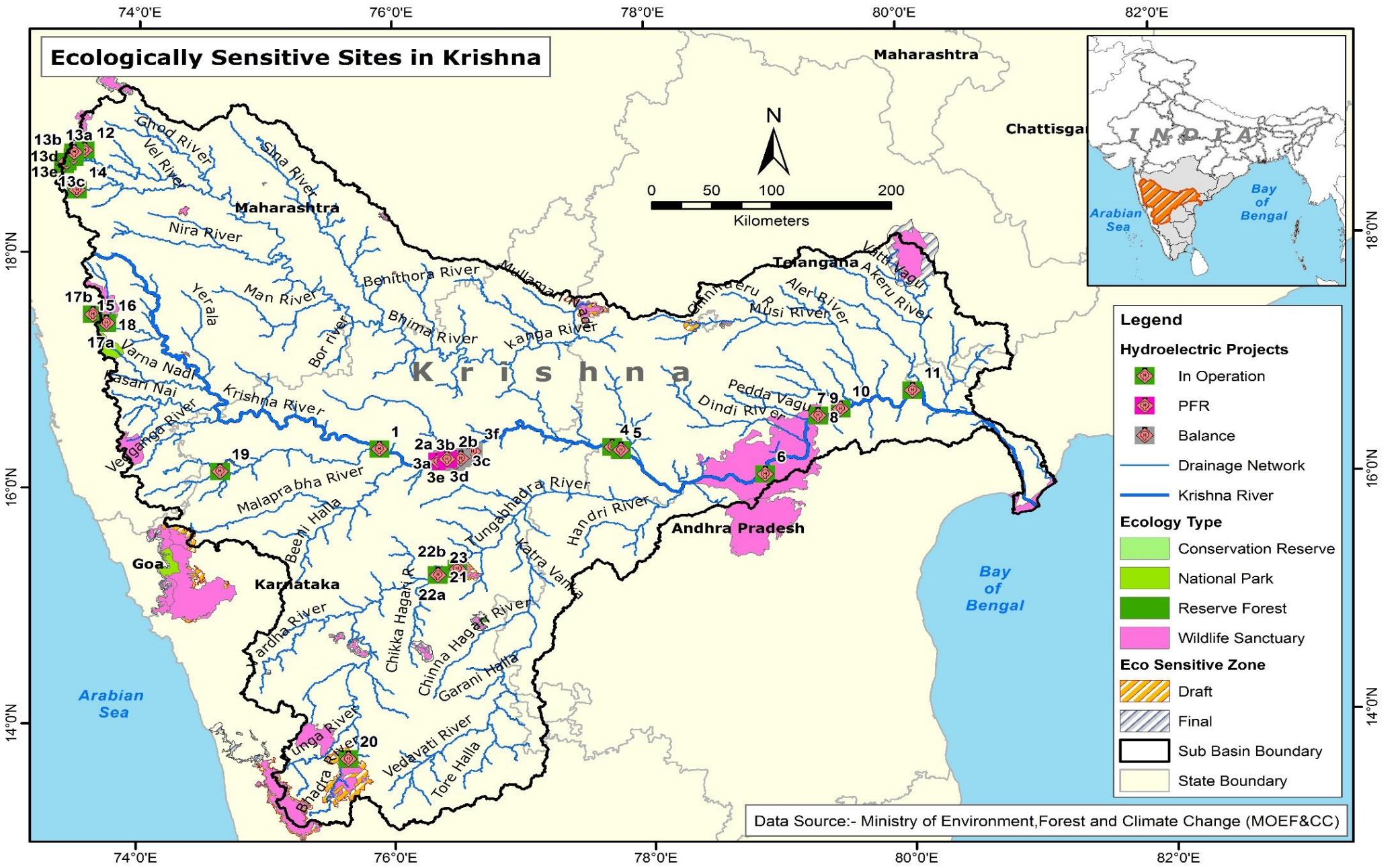


Figure 2.17 Ecologically Sensitive Area Map of Krishna Sub-Basin

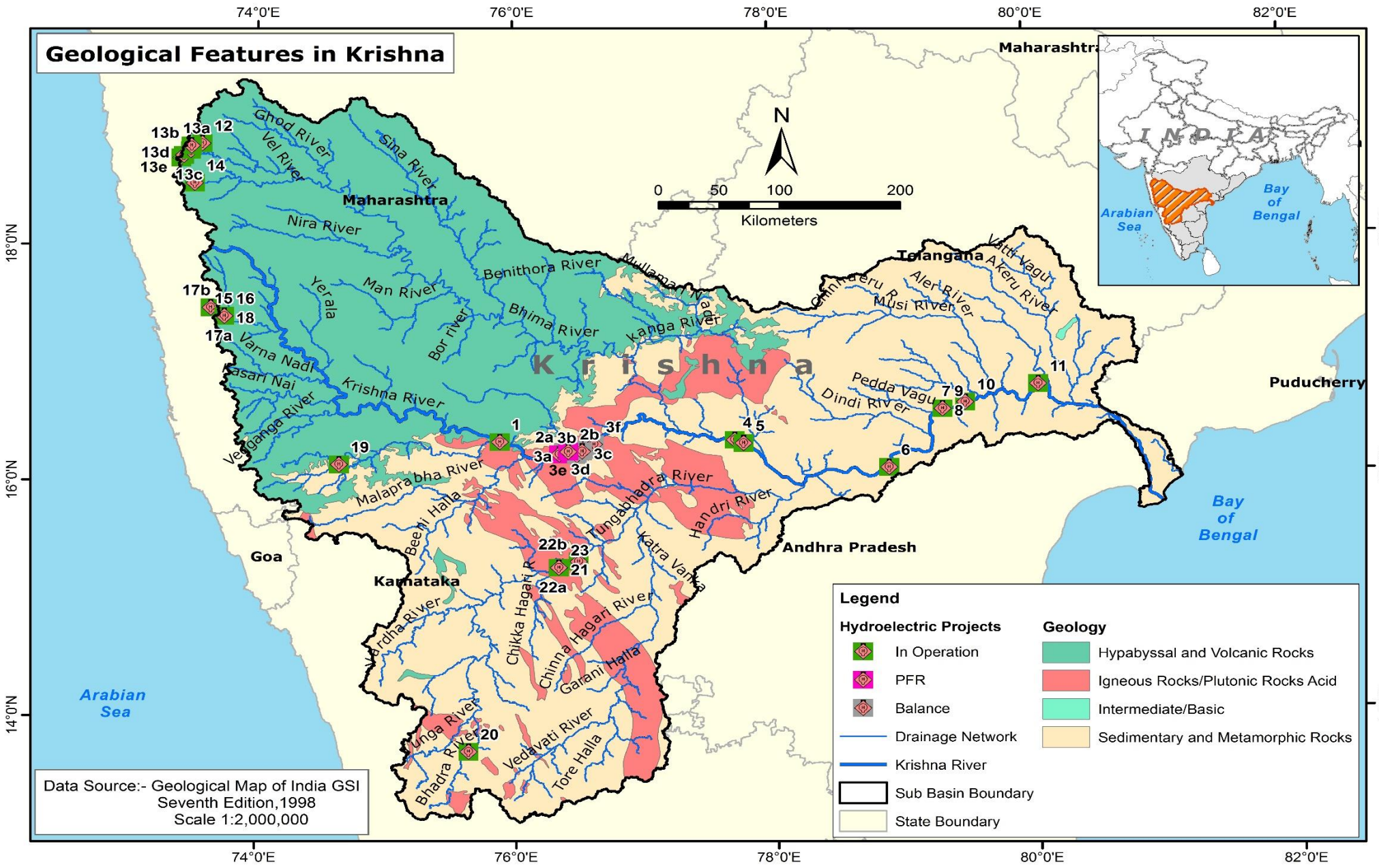


Figure 2.18 Geological Map of Krishna Sub-Basin

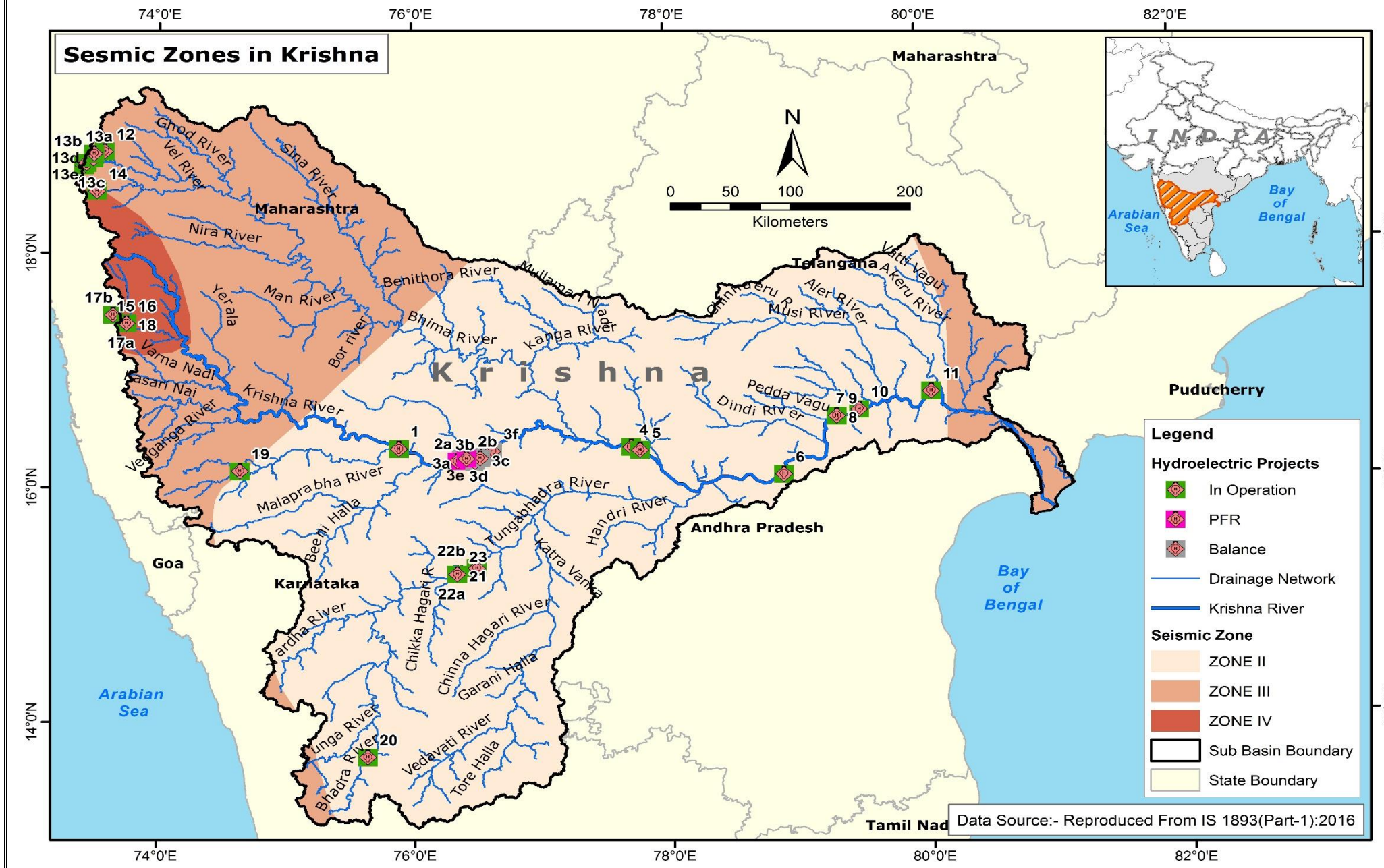


Figure 2.19 Seismic Map of Krishna Sub-Basin

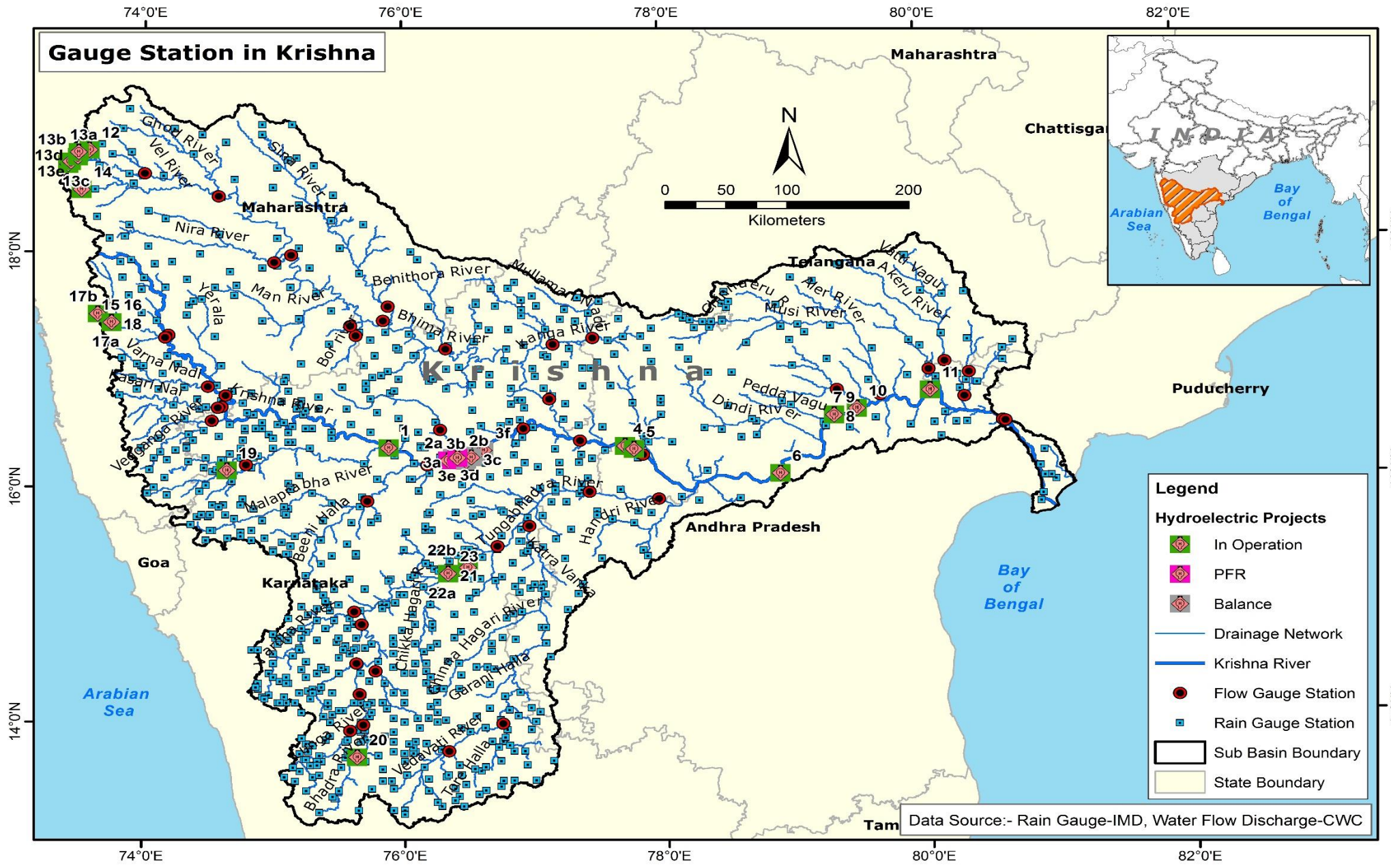


Figure 2.20 CWC Gauge Discharge Sites & IMD Rain Gauge Sites of Krishna Sub-Basin

2.2.2 RIVER PROFILE

2.2.2.1 KRISHNA RIVER

The Krishna River originates in the Western Ghats near Mahabaleshwar at an elevation of about 1,300 metres, in the state of Maharashtra in central India. It is one of the longest rivers in India. The Krishna River traverses for a length of about 1300 km through state of Maharashtra, Karnataka, Telangana and Andhra Pradesh before emptying into the Bay of Bengal at Hamasaladeevi (near Koduru) in Andhra Pradesh, on the east coast. Krishna is the second largest east flowing Peninsular River.

The largest tributary of the Krishna River is the Tungabhadra River with a drainage basin measuring 71,417 km^2, running for about 531 km, but the longest tributary is the Bhima River, which makes a total run of 861 km and has an equally large drainage area of 70,614 km^2 .Three tributaries Panchganga, Warna and Yerla meet Krishna river near Sangli. The river flows quickly, causing much erosion in June and August. During this time, Krishna takes fertile soil from Maharashtra, Karnataka and western Andhra Pradesh towards the delta region. The river has a number of tributaries but Tungabhadra is the principal tributary. Other tributaries include the Mallaprabha, Koyna, Bhima, Ghataprabha, Yerla, Warna, Dindi, Musi and Dudhganga. Leaving Mahabaleswar behind, the Krishna takes the form of the Dhom Lake in Panchgani, a popular hill station just 17 km from Mahabaleswar.

KOYNA RIVER

The Koyna River originates near Mahabaleshwar, District Satara in the ranges of Sahyadri Mountain and flows in a north south direction almost parallel to the Arabian Sea coast for a distance of 65 Km from Mahabaleshwar to Helwak, Skirting King Shiwaji's Fort at Pratapgad on the way. Then near village Helwak (Taluka-Patan, District- Satara) it turns sharply eastwards and joins river Krishna at Karad. After joining Krishna at Karad, it flow eastward with the name Krishna, for a distance of 850 km and terminate at Bay of Bengal. Unlike the other rivers rising in the Deccan Plateau which flow in an eastern or south-western direction and therefore attracts high rainfall only at their source, the Koyna, flowing alongside the mountains and parallel to the Arabian Sea for more than half its course, covers a catchment of about 892 sq. km and receives

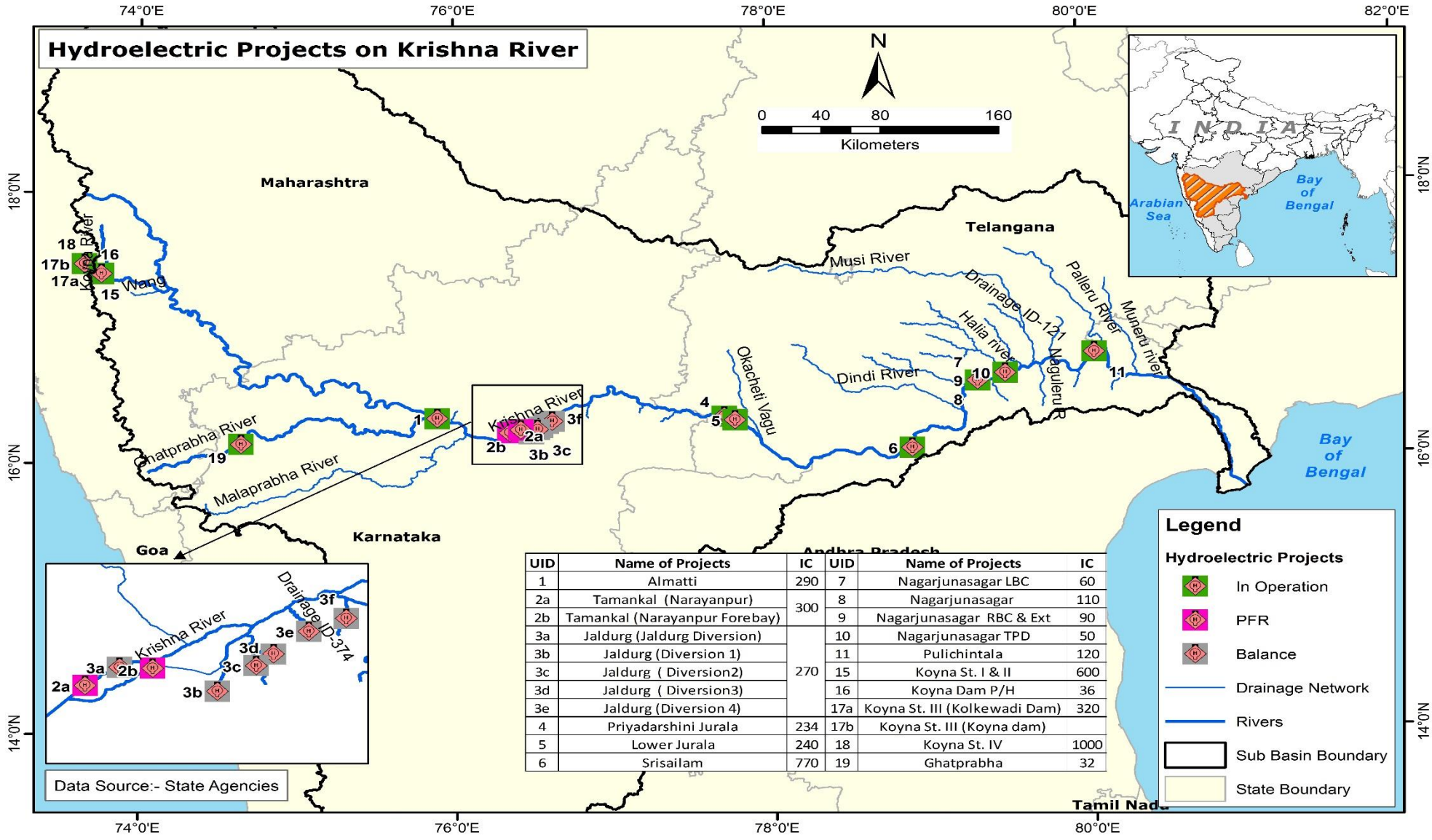
in its deep boat like basin a rainfall of well over 5080 mm. It is this water that is being impounded by the Koyna Dam and utilized for Power generation.

GHATPRABHA RIVER

Ghatprabha River originates in the Western Ghats near Chaukul village. The river flows eastward into the Kolhapur district of Maharashtra The river provides a natural boundary between the adjoining states of Maharashtra and Karnataka for a short length of about 10 km and after traversing for some distance joined by the Hiranyakeshi River and the Markandeya River, on left and right banks respectively and ultimately merges with the backwaters of the Almatti dam built on river Krishna.

List of the projects and their geographical locations on Krishna River & its tributaries/sub-tributaries (Koyna and Ghatprabha) is shown in **Figure 2.21** & **Figure 2.22.**

Map showing Hydroelectric Projects on Krishna River



UID	Name of Projects	IC	UID	Name of Projects	IC
1	Almatti	290	7	Nagarjunasagar LBC	60
2a	Tamankal (Narayanpur)	300	8	Nagarjunasagar	110
2b	Tamankal (Narayanpur Forebay)		9	Nagarjunasagar RBC & Ext	90
3a	Jaldurg (Jaldurg Diversion)	270	10	Nagarjunasagar TPD	50
3b	Jaldurg (Diversion 1)		11	Pulichintala	120
3c	Jaldurg (Diversion2)		15	Koyna St. I & II	600
3d	Jaldurg (Diversion3)		16	Koyna Dam P/H	36
3e	Jaldurg (Diversion 4)		17a	Koyna St. III (Kolkewadi Dam)	320
4	Priyadarshini Jurala	234	17b	Koyna St. III (Koyna dam)	
5	Lower Jurala	240	18	Koyna St. IV	1000
6	Srisailam	770	19	Ghatprabha	32

Figure 2.21

Map showing Geological Features of Krishna River

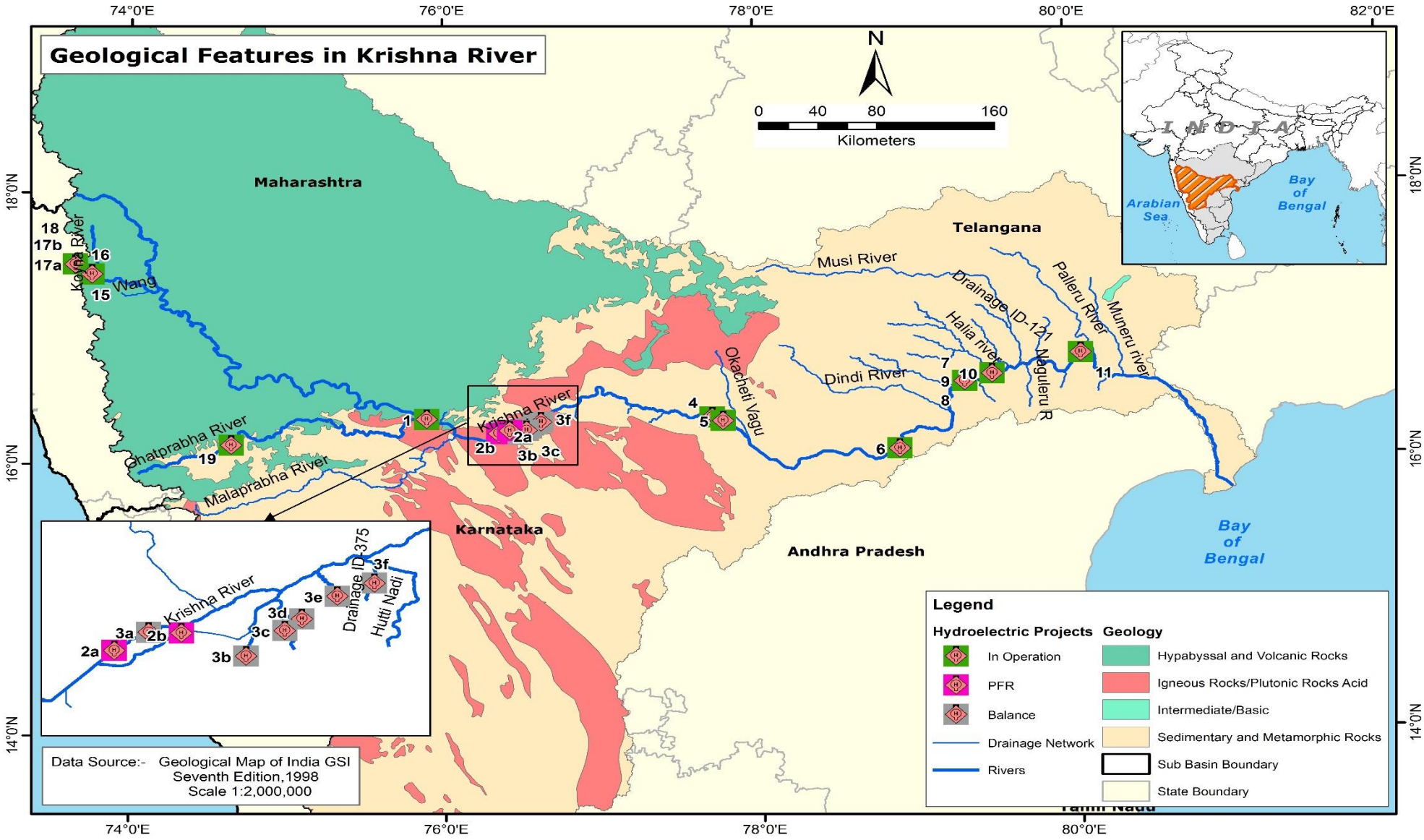


Figure 2.22

2.2.2.2 INDRAYANI RIVER

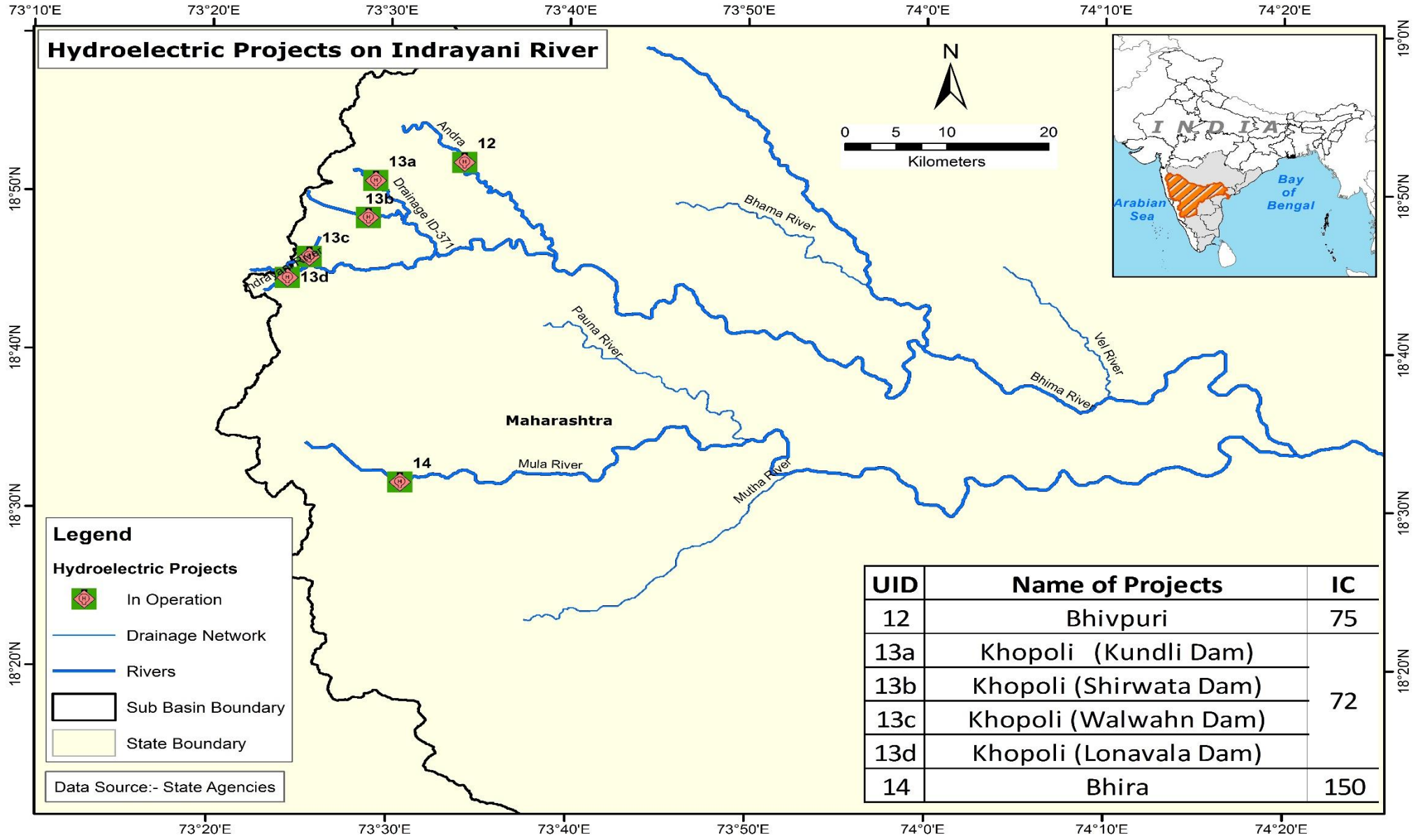
The Indrayani River a major tributary of river Bhima. It originates in Kurvande village near Lonavla, a hill station in the Sahyadri mountains of Maharashtra. It follows a course mostly north of the city of Pune. The Andhra is one of the sub-tributaries of Bhima River that joins the Indrayani River near Karwadi Township. The Andhra River has its origin in the Western Ghats and gets sufficiently high rainfall. Bhivpuri Hydroelectric project comprising of dam across river Andhra, constructed 20 km downstream of its origin and Power House is already in operation.

MULA RIVER

Mulshi Dam has been constructed across Mula River near Western Ghats in Pune and the lake form is known as Mulshi Lake. Downstream, it merges with the Pawana River on the left bank and Mutha River on the right bank to form the Mula-Mutha River, which subsequently joins the Bhima River.

List of the projects and their geographical locations on Indrayani River & its tributaries/sub-tributaries (Mula) is shown in **Figure 2.23** & **Figure 2.24.**

Map showing Hydroelectric Projects on Indrayani River



UID	Name of Projects	IC
12	Bhivpuri	75
13a	Khopoli (Kundli Dam)	72
13b	Khopoli (Shirwata Dam)	
13c	Khopoli (Walwahn Dam)	
13d	Khopoli (Lonavala Dam)	
14	Bhira	150

Figure 2.23

Map showing Geological Features of Indrayani River

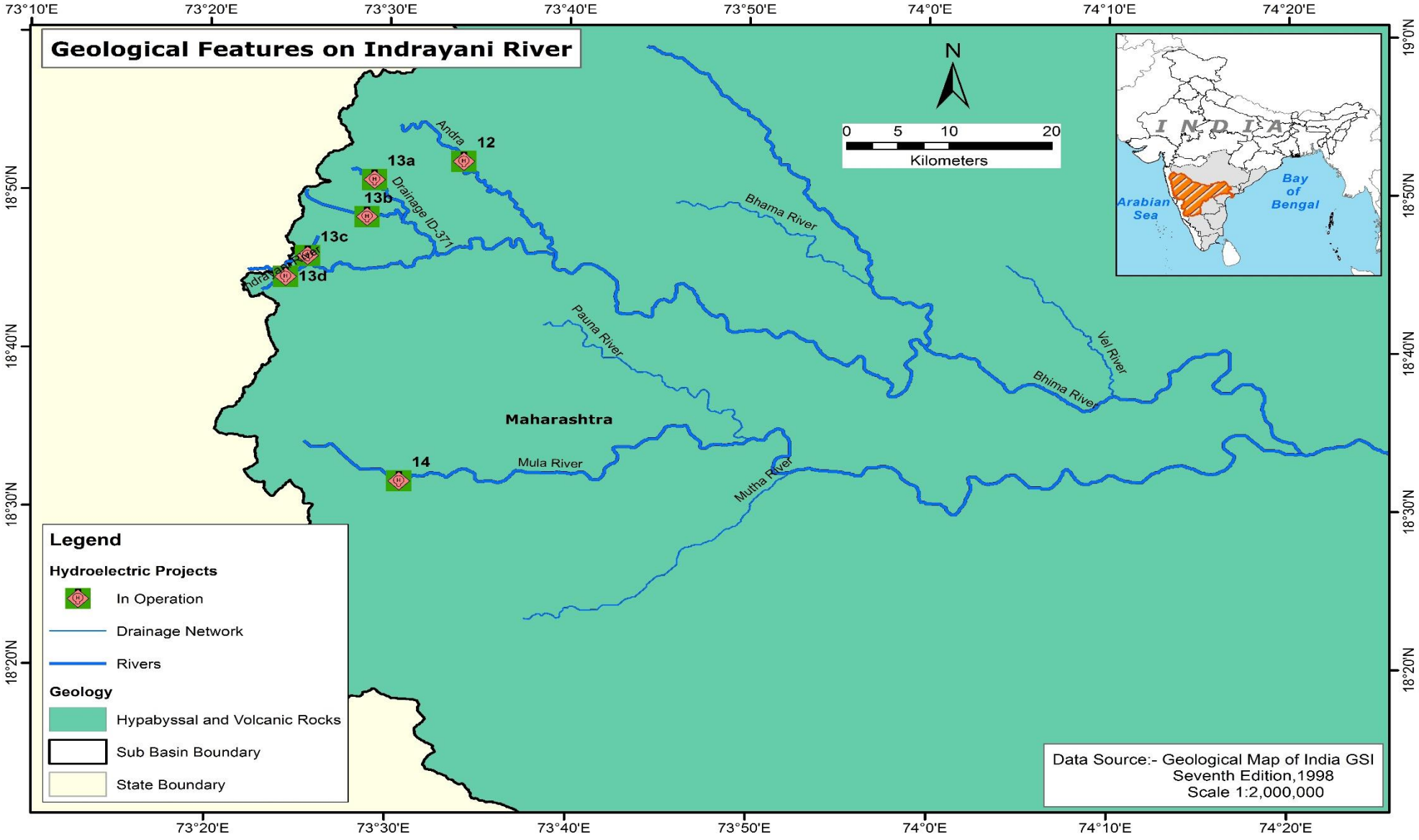


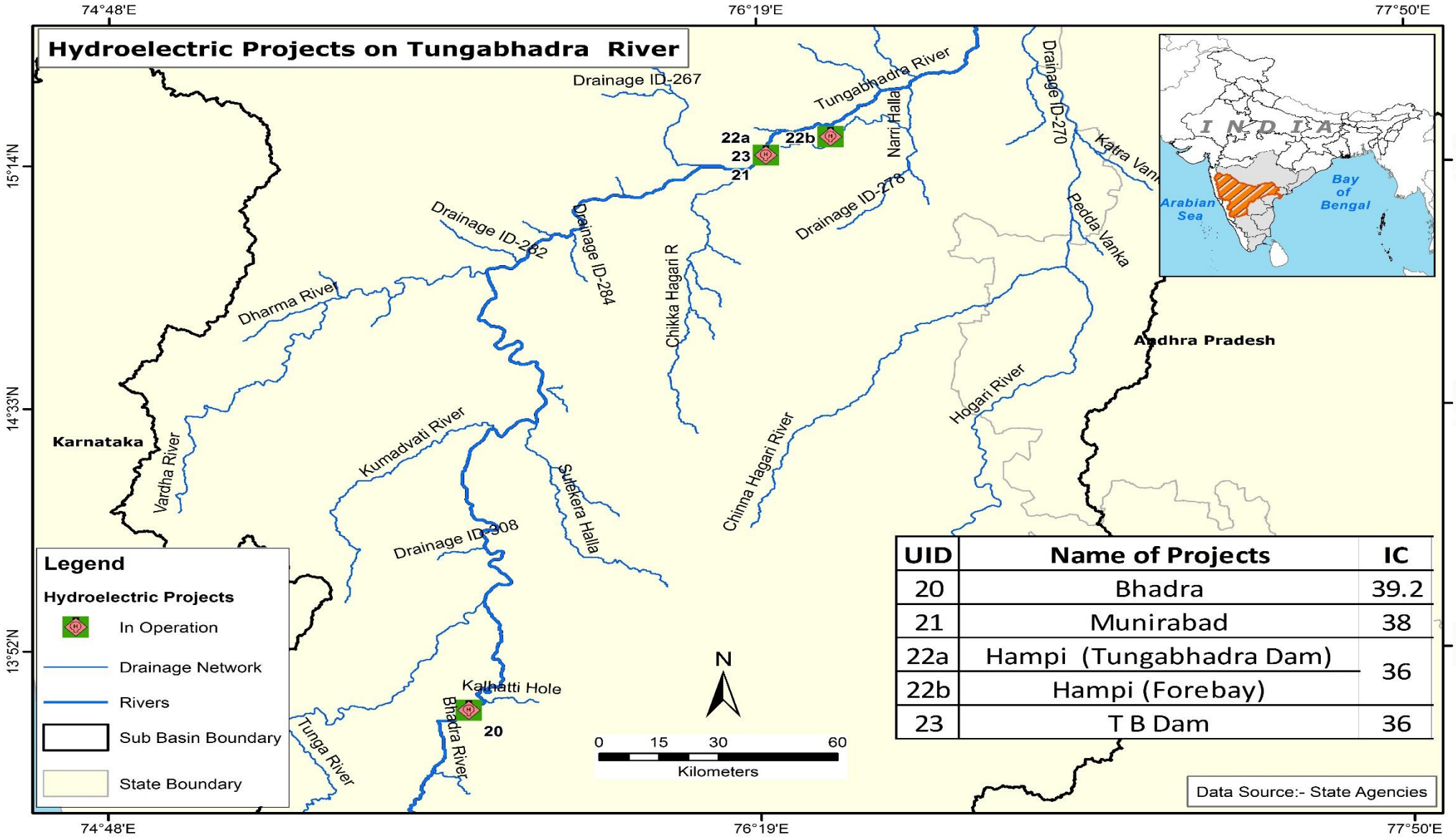
Figure 2.24

2.2.2.3 TUNGABHADRA RIVER

The Tungabhadra River is formed by the confluence of the Tunga River and the Bhadra River at Koodli which flow down the eastern slope of the Western Ghats in the state of Karnataka. The two rivers originate in Mudigere Taluk of Chikmagalur District of Karnataka along with the Nethravathi (west-flowing river, joining the Arabian Sea near Mangalore), the Tunga and the Bhadra rise at Gangamoola, in Varaha Parvatha in the Western Ghats at an elevation of 1198 metres (near Samse Village). After emerging from the Source, The Bhadra River flows through Kudremukh mountain region, Tarikere Taluk and the industrial city Bhadravathi. Whereas, Tunga River flows through Sringeri Taluk, Thirthahalli Taluk and Shimoga Taluk. More than 100 tributaries, streams, creeks, rivulets and the like contribute to the two rivers. The journey of the Tunga and the Bhadra is 147 km and 171 km respectively, till they join at Koodli, at an elevation of about 610 metres near Holehonnur, about 15 km from Shivamogga, areca granary of the country. Though both Tunga and Bhadra rivers start at same source (Gangamoola), they flow separately for some distance and then they later unite with each other at Koodali village. Hence from there, the name Tungabhadra was given. From there, the Tungabhadra meanders through the plains to a distance of 531 km. After confluence, the mighty Tunga Bhadra River flows through Honnali and Harihara taluks of Davangere district. Then it flows through Harapanahalli, Hoovina Hadagali, Hagaribomannahalli, Hospet and Siruguppa Taluks of Bellary district. In Siruguppa Taluk of Bellary district, it receives its tributary Vedavathi River. The river forms natural boundary between Bellary and Koppal districts and then between Bellary and Raichur districts along its course. After entering Andhra pradesh State, it flows through temple town of Mantralaya and then through Kurnool City. It receives its tributary Handri River near Kurnool City. Then it mingles with the Krishna near Alampur Village of Mehaboobnagar district of Telangana state. The Varada flowing through Shimoga, Uttara Kannada and Haveri districts and Vedavathi in Chikkamagalur, Chitradurga and Bellary districts in Karnataka and the Handri in Kurnool district of Andra Pradesh are the main tributaries of the Tungabhadra.

List of the projects and their geographical locations on Tungabhadra River is shown in in **Figure 2.25** & **Figure 2.26.**

Map showing Hydroelectric Projects on Tungabhadra River



UID	Name of Projects	IC
20	Bhadra	39.2
21	Munirabad	38
22a	Hampi (Tungabhadra Dam)	36
22b	Hampi (Forebay)	
23	T B Dam	36

Figure 2.25

Map showing Geological Features of Tungabhadra River

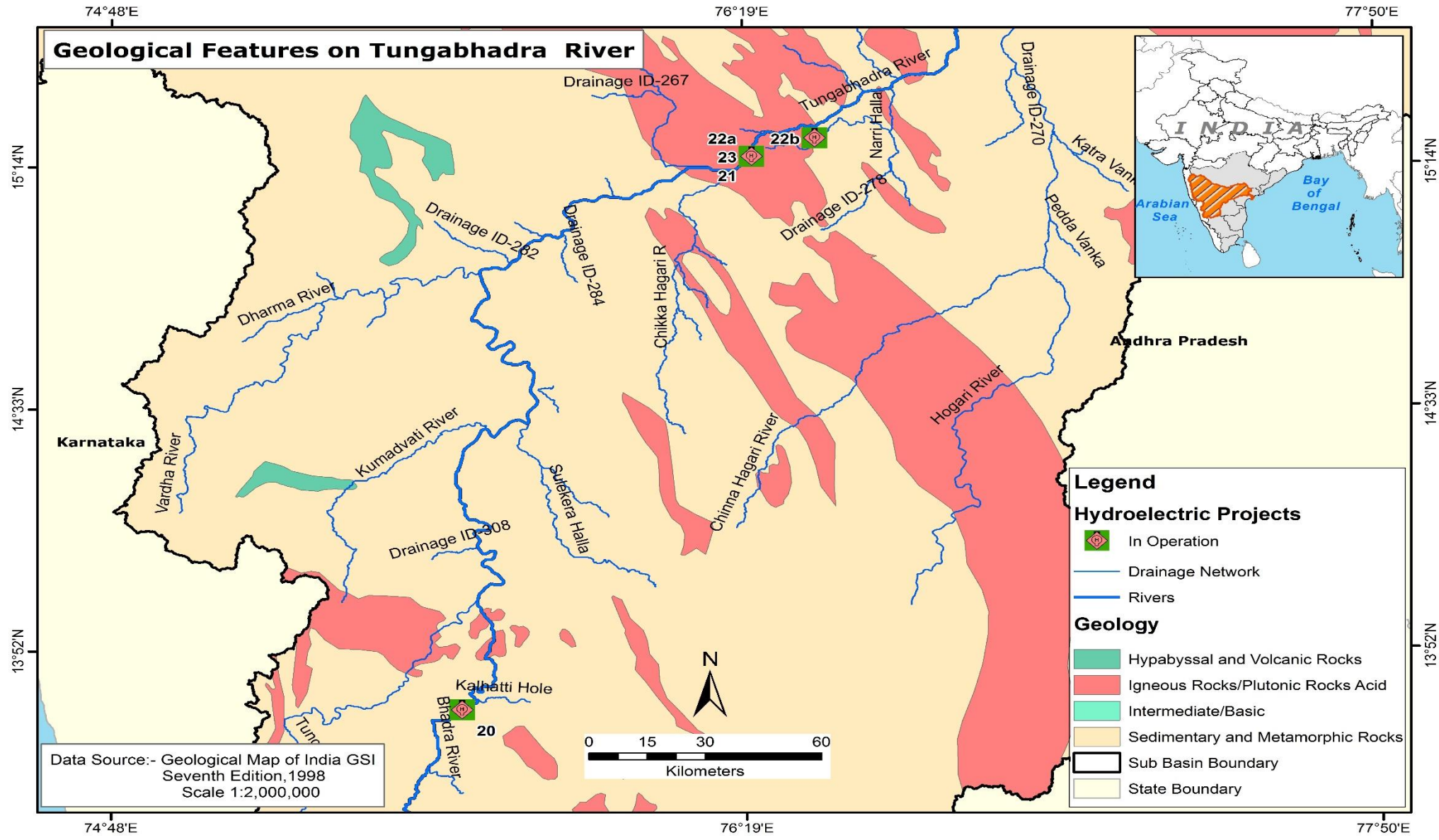


Figure 2.26

2.3 CAUVERY SUB-BASIN

States Involved – Tamil Nadu, Karnataka and Kerala

The Cauvery basin extends over states of Tamil Nadu, Karnataka, Kerala and Union Territory of Puducherry draining an area of 81,155 Sq.km which is nearly 2.7% of the total geographical area of the country with a maximum length and width of about 560 km and 245 km. It lies between 75°27' to 79°54' east longitudes and 10°9' to 13°30' north latitudes. It is bounded by the Western Ghats on the west, by the Eastern Ghats on the east and the south and by the ridges separating it from Krishna basin and Pennar basin on the north. The Cauvery River is one of the major rivers of the peninsula. It rises at an elevation of 1,341 m at Talakaveri on the Brahmagiri range near Cherangala village of Kodagu district of Karnataka. The total length of the river from origin to outfall is 800 km. Its important tributaries joining from left are the Harangi, the Hemavati, the Shimsha and the Arkavati whereas the Lakshmantirtha, the Kabbani, the Suvarnavati, the Bhavani, the Noyil and the Amaravati joins from right. The river drains into the Bay of Bengal. The major part of basin is covered with agricultural land accounting to 66.21% of the total area and 4.09% of the basin is covered by water bodies.

At Shivanasamudram, the Cauvery river branches off into two parts and falls through a height of 91 m. in a series of falls and rapids. The falls at this point is utilised for power generation. The power station at Shivanasamudram was built as early as 1902. The two branches of the river join after the fall and flow through a wide gorge which is known as "Mekadatu"(Goats leap) and continues its journey to form the boundary between Karnataka and Tamil Nadu States for a distance of 64 Kms. At Hogennekkal Falls, it takes Southernly direction and enters the Mettur Reservoir which was constructed in 1934.A tributary called Bhavani joins Cauvery on the Right bank about 45 Kms below Mettur Reservoir. Thereafter it takes Easternly course to enter the plains of Tamil Nadu. Two more tributaries Noyil and Amaravathi join on the right bank and here the river widens with sandy bed and flows as "Akhanda Cauvery".

Immediately after crossing Tiruchirapalli district, the river divides into two parts, the Northern branch being called "The Coleron" and Southern branch remains as Cauvery and from here the Cauvery Delta begins. After flowing for about 16 Kms, the two branches join again to form "Srirangam Island". On the Cauvery branch lies the "Grand Anicut" said to have been constructed by a

Chola King in 1st Century A.D. Below the Grand Anicut, the Cauvery branch splits into two, Cauvery and Vennar. These branches divide and sub-divide into small branches and form a network all over the delta.

The total length of the river from the origin to its outfall into the sea is 800 Kms. of which 320 Kms. is in Karnataka, 416 Kms. in Tamil Nadu and 64 Kms. forms the common border between the Karnataka and Tamil Nadu states. The Cauvery basin is fan shaped in Karnataka and leaf shaped in Tamil Nadu. The run-off does not drain off quickly because of its shape and therefore no fast raising floods occur in the basin. The basin receives rainfall mainly from the S-W Monsoon season and partially from N-E Monsoon season in the Karnataka. The basin in Tamilnadu receives good flows from the North-East Monsoon season.

Physiography- Cauvery basin extends over an area of 81155 sq.km. which is nearly 2.7% of the total geographical area of the country. It is bounded on the west by the Western Ghats, on the east and south by the Eastern Ghats and on the north by the ridges separating it from the Tungabhadra and Pennar basins. The basin lies in the States of Tamil Nadu, Karnataka and Kerala.

Physiographically, the basin can be divided into three parts – the Westen Ghats, the Plateau of Mysore and the Delta. The delta area is the most fertile tract in the basin. The principal soil types found in the basin are black soils, red soils, laterites, alluvial soils, forest soils and mixed soils. Red soils occupy large areas in the basin. Alluvial soils are found in the delta areas. The culturable area of the basin is about 5.8 M.ha which is about 3% of the culturable area of the country.

Climate- In the Cauvery basin, four distinct seasons occur. They are cold weather, hot weather, South-West Monsoon season and North-East Monsoon season. The climate at the basin level generally remains dry except from monsoon months. There is a considerable variation in the mean daily maximum and minimum temperatures across the basin.in the cold season, the Western Ghat is cooler than the rest of the basin and the climate is generally pleasant. In the hot weather season, the Central, Northern and Eastern regions are hotter than the Western most parts.

The South-West monsoon season sets by middle of June and ends by middle of September. During this season the basin receives major part of

its total annual Rainfall. The North-East monsoon season is from October to December and is important particularly for the Eastern part of the basin.

Rainfall- There are many rain gauge stations inside the basin. The rainfall in the basin varies from region to region. In the Western Ghats it ranges from 1700 mm to 3800 mm. In Karnataka for the Cauvery basin, the average rainfall is between 600 mm to 800 mm resulting into semi-arid condition. In Tamil Nadu, under the Cauvery basin the average rainfall is low ranging from 500 mm to 1000 mm and is semi-arid. In general, the highest rainfall in the Cauvery basin usually occur in July or early August and the mean annual rainfall is around 1075.23 mm.

The basin is mainly influenced by South-West monsoon season in the Karnataka & Kerala and North-East monsoon season in Tamil Nadu. Most of the parts in Tamil Nadu receive rainfall from the North-East Monsoon season. Rainfall in the delta area is of the order of 1000 mm annually. In the coastal areas the highest rainfall months are October, November and December, while further inland the peak monthly rainfall is early October. This pattern of rainfall is conductive to a fairly high flow during the irrigation season from June to January, except for a short period of about six weeks when there is a break in the monsoon season. While the South-West monsoon season supply is copious and dependable, the North-East monsoon season supply is irregular and subject to frequent failure.

Large Hydroelectric Projects in this sub-basin are situated in Kundah, Moyar, Bhavani, Pyakara, Mananthavady, Avalanche Stream and Pegumbahallah rivers.

Location of Hydroelectric projects in Cauvery sub-basin and their salient features is given in **Figure 2.27** and **Table 2.3** respectively**.**

2.3.1 Physiographic status of Cauvery Sub-Basin

In Cauvery sub-basin, the physiographic status of the study area is shown in various maps prepared on GIS platform and these maps are as follows:

1. Hydroelectric Projects in Cauvery sub-basin/ River (**Figure 2.27**)
2. Topographic (Elevation Data) Map (**Figure 2.28**)
3. Ecologically Sensitive Area Map (**Figure 2.29**)
4. Geological Map (**Figure 2.30**)
5. Seismic Map (**Figure 2.31**)
6. CWC Gauge Discharge Sites & IMD Rain Gauge Sites (**Figure 2.32**)

Table 2.3 Salient Features of Hydroelectric Projects in Cauvery Sub-Basin.

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
1a	Shivasamudram (Shiva Anicut)	Karnataka	Mandya	Cauvery	42	RoR		126.49	181.17	609.4	472.74	12°16' 14.4"N	77°09' 52.9"E	12°18' 27.4"N	77°09' 55.6"E	KPCL	In Operation
1b	Shivasamudram (Balancing reservoir)									609.6		12°17' 35.5"N	77°09' 28.6"E				
1c	Shivasamudram (Forebay)									601.06		12°18' 20.2"N	77°09' 48.2"E				
2	Sivasamudram	Karnataka	Mandya	Cauvery	345	RoR		186.5	1034	609.6	407.8	12°16' 55.99"N	77°10' 45.27"E	12°18' 07.8"N	77°13' 08.5"E		DPR Returned for Re-submission
3a	Mekadatu (Lifting dam)	Karnataka	Chamarajnagar	Cauvery	400	RoR		91.4	796	407.8	316.7	12°16' 23.18"N	77°26' 24.64"E	12°14' 42.74"N	77°27' 3.07"E		DPR Returned for Re-submission
3b	Mekadatu (Forebay Dam)											12°15' 12.95"N	77°26' 21.82"E				
4	Rasimanal	Tamil Nadu	Chamarajnagar	Cauvery	360	RoR		50.8	453	316.7	265.9	12°10' 58.4"N	77°43' 13.8"E	12°10' 58.4"N	77°43' 13.8"E		DPR Returned for Re-submission
5	Hogenekkal	Tamil Nadu	Chamarajnagar	Cauvery	120	RoR		20.5	183	265.9	240.4	12°07' 16"N	77°46' 22"E	12°07' 07.7"N	77°46' 17.0"E		DPR Returned for Re-submission
6	Mettur Dam	Tamil Nadu	Salem	Cauvery	50	Storage	2646.77	48.77	82	240.62	193.25	11°48' 03.1"N	77°48' 36.0"E	11°48' 01.4"N	77°48' 36.1"E	TANGED CO	In Operation
7	Mettur Tunnel	Tamil Nadu	Salem	Cauvery	200	Storage	2646.77	48.77	520	240.79	193.25	11°48' 03.1"N	77°48' 36.0"E	11°47' 52.5"N	77°48' 38.8"E	TANGED CO	In Operation
8	Lower Mettur-I	Tamil Nadu	Salem	Cauvery	30	RoR	15.2	9	95	193.25	184.25	11°43' 38.8"N	77°46' 51.4"E	11°43' 38.97"N	77°46' 45.69"E	TANGED CO	In Operation
9	Lower Mettur-II	Tamil Nadu	Erode	Cauvery	30	RoR	12.65	9	99	184.25	175.25	11°38' 35.56"N	77°45' 27.50"E	11°38' 37.8"N	77°45' 22.97"E	TANGED CO	In Operation
10	Lower Mettur-III	Tamil Nadu	Erode	Cauvery	30	RoR	15.35	6.5	91	175.25	166.25	11°34' 34.5"N	77°44' 36.4"E	11°34' 30.7"N	77°44' 31.1"E	TANGED CO	In Operation

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
11	Lower Mettur-IV	Tamil Nadu	Erode	Cauvery	30	RoR	16.24	9	69	166.25	157.25	11°29' 04.4"N	77°42' 12.1"E	11°29' 07.6"N	77°42' 06.3"E	TANGED CO	In Operation
12	Bhavani Kattalai Barrage -I	Tamil Nadu	Namakkal	Cauvery	30	RoR	8.26	6.5	69.68	157.25	148.25	11°23' 01.6"N	77°42' 48.2"E	11°23' 02.7"N	77°42' 52.6"E	TANGED CO	In Operation
13	Bhavani Kattalai Barrage -II	Tamil Nadu	Erode	Cauvery	30	RoR	6.99	6.5	94	148.25	139.25	11°19' 55.9"N	77°45' 31.4"E	11°19' 51.0"N	77°45' 29.0"E	TANGED CO	In Operation
14	Bhavani Kattalai Barrage -III	Tamil Nadu	Namakkal	Cauvery	30	RoR	Pondage Depeleted	6.5	94	139.25	128.25	11°14' 34.2"N	77°51' 53.5"E	11°14' 34.8"N	77°51' 57.6"E	TANGED CO	In Operation
15	Mananthavady	Kerala	Wynad& Kannur	Kabini	225	Storage	451.6	623.8	687	748.5	120	11°46' 53.76"N	75°55' 10.92"E	11°51’ 51.35”N	75°52’ 22.12”E		DPR Returned for Re-submission
16a	Parson’s Valley (Western Catchment 2)	Tamil Nadu	Nilgiris	Bhavani	30	Storage		209.62	57	2379.26	1985.7	11°19' 09.7"N	76°32' 34.7"E	11°21' 52.1"N	76°36’ 15.9”E	TANGED CO	In Operation
16b	Parson’s Valley (Western catchment 3)									2339.64		11°19' 59.8"N	76°33' 05.4"E				
16c	Parson’s Valley (Porthimund Dam)						57.29			2220.5		11°22' 35.0"N	76°34' 20.3"E				
16d	Parson’s Valley (Parson’s Valley Dam)						13.56			2209.83		11°23' 40.6"N	76°35' 35.8"E				
17a	Pykara Ultimate (Mukurthi dam)	Tamil Nadu	Nilgiris	Pykara	150	Storage	6.59	1026	332.42	2098.24	946	11°24' 35.9"N	76°33' 49.4"E	11°31' 23.5"N	76°36' 01.8"E	TANGED CO	In Operation
17b	Pykara Ultimate (Pykara Dam)									2072.33		11°27' 44.5"N	76°36' 12.1"E				
17c	Pykara Ultimate (Glenmorgan dam)									2018.69		11°29' 52.5"N	76°36' 26.8"E				
17d	Pykara Ultimate (Glenmorgan Forebay)									1972.10		11°30' 10.7"N	76°35' 26.8"E				
17e	Pykara Ultimate									2145.48		11°26' 38.4"N	76°39' 07.9"E				

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
	(Sandynallah Dam)																
17f	Pykara Ultimate (Melkomund Weir)									2051		11°27’ 54.56”N	76°38’ 32.35” E				
17g	Pykara Ultimate (Lone Valley Arm I Weir)									2034		11°29’ 03.93”N	76°37’32. 33” E				
17h	Pykara Ultimate (Lone Valley Arm II Weir)									2043.5		11°28’ 54.04”N	76°38’ 09.27”E				
17i	Pykara Ultimate (Naduvattam Diversion Weir)									1979.68		11°27' 57.5"N	76°33' 44.8"E				
18a	Pykara (Mukurthi dam)	Tamil Nadu	Nilgiris	Pykara	59.2	Storage	6.59	7 MW – 943.4 11 MW-857.5 13.6MW-866.2	352	2098.24	1033	11°24' 35.9"N	76°33' 49.4"E	11°32' 01.3"N	76°36' 03.5"E	TANGEDCO	In Operation
18b	Pykara (Pykara Dam)									2072.33		11°27' 44.5"N	76°36' 12.1"E				
18c	Pykara (Glenmorgan dam)									2018.69		11°29' 52.5"N	76°36' 26.8"E				
18d	Pykara (Glenmorgan Forebay)									1972.10		11°30' 10.7"N	76°35' 26.8"E				
18e	Pykara (Sandynallah Dam)									2051		11°26' 38.4"N	76°39' 07.9"E				
18f	Pykara (Melkomund Weir)									2034		11°27’ 54.56”N	76°38’ 32.35” E				
18g	Pykara (Lone Valley Arm I Weir)									2043.5		11°29’ 03.93”N	76°37’ 32.33” E				
18h	Pykara (Lone Valley Arm II Weir)									1979.68		11°28’ 54.04” N	76° 38’ 09.27” E				
18i	Pyakra (Naduvattam Diversion Weir)									2051		11°27' 57.5"N	76°33' 44.8"E				

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
19a	Lower Moyar (Pickup Dam)	Tamil Nadu	Nilgiris	Moyar	33	Storage	19.1	117.3	126	503.7	381	11° 36' 44.70"N	76° 46' 26.09"E	11°35' 11.8"N	76°50' 45.7"E		Balance
19b	Lower Moyar (Forebay Dam)									502.9		11°34' 13.5"N	76°48' 14.7"E				
20a	Moyar (Maravakandy Dam)	Tamil Nadu	Nilgiris	Moyar	36	Storage	0.164	371.55	159.27	914	506.6	11°34' 26.8"N	76°39' 15.6"E	11°36' 50.1"N	76°41' 33.6"E	TANGED CO	In Operation
20b	Moyar(Forebay)									902.5		11°36' 20.6"N	76°41' 28.7"E				
21a	Kundah-V (Upper Bhavani Dam)	Tamil Nadu	Nilgiris	Bhavani	40	Storage	85.34	268.08	63.34	2276.88	1985.77	11°13' 46.1"N	76°31' 24.3"E	11°18' 16.0"N	76°34' 32.3"E	TANGED CO	In Operation
21b	Kundah-V (Western catchment No. 1)											11°16' 53.1"N	76°31'51.0"E				
22	Kundah-IV	Tamil Nadu	Coimbatore	Bhavani	100	Storage	34.93	63.2	143.66	426.72	342.6	11°15’ 36”	76°48' 21.6"E	11°15' 36.8"N	76°48' 21.6"E	TANGED CO	In Operation
23	Nellithorai	Tamil Nadu	Coimbatore	Bhavani	50	Storage	15	27.5	41	351	318.8	11°16 '56.48"N	76°52' 18.34"E	11°17' 0.58"N	76°52' 17.38"E		DPR Returned for Re-submission
24a	Kundah-I (West Varahapallam dam)	Tamil Nadu	Nilgiri	Avalanche Stream	60	Storage	153.97	317	218.36	2206.14	1628.55	11°13' 57.0"N	76°34'0 4.0"E	11°17' 10.6"N	76°39' 04.9"E	TANGED CO	In Operation
24b	Kundah-I (East Varahapallam dam)									2115.61		11°14' 19.8"N	76°34' 48.7"E				
24c	Kundah-I (Emerald Dam)									1985.77		11°19' 38.7"N	76°37' 15.8"E				
24d	Kundah-I (Avalanche Dam)									1985.77		11°19' 12.84"N	76°36' 57"E				
25	Kundah-II	Tamil Nadu	Nilgiris	Avalanche Stream	175	Storage	1.56	713.23	552.4	1624.6	69.27	11°16' 59.3"N	76°39' 10.4"E	11°15' 01.1"N	76°40' 51.6"E	TANGED CO	In operation

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
26a	Kundah-III (Pengumbahalla Dam)	Tamil Nadu	Coimbatore	Pegumbahallah	180	Storage	1.02	409	346.84	869.3	424.43	11°14' 52.3"N	76°40' 54.3"E	11°14' 34.9"N	76°46' 10.5"E	TANGEDCO	In operation
26b	Kundah-III (Niralapallam D. W)									890.02		11°16' 52.6"N	76°46' 01.3"E				
26c	Kundah-III (Katteri Halla D. W)									1683.41		11°20' 18.6"N	76°44' 13.5"E				

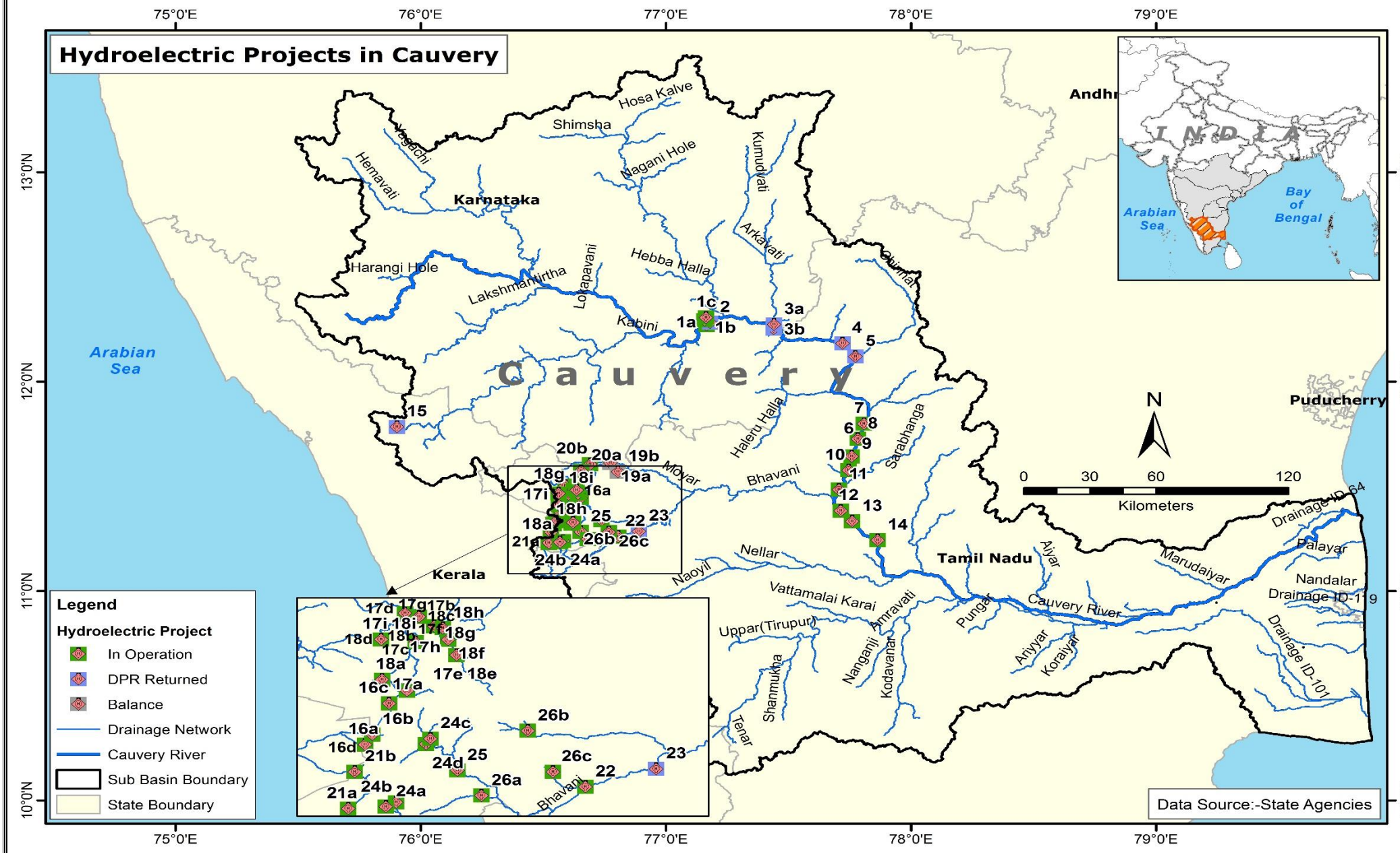


Figure 2.27 Hydroelectric Projects in Cauvery Sub-Basin

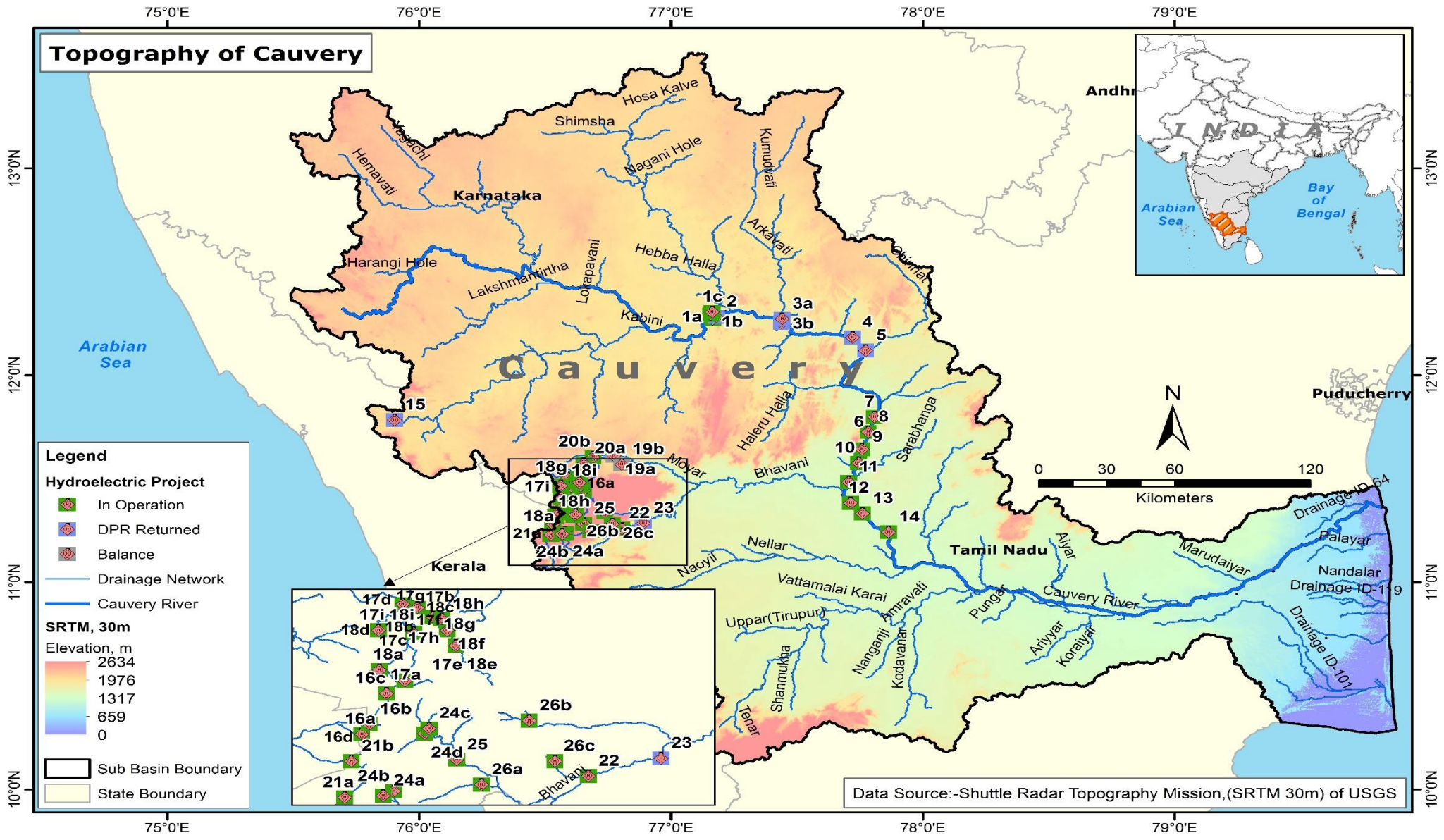


Figure 2.28 Topographical (Elevation Data) Map of Cauvery Sub-Basin

The Resolution of this data is 1 arc-second (30 meters).The maximum elevation of this area is 2634 meter.

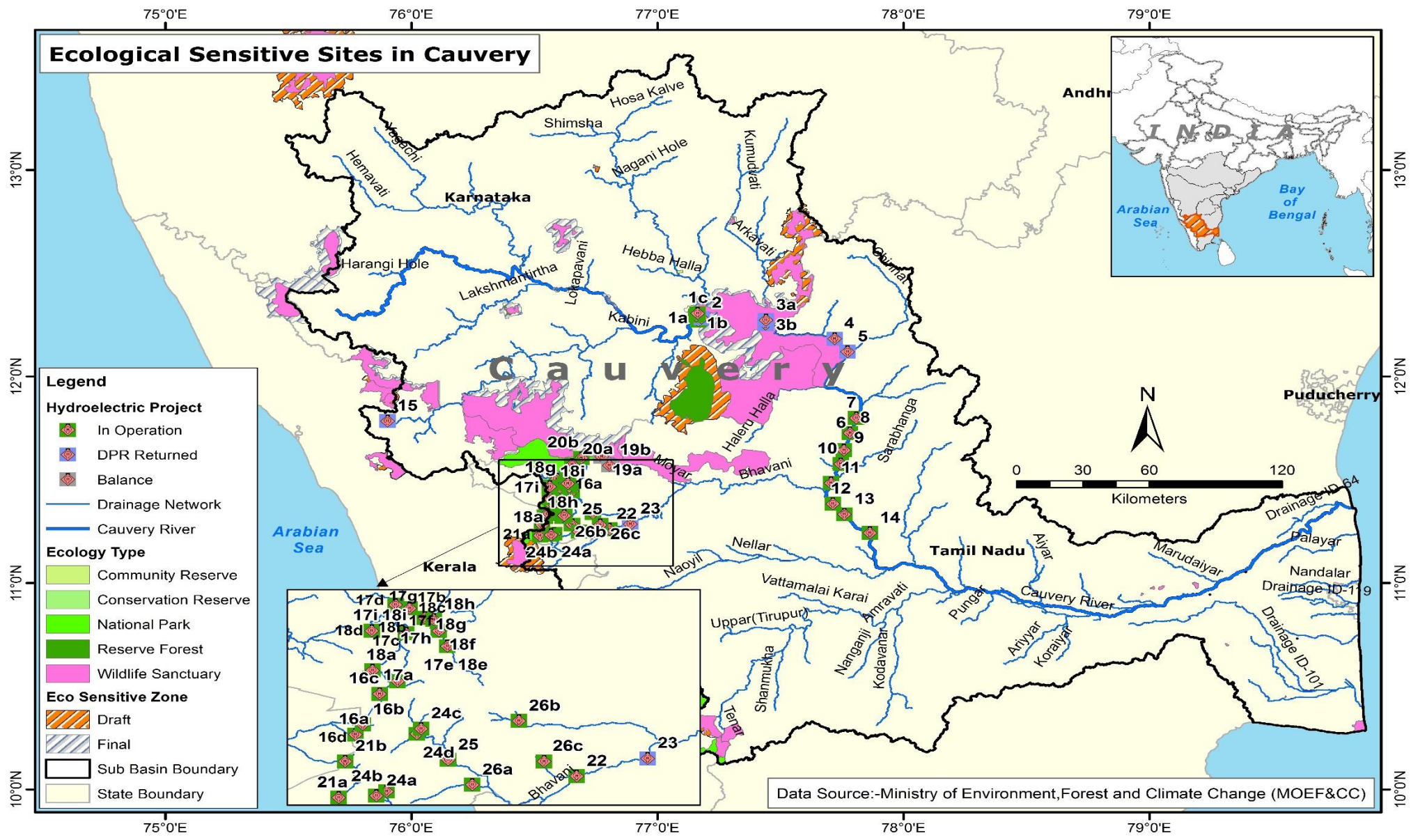


Figure 2.29 Ecologically Sensitive Area Map of Cauvery Sub-Basin

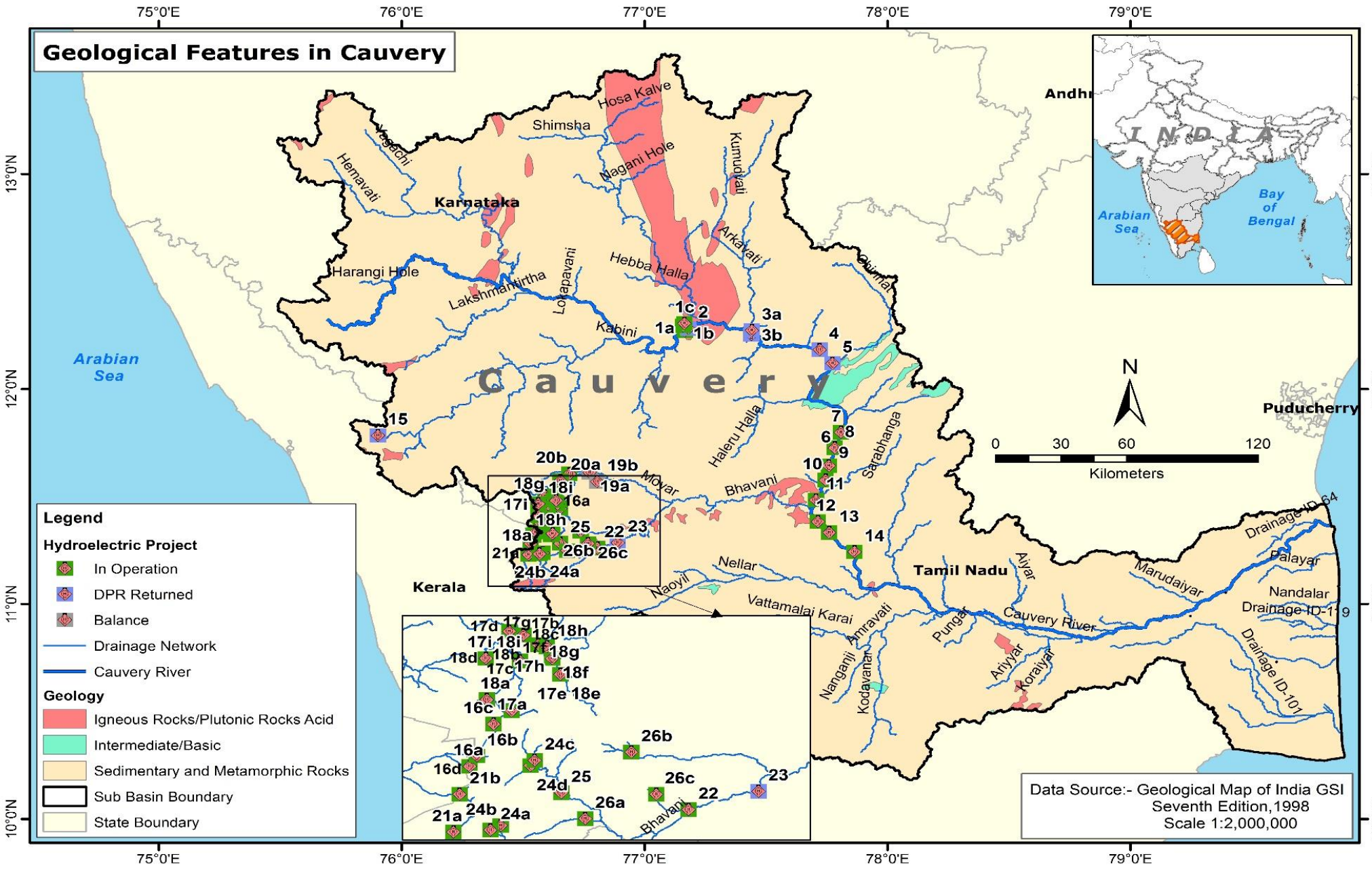


Figure 2.30 Geological Map of Cauvery Sub-Basin

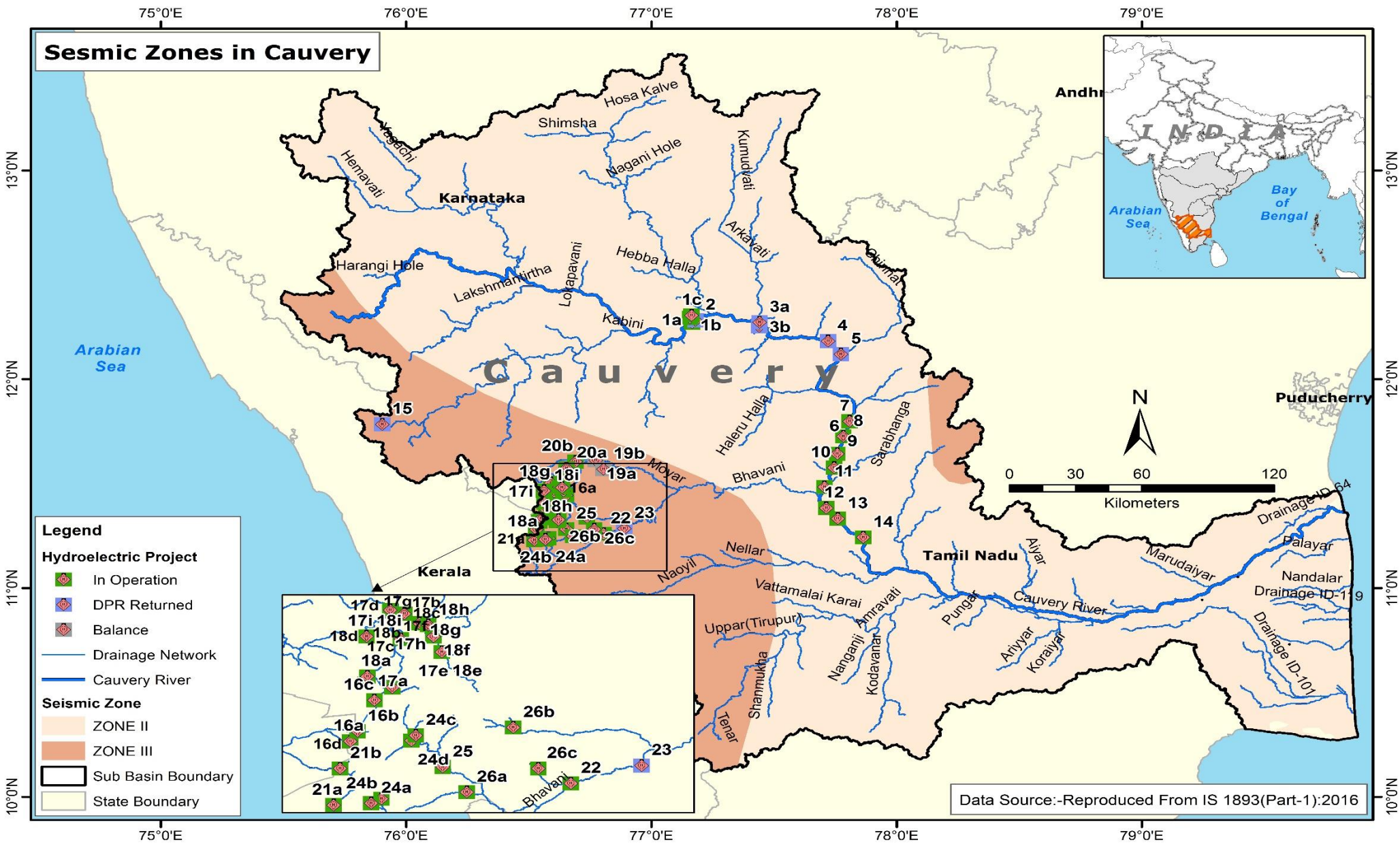


Figure 2.31 Seismic Map of Cauvery Sub-Basin

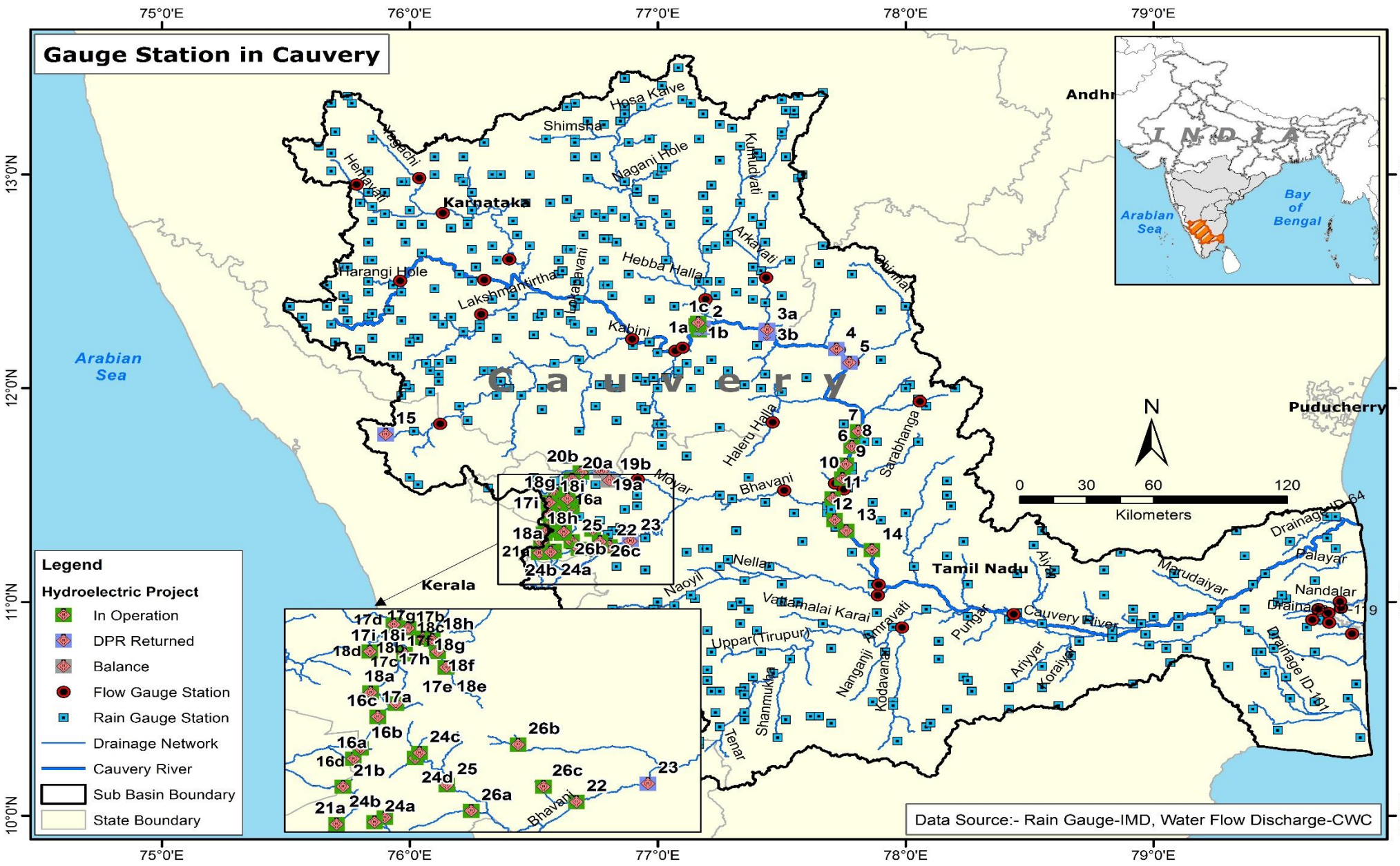


Figure 2.32 CWC Gauge Discharge Sites & IMD Rain Gauge Sites of Cauvery Sub-Basin

2.3.2 RIVER PROFILE

2.3.2.1 CAUVERY RIVER

Cauvery, also referred as Ponni, during its course through the states of Karnataka, and Tamil Nadu .The Cauvery Basin is the third largest basin of south India, after Godavari and Krishna. The river originates at an elevation of about 1340 m in the Brahmgiri hill range in foothills of Western Ghats at Talakaveri, Kodagu in Karnataka and after traversing for about 100 km is joined by its first important tributary, it forms two islands in Mandya district's Srirangapatna and Shivanasamudra. At Shivanasamudra the river has a drop of 98 m, forming the famous Shivanasamudra falls. Asia's first hydroelectric plant was built in 1902 on the left fall and supplied power to the city of Bangalore. In its course through Karnataka, the channel is interrupted by 12 "anekattu" (dams) for the purpose of irrigation and water supply.

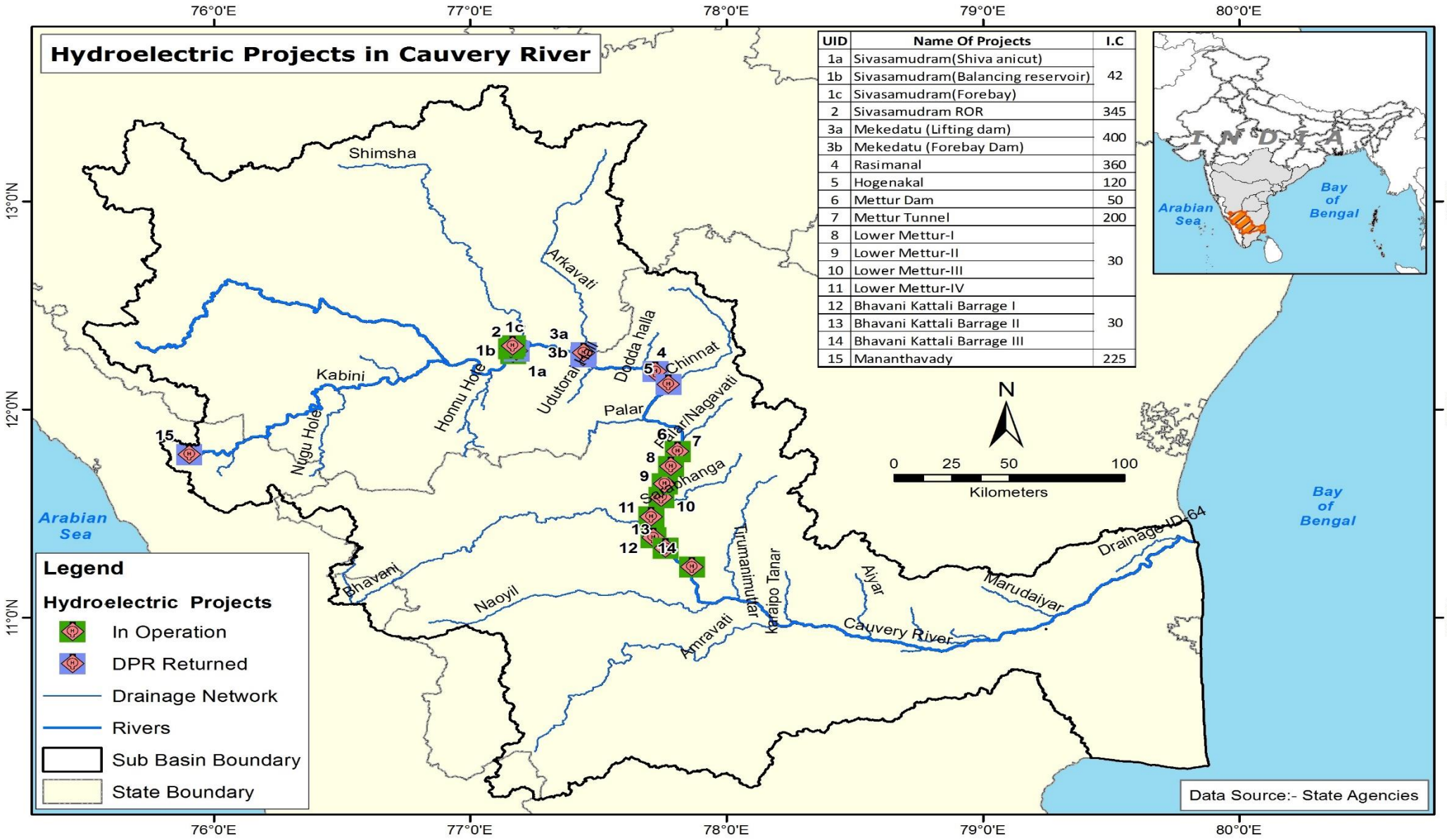
The river enters Tamil Nadu at Dharmapuri district and drop creating famous Hogenakkal Falls. The three minor tributaries, Palar, Chinnar and Thoppar enter into the Cauvery on her course, above Stanley Reservoir in Mettur, where the dam has been constructed. It flows further through of Erode district where river Bhavani, merges with it. Noyyal and Amaravathi join it in Karur district before it reaches Tiruchirapalli district. Here the river becomes wide, with a sandy bed, and flows in an eastern direction until it splits into two at upper Anicut about 14 kilometres west of Tiruchirappalli. The northern branch of the river is called the Kollidam while the southern branch retains the name Cauvery and then goes directly eastwards into Thanjavur District. These two rivers join again and form the Srirangam Island that is a part of the city of Tiruchirapalli. From Thanjavur, the river splits and goes to few places in the Delta Cauvery. The total length of the river from the origin to its outfall into the sea is 800 Kms. of which 320 Kms. is in Karnataka, 416 Kms. in Tamil Nadu and 64 Kms. forms the common border between the Karnataka and Tamil Nadu states. The other prominent tributaries of the Cauvey are Shimsha, Bhavani, Amaravati and Moyar.

KABINI RIVER

The Kabini, also called Kapila, is one of the major tributaries of the river Cauvery in southern India and it is also one of the only three east flowing rivers in Kerala. It originates in the Wayanad District of Kerala state by the

confluence of the Panamaram River and the Mananthavady River. It flows eastward to join the Cauvery River at Tirumakudalu Narasipura in Karnataka. List of the projects and their geographical locations on Cauvery River & its tributaries/sub-tributaries (Kabini) is shown in **Figure 2.33** & **Figure 2.34.**

Map showing Hydroelectric Projects on Cauvery River



UID	Name Of Projects	I.C
1a	Sivasamudram(Shiva anicut)	42
1b	Sivasamudram(Balancing reservoir)	
1c	Sivasamudram(Forebay)	
2	Sivasamudram ROR	345
3a	Mekedatu (Lifting dam)	400
3b	Mekedatu (Forebay Dam)	
4	Rasimanal	360
5	Hogenakal	120
6	Mettur Dam	50
7	Mettur Tunnel	200
8	Lower Mettur-I	30
9	Lower Mettur-II	
10	Lower Mettur-III	
11	Lower Mettur-IV	
12	Bhavani Kattali Barrage I	30
13	Bhavani Kattali Barrage II	
14	Bhavani Kattali Barrage III	
15	Mananthavady	225

Figure-2.33

Map showing Geological Features of Cauvery River

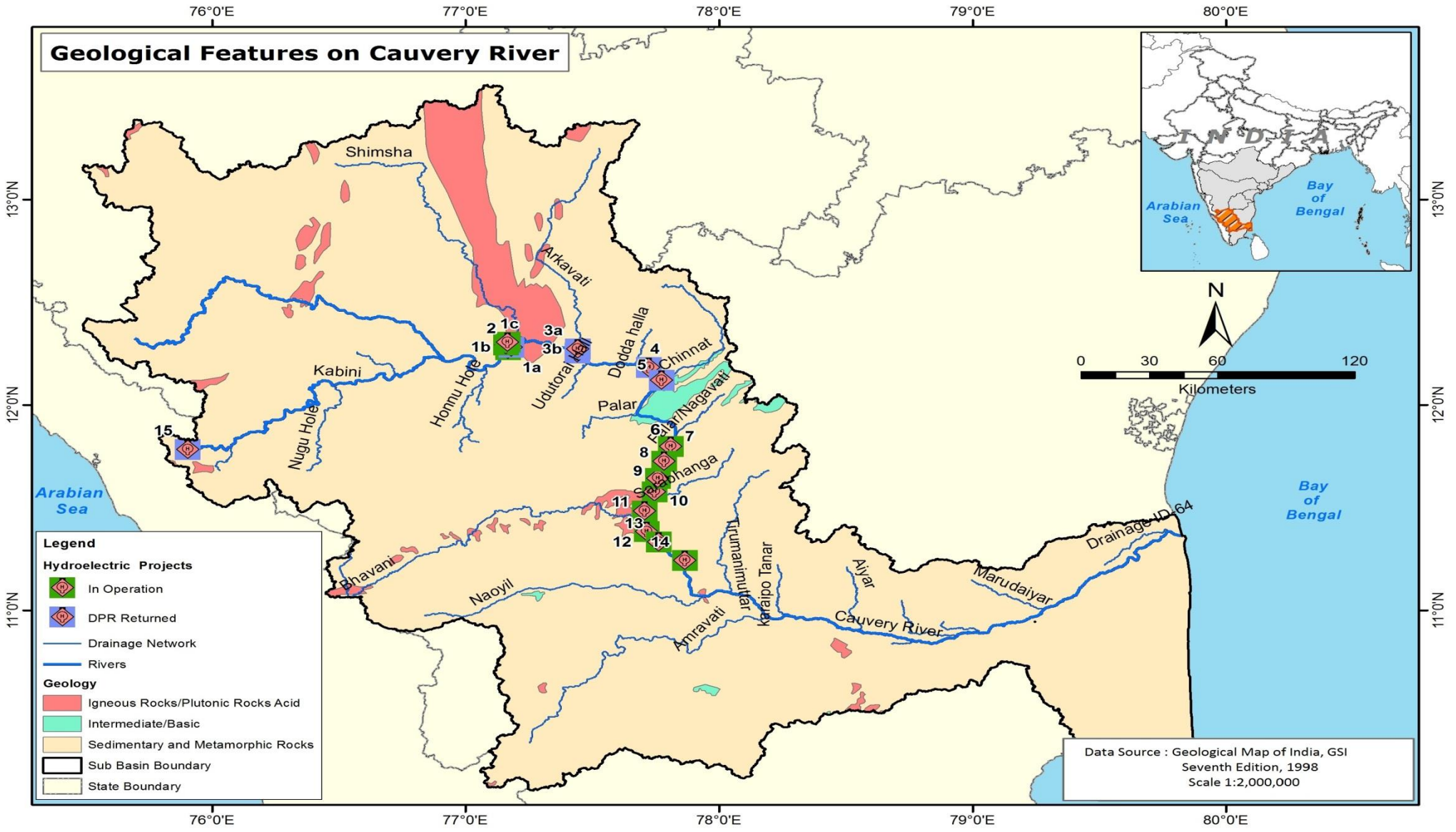


Figure-2.34

2.3.2.2 BHAVANI RIVER

Bhavani River originates from Nilgiri hills of the Western Ghats, enters the Silent Valley National Park in Kerala and flows back towards Tamil Nadu. The Bhavani is a 217 kilometre long perennial river fed mostly by the southwest monsoon season and supplemented by the northeast monsoon season. Its watershed drains an area of 2,400 sq mil spread over Tamil Nadu (87%), Kerala (9%) and Karnataka (4%).

Twelve major rivulets including West and East Varagar rivers join Bhavani draining the southern Nilgiri slopes. Siruvani River, a perennial stream and the Kodungarapallam River, flowing from the south and southeast respectively join the Bhavani at Kerala-Tamil Nadu border. The river is then joined by Coonoor River coming from northwest and about 30 kilometres downstream, Moyar River, a major tributary joins Bhavani from the northwest. Lower Bhavani Dam is constructed discharge of confluence with Moyar, feeding Lower Bhavani Project Canal near Sathyamangalam in Erode District. The river continues east for over 160 kilometres through Erode District. River Kundah, a left bank tributary of Bhavani is formed in its initial reach by two major streams, the Avalanche and Emerald. Two dams on these two streams have been constructed harness the Power Potential at Kundah–II hydroelectric project .The tail race discharge of Kundah-II is again collected in a forebay near the township Gedde on the stream Pegumbuhalla. This water augmented by the waters diverted from adjoining Kattori and Nirarpallam streams is utilized at Kundah –III power house for power generation.

MOYAR RIVER

River Moyar originates in the Nilgiris of the Western Ghats, flowing West to East along the Tamil Nadu and Karnataka State border. The river meanders through dry forest plains before draining in to the Bhavanisagar reservoir. The three major tributaries of River Moyar are Kedrahalla, Sigur River and Kahanhalla. River Moyar has the distinction of running its course through the forests of the Western Ghats, on a rainfall gradient of about 5000 mm at the Nilgiris to Bhavanisagar where the annual rainfall is just 500-600 mm.

PYKARA RIVER

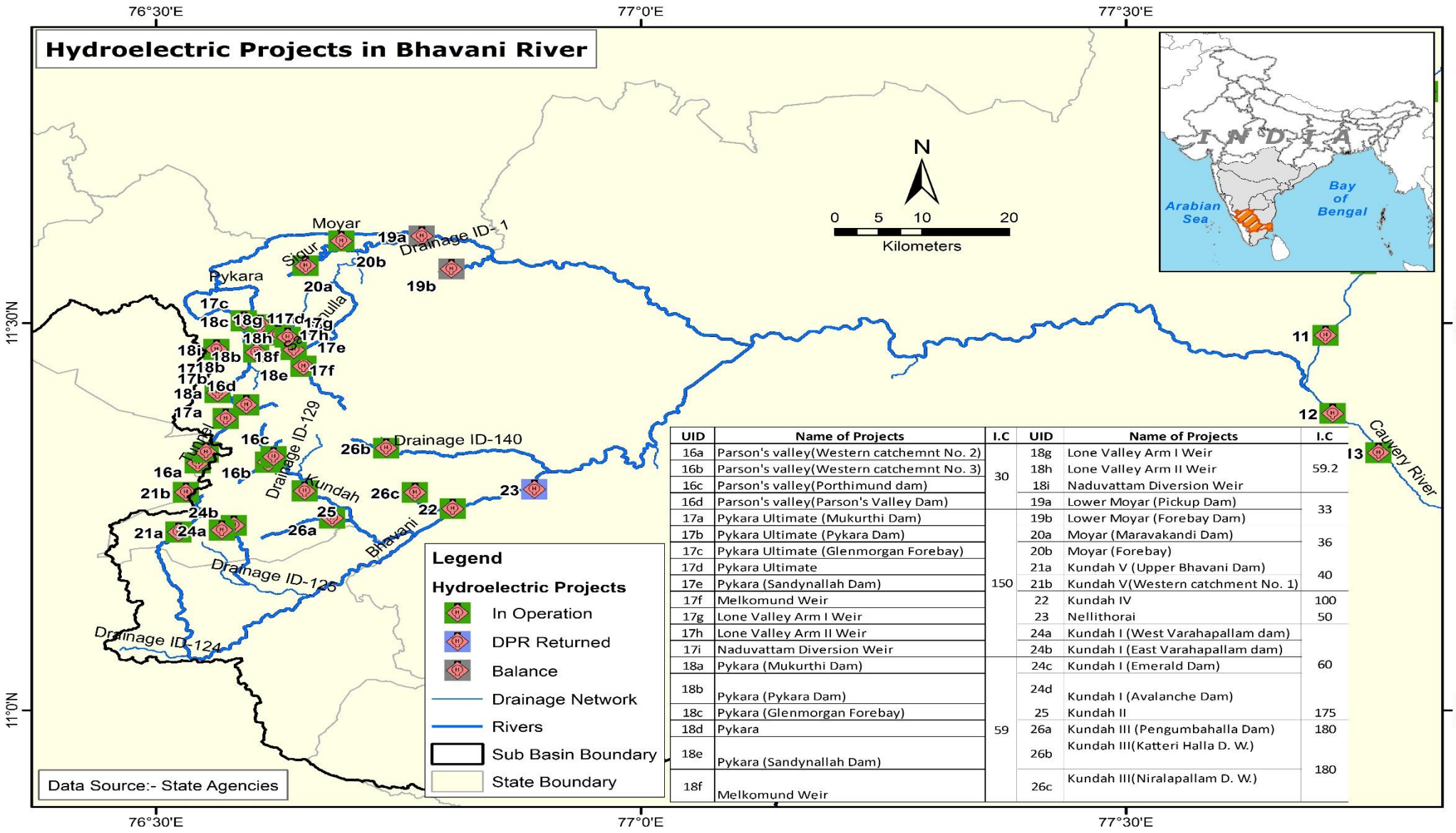
Pykara River originates at an elevation of at Mukurthi peak and it flows northwards and after reaching the edge of the plateau turns to the west.

Murkurti, Pykara and Glenmorgan dams have been constructed across Pykara to utilize its Hydro Power Potential .

The river flows over a series of waterfalls, the last two being of the order of 55 metres and 61 metres popularly known as Pykara Falls.

List of the projects and their geographical locations on Bhavani River & its tributaries/sub-tributaries (Moyar and Pykara) is shown in **Figure 2.35** & **Figure 2.36 .**

Map showing Hydroelectric Projects on Bhavani River



UID	Name of Projects	I.C	UID	Name of Projects	I.C
16a	Parson's valley(Western catchemnt No. 2)	30	18g	Lone Valley Arm I Weir	59.2
16b	Parson's valley(Western catchemnt No. 3)		18h	Lone Valley Arm II Weir	
16c	Parson's valley(Porthimund dam)		18i	Naduvattam Diversion Weir	
16d	Parson's valley(Parson's Valley Dam)		19a	Lower Moyar (Pickup Dam)	33
17a	Pykara Ultimate (Mukurthi Dam)	150	19b	Lower Moyar (Forebay Dam)	
17b	Pykara Ultimate (Pykara Dam)		20a	Moyar (Maravakandi Dam)	36
17c	Pykara Ultimate (Glenmorgan Forebay)		20b	Moyar (Forebay)	
17d	Pykara Ultimate		21a	Kundah V (Upper Bhavani Dam)	40
17e	Pykara (Sandynallah Dam)		21b	Kundah V(Western catchment No. 1)	
17f	Melkomund Weir		22	Kundah IV	100
17g	Lone Valley Arm I Weir		23	Nellithorai	50
17h	Lone Valley Arm II Weir		24a	Kundah I (West Varahapallam dam)	
17i	Naduvattam Diversion Weir		24b	Kundah I (East Varahapallam dam)	
18a	Pykara (Mukurthi Dam)	59	24c	Kundah I (Emerald Dam)	60
18b	Pykara (Pykara Dam)		24d	Kundah I (Avalanche Dam)	
18c	Pykara (Glenmorgan Forebay)		25	Kundah II	175
18d	Pykara		26a	Kundah III (Pengumbahalla Dam)	180
18e	Pykara (Sandynallah Dam)		26b	Kundah III(Katteri Halla D. W.)	180
18f	Melkomund Weir		26c	Kundah III(Niralapallam D. W.)	

Figure 2.35

Map showing Geological Features of Bhavani River

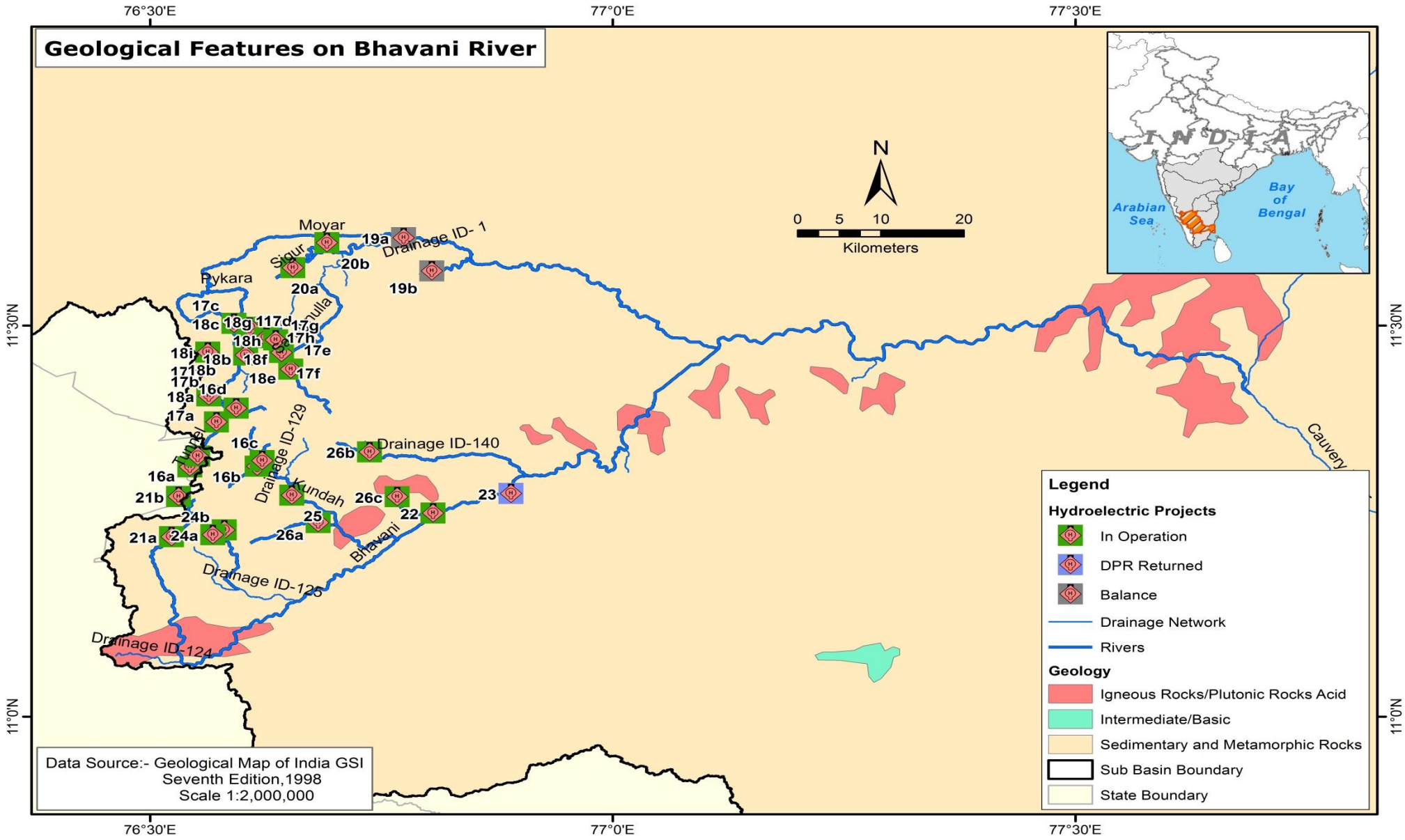


Figure 2.36

2.4 SOUTH OF CAUVERY SUB-BASIN

States Involved – Tamil Nadu

The basin of East Flowing Rivers between Cauvery and Kanyakumari lies in the peninsular India covering a large area in the state of Tamil Nadu including the drainage area of about 6865 sq. kms of Andaman & Nicobar Islands. The total area drained by the basin is about 27,920 sq. kms. The various rivers draining the areas between Cauvery & Kanyakumari are Vellar, Varshalei, Vaigai, Gunder, Vaippar, Thambraparni, the area drained in Andaman & Nicobar islands is mainly by the Betapur, Bolungta, Tigapur and Melagar including small streams like Kalara, Prangara. These rivers between Cauvery & Kanyakumari have length varying from a maximum of 285 kms to a minimum of 21 kms. Their origin is comparatively at low elevation ranging from 550 m to 1700 m from the hills of Western Ghat and Vasusha Nath hills and flow down to drain into Palk Bay/ Gulf of Mannar near Kanyakumari.

The basin of these rivers gets rainfall from (i) south-west monsoon season (ii) north-east monsoon season. The south–west monsoon season extends from June to September while north-east monsoon season from October to January. The distribution of rainfall varies from a minimum of about 635mm at the south –eastern extremity to about 1270 mm at the western extremity of the basin.The western part of the basin is generally hilly and the plains extend from the eastern slopes of the hills, sloping down generally to south-east.

Large Hydroelectric Projects in this sub-basin are situated in Thamirabarani and Suruli rivers.

Location of Hydroelectric project in South of Cauvery sub-basin and their salient features are given in **Figure 2.37** and **Table 2.4** respectively**.**

2.4.1 Physiographic status of South of Cauvery Sub-Basin

In South of Cauvery sub-basin, the physiographic status of the study area is shown in various maps prepared on GIS platform and these maps are as follows:

1. Hydroelectric Projects in South of Cauvery sub-basin (**Figure 2.37**)
2. Topographic (Elevation Data) Map (**Figure 2.38**)
3. Ecologically Sensitive Area Map (**Figure 2.39**)
4. Geological Map (**Figure 2.40**)
5. Seismic Map (**Figure 2.41**)
6. CWC Gauge Discharge Sites & IMD Rain Gauge Sites (**Figure 2.42**)

Table 2.4 Salient Features of Hydroelectric Projects in South of Cauvery Sub-Basin.

UID	Name of Project	State	District	River	I.C (MW)	Storage / RoR Type	Live Storage (Mcum)	Rated/ Average Head (m)	Annual Energy (MU)	FRL (m)	TWL (m)	Dam Latitude	Dam Longitude	Power House Latitude	Power House Longitude	Agency	Status
1a	Suruliyar (Eravangalar Dam)	Tamil Nadu	Theni	Suruli	35	Storage	2.09	979.15	306	1472	440.4	9°36' 28.7"N	77°18' 03.7"E	9°37' 12.5"N	77°16' 21.7"E	TANGED CO	In Operation
1b	Suruliyar (Vennriar dam)									1473.75		9°37' 23.8"N	77°19' 24.9"E				
1c	Suruliyar (Vennirar Weir)									1498		9°37' 36.70"N	77°19' 22.72"E				
1d	Suruliyar (Manalar Dam)									1492		9°38' 17.3"N	77°20' 45.6"E				
1e	Suruliyar (Highwavys Dam)									1505.75		9°38' 54.1"N	77°21' 38.4"E				
1f	Suruliyar (Highwavys Weir)									1435.60		9°38' 58.2"N	77°21' 16.0"E				
2a	Papanasam (Servalar Dam)	Tamil Nadu	Tiruneiveli	Thamirabarani	32	Storage	149.51	100.6	280	264.57	91.16	8°41' 25.6"N	77°18' 17.1"E	8°42' 23.8"N	77°21' 45.5"E	TANGED CO	In Operation
2b	Papanasam (Diversion Weir)									193.55		8°41' 46.3"N	77°21' 31.8"E				
2c	Papanasam (Thambraparni Dam)									264.57		8°39' 03.4"N	77°18' 39.9"E				

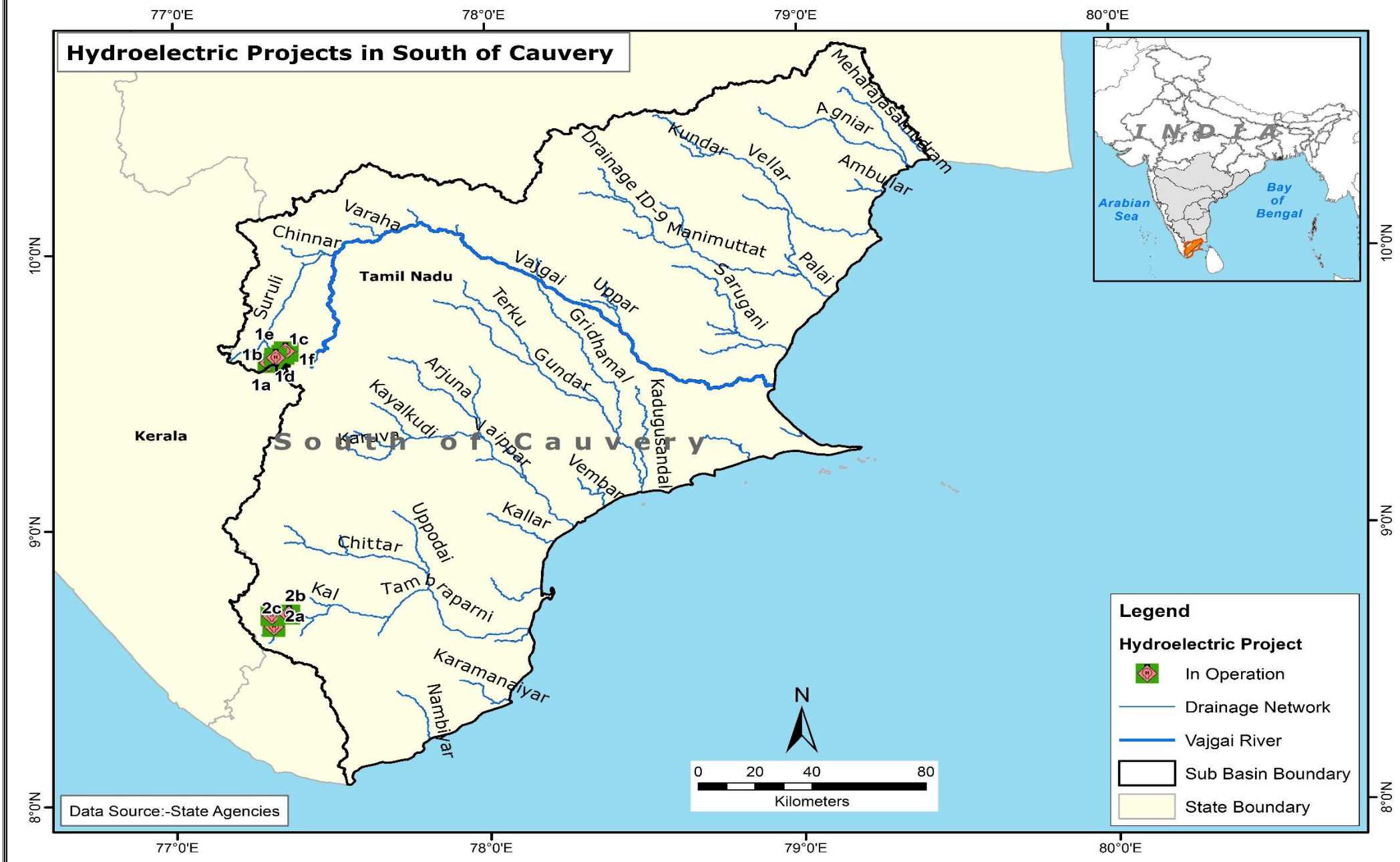


Figure 2.37 Hydroelectric projects in South of Cauvery Sub-Basin

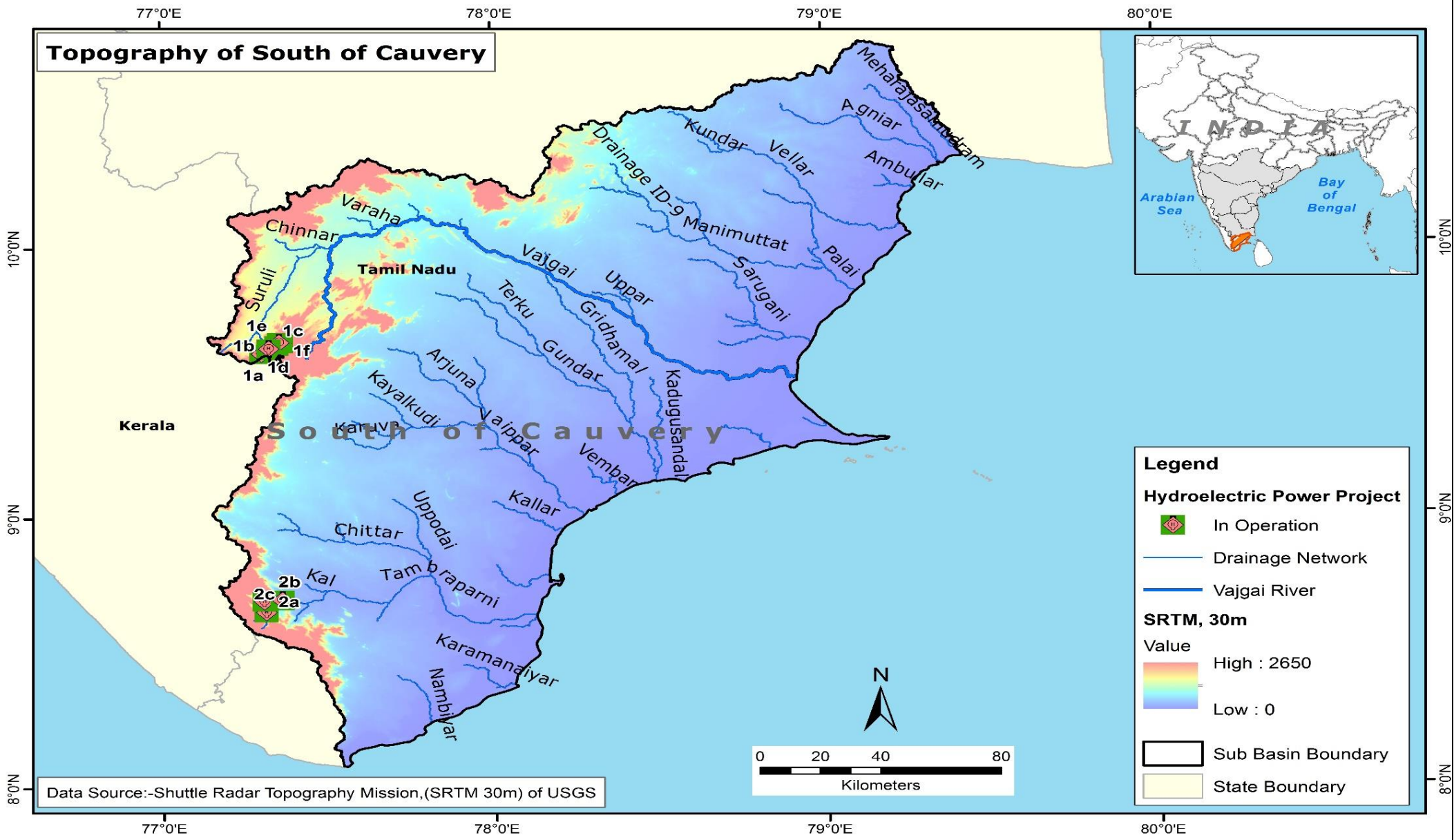


Figure 2.38 Topographic (Elevation Data) Map of South of Cauvery Sub-Basin

The Resolution of this data is 1 arc-second (30 meters). The maximum elevation of this area is 2650 meter.

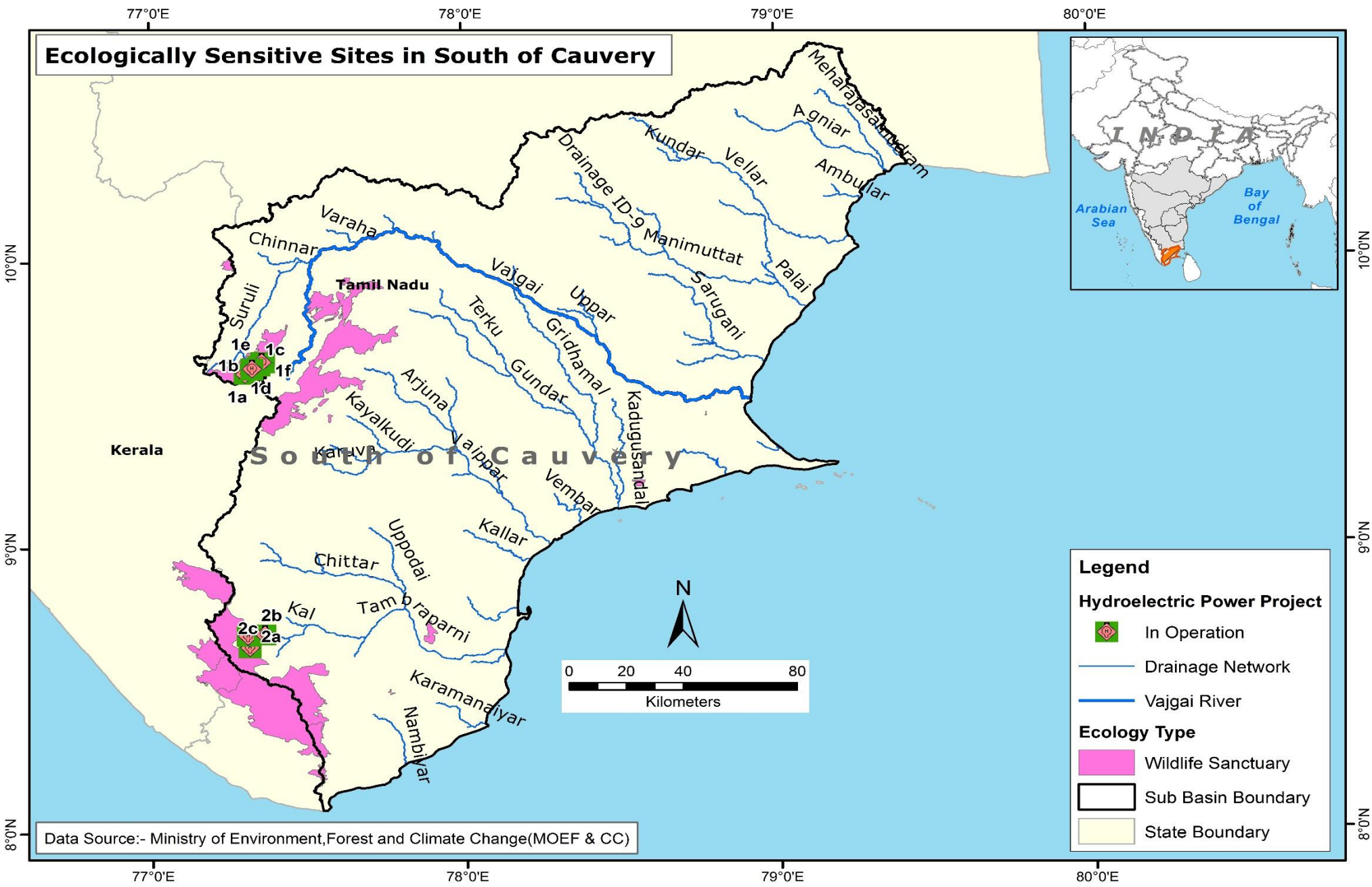


Figure 2.39 Ecologically Sensitive Area Map of South of Cauvery Sub-Basin

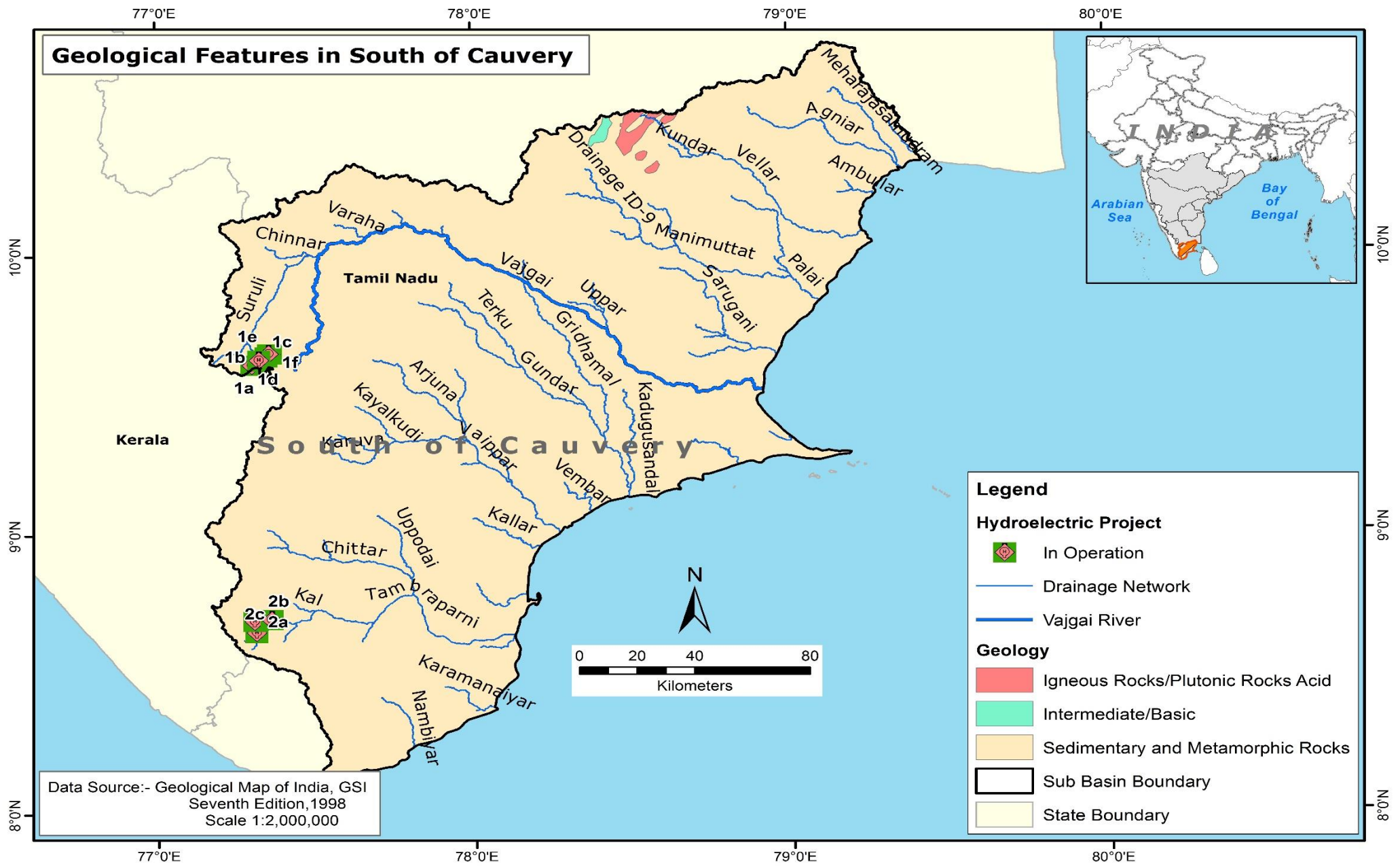


Figure 2.40 Geological Map of South of Cauvery Sub-Basin

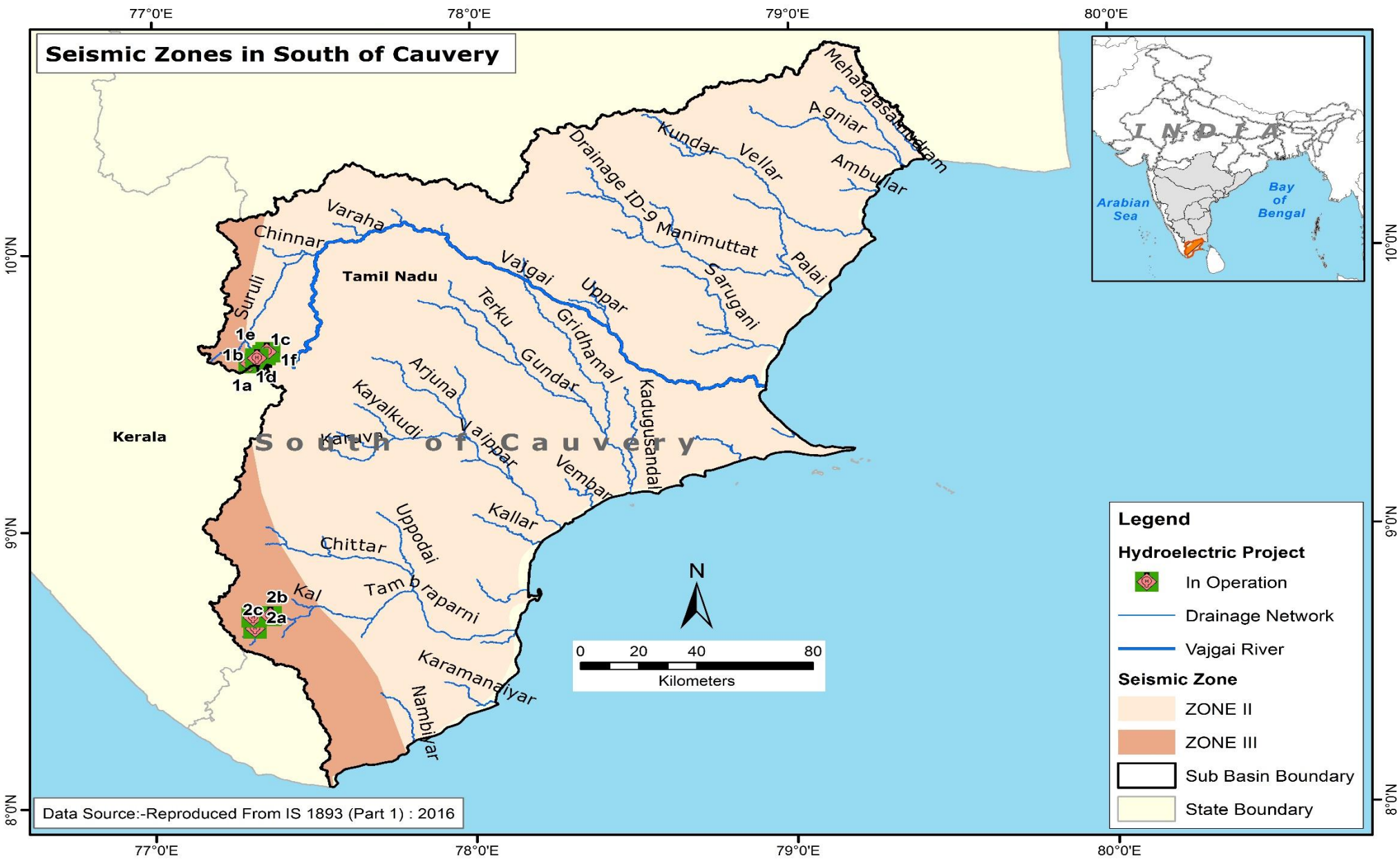


Figure 2.41 Seismic Map of South of Cauvery Sub-Basin

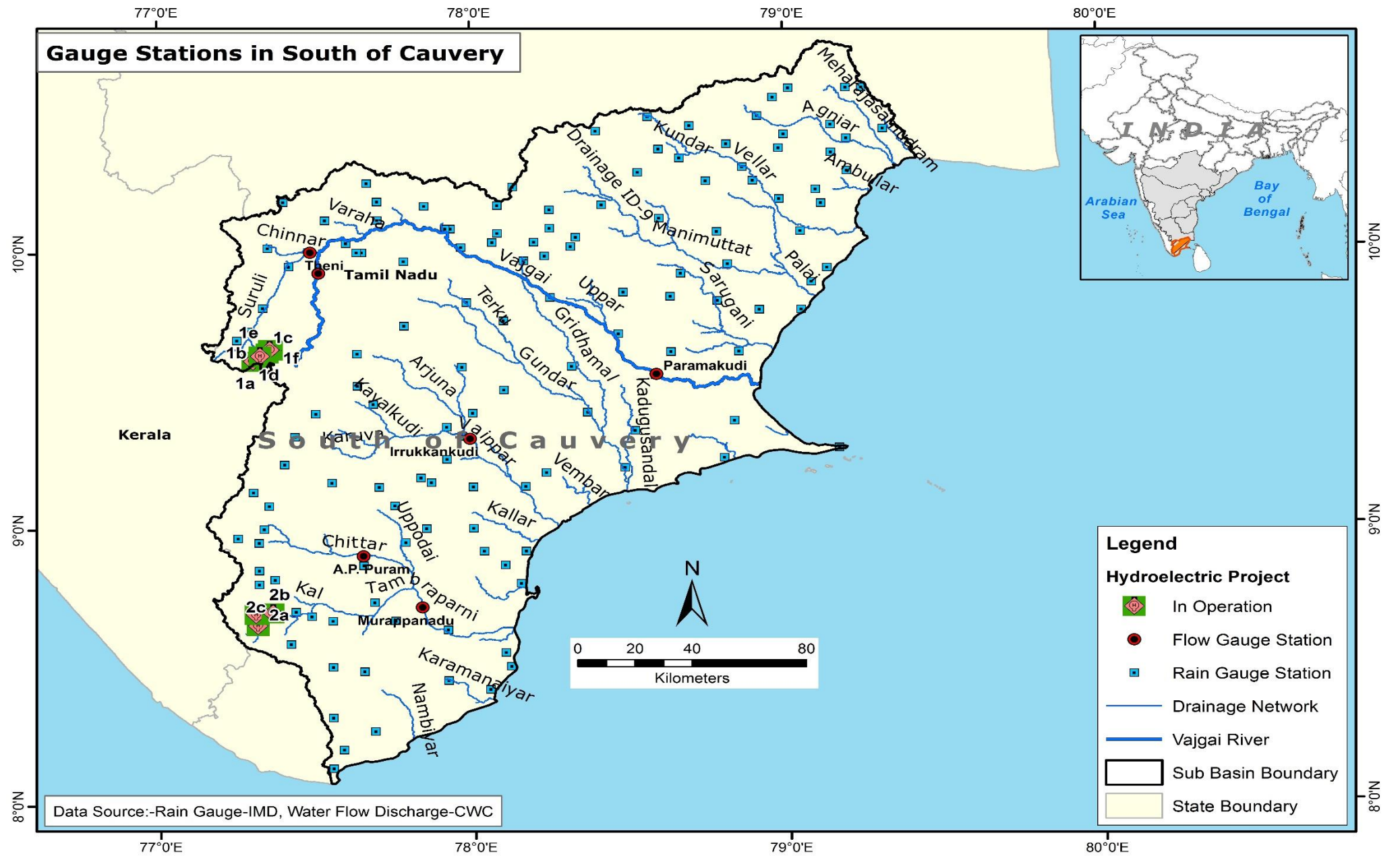


Figure 2.42 CWC Gauge Discharge Sites & IMD Rain Gauge Sites of South of Cauvery Sub-Basin

2.4.2 RIVER PROFILE

2.4.2.1 SURULI RIVER

Suruli River which is a tributary of the Vaigai, is known after its origin in the Western Ghats as the Vairavan River. This stream receives the diverted water from the Periyar Lake formed in the Thekkedi catchment by the construction of Periyar dam across the west flowing Periyar River. Due to steep gradient of this stream , the augmented water of Vairavan is picked up a few kilometres downstream of the origin and diverted through long channel to drop over an average gross head of about 61 m on Eravangel, a right bank stream of the Suruli. The river Suruli is joined from the right by a number of small streams which originate from the East Kambam valley. This valley is harnessed for hydel potential by diverting the waters of small stream through a series of weir and interconnecting tunnels and finally leading the water to a forebay provided on Eravangal stream.

List of the projects and their geographical locations on Suruli River is shown in **Figure 2.43** & **Figure 2.44**.

Map showing Hydroelectric Projects on Suruli River

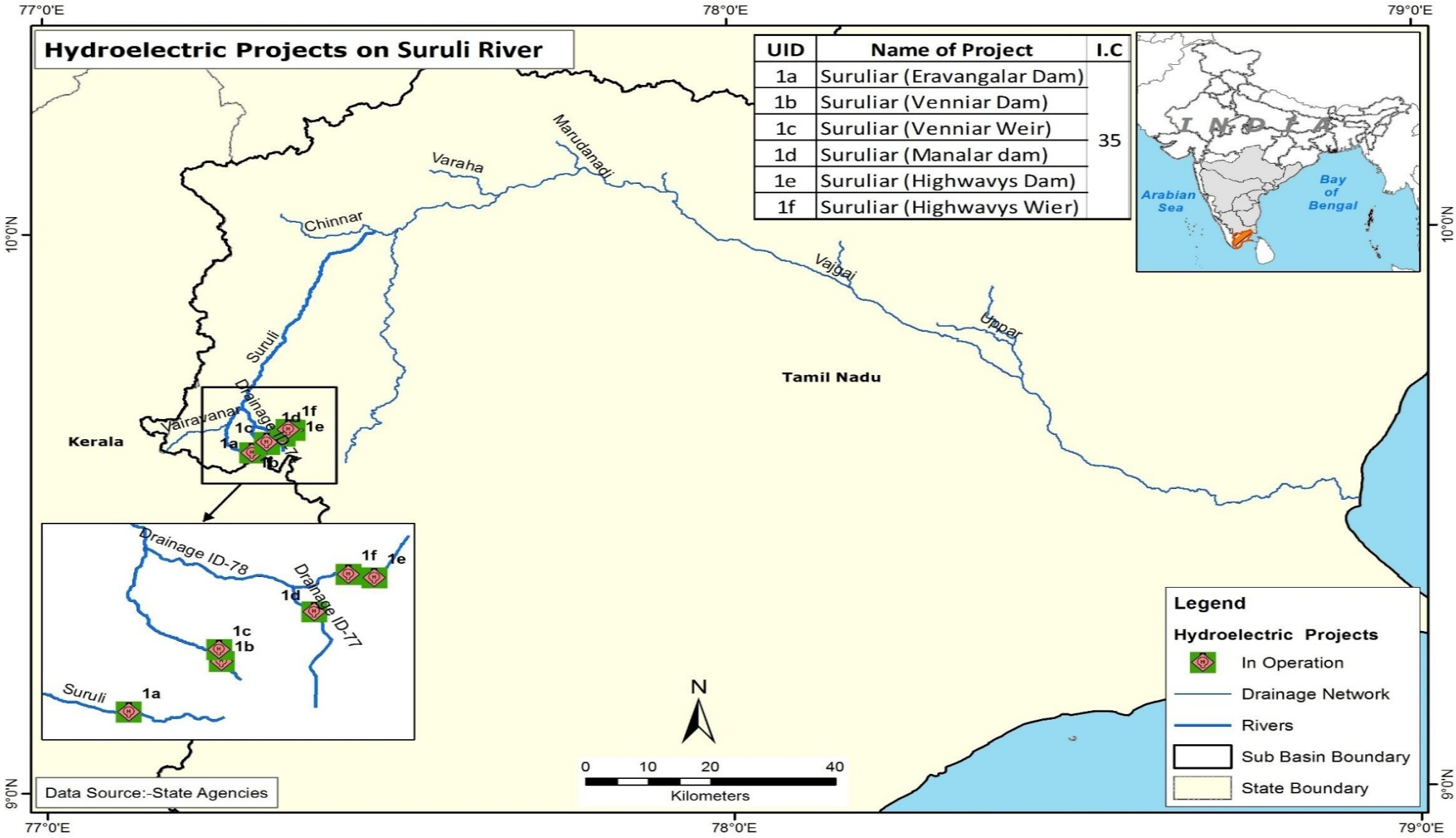


Figure 2.43

Map showing Geological Features of Suruli River

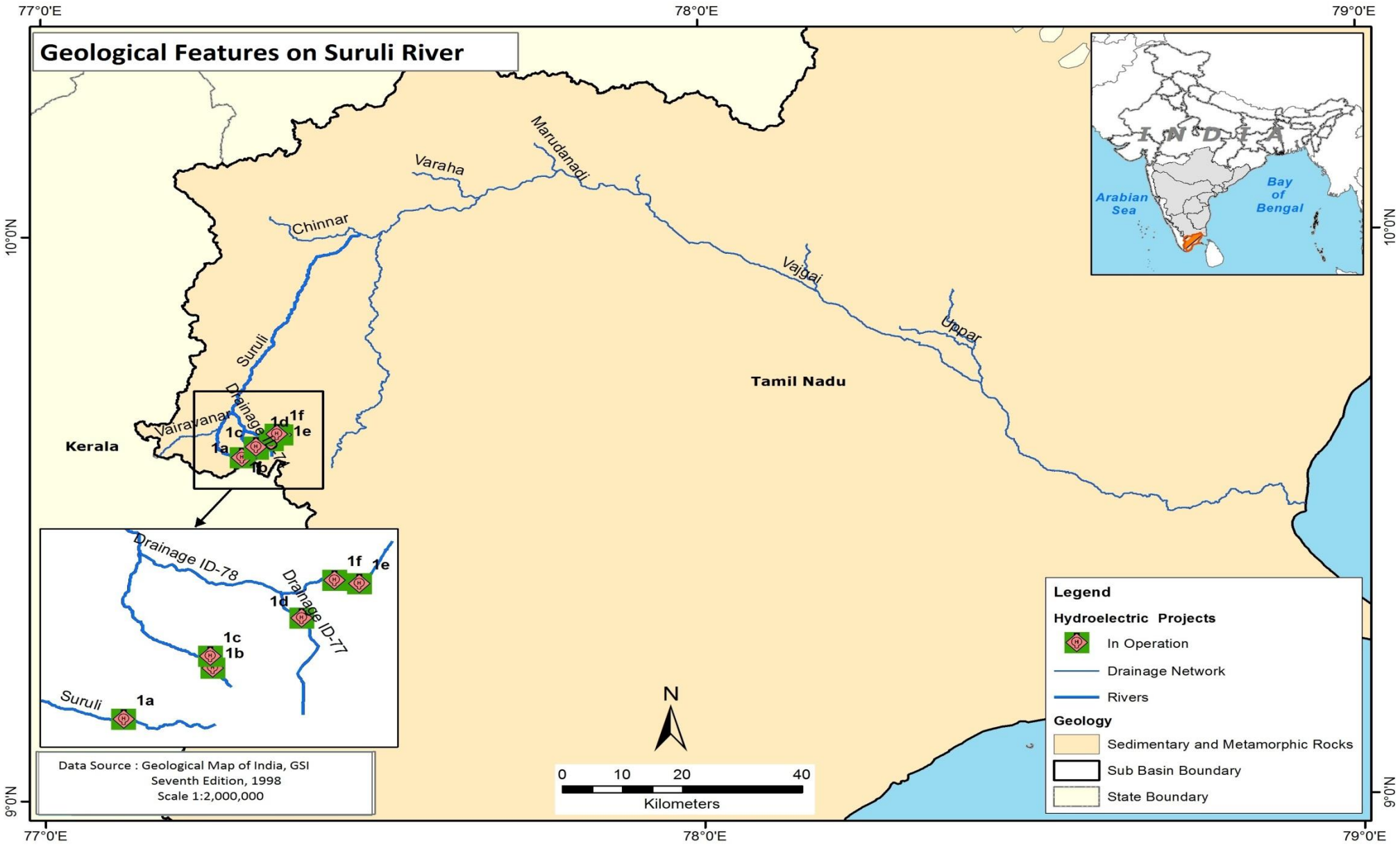


Figure 2.44

2.4.2.2 THAMIRABARANI RIVER

It rises on the slopes of the peak Agastyamalai in the Western Ghats at an elevation of about 1370 m and after a course of some km through this range, descends to the plains in five beautiful falls at Papanasam, a very sacred spot. Higher up, in the heart of the hills, it forms another fall called the Bana-tirtham. From Papanasam it runs eastward across Tinnevelly District, receiving a number of tributaries important being Chiltar and Manimuttar. During its course of 138 km, Thamirabarani River attracts a drainage area of 5514 sq.km before its falls into the Gulf of Manaar.

List of the projects and their geographical locations on Thamirabarani River is shown in **Figure 2.45** & **Figure 2.46**.

Map showing Hydroelectric Projects on Thamirabarani River

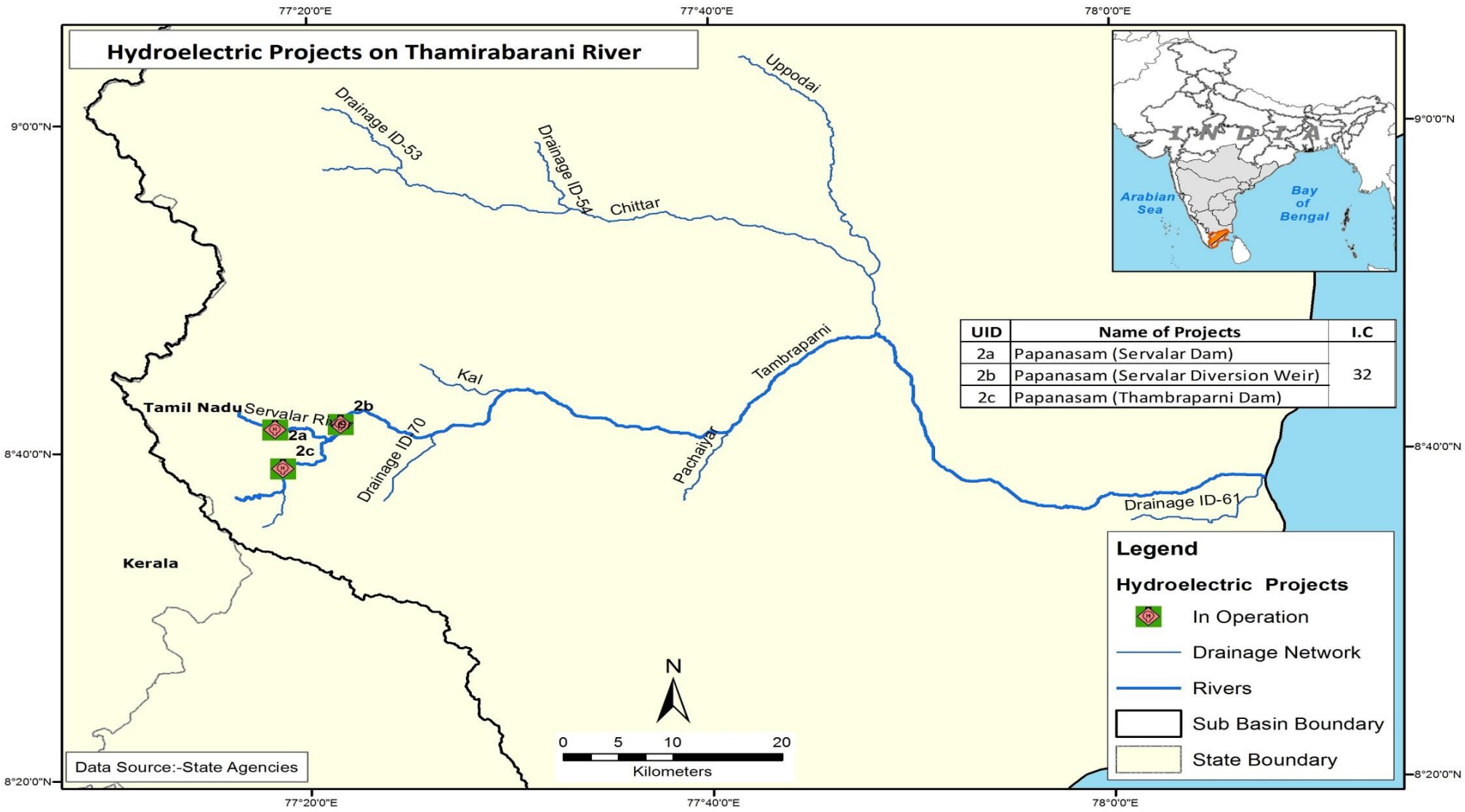


Figure 2.45

Map showing Geological Features of Thamirabarani River

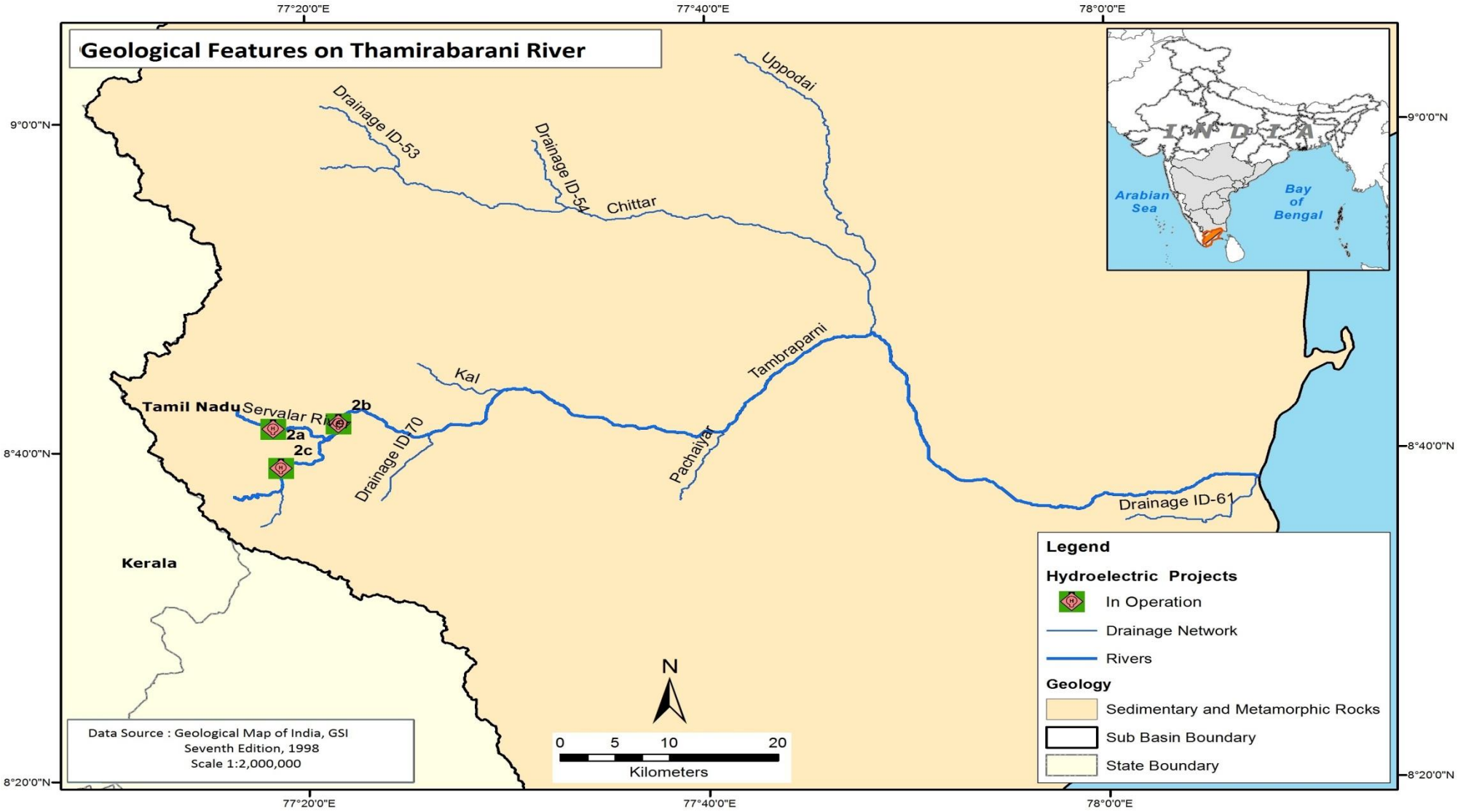


Figure 2.46

Chapter - 3
PROJECT PROFILE OF HYDRO PROJECTS
(Excluding hydro projects taken up for further studies)

A. Projects In Operation (ref Annexure-II in Chapter-1)

3.1 BHANDARDARA ST- II HYDROELECTRIC PROJECT (1x34MW=34MW)

1. INTRODUCTION

The Bhandardara St-II Hydroelectric Project is a Run of River (RoR) with pondage main storage Bhandardara dam. Shendi village is located approximately 0.62 km from the dam site. Water released from bhandardara dam is diverted from Randha Pickup weir. The project is located in Ahmednagar district of Maharashtra state utilising the water of Pravara River for power generation. The project utilise tail race discharges of Bhandardara-I Hydroelectric project built across Pravara River. A pickup weir is built about 450m upstream of Randha fall and the water collected at weir is utilized for Bhandardara Hydroelectric project. The project has well type powerhouse with Installed Capacity of 34MW (1X34MW) utilizing the design head of about 50 m. The project was commissioned by Govt. of Maharashtra Water Resource Depatment (GOMWRD) on 19-05-1999 and Handed over to Dodson Lindblom Hydro Power Private HPP Ltd (DLHP) on 19-12-2006.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Pravara River having Latitude 19°32'50"N & Longitude 73°45'26"E with Randha Pickup weir being located at Latitude 19°32'38.0"N & Longitude 73°48'09.1"E and the Power house located at Latitude 19°33'20"N & Longitude 73°48'31"E in Ahmednagar district of Maharashtra. The nearest railway station from the project is Ahmednagar and nearest airport is Aurangabad.

3. PROJECT FEATURES

Bhandardara St-II Hydroelectric Project consists of 82.32m high Bhandardara Masonary Dam and 13.5 m high concrete pick up weir across the river Pravara. The reservoir formed by the dam has a live storage of 277.20 Mcum at Bhandandara dam and 1.42 Mcum at Randha Pickup Weir with Full Reservoir Level (FRL) of 744.73 m at Bhandardara dam and 668.35 m at Randha Pickup Weir and Minimum Draw Down Level (MDDL) of 666.45 m at Randha Pickup Weir. The water conductor system comprise of 1 no of Head

Race Tunnel (HRT) of length 1120.20 m which carries water to the powerhouse. The Power house has one unit of 34 MW using Vertical Francis turbine operated under design head of 50 m with an installed capacity of 34 MW. A Tail Race Channel/Tunnel carries powerhouse discharge back to the river.

4. HYDROLOGY

The Pravara River drains a catchment area of about 121.70 sq km upto Bhandhandara dam and 184.30 sq km upto the Randha pick up weir.

5. POWER & ENERGY BENEFITS

The Installed capcity of Bhandardara St-II Hydroelectric project is 34 MW. The Project has annual energy of 36.26 MU in 90% dependable year. The Firm Power vary from 34 MW to 11.49 MW depending upon Nilwand water level.

6. HISTORICAL BACKGROUND

Construction work on Bhandardara Dam was started in 1910, this dam is located 270 feet high above the river bed and 278 feet above its lowest foundation.At the time of completion of the construction work, the dam was considered as the highest in Asia involving an estimated amount of nearly Rs. 84,14,188. The dam was inaugurated by Excellency Lt. Col. Leslie Orme Wilson, who was the governor of Bombay at that time in December 1926. The dam was named after colonel, keeping in mind his contribution to the British government.

Arthur Hill discovered the site for this dam in 1903. Hill was serving as chief engineer for irrigation and secretary to the government of Bombay at that time. The British government decided to name a lake after him to honour his valuable services in the area of irrigation in Bombay Presidency. Lake Arthur Hill is also famously known as Bhandardara Lake.

SALIENT FEATURES
BHANDARDARA ST-II HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Ahmadnagar
River	Pravara
Type of Development	Run-of River with pondage main storage Bhandardara dam, water released from bhandardara dam is diverted from Randha Pickup weir.
Nearest Railhead	Ahmednagar
Nearest Airport	Aurangabad

LOCATION:

Bhandardara Dam : Latitude & Longitude	19°32'50"N, 73°45'26"E
Randha Pickup Weir : Latitude & Longitude	19°32'38.0"N, 73°48'09.1"E
Power House : Latitude & Longitude	19°33'20"N, 73°48'31"E

HYDROLOGY:

Catchment Area (Sq. Km)	121.70 (Bhandardara Dam) 184.30 (Randha Pickup Weir)

DAM:	**BHANDARDARA DAM**	**PICKUP WEIR**
Type	Masonry	Composite
Length (m)		178.5
Height (m)	82.32	13.50

RESERVOIR:	**BHANDARDARA DAM**	**PICKUP WEIR**
Full Reservoir Level (FRL) (m)	744.73	668.35
Minimum Draw Down Level (MDDL) (m)		666.45
Live Storage (Mcum)	277.20	1.42

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Type	Inclined,Unlined
Shape	D Shape
Number	1
Length (m)	1120.20
Size (m)	7.6 x 3.8 with semi circular top
SURGE TANK	
Type	Well
Shape	Circular C.C Lined
Height (m)	74
TAIL RACE TUNNEL	
Shape	'D' Shape
Number	1
Length (m)	85
TAIL RACE CHANNEL	
Type	Unlined
Shape	Trapezoidal
Length (m)	300

POWER HOUSE:

Type	Well
No. of Generating Units	1
Capacity of each Unit (MW)	34
Firm Power (MW)	Power Varying from 34 MW to 11.49 MW depending upon Nilwand water level
Installed Capacity (MW)	34
Design Head (m)	50
Gross Head (Max.) (m)	59.50
Gross Head (Min.) (m)	28.10
Type of Turbine	Vertical Francis

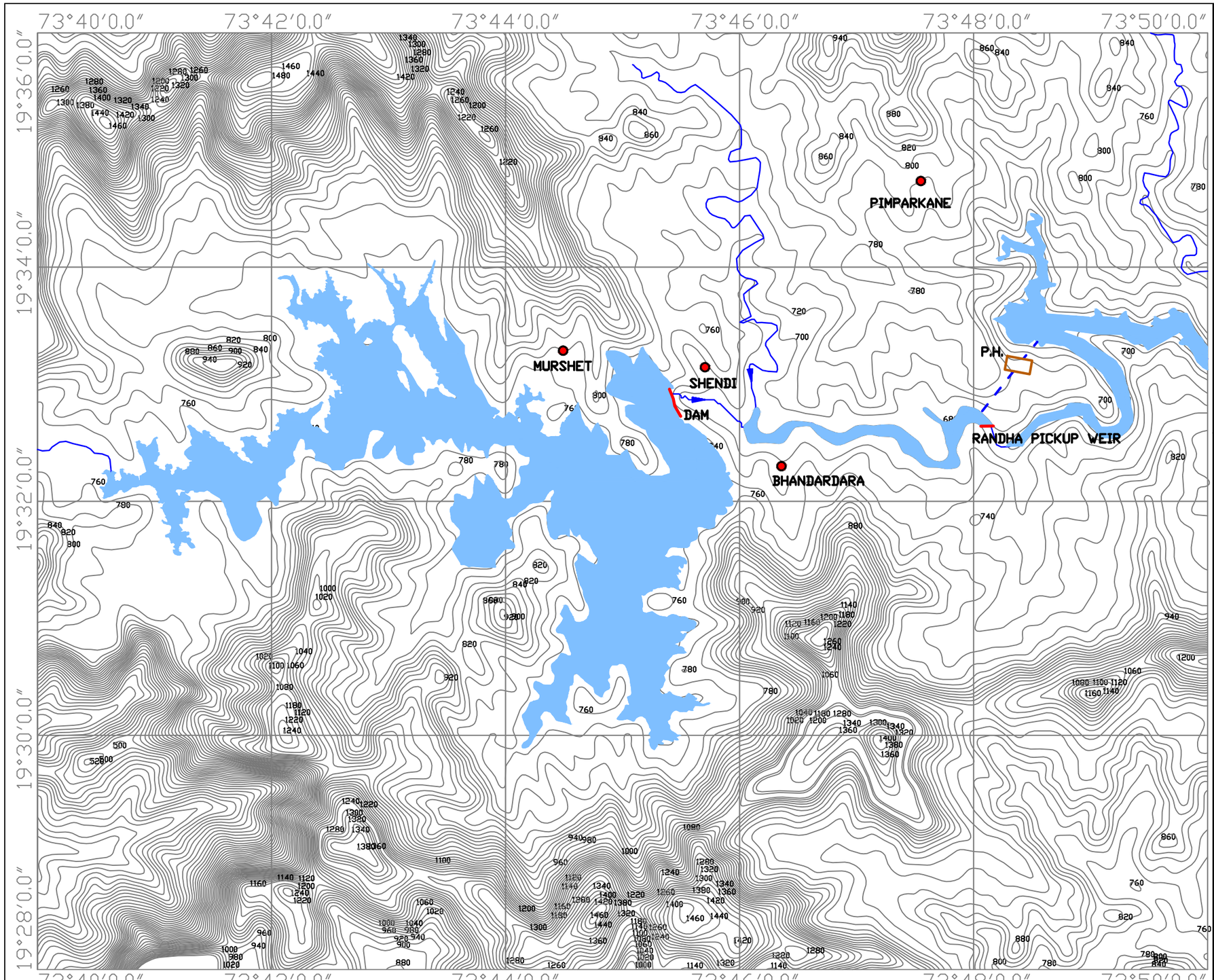
Tail Water Level (TWL) (Min.) (m)	608
Tail Water Level (TWL) (Max.) (m)	639.20
Annual Energy (MU)	36.26

COST ASPECTS:

Levellised Tariff (Rs/KWh)	4.13
Estimated Cost (Rs. Crores)	117.03

COMMISSIONING DETAILS:

Commissioning Year	Commissioned by GOMWRD on 19-05-1999 , handed over to Dodson Lindblom HPP Ltd on 19-12-2006



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE
- CONTOUR INTERVAL - 20M

RANDHA PICKUP WEIR

FRL- 668.35 M
MDDL- 666.45 M
DAM HEIGHT- 13.50 M

BHANDARDARA DAM

FRL- 744.73 M
LIVE STORAGE - 277.20 MCuM
DAM HEIGHT- 82.32 M

POWER HOUSE

TWL- 608 M
AVG. GROSS HEAD- 59.5 M
INST. CAPACITY- 34 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BHANDADARA ST-II HYDROELECTRIC PROJECT
(1X34) = 34 MW

3.2 PENCH HYDROELECTRIC PROJECT (2X80MW=160MW)

1. INTRODUCTION

Pench Hydroelectric Project is a storage type of development located in the Nagpur district of Maharashtra and utilizes the water of Pench River for power generation. Thuepani village is located approximately 8.5 km from the dam site. The project has an underground powerhouse with installed capacity of 160MW (2X80 MW) utilizing rated head of 150 m to generate annual energy of 315.36 MU in a 90% dependable year. All the units were commissioned in between 1986-1987 and is executed by Madhya Pradesh Power Generation Company Limited (MPPGCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Pench River having Latitude 21°39'32.2"N & Longitude 79°13'53.4"E and the Power house is located at Latitude 21°39'30"N & Longitude 79°14'E in Nagpur district of Maharashtra.The nearest railway station and airport from the project site is Nagpur.

3. PROJECT FEATURES

Pench Hydroelectric Project consists of 74.5 m high and 680 m long storage dam. The reservoir formed by the dam has a live storage of 1088 Mcum between Full Reservoir Level (FRL) of 490 m and Minimum Draw down Level (MDDL) of 464 m. The Water Conductor System comprises of Head Race Tunnel (HRT) of length 261.6m. The Underground Powerhouse has 2 units of 80MW using Francis turbine operated under rated head of 150m with Installed Capacity of 160 MW.

4. HYDROLOGY

The river drains a catchment area of about 4275 Sq km upto dam site.

5. POWER & ENERGY BENEFITS

Power is being shared in the ratio of 66.69:33.31 between Madhya Pradesh & Maharashtra. Pench hydroelectric project has 2 units of 80 MW each with installed capacity of 160MW. The project generates annual energy of 315.36 MU in a 90% dependable year. The Firm power capacity of the Hydroelectric Project is 48.2 MW.

SALIENT FEATURES
PENCH HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Nagpur
River	Pench
Type of Development	Storage
Nearest Railhead	Nagpur
Nearest Airport	Nagpur

LOCATION:

Dam : Latitude & Longitude	21°39'32.2"N, 79°13'53.4"E
Power House : Latitude & Longitude	21°39' 30"N, 79°14' E

HYDROLOGY:

Catchment Area (Sq. Km)	4275

DAM:

Type	Gravity
Length (m)	680
Height (m)	74.5

RESERVOIR:

Full Reservoir Level (FRL) (m)	490
Minimum Draw Down Level (MDDL) (m)	464
Live Storage (Mcum)	1088

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Length	261.6

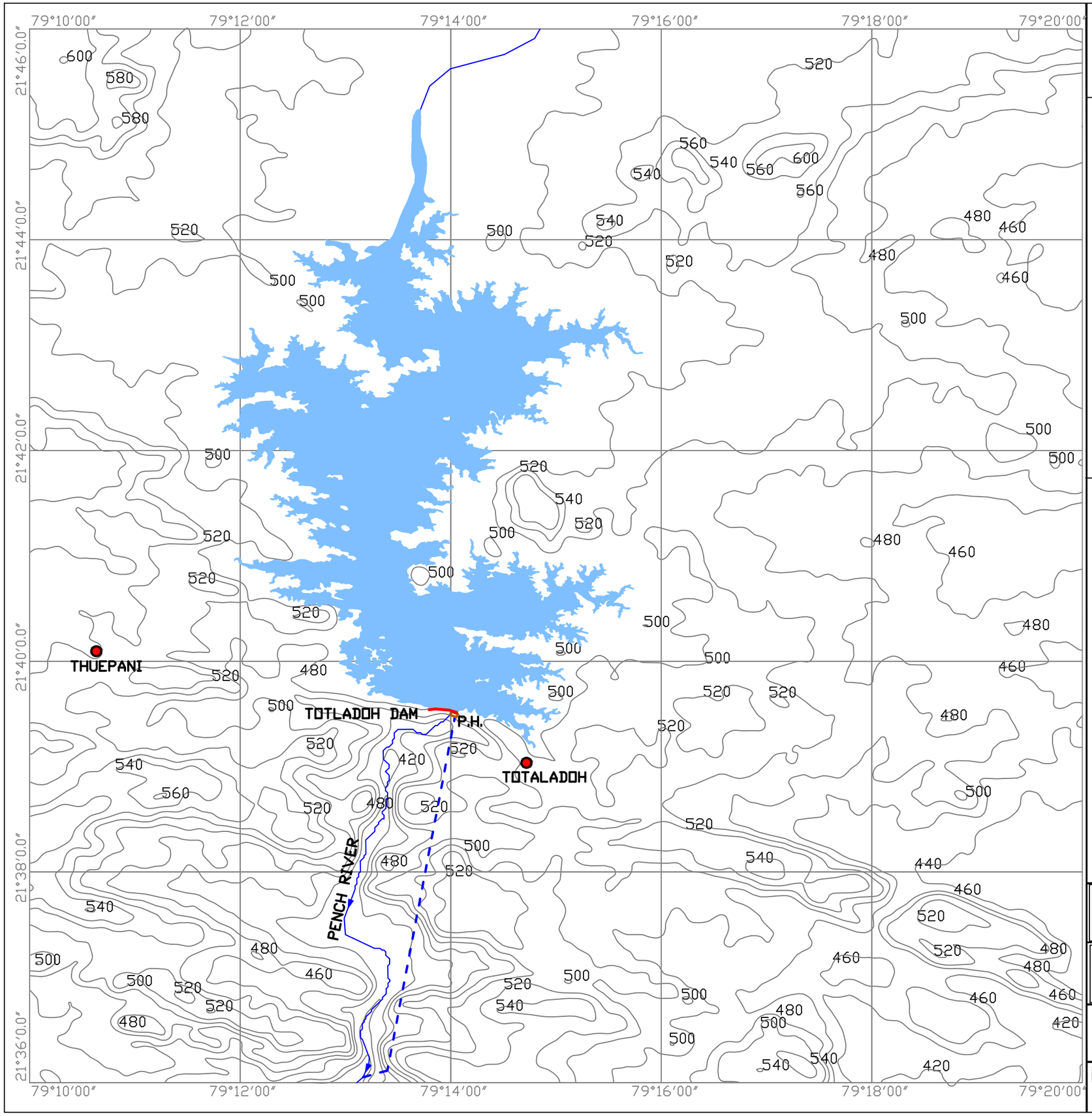
POWER HOUSE:

Type	Underground
No. of Generating Units	2
Capacity of each Unit (MW)	80
Firm Power (MW)	48.2

Installed Capacity (MW)	160
Rated Head (m)	150
Avg. Gross Head (Max.) (m)	159
Avg. Gross Head (Min.) (m)	133
Type of Turbine	Francis
Tail Water Level (TWL) (m)	327.5
Annual Energy (MU)	315.36

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	1986
Unit-II	1987



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

TOTLADOH DAM

FRL- 490 M

MDDL- 464 M

DAM HEIGHT- 74.5 M

LIVE STORAGE- 1088 MCuM

POWER HOUSE

TWL- 327.5 M

AVG. GROSS HEAD- 159 M

INST. CAPACITY- 160 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

PENCH HYDROELECTRIC PROJECT (2X80) = 160 MW

3.3 POCHAMPAD HYDROELECTRIC PROJECT (4x9MW=36MW)

1. INTRODUCTION

Pochampad Project is constructed on SRSP (Siram Sagar Project Dam). Pochampad Hydroelectric Project is a Storage type development located near Bussapur village approximately 4 km from the project site and utilizes the water of Godavari River for power generation. The project is designed to generate power, utilizing rated head of 21.35 m. The project has 4 units of 9 MW in surface power house to generate annual energy of 107.5 MU in 90% dependable year. Project was commissioned in between 1987-2010 and is executed by Telangana Power Generation Corporation Limited (TSGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of project is located at Latitude 18°58'7.8"N & Longitude 78°20'28.0"E. The Power house is located at Latitude 18°57'59.9"N & Longitude 78°20'41.4"E. Nizamabad is the nearest railway station and Hyderabad is the nearest airport.

3. PROJECT FEATURES

Pochampad Hydroelectric Project involves construction of 43m high and 1459 m long Composite dam. The reservoir formed by the dam has a live storage of 2297.67 Mcum between Full Reservoir Level (FRL) of 332.53 m and Minimum Draw down Level (MDDL) of 324.30m. The water conductor system comprises of circular Head Race Tunnel (HRT) of length 30.48 m and 4.27m diameter carrying water to the powerhouse. The powerhouse has 4 units of 9MW using Kaplan type turbine operated under rated head of 21.35 m with an Installed capacity of 36 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 35425 Sq. km.

5. POWER & ENERGY BENEFITS

Pochampad Hydroelectric Project has four units of 9 MW each with Installed Capacity of 36MW and the annual energy of the project is 107.5 MU in 90% dependable year.

SALIENT FEATURES
POCHAMPAD HYDROELECTRIC PROJECT

GENERAL:

State	Telangana
District	Nizambad
River	Godavari
Type of Development	Storage
Nearest Railhead	Nizamabad
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	18°58'07.8"N, 78°20'28.0"E
Power House : Latitude & Longitude	18°57'59.9"N, 78°20'41.4"E

HYDROLOGY:

Catchment Area (Sq. Km)	35425
Max. Annual Rainfall (mm)	1200
Min. Annual Rainfall (mm)	500
Mean Annual Rainfall (mm)	800

DAM:

Type	Composite
Length (m)	1459
Height (m)	43

RESERVOIR:

Full Reservoir Level (FRL) (m)	332.53
Minimum Draw Down Level (MDDL) (m)	324.30
Live Storage (Mcum)	2297.67
Gross Storage (Mcum)	3170.16

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Circular
Number	4

Length (m)	30.48
Diameter (m)	4.27

POWER HOUSE:

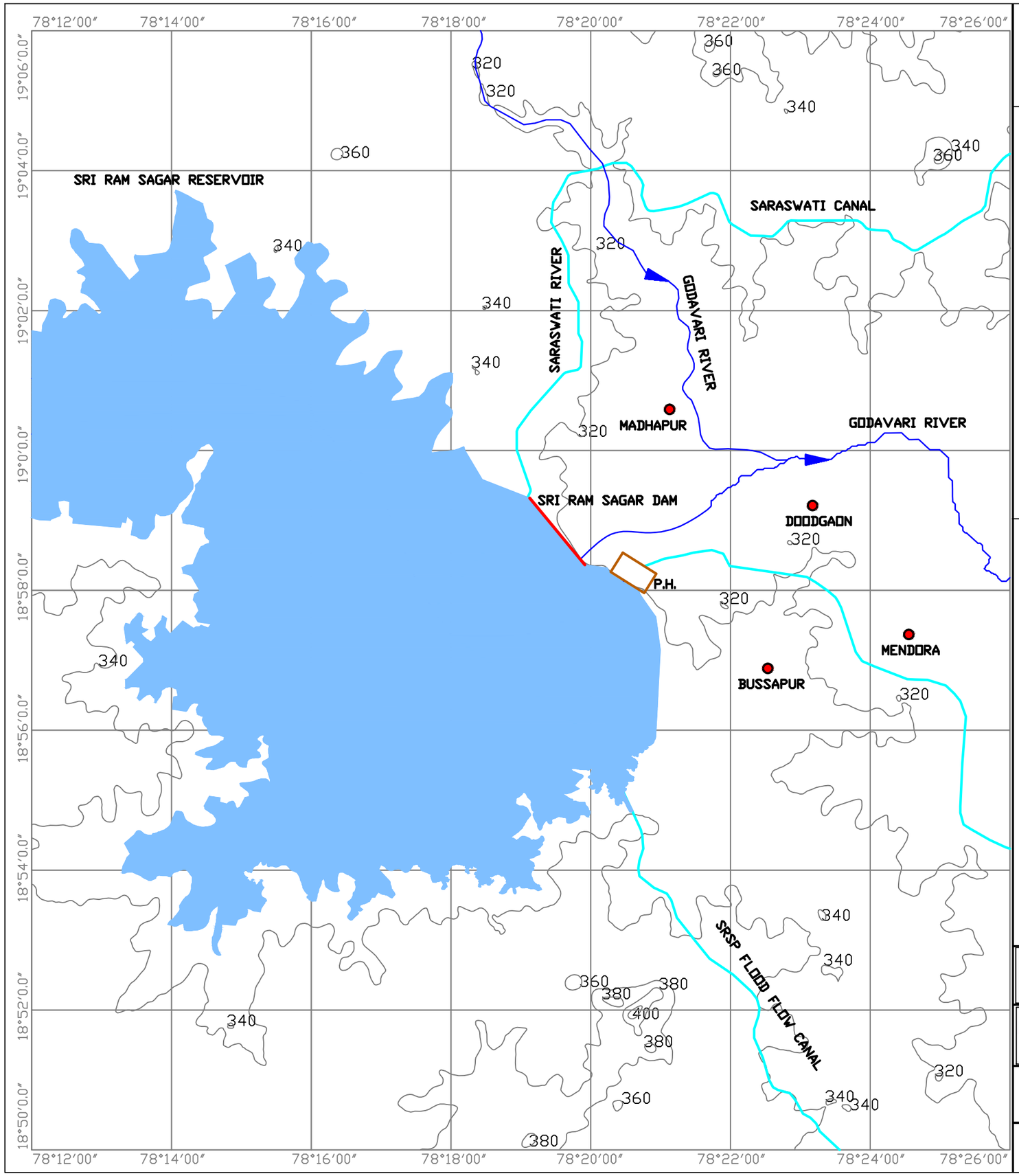
Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	9
Installed Capacity (MW)	36
Rated Head (m)	21.35
Avg. Gross Head (Max.) (m)	22.93
Avg. Gross Head (Min.) (m)	12.50
Type of Turbine	Vertical Kaplan
Tail Water Level (TWL) (m)	312.50
Design Discharge (Cumec/Unit)	45300
Annual Energy (MU)	107.5

COST ASPECTS:

Estimated Cost (Rs. Crores)	58 (Price Level,1984)
Levellised Tariff (Rs/KWh)	0.88

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1987
Unit- II	1987
Unit- III	1988
Unit- IV	2010



N

W E

S

LEGENDS.

- CONTOUR
- RIVER
- CANAL
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

SRI RAM SAGAR DAM

FRL- 332.53 M
MDDL- 324.3 M
DAM HEIGHT- 43 M
LIVE STORAGE- 2297.67 MCuM

POWER HOUSE

TWL- 312.5 M
AVARAGE HEAD- 22.93 M
INST. CAPACITY- 36 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

POCHAMPAD HYDROELECTRIC PROJECT
(4X9) = 36 MW

3.4 UPPER INDRAVATI HYDROELECTRIC PROJECT (4x150MW=600MW)

1. INTRODUCTION

Upper Indravati Hydroelectric project is a storage type development near Khatiguda approximately 6252m from the project site located in Kalahandi district of Odisha. The project utilize water of Indravati River for power generation. The project involve construction of 4 dams across the Indravati and its tributaries, 8 dykes and two inter-linking channels to from a single reservoir. The surface powerhouse has 4 units of 150 MW enabling installed capacity of 600 MW. The Project was commissioned in between 1999-2001 and executed by Odisha Hydro Power Corporation (OHPC).

2. LOCATION/ACCESSIBILITY

This hydroelectric project consist of 4 dams located on Indravati River. The first dam is Upper Indravati dam located at Latitude 19°16'33.9''N & Longitude 82°49'47''E, second dam is Podagada Dam at Latitude 19°13'49.7"N & Longitude 82°48'36.2"E, third dam is Kapur dam located at Latitude 19°11'47.3"N & Longitude 82°46'48.5"E and the fourth dam is Muran dam located at Latitude 19°06'20.7"N & Longitude 82°45'44.1"E. The powerhouse is located at Latitude 19°25'37.4''N & Longitude 82°51'34''E in Kalahandi district of Odisha. The nearest railway station is Jeypore railway station and the nearest Airport is Raipur airport.

3. PROJECT FEATURES

Indravati Hydroelectric project involves construction of 4 dam on Indravati River with formation of a reservoir with a gross storage capacity of 2300 Mcum between Full Reservoir Level (FRL) of 642 m and Minimum drawn down level (MDDL) of 625m. The water conductor system comprises of Head Race Tunnel (HRT) of length 4.32 km & 7 m diameter and 4 nos. of penstock of length 790 m which carries water to the power house. A surface power house with an installation of 4 units of 150 MW each operate under rated head of 360 m. The discharged water from surface powerhouse is carried back to the river by Tail Race Channel of length 9 km.

4. HYDROLOGY

The catchment area of the river upto the dam site is 2630 Sq. km.

5. POWER & ENERGY BENEFITS

The Upper Indravati Hydroelectric project has four units of 150 MW with installed capacity of 600 MW and design energy of the project is 1962 MU in 90 % dependable year at 95 % machine availability.

SALIENT FEATURES
UPPER INDRAVATI HYDROELECTRIC PROJECT

GENERAL:

State	Odisha
District	Kalahandi
River	Indravati
Type of Development	Storage
Nearest Railhead	Jeypore
Nearest Airport	Raipur

LOCATION:

Upper Indravati Dam : Latitude & Longitude	19°16'33.9" N, 82°49'47" E
Podagada Dam : Latitude & Longitude	19°13'49.7"N, 82°48'36.2"E
Kapur Dam : Latitude & Longitude	19°11'47.3"N, 82°46'48.5"E
Muran Dam : Latitude & Longitude	19°06'20.7"N, 82°45'44.1"E
Power House : Latitude & Longitude	19°25'37.4" N, 82°51'34"E

HYDROLOGY:

Catchment Area (Sq. Km)	2630

DAM:

Type	Masonry Gravity
Length (m)	531
Height (m)	45

RESERVOIR:

Full Reservoir Level (FRL) (m)	642
Minimum Draw Down Level (MDDL) (m)	625
Live Storage (Mcum)	1435.5
Gross Storage (Mcum)	2300

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Length (m)	4320

Diameter (m)	7
PENSTOCK	
Number	4
Length (m)	790
Diameter (m)	5.25

POWER HOUSE:

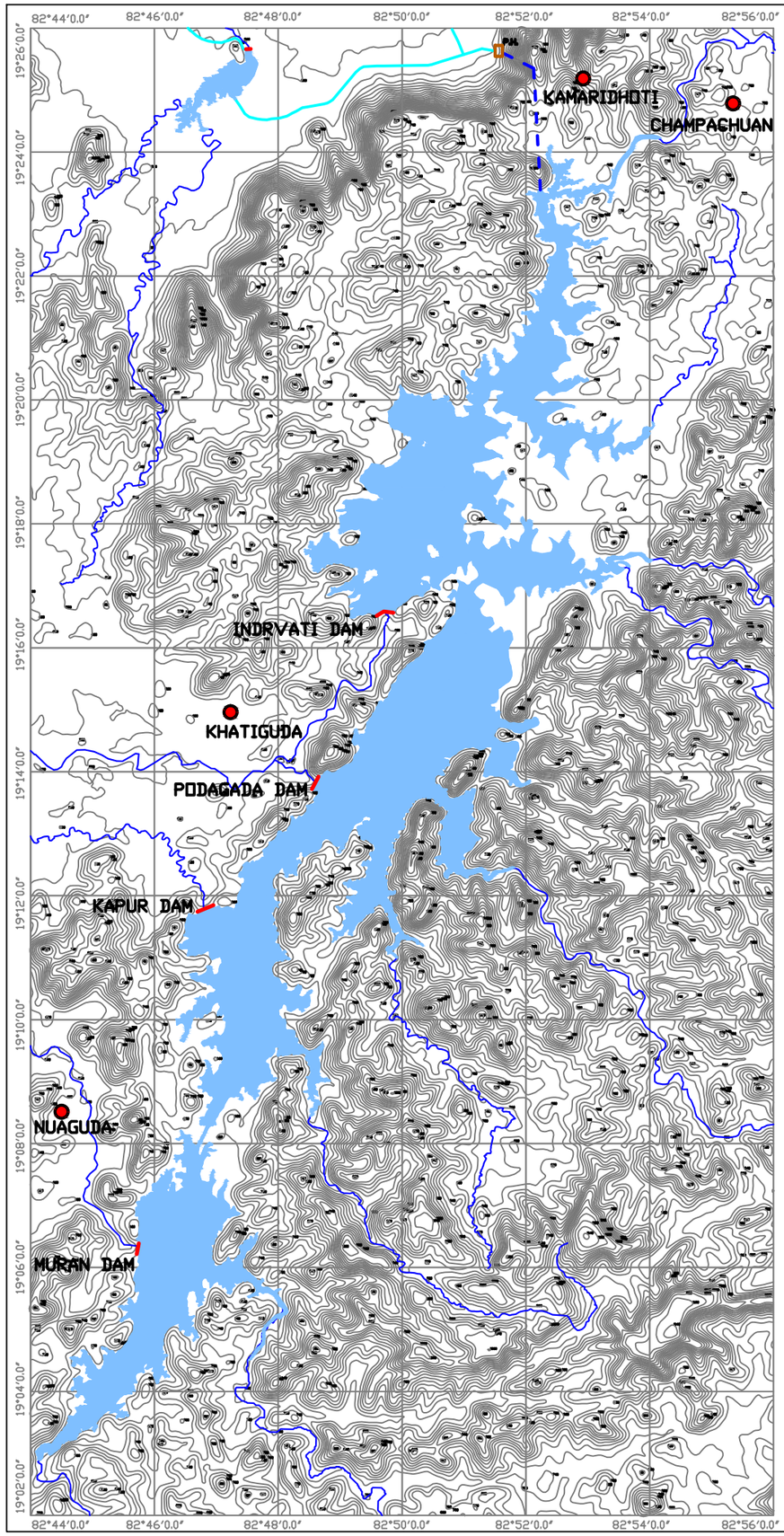
Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	150
Installed Capacity (MW)	600
Rated Head (m)	360
Net Head (Max.) (m)	379
Net Head (Min.)(m)	358
Type of Turbine	Francis
Tail Water Level (TWL) (Min.) (m)	263
Tail Water Level (TWL) (Max.) (m)	267
Design Discharge (Cumec/Unit)	210
Design Energy (MU)	1962

COST ASPECTS:

Levellised Tariff (Rs/KWh)	38.784 (For FY 2017-18)

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit -I	1999
Unit -II	1999
Unit -III	2000
Unit -IV	2001





LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- CANAL
- RESERVOIR
- TOWN/VILLAGE
- CONTOUR INTERVAL - 20M

UPPER INDRAVATI DAM

FRL- 642 M

MDDL- 625 M

DAM HEIGHT- 45 M

LIVE STORAGE- 1435.5 MCuM

POWER HOUSE

TWL- 263 M

RATED HEAD- 360 M

INST. CAPACITY- 600 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

UPPER INDRAVATI HYDROELECTRIC PROJECT
(4X150) = 600MW

3.5 UPPER KOLAB HYDROELECTRIC PROJECT (4x80MW=320MW)

1. INTRODUCTION

Upper Kolab Hydroelectric Project is a storage type development located near Machhara-I village approximately 6 km from the project site in Koraput district of Odisha and utilizes the water of Kolab River for power generation. The project is designed to generate power, utilizing rated head of 241.72 m. The project has 4 units of 80 MW each in an underground power house to generate design energy of 832.2 MU in 90% dependable year at 95 % machine availability. Project was commissioned in between 1988-93 and is executed by Odisha Hydro Power Corporation Limited (OHPC).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 18°47'18''N & Longitude 82° 36'02''E and the power house is located at Latitude 18°49'53.9''N & Longitude 82°35'37.1''E in Koraput district of Odisha. Koraput is the nearest railway station and Visakhapatnam is the nearest reachable airport.

3. PROJECT FEATURES

Upper Kolab Hydroelectric Project involves construction of 54.5m high and 630.5 m long concrete cum masonry dam. The reservoir formed by the dam has a live storage of 935 Mcum between Full Reservoir Level (FRL) of 858 m and Minimum Draw down Level (MDDL) of 844 m. The water conductor system comprise of Head Race Tunnel (HRT) of length 4770m and 4 nos of penstock of length 537m and 3.5 m diameter which carries water to the powerhouse. The powerhouse has 4 units of 80 MW using Francis turbine and operate under rated head of 241.72 m with installed capacity of 320 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 1630 Sq. Km.

5. POWER & ENERGY BENEFITS

Upper Kolab Hydroelectric Project has four units of 80 MW with Installed Capacity of 320MW and the design energy of the project is 832.2 MU in 90% dependable year at 95 % machine availability.

6. HISTORICAL BACKGROUND

Preliminary investigations for the project were carried out by the Goverment of Madras before April 1936. At that time Koraput district was a part of Madras Presidency and subsequently detailed investigations were carried out by Govt. of odisha after 1961. The present proposal was finalised after investigating

several proposals with alternative dam sites and water conductor systems. The first stage work of power project for installation of 3 nos. 80MW Hydro Generator Units along with associated water conductor system, reservoir, tailrace channel etc. was approved by the Planning commission Govt. of India during August 1975 and that of Irrigation project in June 1976. The second stage work of Power Project for installation of 1 x 80 MW generating unit was approved by the Planning Commission, Govt. of India in 1987.

SALIENT FEATURES
UPPER KOLAB HYDROELECTRIC PROJECT

GENERAL:

State	Odisha
District	Koraput
River	Kolab
Type of Development	Storage
Nearest Railhead	Koraput
Nearest Airport	Visakhapatnam

LOCATION:

Dam : Latitude & Longitude	18°47'18"N, 82°36'02"E
Power House : Latitude & Longitude	18°49' 53.9"N, 82°35'37.1"E

HYDROLOGY:

Catchment Area (Sq. Km)	1630

DAM:

Type	Concrete cum Masonry
Height (m)	54.5
Length (m)	630.5

RESERVOIR:

Full Reservoir Level (FRL) (m)	858
Minimum Draw Down Level (MDDL) (m)	844
Live Storage (Mcum)	935
Gross Storage (Mcum)	1215

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Length (m)	4770
PENSTOCK	
Number	4
Length(m)	537
Diameter (m)	3.5

SURGE TANK	
Type	Simple Type
Diameter (m)	15
Depth	145

POWER HOUSE:

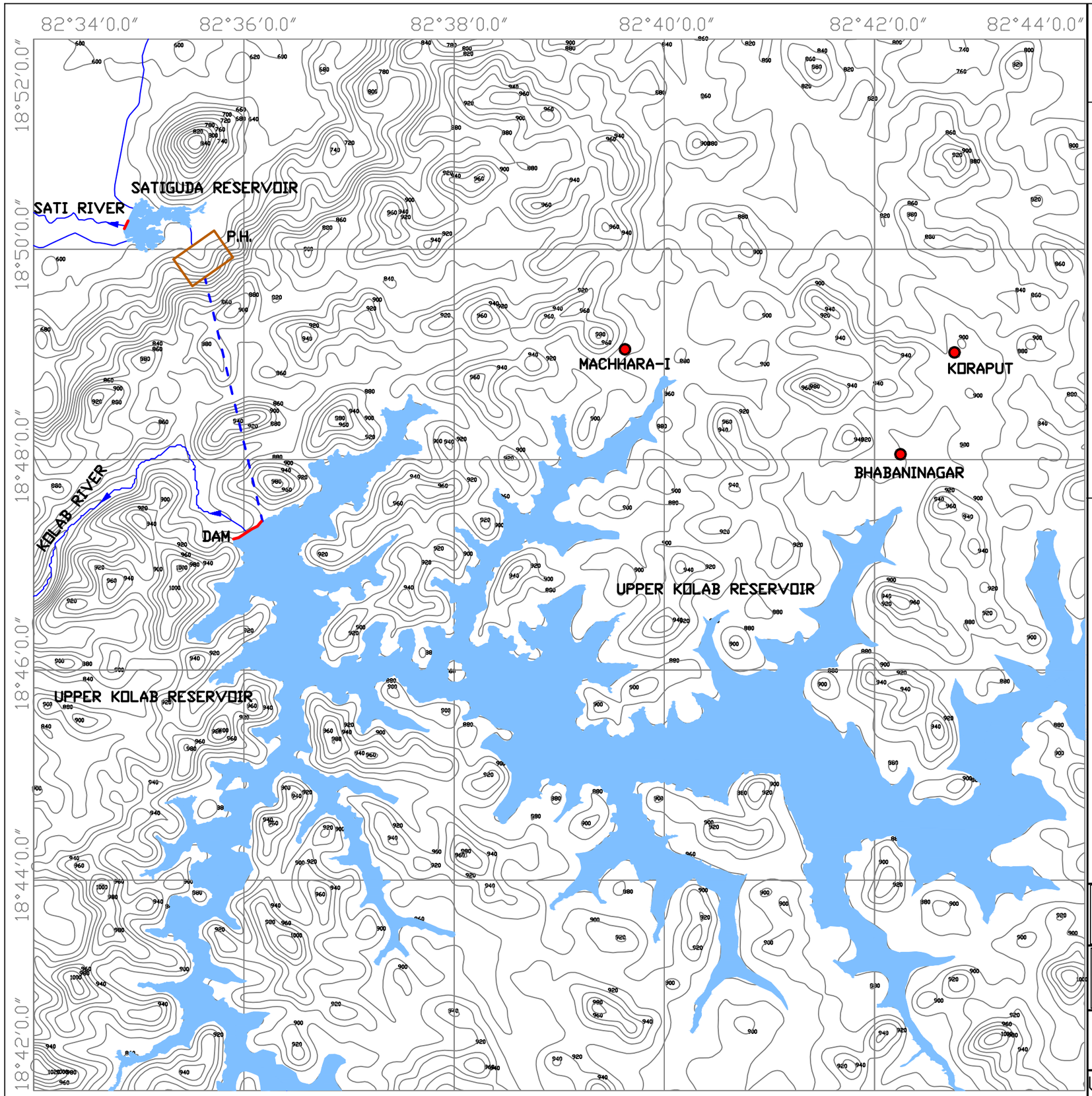
Type	Underground
No. of Generating Units	4
Capacity of each Unit (MW)	80
Firm Power (MW)	95
Installed Capacity (MW)	320
Rated Head (m)	241.72
Avg. Gross Head (m)	264
Type of Turbine	Francis
Tail Water Level (TWL) (Max.)(m)	595.2
Tail Water Level (TWL) (Min.) (m)	587.68
Design Energy (MU)	832.2

COST ASPECTS:

Levellised Tariff (Paisa)	27.872

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1988
Unit- II	1988
Unit- III	1990
Unit- IV	1993



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KOLAB DAM

FRL- 858 M

MDDL- 844 M

DAM HEIGHT- 54.5 M

LIVE STORAGE- 935.00 MCuM

POWER HOUSE

TWL- 587.68 M

AVERAGE GROSS HEAD- 264 M

INST. CAPACITY- 320 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

UPPER KOLAB HYDROELECTRIC PROJECT
(4X80) = 320 MW

3.6 MACHKUND HYDROELECTRIC PROJECT (3X17MW+3X23MW=120MW)

1. INTRODUCTION

Machkund Hydroelectric (Joint) Project is an Inter-State Project of Government of Andhra Pradesh and Government of Odisha. The Project is located on the western slopes of the Eastern Ghats near the well known Duduma falls on Machkund River. As per the Inter State Agreement, Andhra Pradesh and Odisha share the capital expenditure and power benefits in the ratio of 70:30 respectively.

Machkund Hydroelectric Project is a storage type development located near Kuyilongi village approximately 5.34 km from project site in Koraput district of Odisha. The project utilizes the water of Machkund River, harnessing rated head of 245.36 m. The project has 3 units of 17 MW and 3 units of 23 MW enabling total installed capacity of 120 MW. The annual energy generation of the project is 630 MU in 90% dependable year. All the units were commissioned in between 1955-59 and is executed by Andhra Pradesh Power Generation Cooperation limited (APGENCO).

2. LOCATION/ACCESSIBILITY

The dam site is located at Latitude 18°27'33.15"N & Longitude 82°32'54.49"E with diversion dam located at Longitude 82°27'51.9"E & Latitude 18°31'57.2"N. The Power house has Latitude 18°30'31.1"N & Longitude 82°26'30.1"E. Visakhapatnam is the nearest railway station and Airport.

3. PROJECT FEATURES

Machkund Hydroelectric Project involves construction of 60.65m high and 419m long Jalaput dam. The reservoir formed by the dam has a live storage of 892.24 Mcum between Full Reservoir Level (FRL) of 838.2m and Minimum Draw Down Level (MDDL) of 818.38 m. A diversion dam is constructed at downstream of Jalaput Dam to divert the water into the power canal. Water conductor system comprises of 6 no. of penstocks of length 504.75m each to carry water to surface powerhouse. The powerhouse has 3 units of 17 MW and 3 units of 23 MW using Francis turbine and operate under rated head of 245.36m with total installed capacity of 120 MW. 6 nos. of Tail Race Tunnel/Channel of diameter 4.8 m carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river upto dam site is 1955 Sq. Km.

5. POWER & ENERGY BENEFITS

Power from Machkund Hydroelectric project is being shared in the ratio of 70:30 between Andhra Pradesh & Odisha. The Project has three units of 17 MW and three units of 23MW with total installed Capacity of 120 MW and the annual anergy of the project is 630 MU in 90% dependable year.

6. HISTORICAL BACKGROUND

Machhakund (or Machkund) Hydroelectric Project is located near Duduma Falls between the Andhra Pradesh and Odisha Border. It is a collaborative project of Government of Andhra Pradesh and Government of Odisha. The Maharaja of Jeypore conceived the idea of a dam in 1928. Although the planning for the project started in 1930's, the actual displacement began in the late 1940s. As the project was started before independence, no proper records for the displacement and rehabilitation are available. Also, the concept of rehabilitation was not evolved at that time.

In the latest conflict, local villagers surrounding the hydroelectric plant had disrupted the power generation function of the plant in December 2010. The agitators protested and their demands were local infrastructure development and jobs in the project.

Following the agitations by the villagers living in close proximity of the plant, power generation at Machkund Hydroelectric Plant was severely disturbed. This was followed by a power supply crisis in various parts in Andhra Pradesh and Odisha.

SALIENT FEATURES
MACHKUND HYDROELECTRIC PROJECT

GENERAL:

State	Odisha
District	Koraput
River	Machkund
Type of Development	Storage
Nearest Railhead	Visakhapatnam
Nearest Airport	Visakhapatnam

LOCATION:

Jalaput Dam : Latitude & Longitude	18°27'33.15"N, 82°32'54.49"E
Diversion Dam : Latitude & Longitude	18°31'57.2"N, 82°27'51.9"E
Power House : Latitude & Longitude	18°30'31.1"N, 82°26'30.1"E

HYDROLOGY:

Catchment Area (Sq. Km)	1955
Max. Annual Rainfall (mm)	200
Min. Annual Rainfall (mm)	100
Mean Annual Rainfall (mm)	150

DAM:

Type	Gravity, Masonry
Height (m)	60.65
Length (m)	419

RESERVOIR:

Full Reservoir Level (FRL) (m)	838.2
Minimum Draw Down Level (MDDL) (m)	818.38
Live Storage (Mcum)	892.24
Gross Storage (Mcum)	970.26

INTAKE:

Gate No.	2

Size (m)	2.43 x 3.65

WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	6
Length (m)	504.75
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangle
Number	6
Length (m)	4.83

POWER HOUSE:

Type	Francis
No. of Generating Units	6
Capacity of each Unit (MW)	3 units of 17 MW & 3 units of 23 MW
Installed Capacity (MW)	120
Rated Head (m)	245.36
Avg. Gross Head (Max.) (m)	266
Avg. Gross Head (Min.) (m)	258
Type of Turbine	Surface
Tail Water Level (TWL) (m)	510.84
Design Discharge (Cumecs)	Stage I : 8.495 Stage II : 11.32
Annual Energy (MU)	630

COST ASPECTS:

Estimated Cost (Rs. Crores)	1.475 (Price Level, 1946)
Levellised Tariff (Rs/kWh)	1.40

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	1955
Unit-II	1955
Unit-III	1956

Unit-IV	1959
Unit-V	1959
Unit -VI	1959

82°24'0.0" 82°26'0.0" 82°28'0.0" 82°30'0.0" 82°32'0.0" 82°34'0.0" 82°36'0.0"

18°34'0.0" 18°32'0.0" 18°30'0.0" 18°28'0.0" 18°26'0.0" 18°24'0.0"

BADIGADA

DIVERSION DAM

ONUKUDELLI

P.H.

DORAGUDA

MACHKUND RIVER

MACHKUND RIVER

JALAPUT DAM

KUYILONGI

N

W E

S

LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

CANAL

TRT

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

JALAPUT DAM

FRL- 838.2 M

MDDL- 818.38 M

DAM HEIGHT- 60.65 M

LIVE STORAGE- 892.24 MCuM

POWER HOUSE

TWL- 510.84 M

AVERAGE HEAD- 266 M

INST. CAPACITY- 120 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MACHKUND HYDROELECTRIC PROJECT
(3X17+3X23) = 120 MW

3.7 BALIMELA HYDROELECTRIC PROJECT (6X60MW+2X75MW=510MW)

1. INTRODUCTION

Balimela Hydroelectric projet is a storage type development near Chitrakonda village approximately 3.6 km from project site in Malkangiri district of Odisha. The project utilizes the water of Sileru River for power generation, harnessing rated head of 274 m. Balimela Hydroelectric project is in cascading with Machkund Hydroelectric project. The water released from Machkund Power House and the inflow from intermediate catchment between Machkund-Balimela Dam is impounded by an Earth-cum-Rock fill at Chitrakonda known as Balimela Dam. This project was commissioned in between 1973-2009 and is executed by Odisha Hydro Power Corporation (OHPC).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Sileru river having Latitude 18°8'25'' N & Longitude 82°7'22''E and the power house is located at Latitude 18°12' 26.7''N & Longitude 82°3'37''E in Malkangiri district of Odisha. The nearest railway station is Jagdalpur and nearest airport is Rajahmundry Airport.

3. PROJECT FEATURES

Balimela Hydroeletcric project involves construction of an Earth cum Rockfill dam of height 70 m and length 1823 m. The project has a Full Reservoir level (FRL) of 462.7m and Minimum drawn down level (MDDL) of 438.9 m. The water conductor system comprises of a Head Race Tunnel (HRT) of length 4036.05 m with 4 nos of Penstock of length 183 m carrying water to the surface powerhouse. The surface power house has 6 units of 60 MW & 2 units of 75 MW each operating under rated head of 274 m with a total installed capacity of 510 MW. The dischargd water from surface powerhouse is carried back to the river by Tail Race Channel/Tunnel.

4. HYDROLOGY

The catchment area of river upto dam site is 4910 Sq. km.

5. POWER & ENERGY BENEFITS

The Balimela Hydroelectric project has six units of 60 MW and two units of 75 MW each with total installed capacity of 510 MW. The project has a design energy 1183 MU in 90% dependable year at 95% machine availability and Firm power capacity of 135 MW.

SALIENT FEATURES
BALIMELA HYDROELECTRIC PROJECT

GENERAL:

State	Odisha
District	Malkangiri
River	Sileru
Type of Development	Storage
Nearest Railhead	Jagdalpur
Nearest Airport	Rajahmundry Airport

LOCATION:

Dam : Latitude & Longitude	18°8'25''N, 82°7'22''E
Power House : Latitude & Longitude	18°12'26.7''N, 82°3'37''E

HYDROLOGY:

Catchment Area (Sq. Km)	4910

DAM:

Type	Earth cum- rock filled dam
Length (m)	1823
Height (m)	70

RESERVOIR:

Full Reservoir Level (FRL) (m)	462.7
Minimum Draw Down Level (MDDL) (m)	438.9
Live Storage (Mcum)	2676.04

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Length (m)	4036.05
PENSTOCK	
Number	4
Length (m)	183
Diameter (m)	3.70
SURGE TANK	

Diametre (m)	20
Height (m)	79

POWER HOUSE:

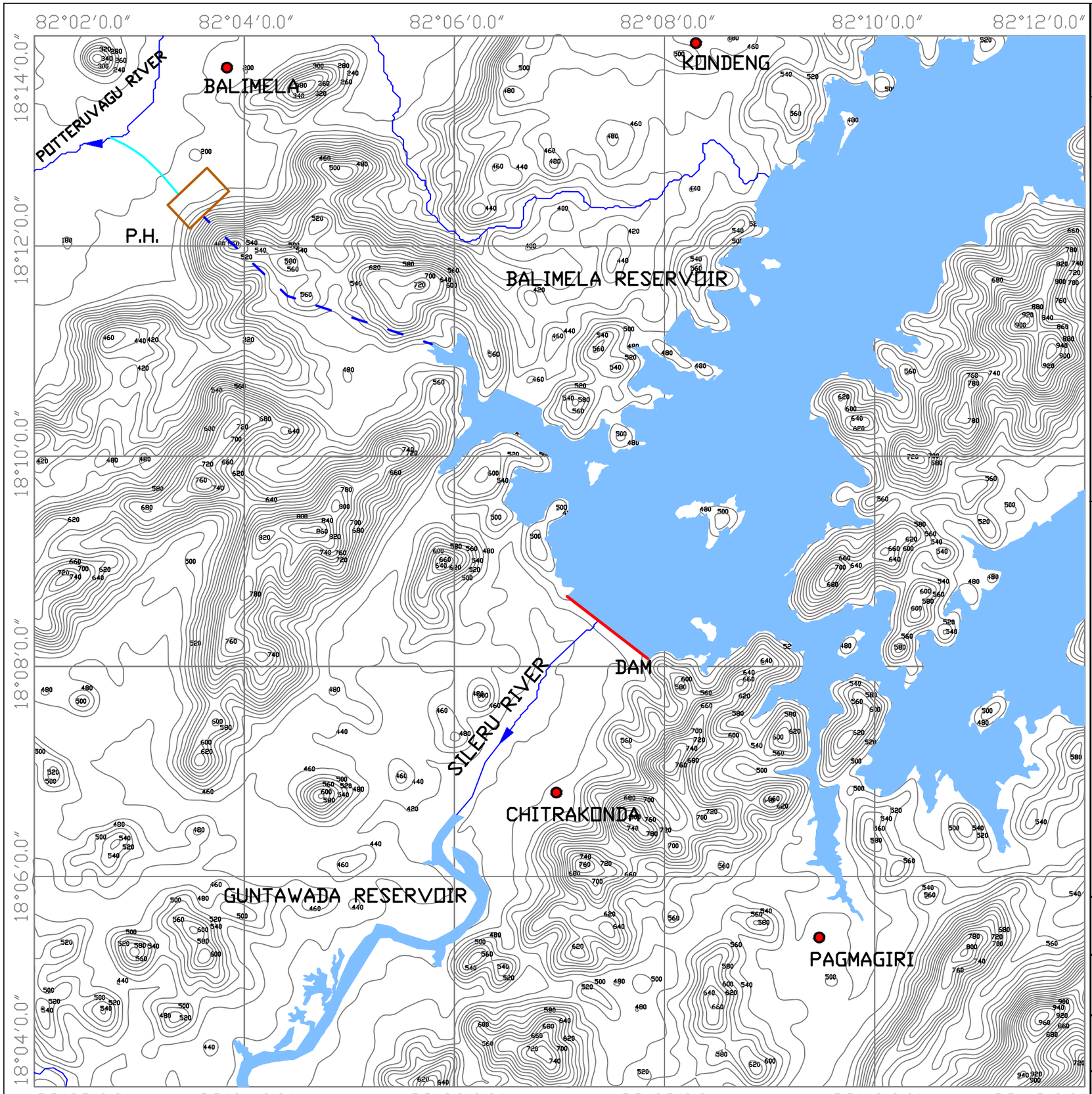
No. of Generating Units	8
Capacity of each Unit (MW)	6 units of 60MW & 2 units of 75 MW
Firm Power (MW)	135
Installed Capacity (MW)	510
Rated Head (m)	274
Gross Head (m)	285.3
Type of Turbine	Francis
Tail Water Level (TWL) (Min.) (m)	162.33
Tail Water Level (TWL) (Max.) (m)	173.20
Design Energy (MU)	1183

COST ASPECTS:

Levellised Tariff (Paisa)	41.252 for the year FY 2017-18
Estimated cost (Rs. Crores)	539.74 (tentative upto 31.03.2017)

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	1973
Unit-II & Unit-III	1974
Unit-IV	1975
Unit-V	1976
Unit-VI	1977
Unit-VII	2008
Unit-VIII	2009



N

W E

S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- CHANNEL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BALIMELA DAM

FRL- 462.7 M
MDDL- 438.9 M
DAM HEIGHT- 70 M
LIVE STORAGE-2676.04 MCuM

POWER HOUSE

TWL- 162.33 M
RATED HEAD- 274 M
INST. CAPACITY- 510 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

वाप्कोस लिमिटेड
WAPCOS LIMITED

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BALIMELA HYDROELECTRIC PROJECT
(6X60)+(2X75) = 510 MW

3.8 UPPER SILERU- I & II HYDROELECTRIC PROJECT (4x60MW=240MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Upper Sileru Hydroelectric Project. Presently, the project is named as Upper Sileru-I & II Hydroelectric Project. Upper Sileru-I & II Hydroelectric Project is a storage type development near Sileru village approximately 1500 m from the project site located in Visakhapatnam district of Andhra pradesh. The project utilizes water of Sileru River for power generation. The water Water is drawn from a weir constructed across Sileru River at Guntawada 9 miles downstream of Balimela Reservoir. The Surface powerhouse has 4 units of 60 MW enabling installed capacity of 240 MW to generate annual energy of 375 MU in 90% dependable year. The project was commissioned in 1967-95 and is executed by Andhra Pradesh Power Generation Corporation (APGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Sileru River having a Guntawada Weir and two Forebay Embankements. Guntawada Weir is located at Latitude 18°03'34.9"N & Longitude 82°02'21.1"E. The first Forebay Embankment is located at Latitude 18°02'57.2"N & Longitude 82°01'22.2"E. The second Forebay Embankment is located at Latitude 18°03'06.3"N & Longitude 82°01'47.5"E with a Power house located at Latitude 18°02'13.99''N & Longitude 82°01'9.43''E in Visakhapatnam district of Andhra Pradesh.

The nearest railway station is Narsipatnam and the nearest airport is Visakhapatnam from the project site.

3. PROJECT FEATURES

Upper Sileru-I&II Hydroelectric Project involves construction of a dam at Guntawada and utilizing max net head of 94.48 m bypassing a 'U' bend of the river below Guntawada village. The Balancing reservoir formed for this project has live storage of 88 Mcum between Full Reservoir Level (FRL) 414.53 m and Minimum drawn down level (MDDL) 406.45 m. The water conductor system comprises of of Penstocks which carries water to powerhouse. The Project has a surface power house operated under rated head of 94.48 m enabling installed capacity of 260 MW. The project has a Tail Water Level (TWL) of

318.56 m. The discharged water from powerhouse is carried back to the river by Tail Race Tunnel/ Channel.

4. HYDROLOGY

The Catchment area of the river upto the dam site is 5164.43 Sq.Km.

5. POWER & ENERGY BENEFITS

Upper Sileru-I & II Hydroelectric Project has installed capacity of 240 MW. The project has an Annual energy of 375 MU in 90% dependable year.

SALIENT FEATURES
UPPER SILERU- I & II HYDROELECTRIC PROJECT

GENERAL:

State	Andhra Pradesh
District	Visakhapatnam
River	Sileru
Type of Development	Storage
Nearest Railhead	Narsipatnam
Nearest Airport	Visakhapatnam

LOCATION:

Guntawada Weir : Latitude & Longitude	18°03'34.9"N, 82°02'21.1"E
Forebay Embankement 1 :Latitude & Longitude	18°02'57.2"N, 82°01'22.2"E
Forebay Embankement 2 :Latitude & Longitude	18°03'06.3"N, 82°01'47.5"E
Power House : Latitude & Longitude	18°02'13.99"N, 82°01'9.43"E

HYDROLOGY:

Catchment Area (Sq. Km)	5164.43

DAM:

Type	Composite
Length (m)	624.8
Height (m)	22.5

RESERVOIR:

Full Reservoir Level (FRL) (m)	414.53
Minimum Draw Down Level (MDDL) (m)	406.45
Live Storage (Mcum)	88
Gross Storage (Mcum)	122.53

POWER HOUSE:

Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	60

Installed Capacity (MW)	240
Rated Head (m)	94.48
Avg. Gross Head (Max.) (m)	88.39
Avg. Gross Head (Min.) (m)	92.65
Type of Turbine	Francis
Tail Water Level (TWL) (m)	318.51
Design Discharge through Machine (Cusecs)	1800
Annual Energy (MU)	375

COST ASPECTS:

Estimated cost (Rs. Crores)	18.06
Levellised Tariff (Rs/KWh)	1.77

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	1967
Unit-II	1968
Unit-III	1994
Unit-IV	1995

82°0'0.0" 82°02'0.0" 82°04'0.0" 82°06'0.0"

18°08'0.0"

18°06'0.0"

18°04'0.0"

18°02'0.0"

RAMPUR

GUNTABEDA

KAMALPUR

GUNTAWADA RESERVOIR

SILERU RIVER

GUNTAWADA WEIR

SILERU

KATRAGEDDA

FOREBAY DAM

P.H.

LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

HRT

TRT

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

UPPER SILERU-I&II DAM

FRL- 414.53 M

MDDL- 406.45 M

DAM HEIGHT- 22.5 M

LIVE STORAGE- 88 MCuM

POWER HOUSE

TWL- 318.51 M

RATED HEAD- 94.48 M

INST. CAPACITY- 240 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

UPPER SILERU-I&II HYDROELECTRIC PROJECT
(4X60) = 240MW

3.9 LOWER SILERU HYDROELECTRIC PROJECT (4x115MW=460MW)

1. INTRODUCTION

Lower Sileru Hydroelectric Project is a storage type of development near Gunthabeda approximately 1650 m from the project site located in East Godavari district of Andhra Pradesh. The project utilizes the water of Sileru River for power generation, harnessing rated head of 188.97 m. The surface powerhouse has 4 units of 115 MW enabling installed capacity of 460 MW generating annual energy of 1050 MU in 90% dependable year. The Project was commissioned in between 1976-78 and is executed by Andhra Pradesh Power Generation Corporation Limited (APGENCO).

2. LOCATION/ACCESSIBILITY

The Lower Sileru Hydroelectric Project is located on Sileru River consist of 3 dams and a forebay. The first dam is Donkarayi dam located at Latitude 17°56'03.8"N & Longitude 81°47'41.9"E along with left flank saddle dam which act as intake for project is located at Latitude 17°55'59.1"N & Longitude 81°48'39.0"E. The Alimeru pickup dam is located at Latitude 17°53'13.6"N & Longitude 81°46'29.3"E. The Forebay dam is located at Latitude 17°51'54.6"N & Longitude 81°42'06.4"E with a Powerhouse located at Latitude 17°52' 12.88''N & Longitude 81°39'33.50''E. The nearest railway station is Narsipatnam road railway station and the nearest airport is Rajahmundry Airport.

3. PROJECT FEATURES

Lower Sileru hydroelectric project involves construction of 3 dams and one forebay. The Donkarayi Dam has a Full reservoir level (FRL) of 316.07m and Minimum drawn down level (MDDL) of 291.084m utilized for power generation by utilizing a net rated head of 188.98m. The water is carried to a Forebay pond of Full reservoir level (FRL) 283.4m and Minimum drawn down level (MDDL) of 280.41m. The water conductor system comprises of Head Race Tunnel (HRT) and Penstocks which carries water to powerhouse. The Project has a Surface power house operated under net rated head of 188.97 m enabling installed capacity of 460 MW. The discharged water from Powerhouse is carried back to the river by Tail Race Tunnel /channel of length 77.724 m.

4. HYDROLOGY

The catchment area of the river upto the dam site is 4908 Sq km.

5. POWER & ENERGY BENEFITS

The Lower Sileru Hydroelectic project has four units of 115 MW each with an installed capacity of 460 MW. The project has an annual energy of 1050 MU in 90% dependable year.

SALIENT FEATURES
LOWER SILERU HYDROELECTRIC PROJECT

GENERAL:

State	Andhra Pradesh
District	East Godavari
River	Sileru
Type of Development	Storage
Nearest Railhead	Narsipatnam
Nearest Airport	Rajahmundry

LOCATION:

Donkarayi Dam : Latitude & Longitude	17°56'03.8"N, 81°47'41.9"E
Left flank Saddle Dam : Latitude & Longitude	17°55'59.1"N, 81°48'39.0"E
Alimeru Vagu Pickup Dam : Latitude & Longitude	17°53'13.6"N, 81°46'29.3"E
Forebay Dam : Latitude & Longitude	17°51'54.6"N, 81°42'06.4"E
Power House : Latitude & Longitude	17°52'12.8"N, 81°39'33.5" E

HYDROLOGY:

Catchment Area (Sq. Km)	4908
Max flood discharge (Cusecs)	275500

DAM:

Type	Composite
Length (m)-Forebay	1356.3
Height (m)-Forebay	15.24

RESERVOIR:	**Donkarayi Dam**	**Forebay**
Full Reservoir Level (FRL) (m)	316.07	283.46
Minimum Draw Down Level (MDDL) (m)	291	280.41
Live Storage (Mcum)	375.17	3.96
Gross Storage (Mcum)	466.95	

WATER CONDUCTOR SYSTEM:

TAIL RACE TUNNEL/CHANNEL	
Length (m)	77.724

POWER HOUSE:

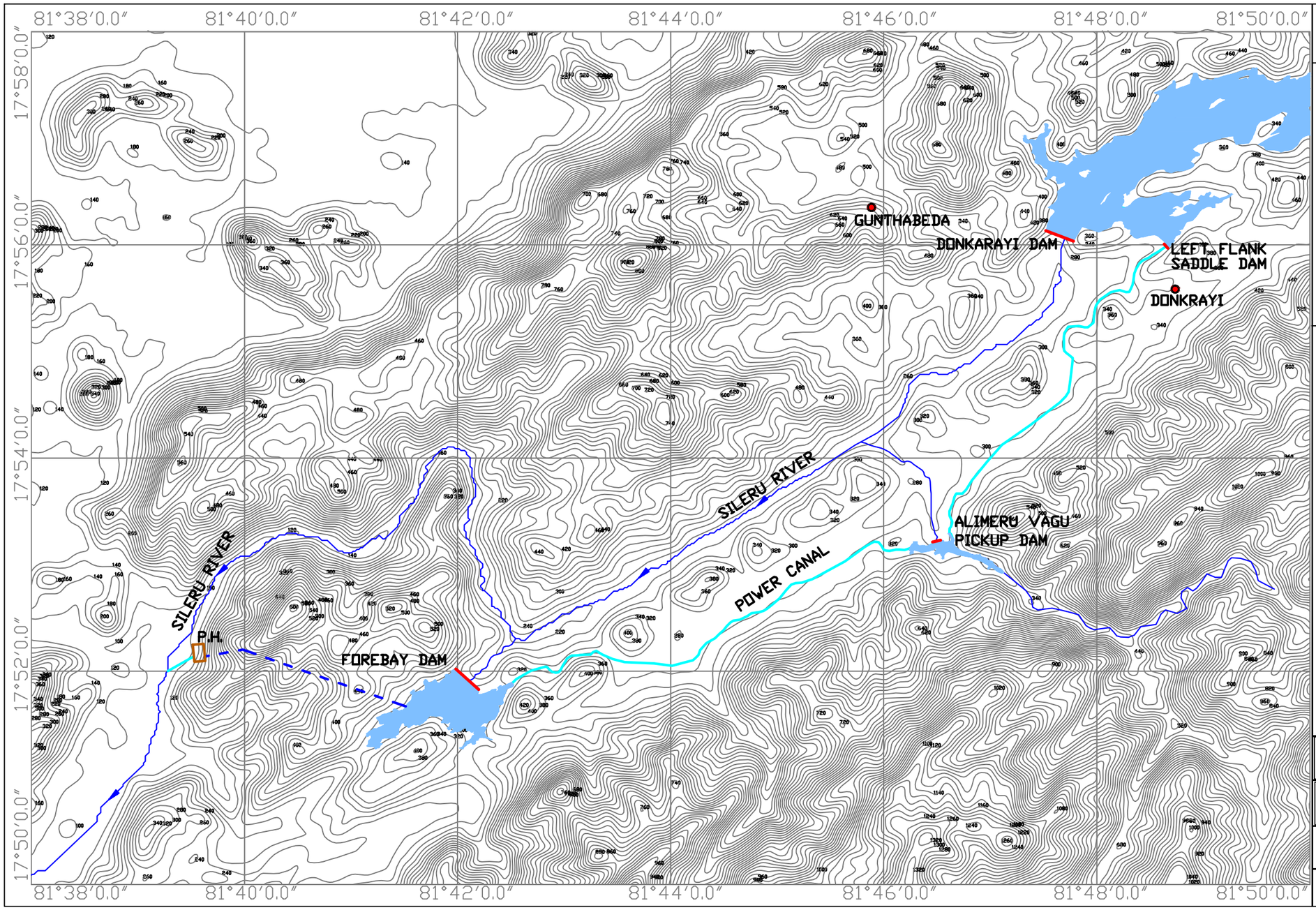
Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	115
Installed Capacity (MW)	460
Net Rated Head (m)	188.97
Type of Turbine	Francis
Tail Water Level (TWL) (m)	77.72
Design Discharge (Cumecs)	72
Annual Energy (MU)	1050

COST ASPECTS:

Levellised Tariff (Rs/KWh)	1.38

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	1976
Unit-II	1976
Unit-III	1977
Unit-IV	1978



LEGENDS.

- CONTOUR
- RIVER
- CANAL
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE
- CONTOUR INTERVAL - 20M

DONKARAYI DAM

FRL- 316.07 M
MDDL- 291 M
LIVE STORAGE- 375.17 MCuM

FOREBAY DAM

FRL- 283.46 M
MDDL- 280.41 M
DAM HEIGHT- 15.24 M
LIVE STORAGE- 3.96 MCuM

POWER HOUSE

TWL- 77.72 M
NET RATED HEAD - 188.97 M
INST. CAPACITY- 460 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER SILERU HYDROELECTRIC PROJECT
(4X115) = 460 MW

3.10 BHIVPURI HYDROELECTRIC PROJECT (3x24MW+2x1.5MW=75 MW)

1. INTRODUCTION

Bhivpuri Hydroelectric Project is a storage type development near Wahangaon village approximately 5608m from the project site located in Raigad district of Maharashtra. The project utilizes the water of Andhra River for power generation by harnessing rated head of 531 m. The surface powerhouse has 3 units of 24 MW and 2 units of 1.5 MW enabling total installed capacity of 75 MW generating annual energy of 193.23 MU in 90 % dependable year. The project was commissioned in 2000 and is executed by Tata Power Company Limited.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Andhra River having Latitude 18°51'54.58"N & Longitude 73°34'8.51"E and the Power house is located at Latitude 18°56'10.9"N & Longitude 73°27'09.9"E in Raigad district of Maharashtra. The nearest railway station and airport is Pune.

3. PROJECT FEATURES

Bhivpuri Hydroelectric Project consists of 57.93 m high dam namely Thokerwadi Dam across the river Andhra with live storage of 352.64 Mcum between Full Reservoir Level (FRL) of 667.17 m and Minimum Draw Down Level (MDDL) of 646.18 m. The water conductor system comprises of Head Race Tunnel (HRT) of length 2661.52 m and 3.4 m diameter, surge shaft which carries water to the powerhouse. The project has surface powerhouse operated under rated head of 531 m enabling total installed capacity of 75 MW. The discharged water from surface powerhouse is carried back to the by Tail Race Channel/Tunnel of length 150 m.

4. HYDROLOGY

The catchment area of the river upto the dam site is 124.32 Sq. Km.

5. POWER & ENERGY BENEFITS

Bhivpuri Hydro Electric project has installed capacity of 75 MW. The project has an annual energy of 193.23 MU in 90 % dependable year.

SALIENT FEATURES
BHIVPURI HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Raigad
River	Andhra
Type of Development	Storage
Nearest Railhead	Pune
Nearest Airport	Pune

LOCATION:

Dam : Latitude & Longitude	18°51'54.58"N 73°34'8.51"E
Power House : Latitude & Longitude	18°56'10.9"N , 73°27'09.9"E

HYDROLOGY:

Catchment Area (Sq. Km)	124.32
Mean Annual Rainfall (mm)	2600

DAM:

Type	Gravity Dam facing in Rubble masonry in Lime surkhi morter.
Length (m)-Forebay	571.50
Height (m)-Forebay	57.93

RESERVOIR:

Full Reservoir Level (FRL) (m)	667.17
Minimum Draw Down Level (MDDL) (m)	646.18
Live Storage (Mcum)	352.64
Gross Storage (Mcum)	363.17

INTAKE:

Gate No.	Tunnel Inlet

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Cylindrical
Number	1
Length (m)	2661.52
Diameter (m)	3.4
TAIL RACE TUNNEL/ CHANNEL	
Number	1
Length (m)	150
Diameter (m)	Cylindrical

POWER HOUSE:

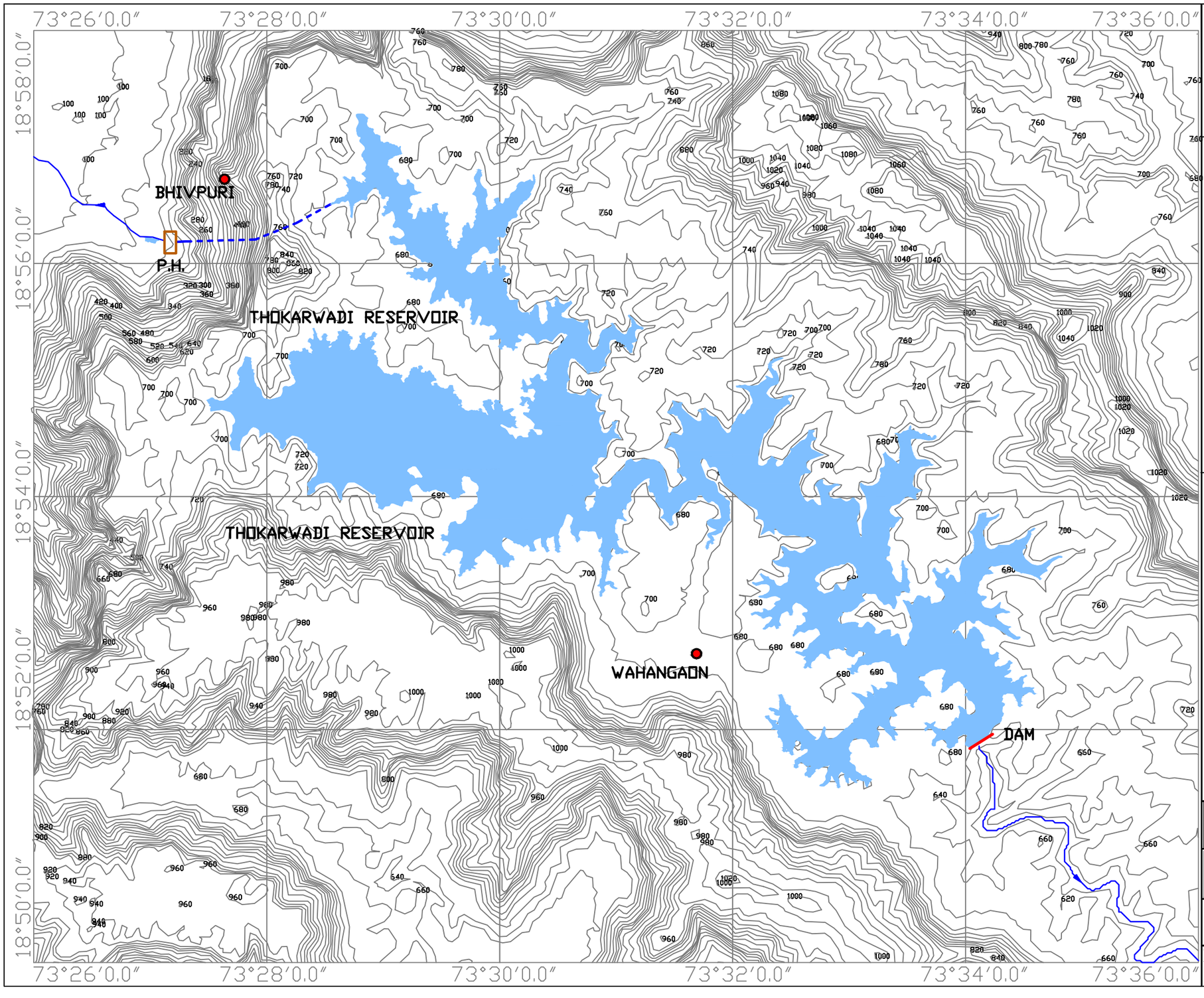
Type	Surface
No. of Generating Units	5
Capacity of each Unit (MW)	3 units of 24MW and 2 units of 1.5 MW
Installed Capacity (MW)	75
Rated Head (m)	531
Type of Turbine	Pelton
Tail Water Level (TWL) (m)	133
Design Discharge (Cumec/unit)	546
Annual Energy (MU)	193.23

COST ASPECTS:

Estimated cost (Rs. Crores)	1.7 (1923, Price Level)

COMMISSIONING DETAILS:

Commissioning Year	2000



N

W E

S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

THOKARWADI DAM

FRL- 667.17 M

MDDL- 646.18 M

DAM HEIGHT- 57.93 M

LIVE STORAGE- 352.64 MCuM

POWER HOUSE

TWL- 133 M

RATED HEAD- 531 M

INST. CAPACITY- 75 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BHIVPURI HYDROELECTRIC PROJECT
(3X24) + (2X1.5) = 75 MW

3.11 KHOPOLI HYDROELECTRIC PROJECT (3x24MW=72MW)

1. INTRODUCTION

Khopoli Hydroelectric Project is a storage type of development near Khopoli village, approximately 724 m from the power house site located in Raigad district of Maharashtra. The project utilizes water of Indrayani River, utilizing rated head of 512.8 m for power generation. The Surface powerhouse has 3 units of 24 MW enabling installed capacity of 72 MW to generate annual energy of 174.68 MU in 90% dependable year. The project was commissioned in 2003 and is executed by Tata Power.

2. LOCATION/ACCESSIBILITY

There are four dam sites of the project located on Indrayani River, First dam Shirwata having Latitude 18° 48' 53.6" N & Longitude 73° 28' 50.4" E, second dam is Walwhan having Latitude 18° 45' 54.3" N & Longitude 73° 25' 32.7"E, third dam is Kundli at Latitude 18°50'42.7"N & Longitude 73°29'10.2"E and fourth dam at Lonavala Latitude 18°44'30.8"N & Longitude 73°24'17.9"E at site while the Forebay dam has a Latitude 18°44'59.47"N & Longitude 73°22'12.60"E. The Power house is located at Latitude 18°46'55.8"N & Longitude 73°21' 15.5"E in Raigad district of Maharashtra. The nearest railway station and the nearest airport is Pune.

3. PROJECT FEATURES

Khopoli Hydroelectric Project consists of four dams naming Walwhan, Shirawta, Lonavala and Kundli. The reservoir formed by the dams has Full Reservoir Level (FRL) of 635.2 m at Walwhan, 656.84 m at Shirawta, 625.46 m at Lonavala and 652 m at Kundli dam. The Minimum Draw down Level (MDDL) at Walwhan, Shirawta, Lonavala and Kundli are 619.35 m, 635.20 m, 619.96 m & 639.40 m respectively. The Live storage at Walwhan, Shirawta, Lonavala and Kundli are 72.12 m, 197.28 m, 11.52 m & 6.34 m respectively. The Water conductor system comprises of 1 no. of Head Race Tunnel (HRT) of length 4025 m and 1 no. of penstock of length 1200 m & 2.9 m diameter which carries water to the powerhouse. The Power house has three units of 24 MW using Pelton turbine operated under rated head of 512.8 m with an installed capacity of 72 MW.

4. HYDROLOGY

The Indrayani River drains a catchment area of about 14.2 Sq km at Walwhan dam, 28.5 Sq km at Shirawta dam, 13.99 Sq km at Lonavala dam and 29 Sq. km at Kundli dam.

5. POWER & ENERGY BENEFITS

The Khopoli Hydroelectric Project has 3 units of 24 MW with installed capacity of 72 MW and annual energy of the project is 174.68 MU at 90% dependable year.

SALIENT FEATURES
KHOPOLI HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Raigad
River	Indrayani
Type of Development	Storage
Nearest Railhead	Pune
Nearest Airport	Pune

LOCATION:

Shirwata Dam : Latitude & Longitude	18° 48' 53.6" N ,73°28' 50.4" E
Walwahn Dam : Latitude & Longitude	18° 45' 54.3"N , 73° 25' 32.7"E
Lonavala Dam : Latitude & Longitude	18°44'30.8"N , 73°24'17.9"E
Kundli Dam : Latitude & Longitude	18°50'42.7"N , 73°29'10.2"E
Forebay : Latitude & Longitude	18°44'59.47"N, 73°22'12.60"E
Power House : Latitude & Longitude	18°46'55.8" N , 73° 21' 15.5" E

HYDROLOGY:

	Shirwata Dam	**Walwhan Dam**	**Lonavala Dam**	**Kundli dam**
Catchment Area (Sq. Km)	28.5	14.2	13.99	29
Average Rainfall (mm)	3456	3088	3830	3000

DAM:

	Shirwata Dam	**Walwhan Dam**	**Lonavala Dam**	**Kundli Dam**
Length (m)	2316.52	1030.2	905.56	205
Height (m)	25.30	21.65	10.51	39.26

RESERVOIR:

	Shirwata Dam	**Walwahn Dam**	**Lonavala Dam**	**Kundli dam**
Full Reservoir Level (FRL) (m)	656.84	635.2	625.46	652
Minimum Draw Down Level (MDDL) (m)	635.20	619.35	619.96	639.40
Live Storage (Mcum)	197.28	72.12	11.52	6.34
Gross Storage (Mcum)	212.97	72.5	11.59	6.34

INTAKE:

Gate No	5 Stoney Sluice Gates
Size (m)	1.6 x 1.6

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Cylindrical
Number	1
Length	4025
PENSTOCK	
Number	1
Length (m)	1200
Diameter (m)	2.9

POWER HOUSE:

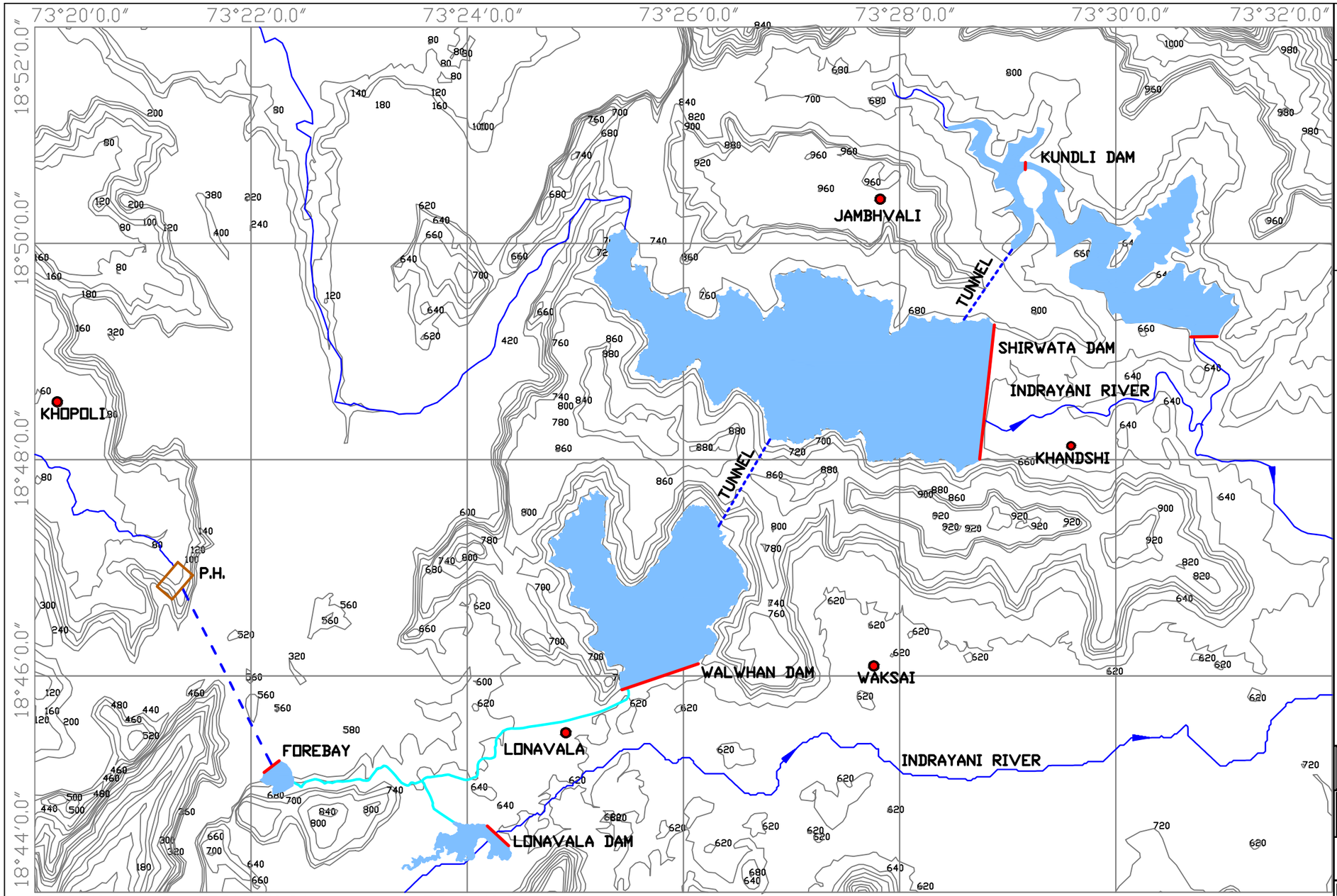
Type	Surface
No. of Generating Units	3
Capacity of each Unit (MW)	24
Installed Capacity (MW)	72
Rated Head (m)	512.8
Type of Turbine	Pelton
Tail Water Level (TWL) (m)	83.11
Design Discharge (Cumec/unit)	171
Annual Energy (MU)	174.68

COST ASPECTS:

Estimated cost (Rs. Crores)	2 (1916, Price Level)

COMMISSIONING DETAILS:

Commissioning Year	2003



LEGENDS.

- CONTOUR
- RIVER
- CANAL
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

WALWAHN DAM

FRL- 635.2 M
MDDL- 619.35 M
DAM HEIGHT- 21.65 M
LIVE STORAGE- 72.12 MCuM

SHIRWATA DAM

FRL- 656.84 M
MDDL- 635.20 M
DAM HEIGHT- 25.30 M
LIVE STORAGE- 197.28 MCuM

LONAVALA DAM

FRL- 625.46 M
MDDL- 619.96 M
DAM HEIGHT- 10.51 M
LIVE STORAGE- 11.52 MCuM

KUNDLI DAM

FRL- 652 M
MDDL- 639.40 M
DAM HEIGHT- 39.26 M
LIVE STORAGE- 6.34 MCuM

POWER HOUSE

TWL- 83.1 M
RATED HEAD- 512.8 M
INST. CAPACITY- 72 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KHOPOLI HYDROELECTRIC PROJECT (3X24) = 72 MW

3.12 BHIRA HYDROELECTRIC PROJECT (6x25MW=150MW)

1. INTRODUCTION

Bhira Hydroelectric Project is a storage type development near maale village approximately 1.359 km from the project site located in Raigad district of Maharashtra. The project utilizes the water of Neela & Mula River for power generation, harnessing rated head of 480m. The underground powerhouse has 6 units of 25 MW enabling installed capacity of 150 MW generating annual energy of 745 MU in 90 % dependable year. The project was commissioned in 1927 and is executed by Tata Power Company Ltd. (TPCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Mula River having Latitude 18°31′37.8"N & Longitude 73°30′39.4″E & and the Power house located at Latitude 18°27'17.7"N & Longitude 73°23'27.8"E in Raigad district of Maharashtra. The nearest railway station and the nearest airport is Pune.

3. PROJECT FEATURES

Bhira Hydroelectric Project consists of a Mulshi dam of 50.60 m height and 1097.27m in length made up of Rubble Masonary type in Surkhi lime mortar across the river Mula. The reservoir formed by the dam has a live storage of 522.76 Mcum between a Full Reservoir Level (FRL) of 607.1 m and Minimum Draw Down Level (MDDL) of 590.09 m respectively. The water conductor system comprises of Head Race Tunnel (HRT) of length 6300 m and 4.5 m in diameter, 12 nos. of penstock of length 1500m and 1.45m diameter carrying water to the powerhouse. The discharged water from powerhouse is carried back to the river by Tail Race Tunnel of length 150m.

4. HYDROLOGY

The catchment area of the river upto the dam site is 248 Sq. Km.

5. POWER & ENERGY BENEFITS

Bhira Hydroelectric Project has six units of 25 MW with an installed capacity of 150 MW and annual energy generation is 745 MU 90% dependable year.

SALIENT FEATURES
BHIRA HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Raigad
River	Neela & Mula
Type of development	Conventional dam
Nearest Railhead	Pune
Nearest Airport	Pune

LOCATION:

Dam : Latitude & Longitude	18°31′37.8"N , 73°30′39.4″ E
Power House : Latitude & Longitude	18°27'17.7"N , 73°23'27.8"E

HYDROLOGY:

Catchment Area (Sq. Km)	248
Mean Annual Rainfall (mm)	4500

DAM:

Type	Gravity dam facing in Rubble Masonary in Surkhi lime mortar
Length (m)	1097.27
Height (m)	50.60

RESERVOIR:

Full Reservoir Level (FRL) (m)	607.1
Minimum Draw Down Level (MDDL) (m)	590.09
Live Storage (Mcum)	522.76
Gross Storage (Mcum)	752.8

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Cylindrical
Number	1
Length (m)	6300

Diameter (m)	4.5
PENSTOCK	
Number	12
Length (m)	1500
Diameter (m)	1.45

POWER HOUSE:

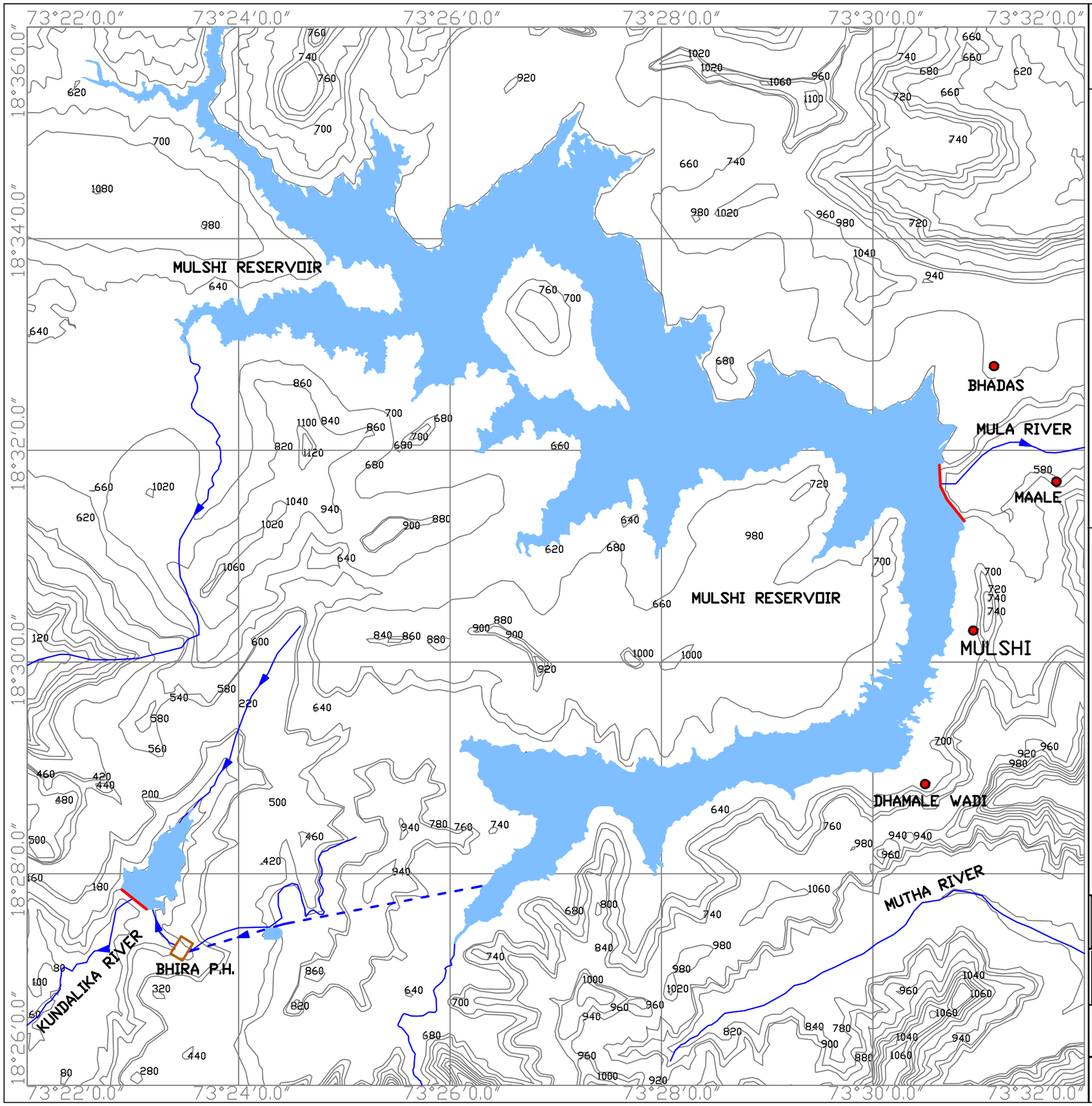
Type	Overground
No. of Generating Units	6
Capacity of each Unit (MW)	25
Installed Capacity (MW)	150
Rated Head (m)	480
Type of Turbine	Pelton
Tail Water Level (TWL) (m)	93
Design Discharge (Cumec/unit)	1982
Annual Energy (MU)	745

COST ASPECTS:

Estimated cost (Rs. Crores)	3.79 (1928, Price Level)

COMMISSIONING DETAILS:

Commissioning Year	1927



N

W E

S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE
- CONTOUR INTERVAL - 20M

MULSHI DAM

FRL- 607.1 M

MDDL- 590.09 M

DAM HEIGHT- 50.6 M

LIVE STORAGE- 522.76 MCuM

POWER HOUSE

TWL- 93 M

RATED HEAD- 480 M

INST. CAPACITY- 150 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BHIRA HYDROELECTRIC PROJECT (6X25) = 150 MW

3.13 KOYNA DPH HYDROELECTRIC PROJECT (2x18MW=36MW)

1. INTRODUCTION

The Koyna River, one of the tributary of the Krishna sub-basin, has its origin in the Western Ghats at a considerable high elevation and the river experiences sufficiently high fall in elevation in its initial reach. A very attractive site appears on the Koyna River which has hydro potential for utilization.

The Koyna dam power house hydroelectric Project located near Koyana Nagar village approximately 1.6km from the project site in Satara district of Maharashtra. The project utilizes water of river Koyna for power generation on a storage type development harnessing a rated head of about 59 m. The project was commissioned in 1980-81 and is executed by Maharashtra State Power Generation Co Ltd (MSPGCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 17°24'8.57"N & Longitude 73°45'5.46"E and the Power house is located at Latitude 17°24'6.85"N & Longitude 73°45'1.34"E & in Satara district of Maharashtra. The nearest railway station is Chiplun and the nearest airport is Karad.

3. PROJECT FEATURES

Koyna DPH Hydroelectric Project involve construction of rubble concrete dam with height of 103.2 m across the Koyna River. The reservoir is named as “Shivaji Sagar lake”. The reservoir has live storage of 2860.88 Mcum between Full Reservoir Level (FRL) of 650.07 m and Minimum Draw Down Level (MDDL) of 609.6 m. The water conductor system comprises of 2 nos. of penstock of diameter 2.43m carries water to underground powerhouse. The dam toe Power house has two units of 18 MW using Francis turbine operated under rated head of 59 m with an installed capacity of 36 MW.

4. HYDROLOGY

The catchment area of the river upto Koyna dam site is 891.8 Sq. km.

5. POWER & ENERGY BENEFITS

Koyna DPH Hydroelectric project has 2 units of 18 MW with installed capacity of 36 MW and the annual energy of the project is 120 MU in 90% dependable year.

6. HISTORICAL BACKGROUND

The Koyna Project took shape mainly as a result of the increasing requirements of power of the highly industrialized city of Mumbai and its environment. This region short of power for several year, was experiencing acute shortage with its phenomenal growth after the Second World War.

Moreover, certain areas in the Southern part of the State were periodical victims of scarcity or famine owing to the frequent failure of the Monsoon. These areas needed an assured supply of water for irrigation and cheap power for lift Irrigation. At the same time, the rural areas are awaking to the need for industrialization, which was possible only through cheap power. Actually the reputed house of Tata's who had earlier commissioned the first hydroelectric power station in the then Bombay state- at Khopoli had started initial surveys on this project around 1910. After the first world war of 1914 to 1918 the surveys were again taken up in 1930-31. But then again due to Second World War from 1939 to 1944 the surveys got hindered. All the investigations of Tata's were however for a surface power station then prevalent in India. But enormous technical advances had taken place in Europe towards underground power houses and high penstocks between 1910 and 1950. Hence when the work of development of Project was taken by the then Electric Grid Department of Bombay State in 1945, the government Engineers made very thorough investigations and studied the Underground power house proposals in consultation with a Swiss Consulting Engineering Firm and others and the Koyna Hydroelectric Project stage 1 power house Project was administratively approved by government in 1953. This Project also provided for irrigation storage for serving irrigation on dams of Koyna and Krishna rivers up to the state boundary.

SALIENT FEATURES
KOYNA DPH HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Satara
River	Koyna
Type of development	Storage
Nearest Railhead	Chiplun
Nearest Airport	Karad

LOCATION:

Dam : Latitude & Longitude	73°45'5.46"E, 17°24'8.57"N
Power House : Latitude & Longitude	73°45'1.34"E, 17°24'6.85"N

HYDROLOGY:

Catchment Area (Sq. Km)	891.8

DAM:

Type	Rubble Concrete
Length (m)	853.5
Height (m)	103.2

RESERVOIR:

Full Reservoir Level (FRL) (m)	650.07
Minimum Draw Down Level (MDDL) (m)	609.6
Live Storage (Mcum)	2860.88

INTAKE:

Gate No	2
Size (m)	2.78 x 2.78

WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	2
Diameter (m)	2.43

POWER HOUSE:

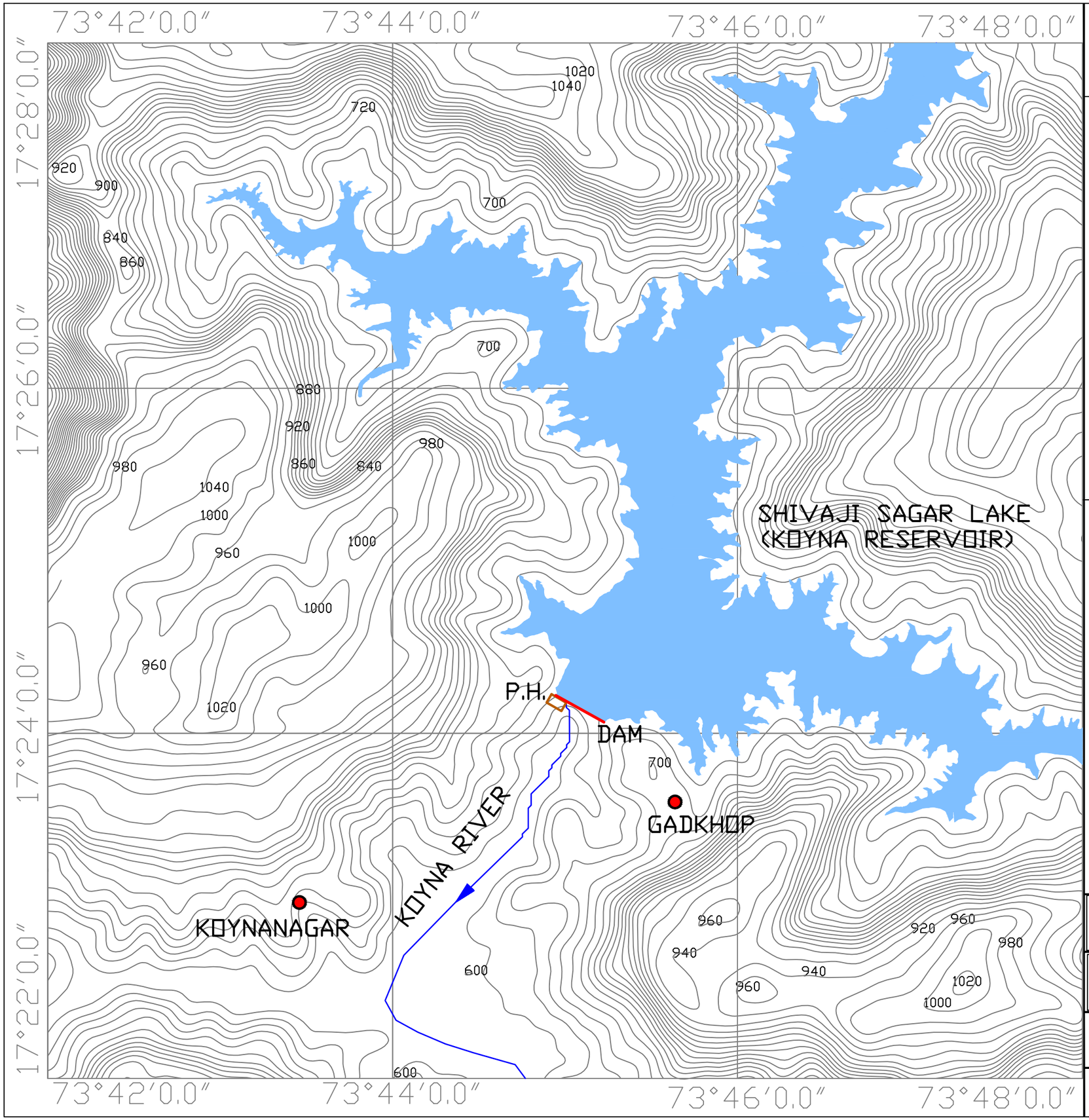
Type	Surface (Dam Toe)
No. of Generating Units	2
Capacity of each Unit (MW)	18
Installed Capacity (MW)	36
Rated Head (m)	59
Avg. Gross Head (m)	59
Type of Turbine	Francis
Tail Water Level (TWL) (m)	591.07
Annual Energy (MU)	120
Design Energy (MU)	110

COST ASPECTS:

Estimated Cost (Rs. Crores)	13 (Price Level, 1981)

COMMISSIONING DETAILS:

COMMISSIONING YEARS	
Unit- I	1980
Unit- II	1981



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KOYNA DAM

FRL- 650.07 M
MDDL- 609.6 M
DAM HEIGHT- 103.2 M
LIVE STORAGE- 2860.88 MCuM

POWER HOUSE

TWL- 591.07 M
RATED HEAD - 59 M
INST. CAPACITY- 36 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KOYNA DPH HYDROELECTRIC PROJECT
(2X18) = 36 MW

3.14 KOYNA ST. I & II HYDROELECTRIC PROJECT (4x70MW+4x80MW=600MW)

1. INTRODUCTION

Koyna St. I & II Hydroelectric Project is located near Pophali village approximately 3.45km from the project site in Ratnagiri district of Maharashtra. The project utilizes the water of Koyna Reservoir for power generation. These water have been led into 3.7kms of tunnel for generation of power at an underground power house at Pophali. The project utilizes rated head of 475 m having capacity of 280 MW for Stage I and rated head of 490 m with capacity of 320 MW for Stage II. The project has 4 units of 70 MW and 4 units of 80 MW in an underground powerhouse to generate design energy of 775 MU in 90% dependable year at 95% machine avilability. The Project was commissioned in between 1962-67 and is executed by Maharashtra State Power Generation Co Ltd (MSPGCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 17°24'8.57"N & Longitude 73°45'5.46"E. The Power house is located at Latitude 17°26'32.3"N & Longitude 73°41'19.8"E. The nearest railway station is Chiplun and the nearest airport is Karad.

3. PROJECT FEATURES

The Koyna St.I&II Hydroelectric Project envisages construction of rubble concrete dam with height of 103.2 m across the Koyna River. The reservoir is named as “Shivaji Sagar lake”. The reservoir has live storage of 2860.88 Mcum between Full Reservoir Level (FRL) of 650.07 m and Minimum Draw Down Level (MDDL) of 609.6 m. The water conductor system comprises of Head race Tunnel (HRT) of length 3749.40m which carries water to underground powerhouse. The underground powerhouse has 8 units using Pelton turbine. The approach tunnel is 864.10m long and 6.7m wide. A 2212.9 m long Tail Race Tunnel carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river upto dam site is 891.8 Sq. km.

5. POWER & ENERGY BENEFITS

Koyna St. I & II has 4 units of 70MW and 4 units of 80 MW with total installed capacity of 600 MW and design energy of the project is 775 MU in 90% dependable year at 95% machine availability .

6. HISTORICAL BACKGROUND

•Work on First stage commeneced with Bhoomipujan of Dam -16-01-1954

•Excavation of approach and ventilation tunnels (Stage I) started -21-05-1956

•Foundation of concrete dam at koyna, laid -01-03-1958

•Excavation of HRT started from both ends -10-10-1958

•TRT done departmentally, completed -13-03-1959

•Filling of Shivaji Sagar started -17-06-1961

•Water let in HRT for testing -10-02-1962

•Commission of 1st 220KV Pophali-Kandalgaon transmission circuit -16-05-1962

•M.S.E. B. took over from project authorities for O&M on lease -01-04-1963

•Work on third stage at Alore commenced with Bhoomipujan -25-12-1965

•Excavation of approach tunnel for stage III started-March 1965

•Completeion of stage 1 & II with commissioning of last turbine generator set-30-06-1967

•First major tremor felt in Koyna Project area -13-09-1967

•Major earthquake at Koynagar and surrounding areas of intensity 6.5 to 7 on richter scale which necessitated dam strengthening -11-12-1967

•Tunneling work of stage III completed-April1970

•Augmentation of station generating capacity 540 MW to 560 MW at Pophali from Jan. 1973 to Jun. 1973

•Water let in HRT of stage III, Alore -25-04-1975

•Work on Koyna Dam foot power house started-01-05-1975

•First turbine generator of III commissioned-06-07-1975

•Investigation for koyna stage IV started-in 1978

•Trial run of Koyna Dam foot power house-30-03-1980

•Renovation of stage II generators and augmentation of station generating capacity from 560 MW to 580 MW – Oct. 1987 to Feb 1990.

•Lake tapping (Under water blasting) stage IV -13-04-1999

•Trail run-Koyna stage IV unit no. 4 (250 MW)-23-06-1999

•Augmentation of station generating capacity from 580 MW to 600 MW at stage I &II Pophali March1997 to Oct 1999

•MSEB took over Stage –IV P.S. from GOMID-16-05-2012

•4-B lake tapping done for KGSC stage IV -25-04-2012

•Lake Tap 4-B was taken in service-26-06-2012

SALIENT FEATURES
KOYNA ST. I & II HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Ratnagiri
River	Koyna
Type of Development	Storage
Nearest Railhead	Chiplun
Nearest Airport	Karad

LOCATION:

Dam : Latitude & Longitude	73°45'5.46"E, 17°24'8.57"N
Power House : Latitude & Longitude	17°26'32.3"N, 73°41'19.8"E

HYDROLOGY:

Catchment Area (Sq. Km)	891.8

DAM:

Type	Rubble Concrete
Length (m)	853.5
Height (m)	103.2

RESERVOIR:

Full Reservoir Level (FRL) (m)	650.07
Minimum Draw Down Level (MDDL) (m)	609.6
Live Storage (Mcum)	2860.88

INTAKE:

Gate No.	2
Length of Intake (m)	1027.20
Shape & Size (m)	6.40 x 2.36

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Length (m)	3749.40
Diameter (m)	6.40

TAIL RACE CHANNEL	
Length (m)	2212.9
Width (m)	7.93

POWER HOUSE:

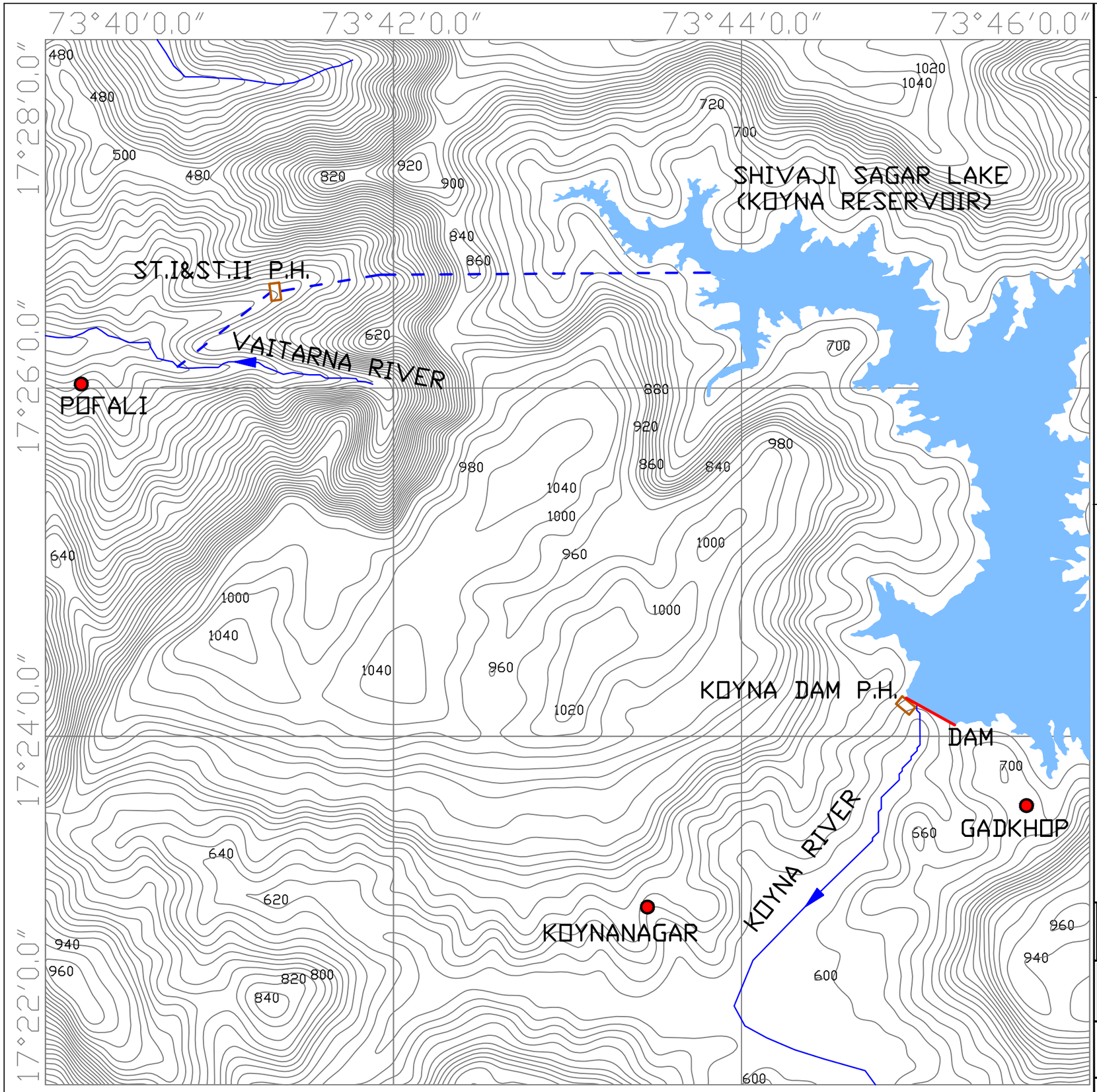
	St. I	St. II
Type	Underground	Underground
No. of Generating Units	4	4
Capacity of each Unit (MW)	70	80
Installed Capacity (MW)	280	320
Rated Head (m)	475	490
Avg. Gross Head (m)	475	490
Type of Turbine	Pelton	Pelton
Tail Water Level (TWL) (m)	135.4	135.4
Design Discharge (Cumec/unit)	164	
Design Energy (MU)	775	

COST ASPECTS:

Estimated Cost (Rs. Crores)	66.15 (Price Level, 1967)

COMMISSIONING DETAILS:

COMMISSIONING YEARS	
Unit-I (St. I)	1962
Unit-II (St. I)	1962
Unit-III (St. I)	1963
Unit-IV (St. I)	1963
Unit-V (St. II)	1967
Unit-VI (St. II)	1966
Unit-VII (St. II)	1966
Unit-VIII (St. II)	1966



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KOYNA DAM

FRL- 650.07 M
MDDL- 609.6 M
DAM HEIGHT- 103.2 M
LIVE STORAGE- 2860.88 MCuM

POWER HOUSE

TWL- 135.4 M
RATED HEAD- STAGE I-475
STAGE II-490
INST. CAPACITY- 600 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KOYNA ST.-I & II HYDROELECTRIC PROJECT
(4X70)+(4X80) = 600 MW

3.15 KOYNA ST. III HYDROELECTRIC PROJECT (4X80MW=320MW)

1. INTRODUCTION

Downstream of power house under Koyna stage II a small pondage has been created from which the water released from the tail race of the power house under Stage II together with water of river Vasishthi (intermediate catchment) are again diverted through a long tunnel to be released into Kolkewadi reservoir. These waters together with water diverted from Koyna reservoir under Stage IV, the tail race of which also feed water into this reservoir called Kolkewadi reservoir are led down to a dam power house.

Koyna St. III Hydroelectric Project is a RoR with storage type Project which is located near Kolkewadi village approximately 1.1km from the project site in Ratnagiri district of Maharashtra. The project utilizes the water of Koyna River for further power generation. The project is designed to generate power, utilizing rated head of 109.7 m. The project has 4 units of 80 MW in an underground powerhouse to generate design energy of 516 MU in 90% dependable year at 95% machine availability. Project was commissioned in 1975-78 and is executed by Maharashtra State Power Generation Co Ltd (MSPGCL).

2. LOCATION/ACCESSIBILITY

The Koyna Stage-III Hydroelectric Project consist of two dams, First dam is Koyna Dam located at Latitude 17°24'8.57"N and Longitude 73°45'5.46"E and the second is Kolkewadi dam located at Latitude 17°28'22.8"N and Longitude 73°38'37.7"E. The Power house is located at Latitude 17°28'22.8"N & Longitude 73°38'37.7"E. The nearest railway station is Chiplun is and the nearest airport is Karad airport.

3. PROJECT FEATURES

The Koyna Stage-III Hydroelectric Project involve construction of Composite masonry type dam (Kolkewadi Dam) of height 65 m. The Kolkewadi reservoir has live storage of 11.22 Mcum between Full Reservoir Level (FRL) of 136.50 m and Minimum Draw Down Level (MDDL) of 133.50. The Koyna reservoir has live storage of 2860.88 Mcum between Full Reservoir Level (FRL) of 650.07 m and Minimum Draw Down Level (MDDL) of 609.6 m. The water conductor system comprises of Head Race Tunnel (HRT) of length 4539 m and 4 nos. of penstock of length 187 m carries water to underground powerhouse. The Underground Power House has 4 units of 80 MW using Francis turbine. The

approach tunnel is of D shape of length 780 m with width and height being 7 m and 6.24 m respectively. A 4548m long Tail Race Tunnel carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river upto Kolkewadi dam site is 25.38 Sq. km and the catchment area of the river upto Koyna dam site is 891.8 Sq. km.

5. POWER & ENERGY BENEFITS

Koyna St. III has 4 units of 80 MW with installed capacity of 320 MW and design energy of the project is 516 MU in 90% dependable year at 95% machine availability.

SALIENT FEATURES
KOYNA ST. III HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Ratnagiri
River	Vasishthi & Water let out through Westward units (st. I, II & IV)
Type of Development	RoR with Storage
Nearest Railhead	Chiplun
Nearest Airport	Karad

LOCATION:

Koyna Dam : Latitude & Longitude	17°24'03.6"N ,73°45'01.4"E
Kolkewadi dam : Latitude & Longitude	17°28'22.8"N 73°38'37.7"E
Power House : Latitude & Longitude	17°28'22.8"N ,73°38'37.7"E

HYDROLOGY:	**Kolkewadi Dam**	**Koyna Dam**
Catchment Area (Sq. Km)	25.38	891.8

DAM:	**Kolkewadi Dam**	**Koyna Dam**
Type	Composite Masonary	Rubble Concrete
Length (m)	498	853.5
Height (m)	65	103.2

RESERVOIR:	**Kolkewadi Dam**	**Koyna Dam**
Full Reservoir Level (FRL) (m)	136.50	650.07
Minimum Draw Down Level (MDDL) (m)	133.50	609.6
Live Storage (Mcum)	11.22	2860.88
Gross Storage (Mcum)	36.22	

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	D-Shape
Length (m)	4539

Size	7.47 x 7.74
PENSTOCK	
Number	4
Length (m)	187
Diameter (m)	4.11
TAIL RACE TUNNEL	
Shape	D-Shape
Length (m)	4548
Size	10.36 x 10.36

POWER HOUSE:

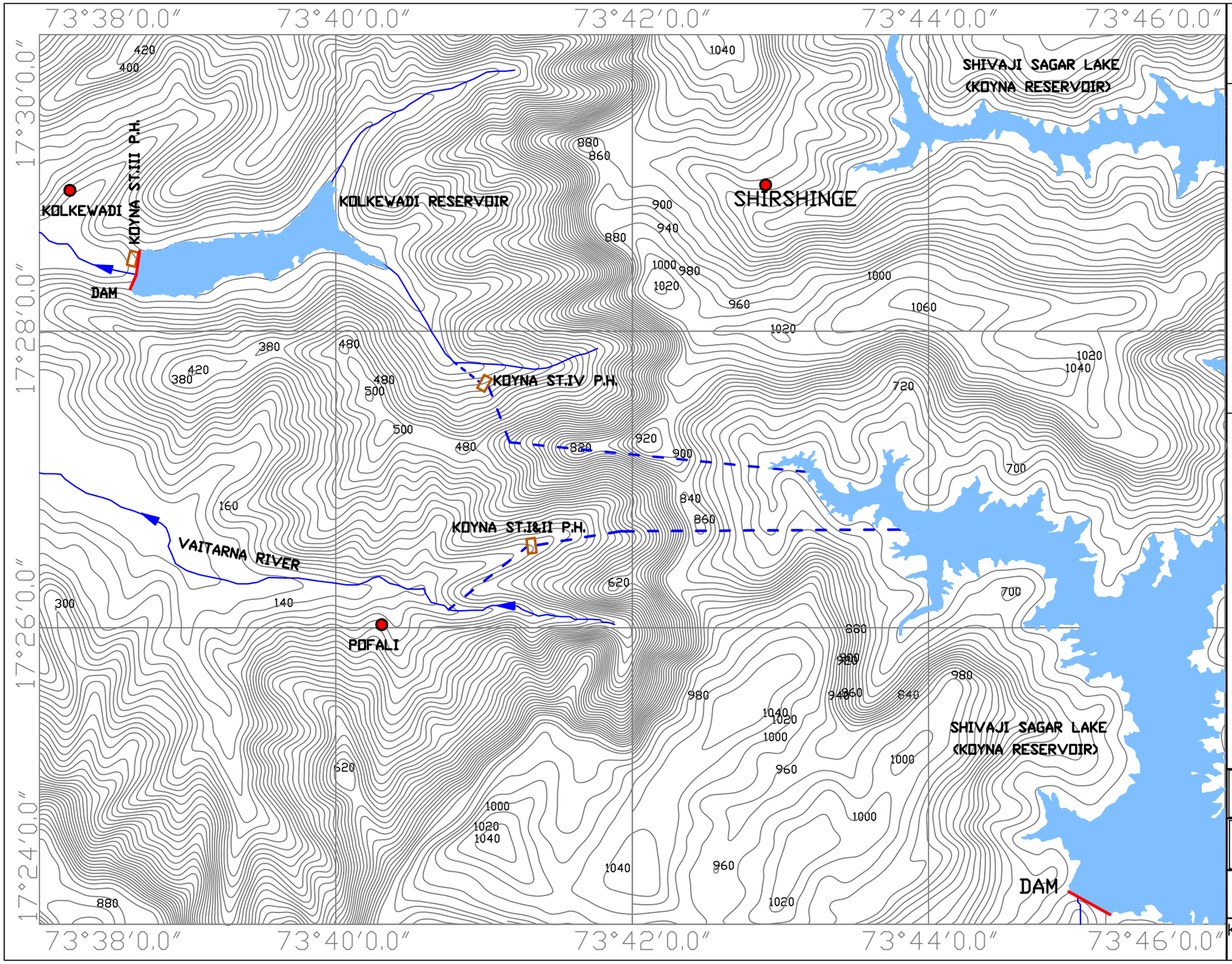
Type	Underground
No. of Generating Units	4
Capacity of each Unit (MW)	80
Installed Capacity (MW)	320
Rated Head (m)	109.7
Avg. Gross Head (m)	130
Type of Turbine	Francis
Tail Water Level (TWL) (m)	15
Design Energy (MU)	516

COST ASPECTS:

Estimated Cost (Rs. Crores)	59.96 (Price Level, 1978)

COMMISSIONING DETAILS:

COMMISSIONING YEARS	
Unit– I	1975
Unit– II	1976
Unit– III	1977
Unit– IV	1978



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KOYNA DAM

FRL- 650.07 M
MDDL- 609.6 M
DAM HEIGHT- 103.2 M
LIVE STORAGE- 2860.88 MCuM

KOLKEWADI DAM

FRL- 136.50 M
MDDL- 133.50 M
DAM HEIGHT- 65 M
LIVE STORAGE- 11.22 MCuM

POWER HOUSE

TWL- 15 M
RATED HEAD - 109.7 M
INST. CAPACITY- 320 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KOYNA ST-III HYDROELECTRIC PROJECT
(4X80) = 320 MW

3.16 KOYNA St. IV HYDROELECTRIC PROJECT (4x250MW=1000MW)

1. INTRODUCTION

The Koyna Stage IV comprises the Project similar to Koyna Stage I & II having its intake in Shivaji Sagar (Koyna Lake) and the power house in adjacent Kolkewadi Valley letting down water in Kolkewadi Lake. It is thus a parallel Project to Stage I & II having capacity of 4 x 250 MW. Koyna St. IV is the first Hydro power plant in India having Generating capacity of 250 MW per unit and having Gas Insulated Switch Gears located inside underground power house.

Koyna St. IV Hydroelectric Project is a storage type Project which is located near Kumbharli village approximately 3.3km from the project site in Ratnagiri district of Maharashtra. The project utilizes the water of Koyna River for further power generation. The project is designed to generate power, utilizing rated head of 500 m. The project has 4 units of 250 MW in an underground powerhouse to generate design energy of 1711 MU in 90% dependable year at 95% machine availability. The Project was commissioned in 1999-2000 and is executed by Maharashtra State Power Generation Co Ltd (MSPGCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 17°24'8.57"N & Longitude 73°45'5.46"E. The Power house is located at Latitude 17°27'38.9"N & Longitude 73°41'00.2"E. The nearest railway station is Chiplun and the nearest airport is Karad.

3. PROJECT FEATURES

The Koyna Stage-IV Hydroelectric Project involves construction of rubble concrete type dam (Koyna Dam) of height 103.2 m. The Koyna reservoir has live storage of 2860.88 Mcum between Full Reservoir Level (FRL) of 650.07 m and Minimum Draw Down Level (MDDL) of 609.6 m. The Underground Power House has 4 units of 250 MW using Francis turbine. The water conductor system comprises of Head Race Tunnel (HRT) of length 4230m which carries water to underground powerhouse. The approach tunnel is of semicircular shape of length 1124.38 m. A 1940m long Tail Race Tunnel carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river upto Koyna dam site is 891.8 Sq. km.

5. POWER & ENERGY BENEFITS

Koyna St. IV has 4 units of 250 MW with installed capacity of 1000 MW and design energy of the project is 1711 MU in 90% dependable year at 95% machine availability.

6. HISTORICAL BACKGROUND

- Investigation for koyna stage IV started-in 1978
- Trial run of Koyna Dam foot power house-30-03-1980
- Renovation of stage II generators and augmentation of station generating capacity from 560 MW to 580 MW – Oct. 1987 to Feb 1990.
- Lake tapping (Under water blasting) stage IV -13-04-1999
- Trail run-Koyna stage IV unit no. 4 (250 MW)-23-06-1999
- MSEB took over Stage –IV P.S. from GOMID-16-05-2012
- 4-B lake tapping done for KGSC stage IV -25-04-2012
- Lake Tap 4-B was taken in service-26-06-2012

SALIENT FEATURES
KOYNA ST. IV HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Ratnagiri
River	Koyna
Type of Development	Storage
Nearest Railhead	Chiplun
Nearest Airport	Karad

LOCATION:

Dam : Latitude & Longitude	17°24'8.57"N,73°45'5.46"E
Power House : Latitude & Longitude	17°27'38.9"N,73°41'00.2"E

HYDROLOGY:

Catchment Area (Sq. Km)	891.8

DAM:

Type	Rubble Concrete
Length (m)	853.5
Height (m)	103.2

RESERVOIR:

Full Reservoir Level (FRL) (m)	650.07
Minimum Draw Down Level (MDDL) (m)	609.6
Live Storage (Mcum)	2860.88

INTAKE:

Gate No	6
Type	Radial
Size (m)	12.5 x 7.62

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Length (m)	4230
Diameter (m)	7 to 9.5

TAIL RACE TUNNEL	
Length (m)	1940

POWER HOUSE:

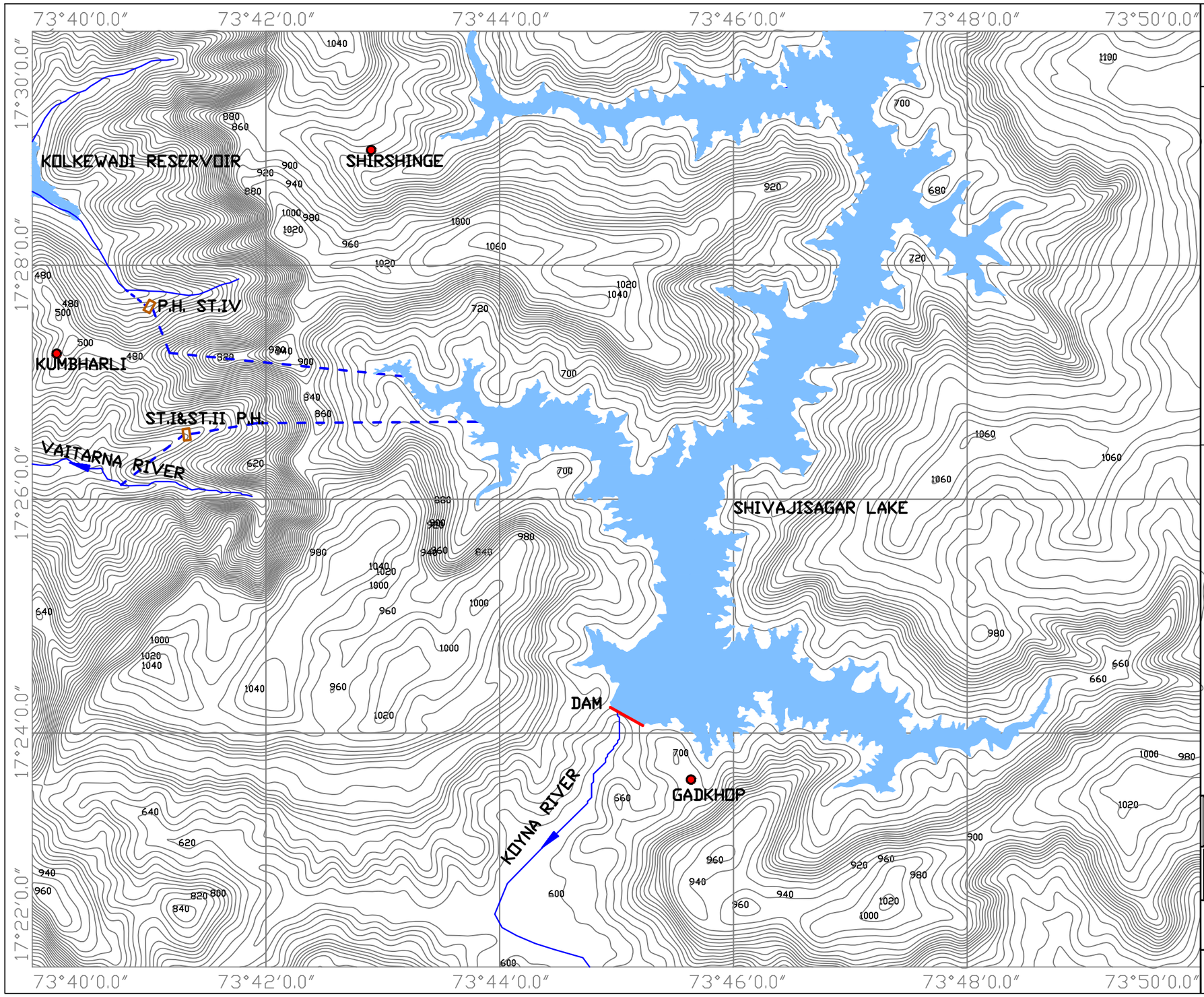
Type	Underground
No. of Generating Units	4
Capacity of each Unit (MW)	250
Installed Capacity (MW)	1000
Rated Head (m)	500
Avg. Gross Head (m)	500
Type of Turbine	Francis
Tail Water Level (TWL) (m)	135.4
Design Energy (MU)	1711

COST ASPECTS:

Estimated Cost (Rs. Crores)	1467 (Price Level, 2000)

COMMISSIONING DETAILS:

COMMISSIONING YEARS	
Unit - I	2000
Unit - II	2000
Unit - III	1999
Unit - IV	1999



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KOYNA DAM

FRL- 650.07 M

MDDL- 609.60 M

DAM HEIGHT- 103.2 M

LIVE STORAGE- 2860.88 MCuM

POWER HOUSE

TWL- 135.4 M

AVG. GOSS HEAD- 500 M

INST. CAPACITY- 1000 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KOYNA ST-IV HYDROELECTRIC PROJECT
(4X250) = 1000 MW

3.17 GHATPRABHA HYDROELECTRIC PROJECT (2x16MW=32MW)

1. INTRODUCTION

Ghatprabha Hydroelectric Project is a storage type development located near Hidkal village approximately 1.47 km from the project site in Belgaum district of Karnataka and utilizes the water of Ghatprabha River for power generation. The project is designed to generate power, utilizing rated head of 32 m. The project has 2 units of 16 MW each in surface power house to generate Design energy of 86 MU in 90% dependable year at 95 % machine availability. Project was commissioned in 1992 and is executed by Karnataka Power Cooperation Limited (KPCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Ghatprabha River having Latitude 16°08'35.7"N & Longitude 74°38'34.3"E and the Power house is located at Latitude 16°08'31.9"N & Longitude 74°38'41.2"E in Belgaum district of Karnataka. Belagavi is the nearest railway station and Belgaum is the nearest airport.

3. PROJECT FEATURES

Ghatprabha Hydroelectric Project involves construction of 51.8m high earthen type dam. The reservoir has a live storage of 1387 Mcum between Full Reservoir Level (FRL) of 662.94 m and Minimum Draw Down Level (MDDL) of 631.55 m. The dam toe power house has two units of 16 MW using Kaplan type turbine operated under rated head of 32 m with an installed capacity of 32 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 1412 Sq. Km.

5. POWER & ENERGY BENEFITS

Ghatprabha Hydroelectric Project has two units of 16 MW each with installed Capacity of 32MW and the design energy of the project is 86 MU in 90% dependable year at 95 % machine availability.

SALIENT FEATURES
GHATPRABHA HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Belgaum
River	Ghatprabha
Type of Development	Storage
Nearest Railhead	Belagavi
Nearest Airport	Belgaum

LOCATION:

Dam : Latitude & Longitude	16°08'35.7"N ,74°38'34.3"E
Power House : Latitude & Longitude	16°08'31.9"N, 74°38'41.2"E

HYDROLOGY:

Catchment Area (Sq. Km)	1412

DAM:

Type	Earthen Dam
Length (m)	1050
Height (m)	51.8

RESERVOIR:

Full Reservoir Level (FRL) (m)	662.94
Minimum Draw Down Level (MDDL) (m)	631.54
Live Storage (Mcum)	1387

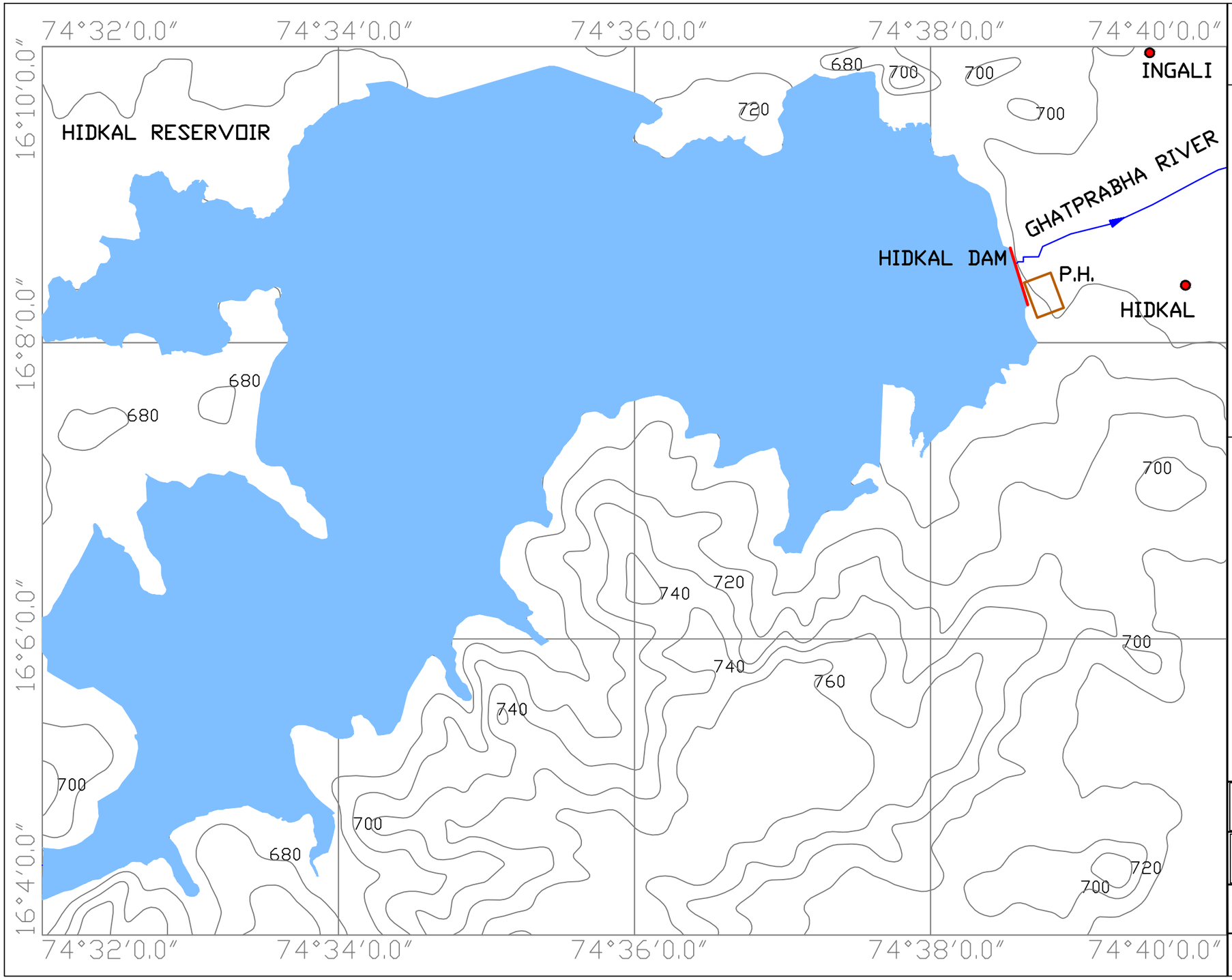
POWER HOUSE:

Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	16
Installed Capacity (MW)	32
Rated Head (m)	32
Avg. Gross Head (m)	32
Type of Turbine	Kaplan

Tail Water Level (TWL) (m)	630.9
Design Energy (MU)	86

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1992
Unit- II	1992



N

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVIOR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

HIDKAL DAM

FRL - 662.94 M
MDDL- 631.55 M
DAM HEIGHT - 51.8 M
LIVE STORAGE- 1387 MCuM

POWER HOUSE

TWL- 630.9M
RATED HEAD- 32 M
INST. CAPACITY- 32 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

GHATPRABHA HYDROELECTRIC PROJECT (2X16) = 32 MW

3.18 ALMATTI HYDROELECTRIC PROJECT (5X55MW+1X15 MW=290MW)

1. INTRODUCTION

The Almatti dam Hydroelectric Project is a Storage type development located in the Bagalkot district of Karnataka state. Araladinni village is located approximately 1.05 km from the dam site. The project utilizes the water of Krishna River for power generation. The dam toe project has Surface powerhouse with Installed Capacity of 290MW (5 units of 55MW+1 units of 15MW) utilizing the rated head of about 24.09 m for unit no 1 and rated head of 26.6 m for unit nos 2,3,4,5 & 6 to generate annual energy of 483 MU in a 90% dependable year. All the units were commissioned in between 2004-05 by Karnataka Power Corporation Limited (KPCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Krishna River having Latitude 16° 19' 48'' N & Longitude 75° 53' 10.7'' E at Almatti dam site and the Power house located at Latitude 16° 19' 40'' N & Longitude 75° 53' 9'' E in Bagalkot district of Karnataka. The nearest railway station from the project is Bijapur and nearest airport is Belagavi.

3. PROJECT FEATURES

Almatti dam Hydroelectric Project involves construction of composite type dam of height 39.4m and 1564.93m length across the river Krishna. The reservoir has a live storage of 3139 Mcum at dam between Full Reservoir Level (FRL) of 519.6m and Minimum Draw Down Level (MDDL) of 511.1m (for 55MW units) and 505.97m (for 15MW units) respectively. It is multipurpose project. The water conductor system comprise of 6 nos. of penstocks of length 84.23 m (for Unit-1) and 81.21 m (for Unit 2 to 6) which carries water to the powerhouse The Dam Toe power house has 5 units of 55 MW and one unit of 15 MW using Kaplan turbine operated under rated head of 24.09 m for Unit no 1 and rated head of 26.6 m for Unit nos 2 to 6 with an installed capacity of 290 MW.

4. HYDROLOGY

The River drains a catchment area of about 35925 Sq km upto the dam site.

5. POWER & ENERGY BENEFITS

The installed capacity of Almatti Hydroelectric Project is 290 MW (5X55MW+1X15MW). The Project generates Annual Energy of 483 MU in a

90% dependable year. The firm power generation for Almatti Hydroelectric Project is 55 MW.

SALIENT FEATURES
ALMATTI HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Bagalkot
River	Krishna
Type of Development	Storage
Nearest Railhead	Bijapur
Nearest Airport	Belagavi

LOCATION:

Dam : Latitude & Longitude	16°19'48''N, 75°53'10.7''E
Power House : Latitude & Longitude	16°19'40''N, 75°53'9''E

HYDROLOGY:

Catchment Area (Sq. Km)	35925
Mean Annual Rainfall (mm)	Varying from 6350mm at the source to 500mm at the dam

DAM:

Type	Composite
Length (m)	1564.93
Height (m)	39.4

RESERVOIR:

Full Reservoir Level (FRL) (m)	519.6
Minimum Draw Down Level (MDDL) (m)	511.16(for 55MW units) 505.97 (for 15MW units)
Live Storage (Mcum)	3139
Gross Storage (Mcum)	3485

WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	6
Length (m)	U-1 : 84.23 U-2 to 6 : 81.21

Diameter (m)	U-1 :3.95 U-2 to 6 :7

POWER HOUSE:

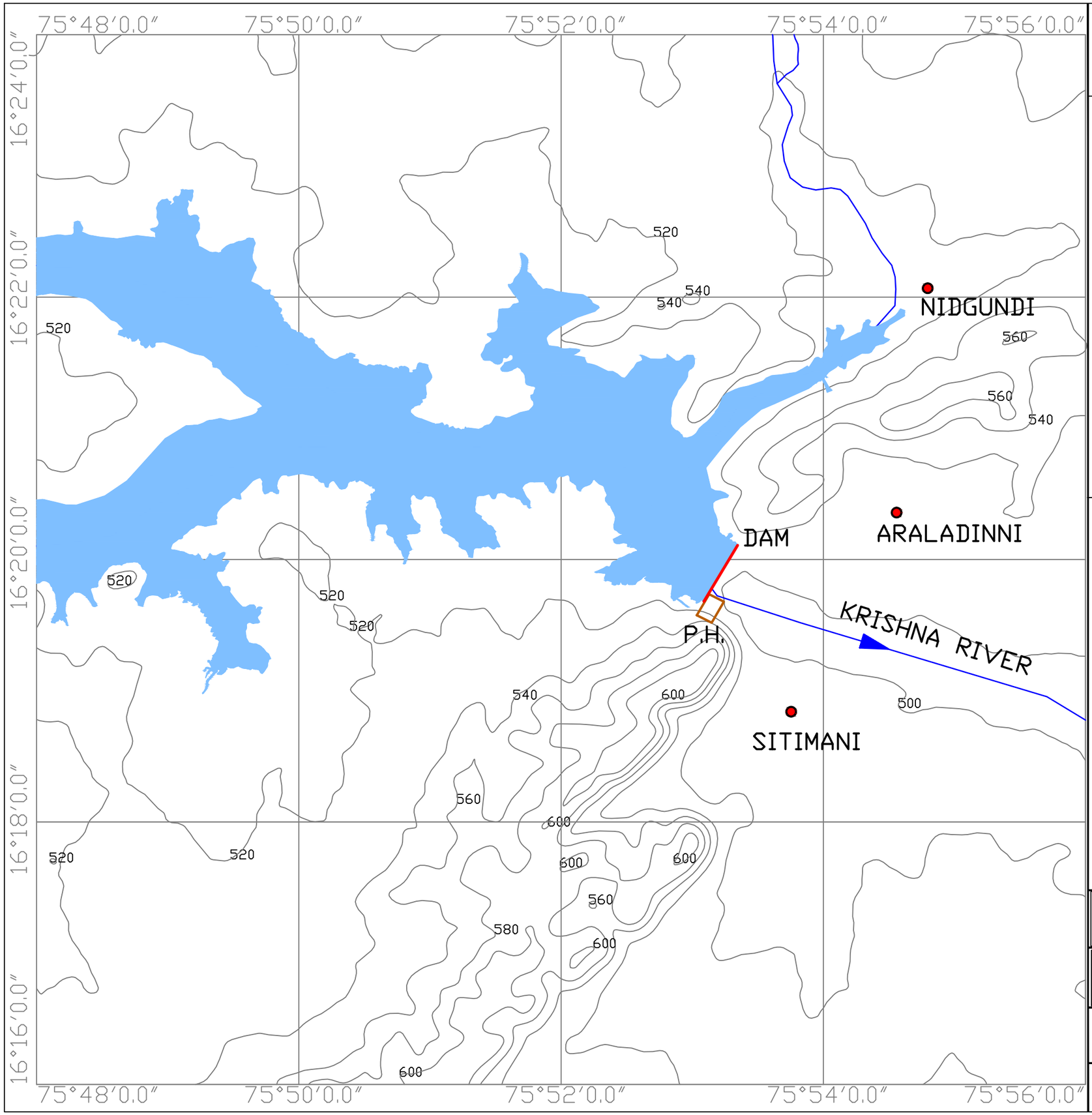
Type	Surface
No. of Generating Units	6
Capacity of each Unit (MW)	5 units of 55MW and 1 unit of 15MW (5 x 55 + 1 x 15)
Firm Power (MW)	55
Installed Capacity (MW)	290
Rated Head (m)	U-1 : 24.09 U-2 to 6 : 26.6
Average Head (max) (m)	U-1 : 13. 72 U-2 to 6 : 18.91
Type of Turbine	Kaplan
Tail Water Level (TWL) (Min.) (m)	492.25
Design Discharge (Cumec/unit)	U-1 : 69.1 U-2 to 6 : 227.9
Annual Energy (MU)	483

COST ASPECTS:

Estimated Cost (Rs. Crores)	528.55
Levellised Tariff (Rs/KWh)	1.77

COMMISSIONING DETAILS:

Commissioning Year	2004-05



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

ALMATTI DAM

FRL - 519.6 M

MDDL- 511.16 (FOR 55 MW)
505.97 (FOR 15MW)

DAM HEIGHT -39.4 M

LIVE STORAGE - 3139 MCuM

POWER HOUSE

TWL- 492.25 M

RATED HEAD- U1-24.09
U-2 TO 6: 26.6

INST. CAPACITY - 290 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

ALMATTI HYDROELECTRIC PROJECT
(5X55)+(1X15) = 290MW

3.19 PRIYADARSHINI JURALA HYDROELECTRIC PROJECT (6x39MW=234MW)

1. INTRODUCTION:

Indira Priyadarshini Jurala Project is constructed on Priyadarshini Jurala Project Dam. As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Priyadarshini Hydroelectric Project. Presently, the project is named as Priyadarshini Jurala Hydroelectric Project. Khammapadu village is located approximately 3.2 km from the dam site .Priyadarshini Jurala Hydroelectric Project is a Run of River (RoR) type of development located at Jogulamba Gadwal district of Telangana and utilizes the water of Krishna River for power generation. The dam toe project has Surface power house with Installed Capacity of 234 MW(6X39MW) utilizing the rated head of 18.87 m to generate Annual Energy of 404 MU in a 90% dependable year. All the units were commissioned in between 2008-11 and is executed by Telangana State Power Generation Corporation Limited (TSGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 16°19'58.3"N & Longitude 77°42'13.1"E. The Power house is located at Latitude 16°19'58.3"N & Longitude 77°42'13.1"E. The nearest railhead from the project is Gadwal railway station and nearest airport from the project site is Hyderabad.

3. PROJECT FEATURES

The Priyadarshni Jurala Hydroelectric project has a Masonary dam of height 40 m and length 4534 m. The reservoir formed by the dam has a live storage of 192.27 Mcum between Full Reservoir Level (FRL) of 318.51 m and Minimum Draw Down Level (MDDL) of 314.86 m. The water conductor system consist of 6 no. of Head Race Tunnel (HRT) of 55.7 m length. The Dam Toe powerhouse has 6 units of 39MW using Bulb type turbine operated under rated head of 18.87 m with Installed Capacity of 234MW. A Tail Race Tunnel of length 680 m will carry water from powerhouse back to the river.

4. HYDROLOGY

The Krishna River drains a catchment area of about 129499 Sq km upto the dam site.

5. POWER & ENERGY BENEFITS

The Installed Capacity of Priyadarshni Jurala Hydroelectric project is 234 MW. The project generates Annual Energy of 404 MU in a 90% dependable year.

The Firm Power capacity of the Priyadarshini Jurala Hydroelectric project is 24 MW.

SALIENT FEATURES
PRIYADARSHINI JURALA HYDROELECTRIC PROJECT

GENERAL:

State	Telangana
District	Jogulamba Gadwal
River	Krishna
Type of Development	RoR
Nearest Railhead	Gadwal
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	16°19'58.3"N 77°42'13.1"E
Power House : Latitude & Longitude	16°19'58.3"N 77°42'13.1"E

HYDROLOGY:

Catchment Area (Sq. Km)	129499
Mean Annual Rainfall (mm)	708

GEOLOGY:

Type of Rock	Granite, Gneisses, Limestone, Shale, Basalt (Hard Rock)

DAM:

Type	Masonary
Length (m)	4534
Height (m)	40

RESERVOIR:

Full Reservoir Level (FRL) (m)	318.51
Minimum Draw Down Level (MDDL) (m)	314.86
Live Storage (Mcum)	192.27
Gross Storage (Mcum)	338.10

INTAKE:

Gate No	12
Size (m)	44.7

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	Rectangular
Number	06
Length (m)	55.7
TAIL RACE TUNNEL/CHANNEL	
Shape	Trapezoidal (Unlined)
Number	6
Length (m)	680

POWER HOUSE:

Type	Surface
No. of Generating Units	6
Capacity of each Unit (MW)	39
Firm Power (MW)	24
Installed Capacity (MW)	234
Rated Head (m)	18.87
Avg. Gross Head (Max.) (m)	19.67
Avg. Gross Head (Min.) (m)	17.04
Type of Turbine	Bulb Type Turbine
Tail Water Level (TWL) (m)	299.60
Design Discharge (Cumec/unit)	35396
Annual Energy (MU)	404

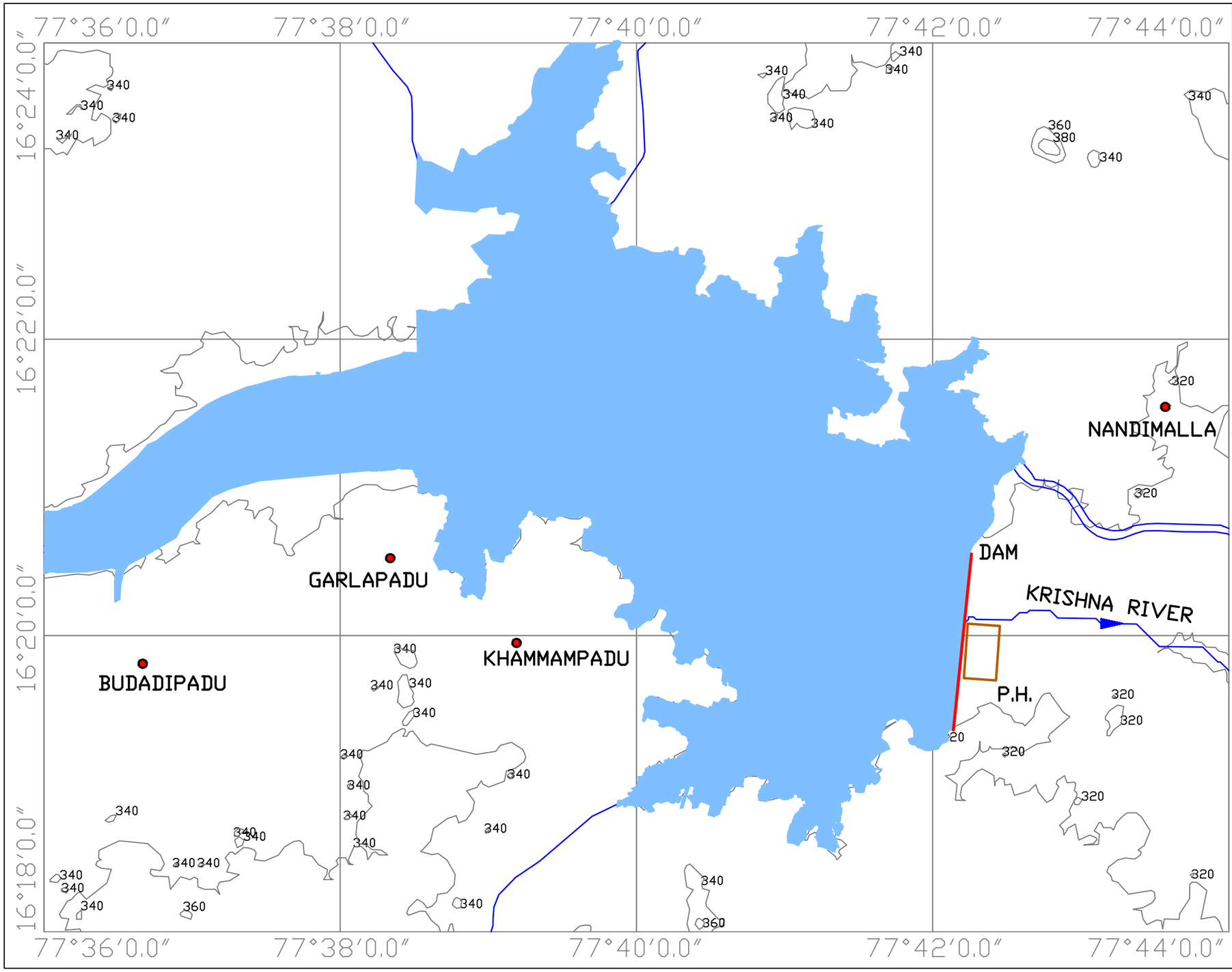
COST ASPECTS:

Estimated Cost (Rs. Crores)	547 (Price Level, 2002)
Levellised Tariff (Rs/KWh)	2.20

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	2008
Unit-II	2008
Unit-III	2009

Unit-IV	2010
Unit-V	2010
Unit-VI	2011



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

PRIYADARSHNI JURALA DAM

FRL- 318.51 M
MDDL- 314.86 M
DAM HEIGHT- 40 M
LIVE STORAGE - 192.27Mcum

POWER HOUSE

TWL- 299.6 M
AVERAGE HEAD - 19.67 M
INST. CAPACITY- 234 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

वाप्कोस लिमिटेड
WAPCOS LIMITED

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

PRIYADARSHNI HYDROELECTRIC PROJECT
(6X39) = 234 MW

3.20 LOWER JURALA HYDROELECTRIC PROJECT (6X40MW=240MW)

1. INTRODUCTION

Lower Jurala Hydroelectric Project is Run of River (RoR) type of development located at Kalwakurthy district of Telangana and utilizes the water of Krishna River for power generation. It is located about 7.9km downstream of existing Priyadarshini Jurala Project and Mulamalla village is located approximately 2.52 km from the project site. The project has Surface powerhouse with Installed Capacity of 240MW (6 units of 40MW) utilize rated head of 20 m to generate annual energy of 534.34 MU in a 90 % dependable year. All the units were commissioned in between 2015-16 and is executed by Telangana State Power Generation Corporation (TSGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 16°18'28.1"N & Longitude 77°46'18.6"E. The Power house is located at Latitude 16°18'46.1"N & Longitude 77°46'38.1"E. The nearest airport is Hyderabad and the nearest railway station Gadwal.

3. PROJECT FEATURES

The Lower Jurala Hydroelectric Project has a Weir of height 11m and length 1005m. The reservoir formed has a live storage of 8.49 Mcum between Full Reservoir Level (FRL) of 299m and Minimum Draw down Level (MDDL) of 292m. The water conductor system consist of 1 no. of Head Race Tunnel (HRT) of 263m length. The Surface Power House has 6 units of 40 MW each using Bulb type turbine operated under rated head of 20 m with Installed Capacity of 240MW. A 1920 m long Tail Race Tunnel/Channel carry powerhouse release back to the river.

4. HYDROLOGY

The Krishna River drains a catchment area of about 130768 Sq km upto Lower Jurala dam.

5. POWER & ENERGY BENEFITS

The Installed Capacity of Lower Jurala Hydroelectric Project is 240MW consist six units of 40MW each. The project generates Annual Energy of about 534.34 MU in 90% dependable year. The firm power capacity of Hydroelectric Project is 26 MW.

SALIENT FEATURES
LOWER JURALA HYDROELECTRIC PROJECT

GENERAL:

State	Telangana
District	Kalwakurthy
River	Krishna
Type of Development	RoR
Nearest Railhead	Gadwal
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	77°46'18.6"E, 16°18'28.1"N
Power House : Latitude & Longitude	77°46'38.1"E, 16°18'46.1"N

HYDROLOGY:

Catchment Area (Sq. Km)	130768
Mean Annual Rainfall (mm)	784

GEOLOGY:

Type of Rock	Hard Rock

DAM:

Type	Weir
Length (m)	1005
Height (m)	11

RESERVOIR:

Full Reservoir Level (FRL) (m)	299
Minimum Draw Down Level (MDDL) (m)	292
Live Storage (Mcum)	8.49
Gross Storage (Mcum)	14.16

INTAKE:

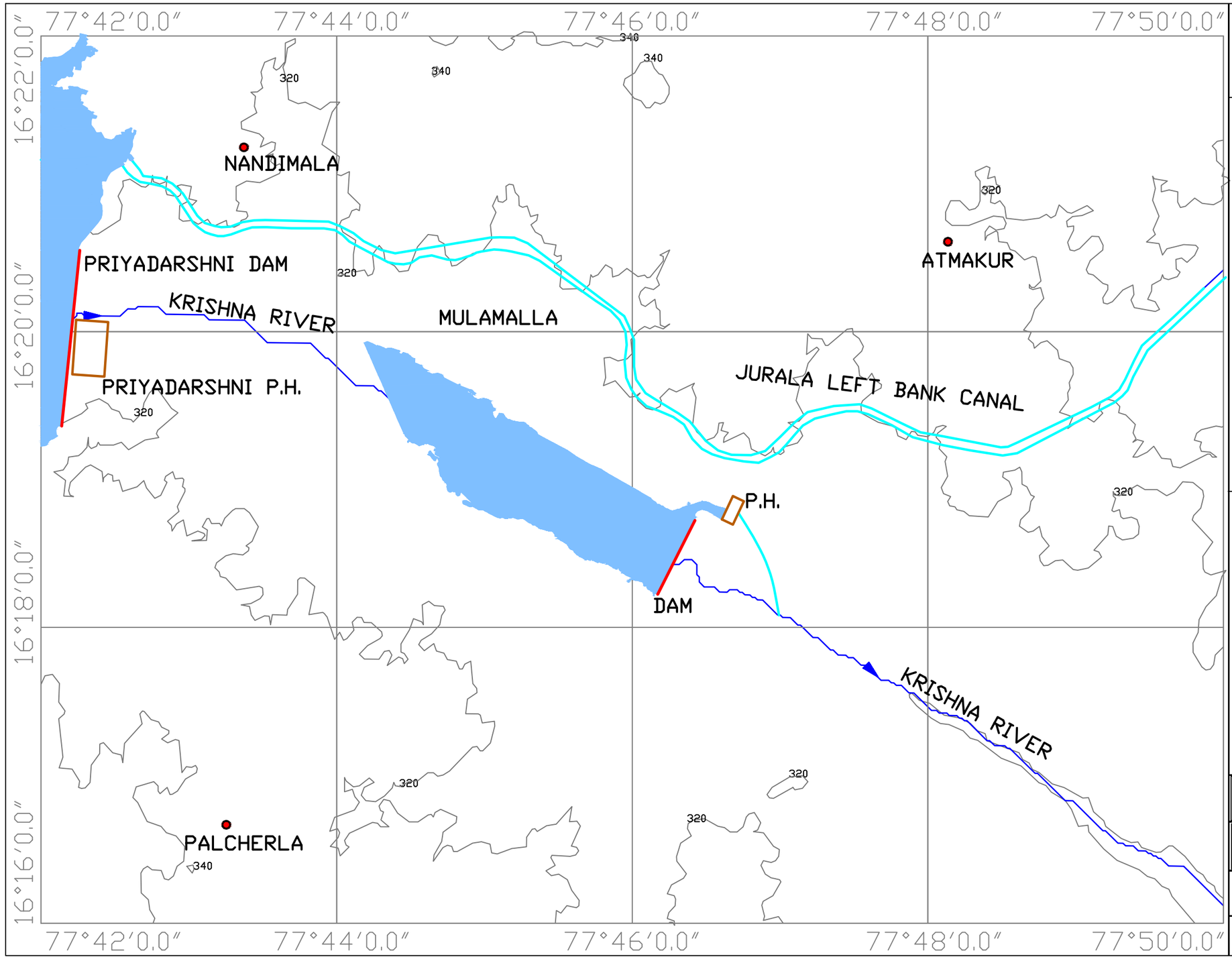
Gate No	12
Size (m)	115

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Trapezoid
Number	1
Length (m)	263
TAIL RACE TUNNEL/CHANNEL	
Shape	Trapezoid (Unlined)
Number	1
Length (m)	1920

POWER HOUSE:

Type	Surface (integrated with intake)
No. of Generating Units	6
Capacity of each Unit (MW)	40
Firm Power (MW)	26
Installed Capacity (MW)	240
Rated Head (m)	20
Avg. Gross Head Maximum (m)	25
Avg. Gross Head Minimum (m)	12
Type of Turbine	Bulb Type
Tail Water Level (TWL) (m)	271.70
Design Discharge (m^3/unit)	212
Annual Energy (MU)	534.34



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- CANAL
- RESERVIOR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

LOWER JURALA

FRL- 299.00 M
MDDL- 292.00 M
DAM HEIGHT- 11.0 M
LIVE STORAGE -8.49 Mcum

POWER HOUSE

TWL- 271.7 M
AVG. GROSS HEAD- 25.0 M
INST. CAPACITY-240 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER JURALA HYDROELECTRIC PROJECT
(6X40) = 240MW

3.21 SRISAILAM HYDROELECTRIC PROJECT (7x110MW=770MW)

1. INTRODUCTION

Srisailam Hydroelectric Project is a storage type development located near Srisailam town approximately 3.5 km from project site in Kurnool district of Andhra Pradesh. The project utilizes the water of Krishna River, harnessing rated head of 91.44 m. The project has 7 units of 110 MW each in surface powerhouse and enables annual energy generation of 1750 MU in 90% dependable year. All the units were commissioned in between 1982-87 and is executed by Andhra Pradesh Power Generation Cooperation limited (APGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Krishna River having Latitude 16°05'12.4"N & Longitude 78°53'47.7"E and the Power house is located at Latitude 16°05'19.12"N & Longitude 78°54'4.87"E in Kurnool district of Andhra Pradesh. Markapur is the nearest railway station and Kurnool is the nearest airport.

3. PROJECT FEATURES

Srisailam Hydroelectric Project involves construction of 145.10 m high and 512.06 m long Stone Masonry Dam. The reservoir formed by the dam has a live storage of 5289.15 Mcum between Full Reservoir Level (FRL) of 269.75 m and Minimum Draw Down Level (MDDL) of 243.90 m. The water conductor system comprises of Head Race Tunnel (HRT) of length 738m, 15m diameter and 7 nos of penstock of length 500 m and 6.1 m diameter which carries water to the powerhouse. The powerhouse has 7 units of 110MW using Francis turbine and operate under rated head of 91.44 m with installed capacity of 770 MW. A Tail Race Tunnel/Channel of length 120 m carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river up to the dam site is 2,03,597 Sq. Km.

5. POWER & ENERGY BENEFITS

Srisailam Hydroelectric Project has seven units of 110 MW with Installed Capacity of 770MW and the annual energy of the project is 1750 MU in 90% dependable year.

6. HISTORICAL BACKGROUND

Some key incidents that took place in the History of the projects are

- Submersion of Srisailam Right Bank Power House on 15-10-1998 due to unprecedented flood
- Submersion of Srisailam Right Bank Power House on 03-10-2009 due to unprecedented flood

SALIENT FEATURES
SRISAILAM HYDROELECTRIC PROJECT

GENERAL:

State	Andhra Pradesh
District	Kurnool
River	Krishna
Type of Development	Storage
Nearest Railhead	Markarpur
Nearest Airport	Kurnool

LOCATION:

Dam : Latitude & Longitude	16°05'12.4"N, 78°53'47.7"E
Power House : Latitude & Longitude	16°05'19.12"N, 78°54'4.87"E

HYDROLOGY:

Catchment Area (Sq. Km)	203597
Max. Annual Rainfall (mm)	1016
Min. Annual Rainfall (mm)	635
Mean Annual Rainfall (mm)	825.5

GEOLOGY:

Type of Rock	Quartzites and Shales

DAM:

Type	Stone Masonry
Length (m)	512.06
Height (m)	145.10

RESERVOIR:

Full Reservoir Level (FRL) (m)	269.75
Minimum Draw Down Level (MDDL) (m)	243.90
Live Storage (Mcum)	5289.15
Gross Storage (Mcum)	6109.29

INTAKE:

Gate No	3
Size (Sq. mtrs)	4.25 x 15

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Circular
Number	1
Length (m)	738
Diameter (m)	15
PENSTOCK	
Number	7
Length (m)	500
Diameter (m)	6.1
TAIL RACE TUNNEL/CHANNEL	
Shape	Circular
Number	1
Length (m)	120
Diameter (m)	8

POWER HOUSE:

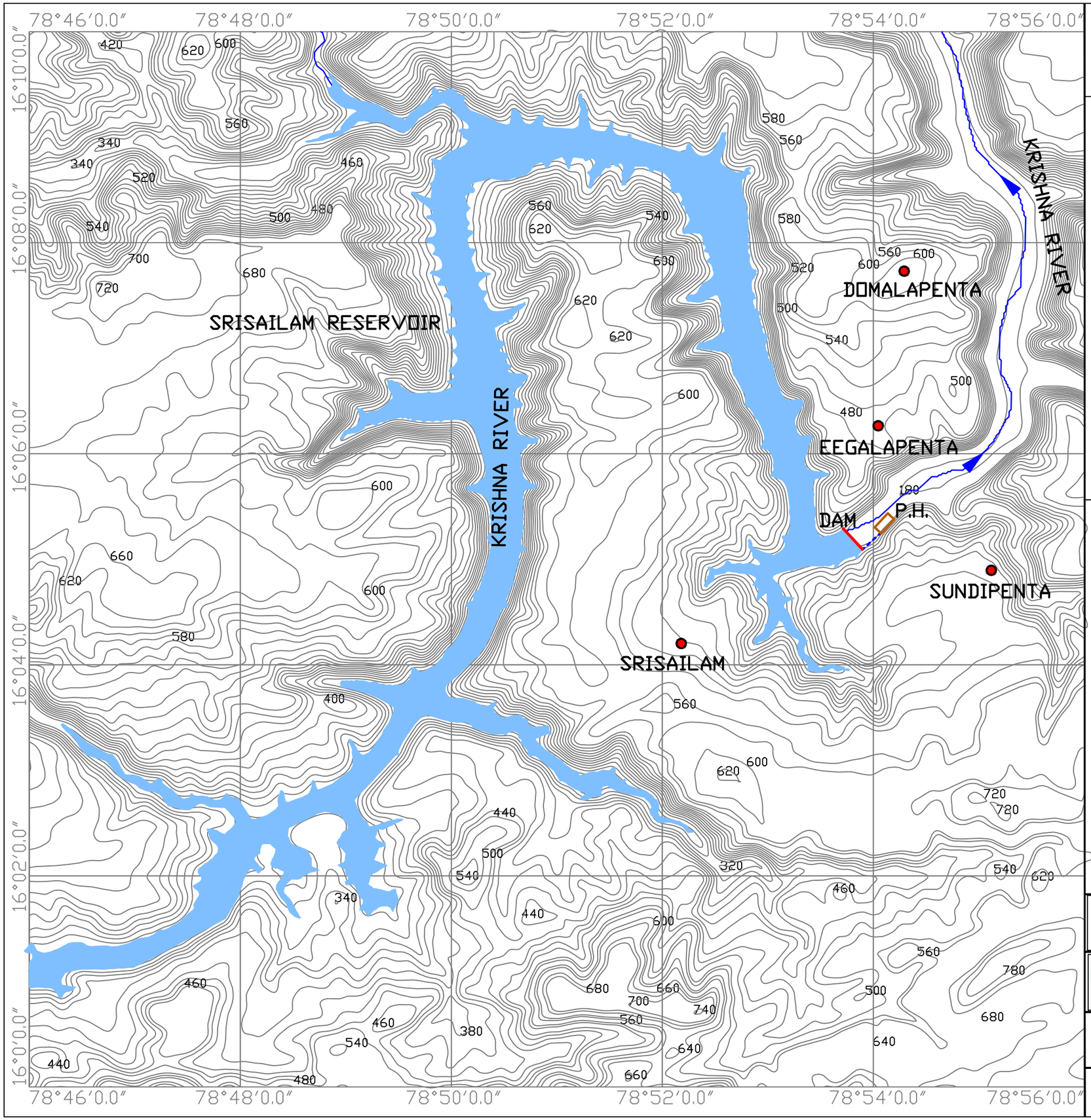
Type	Surface
No. of Generating Units	7
Capacity of each Unit (MW)	110
Installed Capacity (MW)	770
Rated Head (m)	91.44
Avg. Gross Head (Max.) (m)	104.85
Avg. Gross Head (Min.) (m)	72.5
Type of Turbine	Francis
Tail Water Level (TWL) (m)	163
Design Discharge (Cumecs)	137.5
Annual Energy (MU)	1750

COST ASPECTS:

Estimated Cost (Rs. Crores)	Stage-1 Rs.230.5 (PL,1975) Stage-2 Rs.39.38
Levellised Tariff (Rs/kWh)	2.34

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1982
Unit- II	1982
Unit- III	1983
Unit- IV	1984
Unit-V	1986
Unit- VI	1986
Unit- VII	1987



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

SRISAILAM DAM

FRL- 269.75 M

MDDL- 243.84 M

DAM HEIGHT- 145.1 M

LIVE STORAGE- 5289.15 MCuM

POWER HOUSE

TWL- 163 M

AVERAGE HEAD - 104.85 M

INST. CAPACITY- 770 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

SRISAILAM HYDROELECTRIC PROJECT (7X110) = 770MW

3.22 NAGARJUNASAGAR RBC & EXT HYDROELECTRIC PROJECT (3x30MW=90MW)

1. INTRODUCTION

As per Reassessment a study done by Central Electricity Authority (CEA) (1978-87), the project was identified as Nagarjunsagar RBC. Presently, the project is named as Nagarjunsagar RBC & Ext. The project is a storage type development located near Chintala Thanda village aprroximately 6 km from project site in Guntur district of Andhra Pradesh. The project has 3 units of 30 MW each in surface powerhouse and enables annual energy generation of 292.5 MU in 90% dependable year. The Project was commissioned in between 1983-90 and is executed by Andhra Pradesh Power Generation Corporation Limited (APGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Krishna River having Latitude 16°34'32.8"N & Longitude 79°18'42.9"E and the Power house located at Latitude 16°34'11.1"N & Longitude 79°18'40.8"E in Guntur district of Andhra Pradesh. Guntur Junction is the nearest railway station and Vijaywada is the nearest airport.

3. PROJECT FEATURES

Nagarjunasagar RBC & Ext. Hydroelectric Project involves construction of 124.66 m high Masonry Type Dam. The reservoir has a live storage of 4074.79 Mcum between Full Reservoir Level (FRL) of 179.83 m and Minimum Draw Down Level (MDDL) of 161.54 m. The water conductor system comprise of 3 nos. of penstock of length 128 m and 6.09 m diameter which carries water to the powerhouse. The Power house has three units of 30 MW using Kaplan type turbine and operate under net rated head of 25m with an installed capacity of 90 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 215194.34 Sq. km.

5. POWER & ENERGY BENEFITS

Nagarjunsagar RBC & Ext Hydroelectric Project has three units of 30 MW each with Installed Capacity of 90MW and the annual energy of the project is 292.54 MU in 90% dependable year.

6. HISTORICAL BACKGROUND

Project construction was officially inaugurated by Prime Minister Jawaharlal Nehru on 10 December 1955 and preceded for the next twelve years. Raja Vasireddy Ramagopala Krishna Maheswara Prasad, popularly known as late Muktyala Raja was instrumental in the construction of the Nagarjunasagar Dam via active political lobbying (a donation of one hundred million British pounds and fifty five thousand acres of land). The reservoir water was released into the left and right bank canals by Prime Minister Indira Gandhi in 1967.

SALIENT FEATURES
NAGARJUNASAGAR RBC & EXT HYDROELECTRIC PROJECT

GENERAL:

State	Andhra Pradesh
District	Guntur
River	Krishna
Type of Development	Storage
Nearest Railhead	Macherla
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	16°34'32.8"N ,79°18'42.9"E
Power House : Latitude & Longitude	16°34'11.1"N ,79°18'40.8"E

HYDROLOGY:

Catchment Area (Sq. Km)	215194.34

DAM:

Type	Masonary
Height (m)	124.66

RESERVOIR:

Full Reservoir Level (FRL) (m)	179.83
Minimum Draw Down Level (MDDL) (m)	161.54
Live Storage (Mcum)	4074.79
Gross Storage (Mcum)	8836.27

WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	3
Length (m)	128
Diameter (m)	6.09

POWER HOUSE:

Type	Surface
No. of Generating Units	3

Capacity of each Unit (MW)	30
Installed Capacity (MW)	90
Rated Head (m)	25
Avg Gross Head (Max.) (m)	33.95
Type of Turbine	Kaplan
Tail Water Level (TWL) (Max.)(m)	154.50
Tail Water Level (TWL) (Min.)(m)	147.50
Design Discharge (Cumecs/Unit)	141.27
Annual Energy (MU)	292.54

COST ASPECTS:

Estimated Cost (Rs. Crores)	Units-I &II : 14.66 (PL, 1970-71) Unit-3: 15.26 (PL ,1983-84)
Levellised Tariff (Rs/kWh)	4.61

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	1983
Unit-II	1983
Unit-III	1990

79°14'0.0" 79°16'0.0" 79°18'0.0" 79°20'0.0" 79°22'0.0"

16°38'0.0"

16°36'0.0"

16°34'0.0"

16°32'0.0"

NELLIKAL

HILL COLONY

NAMBAPURAM

NAGARJUNA SAGAR

NAGARJUNSAGAR P.H.

KRISHNA RIVER

NAGARJUNSAGAR RBC & EXT. P.H.

NSP RIGHT CANAL

CHINTALA THANDA

240 220 260 160 140 180 80 100 200 260

LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

CANAL

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NAGARJUNASAGAR DAM

FRL- 179.83 M

MDDL- 161.54 M

DAM HEIGHT- 124.66 M

LIVE STORAGE- 4074.79 MCuM

POWER HOUSE

TWL- 147.50 M

RATED HEAD - 25 M

INST. CAPACITY- 90 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

NAGARJUNASAGAR RBC & EXT.
HYDROELECTRIC PROJECT
(3X30) = 90 MW

3.23 NAGARJUNASAGAR TPD HYDROELECTRIC PROJECT (2x25MW=50MW)

1. INTRODUCTION

Nagarjunasagar tail pond is a multipurpose reservoir located 21 km downstream from the Nagarjunasagar Dam across the Krishna River. Nagarjunasagar TPD Hydroelectric Project is a Run of River (RoR) type development located near Mallavaram approximately 3.3 km from the project site and utilizes the water of Krishna River for power generation. The project is designed to generate power, utilizing rated head of 21.19 m. The project has 2 units of 25 MW in surface power house to generate annual energy of 177 MU in 90% dependable year. The Hydroelectric Project was commissioned in 2017 and is executed by Andhra Pradesh Power Generation Corporation Limited (APGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Krishna River having Latitude 16°37'35.71"N & Longitude 79°29'26.09"E and the Power house located at Latitude 16°37'33.78"N & Longitude 79°29'27.71"E in Guntur district of Andhra Pradesh. Macherla is the nearest railway station and Hyderabad is the nearest airport.

3. PROJECT FEATURES

Nagarjunasagar TPD Hydroelectric Project involves construction of 38.4m high and 460.75m long concrete type dam. The reservoir formed by the dam has a live storage of 29.55 Mcum between Full Reservoir Level (FRL) of 75.5 m and Minimum Draw Down Level (MDDL) of 74 m. The Water conductor system comprises of 2 no. of penstocks of length 53 m and 6.60 m diameter carrying water to the powerhouse. The powerhouse has 2 units of 25 MW using Kaplan turbine operated under rated head of 21.19 m with installed capacity of 50MW. A Tail Race Tunnel/Channel of length 540 m carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river up to the dam site is 4711 Sq. km

5. POWER & ENERGY BENEFITS

Nagarjunsagar TPD Hydroelectric Project has two units of 25 MW each with Installed Capacity of 50MW and the Annual Energy of the project is 177 MU in 90% dependable year.

SALIENT FEATURES
NAGARJUNSAGAR TPD HYDROELECTRIC PROJECT

GENERAL:

State	Andhra Pradesh
District	Guntur
River	Krishna
Type of Development	RoR
Nearest Railhead	Macherla
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	16°37'35.71"N 79°29' 26.09"E
Power House : Latitude & Longitude	16°37'33.78"N, 79°29'27.71"E

HYDROLOGY:

Catchment Area (Sq. Km)	4711
Max. Annual Rainfall (mm)	591.20
Mean Annual Rainfall (mm)	449

GEOLOGY:

Type of Rock	Hard Rock

DAM:

Type	Concrete
Length (m)	460.75
Height (m)	38.4

RESERVOIR:

Full Reservoir Level (FRL) (m)	75.5
Minimum Draw Down Level (MDDL) (m)	74
Live Storage (Mcum)	29.55
Gross Storage (Mcum)	200.48

INTAKE:

Gate No	2
Size (m)	7.14 x 11.10

WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	2
Length (m)	53
Diameter (m)	6.60
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangle
Number	1
Length (m)	540

POWER HOUSE:

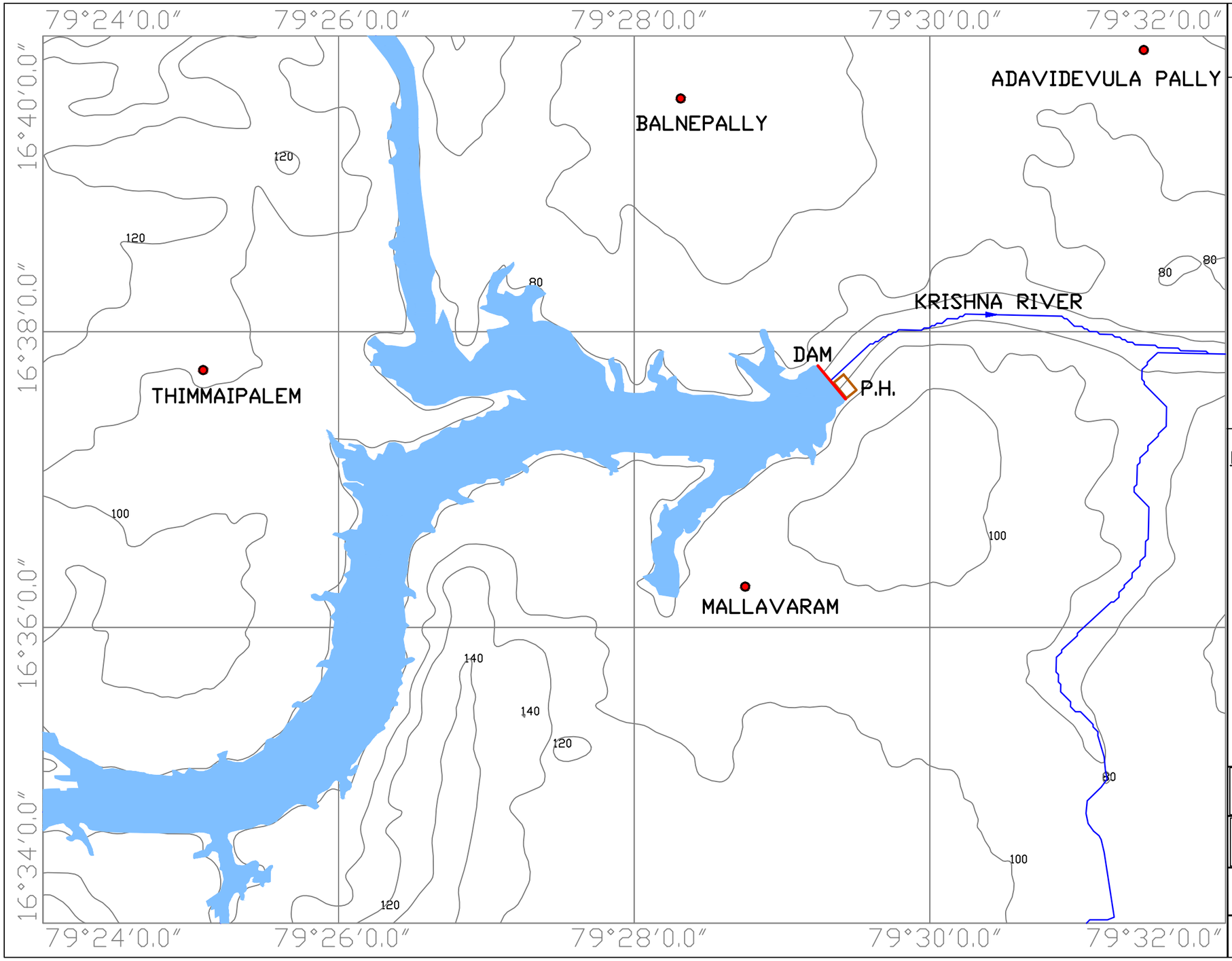
Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	25
Installed Capacity (MW)	50
Rated Head (m)	21.19
Avg. Gross Head (Min.) (m)	4.5
Avg. Gross Head (Max.) (m)	16.5
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	71
Design Discharge (Cumecs)	135
Annual Energy (MU)	177

COST ASPECTS:

Estimated Cost (Rs. Crores)	295 (Actual Cost) (PL,2017)
Levellised Tariff (Rs/kWh)	5.72

COMMISSIONING DETAILS

Commissioning Year	2017



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NAGARJUNASAGAR TAIL POND DAM

FRL- 75.5 M

MDDL- 74 M

DAM HEIGHT- 38.4 M

LIVE STORAGE- 29.55 MCuM

POWER HOUSE

TWL- 71 M

AVERAGE HEAD- 16.5 M

INST. CAPACITY- 50 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

NAGARJUNASAGAR TPD HYDROELECTRIC PROJECT
(2X25) = 50 MW

3.24 NAGARJUNASAGAR LBC HYDROELECTRIC PROJECT (2x30MW=60MW)

1. INTRODUCTION

Nagarjunasagar LBC Hydroelectric Project is a storage type of development located at Nalkonda district of Telangana and utilizes the water of Krishna River for power generation. Nambapuram village is located approximately 5.86 km from the dam site. The project has semi underground powerhouse with Installed Capacity of 60MW (2X30MW) utilizing the rated head of 24.8 m to generate annual energy of 127.40 MU in a 90% dependable year. All the units were commissioned in 1992 and is executed by Telangana State Power Generation Corporation Limited (TSGENCO).

2. LOCATION/ACCESSIBILITY

The dam site is located in Nalgonda district, Telangana at Latitude 16°34'32.8" N & Longitude 79°18'42.9"E . The Power house has Latitude 16°39'51.6"N & Longitude 79°16'55"E. The nearest railway station from the project site is Machrela and nearest airport is Hyderabad.

3. PROJECT FEATURES

The Nagarjunasagar LBC Hydroelectric Project has a Masonry dam of height 124 m and 1550 m length. The reservoir has a live storage of 3020.27 Mcum between having Full Reservoir Level (FRL) of 179.83 m and Minimum Draw Down Level (MDDL) of 167.03 m. The water conductor system consist of 1 no. Head Race Tunnel of length 579 m of Horse shoe type, 2 no. of penstock of length 27.10m and 5.85m diameter. A Tail Race Tunnel of length 875 m carries powerhouse release back to the river.

4. HYDROLOGY

The catchment area of the river upto the dam site is 214185 Sq.km.

5. POWER & ENERGY BENEFITS

The installed capacity of Nagarjunasagar LBC Hydroelectric Project is 60 MW. The project generates annual energy of 127.40 MU in 90% dependable year. The firm power capacity of Hydroelectric Project is 25MW.

SALIENT FEATURES
NAGARJUNASAGAR LBC HYDROELECTRIC PROJECT

GENERAL:

State	Telangana
District	Nalkonda
River	Krishna
Type of Development	Storage
Nearest Railhead	Macherla
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	79°18'42.9"E, 16°34'32.8"N
Power House : Latitude & Longitude	79°16'55.0"E, 16°39'51.6"N

HYDROLOGY:

Catchment Area (Sq. Km)	214185
Maximum Annual Rainfall (mm)	1500
Minimum Annual Rainfall (mm)	377
Mean Annual Rainfall (mm)	938.5

GEOLOGY:

Type of Rock	Sedimentary Rock

DAM:

Type	Masonary dam with earth dam on flanks
Length (m)	1550
Height (m)	124

RESERVOIR:

Full Reservoir Level (FRL) (m)	179.83
Minimum Draw Down Level (MDDL) (m)	167.03
Live Storage (Mcum)	3020.27
Gross Storage (Mcum)	8836.94

INTAKE:

Gate No	2
Size (m)	4.62 x 8.83

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Horse Shoe Tunnel
Number	1
Length (m)	579
PENSTOCK	
Number	2
Length (m)	27.10
Diameter (m)	5.85
TAIL RACE TUNNEL/CHANNEL	
Shape	Horse Shoe Tunnel
Number	1
Length (m)	875

POWER HOUSE:

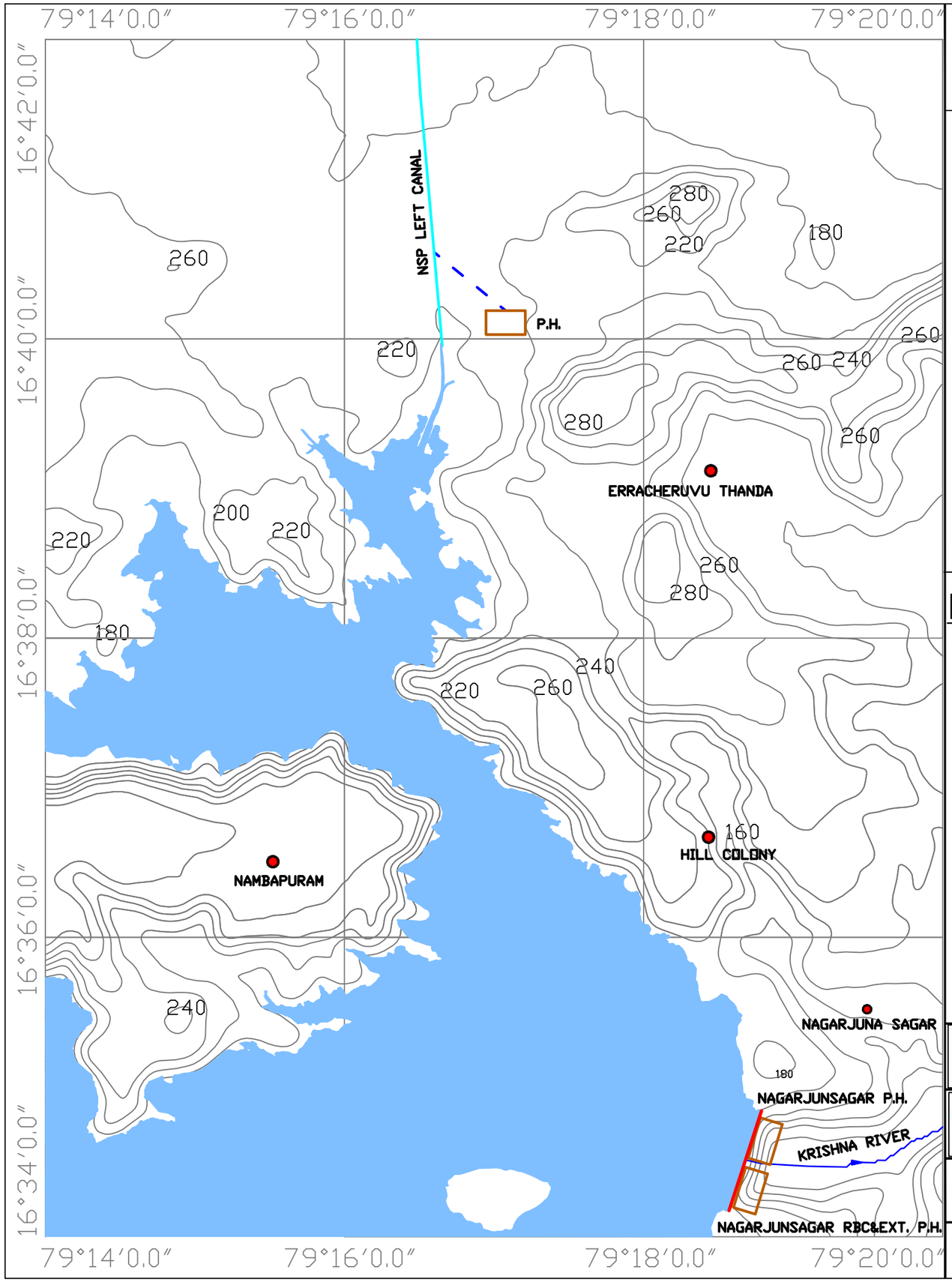
Type	Semi Underground
No. of Generating Units	2
Capacity of each Unit (MW)	30
Firm Power (MW)	25
Installed Capacity (MW)	60
Rated Head (m)	24.8
Avg. Gross Head (Min.) (m)	8
Avg. Gross Head (Max.) (m)	26
Type of Turbine	Vertical Kaplan
Tail Water Level (TWL) (m)	155.76
Design Discharge (Cumec/unit)	155.75
Annual Energy (MU)	127.40

COST ASPECTS:

Estimated Cost (Rs. Crores)	34 (Price Level, 1984)
Levellised Tariff (Rs/kWh)	0.71

COMMISSIONING DETAILS:

Commissioning Year	1992





LEGENDS.

- CONTOUR
- RIVER
- DAM
- TRT
- POWER HOUSE
- CANAL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NAGARJUNA SAGAR DAM

FRL- 179.83 M

MDDL- 167.03 M

DAM HEIGHT- 124 M

LIVE STORAGE- 3020.27 MCuM

POWER HOUSE

TWL- 155.76 M

AVERAGE HEAD- 26 M

INST. CAPACITY- 60 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

NAGARJUNA SAGAR LBC
HYDROELECTRIC PROJECT
(2X30) = 60 MW

3.25 NAGARJUNASAGAR HYDROELECTRIC PROJECT (1X110MW=110MW)

1. INTRODUCTION

Nagarjunasagar Hydroelectric Project was constructed on Nagarjuna Sagar Dam. Nagarjunasagar Hydroelectric Project is Storage type of development located at Nalgonda district of Telangana and utilizes the water of Krishna River for power generation. Nambapuram village is located approximately 5.86 km from the dam site. The Dam toe project has Surface power house with Installed Capacity of 110MW (1 unit of 110 MW) utilizing the rated head of 93 m to generate annual energy of 992 MU in a 90 % dependable year. The project was commissioned in 1979 and is executed by Telangana State Power Generation Corporation Limited (TSGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 16°34'32.8"N & Longitude 79°18'42.9"E. The Power house is located at Latitude 16°34'40.7"N & Longitude 79°18'50.4"E in Nalgonda district of Telangana. The nearest railway station is Macherla & & Mirialaguda and nearest airport is Hyderabad Airport.

3. PROJECT FEATURES

The Nagarjunasagar Hydroelectric Project has masonary dam of height 125 m and 1450 m length. The reservoir has a live storage of 5733.95 Mcum between Full Reservoir Level (FRL) of 179.8 m and Minimum Draw Down Level (MDDL) of 157.9 m. The water conductor system comprise of 8 no. of penstock of length 159 m which carries water to the powerhouse. The Surface power house has 1 units of 110 MW using Francis turbine operating under rated head of 93 m with Installed Capacity of 110MW. 8 no. of Tail Race Tunnel would carry powerhouse discharge back to the river.

4. HYDROLOGY

The Krishna River drains a catchment area of about 214185 sq km upto Nagarjunasagar Dam.

5. POWER & ENERGY BENEFITS

The Installed Capacity of Nagarjunasagar Hydroelectric Project is 110 MW. The project generates annual energy of 992 MU in a 90 % dependable year. The firm power capacity of Hydroelectric Project is 75 MW.

6. ENVIRONMENTAL CONSIDERATION

The artificial lift irrigation based diversion of the river from its natural delta area into Nalkonda district caused erosion of the Florine rich volcanic rocks in Nalkonda and contaminated its ground water supply. It also caused uncertain flows of water into the Krishna river delta area and shrinkage of the natural wonder "The Kolleru Lake" The use of erosion resistant canals interfered with the natural silting process of a river to the deltas and created long term ecological issues to the health of the delta lands. Reduced flows into the sea resulted in land salination and sea encroachment of coastal lands in Diviseema. The diversion of Krishna water for 200 km to Hyderabad resulted in massive evaporation losses especially in summer and reduced the size of Krishna River. The river water needs to be lifted 1600 ft above its natural flow for it to reach Hyderabad, power consumption that is unjustifiable given that there are cheaper ways to get water to Hyderabad. Nagarjuna sagar, Srisailam, Almati and Ujjani dams together successfully halted the flow of Krishna River before it reaches the delta and is good case study of how to kill a mighty river with poor environmental oversight - the fourth largest in the country. Desertification of various flood plains is already recorded. Many forest preserves along the natural Krishna flow are now categorized as "completely degraded" forest areas. Krishna river once home to an ecological wonderland of fresh water fish and aquatic population is now completely depopulated. The river stopped being navigable since the year of Nagarjuna sagar construction.

7. HISTORICAL BACKGROUND

Project construction was officially inaugurated by Prime Minister Jawaharlal Nehru on 10 December 1955 and proceeded for the next twelve years. The construction of the dam submerged an ancient Buddhist settlement, Nagarjunakonda, which was the capital of the Ikshvaku dynasty in the 1st and 2nd centuries, the successors of the Satavahanas in the Eastern Deccan. Excavations here had yielded 30 Buddhist monasteries, as well as art works and inscriptions of great historical importance. In advance of the reservoir's flooding, monuments were dug up and relocated. Some were moved to Nagarjunakonda, now an island in the middle of the reservoir. Others were moved to the nearby mainland village called Anupu. The reservoir water was released into the left and right bank canals by Prime Minister Indira Gandhi in 1967 August. Construction of the hydropower plant followed, with generation

increasing between 1978 and 1985, as additional units came into service. In the year 2015, diamond jubilee celebrations of project's inauguration was celebrated remembering the prosperity the dam has ushered in the region.

SALIENT FEATURES
NAGARJUNASAGAR HYDROELECTRIC PROJECT

GENERAL:

State	Telangana
District	Nalgonda
River	Krishna
Type of Development	Storage
Nearest Railhead	Macherka & Mirialaguda
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	16° 34'32.8"N ,79°18’42.9”E
Power House : Latitude & Longitude	16°34'40.7" N, 79°18’50.4”E

HYDROLOGY:

Catchment Area (Sq. Km)	214185
Maximum Annual Rainfall (mm)	1500
Minimum Annual Rainfall (mm)	377
Mean Annual Rainfall (mm)	938.5

GEOLOGY:

Type of Rock	Sedimentary Rock

DAM:

Type	Masonary with earth dam on flanks
Length (m)	1450
Height (m)	125

RESERVOIR:

Full Reservoir Level (FRL) (m)	179.8
Minimum Draw Down Level (MDDL) (m)	157.9
Live Storage (Mcum)	5733.95
Gross Storage (Mcum)	11550

INTAKE:

Gate No	26
Size (m)	13.7 x 13.4

WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	8
Length (m)	159
Diameter (m)	4.8
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	8
Diameter (m)	5.45

POWER HOUSE:

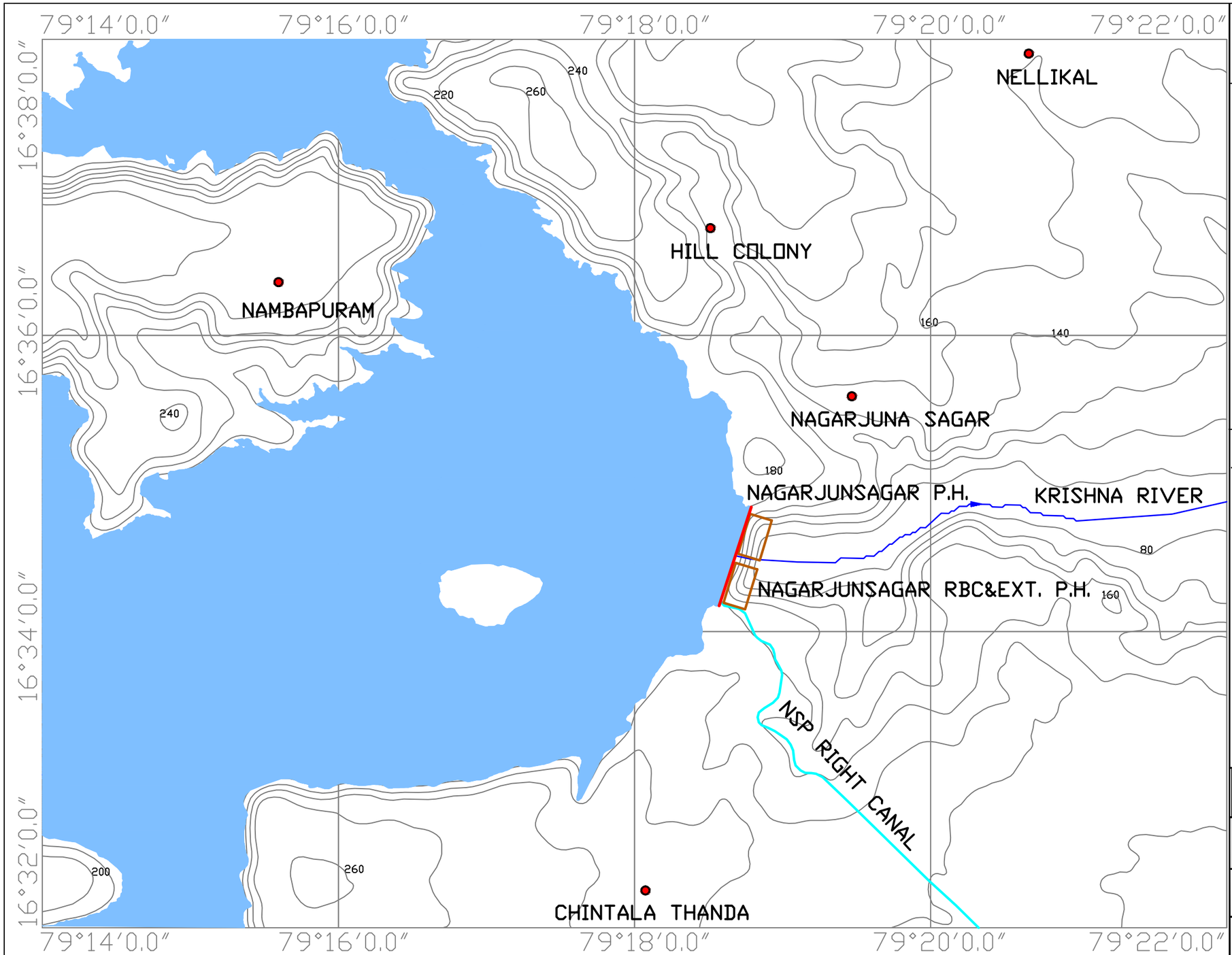
Type	Surface
No. of Generating Units	1
Capacity of each Unit (MW)	110
Firm Power (MW)	75
Installed Capacity (MW)	110
Rated Head (m)	93
Avg. Gross Head (Min.) (m)	72.4
Avg. Gross Head (Max.) (m)	105.5
Type of Turbine	Francis Veritcal Mounted
Tail Water Level (TWL) (Min.)(m)	73.15
Tail Water Level (TWL) (Max.)(m)	90
Design Discharge (Cumec/unit)	146
Annual Energy (MU)	992

COST ASPECTS:

Estimated Cost (Rs. Crores)	137.13 (Price Level, 1976)
Levellised Tariff (Rs/kWh)	0.18

COMMISSIONING DETAILS:

COMMISSIONING YEARS:-	
Unit -I	1979
Unit -II	1980
Unit -III	1981
Unit -IV	1982
Unit -V	1983
Unit -VI	1984
Unit -VII	1985
Unit -VIII	1986



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- CANAL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NAGARJUNA SAGAR DAM

FRL- 179.8 M
MDDL- 157.9 M
DAM HEIGHT- 125 M
LIVE STORAGE- 5733.95 MCuM

POWER HOUSE

TWL- 73.15 M
RATED HEAD - 93 M
INST. CAPACITY- 110 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

NAGARJUNASAGAR HYDROELECTRIC PROJECT
(1X110) = 110 MW

3.26 T B DAM HYDROELECTRIC PROJECT (4x9MW=36MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Tungabhadra Right Bank Hydroelectric Project. Presently, the project is named as T B Dam hydroelectric powerhouse. Although primarily intended as an Irrigation Project, the impounded water in Tungabhadra Reservoir is also utilized to generate power before being let out into the canals for irrigation purpose. The power generated on the left side is entirely used by Karnataka while that generated through two power houses on the right side is shared by states of Karnataka and Andhra Pradesh in the ratio of 20:80. One Power House is at the foot of the dam and another at Hampi which is 21 Km from the dam.

T B Dam Hydroelectric Project is located near Hosapete town approximately 5.8km from the project site in Bellary district of Karnataka. The main objective of the project being irrigation, electricity generation is dependent on the water releases made for irrigation requirements in the RBLLC and river assistance to RDS and KC Canal. Water releases vary from time to time as per irrigation demands furnished by the states. The project is designed to generate power, utilizing rated head of 26.82 m. The project has 4 units of 9 MW in surface powerhouse to generate annual energy of 70 MU in 90% dependable year. TB Dam Hydroelectric Project was commissioned in between 1957-64 and executed by Andhra Pradesh Power Generation Corporation Limited (APGENCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Tungbhadra River having Latitude 15°15'50.1"N & Longitude 76°19'59.1"E and the Power house located at Latitude 15°15'41"N & Longitude 76°20'17.4"E in Bellary district of Karnataka. The nearest railway station is Hospet and the nearest airport is Tornagallu.

3. PROJECT FEATURES

T B Dam House Hydroelectric Project involves construction of Composite type Dam of height 49.5 m across the Tungabhadra River. The reservoir has a live storage of 2831.67 Mcum between Full Reservoir Level (FRL) of 497.74 m and Minimum Draw Down Level (MDDL) of 482.19 m. The water conductor system comprises of 4 nos of penstock of length 45.42 m carries water to surface powerhouse. The dam toe Power house has four units of 9 MW each of vertical

Kaplan type turbine operated under rated head of 26.82 m with an installed capacity of 36 MW.

4. HYDROLOGY

The catchment area of the river up to dam site is 28179.071 Sq. km.

5. POWER & ENERGY BENEFITS

Power is being shared in the ratio of 80:20 between Andhra Pradesh & Karnataka. T B Dam Hydroelectric project has 4 units of 9 MW with installed capacity of 36 MW and the annual energy of the project is 70 MU in 90% dependable year

SALIENT FEATURES
T B DAM HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Bellary
River	Tungabhadra
Type of Development	Storage
Nearest Railhead	Hospet
Nearest Airport	Tornagallu

LOCATION:

Dam : Latitude & Longitude	15°15'50.1"N, 76°19'59.1"E
Power House : Latitude & Longitude	15°15'41"N, 76°20'17.4"E

HYDROLOGY:

Catchment Area (Sq. Km)	28179.071

DAM:

Type	Composite
Length (m)	2449
Height (m)	49.5

RESERVOIR:

Full Reservoir Level (FRL) (m)	497.74
Minimum Draw Down Level (MDDL) (m)	482.19
Live Storage (Mcum)	2831.67
Gross Storage (Mcum)	3766.13

INTAKE:

Number	4
Size (m)	5.87 x 4.03

WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	4
Length (m)	45.42

Diameter (m)	3.35

POWER HOUSE:

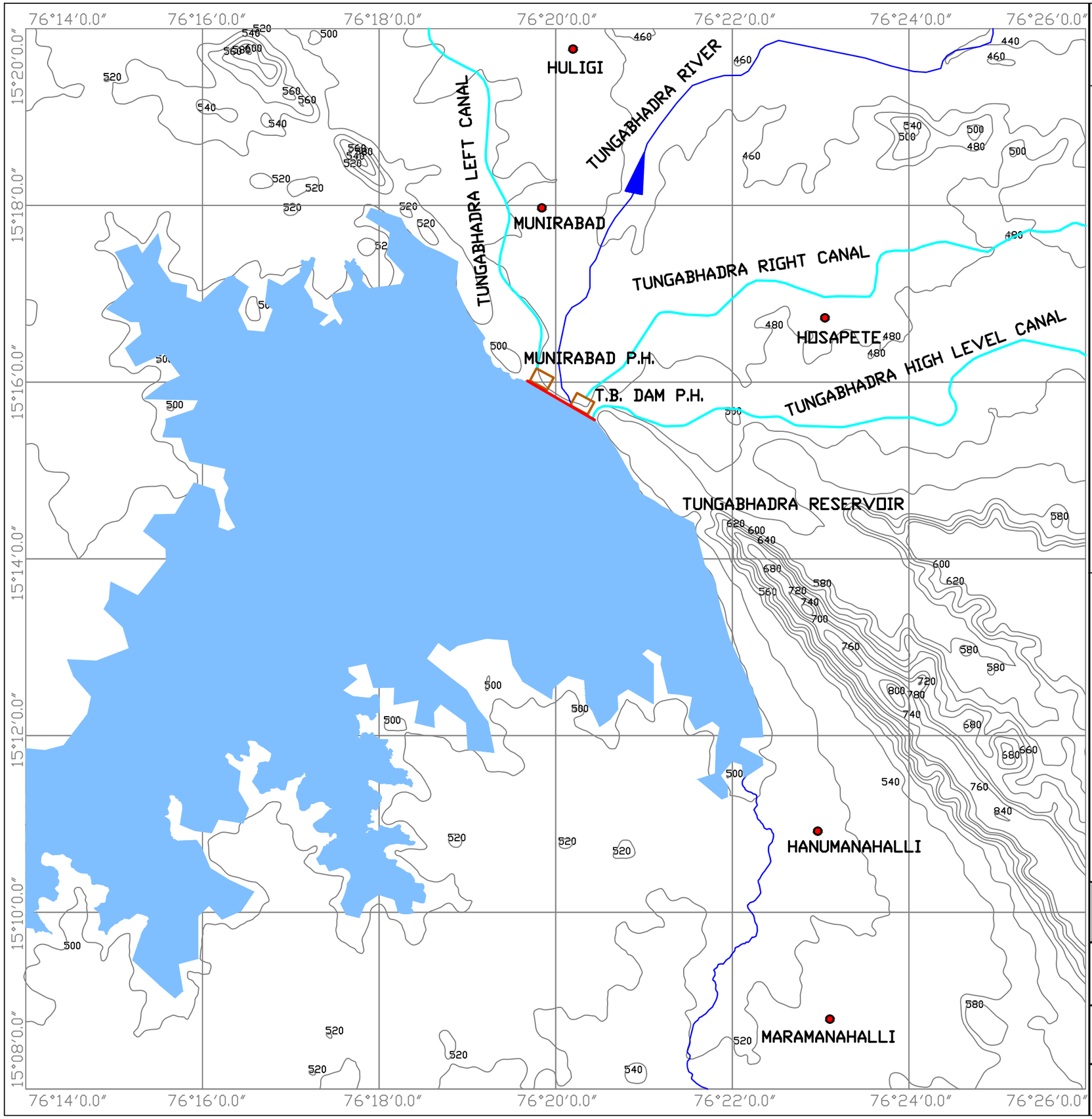
Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	9
Installed Capacity (MW)	36
Rated Head (m)	26.82
Gross Head (Max.) (m)	26.82
Gross Head (Min.) (m)	11.28
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	470.92
Design Discharge (Cumecs)	43.89
Annual Energy (MU)	70

COST ASPECTS:

Estimated Cost (Rs. Crores)	7.12 (Price Level, 1958)
Levellised Tariff (Rs/kWh)	1.40

COMMISSIONING DETAILS:

COMMISSIONING YEARS:-	
Unit -I	1957
Unit -II	1957
Unit -III	1964
Unit -IV	1964



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

CANAL

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

TUNGABHADRA DAM

FRL- 497.74 M

MDDL- 482.19 M

DAM HEIGHT- 49.50 M

LIVE STORAGE- 2831.67 MCuM

POWER HOUSE

TWL- 470.92 M

AVG. GROSS HEAD- 26.82 M

INST. CAPACITY- 36 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

T.B.DAM HYDROELECTRIC PROJECT (4X9) = 36 MW

3.27 HAMPI HYDROELECTRIC PROJECT (4x9MW=36MW)

1. INTRODUCTION

Hampi Hydroelectric Project is located near Sitaram Tanda village approximately 1.5km from power house in Bellary district of Karnataka. The water of Tungabhadra reservoir is released through a Power house located on the right bank from the tail race of which right bank irrigation canal takes off. The Hampi power house is located on this canal and operating under average gross head of about 36.73 m. Hampi Hydroelectric Project utilizes water of river Tungabhadra for power generation on a storage type project. Hampi Power House is fed from the tailrace water from dam powerhouse through the Power Canal. A forebay is located at the end of this canal. There are two low-pressure steel pipe lines (LPPL) each of 5.48 m dia and 868.3 m in length carrying discharge from forebay to the powerhouse.

The generation at Hampi Power House is dependent on water discharge through Power Canal. The water discharged from Hampi power house is led into Low level Canal and is allowed through Gundlakeri escape in case of demand for river assistance. The project is designed to generate power, utilizing rated head of 35.96 m. The project has 4 units of 9 MW in surface powerhouse to generate annual energy of 70 MU in 90% dependable year. Hampi Hydroelectric Project was commissioned in 1958-64 and is executed by Andhra Pradesh Power Generation Corporation Limited (APGENCO).

2. LOCATION/ACCESSIBILITY

The Tungbhadra dam site of the project is located on Tungabhadra River having Latitude 15°15'50.1"N & Longitude 76°19'59.1"E and the Forebay Dam is located at Latitude 15°18'45.7"N & Longitude 76°29'22.0"E. The Power house located at Latitude 15°18'58"N & Longitude 76°29'50"E in Bellary district of Karnataka. The nearest railway station is Hoapet and the nearest airport is Tornagallu.

3. PROJECT FEATURES

Hampi Hydroelectric Project involves construction of Forebay dam with height of 24.38 m. The reservoir has live storage of 0.74 Mcum between Full Reservoir Level of 463.3 m and Minimum Draw Down Level (MDDL) of 462.08 m. The water conductor system comprises of 2 nos. of Head race Tunnel (HRT) of length 868.30 m, surge shaft and 4 nos. of penstock of length 103.60 m carries water to surface powerhouse. The surface power house has four units

of 9 MW each of Francis type turbine operated under rated head of 35.96 m with an installed capacity of 36 MW. A 967.50 m long Tail Race Tunnel carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river up to Tungabhadra dam sie is 28179.071 Sq. km.

5. POWER & ENERGY BENEFITS

Power from Hampi Hydroelectric project is being shared in the ratio of 80:20 between Andhra Pradesh & Karnataka. The project has 4 units of 9 MW with installed capacity of 36 MW and the annual energy of the project is 70 MU in 90% dependable year.

SALIENT FEATURES
HAMPI HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Bellary
River	Tungabhadra
Type of Development	Storage
Nearest Railhead	Hospet
Nearest Airport	Tornagallu

LOCATION:

Dam : Latitude & Longitude	15°15'48.9"N 76°20'01.6"E
Forebay : Latitude & Longitude	15°18'45.7"N, 76°29'22.0"E
Power House : Latitude & Longitude	15° 18' 58"N, 76° 29' 50" E

HYDROLOGY:

Catchment Area (Tungabhadra Dam) (Sq. Km)	28179.071

DAM:

TUNGBHADRA	
Type	Composite
Length (m)	2449
Height (m)	49.5
FOREBAY	
Type	Composite
Length (m)	1557.5
Height (m)	24.38

RESERVOIR:

TUNGABHADRA	
Full Reservoir Level (FRL) (m)	497.74
Minimum Draw Down Level (MDDL) (m)	482.19
Live Storage (Mcum)	2831.67
Gross Storage (Mcum)	3766.13

FOREBAY	
Full Reservoir Level (FRL) (m)	463.3
Minimum Draw Down Level (MDDL) (m)	462.08
Live Storage (Mcum)	0.74

INTAKE:

Number	2
Size (m)	5.49 x 5.49

WATER CONDUCTOR SYSTEM:

HEAD RACE CHANNEL	
Shape	Circle
Number	2
Length (m)	868.3
Diameter (m)	5.48
PENSTOCK	
Number	4
Length (m)	103.6
Diameter (m)	3.65
TAIL RACE CHANNEL	
Number	1
Length (m)	967.5
Diameter (m)	50.6

POWER HOUSE:

Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	9
Installed Capacity (MW)	36
Rated Head (m)	35.96
Avg. Gross Head (Max.) (m)	36.73
Avg. Gross Head (Min.) (m)	34.75
Type of Turbine	Vertical Francis

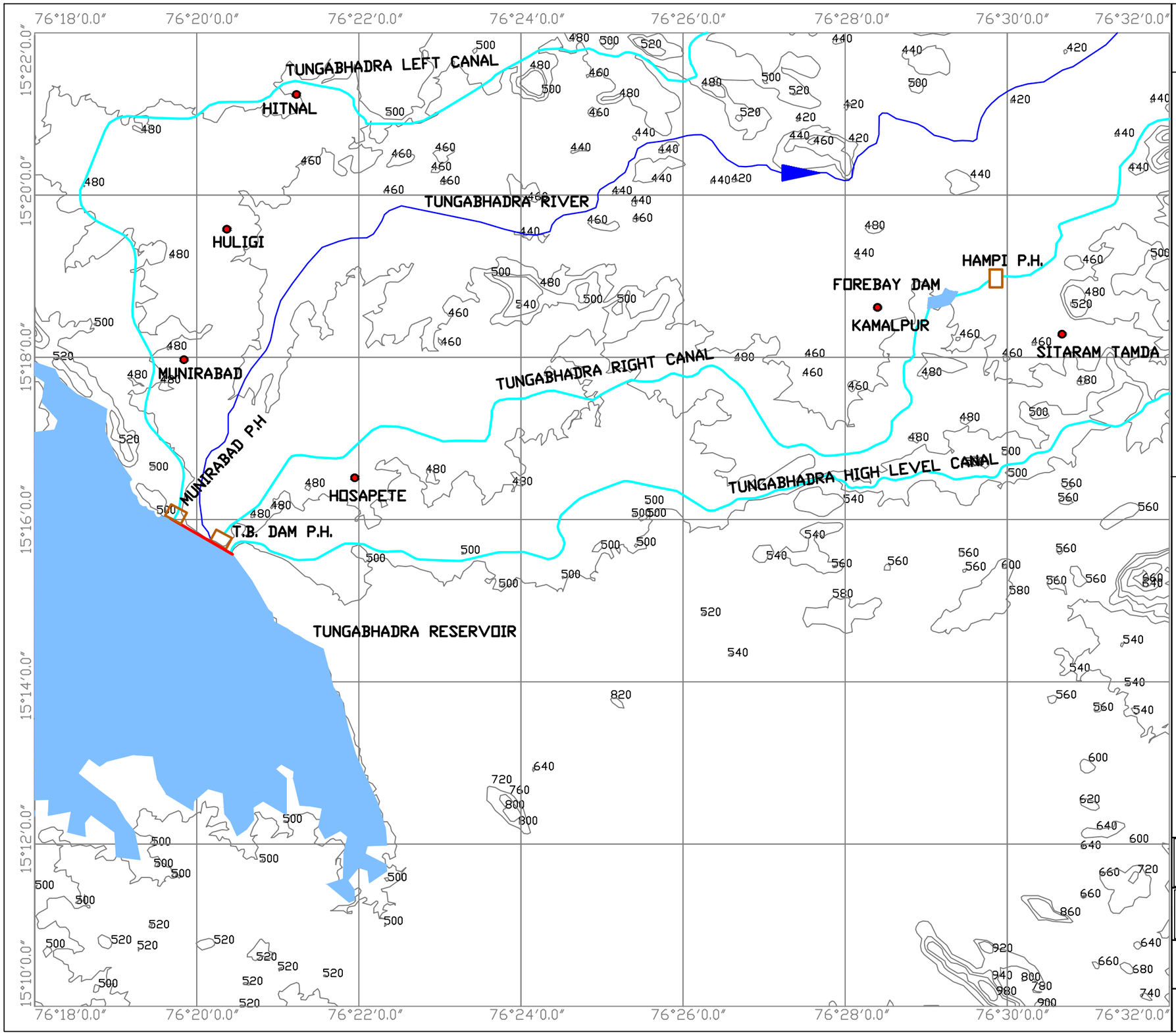
Tail Water Level (TWL) (m)	426.72
Design Discharge (Cumecs)	31.15
Annual Energy (MU)	70

COST ASPECTS:

Estimated Cost (Rs. Crores)	0.8475 (Price Level, 1961)

COMMISSIONING DETAILS:

COMMISSIONING YEARS	
Unit-I	1958
Unit-II	1959
Unit-III	1964
Unit-IV	1964



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- CANAL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

TUNGABHADRA DAM

FRL- 497.74 M
MDDL- 482.19 M
DAM HEIGHT- 49.50 M
LIVE STORAGE- 2831.67 MCuM

FOREBAY DAM

FRL- 463.3 M
MDDL- 462.08 M
DAM HEIGHT- 24.38 M
LIVE STORAGE- 0.74 M

POWER HOUSE

TWL- 426.72 M
RATED HEAD- 35.96 M
INST. CAPACITY- 36 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

HAMPI HYDROELECTRIC PROJECT
(4X9) = 36 MW

3.28 MUNIRABAD HYDROELECTRIC PROJECT (2x9MW+2x10MW=38MW)

1. INTRODUCTION

Munirabad Hydroelectric Project is a storage type development which is located on the river Tungabhadra near Munirabad town approximately 1.5km from project site in Bellary district of Karnataka. The project utilizes water of Tungabhadra River for power generation. The project is designed to generate power, utilizing rated head of 19.81 m. The power house is located on the left bank at the toe of the dam from the tail race of which a left bank canal takes off. The reach of the river forms a boundary between Andhra Pradesh and Karnataka. The Munirabad Power house is in Karnataka State. The project has 2 unit of 9 MW and 2 units of 10 MW with total installed capacity of 38 MW to generate annual energy of 76.5 MU in 90 % dependable year. Munirabad Hydroelectric Project was commissioned in 1962-65 and is executed by Karnataka Power Corporation Limited (KPCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Tungbhadra River having Latitude 15°15'59.7"N & Longitude 76°19'43.2"E and the Power house located at Latitude 15°15'59.7"N & Longitude 76°19'43.7"E in Bellary district of Karnataka. The nearest railway station is Hospet and the nearest airport is Bellary.

3. PROJECT FEATURES

Munirabad Hydroelectric Project involves construction of Masonry Dam with height of 35.4 m. The reservoir has a live storage of 2775.05 Mcum between Full Reservoir Level (FRL) of 497.74 m and Minimum Draw Down Level (MDDL) of 483.41 m. The water conductor system comprises of penstock of length 23.47 m carries water to surface powerhouse. The dam toe Power house has two units of 9 MW and one unit of 10 MW using Kaplan type turbine operated under rated head of 19.81 m with total installed capacity of 38 MW.

4. HYDROLOGY

The catchment area of the river upto Tungabhadra dam site is 28180 Sq. km.

5. POWER & ENERGY BENEFITS

Munirabad Hydroelectric project has 2 units of 9 MW and 2 units of 10 MW with total installed capacity of 38 MW and the annual energy of the project is 76.5 MU in 90% dependable year

SALIENT FEATURES
MUNIRABAD HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Bellary
River	Tungabhadra
Type of Development	Storage
Nearest Railhead	Hospet
Nearest Airport	Bellary

LOCATION:

Dam : Latitude & Longitude	15°15'59.7"N, 76°19'43.2"E
Power House : Latitude & Longitude	15°15'59.7"N, 76°19'43.7"E

HYDROLOGY:

Catchment Area (Sq. Km)	28180

DAM:

Type	Masonry
Length (m)	2448
Height (m)	35.4

RESERVOIR:

Full Reservoir Level (FRL) (m)	497.73
Minimum Draw Down Level (MDDL) (m)	483.41
Live Storage (Mcum)	2775.05

INTAKE:

Gate No	10 nos. of irrigation cum power sluices are provided
Size (m)	3.2 x 4

WATER CONDUCTOR SYSTEM:

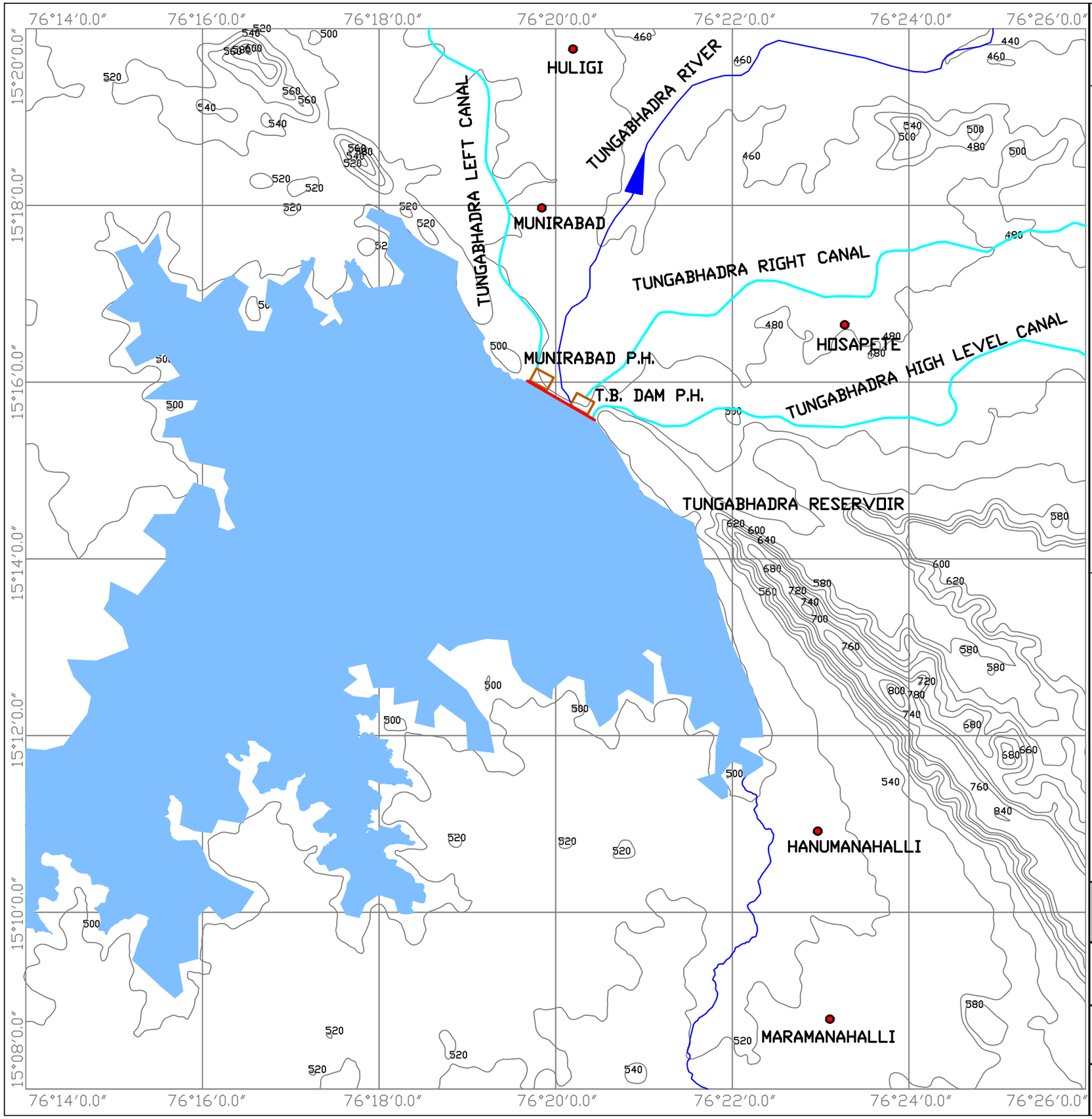
PENSTOCK	
Length (m)	23.47
Diameter (m)	2.66 x 3.5

POWER HOUSE:

Type	Surface (Dam Toe)
No. of Generating Units	4
Capacity of each Unit (MW)	2x9MW+2x10MW
Installed Capacity (MW)	38
Rated Head (m)	19.81
Avg. Gross Head (Max.) (m)	23.47
Avg. Gross Head (Min.) (m)	9.14
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	474.27
Annual Energy (MU)	76.5
Design Discharge (Cumec/unit)	U-1&2 : 53.8 U-3 :55.8

COMMISSIONING DETAILS:

COMMISSIONING YEARS	
Unit -I	1962
Unit -II	1962
Unit -III	1965



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

CANAL

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

TUNGABHADRA DAM

FRL- 497.73 M

MDDL- 483.41 M

DAM HEIGHT- 35.40 M

LIVE STORAGE- 2775.05 MCuM

POWER HOUSE

TWL- 474.27 M

AVG. GROSS HEAD- 23.47 M

INST. CAPACITY- 38 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MUNIRABAD HYDROELECTRIC PROJECT
(2X9)+(2X10) = 38 MW

3.29 BHADRA HYDROELECTRIC PROJECT (1x2MW+2x12MW+1x7.2MW+1x6MW=39.2MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was named as Bhadra LBC & Bhadra Hydroelectric Project. Presently, the project are combined and named as Bhadra Hydroelectric Project. The Bhadra Hydroelectric Project is storage type development which is located on the river Bhadra near Lakkavalli village approximately 2km from project site in Chikkamagaluru district in Karnataka. The project utilizes water of Kali river for power generation. The project is designed to generate power utilizing rated head of 41.91 m, 34.75 m & 17.6 m for RBPH, LBCPH & RBCPH respectively. The project has 2 units of 12 MW for RBPH, 1 unit of 2 MW for LBCPH and 1 unit of 7.2 MW & 1 unit of 6 MW for RBCPH to generate annual energy of 51 MU in 90% dependable year. Bhadra Hydroelectric Project was commissioned in 1962-1968 and is executed by Karnataka Power Corporation Limited (KPCL).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 13°42'4.84" N & Longitude 75°38'11.78"E and the Power house is located at Latitude 13°42'02.90"N & Longitude 75°38'14.63"E in Karnataka. The nearest railway station is Tarikere and the nearest airport is Mangalore INA.

3. PROJECT FEATURES

Bhadra Hydroelectric Project involves construction of Composite type dam of height 59.1 m across Bhadra River. The reservoir has a live storage of 1783.96 Mcum between Full Reservoir Level (FRL) of 657.76 m and Minimum Draw Down Level (MDDL) of 638.15 m. The water conductor system comprises of penstock of length 57.22 m for RBPH, 55.32 m for LBCPH and 28.04 m for RBCPH which carries water to surface powerhouse. The left Bank dam toe Power house has one unit of 2 MW operated under rated head of 34.75 m, River bed dam toe power house have two units of 12 MW using operated under rated head of 41.91 m and Right Bank dam toe power house have two units, one of 7.2 MW & second of 6 MW operated under rated head of 17.6 m with an total installed capacity of 39.2 MW.

4. HYDROLOGY

The catchment area of the river up to dam site is about 1968 Sq km.

5. POWER & ENERGY BENEFITS

Bhadra Hydroelectric project project has 2 units of 12 MW for RBPH, 1 unit of 2 MW for LBCPH and 1 unit of 7.2 MW & 1 unit of 6 MW for RBCPH with total installed capacity of 39.2 MW and the annual energy of the project is 51 MU in 90% dependable year

SALIENT FEATURES
BHADRA HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Chikkamagaluru
River	Bhadra
Type of Development	Storage
Nearest Railhead	Tarikere
Nearest Airport	Mangaluru

LOCATION:

Dam : Latitude & Longitude	13°42'4.84" N,75°38'11.78" E
Power House : Latitude & Longitude	13°42'02.90"N,75°38'14.63"E

HYDROLOGY:

Catchment Area (Sq. Km)	1968

DAM:

Type	Composite
Height (m)	59.1

RESERVOIR:

Full Reservoir Level (FRL) (m)	657.76
Minimum Draw Down Level (MDDL) (m)	638.15
Live Storage (Mcum)	1783.96
Gross Storage (Mcum)	2025

WATER CONDUCTOR SYSTEM:

PENSTOCK	**River Bed (RB)**	**LBC**	**RBC**
Length (m)	57.22	55.32	28.04
Diameter (m)	3.05	1.82	3.05

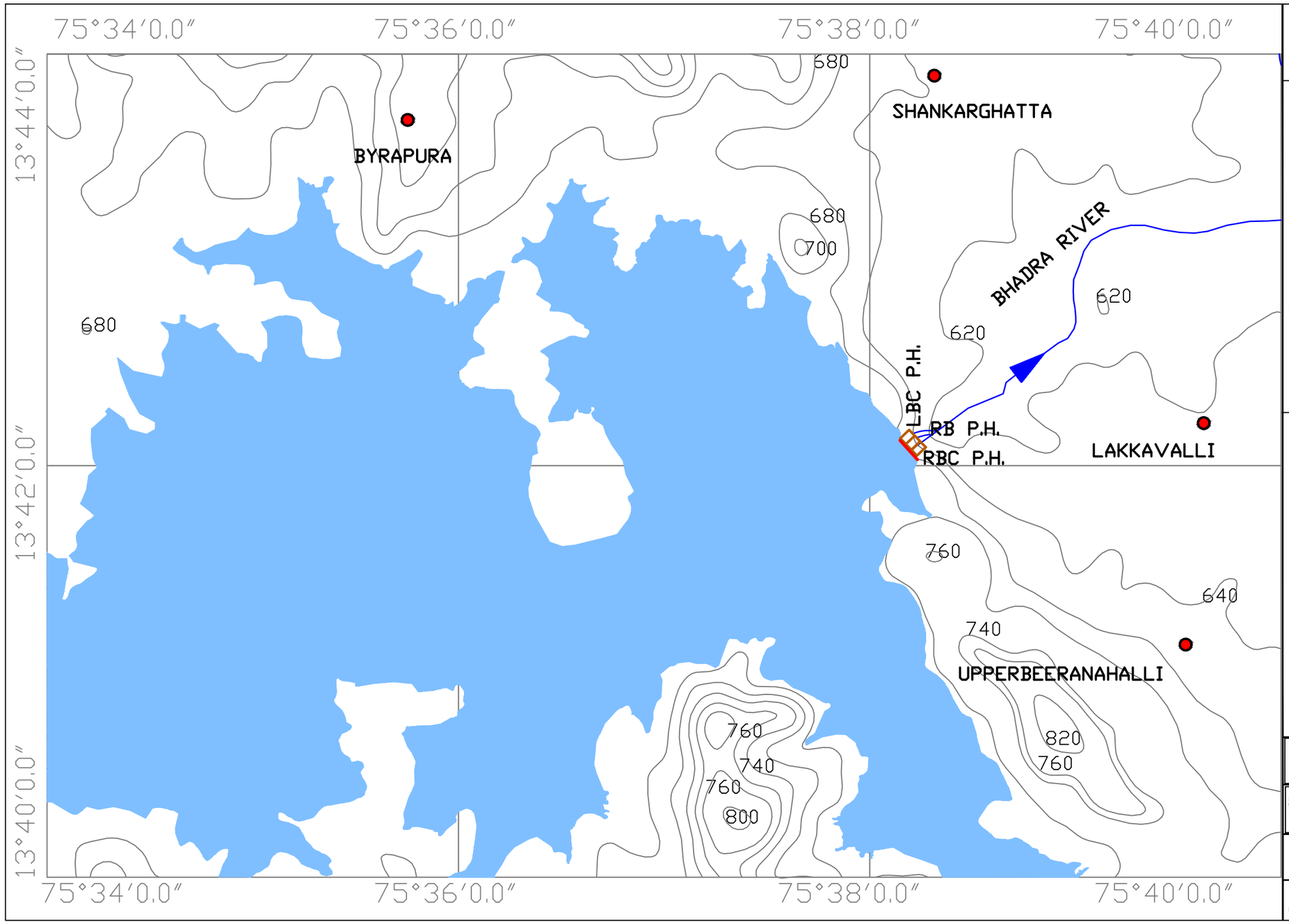
POWER HOUSE:

	River Bed (RB)	**LBC**	**RBC**
Type	Surface (Dam Toe)		

No. of Generating Units	2	1	2
Capacity of each Unit (MW)	12	2	(1x7.2)+(1x6)
Installed Capacity (MW)	24	2	13.2
Rated Head (m)	41.91	34.75	17.6
Avg. Gross Head (Max.) (m)	49.39	43.75	21.18
Type of Turbine	Vertical Kaplan	Horizontal Francis	Vertical Kaplan
Tail Water Level (TWL) (m)	608.37	614.01	636.58
Design Discharge (Cumec/unit)	33.31	6.91	49.39
Annual Energy (MU)	51		

COMMISSIONING DETAILS:

COMMISSIONING YEARS	
Unit - I (LBC)	1962
Unit - II (RB1)	1963
Unit - III (RB2)	1963
Unit - IV (RBC1)	1963
Unit - V (RBC2)	1988



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVIOR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BHADRA DAM

FRL - 657.76 M
MDDL- 638.15 M
DAM HEIGHT - 59.1 M
LIVE STORAGE- 1783.96 MCuM

POWER HOUSE

TWL (RB)-608.37 M
TWL (LBC)-614.01 M
TWL (RBC)-636.58 M
AVG. GROSS HEAD (RB)-49.39M
AVG. GROSS HEAD (LBC)-43.75M
AVG. GROSS HEAD (RBC)-21.18M
INST. CAPACITY- 39.2 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDRO-ELECTRIC POTENTIAL IN THE COUNTRY

BHADRA HYDROELECTRIC PROJECT
(2x12)+(1x2)+(1x7.2)+(1x6) =39.2MW

3.30 PULICHINTALA HYDROELECTRIC PROJECT(4X30MW=120MW)

1. INTRODUCTION

Pulichintala Hydroelectric Project was constructed on Pulichintala reservoir known as Dr. K. L. Rao Sagar. Pulichintala Hydroelectric Project dam is a Storage type of development located at the downstream of Nagarjunasagar dam. Vajinepally village is located approximately 1.81 km from the dam site. It is a multipurpose project serving irrigation needs, hydropower generation and flood control utilizing the water of Krishna River for power generation. The dam toe project has Surface power house with Installed Capacity of 120MW (4X30MW) utilizing the rated head of 24m to generate annual energy of 219.49 MU in a 90 % dependable year. The project was commissioned in between 2016-18 and is executed by Telangana Power Generation Corporation Limited (TSGENCO).

2. LOCATION/ACCESSIBILITY

The dam site is located at Latitude 16°46'16.1"N & Longitude 80°03'20.4"E and the Power house is located at Latitude 16°46'25.6"N & Longitude 80°03'10.2"E in the Suryapet district, Tamil Nadu.The nearest railway station from project site is Bonakal and nearest airport is Gannavaram.

3. PROJECT FEATURES

The Pulichintala Hydroelectric Project has a Concrete Gravity Dam of height 33 m and 934 m length. The reservoir formed by the dam has a live storage of 983 Mcum between Full Reservoir Level (FRL) of 53.34 m and Minimum Draw Down Level (MDDL) of 42.67 m. The water conductor system comprises of 1 number of Head Race Tunnel (HRT) of length 280 m and 1 number of penstock of length 58m which carries water to the surface powerhouse. The Surface powerhouse has 4 units of 30MW using Kaplan turbine operated under rated head of 24 m with Installed Capacity of 120 MW. A 950 m long Tail Race Tunnel/Channel carries powerhouse release back to the river

4. HYDROLOGY

The catchment area of the river upto the dam site is 258948 Sq. km.

5. POWER & ENERGY BENEFITS

Pulichintala Hydroelectric project has 4 units of 30 MW each with installed capacity of 120 MW. The project generates annual energy of 219.49 MU in a 90% dependable year. The firm power capacity of Hydroelectric Project is about 9MW.

SALIENT FEATURES
PULICHINTALA HYDROELETRIC PROJECT

GENERAL:

State	Telangana
District	Suryapet
River	Krishna
Type of Development	Storage
Nearest Railhead	Bonakal
Nearest Airport	Gannavaram

LOCATION:

Dam : Latitude & Longitude	80°03'20.4"E,16°46'16.1"N
Power House : Latitude & Longitude	80°03'10.2"E, 16°46'25.6"N

HYDROLOGY:

Catchment Area (Sq. Km)	258948
Maximum Annual Rainfall (mm)	670.30

GEOLOGY:

Type of Rock	Consist of Limestone's , slate, shale & quartzite , limestone's from lower rock of the series and dip at gentle angles underneath the slates and quartzite.

RESERVOIR:

Full Reservoir Level (FRL) (m)	53.34
Minimum Draw Down Level (MDDL) (m)	42.67
Live Storage (Mcum)	983
Gross Storage (Mcum)	1296

DAM:

Type	Concrete gravity dam
Length (m)	934
Height (m)	33

INTAKE:

Gate No.	4
Size (m)	6.80 x 10.89

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Rectangle
Number	1
Length (m)	280
PENSTOCK	
Number	4
Length (m)	58
Diameter(m)	6.34
TAIL RACE TUNNEL/CHANNEL	
Shape	Trapezoidal
Number	1
Length (m)	950

POWER HOUSE:

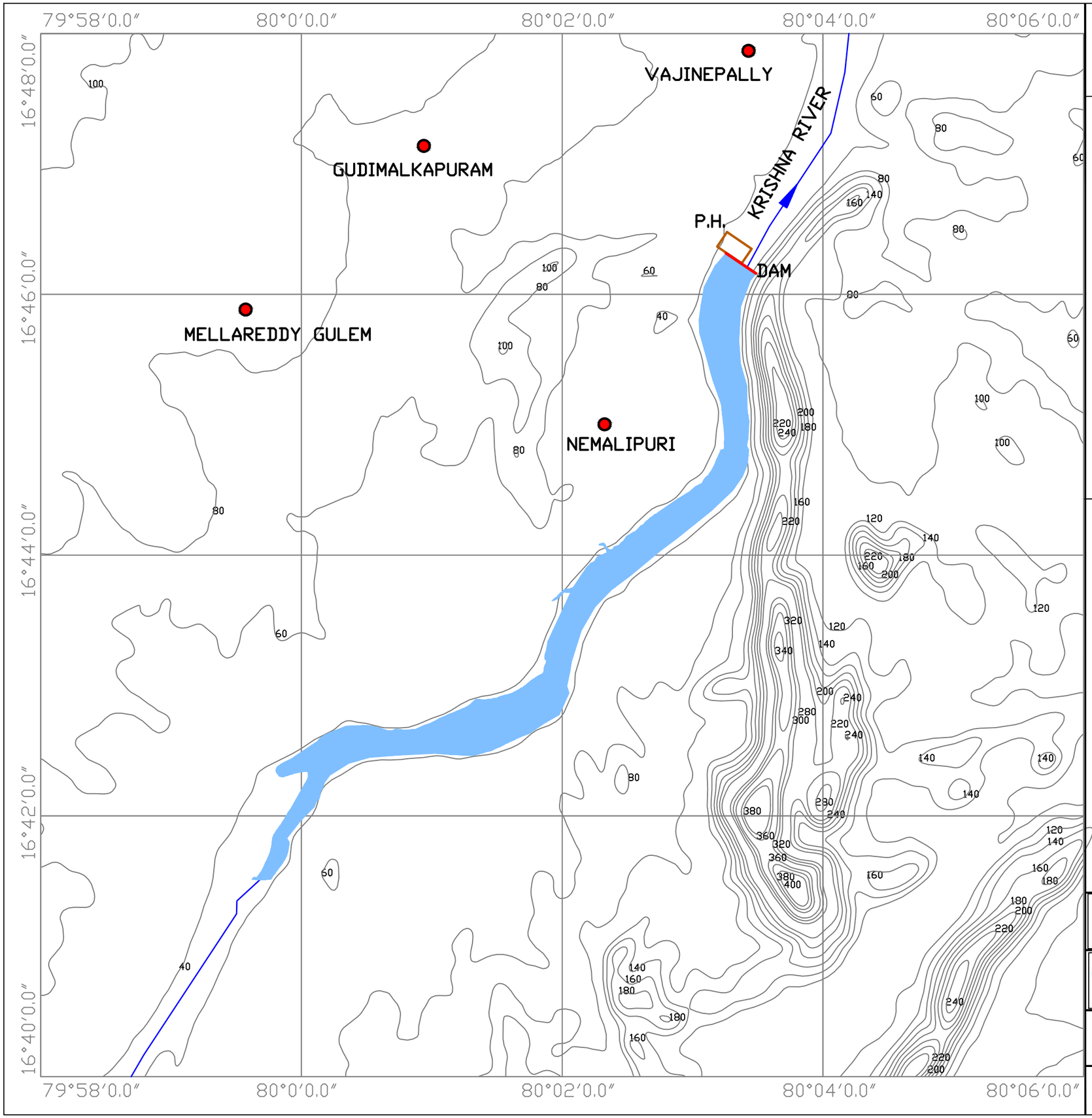
Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	30
Firm Power (MW)	9
Installed Capacity (MW)	120
Rated Head (m)	24
Avg. Gross Head (Min.) (m)	14.80
Avg. Gross Head (Max.) (m)	28.62
Type of Turbine	Vertical Kaplan
Tail Water Level (TWL) (m)	27.86
Design Discharge (Cumecs)	57700
Annual Energy (MU)	219.49

COST ASPECTS:

Estimated Cost (Rs. Crores)	563.50 (Price Level-2016)
Levellised Tariff (Rs/KWh)	4.16

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	2016
Unit- II	2017
Unit- III	2017
Unit- IV	2018



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

PULICHINTALA DAM

FRL- 53.34 M
MDDL- 42.67 M
DAM HEIGHT- 33 M
LIVE STORAGE- 983 MCuM

POWER HOUSE

TWL- 27.86 M
RATED HEAD- 24 M
INST. CAPACITY- 120 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

PULICHINTALA HYDROELECTRIC PROJECT
(4X30) = 120 MW

3.31 METTUR DAM HYDROELECTRIC PROJECT (4x12.5MW=50MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Mettur Dam P/H Hydroelectric Project. Presently, the project is named as Mettur Dam Hydroelectric Project. Mettur Dam Hydroelectric Project is a storage type development which is located near Samballi village approximately 4.19 Km. from project site in Salem district of Tamilnadu. The Mettur reservoir constitutes the prime regulating basin supply to the irrigation requirement of the centuries old and vast canal system in Tamil Nadu in the Cauvery Delta. The project utilizes water of Cauvery River for power generation, harnessing rated head of 48.77m. The project has an installed capacity of 50 MW with 4 units of 12.5 MW in surface type powerhouse generating annual energy of 82 MU in 90 % dependable year. The Project was commissioned in 1937-46 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°48'3.1"N and Longitude 77°48'36"E. The Power house is located at Latitude 11°48'1.4"N and Longitude 77°48'36.1"E. The Nearest Railway station from the project site is Mettur railway station and Airport is Salem.

3. PROJECT FEATURES

Mettur Hydroelectric Project involves construction of Masonary type dam of height 65.23m and length 1615.44 across the Cauvery River. The reservoir has live storage of 2646.77 Mcum between Full Reservoir Level (FRL) of 240.62m and Minimum Draw Down Level (MDDL) of 204.22m. The water conductor system comprises of 4 nos. of Head Race Tunnel (HRT) of length 42.67m and 4 nos. of penstock which carries water to the powerhouse. The project has dam toe powerhouse (surface) with installed capacity of 50 MW (4 x 12.5 MW) utilizing rated head of 48.77 m. A Tail Race Tunnel/Channel of length 52.5m carries powerhouse release back to the river.

4. HYDROLOGY

The catchment area of the river upto the dam site is 42217 Sq. Km.

5. POWER & ENERGY BENEFITS

Mettur dam hydroelectric project has 4 units of 12.5 MW wih an installed capacity of 50 MW. The annual energy of the project is 82 MU in 90% dependable year.

SALIENT FEATURES
METTUR DAM HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Salem
River	Cauvery
Type of Development	Storage
Nearest Railhead	Mettur
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°48'03.1"N 77°48'36.0"E
Power House : Latitude & Longitude	11°48'01.4"N, 77°48'36.1"E

HYDROLOGY:

Catchment Area (Sq. Km)	42217
Maximum Annual Rainfall (mm)	66
Minimum Annual Rainfall (mm)	0.2
Mean Annual Rainfall (mm)	62.14

DAM:

Type	Masonary
Length (m)	1615.44
Height (m)	65.23

RESERVOIR:

Full Reservoir Level (FRL) (m)	240.62
Minimum Draw Down Level (MDDL) (m)	204.22
Live Storage (Mcum)	2646.77
Gross Storage (Mcum)	2708.8

INTAKE:

Gate No	4
Size (m)	2.75 x 3.67

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	4
Length (m)	42.67
PENSTOCK	
Number	4
Length (m)	23.14 & 23.83
Diameter (m)	2.59 & 1.83
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1
Length (m)	52.5

POWER HOUSE:

Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	12.5
Installed Capacity (MW)	50
Rated Head (m)	48.77
Avg. Gross Head (Max.) (m)	48.77
Avg. Gross Head (Min.) (m)	18.29
Type of Turbine	Francis
Tail Water Level (TWL) (m)	193.25
Annual Energy (MU)	82

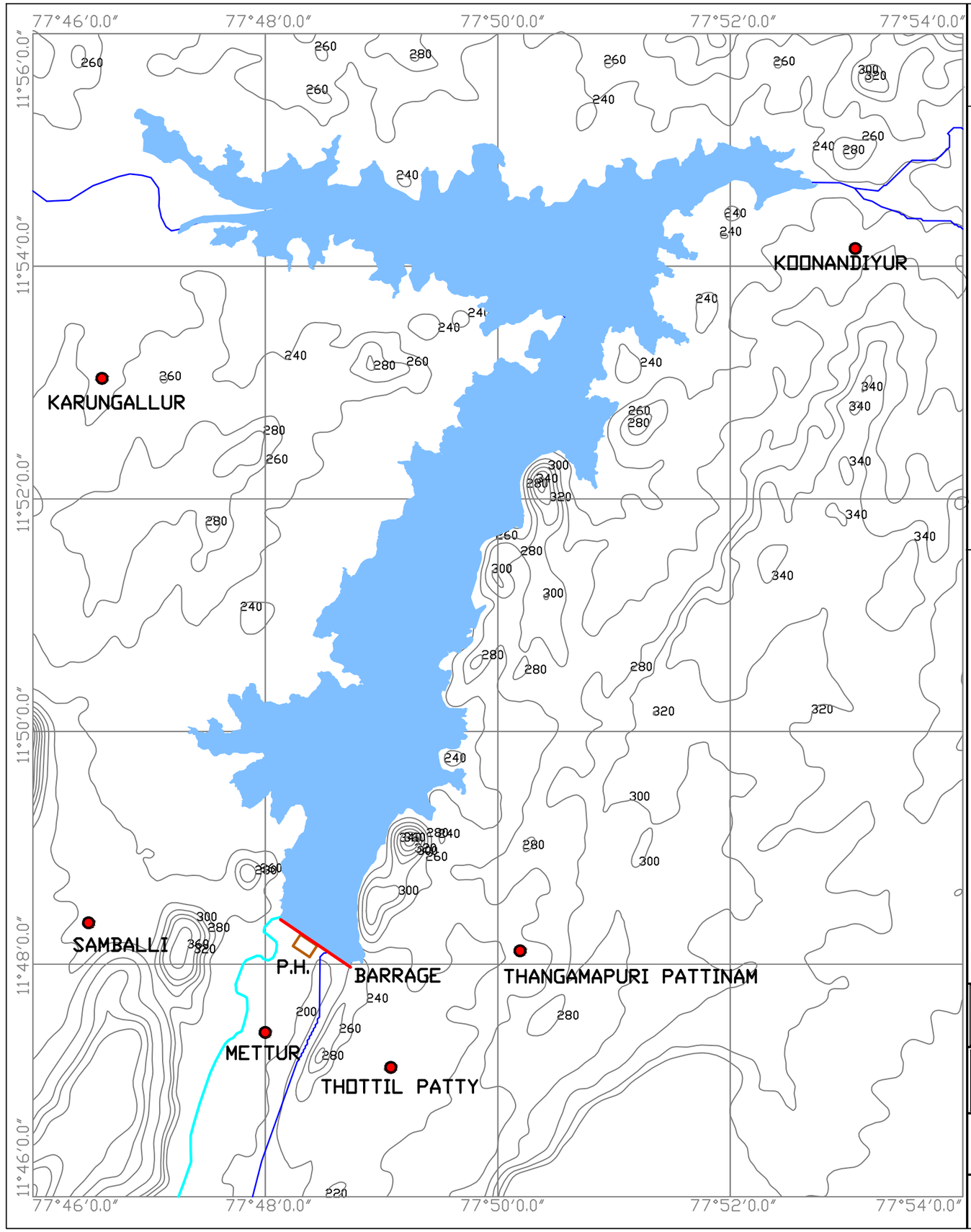
COST ASPECTS:

Estimated Cost (Rs. Crores)	1.26 (Price Level, 1937)

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1937
Unit- II	1937

Unit- III	1938
Unit- IV	1946



LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- POWER HOUSE
- CANAL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

METTUR DAM

FRL- 240.62 M
MDDL- 204.22 M
DAM HEIGHT- 65.23M
LIVE STORAGE- 2646.77 MCuM

POWER HOUSE

TWL- 193.25 M
RATED HEAD- 48.77 M
INST. CAPACITY- 50 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

METTUR DAM HYDROELECTRIC PROJECT
(4X12.5) = 50 MW

3.32 METTUR TUNNEL HYDROELECTRIC PROJECT (4x50MW=200MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Mettur Tunnel P/H Hydroelectric Project. Presently, the project is named as Mettur Tunnel Hydroelectric Project. Mettur Tunnel Hydroelectric Project is a storage type of development which is located near Samballi village, approximately 4.19 Km. from project site in Salem district of Tamilnadu. The Mettur tunnel project utilize this surplus water for generation of power by leading the water through a short tunnel in the left abutment, by-passing the dam, come up the surge shafts and flow down the penstocks to the turbines and tail race into the river about 400 m downstream the dam. The Mettur reservoir constitutes the prime regulating basin supply to the irrigation requirement of the centuries old and vast canal system in Tamil Nadu in the Cauvery Delta. The project utilizes the water of Cauvery River for power generation, harnessing rated head of 48.77m. The project has an installed capacity of 200 MW with 4 units of 50 MW in surface type powerhouse, generating annual energy of 520 MU in 90% dependable year. The Hydroelectric Project was commissioned in 1965-66 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°48'3.1"N and Longitude 77°48'36"E. The Power house is located at Latitude 11°47' 52.5"N and Longitude 77°48'38.8"E. The Nearest Railway station from project site is Mettur railway station and Airport is Salem.

3. PROJECT FEATURES

Mettur Tunnel Hydroelectric Project involves construction of Masonary type dam of height 65.23m and length 1615.44 across the river Cauvery. The reservoir has live storage of 2646.77 Mcum between Full Reservoir Level (FRL) of 240.79m and Minimum Draw Down Level (MDDL) of 219.45m. The water conductor system comprises of 1 nos. of Head Race Tunnel of length 406.91m and 4 nos. of penstock of length 126.61 m which carries water to the powerhouse. The project has surface powerhouse with an installed capacity of

200 MW (4x50MW) utilizing rated head of 48.77m. A Tail Race Channel/Tnnel of length 126.61 m carries powerhouse release back to the river.

4. HYDROLOGY

The catchment area of the river upto the dam site is 42217 Sq. Km.

5. POWER & ENERGY BENEFITS

Mettur tunnel hydroelectric project has 4 units of 50 MW with installed capacity of 200 MW. The annual energy of the Project is 520 MU in 90 % dependable year.

SALIENT FEATURES
METTUR TUNNEL HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Salem
River	Cauvery
Type of Development	Storage
Nearest Railhead	Mettur
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°48'03.1"N , 77°48'36.0"E
Power House : Latitude & Longitude	11°47'52.5"N, 77°48'38.8"E

HYDROLOGY:

Catchment Area (Sq. Km)	42217
Maximum Annual Rainfall (mm)	66
Minimum Annual Rainfall (mm)	0.2
Mean Annual Rainfall (mm)	62.14

DAM:

Type	Masonary
Length (m)	1615.44
Height (m)	65.23

RESERVOIR:

Full Reservoir Level (FRL) (m)	240.79
Minimum Draw Down Level (MDDL) (m)	219.45
Live Storage (Mcum)	2646.77
Gross Storage (Mcum)	2708.8

INTAKE:

Gate No	4
Size (m)	5.48 x 8.01

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Horse Shoe
Number	1
Length (m)	406.91
Diameter (m)	13.71
PENSTOCK	
Number	4
Length (m)	126.61
Diameter (m)	6.55
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1
Length (m)	115

POWER HOUSE:

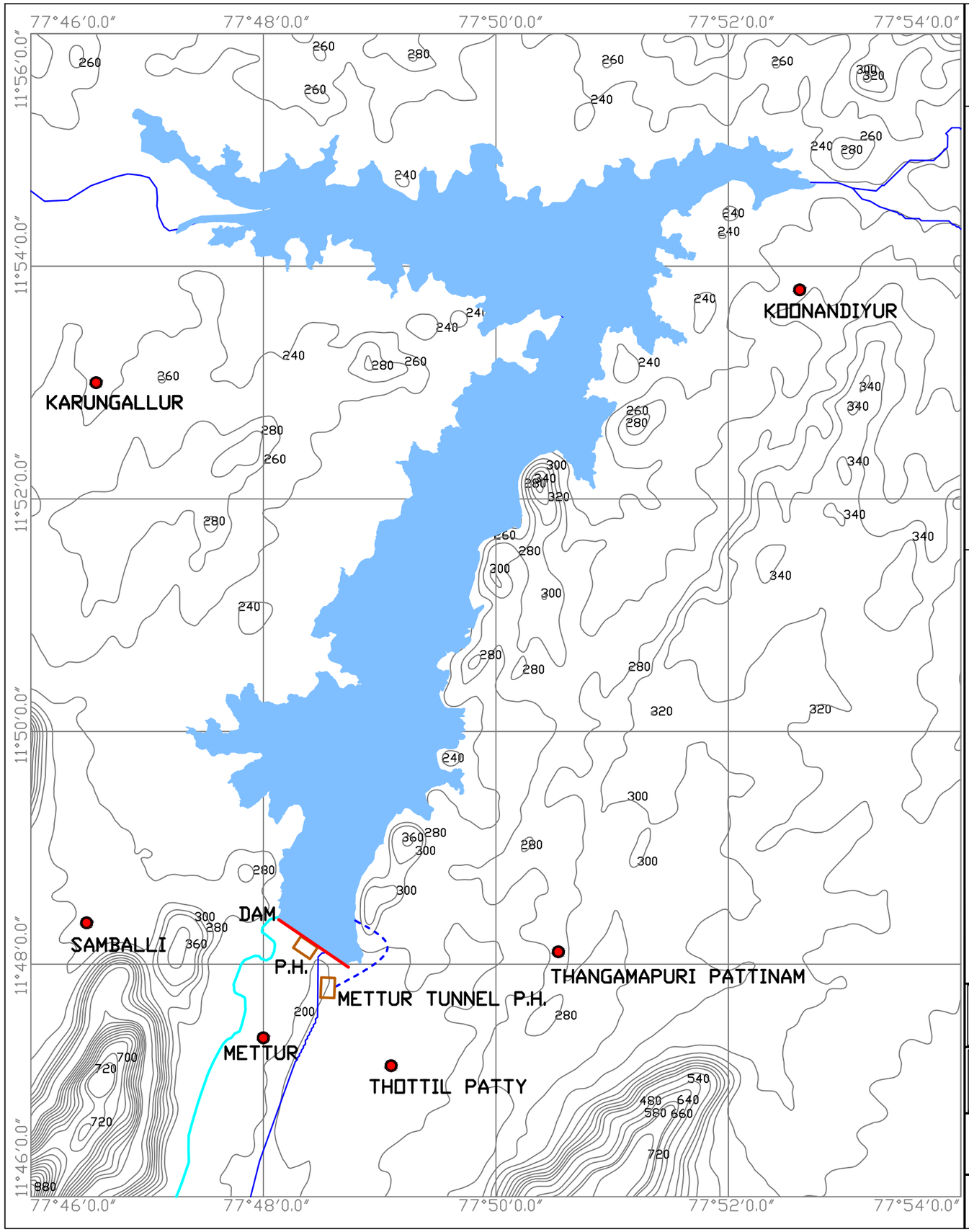
Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	50
Installed Capacity (MW)	200
Rated Head (m)	48.77
Avg. Gross Head (Max.) (m)	48.77
Avg. Gross Head (Min) (m)	35.53
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	193.25
Annual Energy (MU)	520

COST ASPECTS:

Estimated Cost (Rs. Crores)	11.82 (Price Level, 1965)

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1965
Unit- II	1966
Unit- III	1966
Unit- IV	1966



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- HRT
- POWER HOUSE
- CANAL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

METTUR DAM

FRL- 240.79 M
MDDL- 219.45M
DAM HEIGHT- 65.23 M
LIVE STORAGE- 2646.77 MCuM

POWER HOUSE

TWL- 193.25 M
RATED HEAD- 48.77 M
INST. CAPACITY- 200 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

METTUR TUNNEL HYDROELECTRIC PROJECT
(4X50) = 200 MW

3.33 LOWER METTUR-I HYDROELECTRIC PROJECT (2x15MW =30MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Lower Mettur Hydroelectric Project. It is executed in 4 stages. Lower Mettur-I is located approximately 280 Km. downstream of Mettur dam. This project is named as Lower Mettur-I Hydroelectric Project. The Project is a Run of River (RoR) type of development which is located near Kolanayakkanpatti village approximately 800m from the project site in Salem district of Tamilnadu. The project utilizes the water of Cauvery River for power generation, harnessing rated head of 9m. The project has an installed capacity of 30MW with 2 units of 15 MW in a powerhouse generating annual energy of 95 MU in 90% dependable year. The Hydroelectric Project was commissioned in 1988 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°43'38.81"N and Longitude 77°46'51.4"E. The Power House is located at Latitude 11°43'38.97" N and Longitude 77°46'45.69"E. The Nearest Railway station from the project site is Mettur railway station and Airport is Salem.

3. PROJECT FEATURES

Lower Mettur-I Hydroelectric Project involves construction of a barrage of height 9m and length 330m across the Cauvery river. The Full Reservoir Level (FRL) of the project is 193.25m and Minimum Draw Down Level (MDDL) is 189.25m. The water conductor system consists of 1 no. of Head Race Tunnel of Bell mouth shape which carries water to the powerhouse. The project has installed capacity of 30MW (2 x 15 MW) utilizing rated head of 9 m. A Tail Race Channel/Tunnel of length 7.32m carries powerhouse release back to the river.

4. POWER & ENERGY BENEFITS

Lower Mettur-I has 2 units of 15MW with an installed capacity of 30MW. The annual energy of the Project is 95 MU in 90% dependable year.

SALIENT FEATURES
LOWER METTUR -I HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Salem
River	Cauvery
Type of Development	RoR
Nearest Railhead	Mettur railway station
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°43'38.81"N , 77°46'51.4"E
Power House : Latitude & Longitude	11°43'38.97"N,77°46'45.69"E

DAM:

Type	Barrage
Length (m)	330
Height (m)	9

RESERVOIR:

Full Reservoir Level (FRL) (m)	193.25
Minimum Draw Down Level (MDDL) (m)	189.25
Gross Storage (Mcum)	15.68

INTAKE:

Gate No	4
Size (m)	6.69 x 15.70

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	1
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1

Length (m)	7.32

POWER HOUSE:

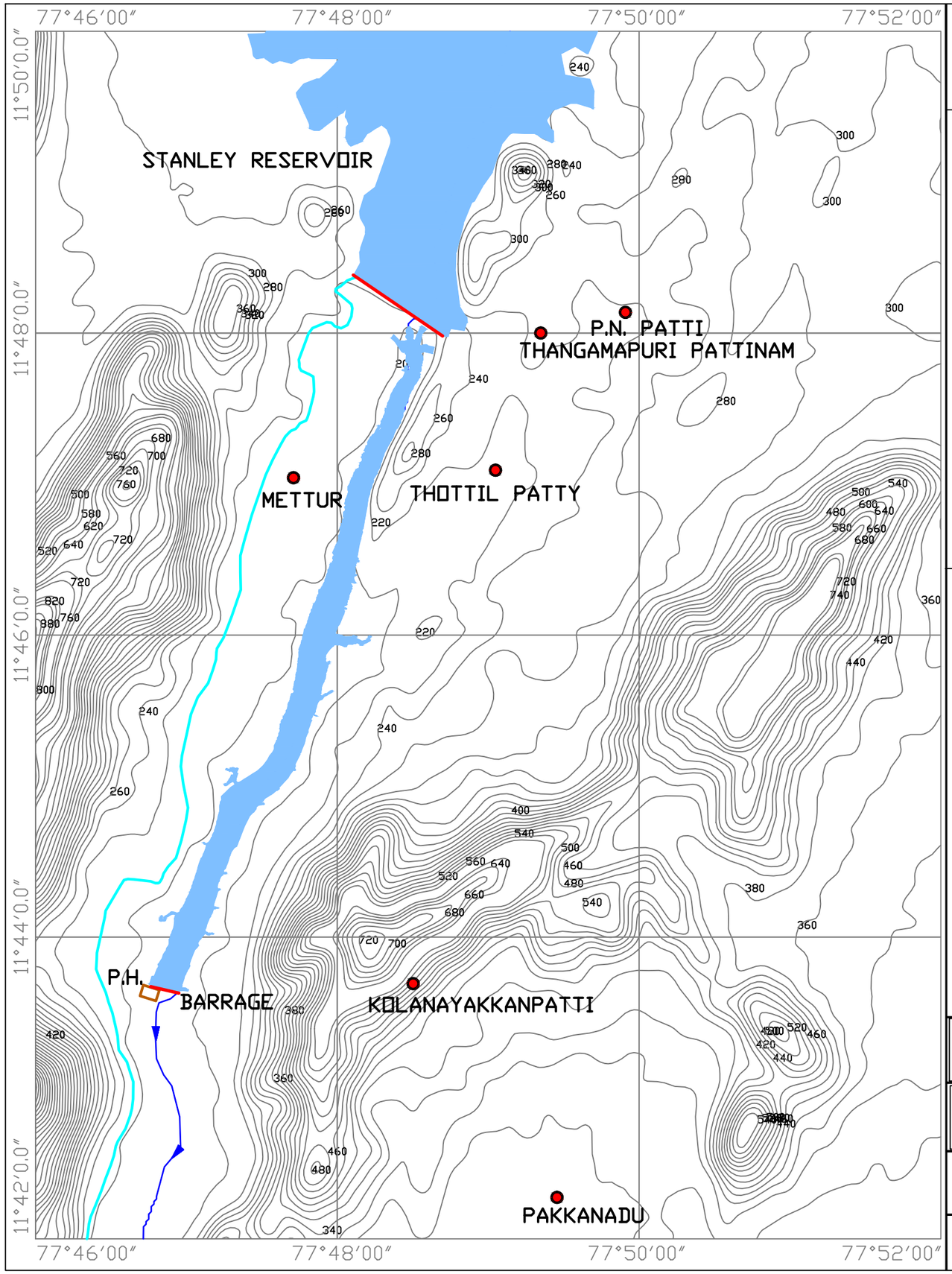
Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	15
Installed Capacity (MW)	30
Rated Head (m)	9
Avg. Gross Head (Max.) (m)	7.5
Avg. Gross Head (Min.) (m)	3.75
Type of Turbine	Bulb
Tail Water Level (TWL) (m)	184.25
Design Discharge (Cumec/unit)	271
Annual Energy (MU)	95

COST ASPECTS:

Estimated Cost (Rs. Crores)	(Price Level, 1987)
Lower Mettur -I	163.85
Lower Mettur -II	
Lower Mettur -III	
Lower Mettur -IV	

COMMISSIONING DETAILS:

Commissioning Year	1988





LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- CANAL
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

LOWER METTUR-I

FRL- 193.25 M

MDDL- 189.25 M

BARRAGE HEIGHT- 9 M

POWER HOUSE

TWL- 184.25 M

RATED HEAD- 9 M

INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER METTUR-I HYDROELECTRIC PROJECT
(2X15) = 30 MW

3.34 LOWER METTUR-II HYDROELECTRIC PROJECT (2x15MW=30MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Lower Mettur Hydroelectric Project. It is executed in 4 stages. Lower Mettur-II is at the downstream of Lower Mettur-I Hydroelectric Project. The project is a Run of River (RoR) type of development which is located near Padavalkalvai village approximately 2.33 Km. from project site in Erode district of Tamilnadu. The project utilizes the water of Cauvery River for power generation, harnessing rated head of 9 m. The project has an installed capacity of 30 MW with 2 units of 15 MW in powerhouse generating annual energy of 99MU in 90% dependable year. The Project was commissioned in 1988 and is executed by Tamil Nadu Generation and Distribution Corporation (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°38'35.56"N and Longitude 77°45'27.50"E. The Power house is located at Latitude 11° 38'37.08"N and Longitude 77°45'22.97"E. The Nearest Railway station is Erode and Airport is Salem.

3. PROJECT FEATURES

Lower Mettur-II Hydroelectric Project involves construction of a barrage of height 9m and length 330m across the Cauvery River. The Full Reservoir Level (FRL) of the project is 184.25m and Minimum Draw Down Level (MDDL) is 180.25m. The water conductor system consists of 1 no. of Head Race Tunnel (HRT) of Bell mouth shape which carries water to the powerhouse. The project has an installed capacity of 30MW (2 x 15MW) utilizing rated head of 9m. A Tail Race Channel/Tunnel of length 7.32 m carries powerhouse release back to the river

4. POWER & ENERGY BENEFITS

Lower Mettur-II project has 2 units of 15 MW with an installed capacity of 30 MW. The annual energy of Lower Mettur-II Hydroelectric Project is 99 MU in 90% dependable year.

SALIENT FEATURES
LOWER METTUR -II HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Erode
River	Cauvery
Type of Development	RoR
Nearest Railhead	Erode
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°38'35.56"N,77°45'27.50"E
Power House : Latitude & Longitude	11°38'37.08"N,77°45'22.97"E

GEOLOGY:

Type of Rock	Hard Rock

DAM:

Type	Barrage
Length (m)	330
Height (m)	9

RESERVOIR:

Full Reservoir Level (FRL) (m)	184.25
Minimum Draw Down Level (MDDL) (m)	180.25
Gross Storage (Mcum)	15

INTAKE:

Gate No	4
Size (m)	6.69 x 15.70

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	1

TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1
Length (m)	7.32

POWER HOUSE:

Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	15
Installed Capacity (MW)	30
Rated Head (m)	9
Avg. Gross Head (Max.) (m)	7.5
Avg. Gross Head (Min.) (m)	3.75
Type of Turbine	Bulb
Tail Water Level (TWL) (m)	175.25
Annual Energy (MU)	99

COST ASPECTS:

Estimated Cost (Rs. Crores)	(Price Level, 1987)
Lower Mettur- I	163.85
Lower Mettur- II	
Lower Mettur- III	
Lower Mettur- IV	

COMMISSIONING DETAILS:

Commissioning Year	1988

77°44'00"
77°46'00"
77°48'00"
11°42'0.0"
11°40'0.0"
11°38'0.0"

1360
1320
1100
840
1220
1060
820
1380
800
920
780
880
740
620
540
340
440
460
380
340
360
320
300
PAKKANADU
320
340
280
260
PADAVALKALVAI
P.H.
BARRAGE
180
200
PILLUKURICHI
CAUVERY RIVER

N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- CANAL
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

LOWER METTUR-II

FRL- 184.25 M
MDDL- 180.25 M
BARRAGE HEIGHT- 9 M

POWER HOUSE

TWL- 175.25 M
RATED HEAD- 9 M
INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

वाप्कोस लिमिटेड
WAPCOS LIMITED
CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER METTUR-II HYDROELECTRIC PROJECT
(2X15) = 30 MW

3.35 LOWER METTUR-III HYDROELECTRIC PROJECT (2x15MW=30MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Lower Mettur Hydroelectric Project. It is executed in 4 stages. The project is in downstream of Lower Mettur-II Hydroelectric Project which is named as Lower Mettur-III Hydroelectric Project. The Project is a Run of River type of development which is located near Koneripatti village approximately 400m from project site in Erode district of Tamilnadu. The project utilizes the water of Cauvery River for power generation, harnessing rated head of 6.5 m. The project has an installed capacity of 30MW with 2 units of 15 MW in powerhouse generating annual energy of 91 MU in 90% dependable year. The Project was commissioned in 1987-88 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°34'34.5"N and Longitude 77°44'36.4"E. The Power house is located at Latitude 11°34'30.7"N and Longitude 77°44'31.1"E. The Nearest Railway station from project site is Erode and Airport is Salem.

3. PROJECT FEATURES

Lower Mettur-III Hydroelectric Project involves construction of a barrage of height 9m and length 330m across the Cauvery River. The Full Reservoir Level (FRL) of the project is 175.25m and Minimum Draw Down Level (MDDL) is 171.25m. The water conductor system consists of 1 no. of Head Race Tunnel (HRT) of Bell mouth shape which carries water to the powerhouse. The project has an installed capacity of 30 MW (2 x 15 MW) utilizing rated head of 6.5 m. A Tail Race Channel/Tunnel of length 7.32 m carries powerhouse release back to the river.

4. POWER & ENERGY BENEFITS

Lower Mettur-III project has 2 units of 15MW with an installed capacity of 30 MW. The annual energy of Lower Mettur-III Hydroelectric Project is 91 MU in 90% dependable year.

SALIENT FEATURES
LOWER METTUR -III HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Erode
River	Cauvery
Type of Development	RoR
Nearest Railhead	Erode
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°34'34.5"N, 77°44'36.4"E
Power House : Latitude & Longitude	11°34'30.7"N, 77°44'31.1"E

DAM:

Type	Barrage
Length (m)	330
Height (m)	9

RESERVOIR:

Full Reservoir Level (FRL) (m)	175.25
Minimum Draw Down Level (MDDL) (m)	171.25
Gross Storage (Mcum)	13.22

INTAKE:

Gate No	4
Size (m)	6.6 x 15.88

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	1
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1

Length (m)	7.32

POWER HOUSE:

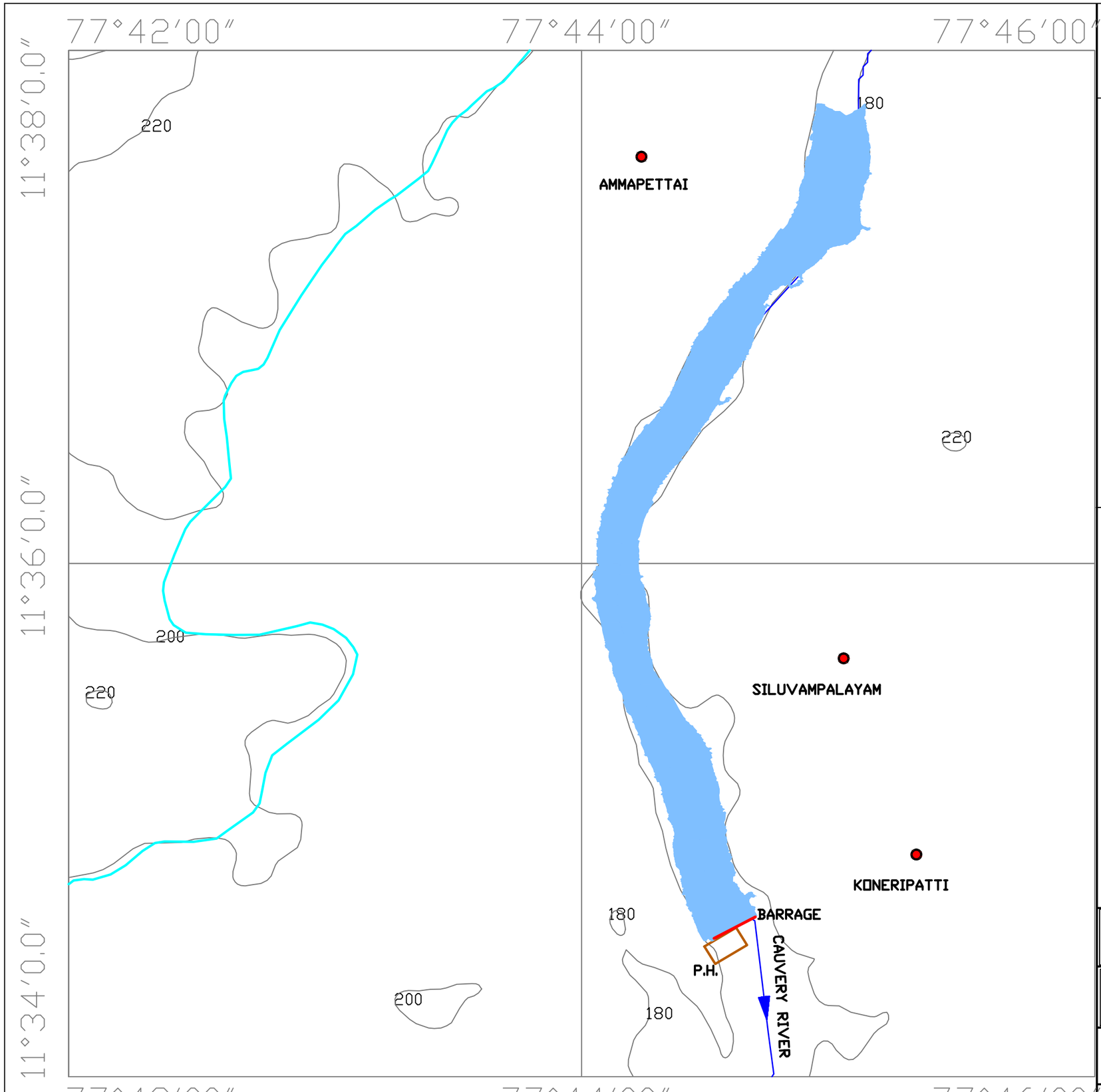
Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	15
Installed Capacity (MW)	30
Rated Head (m)	6.5
Avg. Gross Head (Max.) (m)	9
Avg. Gross Head (Min.) (m)	3
Type of Turbine	Bulb
Tail Water Level (TWL) (m)	166.25
Annual Energy (MU)	91

COST ASPECTS:

Estimated Cost (Rs. Crores)	(Price Level, 1987)
Lower Mettur- I	163.85
Lower Mettur- II	
Lower Mettur- III	
Lower Mettur- IV	

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit -I	1988
Unit -II	1987



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- CANAL
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

LOWER METTUR-III

FRL- 175.25 M
MDDL- 171.25 M
BARRAGE HEIGHT- 9 M

POWER HOUSE

TWL- 166.25 M
RATED HEAD- 6.5 M
INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER METTUR-III HYDROELECTRIC PROJECT
(2X15) = 30 MW

3.36 LOWER METTUR-IV HYDROELECTRIC PROJECT (2 x15MW=30MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Lower Mettur Hydroelectric Project. It is executed in 4 stages. The Lower Mettur-IV project is in downstream of Lower Mettur-III Hydroelectric Project. The Project is a Run of River type of development which is located near Uratchikottai town approximately 1 Km. from project site in Erode district of Tamilnadu. The project utilizes the water of Cauvery river for further power generation, harnessing rated head of 9 m. The project has an installed capacity of 30MW with 2 units of 15MW in powerhouse generating annual energy of 69 MU in 90% dependable year. The Project was commissioned in 1988-89 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°29'4.4"N and Longitude 77°42'12.1"E. The Power house is located at Latitude 11°29' 7.6"N and Longitude 77°42'6.3"E. The Nearest Railway station is Erode and Airport is Salem.

3. PROJECT FEATURES

Lower Mettur-IV Hydroelectric Project involves construction of a barrage of height 9m and length 330 m across the Cauvery river. The Full Reservoir Level (FRL) of the project is 166.25 m and Minimum Draw Down Level (MDDL) is 162.25m. The water conductor system consists of 1 no. of Head Race Tunnel (HRT) of Bell mouth shape which carries water to the powerhouse. The project has an installed capacity of 30 MW (2 x 15 MW) utilizing rated head of 9m. A Tail Race Channel/Tunnel of length 7.32 m carries powerhouse release back to the river.

4. POWER & ENERGY BENEFITS

Lower Mettur-IV project has 2 units of 15 MW with installed capacity of 30 MW. The annual energy of Lower Mettur-IV Hydroelectric Project is 69 MU in 90% dependable year.

SALIENT FEATURES
LOWER METTUR -IV HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Erode
River	Cauvery
Type of Development	RoR
Nearest Railhead	Erode
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°29'04.4"N, 77°42'12.1"E
Power House : Latitude & Longitude	11°29'07.6"N, 77°42'06.3"E

DAM:

Type	Barrage
Length (m)	330
Height (m)	9

RESERVOIR:

Full Reservoir Level (FRL) (m)	166.25
Minimum Draw Down Level (MDDL) (m)	162.25
Gross Storage (Mcum)	13.31

INTAKE:

Gate No	4
Size (m)	5.69 x 15.70

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	1
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1

Length (m)	7.32

POWER HOUSE:

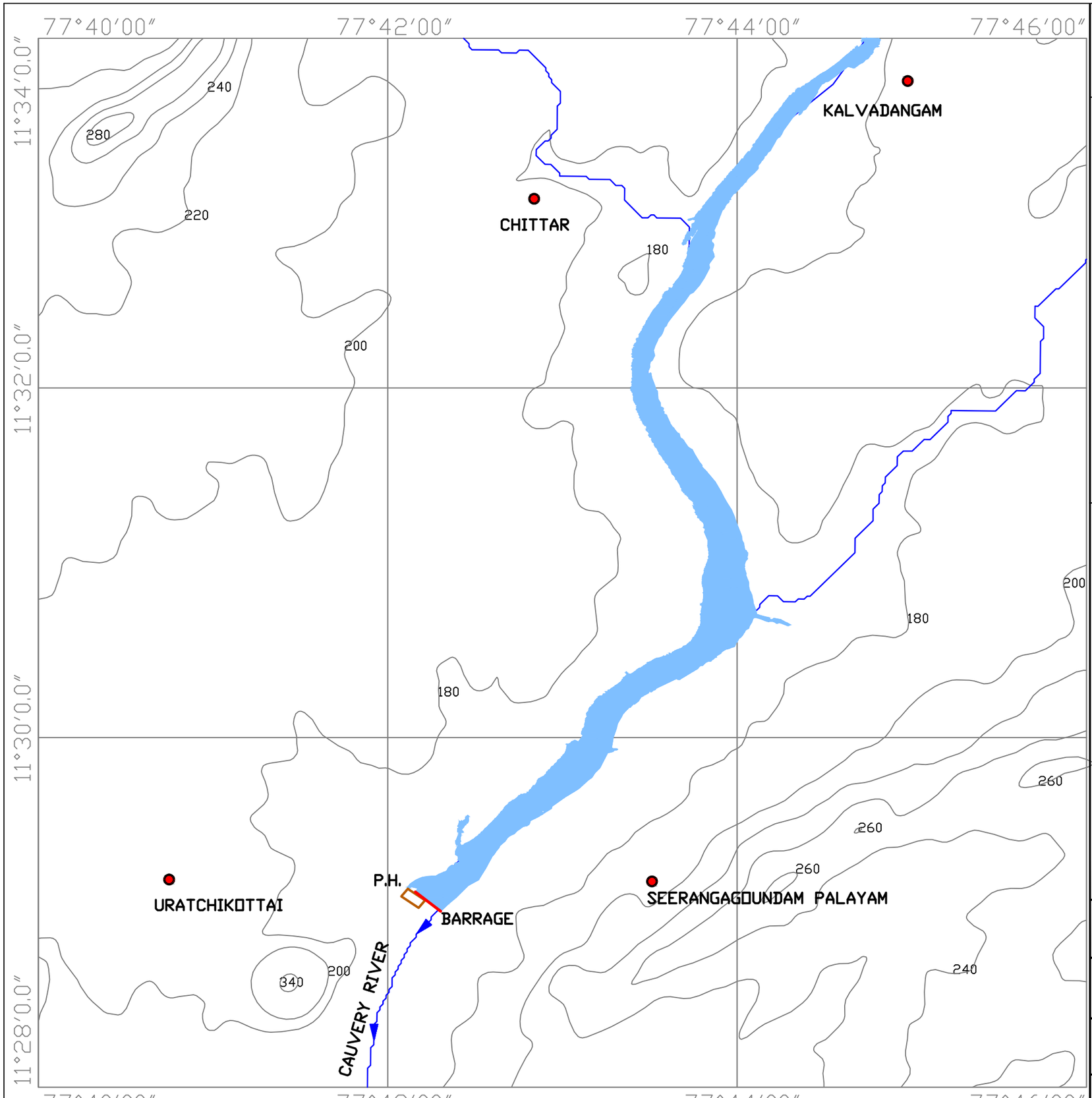
Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	15
Installed Capacity (MW)	30
Rated Head (m)	9
Avg. Gross Head (Max.) (m)	6.5
Avg. Gross Head (Min.) (m)	3
Type of Turbine	Bulb
Tail Water Level (TWL) (m)	157.25
Annual Energy (MU)	69

COST ASPECTS:

Estimated Cost (Rs. Crores)	(Price Level, 1987)
Lower Mettur- I	163.85
Lower Mettur- II	
Lower Mettur- III	
Lower Mettur- IV	

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1989
Unit- II	1988



LEGENDS.

CONTOUR

RIVER

BARRAGE

CANAL

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

LOWER METTUR-IV

FRL- 166.25 M

MDDL- 162.25 M

BARRAGE HEIGHT- 9 M

POWER HOUSE

TWL- 157.25 M

RATED HEAD - 9 M

INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER METTUR-IV HYDROELECTRIC PROJECT
(2X15) = 30 MW

3.37 BHAVANI KATTALAI BARRAGE - I HYDROELECTRIC PROJECT (2 x15MW=30MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Bhavani Kattalai Hydroelectric Project. It is executed in 3 stages. Bhavani Kattalai Barrage-I is located downstream of Lower Mettur IV. The project envisages utilization of the irrigation discharge from Lower Mettur project and the contributary flow from Bhavani River. This Project is a Run of River (RoR) type of development which is located near Samayasangili Agraharam approximately 750m from project site in Namakkal district of Tamilnadu. The project utilizes the water of Cauvery River for power generation, harnessing rated head of 6.5 m. The project has an installed capacity of 30 MW with 2 units of 15 MW in powerhouse generating annual energy of 69.68 MU in 90% dependable year. The Hydroelectric Project was commissioned in 2006 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°23'1.6"N and Longitude 77°42'48.2"E. The Power house is located at Latitude 11°23'2.7"N and Longitude 77°42'52.6"E. The Nearest Railway station from the project site is Erode and Airport is Salem.

3. PROJECT FEATURES

Bhavani Kattalai Barrage-I Hydroelectric Project involves construction of a barrage of height 9m and length 381m across the Cauvery River. The Full Reservoir Level (FRL) of the project is 157.25m and Minimum Draw down Level (MDDL) is 154.25m. The water conductor system consists of 1 no. of Head Race Tunnel (HRT) of Bell mouth shape which carries water to the powerhouse. The project has an installed capacity of 30 MW (2 x 15 MW) utilizing rated head of 6.5 m. A Tail Race Channel/Tunnel of length 7.32 m carries powerhouse release back to the river.

4. HYDROLOGY

The mean annual rainfall of the project is 644mm.

5. POWER & ENERGY BENEFITS

Bhavani Kattalai Barrage-I project has 2 units of 15 MW with installed capacity of 30 MW. The annual energy of Bhavani Kattalai-I Hydroelectric project is 69.68 MU in 90% dependable year.

SALIENT FEATURES
BHAVANI KATTALAI BARRAGE - I HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Namakkal
River	Cauvery
Type of Development	RoR
Nearest Railhead	Erode
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°23'01.6"N, 77°42'48.2"E
Power House : Latitude & Longitude	11°23'02.7"N, 77°42'52.6"E

HYDROLOGY:

Mean Annual Rainfall (mm)	644

DAM:

Type	Barrage
Length (m)	381
Height (m)	9

RESERVOIR:

Full Reservoir Level (FRL) (m)	157.25
Minimum Draw Down Level (MDDL) (m)	154.25
Gross Storage (Mcum)	13.47

INTAKE:

Gate No	4
Size (m)	5.69 x 15.10

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	1

TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1
Length (m)	7.32

POWER HOUSE:

Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	15
Installed Capacity (MW)	30
Rated Head (m)	6.5
Avg. Gross Head (Max.) (m)	9
Avg. Gross Head (Min.) (m)	3
Type of Turbine	Bulb
Tail Water Level (TWL) (m)	148.25
Annual Energy (MU	69.68

COST ASPECTS:

Estimated Cost (Rs. Crores)	90.62 (Price Level, 1995)

COMMISSIONING DETAILS:

Commissioning Year	2006

77°38'0.0"
77°40'0.0"
77°42'0.0"
77°44'0.0"
77°46'0.0"
11°28'0.0"
11°26'0.0"
11°24'0.0"
11°22'0.0"
11°20'0.0"

CHITODE

SAMAYASANGILI AGRAHARAM

P.H.

BARRAGE

ASHOKAPURAM

CAUVERY RIVER

VERRAPPANCHATRAM

INDRANAGAR

ERODE

LEGENDS.

CONTOUR

RIVER

BARRAGE

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BHAVANI KATTALAI BARRAGE-I

FRL- 157.25 M
MDDL- 154.25 M
BARRAGE HEIGHT- 9 M

POWER HOUSE

TWL- 148.25 M
RATED HEAD- 6.5 M
INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BHAVANI KATTALAI BARRAGE-I HYDROELECTRIC PROJECT
(2X15) = 30 MW

3.38 BHAVANI KATTALAI BARRAGE - II HYDROELECTRIC PROJECT (2 x15MW=30 MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Bhavani Kattalai Hydroelectric Project. Presently, it is executed in 3 stages. Bhavani Kattalai Barrage-II is at the downstream of Bhavani Kattalai Barrage-I Hydroelectric Project. The project is a Run of River (RoR) type of development which is located near pappampalayam approximately 2.1 Km. from project site in Erode district of Tamilnadu. The project utilizes the water of Cauvery River for further power generation, harnessing rated head of 6.5 m. The project has an installed capacity of 30 MW with 2 units of 15 MW in powerhouse generating annual energy of 94 MU in 90% dependable year. The Hydroelectric Project was commissioned in 2011 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°19'55.9"N and Longitude 77°45'31.4"E. The Power house is located at Latitude 11°19' 51"N and Longitude 77°45'29"E. The Nearest Railway station from the project site is Erode and Airport is Salem.

3. PROJECT FEATURES

Bhavani Kattalai Barrage-II Hydroelectric Project involves construction of a barrage of height 9 m and length 324 m across the Cauvery river. The Full Reservoir Level (FRL) of the project is 148.25 m and Minimum Draw Down Level (MDDL) is 146.25 m. The water conductor system consists of 1 no. of Head Race Tunnel (HRT) of Bell mouth shape which carries water to the powerhouse. The project has an installed capacity of 30 MW (2x15MW) utilizing rated head of 6.5 m. A Tail Race Channel/Tunnel of length 7.32 m carries powerhouse release back to the river.

4. HYDROLOGY

The mean annual rainfall of the project is 644mm.

5. POWER & ENERGY BENEFITS

Bhavani Kattalai Barrage -II project has 2 units of 15 MW with installed capacity of 30 MW. The annual energy of Bhavani Kattalai-II hydroelectric project is 94 MU in 90% dependable year.

SALIENT FEATURES
BHAVANI KATTALAI BARRAGE - II HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Erode
River	Cauvery
Type of Development	RoR
Nearest Railhead	Erode
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°19'55.9"N, 77°45'31.4"E
Power House : Latitude & Longitude	11°19'51.0"N,77°45'29.0"E

HYDROLOGY:

Mean Annual Rainfall (mm)	644

DAM:

Type	Barrage
Length (m)	324
Height (m)	9

RESERVOIR:

Full Reservoir Level (FRL) (m)	148.25
Minimum Draw Down Level (MDDL) (m)	146.25
Gross Storage (Mcum)	15.83

INTAKE:

Gate No	2
Size (m)	5.69 x 15.93

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	1

TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1
Length (m)	7.32

POWER HOUSE:

Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	15
Installed Capacity (MW)	30
Rated Head (m)	6.5
Avg. Gross Head (Max.) (m)	9
Avg. Gross Head (Min.) (m)	6
Type of Turbine	Bulb
Tail Water Level (TWL) (m)	139.25
Annual Energy (MU)	94

COST ASPECTS:

Estimated Cost (Rs. Crores)	99.15 (Price Level, 1997)

COMMISSIONING DETAILS:

Commissioning Year	2011

77°44'0.0"
77°46'0.0"
77°48'0.0"
11°22'0.0"
11°20'0.0"
11°18'0.0"
180
160
INDRANAGAR
BARRAGE
P.H.
PALLIPALAYAM
160
CAUVERY RIVER
160
KOKKARAYANPETTAI
180

N
W
E
S

LEGENDS.

CONTOUR

RIVER

BARRAGE

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BHAVANI KATTALAI BARRAGE-II

FRL- 148.25 M
MDDL- 146.25 M
BARRAGE HEIGHT- 9 M

POWER HOUSE

TWL- 139.25 M
RATED HEAD- 6.5 M
INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BHAVANI KATTALAI BARRAGE-II HYDROELECTRIC PROJECT
(2X15) = 30 MW

3.39 BHAVANI KATTALAI BARRAGE- III HYDROELECTRIC PROJECT (2 x15MW=30MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Bhavani Kattalai Hydroelectric Project. Presently, it is executed in 3 stages. Bhavani Kattalai Barrage-III is at the downstream of Bhavani Kattalai Barrage-II Hydroelectric Project. The project is a Run of River (RoR) type of development which is located near Solasiramani approximately 1 Km. from project site in Namakkal district of Tamilnadu. The project utilizes the water of Cauvery River for further power generation, harnessing rated head of 6.5 m. The project has an installed capacity of 30 MW with 2 units of 15 MW in powerhouse generating annual energy of 94 MU in 90% dependable year. The Hydroelectric Project was commissioned in 2012 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site is located on Cauvery river having Latitude 11°14'34.2"N and Longitude 77°51'53.5"E. The Power house is located at Latitude 11°14' 34.8"N and Longitude 77°51'57.6"E. The Nearest Railway station is Erode and Airport is Salem.

3. PROJECT FEATURES

Bhavani Kattalai Barrage-III Hydroelectric Project involves construction of a barrage of height 9 m and length 291 m across the Cauvery River. The Full Reservoir Level (FRL) of the project is 139.25 m and Minimum Draw Down Level (MDDL) is 137.25 m. The water conductor system consists of 1 no. of Head Race Tunnel (HRT) of Bell mouth shape which carries water to the powerhouse. The project has an installed capacity of 30 MW (2 x 15 MW) utilizing rated head of 6.5 MW. A Tail Race Channel/Tunnel of length 7.32 m carries powerhouse release back to the river.

4. POWER & ENERGY BENEFITS

Bhavani Kattalai Barrage–III project has 2 units of 15 MW with installed capacity of 30 MW. The annual energy of Bhavani Kattalai–III Hydroelectric project is 94 MU in 90% dependable year.

SALIENT FEATURES
BHAVANI KATTALAI BARRAGE-III HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Namakkal
River	Cauvery
Type of Development	RoR
Nearest Railhead	Erode
Nearest Airport	Salem

LOCATION:

Dam : Latitude & Longitude	11°14'34.2"N, 77°51'53.5"E
Power House : Latitude & Longitude	11°14'34.8"N, 77°51'57.6"E

DAM:

Type	Barrage
Length (m)	291
Height (m)	9

RESERVOIR:

Full Reservoir Level (FRL) (m)	139.25
Minimum Draw Down Level (MDDL) (m)	137.25
Gross Storage (Mcum)	22.76

INTAKE:

Gate No	2
Size (m)	5.69 x 15.93

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Bell Mouth
Number	1
TAIL RACE TUNNEL/CHANNEL	
Shape	Rectangular
Number	1

Length (m)	7.32

POWER HOUSE:

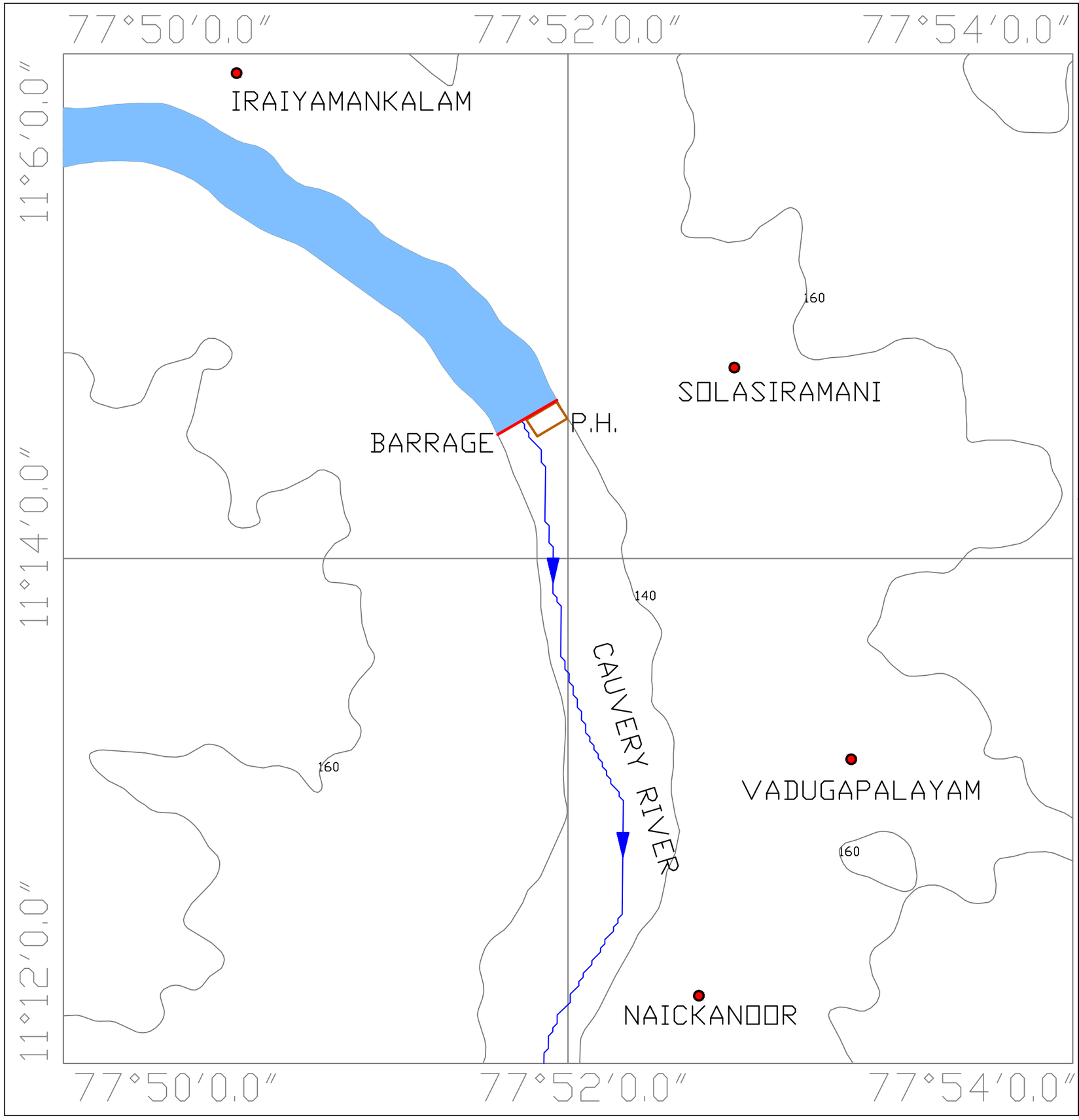
Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	15
Installed Capacity (MW)	30
Rated Head (m)	6.5
Avg. Gross Head (Max.) (m)	9
Avg. Gross Head (Min.) (m)	6
Type of Turbine	Bulb
Tail Water Level (TWL) (m)	128.25
Annual Energy (MU)	94

COST ASPECTS:

Estimated Cost (Rs. Crores)	99.75 (Price Level, 2000)

COMMISSIONING DETAILS:

Commissioning Year	2012



LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BHAVANI KATTALAI BARRAGE-III

FRL- 139.25 M
MDDL- 137.25 M
BARRAGE HEIGHT- 9 M

POWER HOUSE

TWL- 128.25 M
RATED HEAD- 6.5 M
INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BHAVANI KATTALAI BARRAGE-III HYDROELECTRIC PROJECT
(2X15) = 30 MW

3.40 PYKARA HYDROELECTRIC PROJECT (3 X7MW+1x11MW+2x13.6MW=59.2MW)

1. INTRODUCTION

Pykara Hydroelectric Project is a Storage type development located approximately 2.3km from Indunagar town and utilizes the water of Pykara River for power generation. The project is designed to generate power, utilizing head of 943 m. The project has 6 units with 3 units of 7 MW, one unit of 11 MW and 2 units of 13.6 MW in a Surface power house to generate annual energy of 352 MU in 90% dependable year. Project was commissioned in between 1933-1964 and executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

Pykara Hydroelectric Project consist of 5 dams and 4 Weirs, the first dam is Mukurthi Dam located at Latitude 11°24'35.9"N & Longitude 76°33'49.4"E, the second dam is Pykara dam located at Latitude 11°27'44.5"N & Longitude 76°36'12.1"E, the third dam is Sandynallah Dam located at Latitude 11°26'38.4"N & Longitude 76°39'07.9"E, the fourth dam is Glenmorgan dam located at Latitude 11°29'52.5"N & Longitude 76°36'26.8"E and the fifth dam is Glenmorgan forebay dam located at Latitude 11°30'10.7"N & Longitude 76°35'26.8"E.

The first weir Naduvattam Diversion Weir located at Latitude 11°27'57.5"N & Longitude 76°33'44.8"E, the second weir is Melkodmund weir located at Latitude 11° 27’ 54.56” N & Longitude 76° 38’ 32.35” E, the third weir is Lone Valley Arm I located at Latitude 11° 29’ 03.93”N & Longitude 76° 37’ 32.33”E and the fourth weir is Lone Valley Arm II located at Latitude 11°28’54.04”N & Longitude 76°38’09.27”E. The Power house is located at Latitude 11°32'01.3"N & Longitude 76°36'03.5"E. Udhagamandalam is the nearest railway station & Coimbatore is the nearest airport to reach the site.

3. PROJECT FEATURES

The Moyar River in its upper reaches, after its two streams Makurti and Parson's valley combine, is known as Pykara River. The water from the intermediate catchment area below Porthimund-Parson's Valley reservoirs upto Pykara township is being regulated at the two existing reservoirs that is Mukurthi Lake where Mukurthi dam has Full Reservoir Level (FRL) of 2098.24 m and Minimum Draw Down Level (MDDL) of 2073.85 m and Pykara reservoir

where the Pykara Dam has Full Reservoir Level (FRL) of 2072.33 m and Minimum Draw Down Level (MDDL) of 2045.20 m for generation of power at Pykara power house.

Besides having existing features of these two dams, water is also diverted via Naduvattam Diversion weir having Full Reservoir Level (FRL) of 1979.68 m and Minimum Draw Down Level (MDDL) of 1978.15 m. A Forebay at Glenmorgan having Full Reservoir Level (FRL) of 1972.10 m and Minimum Draw Down Level (MDDL) of 1962.9 m directs a pipeline penstock to lead the water to powerhouse near Singara Township. In addition, the water collected at Sandynalla stream is diverted by gravity to Melkodmund stream. From Melkodmund Weir having Full Reservoir Level (FRL) of 2051m, water is diverted to Lone Valley Arm-II through a tunnel. Lone Valley Arm-II Weir having Full Reservoir Level (FRL) of 2043.5 m diverts flow of Lone Valley Arm-II stream into the above tunnel through a shaft.

Entire collection of Sandynallah, Melkodmund, and Lone Valley Arm-II & Lone Valley Arm-I is taken to the existing Glenmorgan Dam having Full Reservoir Level (FRL) of 2018.69 m (subsidiary storage to Pykara Power House) through a tunnel from Lone Valley Arm-I having Full Reservoir Level (FRL) of 2034 m. The water from this dam is let into the Glenmorgan forebay through open Flume. The water conductor system comprises of 1 no. of Head Race Tunnel (HRT) and 4 nos. of penstock of length 2981 m which carries water to the powerhouse. The surface power house has 3 units of 7MW, one unit of 11 MW and 2 units of 13.6 MW using Pelton wheel type turbine enbling total installed capacity of 59.2 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 15.02 Sq. km.

5. POWER & ENERGY BENEFITS

Pykara Hydroelectric Project has three units of 7 MW, one unit of 11 MW and two units of 13.6 MW with total installed Capacity of 59.2 MW and the Annual Energy of the project is 352 MU at 90% dependable year.

SALIENT FEATURES
PYKARA HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiris
River	Pykara
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore

LOCATION:

Mukurthi Dam : Latitude & Longitude	11°24'35.9"N, 76°33'49.4"E
Pykara Dam : Latitude & Longitude	11°27'44.5"N,76°36'12.1"E
Sandynallah Dam : Latitude & Longitude	11°26'38.4"N,76°39'07.9"E
Glenmorgan Forebay Dam : Latitude & Longitude	11°30'10.7"N,76°35'26.8"E
Glenmorgan Dam : Latitude & Longitude	11°29'52.5"N ,76°36'26.8"E
Lone Valley Arm I Weir : Latitude & Longitude	11°29’3.93”N ,76°37’32.33”E
Lone Valley Arm II Weir : Latitude & Longitude	11°28’54.04”N,76°38’09.27”E
Melkodmund Weir : Latitude & Longitude	11°27’54.56”N,76°38’32.35”E
Naduvattam Diversion Weir : Latitude & Longitude	11°27'57.5"N, 76°33'44.8"E
Power House : Latitude & Longitude	11°32'01.3"N, 76°36'03.5"E

HYDROLOGY:

Catchment Area (Sq. Km)	15.02
Maximum Annual Rainfall (mm)	2300
Minimum Annual Rainfall (mm)	450
Mean Annual Rainfall (mm)	1200

DAM:

Type	Masonry
Length (m)	79.55

Height (m)	16

RESERVOIR:

MUKURTHI DAM	
Full Reservoir Level (FRL) (m)	2098.24
Minimum Draw Down Level (MDDL) (m)	2073.85
PYKARA DAM	
Full Reservoir Level (FRL) (m)	2072.33
Minimum Draw Down Level (MDDL) (m)	2045.20
SANDYNALLAH DAM	
Full Reservoir Level (FRL) (m)	2145.48
Minimum Draw Down Level (MDDL) (m)	2132.07
GLENMORGAN DAM	
Full Reservoir Level (FRL) (m)	2018.69
GLENMORGAN FOREBAY	
Full Reservoir Level (FRL) (m)	1972.10
Minimum Draw Down Level (MDDL) (m)	1962.9
Live Storage (Mcum)	6.59
LONE VALLEY ARM-I WEIR	
Full Reservoir Level (FRL) (m)	2034
LONE VALLEY ARM-II WEIR	
Full Reservoir Level (FRL) (m)	2043.5
MELKODMUND WEIR	
Full Reservoir Level (FRL) (m)	2051
NADUVATTAM DIVERSION WEIR	
Full Reservoir Level (FRL) (m)	1979.68
Minimum Draw Down Level (MDDL) (m)	1978.15

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	Circular
Number (m)	1

Diameter (m)	1.98
PENSTOCK	
Number	4
Length (m)	2981

POWER HOUSE:

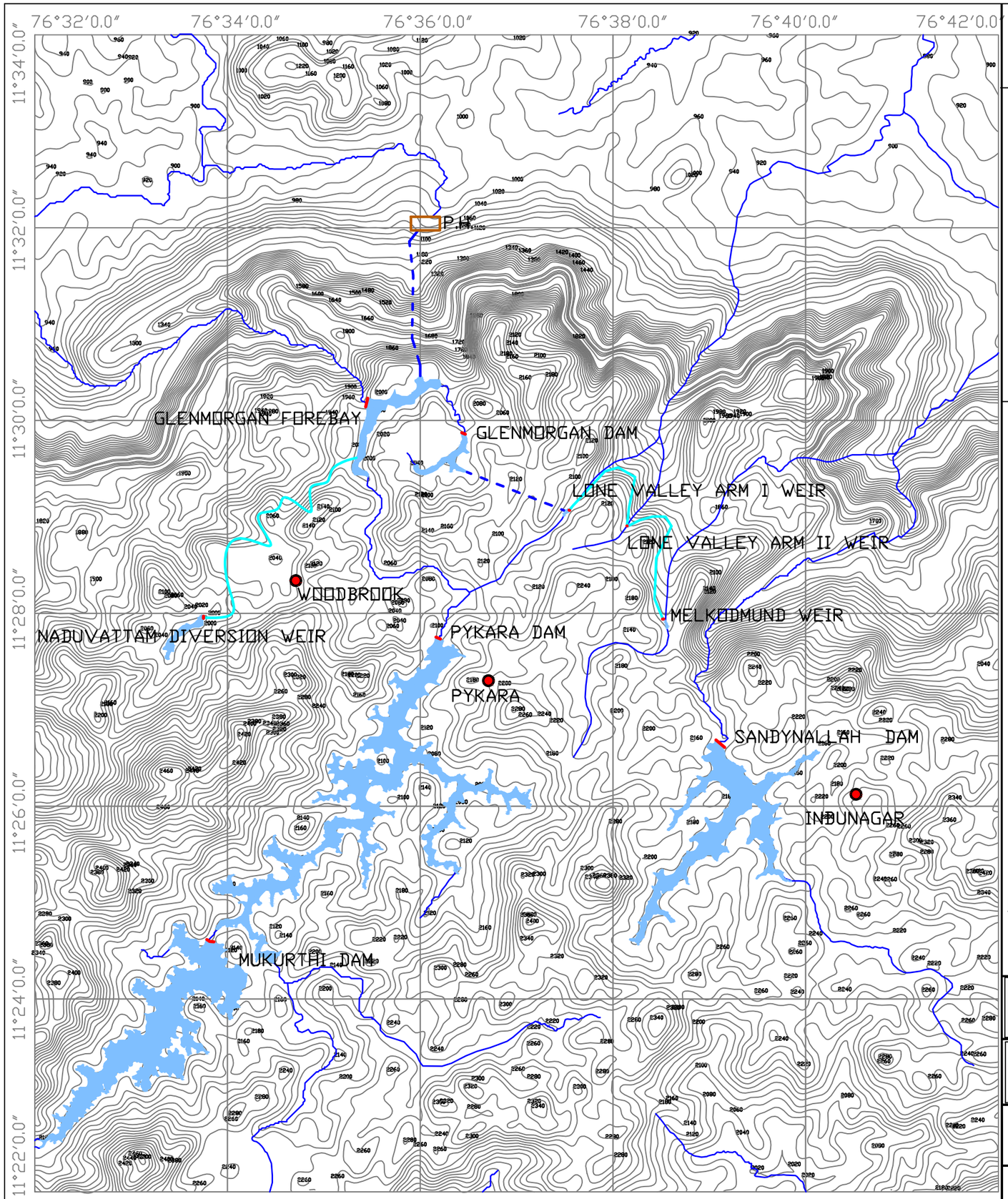
Type	Surface
No. of Generating Units	6
Capacity of each Unit (MW)	3 units of 7MW ,1 unit of 11MW and 2 units of 13.6 MW
Firm Power (MW)	59.2
Installed Capacity (MW)	59.2
Rated Head (m)	7 MW -943.4 11 MW -857.5 13.6 MW -866.2
Type of Turbine	Horizontal Pelton Wheel Impulse Turbine
Tail Water Level (TWL) (m)	1033
Annual Energy (MU)	352

COST ASPECTS:

Estimated Cost (Rs. Crores)	6.74 (Price Level, 1954)

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1933
Unit- II	1932
Unit- III	1932
Unit- IV	1939
Unit- V	1954
Unit- VI	1964



LEGENDS.

CONTOUR
RIVER
DAM
POWER HOUSE
FLUME
HRT
TRT
RESERVOIR
TOWN/VILLAGE
CONTOUR INTERVAL - 20M

PYKARA DAM
FRL- 2072.33 M
MDDL-2045.20 M

MUKURTHI DAM
FRL- 2098.24 M
MDDL-2073.85 M

SANDYNALLAH DAM
FRL- 2145.48 M
MDDL-2132.07 M

GLENMORGAN FOREBAY
FRL- 1972.10 M
MDDL-1962.9 M
LIVE STORAGE - 6.59 Mcum
DAM HEIGHT - 16 M

GLENMORGAN DAM
FRL- 2018.69 M

LONE VALLEY ARM I WEIR
FRL- 2034 M

LONE VALLEY ARM II WEIR
FRL- 2043 M

MELKODMUND WEIR
FRL- 2051 M

NADUVATTAM DIVERSION WEIR
FRL- 1979.68 M
MDDL-1978.15 M

POWER HOUSE
TWL- 1033 M
RATED HEAD- 7MW-943.4M,11MW-857.5M
13.6MW-866.2M
INST. CAPACITY- 59.2 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

PYKARA HYDROELECTRIC PROJECT
(3X7+1X11+2X13.6) = 59.2 MW

3.41 PYKARA ULTIMATE HYDROELECTRIC PROJECT (3X50MW=150MW)

1. INTRODUCTION

Pykara Hydroelectric Project is a Storage type development located approximately 2.3 km from Indunagar town from and utilizes the water of Pykara River for power generation. The project is designed to generate power, utilizing head of 1026 m. The project has 3 units of 50 MW in an Underground power house to generate annual energy of 332.42 MU in 90% dependable year. Project was commissioned in 2005 and executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

Pykara Hydroelectric Project consist of 5 dams and 4 Weirs, the first dam is Mukurthi Dam located at Latitude 11°24'35.9"N & Longitude 76°33'49.4"E, the second dam is Pykara dam located at Latitude 11°27'44.5"N & Longitude 76°36'12.1"E, the third dam is Sandynallah Dam located at Latitude 11°26'38.4"N & Longitude 76°39'07.9"E, the fourth dam is Glenmorgan dam located at Latitude 11°29'52.5"N & Longitude 76°36'26.8"E and the fifth dam is Glenmorgan forebay dam located at Latitude 11°30'10.7"N & Longitude 76°35'26.8"E.

The first weir Naduvattam Diversion Weir located at Latitude 11°27'57.5"N & Longitude 76°33'44.8"E, the second weir is Melkodmund weir located at Latitude 11° 27’ 54.56” N & Longitude 76° 38’ 32.35” E, the third weir is Lone Valley Arm-I located at Latitude 11° 29’ 03.93”N & Longitude 76° 37’ 32.33”E and the fourth weir is Lone Valley Arm-II located at Latitude 11°28’54.04”N & Longitude 76°38’09.27”E. The Power house is located at Latitude 11°31'23.5"N & Longitude 76°36'01.8"E. Udhagamandalam is the nearest railway station & Coimbatore is the nearest airport to reach the site.

3. PROJECT FEATURES

The Moyar River in its upper reaches, after its two streams Makurti and Parson's valley combine, is known as Pykara River. The waters from the intermediate catchment area below Porthimund-Parson's Valley reservoirs upto Pykara township is being regulated at the two existing reservoirs that is Mukurthi Lake where Mukurthi dam has Full Reservoir Level (FRL) of 2098.24m and Minimum Draw Down Level (MDDL) of 2073.85m and Pykara reservoir where the Pykara Dam has Full Reservoir Level (FRL) of 2072.33m

and Minimum Draw Down Level (MDDL) of 2045.20m for generation of power at Pykara power house.

Besides having existing features of these two dams, water is also diverted via Naduvattam Diversion weir having Full Reservoir Level (FRL) of 1979.68 m and Minimum Draw Down Level (MDDL) of 1978.15 m .Water from Forebay at Glenmorgan having Full Reservoir Level (FRL) of 1972.10 m and Minimum Draw Down Level (MDDL) of 1962.9 m is lead through small length of power tunnel and long pipe line penstock, running parallel on the left of Pykara Hydroelectric Project to a separate powerhouse. In addition, the Water collected at Sandynalla stream is diverted by gravity to Melkodmund stream. From Melkodmund Weir having Full Reservoir Level (FRL) of 2051m, water is diverted to Lone Valley Arm II through a tunnel. Lone Valley Arm-II Weir having Full Reservoir Level (MDDL) of 2043.5 m diverts flow of Lone Valley Arm-II stream into the above tunnel through a shaft.

Entire collection of Sandynalla, Melkodmund, and Lone Valley Arm II & Lone Valley Arm I is taken to the existing Glenmorgan Dam having Full Reservoir Level (FRL) of 2018.69 m (subsidiary storage to Pykara Power House) through a tunnel from Lone Valley Arm-I having Full Reservoir Level (FRL) of 2034 m. The water from this dam is let into the Glenmorgan forebay through open Flume.

The water conductor system comprises of 1 no. of Head Race Tunnel (HRT) of length 359 m which carries water to the powerhouse. The underground power house has 3 units of 50 MW using Pelton type turbine enbling installed capacity of 150 MW. A Tail Race Tunnel of length 6805 m carries powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river up to the dam site is 15.02 Sq. km.

5. POWER & ENERGY BENEFITS

Pykara Ultimate Hydroelectric Project has three units of 50 MW with installed capacity of 150 MW and the annual energy of the project is 332.42 MU at 90% dependable year.

SALIENT FEATURES
PYKARA ULTIMATE HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiris
River	Pykara
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore

LOCATION:

Mukurthi Dam : Latitude & Longitude	11°24'35.9"N, 76°33'49.4"E
Pykara Dam : Latitude & Longitude	11°27'44.5"N,76°36'12.1"E
Sandynallah Dam : Latitude & Longitude	11°26'38.4"N,76°39'07.9"E
Glenmorgan Forebay Dam : Latitude & Longitude	11°30'10.7"N,76°35'26.8"E
Glenmorgan Dam : Latitude & Longitude	11°29'52.5"N ,76°36'26.8"E
Lone Valley Arm I Weir : Latitude & Longitude	11°29’03.93”N,76°37’32.33”E
Lone Valley Arm II Weir : Latitude & Longitude	11°28’54.04”N,76°38’09.27”E
Melkodmund Weir : Latitude & Longitude	11°27’54.56”N,76°38’32.35”E
Naduvattam Diversion Weir : Latitude & Longitude	11°27'57.5"N, 76°33'44.8"E
Power House : Latitude & Longitude	11°31'23.5"N ,76°36'01.8"E

HYDROLOGY:

Catchment Area (Sq. Km)	15.02
Maximum Annual Rainfall (mm)	2300
Minimum Annual Rainfall (mm)	450
Mean Annual Rainfall (mm)	1200

DAM:

Type	Masonry
Length (m)	79.55
Height (m)	16

RESERVOIR:

MUKURTHI DAM	
Full Reservoir Level (FRL) (m)	2098.24
Minimum Draw Down Level (MDDL) (m)	2073.85
PYKARA DAM	
Full Reservoir Level (FRL) (m)	2072.33
Minimum Draw Down Level (MDDL) (m)	2045.20
SANDYNALLAH DAM	
Full Reservoir Level (FRL) (m)	2145.48
Minimum Draw Down Level (MDDL) (m)	2132.07
GLENMORGAN DAM	
Full Reservoir Level (FRL) (m)	2018.69
GLENMORGAN FOREBAY	
Full Reservoir Level (FRL) (m)	1972.10
Minimum Draw Down Level (MDDL) (m)	1962.9
Live Storage (Mcum)	6.59
LONE VALLEY ARM-I WEIR	
Full Reservoir Level (FRL) (m)	2034
LONE VALLEY ARM-II WEIR	
Full Reservoir Level (FRL) (m)	2043.5
MELKODMUND WEIR	
Full Reservoir Level (FRL) (m)	2051
NADUVATTAM DIVERSION WEIR	
Full Reservoir Level (FRL) (m)	1979.68
Minimum Draw Down Level (MDDL) (m)	1978.15

INTAKE:

Gate No.	1
Size (m)	6.5 x 6.3

WATER CONDUCTOR SYSTEM:

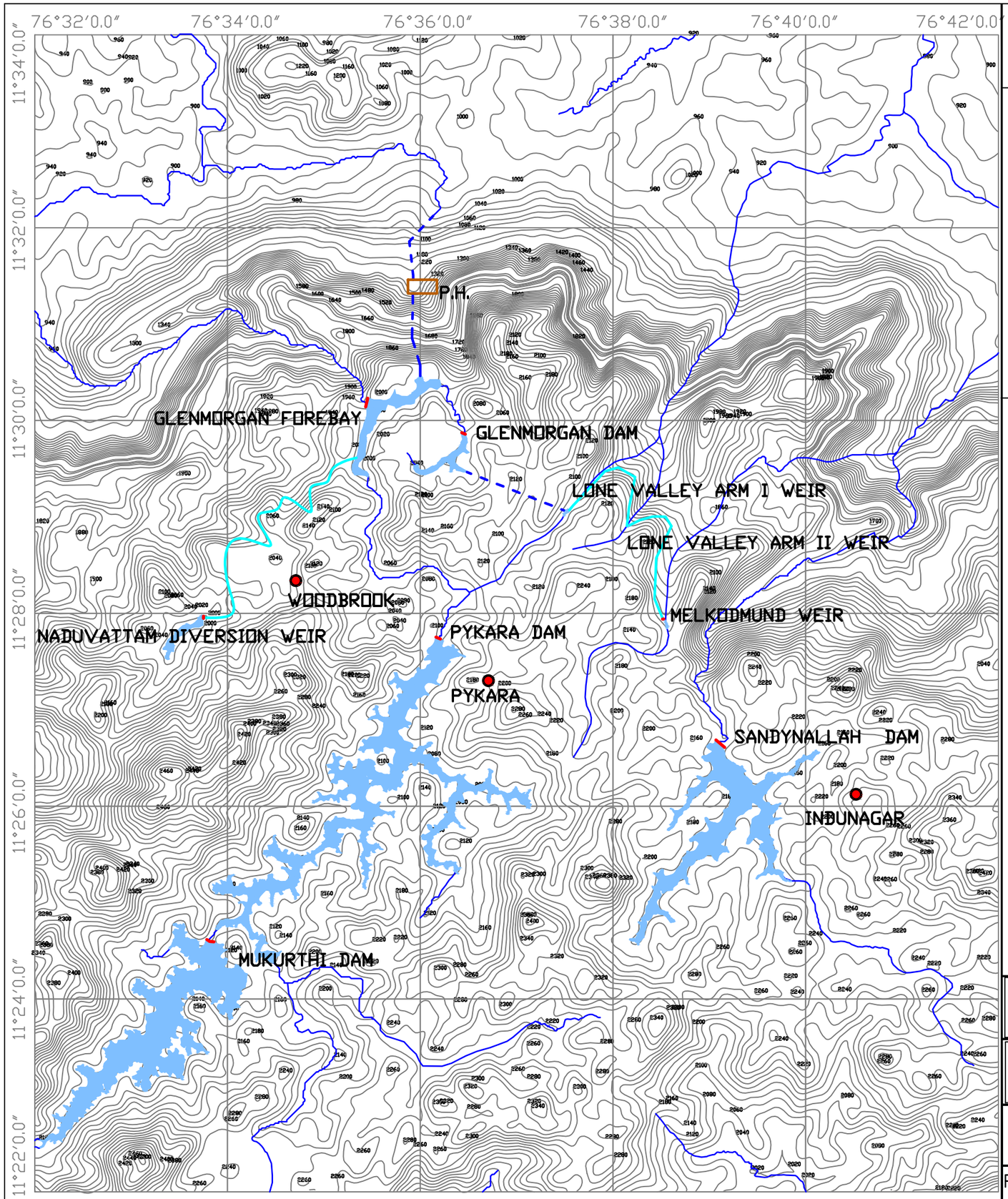
HEAD RACE TUNNEL	
Shape	D Shape
Number (m)	1
Length (m)	359
TAIL RACE TUNNEL	
Shape	D Shape
Number	1
Length (m)	6805

POWER HOUSE:

Type	Underground
No. of Generating Units	3
Capacity of each Unit (MW)	50
Installed Capacity (MW)	150
Rated Head (m)	1026
Avg. Gross Head (Max.) (m)	1039
Avg. Gross Head (Min.) (m)	1023
Type of Turbine	Vertical impulse Pelton
Tail Water Level (TWL) (m)	946
Annual Energy (MU)	332.42

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	2005
Unit- II	2005
Unit- III	2005



N
W
E
S

LEGENDS.

CONTOUR
RIVER
DAM
POWER HOUSE
FLUME
HRT
TRT
RESERVOIR
TOWN/VILLAGE
CONTOUR INTERVAL - 20M

PYKARA DAM
FRL- 2072.33 M
MDDL-2045.20 M

MUKURTHI DAM
FRL- 2098.24 M
MDDL-2073.85 M

SANDYNALLAH DAM
FRL- 2145.48 M
MDDL-2132.07 M

GLENMORGAN FOREBAY
FRL- 1972.10 M
MDDL-1962.9 M
LIVE STORAGE - 6.59 Mcum
DAM HEIGHT - 16 M

GLENMORGAN DAM
FRL- 2018.69 M

LONE VALLEY ARM I WEIR
FRL- 2034 M

LONE VALLEY ARM II WEIR
FRL- 2043.5 M

MELKODMUND WEIR
FRL- 2051 M

NADUVATTAM DIVERSION WEIR
FRL- 1979.68 M
MDDL-1978.15 M

POWER HOUSE
TWL- 946 M
RATED HEAD- 1026 M
INST. CAPACITY- 150 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDRO-ELECTRIC POTENTIAL IN THE COUNTRY

PYKARA ULTIMATE HYDROELECTRIC PROJECT
(3X50) = 150 MW

3.42 KUNDAH- I HYDROELECTRIC PROJECT (3x20MW=60MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Avalanche Emerald (Kundah 1) Hydroelectric Project. Presently, the project is named as Kundah I Hydroelectric Project. The river Kundah, a left bank tributary of the Bhavani, is formed in its initial reaches by two major streams, viz. the Avalanche and Emerald. Under the Stage-I development, two dams on these two stream, just upstream of their confluence are constructed and their regulated flows is utilized by leading them through a system of tunnel and penstock and dropping over at the Power House No.1 located on the right bank of the Kundah river near Kundapallam village, for the generation of power.

Kundah-I Hydroelectric Project is a Storage type development and Belithala village is located approximately 2.10 km from Emerald dam site. The project is designed to generate power, utilizing rated head of 317 m. The project has 3 units of 20 MW in surface power house to generate annual energy of 218.36 MU in 90% dependable year. Kundah-I Hydroelectric Project was commissioned in between 1960-64 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

Kundah-I Hydroelectric project consist of 4 dams, first dam is East Varahapallam Dam located at Latitude 11°14'19.8"N & Longitude 76°34'48.7"E, second Dam is West Varahapallam Dam located at Latitude 11°13'57.0"N & Longitude 76°34'04.0"E, third Dam is Avalanche Dam located at Latitude 11°19'12.84"N & Longitude 76°36'57"E and the fourth Dam is Emerald Dam located at Latitude 11°19'38.7"N & Longitude 76°37'15.8"E. The Power houses is located at Latitude 11°17'10.6"N & Longitude 76°39'04.9"E. Udagamandalam is the nearest railway station & Coimbatore international is the nearest airport and to the project site.

3. PROJECT FEATURES

Kundah-I Hydroelectric Project involves construction of Avalanche dam of height 57 m and 365.74 m long masonry dam. The combined live storage of Avalanche–Emerald Dam is 153.97 Mcum between Full Reservoir Level (FRL) of 1985.77 m and Minimum Draw down Level (MDDL) of 1943.1m. The following diversions from adjoining river valleys are also included in this

project i.e Diversion of 30 sq. kms of catchments of West & East Varahapallam streams of the Upper Bhavani river and Regulated flow from the tail races of Power House Nos. 5 & 6. The Full Reservoir Level of East Varahapallam dam and West Varahapallam dam are 2115.61m and 2206.14m respectively The water conductor system comprises of Head Race Tunnel (HRT) of length 4634.18 m, 3.5 m diameter and 3 nos.of penstock of length 987.86 m which carries water to the powerhouse. The Surface Power House has 3 units of 20 MW each using vertical Impulse type turbine operated under rated head of 317 m with an installed capacity of 60 m.

4. HYDROLOGY

The catchment area of the river up to the dam site is 58.53 Sq. km

5. POWER & ENERGY BENEFITS

Kundah-I Hydroelectric Project has three units of 20 MW each with Installed Capacity of 60MW and the Annual Energy of the project is 218.36 MU in 90% dependable year.

SALIENT FEATURES
KUNDAH-I HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiri
River	Avalanche stream
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore

LOCATION:

East Varahapallam Dam : Latitude & Longitude	11°14'19.8"N 76°34'48.7"E
West Varahapallam Dam : Latitude & Longitude	11°13'57.0"N, 76°34'04.0"E
Avalanche Dam : Latitude & Longitude	11°19'12.84"N,76°36'57"E
Emerald Dam : Latitude & Longitude	11°19'38.7"N, 76°37'15.8"E
Power House : Latitude & Longitude	11°17'10.6"N, 76°39'04.9"E

HYDROLOGY:

Catchment Area (Sq. Km)	58.53
Maximum Annual Rainfall (mm)	5000
Minimum Annual Rainfall (mm)	500
Mean Annual Rainfall (mm)	3000

DAM:

AVALANCHE DAM	
Type	Masonary
Length (m)	365.74
Height (m)	57

RESERVOIR:

AVALANCHE-EMERALD DAM	
Full Reservoir Level (FRL) (m)	1985.77

Minimum Draw Down Level (MDDL) (m)	1943.1
Live Storage (Mcum)	153.97 (Combined)
Gross Storage (Mcum)	156.8 (Combined)
EAST VARAHAPALLAM DAM	
Full Reservoir Level (FRL) (m)	2115.61
WEST VARAHAPALLAM DAM	
Full Reservoir Level (FRL) (m)	2206.14

INTAKE:

Gate No.	1
Size (m)	3.05 x 3.05

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	Horse shoe and tunnel
Number	1
Length(m)	4634.18
Diameter (m)	3.5
PENSTOCK	
Number	3
Length(m)	987.86
Diameter (m)	1.6

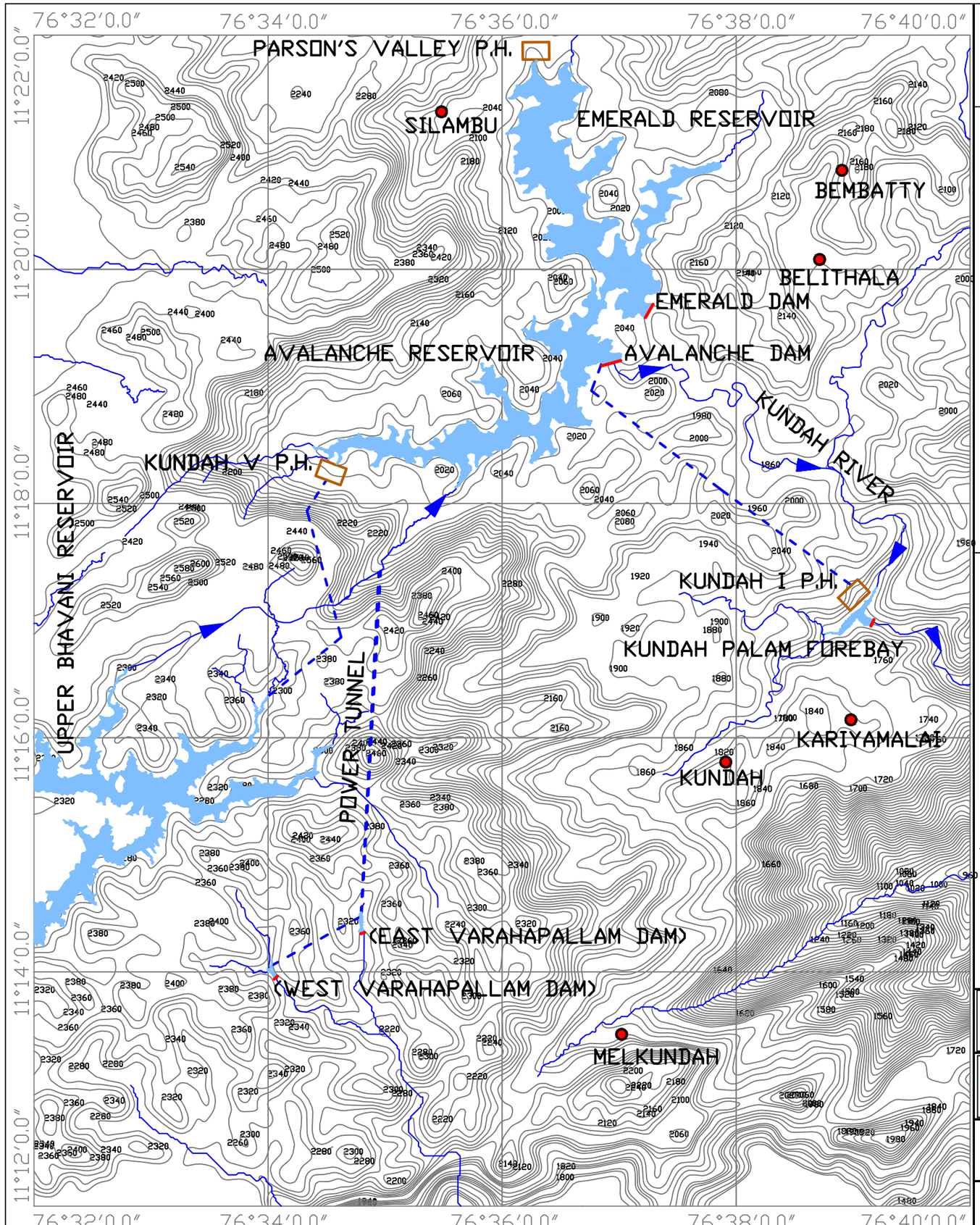
POWER HOUSE:

Type	Surface
No. of Generating Units	3
Capacity of each Unit (MW)	20
Firm Power (MW)	69.84
Installed Capacity (MW)	60
Rated Head (m)	317
Avg. Gross Head (Max.) (m)	359.64
Avg. Gross Head (Min.) (m)	316.06
Type of Turbine	Vertical Impulse Turbine

Tail Water Level (TWL) (m)	1628.55
Annual Energy (MU)	218.36

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit-I	1960
Unit-II	1960
Unit-III	1964



N
W E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

AVALANCHE DAM

FRL- 1985.77 M
MDDL-1943.1 M
DAM HEIGHT- 57 M
LIVE STORAGE - 153.97 MCuM

EMERALD DAM

FRL- 1985.77 M
MDDL-1943.1 M
LIVE STORAGE - 153.97 MCuM

EAST VARAHAPALLAM DAM

FRL- 2115.61 M

WEST VARAHAPALLAM DAM

FRL- 2206.14 M

POWER HOUSE

TWL- 1628.55 M
AVERAGE HEAD- 359.64 M
INST. CAPACITY- 60 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUNDAH-I HYDROELECTRIC PROJECT (3X20) = 60 MW

3.43 KUNDAH-II HYDROELECTRIC PROJECT (5x35MW =175MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Kundapallam (Kundah 2) Hydroelectric Project. Presently, the project is named as Kundah II Hydroelectric Project. The regulated water from the tail race of Kundah PH.1 is collected in a Forebay constructed on the Kundah River near Kundahpallam village and is diverted through a long system of tunnel and penstock to the Power House No.2 .

Kundah-II Hydroelectric Project is a storage type development located near Denadu Hatty village approximately 2 km from the project site in Nilgiris district of Tamil Nadu and utilizes the water of Avalanche Stream for power generation. The project is designed to generate power, utilizing rated head of 713.23 m. The project has 5 units of 35 MW each in surface power house to generate annual energy of 552.4 MU in 90% dependable year. Project was commissioned in between 1960-64 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The dam site of the project is located at Latitude 11°16'59.3"N & Longitude 76°39’10.4”E. The Power house is located at Latitude 11°15'1.1"N & Longitude 76°40'51.6"E. Udhagamandalam is the nearest railway station & Coimbatore international is the nearest airport to the project site.

3. PROJECT FEATURES

Kundah-II involves construction of Kundahpalam forebay of height 32m and length 152.4m. The reservoir formed by the forebay has a live storage of 1.56 Mcum between Full Reservoir Level (FRL) of 1624.6 m and Mininmum Draw down level of 1609.34 m. The water conductor system comprises of Head Race Tunnel (HRT) of length 3518 m and 5 number of penstock of length 1589.93 m which carries water to the surface powerhouse. The Surface Power House has 5 units of 35 MW each using vertical Impulse type turbine operated under rated head of 713.23m with an installed capacity of 175 m.

4. HYDROLOGY

The catchment area of the river up to the dam site is 113.96 Sq. km.

5. POWER & ENERGY BENEFITS

Kundah-II Hydroelectric Project has five units of 35 MW each with Installed Capacity of 175 MW and the annual energy of the project is 552.4 MU in 90% dependable year.

SALIENT FEATURES
KUNDAH-II HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiris
River	Avalanche stream
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore

LOCATION:

Dam : Latitude & Longitude	11°16'59.3"N, 76°39'10.4"E
Power House : Latitude & Longitude	11°15'01.1"N, 76°40'51.6"E

HYDROLOGY:

Catchment Area (Sq. Km)	113.96
Maximum Annual Rainfall (mm)	2800
Minimum Annual Rainfall (mm)	600
Mean Annual Rainfall (mm)	1500

DAM:

Type	Masonary
Length (m)	152.4
Height (m)	32

RESERVOIR:

Full Reservoir Level (FRL) (m)	1624.6
Minimum Draw Down Level (MDDL) (m)	1609.34
Live Storage (Mcum)	1.56
Gross Storage (Mcum)	1.76

INTAKE:

Gate No.	1
Size (m)	3.43

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	Horse shoe and tunnel
Number	1
Length(m)	3518
PENSTOCK	
Number	5
Length(m)	1589.93
Diameter (m)	1.45

POWER HOUSE:

Type	Surface
No. of Generating Units	5
Capacity of each Unit (MW)	35
Firm Power (MW)	189
Installed Capacity (MW)	175
Rated Head (m)	713.23
Avg. Gross Head (Max.) (m)	752.82
Avg. Gross Head (Min.) (m)	737.58
Type of Turbine	Vertical Impulse Turbine
Tail Water Level (TWL)(m)	869.27
Annual Energy (MU)	552.4

COMMISSIONING DETAILS

COMMISSIONING YEAR	
Unit- I	1960
Unit- II	1961
Unit- III	1961
Unit- IV	1961
Unit- V	1964

76°38'0.0"
76°40'0.0"
76°42'0.0"
11°18'0.0"
11°16'0.0"
11°14'0.0"

MUCKIMALAI
BENGALMATTAM
DENADU HATTY
KUNDAH I P.H.
KUNDAH PALAM FOREBAY
KUNDAH RIVER
KIL KUNDHA
PEGUMBAHALLAH RIVER
PEGUMBAHALLAH DAM
KUNDAH II P.H.

1940 1980 1920 1900 1840 1820 1760 1740 1700 1720 1800 1680 1660 1580 1640 1860 1280 1300 940 960 1160 1120 1180 1020 1000 1220 1240 1260 1620 1600 1320 1580 1380 1360 1400 1520 880 860 800

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KUNDAH PALAM FOREBAY

FRL- 1624.6 M
MDDL-1609.34 M
DAM HEIGHT- 32 M
LIVE STORAGE - 1.56 Mcum

POWER HOUSE

TWL- 869.27 M
AVERAGE HEAD- 752.82 M
INST. CAPACITY- 175 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUNDAH-II HYDROELECTRIC PROJECT (5X35) = 175 MW

3.44 KUNDAH-III HYDROELECTRIC PROJECT (3x60MW=180MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Pengumbahalla (Kundah 3) Hydroelectric Project. Presently, the project is named as Kundah III Hydroelectric Project. The tail race discharge of Kundah II is again collected in a forebay near the township Gedde on the stream Pegumbahallah. This water augmented by the waters diverted from adjacent Kattori and Nirarpallam streams from the adjoining Kallar Valley and led through a water conducting system comprising of Head Race Tunnel (HRT) and penstock to a Power House No.3. The water after generating power is released through a tail race tunnel on Bhavani River a few kms downstream of its confluence with Kundah River.

The Kundah-III Hydroelectric Project is a Storage type development located near Hidkal village approximately 1.47 km from the project site and utilizes the water of Pegumbahallah River for power generation. The project has Surface powerhouse with Installed Capacity of 180 MW utilizing the rated head of 409 m to generate annual energy of 346.84 MU in a 90% dependable year. All the units were commissioned in between 1965-78 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

Kundah-III Hydroelectric project consist of one dam and two weirs, the Pegumbahallah dam is located at Latitude 11°14'52.3"N & Longitude 76°40'54.3"E, the first weir namely KatteriHalla Diversion Weir is located at Latitude 11°20'18.6"N & Longitude 76°44'13.5"E and second weir namely Niralapallam Diversion Weir is located at Latitude 11°16'52.6"N & Longitude 76°46'01.3"E. The powerhouse is located at Latitude 11°14'34.9"N & Longitude 76°46'10.5"E. The nearest railway & airport to the project site is Coimbatore.

3. PROJECT FEATURES

Kundah III involves construction of Pegumbahallah Dam which is a Masonry dam of height 55.47 m and length 181m. The reservoir formed by the dam has a live storage of 1.02 Mcum between Full Reservoir Level (FRL) of 869.3m and Minimum Draw down level (MDDL) of 834.85 m. The Full Reservoir Level of Niralapallam Diversion Weir and Katterihalla Diversion Weir is 890.02m & 1683.41m respectively. The water conductor system comprises of Head Race Tunnel (HRT) of length 10768 m and 3 nos. of penstock of length 1077 m

which carries water to the powerhouse. The Surface Power House has 3 units of 60MW each using Vertical shaft impulse type turbine operated under rated head of 409 m with an installed capacity of 180 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 41.44 Sq. km

5. POWER & ENERGY BENEFITS

Kundah-III Hydroelectric Project has three units of 60 MW each with Installed Capacity of 180 MW and the annual energy of the project is 346.84 MU in 90% dependable year.

SALIENT FEATURES
KUNDAH-III HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Coimbatore
River	Pegumbahallah
Type of Development	Storage
Nearest Railhead	Coimbatore
Nearest Airport	Coimbatore

LOCATION:

Pegumbahallah Dam : Latitude & Longitude	11°14'52.3"N ,76°40'54.3"E
Katteri Halla Diversion Weir : Latitude & Longitude	11°20'18.6"N ,76°44'13.5"E
Niralapallam Diversion Weir : Latitude & Longitude	11°16'52.6"N ,76°46'01.3"E
Power House : Latitude & Longitude	11°14'34.9"N, 76°46'10.5"E

HYDROLOGY:

Catchment Area (Sq. Km)	41.44
Maximum Annual Rainfall (mm)	3500
Minimum Annual Rainfall (mm)	550
Mean Annual Rainfall (mm)	1000

DAM:

PEGUMBAHALLAH DAM	
Type	Masonary
Length (m)	181
Height (m)	55.47
KATTERI HALLA DIVERSION WEIR	
Length (m)	80.77
Height (m)	13
NIRALAPALLAM DIVERSION WEIR	
Length (m)	60.35

Height (m)	18

RESERVOIR:

PEGUMBAHALLAH DAM	
Full Reservoir Level (FRL) (m)	869.3
Minimum Draw Down Level (MDDL) (m)	834.85
Live Storage (Mcum)	1.02
Gross Storage (Mcum)	1.07
KATTERI HALLA DIVERSION WEIR	
Full Reservoir Level (FRL) (m)	1683.41
NIRALAPALLAM DIVERSION WEIR	
Full Reservoir Level (FRL) (m)	890.02

INTAKE:

Gate No.	1
Size (m)	3.73

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Shape	Horse shoe and tunnel
Number	1
Length (m)	10768
PENSTOCK	
Number	3
Length (m)	1077
Diameter (m)	2.43

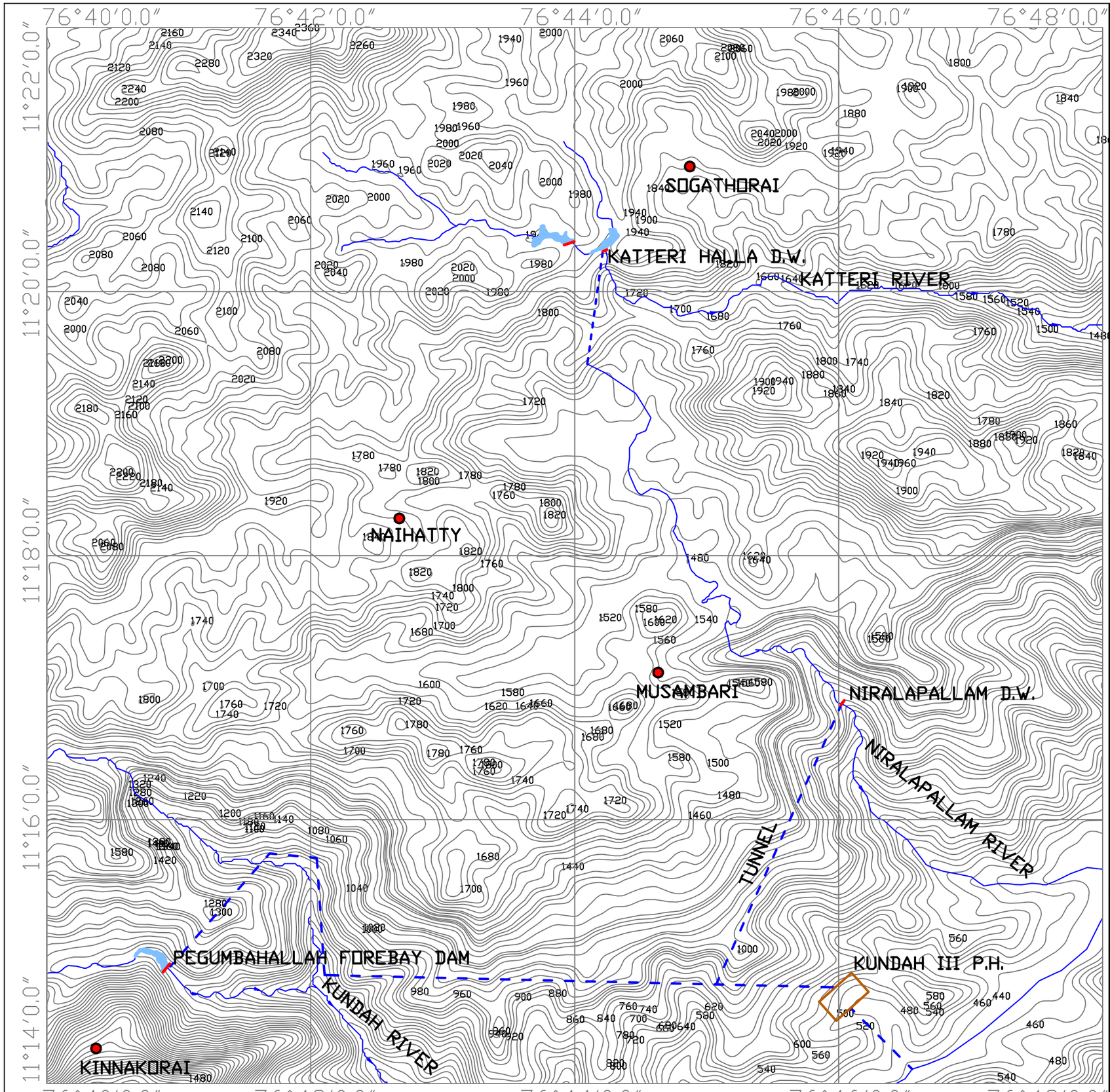
POWER HOUSE:

Type	Surface
No. of Generating Units	3
Capacity of each Unit (MW)	60
Firm Power (MW)	180
Installed Capacity (MW)	180

Rated Head (m)	409
Avg. Gross Head (Max.) (m)	439.5
Avg. Gross Head (Min.) (m)	405.06
Type of Turbine	Vertical shaft impulse turbine
Tail Water Level (TWL) (m)	424.43
Annual Energy (MU)	346.84

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1965
Unit- II	1965
Unit- III	1978



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

HRT

TRT

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KATTERI HALLA D.W.

FRL- 1683.41 M

DAM HEIGHT- 13 M

NIRALAPALLAM D.W.

FRL- 890.02 M

DAM HEIGHT- 18 M

PEGUMBAHALLAH DAM

FRL- 869.3 M

MDDL- 834.85 M

DAM HEIGHT- 55.47 M

LIVE STORAGE - 1.02 MCuM

POWER HOUSE

TWL- 424.43 M

AVERAGE HEAD- 439.5 M

INST. CAPACITY- 180 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUNDAH-III HYDROELECTRIC PROJECT (3X60) = 180 MW

3.45 KUNDAH-IV HYDROELECTRIC PROJECT (2x50MW=100MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Pillur (Kundah 4) Hydroelectric Project. Presently, the project is named as Kundah IV Hydroelectric Project.

The intermediate catchment area of Bhavani River between Upper Bhavani dam and the confluence of Kundah River in addition to the regulated flow from Kundah PH-3 provides possibility for another hydroelectric project. The project is in the downstream of the tail race discharge from Kundah PH-3 on Bhavani River near village Pillur.

The Kundah-IV Hydroelectric Project is a Storage development located near Selvanagar approximately 5.3 km from the project site and utilizes the water of Bhavani River for power generation. The project is designed to generate power, utilizing the rated head of 63.2 m to generate annual energy of 143.66 MU in a 90% dependable year. All the units were commissioned in between 1966-78 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

This project is located in the Coimbatore district, Tamil Nadu. The dam site of the project is located at Latitude 11°15'36.8" N & Longitude 76°48’21.6” E. The Power house are located at Latitude 11°15'36.8" N & Longitude 76°48'21.6" E. The nearest railway station & nearest airport to the project site is Coimbatore.

3. PROJECT FEATURES

Kundah-IV has involves construction of Masonry dam of height 87.78 m and length 357.2 m. The reservoir formed by the dam has a live storage of 34.93 Mcum between Full Reservoir Level (FRL) of 426.72 m and Minimum Draw Down Level (MDDL) of 396.25 m. Water conductor system comprises of 2 nos. of penstock of length 67.06 m and 5.48 m diameter carrying water to the powerhouse. The surface power house has two units of 50 MW operated under rated head of 63.2 m with an installed capacity of 100 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 1191.4 Sq. km.

5. POWER & ENERGY BENEFITS

Kundah-IV Hydroelectric Project has two units of 50 MW each with Installed Capacity of 100 MW and the annual energy of the project is 143.66 MU in 90% dependable year.

SALIENT FEATURES
KUNDAH-IV HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Coimbatore
River	Bhavani
Type of Development	Storage
Nearest Railhead	Coimbatore
Nearest Airport	Coimbatore

LOCATION:

Dam : Latitude & Longitude	11°15'36.8"N, 76°48'21.6"E
Power House : Latitude & Longitude	11°15'36.8"N, 76°48'21.6"E

HYDROLOGY:

Catchment Area (Sq. Km)	1191.4
Maximum Annual Rainfall (mm)	1500
Minimum Annual Rainfall (mm)	600
Mean Annual Rainfall (mm)	800

DAM:

Type	Masonry
Length (m)	357.2
Height (m)	87.78

RESERVOIR:

Full Reservoir Level (FRL) (m)	426.72
Minimum Draw Down Level (MDDL) (m)	396.25
Live Storage (Mcum)	34.93
Gross Storage (Mcum)	44.41

INTAKE:

Gate No.	1
Size (m)	4.27

WATER CONDUCTOR SYSTEM:

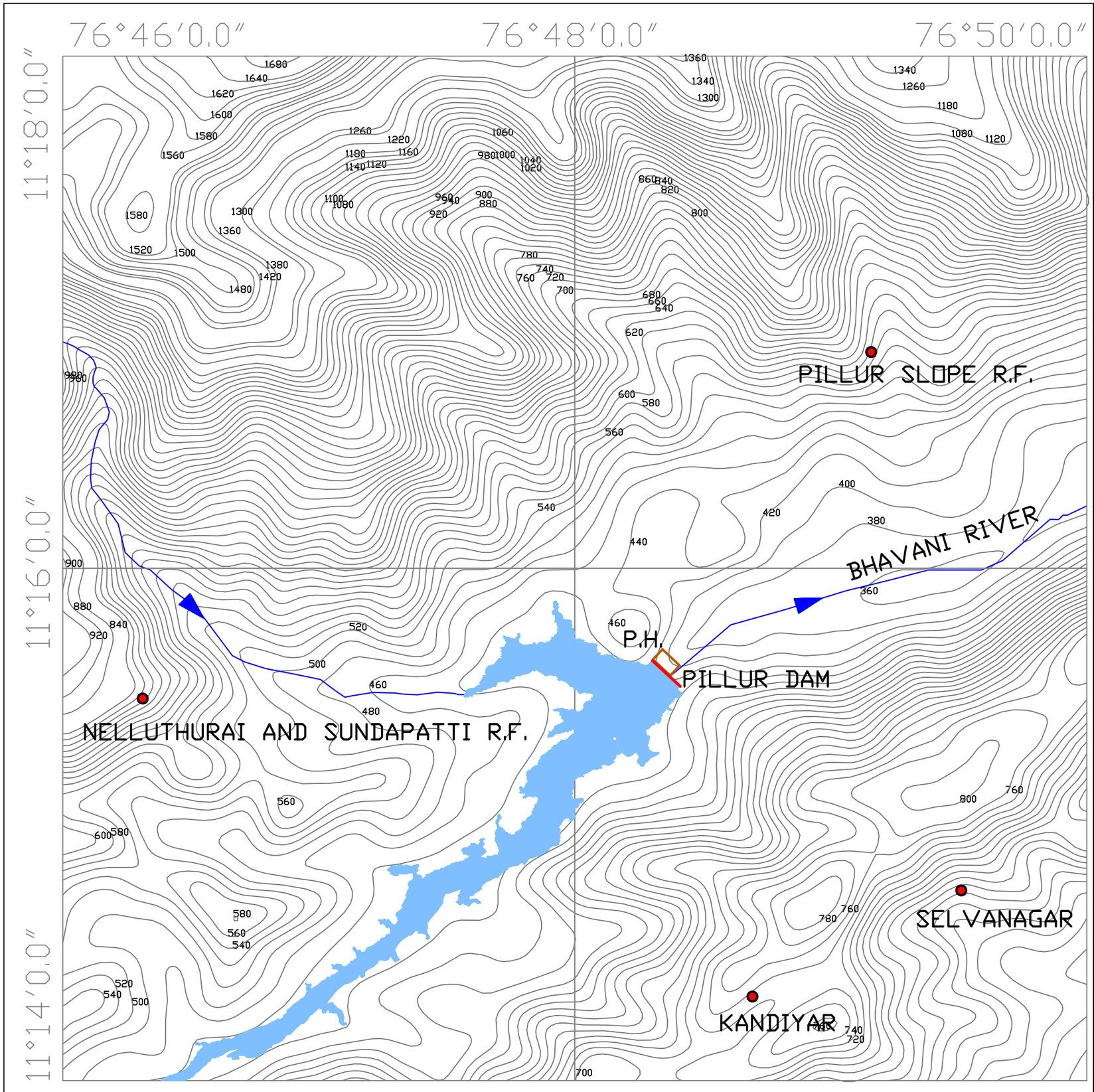
PENSTOCK	
Number	2
Length(m)	67.06
Diameter (m)	5.48

POWER HOUSE:

Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	50
Firm Power (MW)	100
Installed Capacity (MW)	100
Rated Head (m)	63.2
Avg. Gross Head (Max.) (m)	74.67
Avg. Gross Head (Min.) (m)	44.19
Type of Turbine	Vertical shaft Reactance Turbine
Tail Water Level (TWL) (m)	342.6
Design Discharge (Cumec/unit)	84.96
Annual Energy (MU)	143.66

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1966
Unit- II	1978



LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

PILLUR DAM

FRL- 426.72 M
MDDL- 396.25 M
DAM HEIGHT - 87.78 M
LIVE STORAGE - 34.93 MCuM

POWER HOUSE

TWL- 342.6 M
AVERAGE HEAD - 74.67 M
INST. CAPACITY- 100 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUNDAH-IV HYDROELECTRIC PROJECT
(2X50) = 100 MW

3.46 KUNDAH-V HYDROELECTRIC PROJECT (2X20MW=40MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Upper Bhavani (Kundah 5) Hydroelectric Project. Presently, the project is named as Kundah-V Hydroelectric Project. The Bhavani River after originating from the Kolari Betta mountain peak of the Nilgiris flows in south-westerly direction till it enters the Coimbatore district of Tamil Nadu where it takes a left bend and flows south-easterly. From the proximity of this mountain peak, originates the stream Avalance, flowing north-easterly and joining the stream Emerald, together to form the river Kundah. Due to intense rainfall in this region, it is found possible to harness potential of Bhavani in its upper reaches by constructing a high dam and dropping the regulated water through a system of tunnel and penstock on a power house located at the on-shore of Avalanche reservoir. The impounded water in Upper Bhavani reservoir is further augmented by diverting the adjacent western Catchment area into this reservoir.

Kundah-V Hydroelectric Project is a Storage type development located near Melkundah village approximately 10 km from the project site and utilizes the water of Bhavani River for power generation. The project is designed to generate power, utilizing rated head of 269.08 m. The project has 2 units of 20 MW each in a Surface power house to generate annual energy of 63.34 MU in 90% dependable year. Project was commissioned in between 1964-89 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The project has 2 dam sites, the first dam is Western catchment one dam located at Latitude 11°16'53.1"N & Longitude 76°31'51.0"E and the second dam is Upper Bhavani dam is located at Latitude 11°13'46.1"N & Longitude 76°31'24.3"E. The Power house is located at Latitude 11°18'16.0"N & Longitude 76°34'32.3"E. Udhagamandalam is the nearest railway station & Coimbatore is the nearest airport to the project site.

3. PROJECT FEATURES

Kundah-V Hydroelectric Project involves construction of 80 m high and 419 m Masonry dam. The reservoir formed by the dam has a live storage of 85.34 Mcum between Full Reservoir Level (FRL) of 2276.88 m and Minimum Draw

down Level (MDDL) of 2249.42 m. The water conductor system comprises of 1 no. of Head Race Tunnel (HRT) of length 4193 m and 2 nos. of penstock of length 672.69 m which carries water to the powerhouse. The surface power house has two units of 20 MW using vertical shaft turbine operat under rated head of 269.08 m with an installed capacity of 40 MW.

4. HYDROLOGY

The catchment area of the river up to the dam site is 33.57 Sq. km

5. POWER & ENERGY BENEFITS

Kundah-V Hydroelectric Project has two units of 20 MW each with installed Capacity of 40MW and the annual energy of the project is 63.34 MU in 90% dependable year.

SALIENT FEATURES
KUNDAH-V HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiris
River	Bhavani
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore

LOCATION:

Upper Bhavani Dam : Latitude & Longitude	11°13'46.1"N, 76°31'24.3"E
Western catchment No. 1 : Latitude & Longitude	11°16'53.1"N 76°31'51.0"E
Power House : Latitude & Longitude	11°18'16.0"N, 76°34'32.3"E

HYDROLOGY:

Catchment Area (Sq. Km)	33.57
Maximum Annual Rainfall (mm)	3500
Minimum Annual Rainfall (mm)	400
Mean Annual Rainfall (mm)	2500

DAM:

Type	Masonary
Length (m)	419
Height (m)	80

RESERVOIR:

Full Reservoir Level (FRL) (m)	2276.88
Minimum Draw Down Level (MDDL) (m)	2249.42
Live Storage (Mcum)	85.34
Gross Storage (Mcum)	101.2

WATER CONDUCTOR SYSTEM:

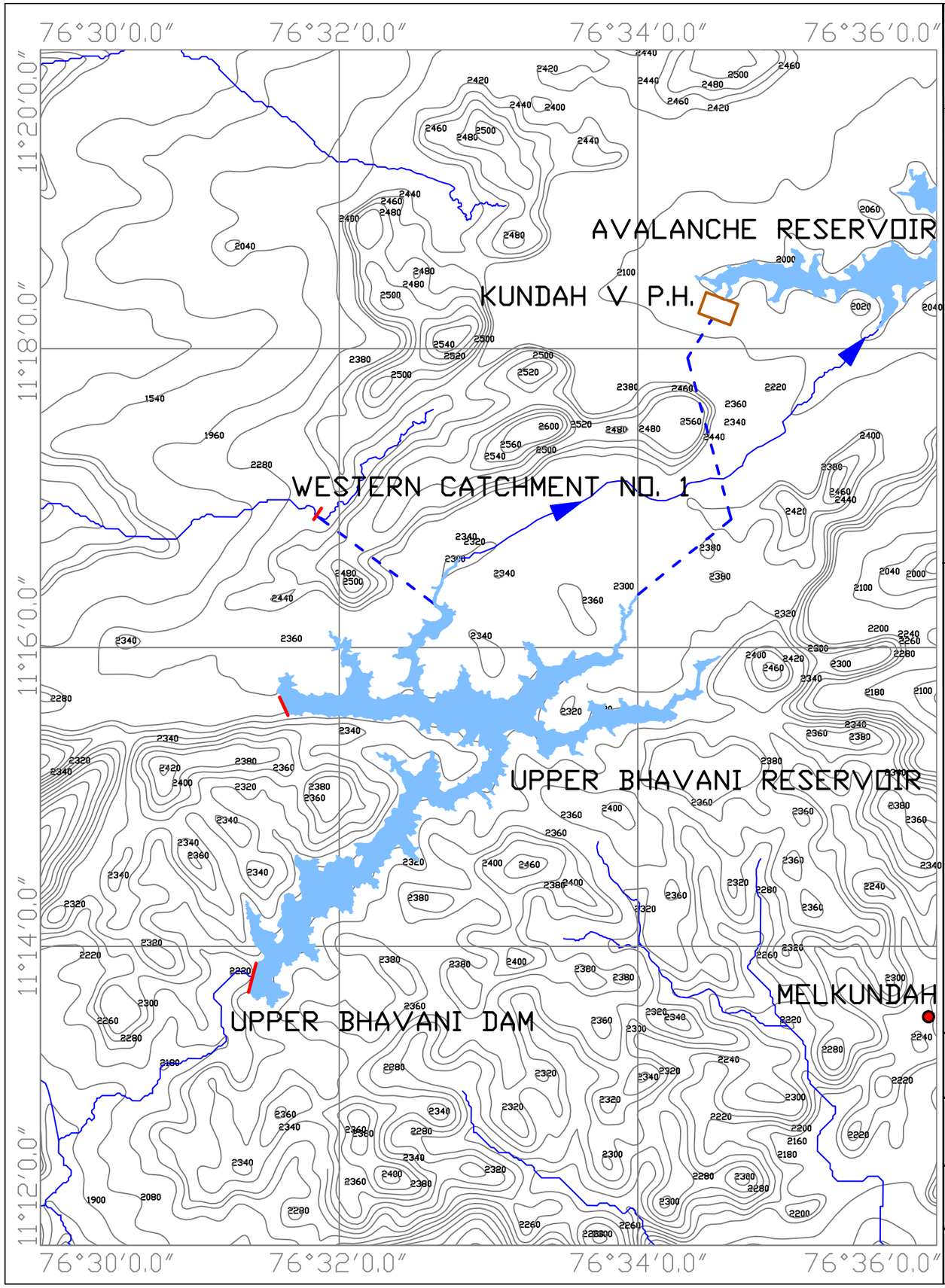
HEAD RACE TUNNEL/CHANNEL	
Shape	Horse shoe
Number	1
Length (m)	4193
PENSTOCK	
Number	2
Length (m)	672.69
Diameter (m)	1.45

POWER HOUSE:

Type	Surface
No. of Generating Units	2
Capacity of each Unit (MW)	20
Firm Power (MW)	40
Installed Capacity (MW)	40
Rated Head (m)	269.08
Avg. Gross Head (Max.) (m)	297.16
Type of Turbine	Vertical shaft reactance turbine
Tail Water Level (TWL) (m)	1985.77
Design Discharge (Cumecs)	9.63
Annual Energy (MU)	63.34

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1964
Unit- II	1989



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

WESTERN CATCHMENT NO. 1

FRL- 2391.46 M

UPPER BHAVANI DAM

FRL- 2276.88 M
MDDL - 2249.42 M
DAM HEIGHT- 80 M
LIVE STORAGE - 85.34 MCuM

POWER HOUSE

TWL- 1985.77 M
AVERAGE HEAD- 297.16 M
INST. CAPACITY- 40 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUNDAH-V HYDROELECTRIC PROJECT
(2X20) = 40 MW

3.47 PARSON'S VALLEY HYDROELECTRIC PROJECT (1X30MW=30MW)

1. INTRODUCTION

As per reassessment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Parson's Valley (Kundah 6) Hydroelectric Project. Presently, the project is named as Parson's Valley Hydroelectric Project. Parson's Valley Hydroelectric Project is a Storage type project which is located approximately 9 km from Ithalar village in Nilgiris district of Tamil Nadu and it utilizes the water of Bhavani River for further power generation. The project is designed to generate power, utilizing rated head of 209.62 m. The project has 1 unit of 30 MW each in a Surface power house to generate annual energy of 57 MU in 90% dependable year. Project was commissioned in 2000 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

Parson's Valley Hydroelectric Project consist of 4 dams, the first dam is Western catchment No. 2 located at Latitude 11°19'09.7"N & Longitude 76°32'34.7"E, the second dam is Western catchment No. 3 located at Latitude 11°19'59.8"N & Longitude 76°33'05.4"E, the third dam is Porthimund dam located at Latitude 11°22'35.0"N & Longitude 76°34'20.3"E and the fourth dam is Parson's Valley Dam located at Latitude 11°23'40.6"N & Longitude 76°35'35.8"E. The Power house is located at Latitude 11°21'52.1"N & Longitude 76°36'15.9"E in Nilgiris district in Tamil Nadu. Udhagamandalam is the nearest railway station & Coimbatore is the nearest airport to the project site.

3. PROJECT FEATURES

Parson's Valley Hydroelectric Project consists of Parson's Valley Dam of height 43m and length 146 m. The reservoir has a live storage of 13.56 Mcum between Full Reservoir Level (FRL) of 2209.83 m and Minimum Draw down Level (MDDL) of 2186.94 m. The second dam namely Porthimund dam is of height 56.39 m and 369 m in length. The reservoir formed by the dam has a live storage of 57.29 Mcum between Full Reservoir Level (FRL) of 2220.5 m and Minimum Draw down Level (MDDL) of 2188.87 m. Water conductor system comprise of Head race Tunnel (HRT) of length 1843 m from Parson's valley Reservoir and 2683m from Porthimund reservoir. A penstock of length

451.77 m and 2.1 m diameter carries water to the powerhouse. The surface power house has one units of 30 MW using vertical shaft type turbine operated under rated head of 209.62 m with an installed capacity of 30 MW.

4. HYDROLOGY

The catchment area of the river upto Parson's Valley reservoir is 14.5 Sq. km and upto Porthimund Reservoir is 10.55 Sq. Km.

5. POWER & ENERGY BENEFITS

Parson's Valley Hydroelectric Project has one unit of 30 MW with installed Capacity of 30 MW and the annual energy of the project is 57 MU at 90% dependable year.

SALIENT FEATURES
PARSON'S VALLEY HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiris
River	Bhavani
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore

LOCATION:

Parson's Valley Dam : Latitude & Longitude	11°23'40.6"N, 76°35'35.8"E
Porthimund Dam : Latitude & Longitude	11°22'35.0"N, 76°34'20.3"E
Western catchement No. 2 : Latitude & Longitude	11°19'09.7"N, 76°32'34.7"E
Western catchment No.3 : Latitude & Longitude	11°19'59.8"N, 76°33'05.4"E
Power House : Latitude & Longitude	11°21'52.1"N, 76°36'15.9"E

HYDROLOGY:

Catchment Area (Sq. Km)	Parson's valley-14.5 Porthimund -10.55
Maximum Annual Rainfall (mm)	6500
Minimum Annual Rainfall (mm)	700
Mean Annual Rainfall (mm)	3000

DAM:

PARSON'S VALLEY	
Type	Masonry
Length (m)	146
Height (m)	43
PORTHIMUND	
Type	Masonry
Length (m)	369

Height (m)	56.39

RESERVOIR:

PARSON'S VALLEY DAM	
Full Reservoir Level (FRL) (m)	2209.83
Minimum Draw Down Level (MDDL) (m)	2186.94
Live Storage (Mcum)	13.56
Gross Storage (Mcum)	19.25
PORTHIMUND DAM	
Full Reservoir Level (FRL) (m)	2220.5
Minimum Draw Down Level (MDDL) (m)	2188.87
Live Storage (Mcum)	57.29
Gross Storage (Mcum)	60.12
WESTERN CATCHMENT II	
Full Reservoir Level (FRL) (m)	2379.26
WESTERN CATCHMENT III	
Full Reservoir Level (FRL) (m)	2339.64

INTAKE:

Gate No.	1
Size (m)	1.79 x 2.21

WATER CONDUCTOR SYSTEM:

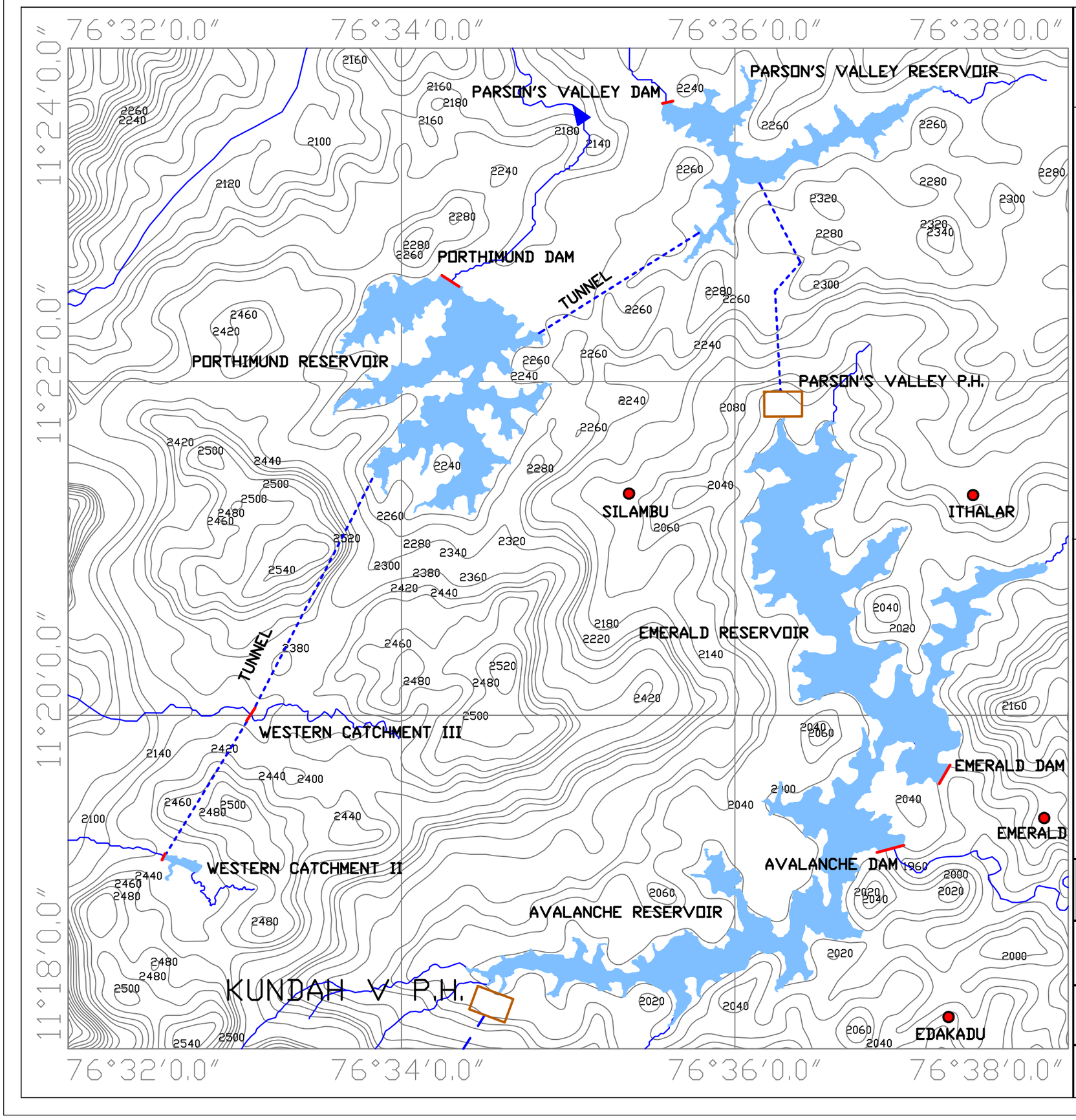
HEAD RACE TUNNEL			
	Parson's valley	**Porthimund**	**Common**
Shape	Vertical sides, semi-circular top with segmental base		
Number	1	1	1
Length (m)	1843	2683	372
Diameter (m)	W-2.134 H-2.362	W-2.134 H-2.362	6-8
PENSTOCK			
Length (m)	451.77		
Diameter (m)	2.1		

POWER HOUSE:

Type	Surface
No. of Generating Units	1
Capacity of each Unit (MW)	30
Firm Power (MW)	34.63
Installed Capacity (MW)	30
Rated Head (m)	209.62
Avg. Gross Head (Max.) (m)	240.94
Avg. Gross Head (Min.) (m)	208.72
Type of Turbine	Vertical Shaft Reaction
Tail Water Level (TWL) (m)	1985.77
Design Discharge (Cumec/unit)	19.31
Annual Energy (MU)	57

COMMISSIONING DETAILS:

Commissioning Year	2000



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

HRT

TRT

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

PORTHIMUND DAM

FRL- 2220.5 M
MDDL - 2188.87 M
DAM HEIGHT- 56.39 M
LIVE STORAGE- 57.29 MCuM

PARSON'S VALLEY

FRL- 2209.83 M
MDDL - 2186.94 M
DAM HEIGHT- 43 M
LIVE STORAGE- 13.56 MCuM

WESTERN CATCHMENT II

FRL- 2379.26 M

WESTERN CATCHMENT III

FRL- 2339.64 M

POWER HOUSE

TWL- 1985.77 M
AVERAGE HEAD- 240.94 M
INST. CAPACITY- 30 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

PARSON'S VALLEY HYDROELECTRIC PROJECT
(1X30) = 30 MW

3.48 SHIVASAMUDRAM HYDROELECTRIC PROJECT (6x3MW+4x6MW=42MW)

1. INTRODUCTION

Due to the agreement signed between the States of Karnataka and Tamil Nadu for the utilization of Cauvery water, the reach between Krishnaraja Sagar Dam and Shivasamudram cannot be utilized for obtaining hydroelectric potential. It is below Shivasamudram where the Cauvery River traverses its most rapid stretch as it breaks through the Eastern Ghat ranges to emerge into the plains, providing hydel potentialities. Immediately below Shivasamudram, the river has a spectacular fall called the Cauvery Falls and thereafter it traverses a short rapid stretch of about 8 kms. upto the confluence of Shimsha river. The Shivasamudram Hydroelectric project is the earliest hydro development in the region, built in 1902, by passing this fall through a channel, leading the water from the Siva Anicut across Cauvery to a balancing reservoir and thereafter through a system of channel and pipe line penstock, is dropped on the right bank of the river Cauvery near Shivasamudram township.

Shivasamudram Hydroelectric Project is a Run of River (RoR) type development located near Mallikyathanahalli village approximately 0.46 km from balancing reservoir and it utilizes the water of Cauvery River for power generation. The project is designed to generate power, utilizing rated head of 126.49 m. The project has 6 units of 3 MW and 4 units of 6 MW each in surface power house to generate Design energy of 181.17 MU in 90% dependable year at 95 % machine aailability. All the units were commissioned in between 1900-1938 and is executed by Karnataka Power Corporation Limited (KPCL).

2. LOCATION/ACCESSIBILITY

The Shivasamudram Hydroelectric project consists of an anicut, a balancing reservoir and forebay. The Anicut is located at Latitude 12°16'14.4"N & Longitude 77°09'52.9"E, the balancing reservoir is located at Latitude 12°17'35.5"N & Longitude 77°09'28.6"E and the Forebay is located at Latitude 12°18'20.2"N & Longitude 77°09'48.2"E. The Power house is located at Latitude 12°18'27.4"N & Longitude 77°09'55.6"E in Mandya district of Karnataka. The nearest railway station is Mandya & nearest airport to the project site is Mysuru

3. PROJECT FEATURES

Shivasamudram Hydroelectric project involves construction of anicut, a balancing reservoir and forebay having Full Reservoir Level (FRL) 609.4 m, 609.6 m and 601.6 m respectively. The Minimum Draw Down Level (MDDL) at Anicut, Balancing reservoir and Forebay is 604.96 m, 608.48 m and 600.46 m respectively. The water conductor system comprises of 6 nos. of penstock of length 232.3 m taking water to 3 MW units and 4 nos. of penstock of length 221.27 m taking water to 6 MW units in the surface powerhouse. The powerhouse has 6 units of 3 MW and 4 units of 6 MW using Francis turbine operated under rated head of 126.49 m with installed capacity of 42 MW .

4. HYDROLOGY

The catchment area from Shiva power channel to forebay is 0.7244 Sq. Km.

5. POWER & ENERGY BENEFITS

Shivasamudram Hydroelectric Project has six units of 3 MW and four units of 6 MW each enabling total Installed Capacity of 42 MW and the design energy of the project is 181.17 MU in 90% dependable year at 95 % machine availability.

SALIENT FEATURES
SHIVASAMUDRAM HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Mandya
River	Cauvery
Type of Development	RoR
Nearest Railhead	Mandya
Nearest Airport	Mysuru

LOCATION:

Shiva Anicut : Latitude & Longitude	12°16'14.4"N,77°09'52.9"E
Balancing reservoir : Latitude & Longitude	12°17'35.5"N ,77°09'28.6"E
Forebay : Latitude & Longitude	12°18'20.2"N, 77°09'48.2"E
Power House : Latitude & Longitude	12°18'27.4"N, 77°09'55.6"E

HYDROLOGY:

Catchment Area (Sq. Km)	0.7244 (Shiva power channel to Forebay)

DAM:

SHIVA ANICUT	
Type	Masonry
Length (m)	682.45
Height (m)	4.11
SHIVA BALANCING RESERVOIR	
Length (m)	74.68

RESERVOIR:

SHIVA ANICUT	
Full Reservoir Level (FRL) (m)	609.4
Minimum Draw Down Level (MDDL) (m)	604.96
SHIVA BALANCING RESERVOIR	
Full Reservoir Level (FRL) (m)	609.6

Minimum Draw Down Level (MDDL) (m)	608.48
SHIVA FOREBAY	
Full Reservoir Level (FRL) (m)	601.6
Minimum Draw Down Level (MDDL) (m)	600.46

INTAKE:

FOR 3MW UNIT	
Gate No	6
Size (m)	2.90
FOR 6MW UNIT	
Gate No	4
Size (m)	6.6

WATER CONDUCTOR SYSTEM:

PENSTOCK	
FOR 3MW UNIT	
Number	6
Length (m)	232.3
Diameter (cm)	145.6(Top) 130 (Bottom)
FOR 6MW UNIT	
Number	4
Length (m)	221.27
Diameter (cm)	168.8 (Top) 145.3 (Bottom)

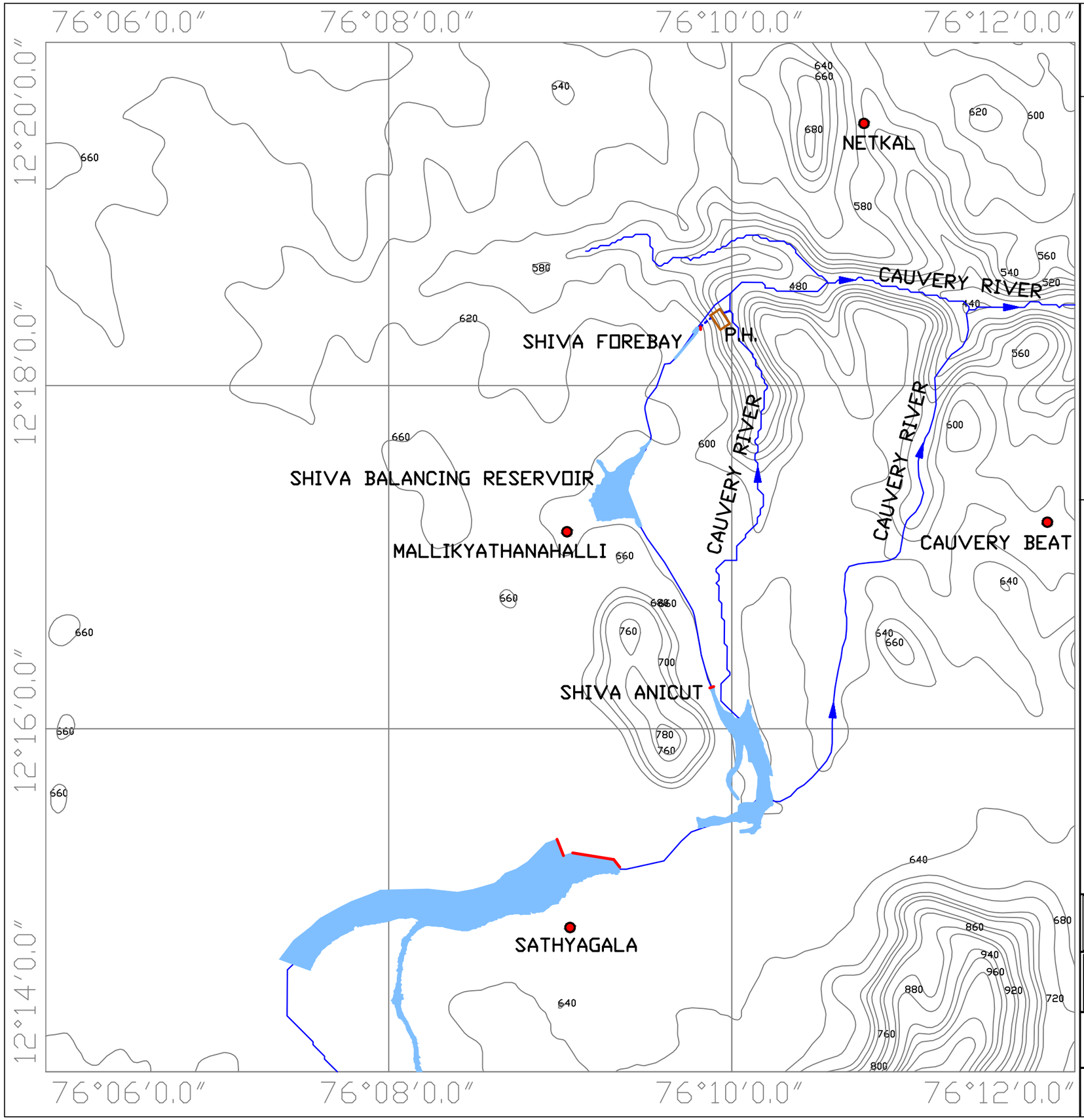
POWER HOUSE:

Type	Surface
No. of Generating Units	10
Capacity of each Unit (MW)	6 units of 3 MW and 4 units of 6MW
Firm Power (MW)	21
Installed Capacity (MW)	42
Rated Head (m)	126.49

Type of Turbine	Francis
Tail Water Level (TWL) (m)	472.74
Design Discharge (Cumec/Unit)	5.95 (for 6MW units) 2.97 (for 3MW units)
Design Energy (MU)	181.17

COMMISSIONING DETAILS:

Commissioning Year	1900-38



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

SHIVA ANICUT

FRL- 609.4 M

MDDL- 604.96 M

DAM HEIGHT- 4.11 M

SHIVA BALANCING RESERVOIR

FRL- 609.6 M

MDDL- 608.48 M

SHIVA FOREBAY

FRL- 601.06 M

MDDL- 600.46 M

POWER HOUSE

TWL- 472.74 M

RATED HEAD- 126.49 M

INST. CAPACITY- 42 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

SHIVASAMUDRAM HYDROELECTRIC PROJECT
(4X6)+(6X3) = 42 MW

3.49 MOYAR HYDROELECTRIC PROJECT (3 X12MW=36MW)

1. INTRODUCTION

Moyar Hydroelectric Project is a Storage type development located near Masinagudi village is located approximately 1.5km from Markavandy Dam site and utilizes the water of Moyar River for further power generation. The project is designed to generate power, utilizing rated head of 371.55 m. The project has 3 units of 12 MW in a Surface power house to generate annual energy of 159.27 MU in 90% dependable year. Project was commissioned in 1952-1953 and executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The project consists of 2 dams. The first dam is Markavandy Dam located at Latitude 11°34'26.8"N & Longitude 76°39'15.6"E , the second dam is a forebay dam located at Latitude 11°36'20.6"N & Longitude 76°41'28.7"E. The Power house is located at Latitude 11°36'50.1"N & Longitude 76°41'33.6"E.

Udhagamandalam is the nearest railway station and Coimbatore is the nearest airport to the project site.

3. PROJECT FEATURES

Moyar Hydroelectric project involves construction of Markavandy Dam of height 21.5m having Full reservoir Level (FRL) of 914 m and Minimum Draw Down Level (MDDL) of 908 m. Water from Markavandy dam is diverted to forebay of height 21.8m and length 396m. The reservoir formed by the forebay has a live storage of 0.164 Mcum between Full Reservoir Level (FRL) of 902.5 m and Minimum Draw Down Level (MDDL) of 897.03 m. The water conductor system comprises of 1 number of Head Race Tunnel (HRT) of length 210.9 m, 2.13 m diameter and 3 nos. of penstock of length 865 m which carries water to the powerhouse. The surface power house has three units of 12 MW using impulse type turbine operated under rated head of 371.55 m with an installed capacity of 36 MW.

4. HYDROLOGY

The catchment area of the river upto the dam site is 154.23 Sq. km.

5. POWER & ENERGY BENEFITS

Moyar Hydroelectric Project has three units of 12 MW each with installed Capacity of 36 MW and the annual energy of the project is 159.27 MU at 90% dependable year.

SALIENT FEATURES
MOYAR HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiris
River	Moyar
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore

LOCATION:

Markavandy Dam	: Latitude & Longitude	11°34'26.8"N ,76°39'15.6"E
Forebay	: Latitude & Longitude	11°36'20.6"N, 76°41'28.7"E
Power House	: Latitude & Longitude	11°36'50.1"N ,76°41'33.6"E

HYDROLOGY:

Catchment Area (Sq. Km)	154.23
Maximum Annual Rainfall (mm)	450
Minimum Annual Rainfall (mm)	50
Mean Annual Rainfall (mm)	300

DAM:

Type	Masonary
Length (m)	396
Height (m)	21.8

RESERVOIR:

Full Reservoir Level (FRL) (m) -Markavandy dam	914
Minimum Draw Down Level (MDDL) (m) -Markavandy dam	908
Full Reservoir Level (FRL) (m)- Forebay	902.5
Minimum Draw Down Level (MDDL) (m) - Forebay	897.03
Live Storage (Mcum)- Forebay	0.164
Gross Storage (Mcum)- Forebay	0.17

INTAKE:

Gate No.	1
Size (m)	3.05 x 3.05

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	Circular
Number	1
Length (m)	210.9
Diameter (m)	2.13
PENSTOCK	
Number	3
Length (m)	865
Diameter (m)	1.14

POWER HOUSE:

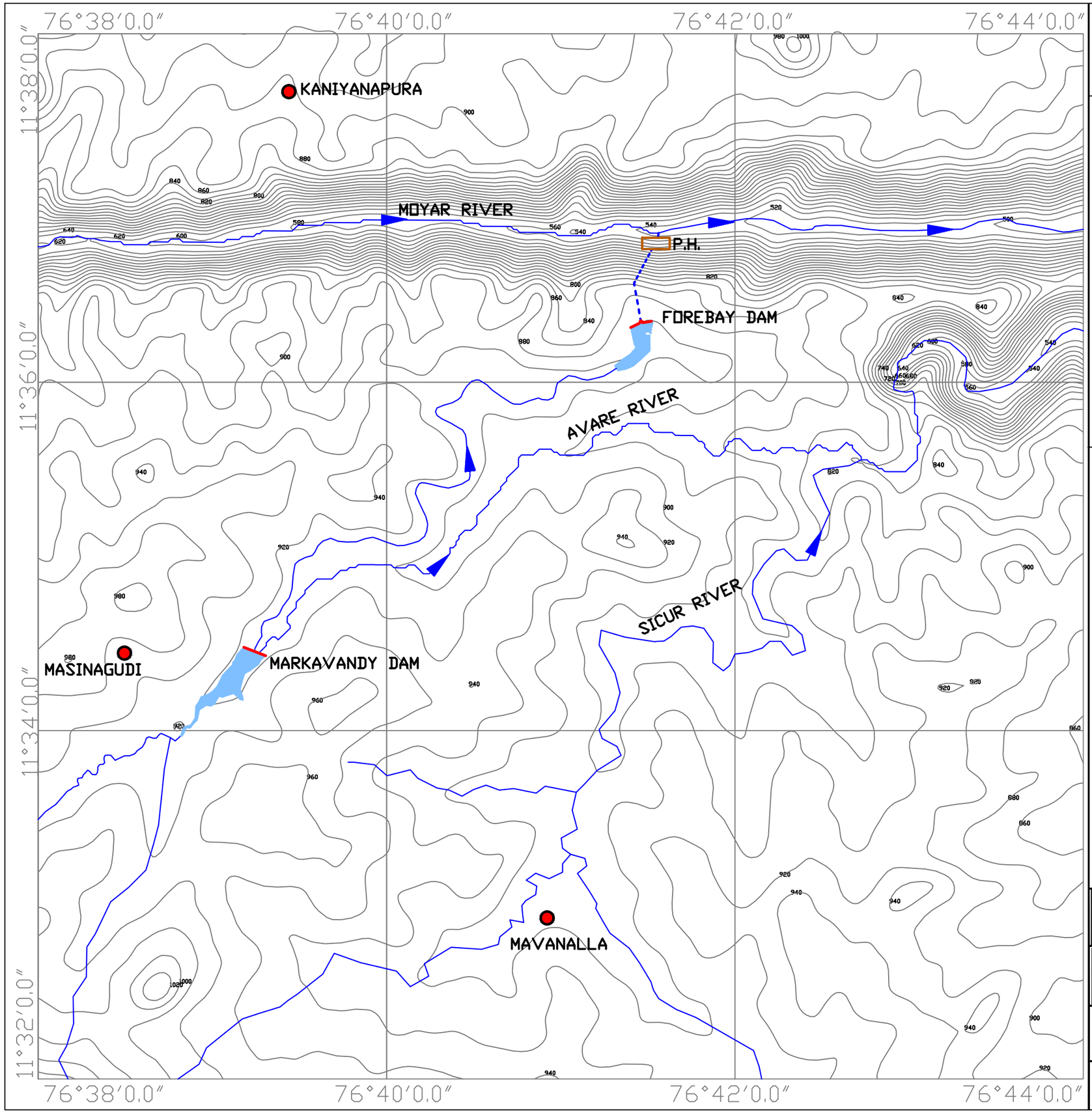
Type	Surface
No. of Generating Units	3
Capacity of each Unit (MW)	12
Firm Power (MW)	36
Installed Capacity (MW)	36
Rated Head (m)	371.55
Avg. Gross Head (Max.) (m)	391.34
Avg. Gross Head (Min.) (m)	371.53
Type of Turbine	Impulse Pelton wheel vertical
Tail Water Level (TWL) (m)	506.6
Design Discharge (Cumec/unit)	4.21
Annual Energy (MU)	159.27

COST ASPECTS:

Estimated cost (Rs. Crores)	4.64 (Price Level, 1952)

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit -I	1952
Unit -II	1952
Unit -III	1953



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

FOREBAY DAM

FRL- 902.5 M
MDDL- 897.03 M
DAM HEIGHT- 21.8 M
LIVE STORAGE -0.164 MCUM

MARKAVANDY DAM

FRL- 914 M
MDDL- 908 M

POWER HOUSE

TWL- 506.6 M
AVERAGE HEAD- 391.34 M
INST. CAPACITY-36 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MOYAR HYDROELECTRIC PROJECT (3X12) = 36 MW

3.50 SURULIYAR HYDROELECTRIC PROJECT (1X35MW=35MW)

1. INTRODUCTION

The river Suruli is joined from the right by a number of small streams, which originate from the East Kambam valley. This valley has been harnessed for hydel potential by diverting the waters of these streams by a series of weir and inters connecting tunnels and finally leading the water in a small forebay provided on the Eravangal stream. The water thus collected in forebay is further diverted to small length of tunnel and long pipeline penstock to a power house located near Vannattipparai village on the right bank of Eravangal.

Suruliyar Hydroelectric Project is a Storage type development which is located near Kulappa Gaundan Patti town approximately 8.5km from Manalar Dam site in Theni district of Tamil Nadu and it utilizes the water of Eravanglar River for power generation. The project is designed to generate power, utilizing rated head of 979.15 m. The project has 1 unit of 35 MW in a Surface power house to generate annual energy of 306 MU in 90% dependable year. The Project was commissioned in 1979 and is executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The project consist of 4 dams and 2 weirs, the first dam is Highwavys Dam located at Latitude 9°38'54.1"N & Longitude 77°21'38.4"E , the second dam is Manalar dam located at Latitude 9°38'17.3"N & Longitude 77°20'45.6"E, the third dam is Vennirar dam located at Latitude 9°37'23.8"N & Longitude 77°19'24.9"E and the fourth dam is Eravangalar dam located at Latitude 9°36'28.7"N & Longitude 77°18'03.7"E.

The first weir is Highwavys weir is located at Latitude 9°38'58.2"N & Longitude 77°21'16.0"E and the second Weir is Vennriar Weir located at Latitude 9°37'36.70''N & Longitude 77°19'22.72''E. The Powerhouse is located at Latitude 9°37'12.5"N & Longitude 77°16'21.7"E. Madurai is the nearest railway station and nearest airport to project site.

3. PROJECT FEATURES

Suruliyar Hydroelectrric project involves constructionn of Highwavys Weir at Full Reservoir Level (FRL) of 1435.60 m from where water is diverted to Highwavys Dam at Full Reservoir Level (FRL) of 1505.75 m. From Highwavys

Dam the water is taken up to Manalar Dam via 1400 m long tunnel at Full Reservoir Level (FRL) of 1492 m.

Vennirar Dam receives water from two sources, first is from Manalar Dam via 2929 m long tunnel and second from Vennirar Diversion weir via 302 m long tunnel. The Full Reservoir Level (FRL) at Vennirar Dam is 1473.75 m. Finally water is diverted from Vennirar Dam to Eravangalar Dam via 2015 m long tunnel.

Eravangalar Dam is masonry gravity dam of height 30 m and 242m length. The reservoir formed by the dam has a live storage of 2.09 Mcum between Full Reservoir Level (FRL) of 1472m and Minimum Draw down Level of 1459.5m. Water conductor system comprises of 1 no. of Head race tunnel (HRT) of length 803 m which carries water to the powerhouse. The surface power house has one unit of 35 MW using impulse type turbine operated under rated head of 979.15 m with an installed capacity of 35 MW.

4. HYDROLOGY

The catchment area of the river upto the dam site is 5.69 Sq. km.

5. POWER & ENERGY BENEFITS

Suruliyar Hydroelectric Project has one unit of 35 MW with installed Capacity of 35MW and the Annual Energy of the project is 306 MU in 90% dependable year.

SALIENT FEATURES
SURULIYAR HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Theni
River	Eravanglar
Type of Development	Storage
Nearest Railhead	Madurai
Nearest Airport	Madurai

LOCATION:

Highwavys Weir	: Latitude & Longitude	9°38'58.2"N, 77°21'16.0"E
Highwavys Dam	: Latitude & Longitude	9°38'54.1"N, 77°21'38.4"E
Manalar Dam	: Latitude & Longitude	9°38'17.3"N, 77°20'45.6"E
Vennirar Dam	: Latitude & Longitude	9°37'23.8"N,77°19'24.9"E
Vennirar Weir	: Latitude & Longitude	9°37'36.70''N, 77°19'22.72''E
Eravangalar Dam	: Latitude & Longitude	9°36'28.7"N, 77°18'03.7"E
Power House	: Latitude & Longitude	9°37'12.5"N, 77°16'21.7"E

HYDROLOGY:

Catchment Area (Sq. Km)	5.70
Maximum Annual Rainfall (mm)	187
Minimum Annual Rainfall (mm)	12
Mean Annual Rainfall (mm)	71.41

DAM:

Type	Masonry Gravity
Length (m)	242
Height (m)	30

HYDROLOGY:

ERAVANGALAR DAM	
Full Reservoir Level (FRL) (m)	1472
Minimum Draw Down Level (MDDL) (m)	1459.5

Live Storage (Mcum)	2.09
Gross Storage (Mcum)	2.4
VENNIRAR DAM	
Full Reservoir Level (FRL) (m)	1473.75
VENNIRAR WEIR	
Full Reservoir Level (FRL) (m)	1498
MANALAR DAM	
Full Reservoir Level (FRL) (m)	1492
HIGHWAVYS DAM	
Full Reservoir Level (FRL) (m)	1505.75
HIGHWAVYS WEIR	
Full Reservoir Level (FRL) (m)	1435.60

INTAKE:

Gate No.	1
Size (m)	2.25 x2.25

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	D section
Number	1
Length (m)	803
TAIL RACE TUNNEL	
Shape	Trapezoidal bottom , width-3.11 mtr
Number	1
Length (m)	200

POWER HOUSE:

Type	Surface
No. of Generating Units	1
Capacity of each Unit (MW)	35
Firm Power (MW)	35

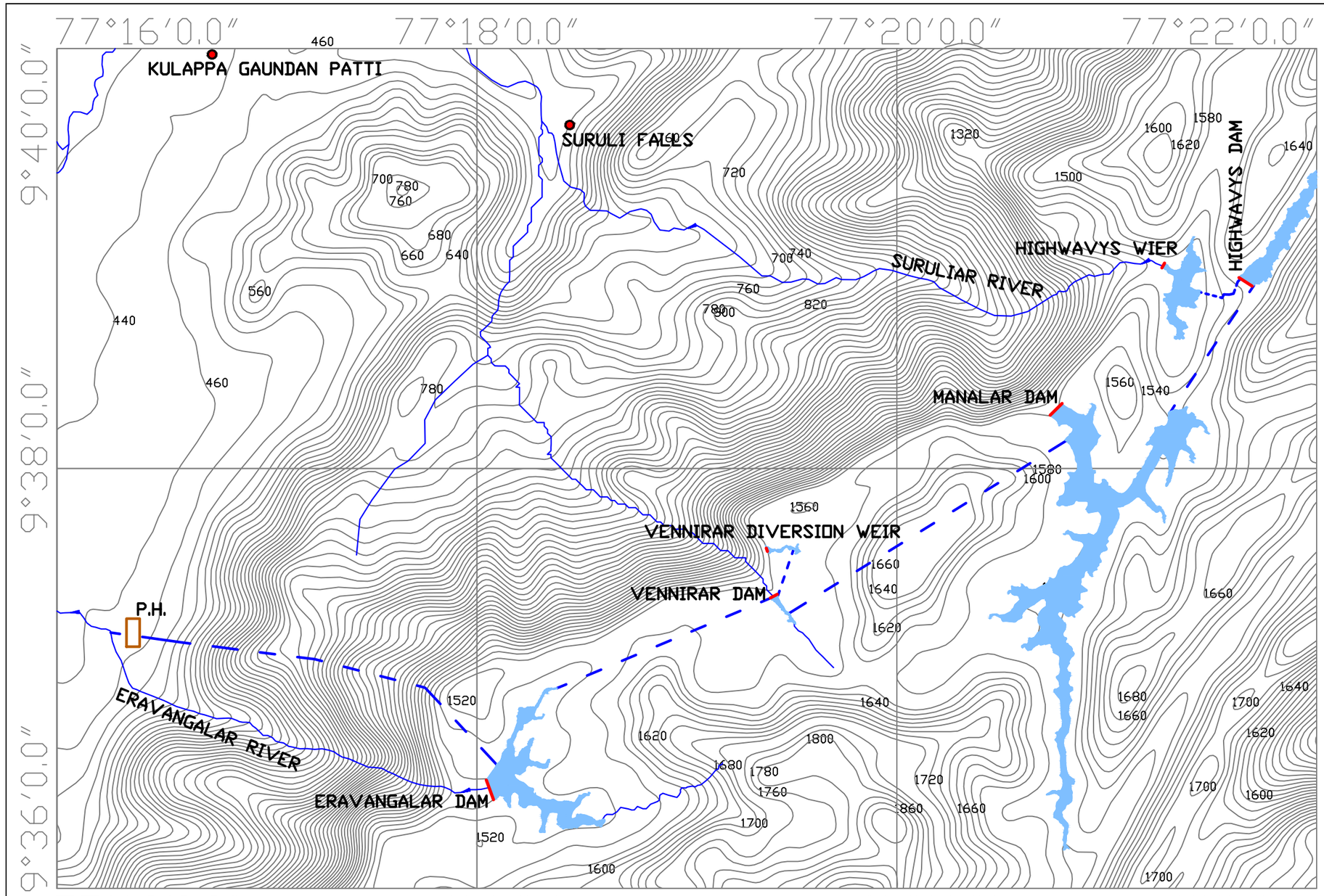
Installed Capacity (MW)	35
Rated Head (m)	979.15
Avg. Gross Head (Max.) (m)	979.15
Avg. Gross Head (Min.) (m)	972.15
Type of Turbine	Impulse Pelton
Tail Water Level (TWL) (m)	440.4
Design Discharge (Cumec/unit)	3.99
Annual Energy (MU)	306

COST ASPECTS:

Estimated cost (Rs. Crores)	26.62 (Price Level, 1978)

COMMISSIONING DETAILS:

Commissioning Year	1979



N

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

ERAVANGALAR DAM
FRL- 1472 M
MDDL- 1459.5 M
DAM HEIGHT- 30M
LIVE STORAGE - 2.09 MCuM

VENNIRAR DAM
FRL- 1473.75 M

VENNIRAR WEIR
FRL- 1498 M

MANALAR DAM
FRL-1492 M

HIGHWAVYS DAM
FRL- 1505.75 M

HIGHWAVYS WEIR
FRL- 1435.60 M

POWER HOUSE
TWL- 440.4 M
AVERAGE HEAD- 979.15 M
INST. CAPACITY- 35 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

SURULIYAR HYDROELECTRIC PROJECT
(1X35) = 35 MW

3.51 PAPANASAM HYDROELECTRIC PROJECT (4X8MW=32MW)

1. INTRODUCTION

Papanasam Hydroelectric project utilizes the regulated flow of Thambraparni dam located near Papanasam Township. A tunnel lead the regulated water of Thambraparni dam to Servalar dam. The tail race discharge from Seravalar Dam is thereafter picked up by Weir lying downstream in the lower reaches. The diverted water from the Forebay made by Weir bypasses the Papnasam falls and provide 32 MW of optimum installed capacity.

Papanasam Hydroelectric Project is a Storage type development located near West Kottaram village approximately 3km from project and utilizes the water of Thamirabarani River for power generation. The project is designed to generate power, utilizing rated head of 90.83 m. The project has 4 unit of 8 MW in a Surface power house to generate Annual energy of 280 MU in 90% dependable year. Project was commissioned in 1944-51 and executed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO).

2. LOCATION/ACCESSIBILITY

The project consists of 2 dams and a weir. The first dam, Thambraparni Dam is located at Latitude 8°39'03.4"N & Longitude 77°18'39.9"E , the second dam is Servalar dam is located at Latitude 8°41'25.6"N & Longitude 77°18'17.1"E . The diversion weir is located at Latitude 8°41'46.3"N & Longitude 77°21'31.8"E The Power house is located at Latitude 8°42'23.8"N & Longitude 77°21'45.5"E. The nearest railway station is Tiruneiveli and nearest airport is Tuticorin.

3. PROJECT FEATURES

The Papanasam Hydroelectric involves construction of a Masonry Gravity dam named Thambraparni Dam of height 66 m and 227 m length. The reservoir formed by the dam has a live storage of 149.51 Mcum between Full Reservoir Level (FRL) of 264.57 m and Minimum Draw Down Level (MDDL) of 224.03 m. The Full Reservoir Level of Servalar Dam and the Diversion weir are 264.57 m and 193.55 m respectively. The water conductor system comprises of 2 number of Head Race Tunnel (HRT) of length 1093 m, 2.74 m diameter and 4 number of penstock of length 196.29 m and 1.75 m diameter which carries water to the powerhouse. The surface power house has four units of 8 MW using francis type turbine operated under rated head of 90.83m with an installed capacity of 32 MW.

4. HYDROLOGY

The catchment area of the river upto the dam site is 149.03 Sq. km.

5. POWER & ENERGY BENEFITS

Papanasam Hydroelectric Project has four units of 8 MW each with installed Capacity of 32MW and the annual energy of the project is 280 MU in 90% dependable year.

SALIENT FEATURES
PAPANASAM HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Tiruneiveli
River	Thamirabarani
Type of Development	Storage
Nearest Railhead	Tirunelveli
Nearest Airport	Tuticorin

LOCATION:

Thambraparni dam	: Latitude & Longitude	8°39'03.4"N, 77°18'39.9"E
Servalar dam	: Latitude & Longitude	8°41'25.6"N, 77°18'17.1"E
Diversion weir	: Latitude & Longitude	8°41'46.3"N, 77°21'31.8"E
Power House	: Latitude & Longitude	8°42'23.8"N,77°21'45.5"E

HYDROLOGY:

Catchment Area (Sq. Km)	149.03
Maximum Annual Rainfall (mm)	1255
Minimum Annual Rainfall (mm)	21
Mean Annual Rainfall (mm)	244.25

DAM:

Type	Masonry
Length (m)	227
Height (m)	66

RESERVOIR:

THAMBRAPARNI DAM	
Full Reservoir Level (FRL) (m)	264.57
Minimum Draw Down Level (MDDL) (m)	224.03
Live Storage (Mcum)	149.51
Gross Storage (Mcum)	155.8
SERVALAR DAM	

Full Reservoir Level (FRL) (m)	264.57
DIVERSION WEIR	
Full Reservoir Level (FRL) (m)	193.55

INTAKE:

Gate No.	2
Size (m)	2.74 x 2.74

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Shape	Circular
Number	2
Length (m)	1093
Diameter (m)	2.74
PENSTOCK	
Number	4
Length (m)	196.29
Diameter (m)	1.75

POWER HOUSE:

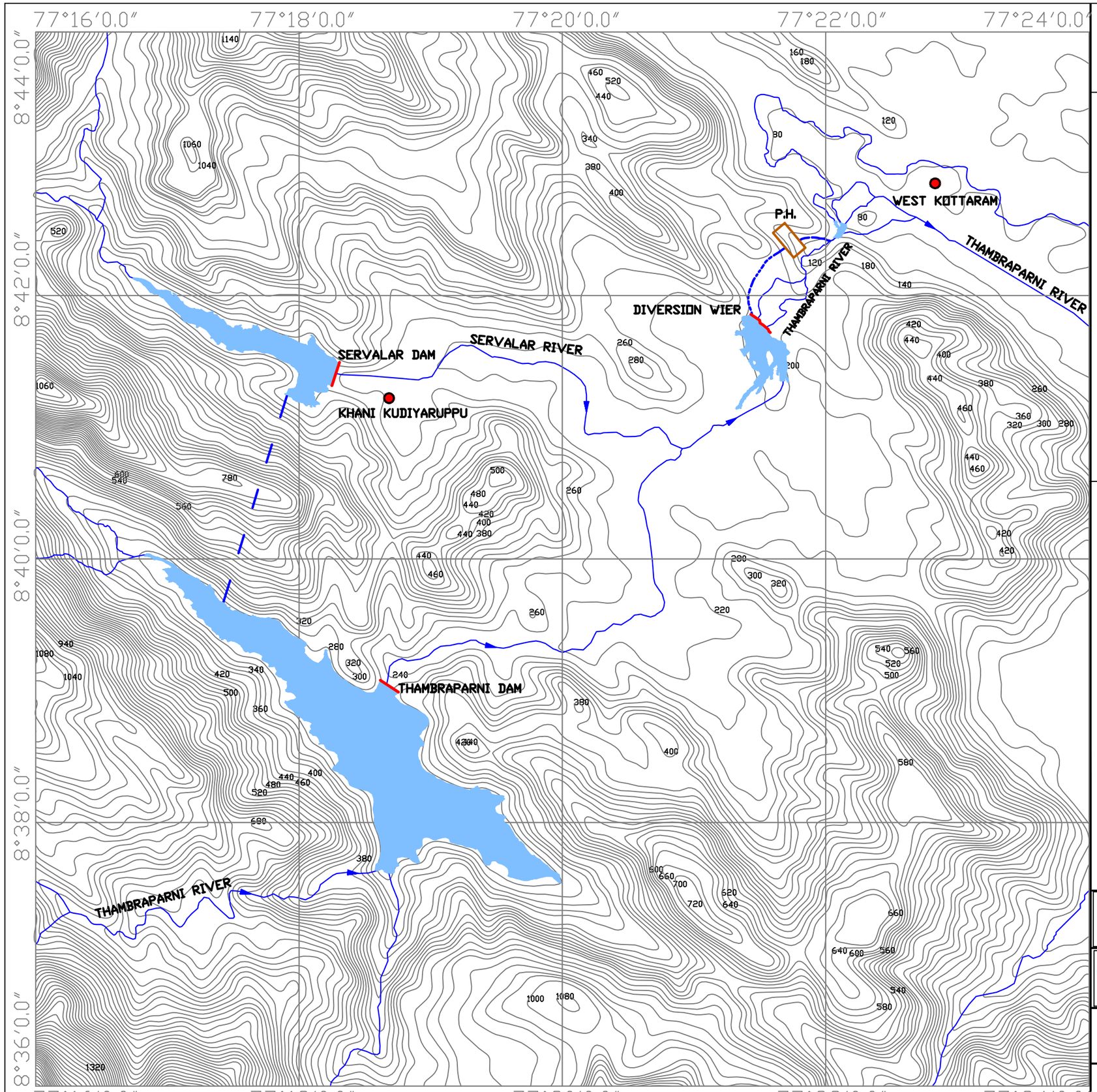
Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	8
Firm Power (MW)	28
Installed Capacity (MW)	32
Rated Head (m)	90.83
Avg. Gross Head (Max.) (m)	100.6
Avg. Gross Head (Min.) (m)	94.2
Type of Turbine	Francis-vertical
Tail Water Level (TWL) (m)	91.16
Design Discharge (Cumec/unit)	11.34
Annual Energy (MU)	280

COST ASPECT:

Estimated Cost (Rs. Crores)	3.06 (Price Level, 1944)

COMMISSIONING DETAILS:

COMMISSIONING YEAR	
Unit- I	1944
Unit- II	1944
Unit- III	1945
Unit- IV	1951



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

THAMBRAPARNI DAM

FRL- 264.6 M
MDDL- 224.03 M
DAM HEIGHT- 66.00 M
LIVE STORAGE - 149.5 MCuM

SERVALAR DAM

FRL- 264.57 M

DIVERSION WEIR

FRL- 193.55 M

POWER HOUSE

TWL- 91.16 M
AVERAGE HEAD- 100.6 M
INST. CAPACITY- 32 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

PAPANASAM HYDROELECTRIC PROJECT
(4X8) = 32 MW

B. Project Under Construction (ref Annexure-II in Chapter-1)

3.52 POLAVARAM HYDROELECTRIC PROJECT(12x80MW=960MW)

1. INTRODUCTION

Polavaram Hydroelectric Project is a Storage type development located near Ramayypeta village of West Godavari District in Andhra Pradesh.The Godavari river basin is considered as surplus while the Krishna river basin is considered to be deficit. Every year, the unutilized water of Godavari river flows into the Bay of Bengal. The study on Godavari revealed that sizeable surplus water could be transferred from Godavari river basin to the Krishna River basin. Polavaram project has been planned on river Godavari. The project is located 42kms upstream of Sir Arthur Cotton Barrage at Dowlaiswaram. Devipatnam village is located approximately 2.85 km from the dam site. The Dam toe project has a Surface powerhouse with Installed Capacity of 960MW (12X80MW) utilizing the rated head of 27 m. The Project is a Multi-purpose terminal reservoir on river Godavari. The project is under construction and is executed by Andhra Pradesh Power Generation Corporation Limited (APGENCO).

2. LOCATION/ACCESSIBILITY

This project is located in West Godavari district, Andhra Pradesh. The dam site is located at Latitude 17°17'14.1"N & Longitude 81°39'48" E. The Power house is located at Latitude 17°17'4.3"N & Longitude 81°40'8.8"E. The nearest railway station and nearest airport from the project site is Rajahmundry.

3. PROJECT FEATURES

Polavaram Hydroelectric Project will consist of 45.32 m high and 2454 m long Earth cum rockfill Dam. The reservoir formed by the dam has a live storage of 2128.16 Mcum between Full Reservoir Level (FRL) of 45.72 m and Minimum Draw Down Level (MDDL) of 41.15 m. The Power house will have twelve units of 80 MW using Kaplan turbine with an installed capacity of 960 MW. To avoid any sort of submersion in the territories of Odisha and Chhattisgarh, the protective embankments are proposed to be constructed to a length of 30.20 Km in Odisha and 29.12 Km in Chhattisgarh. Series of structures/components are proposed such as regulators, tunnels with suitable entry and exit channels, saddle dams etc for connecting the main reservoir to the Right Main Canal and Left Main Canal of the Polavaram

Project. A Tail Race Channel of length 1130 m would carry powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river upto the dam site is 306643 Sq. km.

5. POWER & ENERGY BENEFITS

The installed capacity of the Polavaram Hydroelectric Project is 960 MW. The Project provides design energy of 2308.41 MU in the First year and 431.27 MU in Final (35th) year of operation.

SALIENT FEATURES
POLAVARAM HYDROELECTRIC PROJECT

GENERAL:

State	Andhra Pradesh
District	West Godavari
River	Godavari
Type of Development	Storage
Nearest Railhead	Rajahmundry
Nearest Airport	Rajahmundry

LOCATION:

Dam : Latitude & Longitude	17°17'14.1"N, 81°39'48" E
Power House : Latitude & Longitude	17°17'4.3"N, 81°40'8.8" E

HYDROLOGY:

Catchment Area (Sq. Km)	306643

DAM:

Type	Earth cum rockfill dam
Length (m)	2454
Height (m)	45.32

RESERVOIR:

Full Reservoir Level (FRL) (m)	45.72
Minimum Draw Down Level (MDDL) (m)	41.15
Live Storage (Mcum))	2128.16

INTAKE:

Gate No.	12
Size (m)	6.50 x 11.90

WATER CONDUCTOR SYSTEM:

TAIL RACE CHANNEL	
Length (m)	1130

POWER HOUSE:

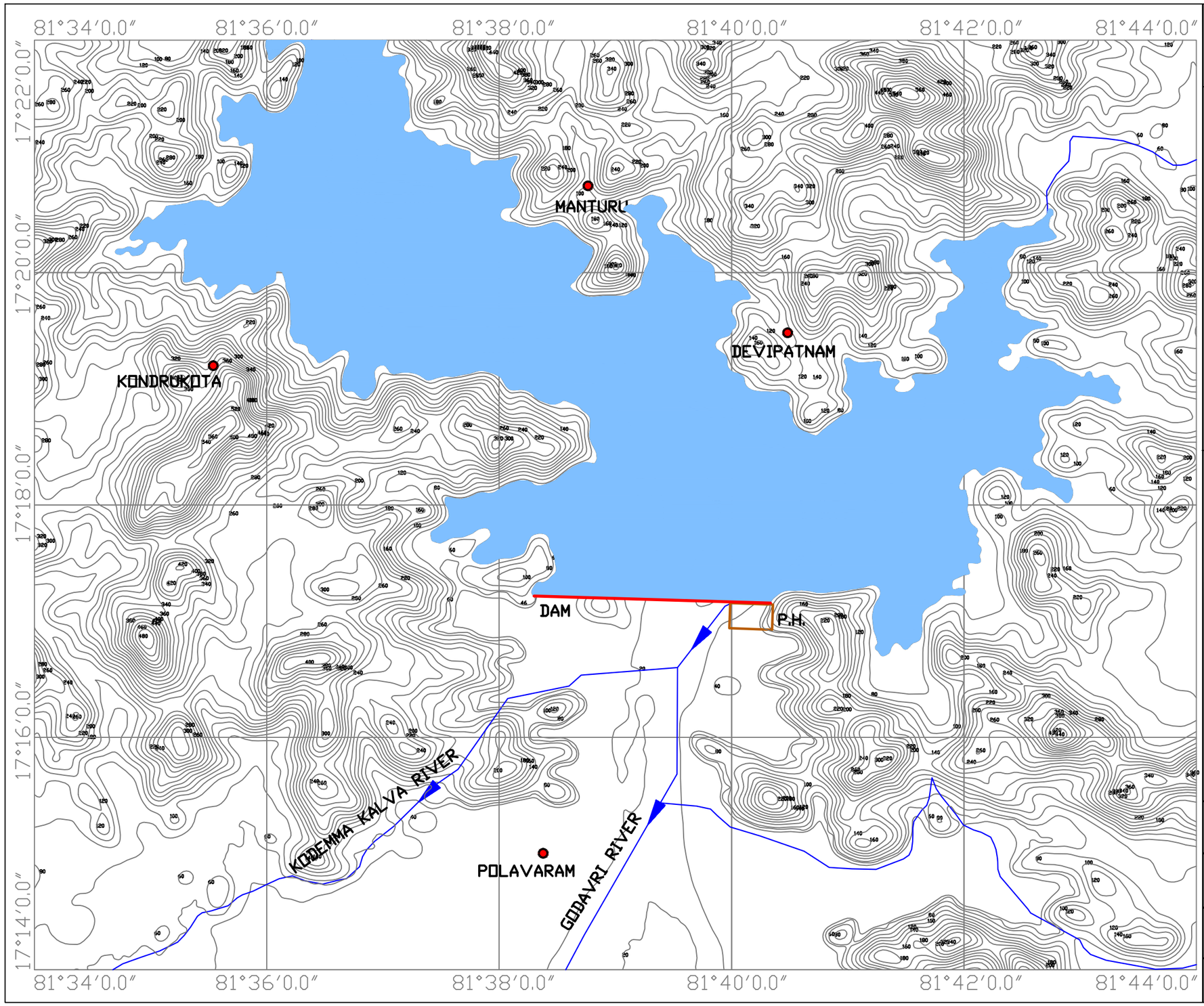
Type	Surface
No. of Generating Units	12
Capacity of each Unit (MW)	80
Installed Capacity (MW)	960
Rated Head (m)	27
Max Net Head (m)	31.08
Min Net Head (m)	17.00
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	13.64
Design Discharge (Cumecs)	331
Design Energy (MU)	2308.41 MU in the First year

COST ASPECTS:

Estimated Cost (Rs. Crores)	4956.39 (Price Level 2016-17)
Levellised Tariff(Rs/Kwh)	4.61

COMMISSIONING SCHEDULE:

Commissioning Year	2023-25



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

POLAVARAM DAM

FRL- 45.72 M

MDDL- 41.15 M

DAM HEIGHT- 45.32 M

LIVE STORAGE- 2128.16 MCuM

POWER HOUSE

TWL- 13.64 M

RATED HEAD- 27 M

INST. CAPACITY- 960 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

POLAVARAM HYDROELECTRIC PROJECT
(12X80) = 960 MW

C. Project Concurred/ Approved By State Government (ref Annexure-II in Chapter-1)

3.53 MATNAR HYDROELECTRICPROJECT (3x20MW=60MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Chitrakot Hydroelectric Project. Presently, the project is named as Matnar Hydroelectric Project. Matnar Hydroelectric Project is a Run of River (RoR) type of development near Mendir village, approximately 1630 m from the power house site located in Bastar district of Chhattisgarh. The project would utilize water of Indravarti River, utilizing net head of 57.75 m for power generation. The Semi Underground powerhouse has 3 units of 20 MW enabling installed capacity of 60 MW to generate annual energy of 177.18 MU in 90% dependable year.

As per MoEF&CC, matter of FC is closed. As per developer, project seems not to viable with revised IC of 40 MW and it is expected to be dropped.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Indravati River having Latitude of 19°12'27" N and Longitude of 81°42'15" E. The Power house is located at Latitude of 19°10'31.7"N and Longitude of 81°39'35.9"E in Bastar district of Chhattisgarh. The nearest railway station is Jagdalpur and nearest airport is Raipur.

3. PROJECT FEATURES

Matnar Hydroelectric Project would involve construction of a Concrete Gravity dam of height 14 m and Length 460 m. The reservoir would have live storage of 26.15 Mcum between Full Reservoir Level (FRL) of 535.50 m and Minimum Draw down Level (MDDL) of 530 m. The water conductor system would comprise of a Head Race Tunnel (HRT) of length 5370 m and 6.5 m diameter, surge shaft and Pressure Shaft which would carry water to the Powerhouse. The Project has a Semi- Underground power house operated under rated net head of 57.75 m enabling installed capacity of 60 MW. The discharged water from powerhouse would be carried back to the river by 860 m long Tail Race Channel.

4. HYDROLOGY

The Catchment area of the river upto the diversion site is 11831.19 Sq.Km.

5. POWER & ENERGY BENEFITS

Matnar Hydroelectric project has an installed capacity of 60 MW and would generate an annual energy of 177.18 MU in 90% dependable year.

SALIENT FEATURES
MATNAR HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Bastar
River	Indravarti
Type of Development	RoR
Nearest Railhead	Jagdalpur
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19°12 '27"N, 81°42'15"E
Power House : Latitude & Longitude	19°10'31.7"N, 81°39'35.9"E

HYDROLOGY:

Catchment Area (Sq. Km)	11831. 19

DAM:

Type	Barrage
Height (m)	14
Length (m)	460

RESERVOIR:

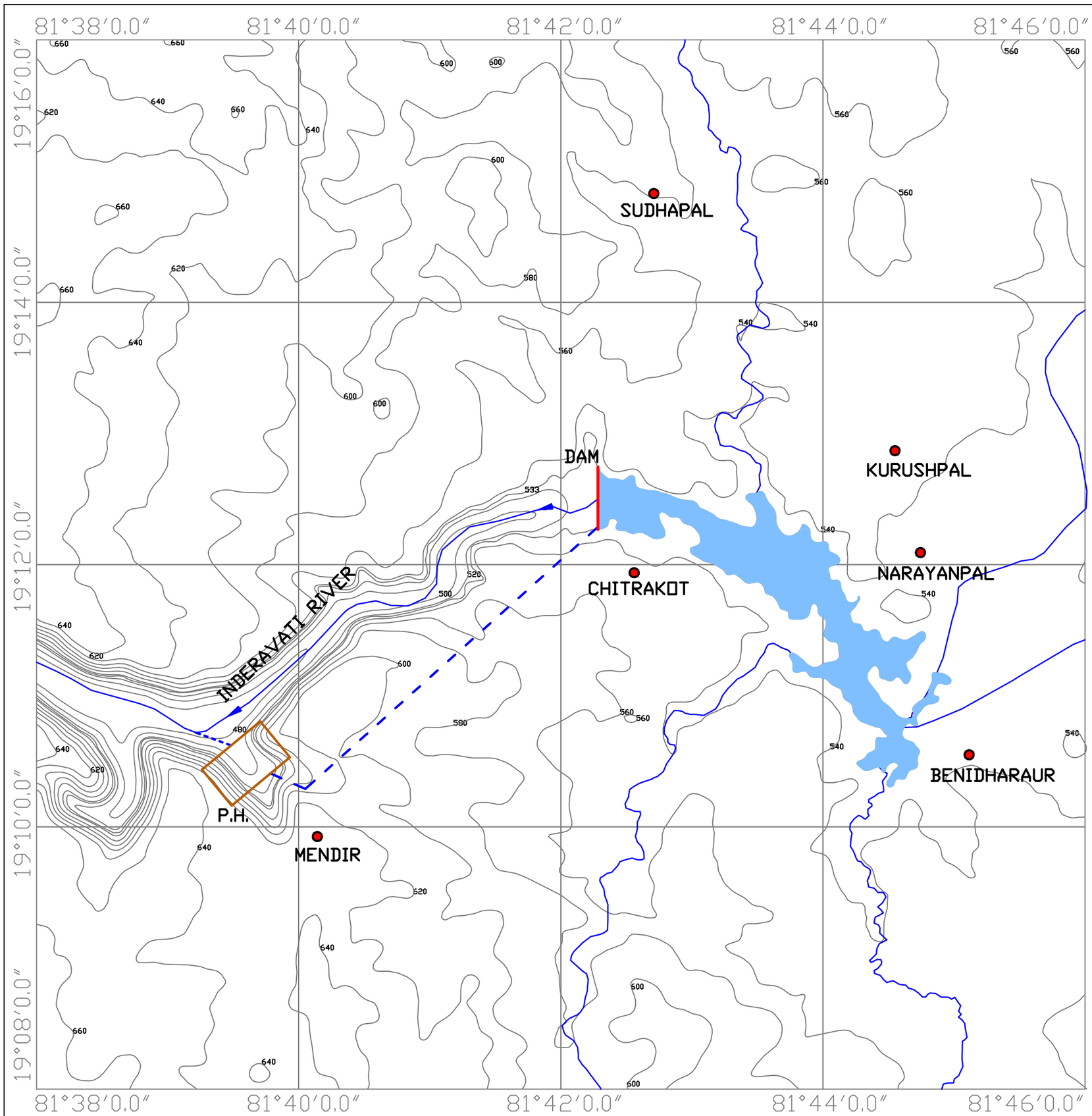
Full Reservoir Level (FRL) (m)	532.50
Minimum Draw Down Level (MDDL) (m)	530
Live Storage (Mcum)	26.15
Gross Storage (Mcum)	351.5

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL	
Length (m)	5370
Diameter (m)	6.5
TAIL RACE CHANNEL	
Length (m)	860

POWER HOUSE:

Type	Semi Underground
No. of Generating Units	2
Capacity of each Unit (MW)	30
Installed Capacity (MW)	60
Net Head (m)	57.75
Tail Water Level (TWL) (m)	466.5
Flood Discharge (Cumecs)	22600
Annual Energy (MU)	177.18



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVIOR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

MATNAR DAM

FRL- 532.50 M
MDDL-530 M
DAM HEIGHT- 14.0 M
LIVE STORAGE -26.15 MCuM

POWER HOUSE

TWL- 466.5 M
NET HEAD- 57.75 M
INST. CAPACITY-60 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

वाप्कोस लिमिटेड
WAPCOS LIMITED
CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MATNAR HYDROELECTRIC PROJECT
(3X20) = 60 MW

D. Projects Having Environmental/ Forest Issues (ref Annexure-II in Chapter-1)

3.54 NUGUR-II HYDROELECTRIC PROJECT (9 X53MW=477MW)

1. INTRODUCTION

Nugur-II Hydroelectric Project is a storage type of development near Koyanguda village, approximately 1150 m from the project site located in Dantewada District of Chhattisgarh. The project would utilize water of Indravati River for power generation. The Surface dam toe powerhouse has 9 units of 53 MW enabling installed capacity of 477 MW to generate annual energy of 961.53 MU in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Indravati River having Latitude of 80°34'E and Longitude of 19°24'N with a dam toe powerhouse located in Dantewada District of Chhattisgarh. The nearest railway station and nearest airport is Raipur.

3. PROJECT FEATURES

Nugur-II Hydroelectric Project would involve construction of 40m high and 596.74m long Roller Compacted Concrete Gravity dam. The reservoir would have live storage of 2741.86 Mcum between a Full Reservoir Level (FRL) of 237 m and Minimum Draw down Level (MDDL) of 223m. The water conductor system would comprise of a circular steel line penstock of length 87.2m and 6.2 m diameter which would carry water to the Powerhouse. The Project has a dam toe surface power house operated under rated head of 27.17 m enabling installed capacity of 477 MW. The discharged water from underground powerhouse would be carried back to the river by Tail Race Tunnel/ Channel keeping Tail Water Level (TWL) at 204 m.

4. HYDROLOGY

The catchment area of the river upto the diversion site is 9848 Sq.Km.

5. POWER & ENERGY BENEFITS

The Nugur-II Hydroelectric Project has an installed capacity of 477 MW and annual energy of the project is 961.53 MU at 90% dependable year.

6. ENVIRONMENTAL ISSUES

The dam and powerhouse site of Nugur-II Hydroelectric Project is situated on the boundary of Indravati National Park (Protected Area).

Location of Dam and powerhouse of Nugur-II Hydro Electric Project on the boundary of Indravati National Park is shown in **Chapter 4, Figure No. 4.2**.

SALIENT FEATURES
NUGUR-II HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Dantewada
River	Indravati
Type of Development	Storage
Nearest Railhead	Raipur
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19° 24' N, 80° 34' E
Power House : Latitude & Longitude	Dam toe

HYDROLOGY:

Catchment Area (Sq. Km)	9848

DAM:

Type	Roller Compacted Concrete Gravity dam
Length (m)	596.74
Height (m)	40

RESERVOIR:

Full Reservoir Level (FRL) (m)	237
Minimum Draw Down Level (MDDL) (m)	223
Live Storage (Mcum)	2741.86

WATER CONDUCTOR SYSTEM:

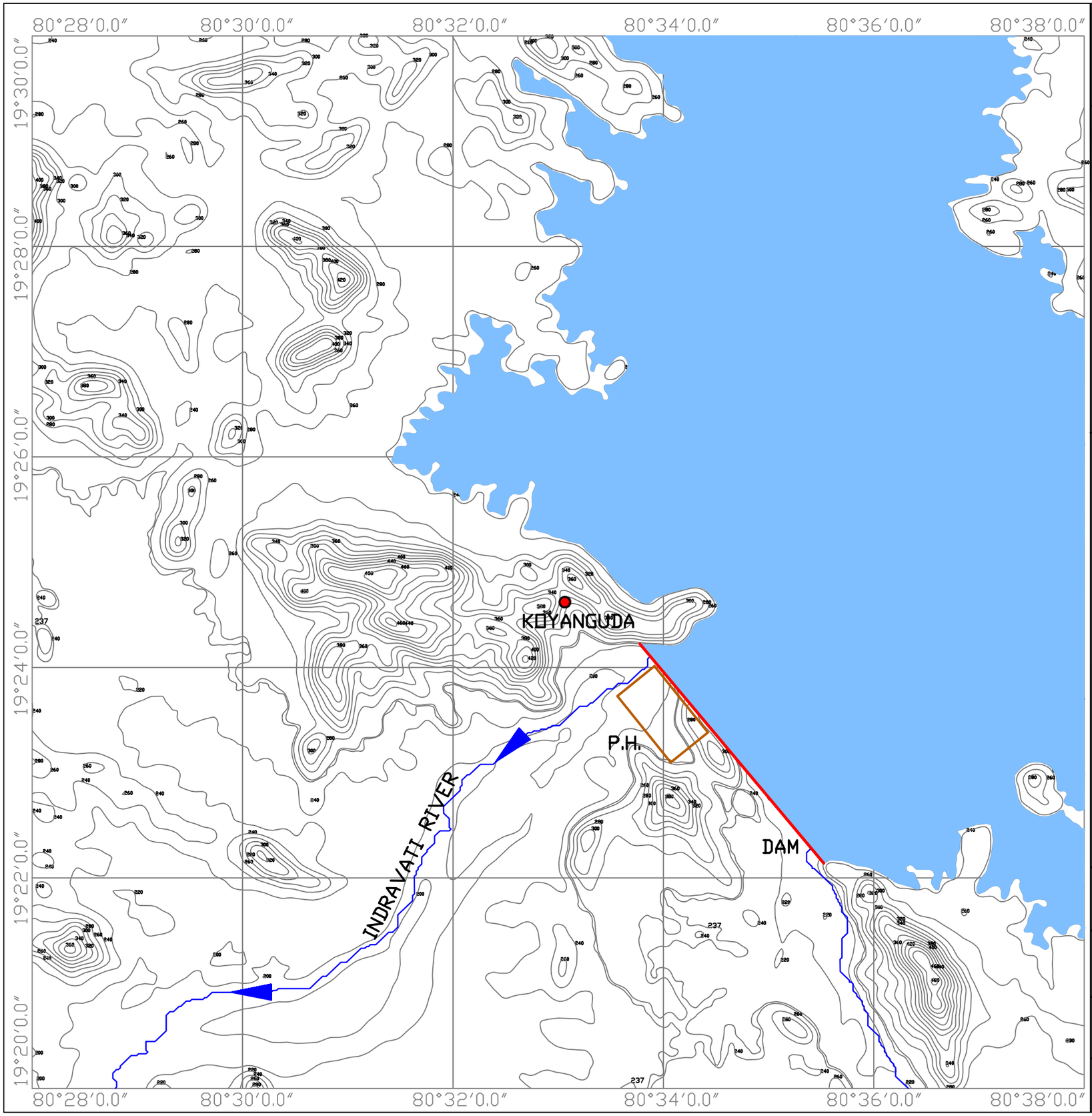
PENSTOCK	
Type	Circular Steel type
Number	9
Length	87.2
Diameter (m)	6.2

POWER HOUSE:

Type	Surface
No. of Generating Units	9
Capacity of each Unit (MW)	53
Firm Power (MW)	59.55
Installed Capacity (MW)	477
Rated Head (m)	27.17
Tail Water Level (TWL) (m) maximum	206
Tail Water Level (TWL) (m) minimum	204
Type of Turbine	Kaplan
Annual Energy (MU)	961.53

COST ASPECTS:

Estimated cost (Rs. Crores)	2264.51





LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NUGUR-II DAM

FRL- 237 M

MDDL-223 M

DAM HEIGHT- 40 M

LIVE STORAGE- 2741.86 MCuM

POWER HOUSE

TWL- 204 M

RATED HEAD - 27.17 M

INST. CAPACITY - 477 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

NUGUR-II HYDROELECTRIC PROJECT (9X53) = 477 MW

3.55 BHOPALPATNAM HYDROELECTRIC PROJECT (3x30MW=90MW)

1. INTRODUCTION

Bhopalpatnam Hydroelectric Project is located near Petha village, approximately 4050 m from the project site located in Dantewada District of Chhattisgarh. The project would utilize water of Indravati River, utilizing rated head of 29.90 m for power generation. The dam toe powerhouse has 3 units of 30 MW enabling installed capacity of 90 MW to generate annual energy of 723.12 MU in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Indravati River having Latitude of 80°18'16"E and Longitude of 19°1'48"N with a dam toe located in Dantewada District of Chhattisgarh. The nearest railway station and nearest airport is Raipur.

3. PROJECT FEATURES

Bhopalpatnam Hydroelectric project would involve construction of 48 m high roller compacted concrete gravity dam. The reservoir would have live storage of 66 Mcum between Full Reservoir Level (FRL) of 152.86 m and Minimum Draw down Level (MDDL) of 135 m. The water conductor system would comprise of 8 nos. penstock of 6.3 m diameter which would carry water to the Powerhouse. The Project has a dam toe house operated under rated head of 29.90 m enabling installed capacity of 90 MW. The discharged water from powerhouse would be carried back to the river by Tail Race Tunnel/ Channel keeping Tail Water Level (TWL) at 116 m.

4. HYDROLOGY

The Catchment area of the river upto the diversion site is 36986 Sq.Km.

5. POWER & ENERGY BENEFITS

The Bhopalpatnam Hydroelectric Project has an installed capacity of 90 MW and annual energy of the project is 723.12 MU at 90% dependable year.

6. ENVIRONMENTAL ISSUES

The dam and powerhouse sites of Bhopalapatnam Hydroelectric Project are located on boundary of the Indravati National Park (Protected Area).

Location of Dam and powerhouse of Bhopalapatnam Hydro Electric Project on the boundary of Indravati National Park is shown in **Chapter 4, Figure No. 4.3**.

SALIENT FEATURES
BHOPALPATNAM HYDROELECTRICPROJECT

GENERAL:

State	Chhattisgarh
District	Dantewara
River	Indravati
Nearest Railhead	Raipur
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19°1'48"N, 80°18'16"E
Power House : Latitude & Longitude	Dam Toe

HYDROLOGY:

Catchment Area (Sq. Km)	36986

DAM:

Type	Roller compacted concrete gravity
Height (m)	48

RESERVOIR:

Full Reservoir Level (FRL) (m)	152.86
Minimum Draw Down Level (MDDL) (m)	135
Live Storage (Mcum)	66

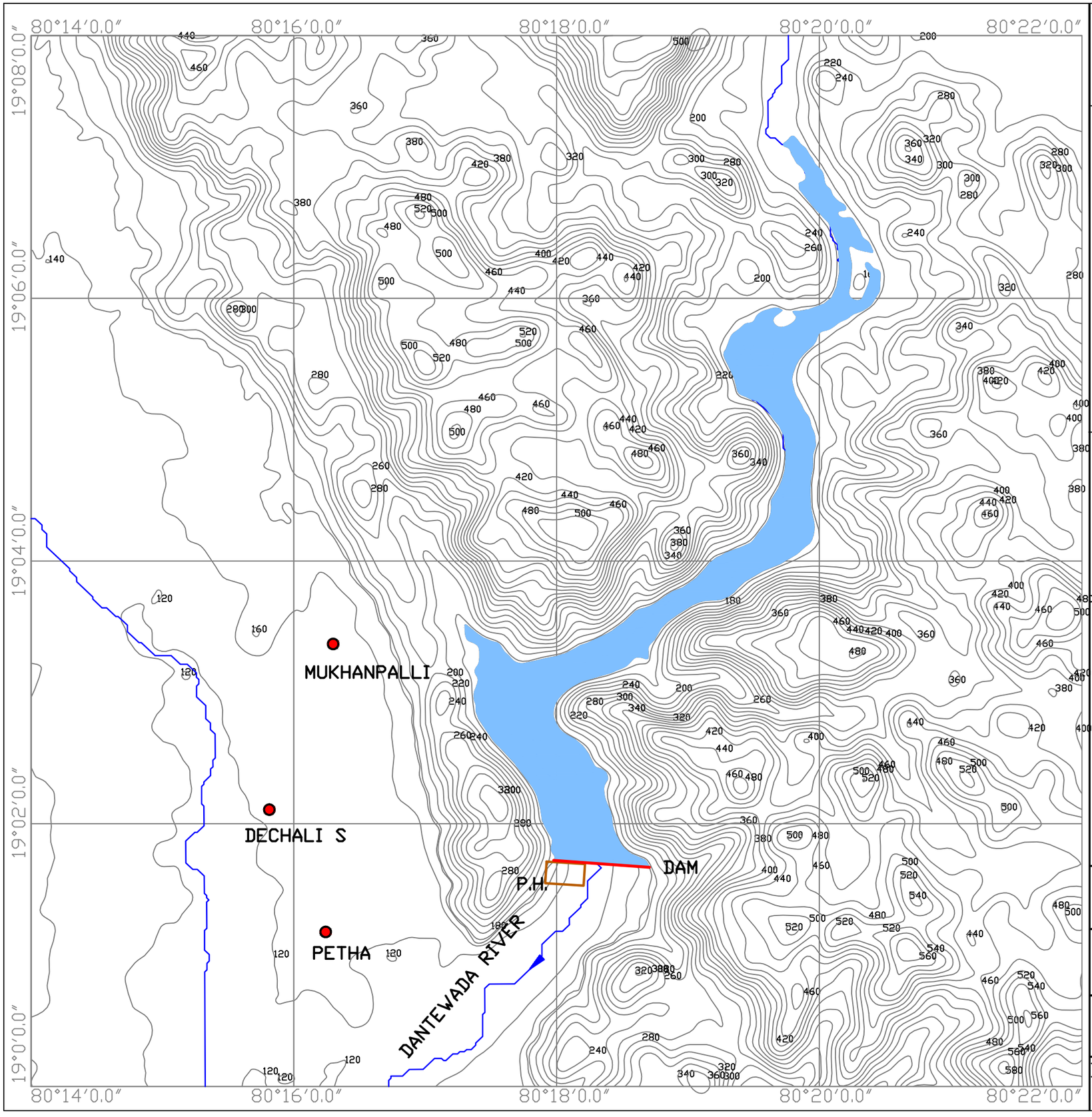
WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	8
Diameter (m)	6.3

POWER HOUSE:

Type	Dam toe
No. of Generating Units	3
Capacity of each Unit (MW)	30
Installed Capacity (MW)	90

Rated Head (m)	29.90
Type of Turbine	Francis
Tail Water Level (TWL) (m)	116
Design Discharge through each unit (Cumecs)	100.3
Annual Energy (MU)	723.12



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BHOPALPATNAM DAM

FRL- 152.86 M
MDDL-135 M
DAM HEIGHT- 48 M
LIVE STORAGE- 66 MCuM

POWER HOUSE

TWL- 116 M
RATED HEAD - 29.90 M
INST. CAPACITY - 90 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BHOPALPATNAM HYDROELECTRIC PROJECT
(3X30) = 90 MW

3.56 LOWER MOYAR HYDROELECTRIC PROJECT (33 MW)

1. INTRODUCTION

The Lower Moyar Hydroelectric Project is a storage type development located in Nilgiris district of Tamil Nadu. Bandipura district forest area is located approximately 3.32 km from the dam site. The project envisages utilization of the water of river Moyar for power generation, harnessing a gross head of about 117.3 m. The project with a proposed installation of 33 MW would afford an annual energy generation of 126 MU in a 90% dependable year.

2. LOCATION/ACCESSIBILITY

The Pickup dam of the project is located at Latitude 11°36' 44.70''N & Longitude 76°46'26.09''E and the Forebay dam is located at Latitude 11°34'13.5"N & Longitude 76°48'14.7"E and the Power house located at Latitude 11°35'11.8"N & Longitude 76°50'45.7"E. The nearest railway from the project site is Udhagamandalam and is the nearest airport is Coimbatore.

3. PROJECT FEATURES

The proposed project envisage utilization of the regulated discharge of Moyar powerhouse and the yield of free catchment below Pykara dam upto Moyar Dam and the flow of Kedarihalla valley. The water from the Lower Moyar reservoir would be diverted to Kedarihalla forebay with Full Reservoir Level (FRL) of 502.9 m through a tunnel of about 6.1 km length and the combined water from the forebay would be further led the powerhouse through a system of power tunnel and penstock and dropped over an average gross head of about 117.3 m.

4. POWER & ENERGY BENEFITS

The Lower Moyar Hydroelecric Project has an Installed Capacity of 33 MW. The project would generate an annual energy generation of about 126 MU in 90% dependable year and enable a firm power generation of 13.3MW.

5. ENVIRONMENTAL ISSUES

The pick up dam site of Lower Moyar is located on the boundary of Bandipur Wildlife Sanctuary (protected Area). The Forebay dam is located of the project is located 4.1 km away from Bandipur Wildlife Sanctuary (protected Area). The Powerhouse site is located 0.5 km inside Bandipur Wildlife Sanctuary (protected Area) as shown in **Chapter 4, Figure No. 4.6**.

SALIENT FEATURES
LOWER MOYAR HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Nilgiris
River	Moyar
Type of Development	Storage
Nearest Railhead	Udhagamandalam
Nearest Airport	Coimbatore Airport

LOCATION:

Pickup Dam : Latitude & Longitude	11°36'44.70''N,76°46'26.09''E
Forebay Dam: Latitude & Longitude	11°34'13.5"N, 76°48'14.7"E
Power House : Latitude & Longitude	11°35'11.8"N 76°50'45.7"E

DAM:

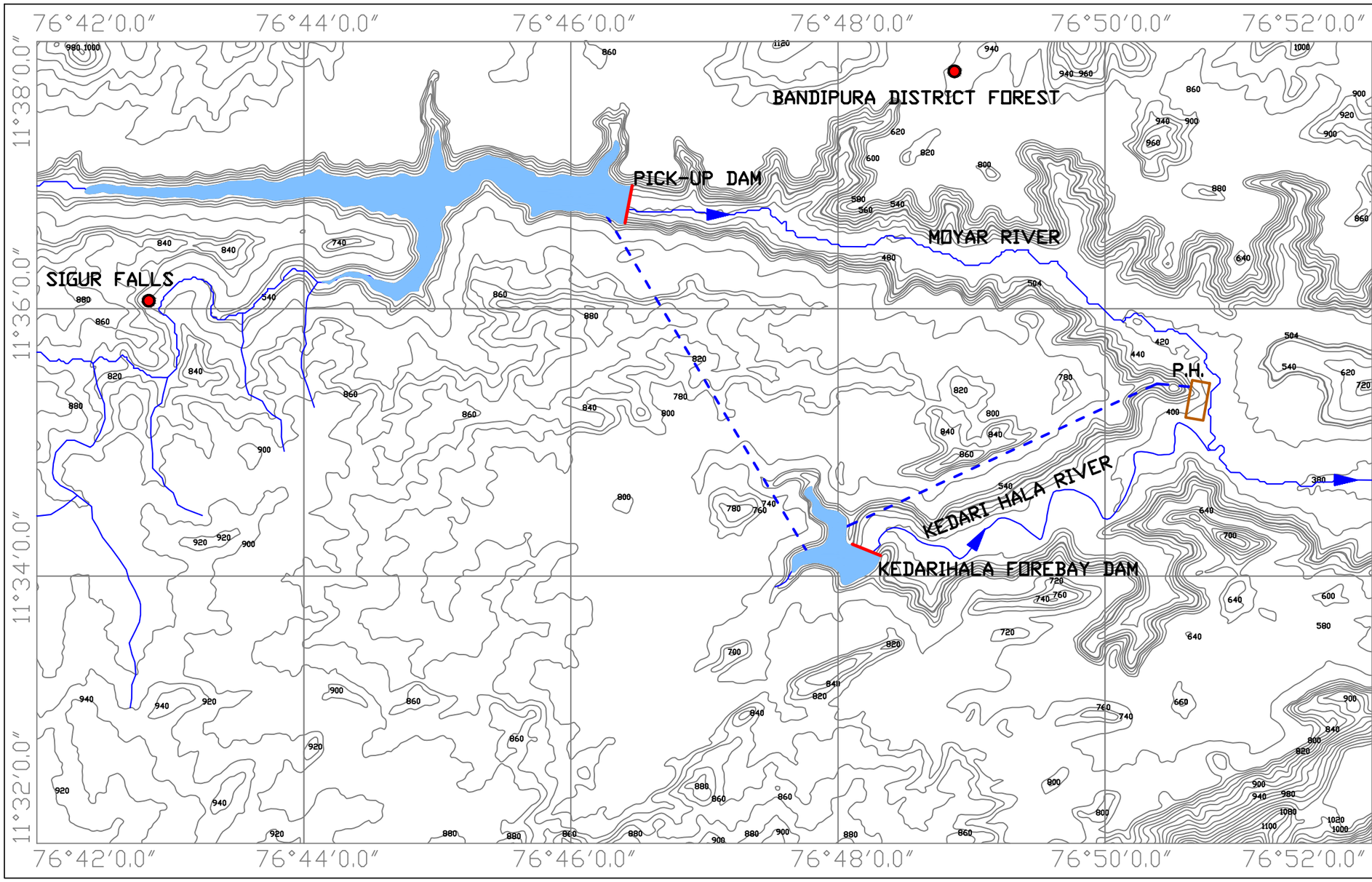
Height (m) -Pickup Dam	45.6

RESERVOIR:

Full Reservoir Level (FRL) (m)-Pickup Dam	503.7
Full Reservoir Level (FRL) (m)-Forebay Dam	502.9
Minimum Draw Down Level (MDDL)(m) - Pickup Dam	495.3
Minimum Draw Down Level (MDDL)(m) - Forebay Dam	489.2
Live Storage (Mcum) -Pickup Dam	19.1

POWER HOUSE:

Firm Power (MW)	13.3
Installed Capacity (MW)	33
Avg. Gross Head (m)	117.3
Tail Water Level (TWL) (m)	381
Annual Energy (MU)	126



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE
- CONTOUR INTERVAL - 20M

PICK-UP DAM

FRL- 503.7 M
MDDL- 495.3 M
DAM HEIGHT- 45.6 M
LIVE STORAGE -19.1 Mcum

KEDARIHALA FOREBAY DAM

FRL- 502.9 M
MDDL- 489.2 M

POWER HOUSE

TWL- 381.0 M
AVG. GROSS HEAD- 117.3 M
INST. CAPACITY-33 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER MOYAR HYDROELECTRIC SCHEME 33 MW

E. Projects Having Inter-State Issues(ref Annexure-II in Chapter-1)

3.57 MIDDLE KOLAB HYDROELECTRIC PROJECT (3x105MW=315MW)

1. INTRODUCTION

The Middle Kolab project envisages construction of a Barrage across river Kolab about 5km downstream of confluence of Joura Nala with Kolab and upstream of Dumajori village in Koraput district of Odisha. Mokagam village is located approximately 3.50 km from the barrage site. A dam is proposed on Kerajodi, a small tributary of Kolab river. A flood flow channel is proposed from Barrage to divert the flood flows of Kolab River into the aforesaid reservoir. It is proposed to generate HydroPower at powerhouse near Kodukugurah. The project with a proposed installation of 315 MW (3x105 MW) operated under gross head of 252.7 m would afford an annual energy generation of 1059.83 MU in a 90% dependable year

2. LOCATION/ACCESSIBILITY:

The Diversion Barrage is located at Latitude 18°59'55"N & Longitude 82°17'10"E and the Dam site is located at Latitude 18°45'37.3"N & Longitude 82°10'15.8"E. The Power house located at Latitude 18°44'35"N & Longitude 82°08'56"E in Koraput district of Odisha.The nearest railway station from the project site is Koraput and nearest airport is Vishakhapatnam.

3. PROJECT FEATURES:

A dam is proposed on Kerajodi, a small tributary of Kolab River with Full Reservoir Level (FRL) of 528 m and Minimum Draw Down Level (MDDL) of 482m with gross head of 252.7 m. The spill channel of Indravati River, for diversion of its flows in the catchment of Kerajodi Nallah a tributary of Kolab joining it from the left downstream of the proposed barrage. A 38.55 km long flood flow channel would be provided for diversion of flows at Diversion Barrage with Full Pond Level (FPL) of 536.5m to the catchment of Kerajodi Nallah. It would also involve a cross drainage work over the above two Nallahs (Kasbal Nallah & Maulajodi nallah) to allow the diverted flows from Diversion Barrage to flow uninterrupted. It aim at construction of a balancing reservoir with gross capacity of 135 Mcum at kerajodi, about 24km downstream of the Kasabal Moulijori Nallah, to regularize flows to the power house near village Kodukugurah with tail race tunnel leading to the main river . The powerhouse

would have 3 units of 105 MW operated under gross head of 252.7 m with installed capacity of 315 MW.

4. HYDROLOGY:

The catchment area at the Kerajodi dam site is of about 25.55 Sq km and at the diversion barrage site is 3103 Sq km.

5. POWER & ENERGY BENEFITS:

The Detail Project Report (DPR) of Middle Kolab was returned by Central Electricity Authority (CEA) due to non compliance of comments. The project has 3 units of 105 MW enabling installed capacity of 315 MW and has annual energy of 1059.83 MU at 90% dependable year.

6. INTERSTATE ASPECTS

a) In the Detailed Project Report (DPR) of Middle Kolab Multipurpose Project of Odisha, observations of Water Resource Deprtment, Govt. of Chhattisgarh are as follows.: -
   i) Rainfall data used in DPR of Middle Kolab Project are from the year 1966-67 to 2002-03, Rainfall data of the year from 2003-04 to 2016-17 has not been considered.
   ii) Flow data of Indravati River and Joura Nalla for the year 2003-04 to 2016-17 has been considered. Since the control structures in Indravati River and Joura Nalla have been completed in June 2016, hence from the year 2002-03 to till completion of control structures and there after, difference occurred in flow data must be calculated.
   iii) Since River Indravati, Joura Nalla and River Kolab (Shabari) are the life lines of both Odisha and Chhattisgarh State, hence it will appropriate to check/investigate the water availability and its use, by the Joint High Level Technical Committee of both the state.
   iv) In the light of aforementioned observations, Joint Inter-State Agreement, Dated 11.07.1979 should be reviewed at high level.

b) After construction of first barrage under Middle Kolab Project , the quantity of water in River Kolab at boundary of Chhattisgarh and Odisha has become reduced, resulting following :-
   i) Govt. of Chhattisgarh allocated 53.69 McuM/year water for Nagamar Steel Plant and 11.00 Mcum/year water for Slurry Pipe Project of N.D.M.C. from Kolab (Shabari) River , but due to reduced water availability in Kolab 9Shabari) River , it will not be possible to full fill the committed water demand of aforesaid industries.
   ii) Total 53 cumecs flow of water, required for proposed 5 No's Hydro Electric Power Project in Kolab (Shabari) River will be affected.
   iii) Before entering Kolab River in Sukuma Distt. Of Chhattisgarh State, its 2751.55 sq km catchment area used by the Odisha State resulting reduction of flow in Sukma Distt.

In the above context, the Govt. of Chhattisgarh is disagree with construction of Middle Kolab Project.

SALIENT FEATURES
MIDDLE KOLAB HYDROELECTRIC PROJECT

GENERAL:

State	Odisha
District	Koraput
River	Kerajodi Nallah/Kolab River
Nearest Railhead	Koraput
Nearest Airport	Vishakhapatnam

LOCATION:

Dam : Latitude & Longitude	18°45'37.3"N, 82°10'15.8"E
Diversion Barrage : Latitude & Longitude	18°59'55"N, 82°17'10"E
Power House : Latitude & Longitude	18° 44' 35" N, 82° 08' 56" E

HYDROLOGY:

Catchment Area (Sq. Km)-Kerajodi Dam	25.55
Catchment Area (Sq. Km)-Diversion Barrage	3103

DAM:

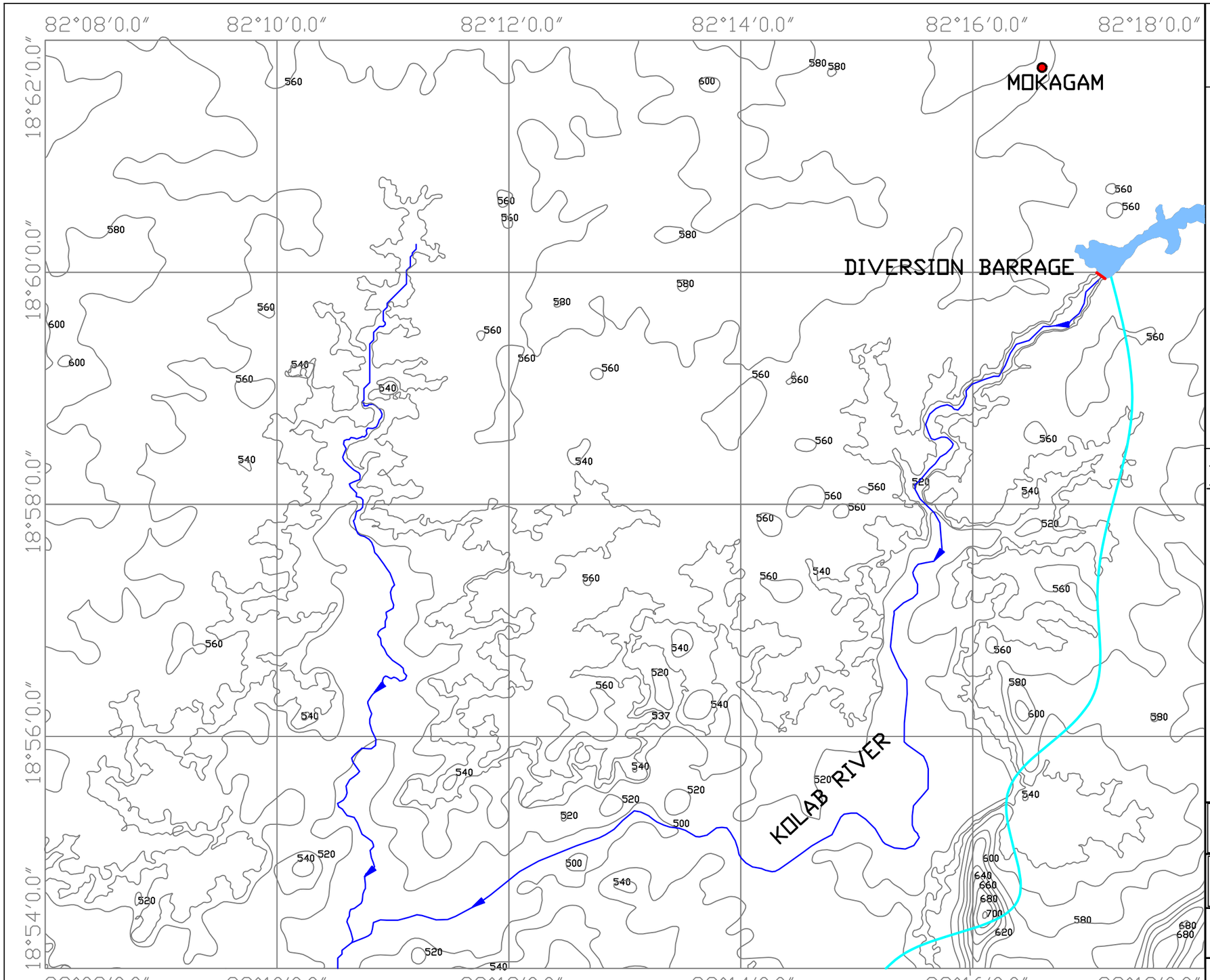
KERAJODI DAM	
Type	Earthen Dam
Length (m)	678.88
Height(m)	94
DIVERSION BARRAGE	
Length (m)	177
Height (m)	21

RESERVOIR:

KERAJODI DAM	
Full Reservoir Level (FRL) (m)	528
Minimum Draw Down Level (MDDL)(m)	482
DIVERSION BARRAGE	
Full Pond Level (FRL) (m)	536.5
Live Storage (Mcum)	135

POWER HOUSE:

No. of Generating Units	3
Capacity of each Unit (MW)	105
Installed Capacity (MW)	315
Gross Head (m)	252.7
Tail Water Level (TWL) (m)	260
Annual Energy (MU)	1059.83



N

W E

S

LEGENDS.

- CONTOUR
- RIVER
- BARRAGE
- POWER HOUSE
- CANAL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

DIVERSION BARRAGE

FRL- 536.5 M

BARAGGE HEIGHT- 21 M

POWER HOUSE

TWL- 260 M

INST. CAPACITY- 315 MW

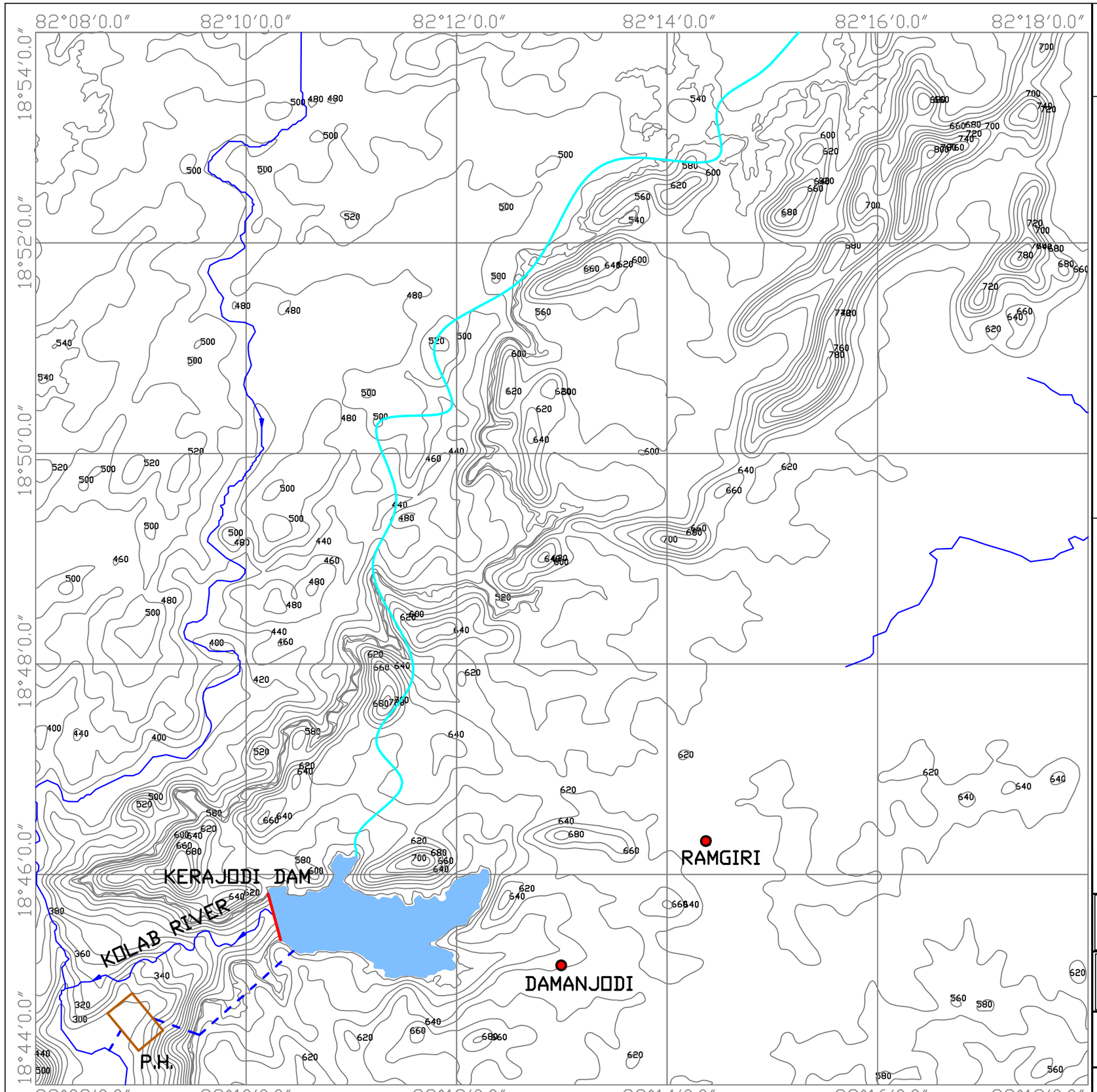
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

वाप्कोस लिमिटेड
WAPCOS LIMITED

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MIDDLE KOLAB HYDROELECTRIC PROJECT
(3X105) = 315MW



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- CANAL
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KERAJODI DAM

FRL- 528 M

MDDL- 482 M

DAM HEIGHT- 94 M

LIVE STORAGE- 135 MCuM

POWER HOUSE

TWL- 260 M

GROSS HEAD- 252.7 M

INST. CAPACITY- 315 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MIDDLE KOLAB HYDROELECTRIC PROJECT
(3X105) = 315 MW

3.58 LOWER KOLAB HYDROELECTRIC PROJECT (3x155MW=465MW)

1. INTRODUCTION

The Lower Kolab Hydroelectric Project located is a storage type development in Koraput district of Orrisa. The project envisages utilization of the river Kolab, a tributary of Godavari River for power generation. Nauguda village is approximately 9.3 km from the dam site. The project with a proposed installation of 465 MW (3x155 MW), operated under gross head of 252.1 m would afford an annual energy generation of 845.86 MU in a 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site is located at Latitude 18°49'40''N & Longitude 82°09'50'' E.The Power house has Latitude 18° 43' 30"N & Longitude 82°9'30" E. Jeypore is the nearest railway station and Visakhapatnam is the nearest reachable Airport.

3. PROJECT FEATURES

The Lower Kolab Hydroelectric project envisages construction of 81.20 m high composite concrete gravity cum earth/rockfill dam across river Kolab. The reservoir would have live storage of 1947.42 Mcum between Full Reservoir Level (FRL) at 506.9 m and Minimum Draw Down Level (MDDL) at 456 m. The Water conductor system would comprise of a 12400 m long and 8.50 m diameter Head Race Tunnel (HRT) terminating in a surge shaft. The surge shaft is 122.3 m high and is of 25 m diameter. Three number of 665 m long and 4.5 m diameter penstocks take water to a surface power house having an installation of three Francis driven generating units of 155 MW each operating under a rated head of 196.9 m. A 510 m long open Tail Race Channel would carry the power house releases back to the river.

4. HYDROLOGY

The Kolab River drains a catchment area of about 3566.0 sq. km at the proposed dam site.

5. POWER & ENERGY BENEFITS

The Installed Capacity of Lower Kolab Hydroelectric project is 465 MW comprising 3 generating units of 155 MW has been proposed. The project generates annual energy of 845.86 MU in a 90% dependable year.

6. INTERSTATE ASPECTS

Lower Kolab is located at the Downstream of Middle Kolab which is Under Interstate issue. As the outflows of Middle Kolab would be taken as inflows for Lower Kolab, therefore Lower Kolab could be taken up for further study only after the resolution of Middle Kolab Interstate Issue.

SALIENT FEATURES
LOWER KOLAB HYDROELECTRIC PROJECT

GENERAL:

State	Odisha
District	Koraput
River	Kolab
Type of Development	Storage
Nearest Railhead	Jeypore railway station
Nearest Airport	Visakhapatnam

LOCATION:

Dam : Latitude & Longitude	18° 49' 40'' N ,82° 09' 50'' E
Power House : Latitude & Longitude	18° 43' 30"N ,82° 9' 30" E

HYDROLOGY:

Catchment Area (Sq. Km)	3566

DAM:

Type	Composite concrete gravity cum earth & rockfill dam
Length (m)	1050
Height (m)	81.2

RESERVOIR:

Full Reservoir Level (FRL) (m)	506.9
Minimum Draw Down Level (MDDL) (m)	456
Live Storage (Mcum)	1947.42
Gross Storage (Mcum)	1957.6

INTAKE:

Number	2
Type	Well type
Size (m)	4.6 x 4.6

WATER CONDUCTOR SYSTEM:

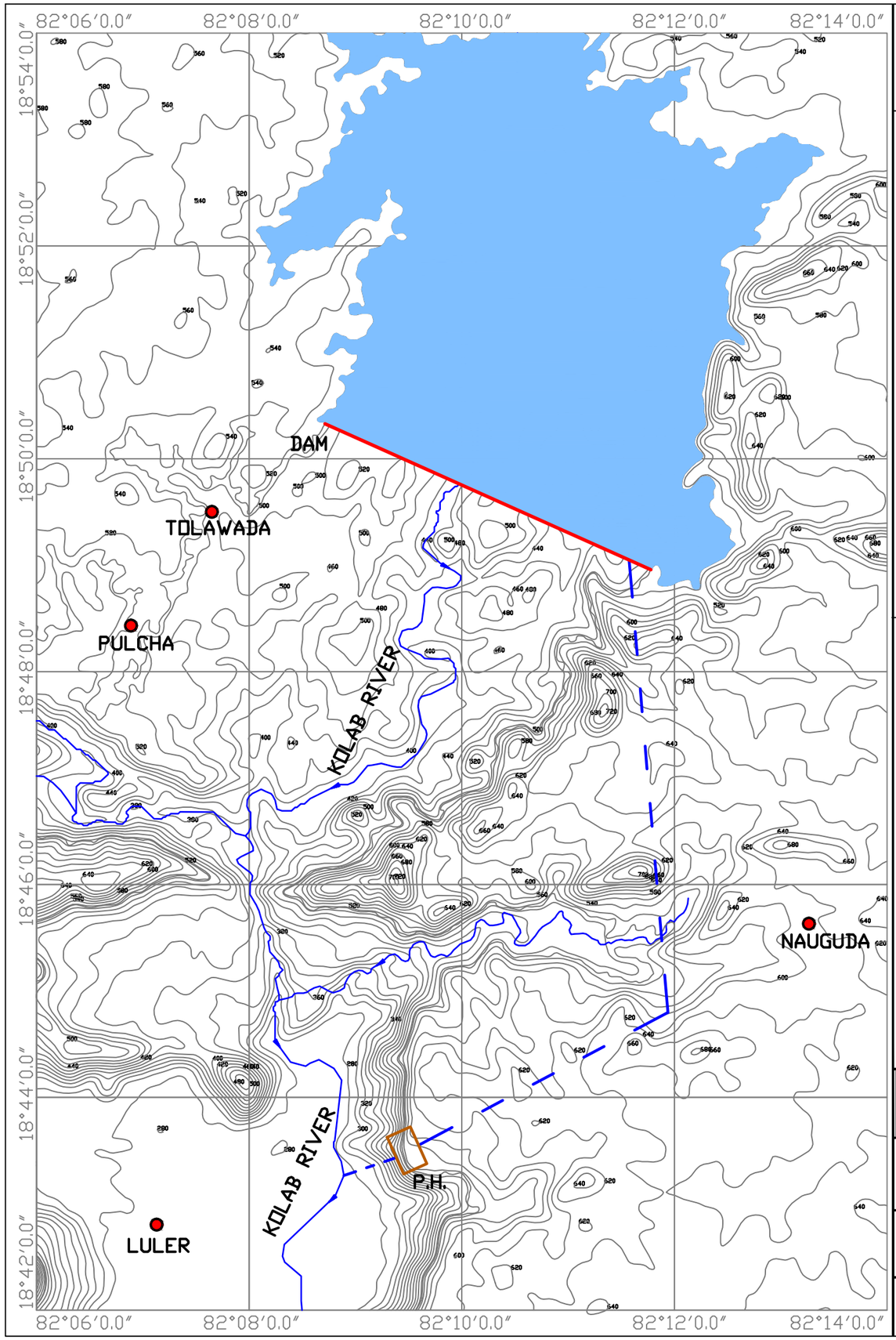
HEAD RACE TUNNEL	
Shape	Horse Shoe
Size (m)	8.50
Number	1
Length (m)	12400
PRESSURE SHAFT CUM PENSTOCKS	
Size (m)	4.5
Number	3
Length (m)	665
TAIL RACE CHANNEL	
Type	Open Channel
Length (m)	510

POWER HOUSE:

Type	Surface
No. of Generating Units	3
Capacity of each Unit (MW)	155
Installed Capacity (MW)	465
Rated Head (m)	196.9
Gross Head Max (m)	252.1
Type of Turbine	Francis
Tail Water Level (TWL) (m)	257.2
Design Discharge (Cumec)	262.68
Annual Energy (MU)	845.86

COST ASPECTS:

Estimated cost (Rs. Crores) (incl IDC & FC)	3661.15 (June, 2003 PL)
Levellised Tariff (Rs/Kw)	6.10



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

LOWER KOLAB DAM

FRL- 506.9 M
MDDL- 456 M
DAM HEIGHT- 81.2 M
LIVE STORAGE- 1947.42 MCuM

POWER HOUSE

TWL- 257.2 M
AVERAGE GROSS HEAD- 252.1 M
INST. CAPACITY- 465 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

LOWER KOLAB HYDROELECTRIC PROJECT
(3X155) = 465MW

3.59 SIVASAMUDRAM HYDROELECTRIC PROJECT (3x100MW +3x15MW= 345MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Cauvery PH-I. Presently, the project is named as Sivasamudram Hydroelectric Project. The project is a RoR type of development located in Mandya district of Karnataka, utilizing the water of Cauvery River. Cauvery Beat village is approximately 0.95 km from the dam site. The project has powerhouse near Mandya with installed capacity of 345 MW (3X100MW+3X15MW) utilizing the average gross head of 186.5 m to generate Annual Energy of 1034 MU in a 90% dependable Year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Krishna River having Latitude 12°16'55.99"N & Longitude 77°10'45.27"E and the Power house located at Latitude 12°18'07.8"N & Longitude 77°13'08.5"E in Guntur district of Andhra Pradesh. The nearest railhead from the project site is Mandya and nearest airport is Mysore.

3. PROJECT FEATURES

The Hydroelectric Project envisage construction of Barrage of height 15.2m across the river cauvery just upstream of Bharchukki falls with Full Reservoir Level (FRL) of 609.6m and diverting the water through long right bank channel to drop the water through a powerhouse on the right bank of river. The surge shaft of the powerhouse is served by creation of a forebay tank having full tank level at an elevation of 594.4 m operating under average grosshead of 186.5m the project would provide firm power of 92.9 MW.

4. POWER & ENERGY BENEFITS

Sivasamudram project has 3 units of 100MW and 3 units of 15MW each enabling total capacity of 345MW and would generate annual energy of 1034 MU at 90% dependable year. The firm power of Sivasamudram Hydroelectric Project is 92.9MW.

5. INTERSTATE ASPECTS

- Sharing of Cauvery water awarded by CWDT.
- With the consent of GOTN and GOK, NHPC took up S&I and preparation of DPR.

• In the Core Group Meeting taken by secretary (Power) on 27.10.2004, it was agreed by GOK and GOTN that Shivasamudram (Karnataka) and Hogenekkal (TN) should be taken up simultaneously in the first phase and remaining two projects viz. Mekadatu (Karnataka) and Rasimanal (T.N.) in the next phase.

• In the Core Group Meeting taken by Secretary (Power) on 21.06.2006, it was agreed that execution of these four projects through NHPC would be most viable proposition. It was decided that representatives of both the Govts. would take up the matter with their respective Govts. and seek their approval and thereafter necessary agreement will be signed between NHPC and the two State Govts. Consent by both the State Govts. was to be communicated to MOP by 31.07.2006. The State of Karnataka in June, 2007 informed that Shivasamudram and Mekadatu will be executed by them in State sector.

• Subsequently, a meting was held on 08.07.2009 under the chairmanship of Secretary (Power) to discuss the pending issue of development of Hydroelectric Projects in Cauvery Basin. Secretary (Power) expressed that Shivasamudaram being a Run of River Project with in the territory of Karnataka, Tamil Nadu should not have any objection to the development of the Project by the State Government. He further opined that there should not be any problem in taking up Shivasamudram Project by the State of Karnataka provided there is joint mechanism for monitoring the water level/ releases of water to Tamil Nadu. He suggested that the Central Water Commission (CWC) could act as an observer in this regard and directed that the GOK would provide/share all the technical details of the Project to/with Tamil Nadu Both the States Government were advised to consult Central Electricity Authority (CEA) and Central Water Commission (CWC) before finalization of designing of the Project.

• As regards other projects located in TN but whose submergence area partly falls in Karnataka, it was suggested the two Governments need to arrive at an arrangement for power sharing.

• KPCL submitted revised DPR of Shivasamudram Run of River Power Project (3x100+3x15=345 MW) in Cauvery Basin to Central Electricity Authority (CEA) vide their letter dated 30.03.2012. In the presentation meeting held in Central Electricity Authority (CEA) on 16.05.2012, it was decided in the meeting that due to non-resolution of Inter-State issues the DPR can not be examined and the same is returned.

SALIENT FEATURES
SIVASAMUDRAM HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Mandya
River	Cauvery
Type of Development	RoR
Nearest Railhead	Mandya
Nearest Airport	Mysuru

LOCATION:

Dam : Latitude & Longitude	12°16'55.99"N,77°10'45.27"E
Power House : Latitude & Longitude	12°18'07.8"N, 77°13'08.5"E

BARRAGE:

Height (m)	15.2

RESERVOIR:

Full Reservoir Level (FRL) (m)	609.6

POWER HOUSE:

No. of Generating Units	6
Capacity of each Unit (MW)	3 units of 100 MW & 3 units of 15MW
Firm Power (MW)	92.9
Installed Capacity (MW)	345
Gross Head (m)	186.5
Tail Water Level (TWL) (m)	407.8
Annual Energy (MU)	1034

77°10'0.0"

77°12'0.0"

77°14'0.0"

12°20'0.0"

12°18'0.0"

12°16'0.0"

NETKAL

CAUVERY RIVER

CAUVERY RIVER

FOREBAY TANK

P.H.

CAUVERY BEAT

BARACHUKKI FALLS

SIVASAMUDRAM BARRAGE

SATHEGALA BEAT

LEGENDS.

CONTOUR

RIVER

BARRAGE

POWER HOUSE

HRT

TRT

CHANNEL

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

SIVASAMUDRAM BARRAGE

FRL- 609.6 M

BARRAGE HEIGHT- 15.2 M

POWER HOUSE

TWL- 407.8 M

AVG. GROSS HEAD- 186.5 M

INST. CAPACITY-345 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

SIVASAMUDRAM HYDROELECTRIC PROJECT
(3X100+3X15) = 345 MW

3.60 MEKADATU HYDROELECTRIC PROJECT (400MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Cauvery PH-II. Presently, the project is named as Mekadatu Hydroelectric Project. The Mekadatu Hydroelectric Project located in Chamarajanagar district of Karnataka envisages utilization of the water of the river Cauvery for power generation. The project would be developed as a Run of River (RoR) type development, harnessing a gross head of about 91.4 m. Bennegodlu village is approximately 3.67 km from the dam site. The project would generate an annual energy of 796 MU in a 90% dependable year with installed capacity of 400 MW.

2. LOCATION/ACCESSIBILITY

The Lifting dam of the project is located Latitude 12°16'23.18"N & Longitude 77°26'24.64"E and the Forebay is located at Latitude 12°15'12.95"N & Longitude 77°26'21.82"E. The powerhouse is located at Latitude 12°14'42.74"N & Longitude 77°27'3.07"E. The nearest railhead from the project site is Channapatna and nearest airport is Salem.

3. PROJECT FEATURES

Mekadatu is served by water diverted at bed level of 356.6 m on Cauvery, a few kms below the confluence of Arkavathi, from a 51.2m high lifting dam to a forebay dam provided on the stream of Mullaihalla with Full Reservoir Level (FRL) of 407.8 m. The combined water would then be dropped over a right bank powerhouse which operate under average gross head of 91.4m near Mekadatu.

4. POWER & ENERGY BENEFITS

The Mekadatu Hydroelectric Project has an installed capacity of 400MW and would generate an annual energy of 796 MU at 90% dependable year. The firm power available from this project would be about 64.5MW.

5. INTERSTATE ASPECTS

- Preliminary report of Stage-I was returned in 10/1996.
- Sharing of Cauvery water awarded by CWDT.
- With the consent of GOTN and GOK, NHPC took up S&I and preparation of DPR.
- In the Core Group Meeting taken by secretary (Power) on 27.10.2004, it was agreed by GOK and GOTN that Shivasamudram (Karnataka) and Hogenekkal

(T.N.) should be taken up simultaneously in the first phase and remaining two projects viz. Mekadatu and Rasimanal in the next phase.

• In the Core Group Meeting taken by Secretary (Power) on 21.06.2006, it was agreed that execution of these four projects through NHPC would be most viable proposition. It was decided that representatives of both the Govt would take up the matter with their respective Govts. and seek their approval and thereafter necessary agreement will be signed between NHPC and the two State Govts. Consent by both the State Govts. was to be communicated to MOP by 31.07.2006. The State of Karnataka in June, 2007 informed that Shivasamudram and Mekadatu will be executed by them in State sector.

• KPCL informed in April, 2009 that the tribunal award is with Supreme Court.

• Subsequently, a meting was held on 08.07.2009 under the chairmanship of Secretary (Power) to discuss the pending issue of development of Hydroelectric Projects in Cauvery Basin. Secretary (Power) expressed that Shivasamudram being a Run of River Project with in the territory of Karnataka, Tamil Nadu should not have any objection to the development of the Project by the State Government. He further opined that there should not be any problem in taking up Shivasamudram Project by the State of Karnataka provided there is joint mechanism for monitoring the water level/releases of water to Tamil Nadu. He suggested that the Central Water Commission (CWC) could act as an observer in this regard and directed that the GOK would provide/share all the technical details of the Project to/with Tamil Nadu.

• As regards other projects located in Tamil Nadu but whose submergence area partly falls in Karnataka, it was suggested the two Governments need to arrive at an arrangement for power sharing

SALIENT FEATURES
MEKADATU HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Chamarajnagar
River	Cauvery
Type of Development	RoR
Nearest Railhead	Channapatna
Nearest Airport	Salem

LOCATION:

Lifting Dam : Latitude & Longitude	12°16'23.18"N,77°26'24.64"E
Forebay Dam : Latitude & Longitude	12°15'12.95"N,77°26'21.82"E
Power House : Latitude & Longitude	12°14'42.74"N,77°27'3.07"E

DAM:

Height (m)- Lifting dam	51.2

RESERVOIR:

Full Reservoir Level (FRL) (m)-Lifting Dam	407.8
Full Reservoir Level (FRL) (m)- Forebay Dam	408.1

POWER HOUSE:

Installed Capacity (MW)	400
Firm Power (MW)	64.5
Avg. Gross Head (m)	91.4
Tail Water Level (TWL) (m)	316.7
Annual Energy (MU)	796

77°22'0.0" 77°24'0.0" 77°26'0.0" 77°28'0.0" 77°30'0.0"

12°20'0.0"

12°18'0.0"

12°16'0.0"

12°14'0.0"

BENNEGODLU

MUGGURU FOREST

LIFTING DAM

SAGGAYAM 'A' BEAT

MEKEDATU

MAHALLI

FOREBAY DAM

P.H

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

LIFTING DAM

FRL- 407.8 M

DAM HEIGHT - 51.2 M

FOREBAY DAM

FRL- 408.1 M

POWER HOUSE

TWL- 316.7 M

AVG. GROSS HEAD- 91.4 M

INST. CAPACITY- 400 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MEKADATU HYDROELECTRIC PROJECT
400 MW

3.61 RASIMANAL HYDROELECTRIC PROJECT (360MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Cauvery PH-III. Presently, the project is named as Rasimanal Hydroelectric Project.The Rasimanal Hydroelectric Project is a Run of River (RoR) type of development, located in Krishnagiri district of Tamil Nadu. Oddapatty R.F. village is located approximately 3.16 km from the dam site. The project envisages utilization of river Cauvery for power generation. The dam toe powerhouse harnesses a gross head of 50.8 m with installed capacity of 360 MW would generate an annual energy generation of 453 MU in a 90% dependable year.

2. LOCATION/ACCESSIBILITY:

The dam site of the project is located on Cauvery River having Latitude 12°10'58.4"N & Longitude 77°43'13.8"E and the Power house located at Latitude 12°10'58.4"N & Longitude 77°43'13.8"E in Krishnagiri district of Tamil Nadu. The nearest railway station and airport from the project is Banglore.

3. PROJECT FEATURES:

Rasimanal Hydroelectric Project envisages construction of 61.6 m high lifting dam at Full Reservoir Level (FRL) of 316.7 m with submergence upto tail race level of Mekadatu on the river Cauvery just after the confluence of Doddahala. The powerhouse is located at the toe of the dam with Tail Water Level (TWL) at 265.9 m and would operate under average gross head of 50.8 m.

4. POWER & ENERGY BENEFITS:

Rasimanal Hydroelectric Project has an installed capacity of 360 MW and would generate an annual energy generation of about of 453 MU at 90% dependable year with firm power generation of 35.9 MW.

5. INTER-STATE ISSUES

- Returned in 2/1997.
- In the Core Group Meeting taken by Secretary (Power) on 27.10.2004, it was agreed by GOK and GOTN that Shivasamudram (in Karnataka) and Hogenekkal (in TN) should be taken up simultaneously in the first phase and remaining two projects viz. Mekadatu (in Karnataka) and Rasimanal (in TN) in the next phase.

• In the Core Group Meeting taken by Secretary (Power) on 21.06.2006, it was agreed that execution of these four projects through NHPC would be most viable proposition. It was decided that representatives of both the Govts. would take up the matter with their respective Govts. and seek their approval and thereafter necessary agreement will be signed between NHPC and the two State Govts. Consent by both the State Govts. was to be communicated to MOP by 31.07.2006. Tripartite agreement between Govt. of Tamil Nadu, Govt. of Karnataka and NHPC was to be signed. However, in June, 2007 the State of Karnataka informed that Shivasamudram and Mekadatu will be executed by Karnataka in State Sector.

• TNEB informed in April, 2009 that Tamil Nadu has given its concurrence to MOP's draft tripartite agreement and sent it to MOP, GOI on 15.12.2008. Tamil Nadu insists the execution of the projects by neutral agency under Govt. of India. Final award of CWDT is yet to be notified in the Gazette of Govt. of India, as the case has been filed in the Supreme Court of India.

• Subsequently, a meting was held on 08.07.2009 under the chairmanship of Secretary (Power) to discuss the pending issue of development of Hydroelectric Projects in Cauvery Basin. Secretary (Power) expressed that Shivasamudaram being a Run of River Project with in the territory of Karnataka, Tamil Nadu should not have any objection to the development of the Project by the State Government. He further opined that there should not be any problem in taking up Shivasamudram Project by the State of Karnataka provided there is joint mechanism for monitoring the water level/releases of water to Tamil Nadu. He suggested that the Central Water Commission (CWC) could act as an observer in this regard and directed that the GOK would provide/share all the technical details of the Project to/with Tamil Nadu. Both the States Governments were advised to consult Central Electricity Authority (CEA) and Central Water Commission (CWC) before finalization of designing of the Project.

• As regards other projects located in Tamil Nadu but whose submergence area partly falls in Karnataka, it was suggested that the two Governments need to arrive at an arrangement for power sharing.

SALIENT FEATURES
RASIMANAL HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Krishnagiri
River	Cauvery
Type of Development	RoR
Nearest Railhead	Salem
Nearest Airport	Bangalore

LOCATION:

Dam : Latitude & Longitude	12°10'58.4"N, 77°43'13.8"E
Power House : Latitude & Longitude	12°10'58.4"N, 77°43'13.8"E

DAM:

Height (m)	61.6

RESERVOIR:

Full Reservoir Level (FRL) (m)	316.7

POWER HOUSE:

Type	Dam Toe
Firm Power (MW)	35.9
Installed Capacity (MW)	360
Avg. Gross Head (m)	50.8
Tail Water Level (TWL) (m)	265.9
Annual Energy (MU)	453

77°38'0.0"
77°40'0.0"
77°42'0.0"
77°44'0.0"
77°46'0.0"
12°16'0.0"
12°14'0.0"
12°12'0.0"
12°10'0.0"

MELLEHALLI R.F.
ODDAPATTY R.F.
ADDAPALLAM
BEJJALANE'A'BEAT
P.H.
BILIGUNDALA
DAM
CAUVERY RIVER

520 520 960 900 560 480 520 440 380 400 460 460 560 580 560 560 580 540 560 480 440 420 380 460 360 400 420 440 460 460 440 440 440

LEGENDS.

CONTOUR
RIVER
DAM
POWER HOUSE
RESERVOIR
TOWN/VILLAGE
CONTOUR INTERVAL - 20M

RASIMANAL DAM

FRL- 316.7 M
DAM HEIGHT-61.6 M

POWER HOUSE

TWL- 265.9 M
AVG. GROSS HEAD - 50.8 M
INST. CAPACITY-360 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

RASIMANAL HYDROELECTRIC PROJECT
360 MW

3.62 HOGENEKKAL HYDROELECTRIC PROJECT (120 MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Cauvery PH-IV Hydroelectric Project. Presently, the project is named as Hogenekkal Hydroelectric Project. The Project is located in Dharmapuri district of Tamil Nadu. Oottamalai village is located approximately 0.84 km from the dam site. The project envisages utilization of the water of the river Cauvery, for power generation. The project would be developed as a Run of River (RoR) type development, harnessing a gross head of about 20.5 m. The project has a dam toe powerhouse with installed capacity of 120 MW would afford an annual energy generation of 183 MU in a 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Cauvery River having Latitude 12°07'16"N & Longitude 77°46'22"E and the Power house located at Latitude 12°07'07.7"N & Longitude 77°46'17.0"E.The nearest railway station from Hogenekkal Hydroelectric Project is Dharampur and nearest airport is Bangalore.

3. PROJECT FEATURES

Hogenekkal Hydroelectric Project consist of a lifting dam with Full Reservoir Level (FRL) at an elevation of 265.9 m and a powerhouse at the toe of the dam with Tail Water Level (TWL) of 240.4 m.

4. POWER & ENERGY BENEFITS

The Hogenekkal Hydroelectric project has an Installed Capacity of 120MW. The project would generate an annual energy generation of 183MU in 90% dependable year and enable a firm power generation of about 14.5MW.

5. INTERSTATE ASPECTS

•Returned in 2/1997.

•In the Core Group Meeting taken by Secretary (Power) on 27.10.2004, it was agreed by GOK and GOTN that Shivasamudram (in Karnataka) and Hogenekkal (in TN) should be taken up simultaneously in the first phase and remaining two projects viz. Mekadatu (in Karnataka) and Rasimanal (in TN) in the next phase.

•In the Core Group Meeting taken by Secretary (Power) on 21.06.2006, it was agreed that execution of these four projects through NHPC would be most

viable proposition. It was decided that representatives of both the Govts. would take up the matter with their respective Govts. and seek their approval and thereafter necessary agreement will be signed between NHPC and the two State Govts. Consent by both the State Govts. was to be communicated to MOP by 31.07.2006. Tripartite agreement between Govt. of Tamil Nadu, Govt. of Karnataka and NHPC was to be signed. However, in June, 2007 the State of Karnataka informed that Shivasamudram and Mekadatu will be executed by Karnataka in State Sector.

•TNEB informed in April, 2009 that Tamil Nadu has given its concurrence to MOP's draft tripartite agreement and sent it to MOP, GOI on 15.12.2008. Tamil Nadu insists the execution of the projects by neutral agency under Govt. of India. Final award of CWDT is yet to be notified in the Gazette of Govt. of India, as the case has been filed in the Supreme Court of India.

•Subsequently, a meting was held on 08.07.2009 under the chairmanship of Secretary (Power) to discuss the pending issue of development of Hydroelectric Projects in Cauvery Basin. Secretary (Power) expressed that Shivasamudaram being a Run of River Project with in the territory of Karnataka, Tamil Nadu should not have any objection to the development of the Project by the State Government. He further opined that there should not be any problem in taking up Shivasamudram Project by the State of Karnataka provided there is joint mechanism for monitoring the water level/releases of water to Tamil Nadu. He suggested that the Central Water Commission (CWC) could act as an observer in this regard and directed that the GOK would provide/share all the technical details of the Project to/with Tamil Nadu. Both the States Governments were advised to consult Central Electricity Authority (CEA) and Central Water Commission (CWC) before finalization of designing of the Project.

•As regards other projects located in Tamil Nadu but whose submergence area partly falls in Karnataka, it was suggested that the two Governments need to arrive at an arrangement for power sharing.

SALIENT FEATURES
HOGENEKKAL HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Dharmapuri
River	Cauvery
Type of Development	RoR
Nearest Railhead	Dharmapur
Nearest Airport	Bangalore International Airport

LOCATION:

Dam : Latitude & Longitude	12°07'16"N , 77°46'22"E
Power House : Latitude & Longitude	12°07'07.7"N, 77°46'17.0"E

RESERVOIR:

Full Reservoir Level (FRL) (m)	265.9

POWER HOUSE:

Type	Dam Toe
Installed Capacity (MW)	120
Firm Power (MW)	14.5
Gross Head (m)	20.5
Tail Water Level (TWL) (m)	240.4
Annual Energy (MU)	183

77°44'0.0"
77°46'0.0"
77°48'0.0"
77°50'0.0"
12°10'0.0"
12°8'0.0"
12°6'0.0"
12°4'0.0"

WODDAPATTI R.F.

OOTTAMALAI

CHINNAR RIVER

DAM

P.H.

MARUKOTTAI

BEVANURMALAI R.F.

CAUVERY RIVER

N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

HOGENEKKAL DAM

FRL- 265.9 M

POWER HOUSE

TWL- 240.4 M

AVERAGE HEAD - 20.50 M

INST. CAPACITY - 120 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

HOGENEKKAL HYDROELECTRIC PROJECT
120 MW

3.63 NELLITHORAI HYDROELECTRIC PROJECT (50MW)

1. INTRODUCTION

Nellithorai Hydroelectric Project is a Storage type of development near Nellithorai village, approximately 1457 m from the power house site located in Coimbatore district of Tamil Nadu. The project would utilize water of Bhavani River, harnessing a gross head of about 27.5 m for power generation. The dam toe powerhouse has an installed capacity of 50 MW to generate annual energy of 41 MU in 90% dependable year.

2. LOCATION/ACCESSIBILITY:

The dam site of the project is located on Bhavani River at Latitude 11°16'56.48"N & Longitude 76°52'18.34"E and a dam toe Power house in Coimbatore district of Tamil Nadu. The nearest railway station and the nearest airport is Coimbatore.

3. PROJECT FEATURES:

The Nellithorai Hydroelectric Project consist of 32.2 m pickup dam. The reservoir would have live storage of 15 Mcum between Full reservoir Level (FRL) at 351 m and Minimum Draw Down Level (MDDL) at 337 m. The Project has a dam toe power house operated under average gross head of 27.5m enabling installed capacity of 50 MW. The discharged water from underground powerhouse would be carried back to the river by Tail Race Tunnel/ Channel.

4. POWER & ENERGY BENEFITS:

The Nellithorai Hydroelectric Project is having interstate issues. The project has an installed capacity of 50 MW, which would generate annual energy of 41 MU in 90% dependable year.

5. INTER-STATE ISSUES

- Sanctioned by Planning Commission in 1974 at an estimated cost of Rs.10.04 crores.
- Concurrence not issued by Central Electricity Authority (CEA) due to objections received from Govt. of Kerala.
- The project is likely to be dropped due to involvement of large extent of forest land.

SALIENT FEATURES
NELLITHORAI HYDROELECTRIC PROJECT

GENERAL:

State	Tamil Nadu
District	Coimbatore
River	Bhavani
Type of Development	Storage
Nearest Railhead	Coimbatore
Nearest Airport	Coimbatore

LOCATION:

Dam : Latitude & Longitude	11°16'56.48"N,76°52'18.34"E
Power House : Latitude & Longitude	11°17'0.58"N , 76°52'17.38"E

DAM:

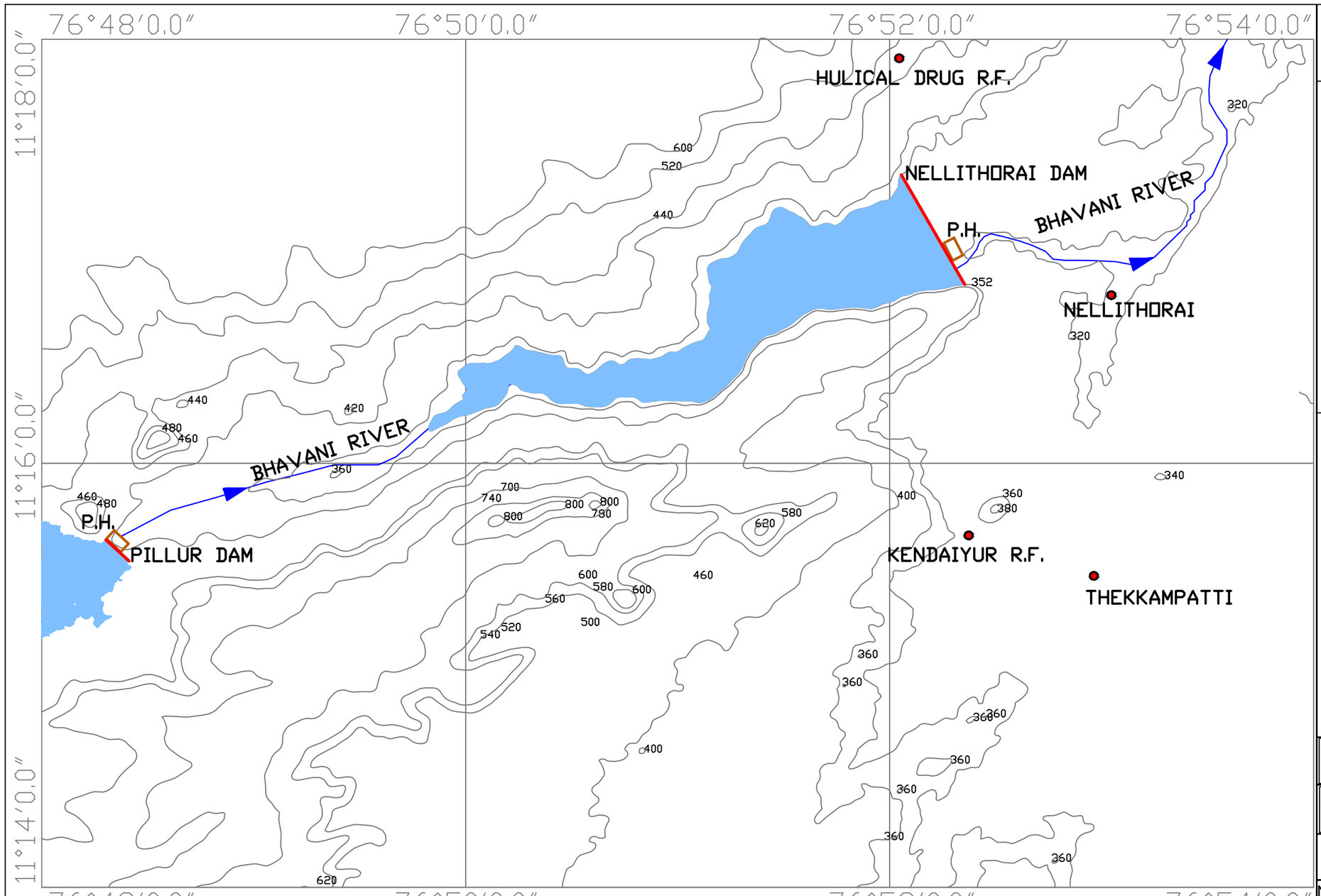
Height (m)	32.2

RESERVOIR:

Full Reservoir Level (FRL) (m)	351
Minimum Draw Down Level (MDDL) (m)	337
Live Storage (Mcum)	15

POWER HOUSE:

Type	Dam Toe
Firm Power (MW)	5.3
Installed Capacity (MW)	50
Avg. Gross Head (m)	27.5
Tail Water Level (TWL) (m)	318.8
Annual Energy (MU)	41



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NELLITHORAI DAM

FRL - 351 M
MDDL- 337 M
DAM HEIGHT -32.2 M
LIVE STORAGE - 15 MCuM

POWER HOUSE

TWL- 318.8 M
AVERAGE HEAD- 27.5 M
INST. CAPACITY-50 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

NELLITHORAI HYDROELECTRIC PROJECT
50 MW

3.64 MANANTHAVADY HYDROELECTRIC PROJECT (5x45MW=225MW)

1. INTRODUCTION

Mananthavady Hydroelectric Project is a Storage type of development which is located near Makkiyad village approximately 4 km. from project site near Lingasugur taluk in Wynad and Kannur district of Kerala. The project envisages utilization of water of Mananthavadi river for further power generation, harnessing rated head of 623.8m. The project has installed capacity of 225 MW with 5 units of 45 MW in a surface powerhouse generating annual energy of 687 Gwh in 90% dependable year.

2. LOCATION/ACCESSIBILITY:

The dam site of the project is located at Latitude 11°46' 53.76" N and Longitude 75°55'10.92"E. The Power house is located at Latitude 11°51'51.35"N and Longitude 75°52'22.12"E. The Nearest Railway station from the project site is Kozhikode and Airport is Karipur International Airport.

3. PROJECT FEATURES:

Mananthavady Hydroelectric Project envisages construction of dam of height 34.6m. The reservior has live storage of 451.6 Mcum between Full Reservoir Level (FRL) of 748.5m and Minimum Draw Down Level (MDDL) of 734.5m. It is proposed to utilize the water of this river in kerala by constructing a dam near Vallat and diverting the water to a combined system of tunnel and penstock to the adjoining valapattanam basin to generate power and subsequently to utilize the tail water for irrigation. The project has surface powerhouse with installed capacity of 225MW (5 x 45 MW) utilizing rated head of 623.8 m.

4. POWER & ENERGY BENEFITS:

Mananthavady Hydroelectric Project has 5 units of 45 MW each with Installed Capacity of 225 MW. The annual energy of the project is 687 MU in 90% dependable year.

5. INTER-STATE ISSUES

- Earlier DPR with estimated cost of Rs 69.17 crores (1980 PL) returned in 07/1980.
- Final award of CWDT stated that the project involves trans- basin diversion of water of Kabini, therefore it is not possible to allocate water for this project.

- Since the tribunal has ruled out transbasin transfer (from interstate rivers), this project remains as a non-starter.
- The final award of CWDT has been challenged by Kerela State before the Honourable Supreme Court of India

SALIENT FEATURES
MANANTHAVADY HYDROELECTRIC PROJECT

GENERAL:

State	Kerala
District	Wynad and Kannur
River	Mananthavady
Type of Development	Storage
Nearest Railhead	Kozhikode
Nearest Airport	Karipur International Airport

LOCATION:

Dam : Latitude & Longitude	11°46'53.76"N,75°55'10.92"E
Power House : Latitude & Longitude	11°51’51.35”N,75°52’22.12”E

DAM:

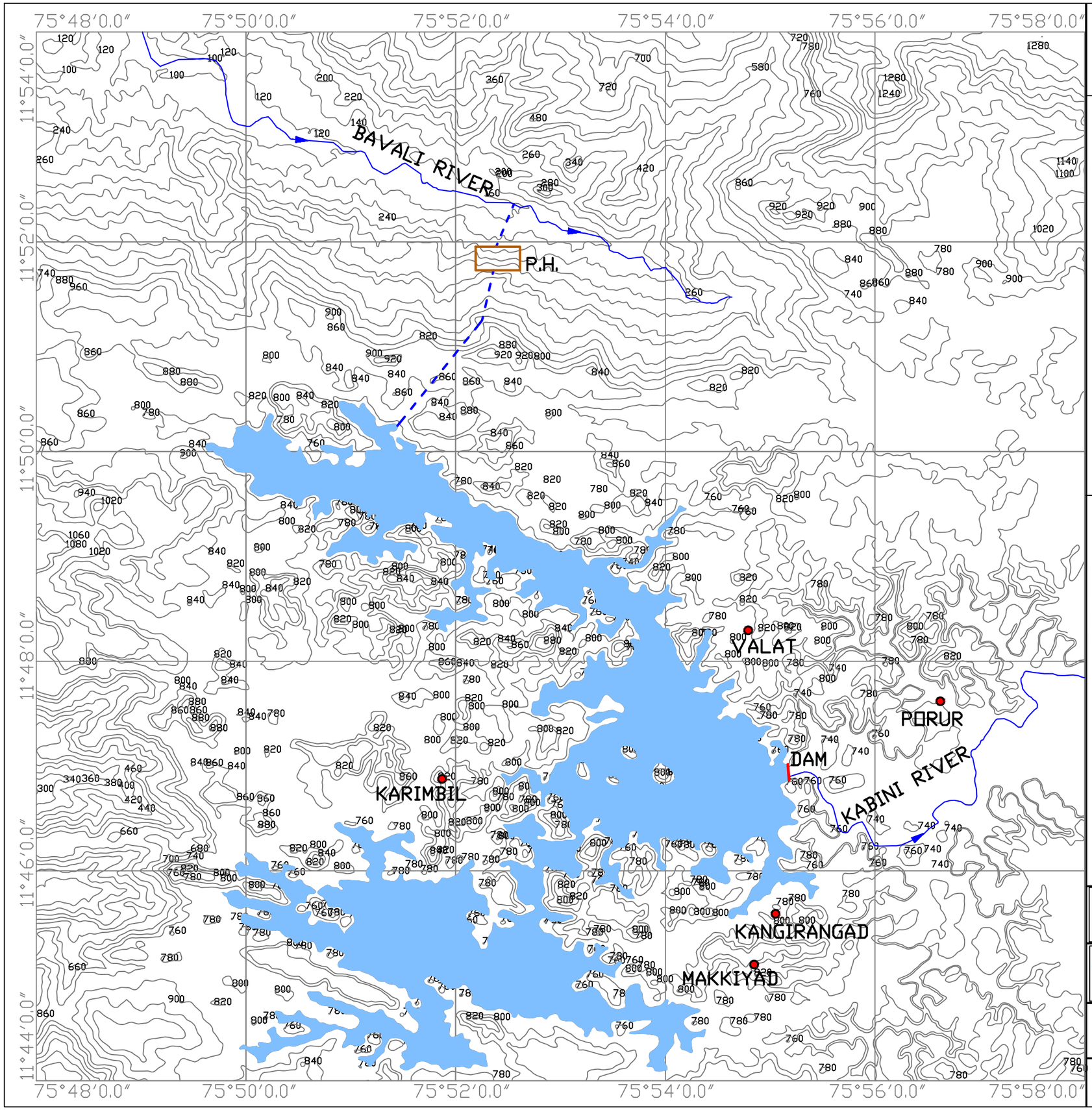
Height (m)	34.6

RESERVOIR:

Full Reservoir Level (FRL) (m)	748.5
Minimum Draw Down Level (MDDL) (m)	734.5
Live Storage (Mcum)	451.6

POWER HOUSE:

Type	Surface
No. of Generating Units	5
Capacity of each Unit (MW)	45
Installed Capacity (MW)	225
Avg. Gross Head (m)	623.8
Tail Water Level (TWL) (m)	120
Annual Energy (Gwh)	687



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

MANANTHAVADY DAM

FRL- 748.5 M
MDDL- 734.5 M
DAM HEIGHT- 34.6 M
LIVE STORAGE-451.6 MCuM

POWER HOUSE

TWL- 120 M
AVG. GROSS HEAD- 623.8 M
INST. CAPACITY-225 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

MANANTHAVADY HYDROELECTRIC PROJECT
(5X45) =225 MW

Chapter - 4

ENVIRONMENTAL ASPECTS

4.1 GENERAL

As apart of the scope of work, among others, environmental aspects are also included. The key aspects to be covered under this component are:

- Review of environmental aspects of the project, location of dam and power house with respect to protected across like National Parks, Sanctuaries, Biosphere Reserves, Eco-Sensitive Zones etc.
- Fixing of levels to ensure free flow for a stretch of 1 km for projects in cascade development.
- Suggest Environmental Flows as per the norms of Ministry of Environment, Forest and Climate Change (MoEF&CC).
- Recommendations, if any, for further studies.

With this background environmental issues have been studied for East flowing rivers of Peninsular India and are outlined in this chapter.

A total of 79 hydroelectric projects in various stages of development in the East Flowing Rivers of Peninsular India have been covered (refer ***Annexure II***). This chapter deals with environmental aspects of East Flowing Rivers of Peninsular India. Out of these projects, 26 nos. of projects are under planning/ DPR preparation stage which are being examined for Environmental Aspects (refer **Section 4.3**).

4.2 PROTECTED AREAS

The Ministry of Environment Forest and Climate Change (MoEF&CC) has formulated guidelines to develop Eco-sensitive Zones (ESZs) around Protected Areas to prevent ecological damage caused due to developmental activities and human interferances around National Parks and Wildlife Sanctuaries.

There are a total of 71 protected areas in the East Flowing Rivers of Peninsular India Basin. The list of the protected areas is given in **Table-4.1**.

Table-4.1: List of Protected Areas in East Flowing Rivers of Peninsular India

S.No.	Name of Sensitive Area	Type of Sensitive Area	Name of State	Status of ESZ Notification
1	Rollapadu	Sanctuary	Andhra Pradesh	Final
2	Kambalkonda	Sanctuary	Andhra Pradesh	Final
3	Nellapattu	Sanctuary	Andhra Pradesh	Final
4	Pulicat Lake	Sanctuary	Andhra Pradesh	Final

S.No.	Name of Sensitive Area	Type of Sensitive Area	Name of State	Status of ESZ Notification
5	Rajiv Gandhi	National Park	Andhra Pradesh	Final
6	Sri Lankamalleswaram	Sanctuary	Andhra Pradesh	Final
7	Sri Penusila Narasimha	Sanctuary	Andhra Pradesh	Draft
8	Pamed	Sanctuary	Chhattisgarh	Final
9	Sitanadi	Sanctuary	Chhattisgarh	Draft
10	Madei	Sanctuary	Goa	Final
11	Ramdevara Betta Vulture	Sanctuary	Karnataka	Final
12	Chincholi	Sanctuary	Karnataka	Draft
13	Malai Mahadeshwara	Sanctuary	Karnataka	Final
14	Gudekote Sloth Bear	Sanctuary	Karnataka	Final
15	Ghataprabha	Sanctuary	Karnataka	Final
16	Daroji Bear	Sanctuary	Karnataka	Draft
17	Ranebennur	Sanctuary	Karnataka	Final
18	Gudavi Bird	Sanctuary	Karnataka	Final
19	Bhadra	Sanctuary	Karnataka	Draft
20	Adichunchunagiri Peacock	Sanctuary	Karnataka	Draft
21	Pushpagiri	Sanctuary	Karnataka	Final
22	Melkote Temple	Sanctuary	Karnataka	Final
23	Talakaveri	Sanctuary	Karnataka	Final
24	Ranganathittu	Sanctuary	Karnataka	Final
25	Cauvery	Sanctuary	Karnataka	Final
26	Arabithittu	Sanctuary	Karnataka	Final
27	Brahmagiri	Sanctuary	Karnataka	Final
28	Biligiri Rangaswami Temple	Sanctuary	Karnataka	Draft
29	Nugu	Sanctuary	Karnataka	Final
30	Kudremukh	National Park	Karnataka	Draft
31	Bannerghatta	National Park	Karnataka	Draft
32	Bandipur	National Park	Karnataka	Final
33	Rangayyanadurga	Sanctuary	Karnataka	Final
34	Bhimgad	Sanctuary	Karnataka	Draft
35	Periyar	National Park	Kerala	Draft
36	Aralam	Sanctuary	Kerala	Draft
37	Chinnar	Sanctuary	Kerala	Draft
38	Shendurney	Sanctuary	Kerala	Draft
39	Peppara	Sanctuary	Kerala	Draft
40	Neyyar	Sanctuary	Kerala	Draft
41	Kottiyoor	Sanctuary	Kerala	Draft
42	Malabar	Sanctuary	Kerala	Draft
43	Periyar	Sanctuary	Kerala	Draft
44	Silent Valley	National Park	Kerala	Draft
45	Eravikulam	National Park	Kerala	Draft
46	Pambadum Shola	National Park	Kerala	Draft

S.No.	Name of Sensitive Area	Type of Sensitive Area	Name of State	Status of ESZ Notification
47	Mathikettan Shola	National Park	Kerala	Draft
48	Bhamragarh	Sanctuary	Maharashtra	Final
49	Great Indian Bustard	Sanctuary	Maharashtra	Final
50	Gautala	Sanctuary	Maharashtra	Final
51	Andhari	Sanctuary	Maharashtra	Draft
52	Sagareshwar	Sanctuary	Maharashtra	Final
53	Jaikwadi	Sanctuary	Maharashtra	Final
54	Nagzira	Sanctuary	Maharashtra	Final
55	Yedsi Ramlin Ghat	Sanctuary	Maharashtra	Final
56	Mayureswar Supe	Sanctuary	Maharashtra	Draft
57	Kalsubai	Sanctuary	Maharashtra	Final
58	Tipeshwar	Sanctuary	Maharashtra	Draft
59	Lonar	Sanctuary	Maharashtra	Final
60	Kothagarh	Sanctuary	Odisha	Draft
61	Pranahita	Sanctuary	Telangana	Draft
62	Pocharam	Sanctuary	Telangana	Final
63	Pakhal	Sanctuary	Telangana	Final
64	Manjira	Sanctuary	Telangana	Final
65	Kinnerasani	Sanctuary	Telangana	Final
66	Eturnagaram	Sanctuary	Telangana	Draft
67	Mrugavani	National Park	Telangana	Draft
68	Mahaveer Harina Vanastha	National Park	Telangana	Final
69	Kanger Valley	National Park	Chhattisgarh	Draft
70	Indravati	National Park	Odisha	
71	Chaplara	Sanctuary	Maharastra	

Table 4.1

4.3 ASSESSMENT OF PROJECTS

4.3.1 Godavari Sub-basin

There are a total of 28 projects proposed in Godavari sub-basin, of which 9 projects are in operation, 1 project is Under construction stage, 1 project in concurred stage, 2 project is in DPR returned stage, 12 in PFR, 2 in Balance category and 1 under Survey & Investigation. The list of projects in operation, under construction, concurred are excluded from the study. The Map showing project location with respect to various boundaries of ecologically sensitive sites is enclosed as **Figure-2.3 in Chapter-2**.

Based on the proximity of the projects with respect to boundaries of ecologically sensitive areas, the project wise recommendations is given in **Table-4.1**.

Table-4.1: Project wise recommendations for Godavari Sub-basin

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
1	Dummugudem H.E. Project, Khammam, Telangana	320	DPR Returned for Re-submission	• Dam Site and Powerhouse site of Dummugudem H.E. Project are located at a distance of about 8.0 and 8.1 km away from Kinnerasani Eco sensitive Zone respectively. • About 95.11 ha area of Eturnagram Eco-Sensitive zone is coming under submergence area of Dummugudem H.E. Project.(**Figure-4.1**) • Proposed Project shall require clearance from National Board for Wildlife (NBWL) • Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
2	Nugur- II H.E. Project, Dantewada, Chhatisgarh	477	PFR	• The dam and powerhouse site of Nugur-II H.E. Project is situated on the boundary of Indravati National Park (Protected Area).(**Figure-4.2**) • The Notification under National Park (protected area) does not permit the development of H.E.Projects.
3	Bhopalpatnam, H.E. Project, Dantewada, Chhatisgarh	90	PFR	• The dam and powerhouse sites of Bhopalpatnam H.E. Project are located on boundary of the Indravati National Park (Protected

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
				Area). (**Figure-4.3**) • The Notification under National Park (protected area) does not permit the development of H.E. Projects.
4	Nugur-I H.E. Project, Dantewada, Chhatisgarh	230	PFR	• The dam and powerhouse sites of Nugur-I H.E. Projects is located at a distance of 5.0 km away from the boundary of Indravati National Park (Protected Area) • About 7.33 ha area of the Indravati National Park is coming under submergence (**Figure-4.4**) • Proposed Project shall require clearance from National Board for Wildlife (NBWL) • Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
5	Kotri H.E. Project, Bastar, Chhatisgarh	111	PFR	• The dam and powerhouse sites of Kotri H.E. Project are located at a distance of 5.8 km away from the boundary of Bhamragarh Wildlife Sanctuary (Protected Area) • Proposed Project shall require clearance from National Board for Wildlife (NBWL) • Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and ClimateChange (MoEF&CC)

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
6	Wainganga H.E. Project, Gadchiroli, Maharashtra	105	PFR	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
7	Samda H.E. Project, Chandrapur, Maharashtra	52	PFR	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
8	Kunghara H.E. Project, Chandrapur, Maharashtra	72	PFR	• The dam and powerhouse sites of Kotri H.E. Project is located at a distance of 1.34 km and 1.26 km away from the boundary of Chaprala Wildlife Sanctuary (Protected Area) respectively • About 2.54 ha area of the Chaplara Wildlife Sanctuary is coming under submergence (**Figure-4.5**) • Proposed Project shall require clearance from National Board for Wildlife (NBWL) • Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
9	Pranhita H.E. Project, Gadchiroli, Maharashtra	48	PFR	• Hydrology Study may be conducted. • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
10	Bodhghat H.E. Project, Dantewada, Chhattisgarh	560	PFR	• Hydrology Study may be conducted. • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
11	Kutru-II H.E. Project, Bastar, Chhattisgarh	300	PFR	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
12	Kutru-I H.E. Project, Bastar, Chhattisgarh	180	PFR	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
13a	Konta H.E. Project (Banigudem), Sukma, Chhattisgarh	65	Balance	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
13b	Konta H.E. Project (Pedda Maduguru), Sukma, Chhattisgarh			
14	Balimela H.E. Project, Malkangiri, Andhra Pradesh	65	Balance	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
15	Tupakulagudem H.E. Project, Mulugu,	240	Under S&I	• Approval of TOR by MEOF&CC vide letter no. J-12011/1/2010-IA-I(Part) dated 03.04.2017.

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
	Telangana			• Proposed project was considered during 27th EAC meeting for River valley committee on 23.09.2019. As per MOM it says that: • Boundary of Eturnagaram WLS is located adjacent to the proposed barrage. • No project activities will be carried out in the Eturnagaram WLS. • Project was recommended for EC on receipt of Stage-I forest Clearance. However as per MOM issued by Principal chief conservator of Forest vide letter no."ref No. 8388/2019/FCA-1, dated 24.07.2019 of Tetangana Forest Department it was stated that: • Proposed project required 18.23 ha land within Eturnagaram Wildlife Sanctuary and 9.63 ha in Draft ESZ of Eturnagaram Wildlife Sanctuary. • Stage-I Forest Clearance received vide letter no.4-TS 165/2020-CHN/409 dated 22.04.2020. The above statements are contradictorty. In view of this clarification may be sought from Irrigation &CAD Department, Government of Telangana *whether the land is being acquired within Eturnagaram Wildlife*

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
				Sanctuary and Draft ESZ of Eturnagaram Wildlife Sanctuary or not.
16	Middle Kolab H.E. Project, Koraput , Odisha	315	DPR Returned for Re-submission	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)
17	Lower Kolab H.E. Project, Koraput, Odisha	465	PFR	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)

*** These Installed Capacity will be revised after Power Potential Studies**

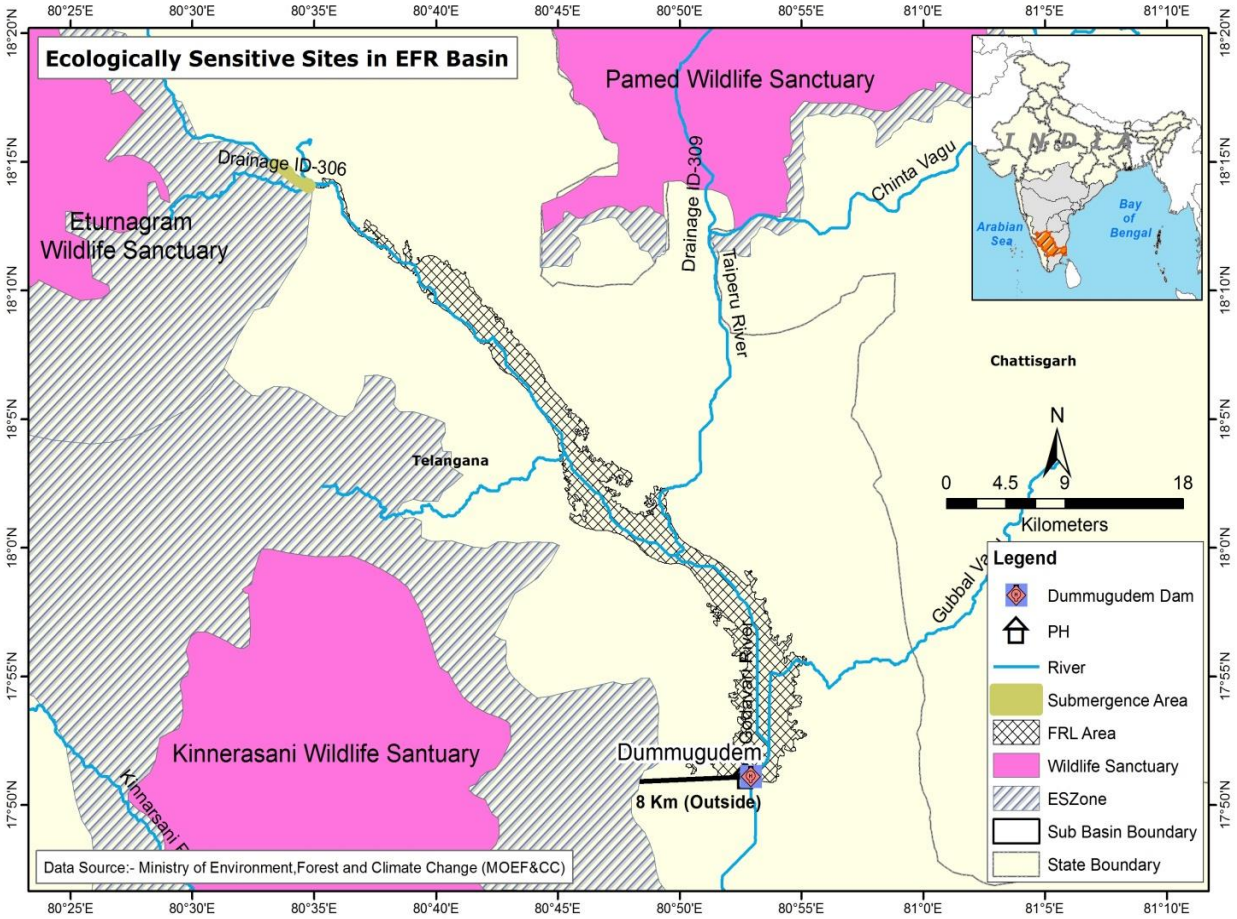


Figure-4.1: Location of Dam site, Powerhouse Site of Dummugudem H.E. Project with respect to Kinnerasani and Eturnagram Eco-Sensitive

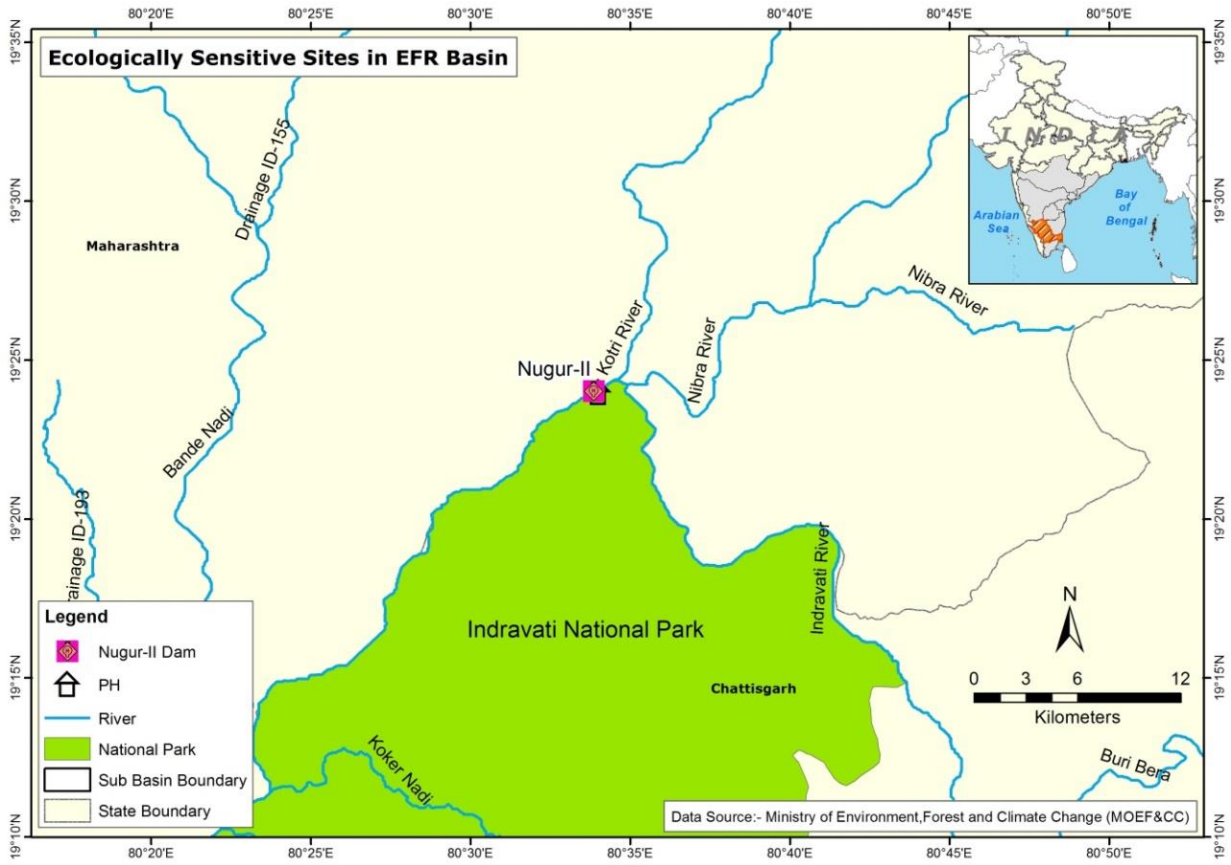


Figure-4.2: Location of Dam and Powerhouse Site of Nugur-II H.E. Project with respect to Indravati National Park

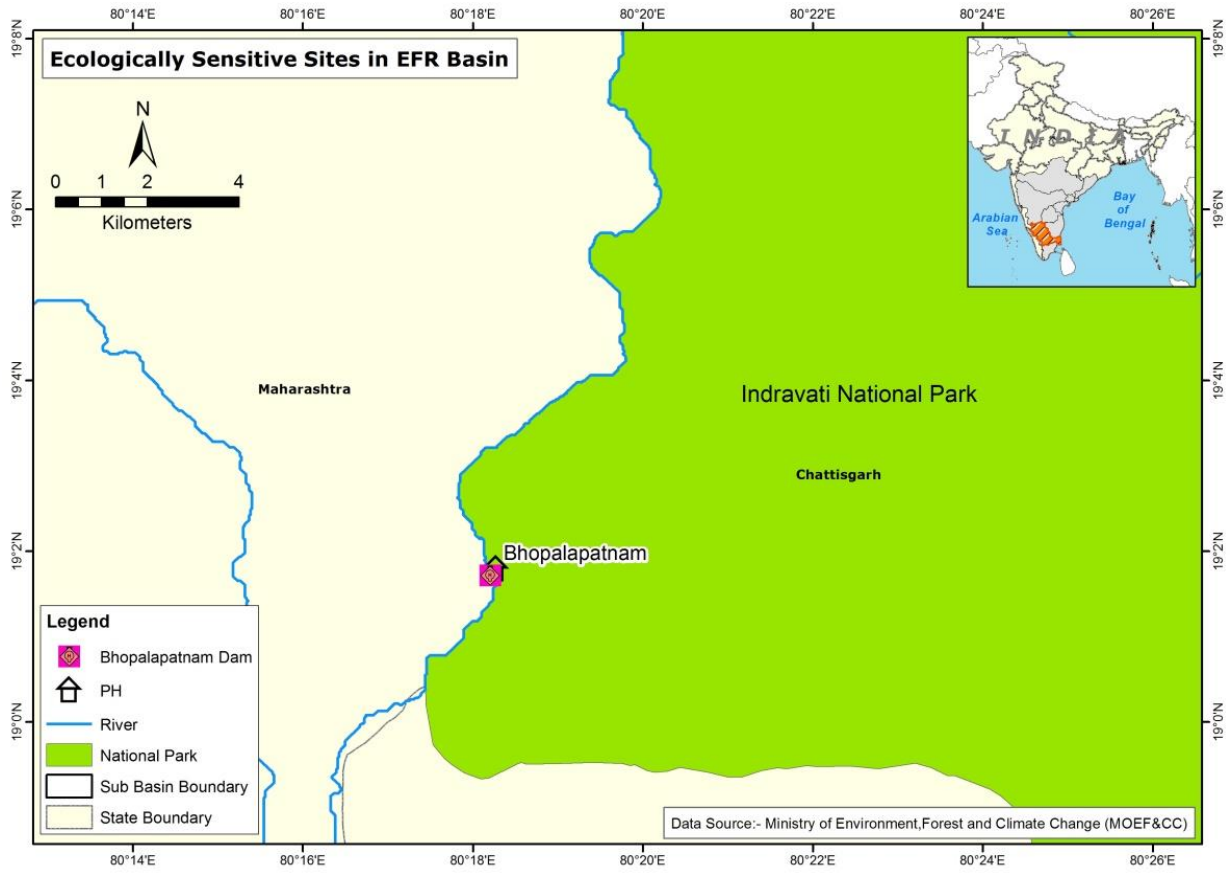


Figure-4.3: Location of Dam and Powerhouse Site of Bhopalpatnam H.E. Project with respect to Indravati National Park

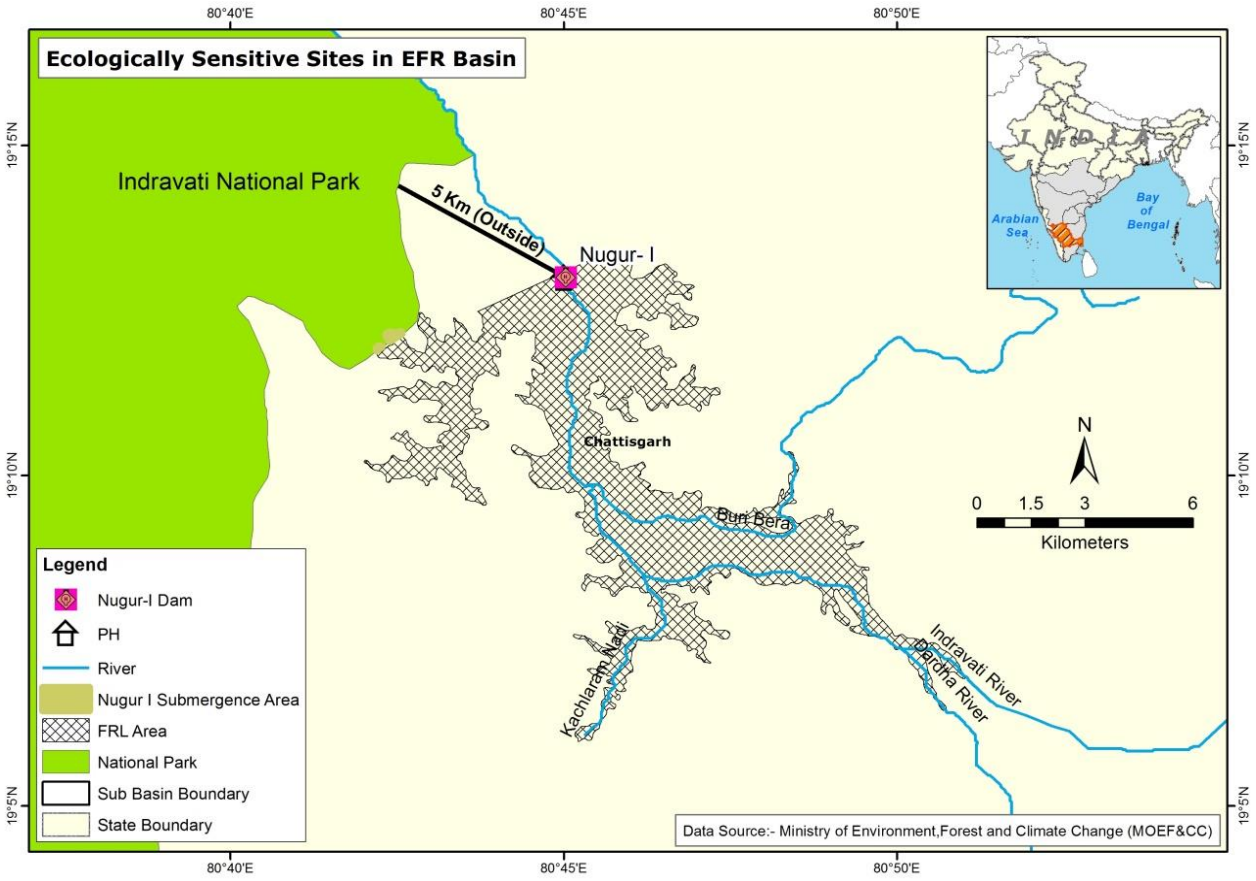


Figure-4.4: Location of Dam and Powerhouse Site of Nugur-I H.E. Project with respect to Indravati National Park

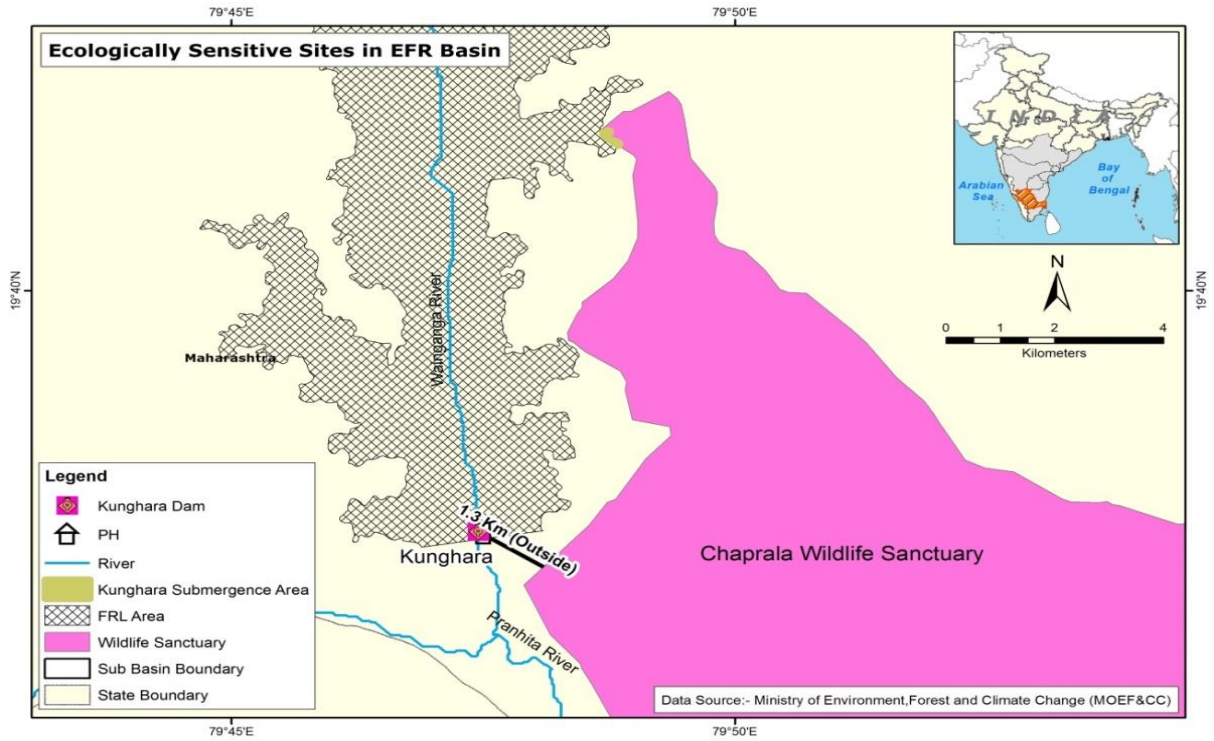


Figure-4.5: Location of Dam and Powerhouse Site of Kunghara H.E. Project with respect to Chaprala Wildlife Sanctuary

4.3.2 Krishna Sub-Basin

There are a total of 23 projects proposed in the Krishna sub-basin of which 21 projects are in operation and 2 projects are in PFR stage. The list of projects in operation is excluded from the study. The Map showing project location with respect to various ecologically sensitive sites of the sub-basin is enclosed as **Figure-2.17 in Chapter-2.**

The project wise recommendations are given in **Table-4.2**.

Table-4.2: Project wise recommendations for Krishna Sub-basin

S. No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
1a.	Tamankal (Narayanpur) H.E. Project, Raichur, Karnataka	300	PFR	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
1b.	Tamankal (Narayanpur Forebay) H.E. Project, Raichur, Karnataka Tamankal			
2a	Jaldurg H.E. Project (Diversion), Raichur, Karnataka	270	Balance	• Hydrology Study may be conducted • Environmental Clearance required from Ministry of Environment Forest and Climate Change (MoEF&CC)
2b	Jaldurg H.E. Project (Diversion-1), Raichur, Karnataka			
2c	Jaldurg H.E. Project (Diversion-2), Raichur, Karnataka			
2d	Jaldurg H.E. Project (Diversion-3), Raichur, Karnataka			
2e	Jaldurg H.E. Project (Diversion-4), Raichur, Karnataka			
2f	Jaldurg H.E. Project (Diversion-5), Raichur, Karnataka			

*** These Installed Capacity will be revised after Power Potential Studies**

4.3.3 Cauvery Sub-Basin

There are 26 projects in Cauvery sub-basin, of which 19 projects are in operation, 6 projects are in DPR returned category and 1 under balance category respectively. The projects In operation are excluded from the study. The boundaries of Projected Areas have been plotted on the GIS platform for Cauvery Sub-Basin. The Map showing project location with respect to various boundaries of Protected Areas is enclosed as **Figure-2.29 in Chapter-2**.

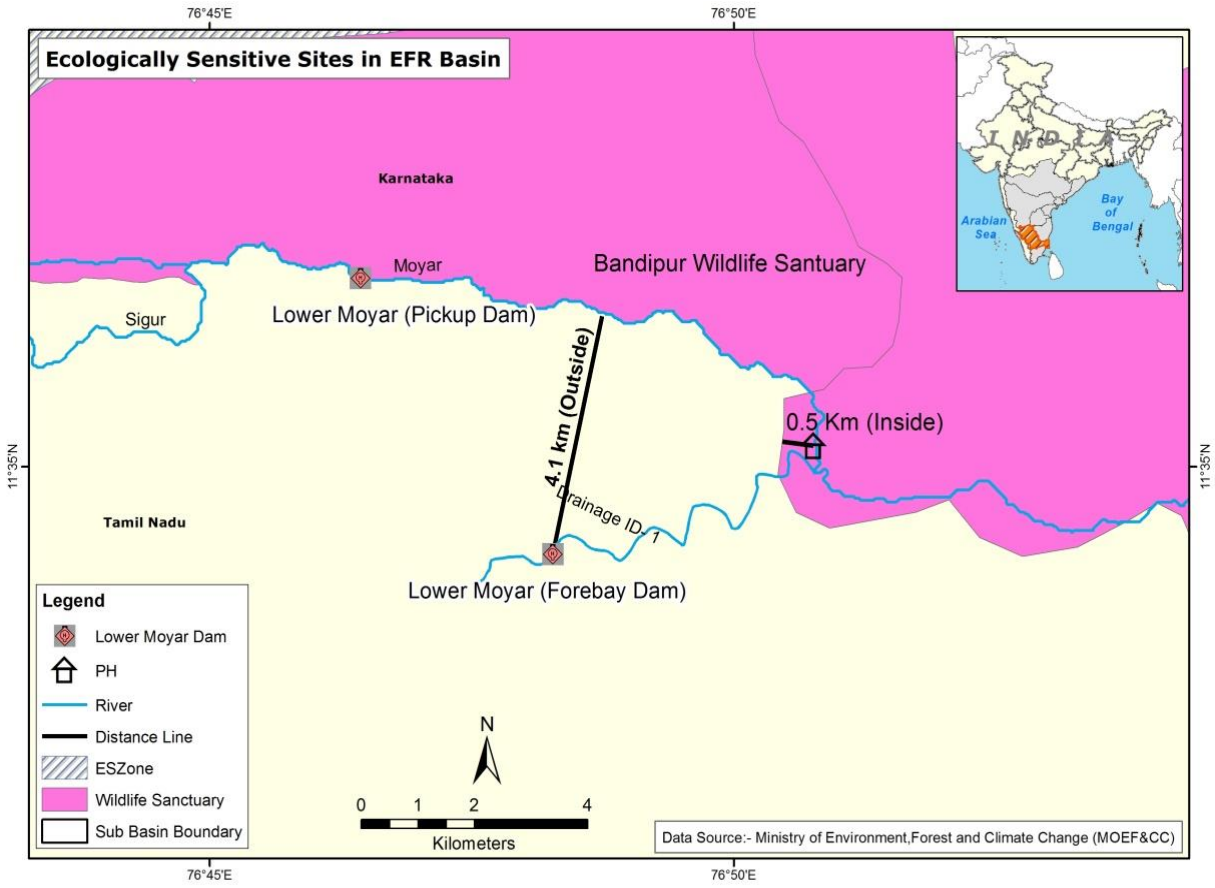
Based on the proximity of the projects with respect to boundaries of ecologically sensitive areas, the project wise recommendations are given in **Table-4.3.**

Table-4.3: Project wise recommendations for Cauvery Sub-basin

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
1	Sivasamudram H.E. Project, Mandya, Karnataka	345	DPR Returned for Re-submission	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)
2	Mekadatu H.E. Project, Chamarajanagar, Karnataka	400	DPR Returned for Re-submission	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)
3	Hogenekkal H.E. Project, Dharmapuri, Tamil Nadu	120	DPR Returned for Re-submission	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)
4	Rasimanal H.E. Project, Krishnagiri, Tamil Nadu	360	DPR Returned for Re-submission	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)
5	Nellithorai H.E. Project, Coimbatore, Tamil Nadu	50	DPR Returned for Re-submission	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)

S.No.	Name of project	Installed Capacity (MW)* (before Power Potential Studies)	Status	Remarks/ Recommendation
6	Mananthavady H.E. Project , Wynad and Kannur, Kerala	225	DPR Returned for Re-submission	The project may not be taken up for further studies due to interstate issue (Details enclosed in **Section 1.9 of Chapter -1**)
7a	Lower Moyar H.E. Project (Pick up Dam), Nilgiri, Tamil Nadu	33	Balance	• The pick up dam site of Lower Moyar is located on the boundary of Bandipur Wildlife Sanctuary (protected Area). (**Figure-4.6**).
7b	Lower Moyar H.E. Project (Forebay), Nilgiri, Tamil Nadu			• The Forebay dam is located of the project is located 4.1 km away from Bandipur Wildlife Sanctuary (protected Area). • The Powerhouse site is located 0.5 km inside Bandipur Wildlife Sanctuary (protected Area) **(Figure-4.6).** • The Notification under Wildlife Sanctuary (protected area) does not permit the development of H.E. Projects.

*** These Installed Capacity will be revised after Power Potential Studies**



Figire-4.6: Location of Dam and powerhouse site of Lower Moyar H.E. Project, Nilgiri, Tamil Nadu

4.3.4 South of Cauvery Sub-Basin

In the South of Cauvery Sub-Basin, there are only 2 projects in South of Cauvery Sub-basin developed by Tamil Nadu Generation and Distribution Corporation Limited (TANGEDCO). Both the projects are operational namely Papanasam H.E. Project (32MW) and Suruliar H.E. Project (35MW). The Map showing project location with respect to various boundaries of Protected Areas is enclosed as **Figure-2.39 in Chapter-2**.

4.4 ECOLOGICAL ASPECTS

4.4.1 Flora

Forest types and vegetation composition in East Flowing Rivers of Peninsular India Sub-Basin Area

The Forest types of India were classified in the Year 1936 By H.G. Champion which was later on revised in the year 1968 by Sir H.G. Champion and S.K. Seth as 'A Revised Survey of Forest Types of India'. The work of Champion and Seth (1968) have been widely accepted in India. Champion and Seth (1968) recognized 16 major forest types comprising 221

minor types in India. They used various criteria for classification of forest types in India, which include: physiognomy, structure, phenology, function, plant association, flora, climate, topography, soil and biotic factors. A forest classification of India has also been developed by GS Puri (Puri et al, 1983) based on ecological considerations and the dominant common or distinctive plant species. The major forest types found in the East flowing rivers of Peninsular India sub-basin area are Evergreen, Semi Evergreen, Moist Deciduous, Dry Deciduous, Dry Mixed, Thorn, Teak mixed, riverine forest and Bamboo mixed. A brief description of forest types in the basin area are given in the following paragraphs:

- Southern Tropical Semi Evergreen Forest
- Southern Tropical Moist Deciduous Forests
- Northern Mixed Dry Deciduous Forests
- Dry deciduous Teak forests
- Southern Tropical Moist Deciduous Riverine Forests
- Tropical Thorny Scrub Forests

Southern Tropical Semi Evergreen Forest

Forests of this type occur mostly on upper hill slopes of Easternghat from 450 meters to 1050 meters above the m.s.l. While the top storey trees are deciduous and remain leafless for a short time, the second storey is evergreen. It is dominated by Terminalia paniculata, Terminalia chebula, Schleichera oleosa, Celtis philippensis, Alseodaphne semicarpifolia, Canthium dicoccum, Syzygium cumini, Nothopegia beddomei, Vitex altissima Mimusops elengi, Lannea coromandelica, Mitragyna parviflora, Salmalia malabaricum, Erythrina variegata, Schleichera oleosa, Lagerstroemia parviflora, Diospyros melanoxylon, Dalbergia latifolia, Tectona grandis, Boswellia serrata, Sterculia urens, Gmelina arborea, Pterocarpus marsupium, Anogeissus latifolia, Terminalia arjuna etc. The middle storey represented by plant species like Acacia catechu, Buchnania lanzan, Emblica officinalis etc. Ground flora consists of shrubs, herbs, grasses and tree saplings. Among shrubs, species like Glycosmis macrocarpa, Amomum muricatum, Strobilanthes warreensis, Leea alata, Colebrookea oppositifolia, Celastrus paniculata, Adhotoda zeylanica, Grewia tiliaefolia, Woodfordia fruiticosa, Helecteres isora are prominent. Major climbers are Combretum ovalifolium, Combratum decandrum, Gnetumula, Strychnos colubrine, Mucuna pruriens, Pueraria tuberosa, Smilax macrophylla, Vitis repanda, Rubia cordifolia, Cryptolepis buchanani, Milletia sp, Ventilago calyculata, Asparagus racemosus, are prominent. Common herbs found in

these forests are Urena lobata, Biophytum reinwarrdtii, Thysanolaena maxima, Eragrostis unioloides, Bothriochloa pertusa, Heteropogon contortus, Sida acuta, Tridex procumbens, Costus speciosus, Chrysopogon serrulatus, Chloris barbata, Cenchrus sp., Andrographis paniculata, Canscora diffusa etc.

Southern Tropical Moist Deciduous Forests

These forests are usually found above an altitude of 800 meters in the basin area. These are typical deciduous forests with high annual rainfall of over 1000 mm. The top canopy of these forests are dominated by species like Tectona grandi, Terminalla tomentosa, Pterocarpus marsupium, Adina cordifolia, Vitex altissima, Xylia xylocarpa, Sterculia urens, Anogelssus latifolla, Pillenla pentagyna, Haldinia cordifolia, Mltragyna parviflora, Diospyros melanoxylon, Schleichera trluga, Manglfera indica, Dalbergia latifolia, Alblzla odoratisslma, These forests are commonly seen with semi evergreen species like Terminalia arjuna and Syzygium cumini common along river banks especially Godavari and Cauvery. Natural regeneration is poor, but slightly better than that in thorny scrub forests. The middle canopy comprises species like Bridelia retusa, Grewia tilifolia, Litsea sp, Gmelina arborea, Glochidion zeylanicum, Holarrhena pubescens, and Mallotus philippensis along with bamboo species, Dendrocalamus strictus and Bambusa arundinacea. The lower storey is mostly formed by Bridelia retusa, Careya arborea, Grewia tlllaefolia, Polyalthla cerasoldes, Kydla calvcina. Gardenia gummifera, Nyctanthus arbor-tristis. Shrubby layer is represented by Calamus rotang, Helicteris isora, Leea alata, Maytenus senegalensis and Asparagus recemosus. Lianas such as Butea superba, Bauhinia vahlii, Derris scandens, Millettia sp, Entada purseatha are conspicuous in the structural diversity of these forests. The herbaceous ground flora is mixed with tall grass species such as Apluda mutica, Elephantopus scaber, Stemona tuberosa, Piper trioicum. Aristida funiculate, Cymbopogon citrates, Andrographis paniculata etc.

Northern Mixed Dry Deciduous Forests

This is the most conspicuous type of deciduous forest in the basin spreading over almost all the reserved forests of the sub-basin area. These are common throughout the sub-basin area and are characterized by leaf-fall by most of the tree species during summer season. In these forests, a mixed type of vegetation is seen. Most of the species are deciduous. This type of forest is confined to some hill slopes and plateu. Some of the predominant trees that are found to

occur in this forest type are Anogeissus latifolla, Albizia amara, Acacia planifrons, Dalbergia latifolia, Schleichera oleosa, Pterocarpus marsupium, Chloroxylon swieteni, Premna tomentosa, Vitex altissima, Cassine glauca, Diospyros ferrea, Strychnos nuxvomica, Tectona grandis, Lagerstgroemia parviflora, Cassia fistula, Hardwickia binata, sterculia urens, Diospyros melanoxylon, Mallotus philippinensis, Phyllanthus emblica, Lannea coromandelica, Mangifera indica and Terminalia tomentosa. Phoenix loureirii and Chloroxylon swietenia are also common throughout the terrain. On hill slopes, Boswellia serrata and Givotia moluccana are seen. Shrub species represented by Maytenus senegalensis, Woodfordia fruticosa, Chromolaena odoratum, Combretum roxburghii, Glycosmis pentaphylla, Flacourtia indica, Calotropis procera, Phoenix acaulis, Vitex negundo, Lantana camara, Zizyphus sp, Abutilon indicum, Breynia rhamnoides, Cipadessa baccifera, Clerodendrum viscosum, Indigofera cassioides, Morinda pubescens etc. Common climbers in this forest are Cissus quadrangularis, Cocculus hirsutus, Scutia myrtina, Cryptolepis grandiflora, Smilax prolifera, Decalepis hamiltonii, Mucuna pruriens, Bauhinia vahlii, Gymnema sylvestre. The common herbs here are Spermacoce ocymoides, Evolvulus alsinoides, Tridex procumbens, Sida cordifolia, Leucas aspera, Elephantopus scaber, Curculigo orchioides and Biophytum reinwarrdtii. The common grasses encountered in these forests are Oplismenus compositus, Aristida setacea, Aristida funiculate, Eragrostis tenella and Cymbopogon coloratus. Common parasite is Cuscuta reflexa and Vanda tessellata is a common epiphyte. The common grass found in these forests is Bracharia sp, Sehima nervosum Cymbopogon coloratus, Heteropogon contortus etc.

Dry deciduous Teak forests

These are distributed mostly lower portion of the sub-basin area. Among abiotic factors such as climate, rainfall, altitude and soil features, the edaphic factors like soil depth, soil texture, water holding capacity, drainage pattern seems to significantly influence the species composition in these forests. The teak, Tectona grandis is the dominant species associated with Anogeissus latifolia, Boswellia serrata, Chloroxylon swietenia, Randia dumetorum, Lannea coromandelica, Haldenia cordifolia etc. The common shrub species reported in this forest types are Chomelia asiatica and Erythroxylum monogynum. The ground layer is covered herbs like Desmodium gangeticum, Cassia tora, Bidens

pilosa, Barleria cristata, Hedyotis corymbosa, Mimosa pudica, Sida acuta, Tridex procumbens, Triumfetta rhomboidea and Curcuma pseudomontana. Small bamboo, Dendrocalamus strictus is common. Alloteropsis cimicina, Oplismenus compositu, Brachiaria ramosa, Aristida funiculate, Chloris barbata are the common grasses.

Southern Tropical Moist Deciduous Riverine Forests

These forests are interspersed in deciduous systems, wherever streams and rivers flow as surface or subsurface channel over longer periods than surroundings. Along the course of rivers and streams in the plains where alluvial soil is deposited there are many predominantly exclusive to these areas. It generally forms a very narrow belt along the banks, sometimes it may extend to the higher elevations. The riparian trees may be evergreen or deciduous depending up on the region. This type of forest presents along the banks of river Godavari, Krishna, Cauvery, Indravati and other streams of the basin. The species constituting such forests include Terminalla Arjuna Mitragyna parviflora, Tamarlndus indlca, Bombax ceiba, Barringtonla acutangula, Butea monosperma, Strychnos nux-vomica, Ponyamia pinnata syzyylum cumini etc. Shrubs consist of species like Ipomoea carnea, Lippia geminate, Vitex negundo, Chromolaena odoratum, Homonoia riparia and Glycosmis pentaphylla. Herbaceous species comprised of Persicarea barbata, Amania bacifera, Lagascea mollis, Hygrophila spinosa, Eclipta prostrate, Cyanotis axillaris, Cyperus rotundus, Cyperus distans, Fimbristylis ovata etc. The dominant grass in this vegetation type is Saccharum spontaneum, Paspalidium flavidum Typha angustata and Arundo donax.

Tropical Thorny Scrub Forests

Due to persistent felling and removal of useful species this forest type was subjected to a high degree of degradation over a prolonged period of time, by which all the tall trees eventually disappeared, resulting in to stunted growth of few scattered trees seen in open forest. These forests are mainly found in areas of relatively lower elevation in the Krishna, Cauvery and Godavari plateau where the soil is infertile, refractory and gravelly with stones and boulders and devoid of humus. This is an open dry deciduous forest in which throny and stunted trees scattered. These forests occur throughout the dry tract of basin area. Some of the common species composition are Chloroxylon swietenia, Dichrostachys cinerea, Diospyros sp, Fiacourtia indica, Balanitis aegyptica,

Butea monosperma, Wrightia tinctoria, Cadaba fruiticosa, Acacia chundra, Acacia ferruginea, Erythroxylon monogynum, Ziziphus mauritiania, Cassia auriculata, Annona squamosa, Euphorbia antiquorum, Dodonaea viscosa, Dichrostachys cinerea, Gymnema sylvestre, Cassia montana etc. Climbers are few and often show xerophytic characters. The ground flora consists of Barleria prionitis, Blumea lacera, Argemone Mexicana, Hedyotis corymbosa, Justicia procumbens, Lepidagathis cristata, Sida cordata, Tridex procumbens and Waltheria indica. Eragrostis tenella, Heteropogon contortus Aristida adscensionis and Bothriochloa pertusa are common grasses. List of plant species reported from the East Flowing Rivers of Peninsular India Sub-basin Area are enclosed as ***Annexure V***.

4.4.2 FAUNA

4.4.2.1 Mammals

The East flowing Rivers of Peninsular India sub-basin system has a large floristic wealth which supports large number of wildlife. Species like Bonnet macaque, Common langur, Nilgai, Striped palm squirrel, Indian mongoose, Indian pangolin, Indian Porcupine and Jackal are found in open habitats of forest fellings or clearings, nearer to forest edges, cultivated areas and human habitations, where as Species like Jungle cat, Hyena, Leopards, Sloth bear, Barking deer, Sambhar deer, Panther, Wild boar and Indian bison are found in dense forest areas with thick canopy cover at high altitudes and undisturbed forest areas with flat terrain and lesser human activity. As per the criterion of International Union for Conservation of Nature (IUCN) redlist, majority of the species are 'least concern, Indian bison (Bos gaurus), Sambar deer (Cervus unicolor), Smooth Coated Otter (Lutrogale perspicillataI), Sloth bear (Melarsus ursinus) and Leopard (Panthera pardus) have been categorised under 'Vulnerable' category while Hyaena hyaena, Indian fox (Vulpes bengalensis), (Striped Hyaena) and Lutra Lutra (Common Otter) are placed under 'Near Threatened' categories. As per the criterion of Indian Wildlife Protection Act (IWPA) (1972) certain species like Leopard (Panthera pardus), Indian bison (Bos gaurus), Honey Badger (Mellivora capensis) and Indian fox (Vulpes bengalensis) are categorised under Schedule I species. The mammalian species reported in the sub-basin area along with their conservation status is enlisted in ***Annexure VI.***

4.4.2.2 Reptiles

The Eastern ghat has a rich reptilian faunal diversity due to varied and dense forest cover. The major reptilian fauna found are Indian Chameleon, Skinks, Gecko, Lizards and number of snakes. The non-poisonous variety of snakes include Common Indian wart snake, Trinket snake, Indian rat snake, Golden tree snake, Common wolf snake, Chequered keelback, blind snake, Russell sand boa, Indian python, Striped keelback, Indian gamma and Common green whip snake are also reoprded in the basin area. Considering the conservation status, most of the species is categorized as 'least concern' while species like Varanus bengalensis, Testudo elegans, Python molurus, Ophiophagus Hannah, Naja tripudians and Crocodylus palustris are considered as 'Vulenerable' and remaining species are not evaluated from their threatened category in International Union for Conservation of Nature (IUCN) redlist. Similarly, many species especially reptiles are not included in the Schedule list of Indian Wildlife Protection Act (IWPA) (1972). A single species namely Elachistodon westermanni (Indian Egg Eater Snake) has been listed as Schedule I while Varanus bengalensis (Common Indian Monitor), Ptyas mucosus (Common Rat Snake), Xenochrophis piscator (Checkered Keel Back), Naja kaouthia (Common Spectacled Cobra) and Daboia russelii (Russell's Viper) as Schedule II. The list of reptilian fauna along with their conservation status is given in ***Annexure VII.***

4.4.2.3 Amphibians

Most of amphebian species in the sub-basin area inhabit arboreal, aquatic and terrestrial habitat. Some common amphebians reported in the sub-asin area include Indian Toad, The Bull Frog, Indian Skipper frog, Skittering Frog, Green Pond Frog, Malabar gliding frog, Plantain Frog and Tree Frog. The details of Ambhibians reported in the sub-basin area are given in ***Annexure VIII***.

4.4.2.4 Avi-fauna

The avi-fauna of sub-basin area is diverse and rich due to large sized aquatic bodies, varied vegetation and favourable environmental conditions. The commonly observed avi-faunal species of terrestrial ecosystem include *Brahminy Starling* (Sturnia pagodarum), *Asian Pied Starling* (Gracupica contra), *Rosy Starling* (Pastor roseus), Rose-ringed Parakeet (Psittacula krameri), *Greater* Orange-billed Babbler (Turdoides rufescens), *Common iora* (Aegithina tiphia), *Red-vented bulbul* (Pycnonotus cafer), *Pied Bush*

Chat (Saxicola caprata), *Indian Bush Llark* (Mirafra erythroptera), *Bay-backed shrike* (Lanius vittatus), *Long-tailed shrike* (Lanius schach), *Purple sunbird* (Cinnyris asiaticus) and *Jungle prinia* (Prinia sylvatica). They inhabit inner forest, open areas, bushes and agricultural landscape. The avi-faunal species commonly reported in the wetlands and water bodies of sub-basin areas are Great Egret (Ardea alba), Little Cormorant (Microcarbo niger), Cattle Egret (Bubulcus ibis), Common Kingfisher (Alcedo atthis), Blue-eared Kingfisher (Alcedo meninting), Eastern Great Egret (Ardea modesta), Whiskered Tern (Chlidonias hybrida), Lesser Crested-Tern (Sterna bengalensis), Gull-billed Tern (Sterna nilotica), Common Sandpiper (Actitis hypoleucos), Indian Pond Heron (Ardeola grayii) and Asian Openbill (Anastomus oscitans). Majority of the species are widely distributed in Deccan and peninsular regions of the sub-basin area. Most of the species reported in the sub-basin area are categorized under 'least concern' category of International Union for Conservation of Nature (IUCN) redlist and Schedul-IV of Indian Wildlife Protection Act (1972). Species like Shikra (Accipiter badius), Nilgiri Wood-Pigeon (Columba elphinstonii) and Greater Spotted Eagle (Aquila clanga) were considered as vulenerable species, while Black-Headed Ibis, (Threskiornis melanocephalus), Oriental Darter (Anhinga melanogaster), Indian River Tern (Sterna aurantia), Painted Stork (Mycteria leucocephala), Stork-billed Kingfisher (Pelargopsis capensis), Alexandrine Parakeet (Psittacula eupatria), River Lapwing (Vanellus duvaucelii) and Orange-Billed Babbler (Turdoides rufescens) are included under 'Near Threatened' category. The list of avi-fauna species reported in the sub-basin area and their conservation status is given in ***Annexure IX.***

4.4.2.5 Butterflies

Butterflies are biological indicators of the habitats. They are very sensitive to their environment, their presence or absence indicates the health of the environment.The forests provide the ideal habitat for a wide variety of rare and endemic butterfly species. The common Butterfly species reported in the various sub-basin areas are, Blue Tiger, Striped Tiger, Grey pansy, Peacock Pansy, Common Rose, Common Leopard, Common Mormon, Common Crow, Common Jezebel, Common Wanderer, Common Emigrant, Grass Demonm Tiny Grass Bluem Common Jay, Grass Dart etc. All species listed in the Table have not been evaluated for their threatened categories under International Union for Conservation of Nature (IUCN) redlist. In the Schedule list of Indian Wildlife

Protection Act (IWPA)(1972), four species, namely Pachliopta hector, Hypolimnas misipus, Chilasa clytia and Castalius rosimon are listed under Schedule I. Species like Appias lyncida, Cepora nerissa, Enchrysops cnejus and Lampides boeticus are listed under Schedule II. The list of the butterflies reported in the sub-basin area is given in ***Annexure X.***

4.4.2.6 Fish and Fisheries

Riverine ecosystems and their biological components, including fish, provide many valuable ecosystem services. Rivers as lotic water bodies are a home to rich and varied life forms. The fish families present in sub-basin area are belonging to Cyprinidae, Mastacembelidae, Bagridae, Notopteridae, Siluridae, Cichlidae, Channidae, Ambassidae, Cobiidae, Sisoridae, Clupeidae, Heteropneustidae, Bagridae and Schilbeidae. The fish species like Catla catla, Labeo rohita, L. calbasu, L. bata, Chanda nama, Channa marulius, Amblypharyngodon mola, Puntius sp, Bangana ariza, Devario malabaricus, Garra mullya, Garra platycephala, Glyptothorax trewavasae, Hypselobarbus dobsoni, Pethia guganio, Sperata aor, Barililius bendelisis, Channa striata, Cirrhinus cirrhosis, Clarias dussumieri, Heteropneustus fossils, Notopterus notopterus, Ompok sp, Channa marulius etc.

As per to International Union for Conservation of Nature (IUCN) red list, Schismatorhynchos nukta and Tor khudree are Endangered species, Botia striata is vulnerable while Esomus danrica, Glossogobius giuris, Macrognathus pancalus, Nemacheilus guentheri, Ompok padba, Wallago attu are under near threatened category. Majority if species are considered as least concern species. The list of fish species reported in the Krishna, Godavari, Cauvary river basin and its tributaries are enlisted in ***Annexure XI.***

4.5 ENVIRONMENTAL FLOWS

Environmental Flows (EF) are the flows of water in rivers that are necessary to maintain aquatic ecosystems. In other words, a flow regime in the river, capable of sustaining a complex set of aquatic habitats and ecosystem processes are referred to as environmental flow. The EF is designed to maintain or upgrade a river in desired, agreed or pre-determined status referred to as an “environmental management class” ranging from A (Negligible modification from natural condition) to F (Critically modified ecosystem).

The regime of a river can be divided into:

- **Low flows** (Base flow): this occurs throughout the year and is more in the wet season than in the dry season and defines if river flow throughout the year. The delayed flow that reaches a stream essentially as groundwater flow is also called base flow. In the annual hydrograph of a perennial stream the base flow is easily recognized as the slowly decreasing flow of the stream in rainless periods.
- **Small floods**: they are small in size, (as compared with high floods) a few number per year and they have a small period of time (days or weeks).
- **Large floods**: they are infrequently and the timing is very short (hours or days)

Identification of these flow components and the understanding the ecosystem consequences of their loss or modification are one of the main objectives of Environmental Flow Assessment (EFA).

Further, flows in most of the river are being modified through impoundments such as dams and weirs, abstractions for agriculture, industrial and domestic supply, hydropower, drainage return flows and through structures for flood control. These interventions have had significant impacts, reducing the total flow of many rivers and affecting both; the seasonality of flows and the size and frequency of floods. In many cases, these modifications have adversely affected the river ecosystem, including the people living near the river banks. The river ecosystem includes both the channel and the floodplain. Regulations of river flows reduce or eliminate the linkage between the river and its floodplain margins.

With this background, it is important to recognize the importance of different flows in the river ecosystem. According to Brown (2003), flow in rivers is generally needed for various purposes such as to:

- Maintain low flow which supports livelihood of the people (people who use the river for drinking, washing, bathing, fishing, recreation, tourism, etc).
- Sustain both terrestrial and aquatic ecosystem. For example, low flow provides water to wild animals, maintain soil-moisture in the banks, etc. Small floods stimulate spawning in fish and allow passage for migratory fish and germination of seeds on river banks. Large floods deposits nutrients on the banks and distribute seeds.

- Recharge groundwater and aquifers by large floods, which maintain perennial nature of rivers acting as source of water during dry season. Further, large floods flush sediments and natural obstructions in the river course and maintain a sufficient deep channel for navigation.
- Preserve estuarine conditions: low flows maintain the required salt-freshwater balance and prevented the incursion of salinity.

In general, flows enabling the river to play its role in the cultural and spiritual live of the people. This is very important in Indian context as some religious festivals reduce the quality and quantity of flow.

The current norms for release of Environmental Flows are listed as below:

- Monsoon Season - 30% of flows in 90% Dependable Year
- Lean Season - 20% of flows in 90% Dependable Year
- Non-Monsoon Non-Lean Season - 25% of flows in 90% Dependable Year

Environmental Flows have been recommended for 13 projects are given in **Table-4.5 to 4.17**.

It is also recommended that to assess the project specific Environmental Flows in basin, the project specific Environmental Flows study to be conducted during the Environmental Appraisal of each project in the basin.

Table-4.5: Recommendation of Environmental Flow for Tupakulagudem Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	308.9	30	92.67
Jul	I	1713.1	30	513.93
Aug	I	3799.7	30	1139.91
Sep	I	1169.9	30	350.97
Oct	I	1204.8	25	361.44
Nov	I	243.9	25	73.17
Dec	I	94.1	20	28.23
Jan	I	75.1	20	22.53
Feb	I	108.4	20	32.52
Mar	I	91.9	20	27.57
Apr	I	45.4	25	13.62
May	I	34.3	25	10.29

Table-4.6: Recommendation of Environmental Flow for Dummugudem Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	19.67	20.00	3.93
	II	28.15	20.00	5.63
	III	385.53	20.00	77.11
Jul	I	1026.03	30.00	307.81
	II	1279.61	30.00	383.88
	III	1523.87	30.00	457.16
Aug	I	2558.99	30.00	767.70
	II	4697.22	30.00	1174.31
	III	5451.71	30.00	1635.51
Sep	I	6376.00	30.00	1912.80
	II	4485.27	30.00	1345.58
	III	1188.66	30.00	356.60
Oct	I	612.85	30.00	183.86
	II	570.11	30.00	171.03
	III	981.75	30.00	294.52
Nov	I	312.43	25.00	78.11
	II	248.66	25.00	62.17
	III	179.97	25.00	44.99
Dec	I	173.52	25.00	43.38
	II	151.06	25.00	37.77
	III	115.90	25.00	28.97
Jan	I	111.53	25.00	27.88
	II	86.37	25.00	21.59
	III	73.56	25.00	18.39
Feb	I	67.19	20.00	13.44
	II	68.91	20.00	13.78
	III	59.99	20.00	12.00
Mar	I	55.63	20.00	11.13
	II	39.18	20.00	7.84
	III	36.67	20.00	7.33
Apr	I	36.59	20.00	7.32
	II	27.28	20.00	5.46
	III	22.26	20.00	4.45
May	I	18.40	20.00	3.68
	II	16.40	20.00	3.28
	III	13.33	20.00	2.67

Table-4.7: Recommendation of Environmental Flow for Bodhghat Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	20.83	25.00	5.21
	II	3.47	25.00	0.87
	III	18.23	25.00	4.56
Jul	I	83.97	30.00	25.19
	II	484.18	30.00	145.25
	III	1161.45	30.00	348.43
Aug	I	227.14	30.00	68.14
	II	312.87	30.00	93.86
	III	1097.73	30.00	329.32
Sep	I	614.28	30.00	184.28
	II	115.86	30.00	34.76
	III	75.51	30.00	22.65
Oct	I	181.04	25.00	45.26
	II	59.28	25.00	14.82
	III	25.84	25.00	6.46
Nov	I	16.06	25.00	4.02
	II	29.75	25.00	7.44
	III	33.83	25.00	8.46
Dec	I	13.06	20.00	2.61
	II	9.45	20.00	1.89
	III	5.98	20.00	1.20
Jan	I	5.64	20.00	1.13
	II	8.53	20.00	1.71
	III	5.99	20.00	1.20
Feb	I	3.62	20.00	0.72
	II	2.62	20.00	0.52
	III	2.15	20.00	0.43
Mar	I	1.55	20.00	0.31
	II	1.43	20.00	0.29
	III	1.47	20.00	0.29
Apr	I	0.96	20.00	0.19
	II	0.93	20.00	0.19
	III	1.29	20.00	0.26
May	I	6.56	20.00	1.31
	II	3.68	20.00	0.74
	III	14.47	20.00	2.89

Table-4.8: Recommendation of Environmental Flow for Kutru-I Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	2.82	20.00	0.56
	II	4.00	20.00	0.80
	III	21.02	20.00	4.20
Jul	I	96.83	30.00	29.05
	II	558.31	30.00	139.58
	III	1339.28	30.00	334.82
Aug	I	261.92	30.00	65.48
	II	360.78	30.00	90.20
	III	1265.80	30.00	379.74
Sep	I	708.33	30.00	212.50
	II	133.60	30.00	40.08
	III	87.07	30.00	26.12
Oct	I	208.75	25.00	52.19
	II	68.36	25.00	17.09
	III	29.79	25.00	7.45
Nov	I	18.52	25.00	4.63
	II	34.31	25.00	8.58
	III	39.00	25.00	9.75
Dec	I	15.05	20.00	3.01
	II	10.90	20.00	2.18
	III	6.89	20.00	1.38
Jan	I	6.50	20.00	1.30
	II	9.84	20.00	1.97
	III	6.91	20.00	1.38
Feb	I	4.18	20.00	0.84
	II	3.02	20.00	0.60
	III	2.48	20.00	0.50
Mar	I	1.79	20.00	0.36
	II	1.65	20.00	0.33
	III	1.70	20.00	0.34
Apr	I	1.10	20.00	0.22
	II	1.07	20.00	0.21
	III	1.48	20.00	0.30
May	I	7.56	20.00	1.51
	II	4.24	20.00	0.85
	III	16.69	20.00	3.34

Table-4.9: Recommendation of Environmental Flow for Kutru-II Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	497.31	30.00	149.19
	II	436.78	30.00	131.03
	III	858.22	30.00	257.47
Jul	I	1542.33	30.00	462.70
	II	3094.44	30.00	773.61
	III	1431.55	30.00	357.89
Aug	I	764.57	30.00	191.14
	II	1192.85	30.00	298.21
	III	2032.29	30.00	609.69
Sep	I	597.82	30.00	179.35
	II	226.64	30.00	67.99
	III	710.89	30.00	213.27
Oct	I	589.82	25.00	147.46
	II	161.54	25.00	40.38
	III	155.83	25.00	38.96
Nov	I	211.79	25.00	52.95
	II	287.17	25.00	71.79
	III	155.83	25.00	38.96
Dec	I	59.10	20.00	11.82
	II	43.77	20.00	8.75
	III	30.67	20.00	6.13
Jan	I	22.78	20.00	4.56
	II	68.18	20.00	13.64
	III	32.01	20.00	6.40
Feb	I	25.90	20.00	5.18
	II	24.12	20.00	4.82
	III	20.69	20.00	4.14
Mar	I	10.87	20.00	2.17
	II	10.57	20.00	2.11
	III	9.53	20.00	1.91
Apr	I	7.59	20.00	1.52
	II	6.25	20.00	1.25
	III	6.10	20.00	1.22
May	I	18.31	25.00	4.58
	II	7.59	25.00	1.90
	III	144.55	25.00	36.14

Table-4.10: Recommendation of Environmental Flow for Nugur-I Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	552.07	25.00	138.02
	II	484.87	25.00	121.22
	III	952.71	25.00	238.18
Jul	I	1712.15	30.00	513.65
	II	3435.15	30.00	858.79
	III	1589.17	30.00	397.29
Aug	I	848.75	30.00	212.19
	II	1324.19	30.00	331.05
	III	2256.06	30.00	676.82
Sep	I	663.64	30.00	199.09
	II	251.59	30.00	75.48
	III	789.16	30.00	236.75
Oct	I	654.77	25.00	163.69
	II	179.32	25.00	44.83
	III	172.98	25.00	43.25
Nov	I	235.11	25.00	58.78
	II	318.79	25.00	79.70
	III	172.98	25.00	43.25
Dec	I	65.61	20.00	13.12
	II	48.59	20.00	9.72
	III	34.04	20.00	6.81
Jan	I	25.28	20.00	5.06
	II	75.69	20.00	15.14
	III	35.53	20.00	7.11
Feb	I	28.75	20.00	5.75
	II	26.77	20.00	5.35
	III	22.97	20.00	4.59
Mar	I	12.06	20.00	2.41
	II	11.73	20.00	2.35
	III	10.58	20.00	2.12
Apr	I	8.43	20.00	1.69
	II	6.94	20.00	1.39
	III	6.78	20.00	1.36
May	I	20.33	20.00	4.07
	II	8.43	20.00	1.69
	III	160.47	20.00	32.09

Table-4.11: Recommendation of Environmental Flow for Kotri Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	22.18	25.00	5.55
	II	48.29	25.00	12.07
	III	12.12	25.00	3.03
Jul	I	31.40	30.00	9.42
	II	184.20	30.00	55.26
	III	314.54	30.00	94.36
Aug	I	65.39	30.00	19.62
	II	75.32	30.00	22.60
	III	443.65	30.00	133.10
Sep	I	493.59	30.00	148.08
	II	78.53	30.00	23.56
	III	163.45	30.00	49.03
Oct	I	145.36	25.00	36.34
	II	50.92	25.00	12.73
	III	26.08	25.00	6.52
Nov	I	21.43	25.00	5.36
	II	29.62	25.00	7.41
	III	25.84	25.00	6.46
Dec	I	13.55	20.00	2.71
	II	10.03	20.00	2.01
	III	7.03	20.00	1.41
Jan	I	5.22	20.00	1.04
	II	15.63	20.00	3.13
	III	7.34	20.00	1.47
Feb	I	5.94	20.00	1.19
	II	5.53	20.00	1.11
	III	4.74	20.00	0.95
Mar	I	2.49	20.00	0.50
	II	2.42	20.00	0.48
	III	2.18	20.00	0.44
Apr	I	1.74	20.00	0.35
	II	1.43	20.00	0.29
	III	1.40	20.00	0.28
May	I	4.20	20.00	0.84
	II	1.74	20.00	0.35
	III	33.14	20.00	6.63

Table-4.12: Recommendation of Environmental Flow for Wainganga Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	6.24	20.00	1.25
	II	4.41	20.00	0.88
	III	5.35	20.00	1.07
Jul	I	84.26	30.00	25.28
	II	1717.33	30.00	429.33
	III	1990.02	30.00	497.50
Aug	I	233.95	30.00	58.49
	II	501.46	30.00	125.36
	III	1479.10	30.00	443.73
Sep	I	1181.90	30.00	354.57
	II	673.30	30.00	201.99
	III	312.95	30.00	93.89
Oct	I	313.08	25.00	78.27
	II	255.34	25.00	63.84
	III	99.08	25.00	24.77
Nov	I	102.08	25.00	25.52
	II	86.03	25.00	21.51
	III	386.89	25.00	96.72
Dec	I	68.30	25.00	17.07
	II	49.25	25.00	12.31
	III	23.78	25.00	5.95
Jan	I	33.15	20.00	6.63
	II	29.38	20.00	5.88
	III	32.00	20.00	6.40
Feb	I	23.47	20.00	4.69
	II	16.02	20.00	3.20
	III	31.51	20.00	6.30
Mar	I	18.54	20.00	3.71
	II	16.59	20.00	3.32
	III	14.22	20.00	2.84
Apr	I	9.14	20.00	1.83
	II	7.38	20.00	1.48
	III	4.75	20.00	0.95
May	I	7.10	20.00	1.42
	II	12.63	20.00	2.53
	III	10.72	20.00	2.14

Table-4.13: Recommendation of Environmental Flow for Samda Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	6.64	20.00	1.33
	II	4.69	20.00	0.94
	III	5.69	20.00	1.14
Jul	I	89.63	30.00	26.89
	II	1826.64	30.00	547.99
	III	2116.69	30.00	635.01
Aug	I	248.84	30.00	74.65
	II	533.38	30.00	160.01
	III	1573.25	30.00	471.97
Sep	I	1257.13	30.00	377.14
	II	716.16	30.00	214.85
	III	332.87	30.00	99.86
Oct	I	333.01	30.00	99.90
	II	271.59	30.00	81.48
	III	105.38	30.00	31.61
Nov	I	108.58	25.00	27.14
	II	91.51	25.00	22.88
	III	411.51	25.00	102.88
Dec	I	72.64	25.00	18.16
	II	52.39	25.00	13.10
	III	25.29	25.00	6.32
Jan	I	35.26	20.00	7.05
	II	31.25	20.00	6.25
	III	34.04	20.00	6.81
Feb	I	24.96	20.00	4.99
	II	17.04	20.00	3.41
	III	33.52	20.00	6.70
Mar	I	19.72	20.00	3.94
	II	17.65	20.00	3.53
	III	15.12	20.00	3.02
Apr	I	9.72	20.00	1.94
	II	7.85	20.00	1.57
	III	5.06	20.00	1.01
May	I	7.55	20.00	1.51
	II	13.44	20.00	2.69
	III	11.40	20.00	2.28

Table-4.14: Recommendation of Environmental Flow for Kunghara Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	7.91	20.00	1.58
	II	87.18	20.00	17.44
	III	6.77	20.00	1.35
Jul	I	106.72	30.00	32.02
	II	2175.09	30.00	652.53
	III	2520.47	30.00	756.14
Aug	I	296.30	30.00	88.89
	II	635.12	30.00	190.54
	III	1873.36	30.00	562.01
Sep	I	1496.94	30.00	449.08
	II	852.77	30.00	255.83
	III	396.37	30.00	118.91
Oct	I	396.54	30.00	118.96
	II	323.40	30.00	97.02
	III	125.48	30.00	37.64
Nov	I	129.29	25.00	32.32
	II	108.96	25.00	27.24
	III	490.01	25.00	122.50
Dec	I	86.51	25.00	21.63
	II	62.38	25.00	15.60
	III	30.12	25.00	7.53
Jan	I	41.99	20.00	8.40
	II	37.21	20.00	7.44
	III	40.52	20.00	8.10
Feb	I	29.72	20.00	5.94
	II	20.30	20.00	4.06
	III	39.91	20.00	7.98
Mar	I	23.48	20.00	4.70
	II	21.01	20.00	4.20
	III	18.00	20.00	3.60
Apr	I	11.58	20.00	2.32
	II	9.34	20.00	1.87
	III	6.02	20.00	1.20
May	I	8.99	20.00	1.80
	II	16.00	20.00	3.20
	III	13.58	20.00	2.72

Table-4.15: Recommendation of Environmental Flow for Pranhita Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	18.53	20.00	3.71
	II	21.94	20.00	4.39
	III	80.99	20.00	16.20
Jul	I	242.55	30.00	72.76
	II	2228.14	30.00	557.03
	III	2819.94	30.00	704.99
Aug	I	400.56	30.00	100.14
	II	600.26	30.00	150.07
	III	1838.24	30.00	551.47
Sep	I	1909.75	30.00	572.92
	II	835.83	30.00	250.75
	III	416.09	30.00	124.83
Oct	I	353.08	25.00	88.27
	II	326.56	25.00	81.64
	III	123.53	25.00	30.88
Nov	I	106.63	25.00	26.66
	II	99.67	25.00	24.92
	III	413.68	25.00	103.42
Dec	I	93.29	25.00	23.32
	II	77.25	25.00	19.31
	III	46.33	25.00	11.58
Jan	I	55.50	20.00	11.10
	II	51.35	20.00	10.27
	III	49.06	20.00	9.81
Feb	I	38.11	20.00	7.62
	II	35.90	20.00	7.18
	III	29.89	20.00	5.98
Mar	I	34.60	20.00	6.92
	II	25.13	20.00	5.03
	III	19.89	20.00	3.98
Apr	I	12.27	20.00	2.45
	II	8.25	20.00	1.65
	III	7.71	20.00	1.54
May	I	5.62	20.00	1.12
	II	10.79	20.00	2.16
	III	12.05	20.00	2.41

Table-4.16: Recommendation of Environmental Flow for Balimela Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	111.9	30	33.58
Jul	I	165.8	30	49.75
Aug	I	168.4	30	50.52
Sep	I	144.9	30	43.46
Oct	I	91.3	25	22.84
Nov	I	24.9	20	4.98
Dec	I	4.4	20	0.89
Jan	I	6.7	20	1.35
Feb	I	9.9	20	1.97
Mar	I	21.4	20	4.27
Apr	I	75.4	25	18.85
May	I	108.6	25	27.15

Table-4.17: Recommendation of Environmental Flow for Konta Project

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Jun	I	143.03	25.00	35.76
	II	149.51	25.00	37.38
	III	154.55	25.00	38.64
Jul	I	161.08	30.00	48.32
	II	429.19	30.00	128.76
	III	405.34	30.00	121.60
Aug	I	916.12	30.00	274.84
	II	1634.42	30.00	490.33
	III	1611.73	30.00	483.52
Sep	I	759.53	30.00	227.86
	II	344.11	30.00	103.23
	III	307.72	30.00	92.32
Oct	I	613.39	30.00	184.02
	II	290.96	30.00	87.29
	III	219.84	30.00	65.95
Nov	I	231.70	25.00	57.92
	II	201.67	25.00	50.42
	III	193.58	25.00	48.39
Dec	I	163.79	25.00	40.95
	II	156.88	25.00	39.22
	III	119.30	25.00	29.83
Jan	I	73.57	20.00	14.71
	II	58.31	20.00	11.66
	III	70.76	20.00	14.15
Feb	I	81.44	20.00	16.29
	II	102.56	20.00	20.51
	III	100.77	20.00	20.15

Months		Inflow (m^3/s)	E Flow (%)	E Flow (m^3/s)
Mar	I	93.78	20.00	18.76
	II	67.34	20.00	13.47
	III	60.23	20.00	12.05
Apr	I	110.38	25.00	27.60
	II	144.79	25.00	36.20
	III	145.51	25.00	36.38
May	I	126.69	25.00	31.67
	II	225.57	25.00	56.39
	III	130.63	25.00	32.66

- As we are using only spill from existing dams of Tamalkal and Jaldurg, we don't need to release E flow for these projects.

- The existing dams are definitely releasing some E flow for the dam currently.

Annexure V

List of plant species reported from the East Flowing Rivers of Peninsular India Sub-basin Area

Botanical Name	**Common Name**	**Family**	**Habit**
Achyranthes aspera	Chir-chira	Acanthaceae	Herb
Adathoda zelanica	Adusa	Acanthaceae	Shrub
Andrographis echioides	-	Acanthaceae	Herb
Andrographis paniculata	-	Acanthaceae	Herb
Barleria cuspidata	-	Acanthaceae	Shrub
Barleria longiflora	-	Acanthaceae	Herb
Barleria prionitis	-	Acanthaceae	Herb
Blepharis maderaspatensis	-	Acanthaceae	Herb
Dipteracanthus prostratus	-	Acanthaceae	Herb
Justicia glauca	-	Acanthaceae	Herb
Justicia procumbens	-	Acanthaceae	Herb
Peristrophe paniculata	-	Acanthaceae	Herb
Rungia pectineta	-	Acanthaceae	Herb
Strobilanthes callosus	-	Acanthaceae	Shrub
Sesuvium portulacastrum	Sea Purslane,	Aizoaceae	Herb
Aerva lanata	Montane knotgrass	Amaranthaceae	Herb
Alternanthera pungence	-	Amaranthaceae	Herb
Alternanthera sessilis	Garundi, Guroo	Amaranthaceae	Herb
Amaranthus spinosus	Spiny amaranthus	Amaranthaceae	Herb
Amaranthus viridis	-	Amaranthaceae	Herb
Gomphrena celosioides	-	Amaranthaceae	Herb
Pupalia lappacea	-	Amaranthaceae	Herb
Anacardium occidentale	Kaju	Anacardiaceae	Tree
Gluta travancorica	-	Anacardiaceae	Shrub
Mangifera indica	Mango	Anacardiaceae	Tree
Rhus chinensis	-	Anacardiaceae	Tree
Semecarpus anacardium	Geru	Anacardiaceae	Tree
Buchanania latifolia	Char, chironji	Anacardiaceae	Tree
Spondias mangifera	Ambara	Anacardiaceae	Tree
Lannea coromandelica	Mohin	Anacardiceae	Tree
Ananas comosus	Ananas	Annonaceae	Shrub
Annona squamosa	Sitafal	Annonaceae	Shrub
Polyalthia fragrans	Asok	Annonaceae	Tree
Centella asiatica	-	Apiaceae	Herb
Holorrhena antihysenterica	Kurchi	Apocyanacea	Shrub
Alstonia scholarias	Devil tree	Apocynaceae	Tree
Carissa carandas	Karonda	Apocynaceae	Shrub
Holarrhena antidysenterica	Kurchi	Apocynaceae	Tree
Hollarhena antidysentric	Kurchi	Apocynaceae	Tree
Pergularia daemia	-	Apocynaceae	Climber
Plumeria sp.	Champa	Apocynaceae	Shrub

Botanical Name	Common Name	Family	Habit
Raowolfia serpentine	Patalgaruda	Apocynaceae	Shrub
Tabernamontana heyneana	Nag kuda	Apocynaceae	Shrub
Thevetia peruviana	-	Apocynaceae	Shrub
Wrightia tinctoria	Kalakundo	Apocynaceae	Tree
Pothos scandens	-	Araceae	Climber
Borassus flabellifer	Toddy palm	Arecaceae	Tree
Calamus sp.	-	Arecaceae	Shrub
Calamus tenuis	Beta	Arecaceae	Shrub
Caryota urens	Mari	Arecaceae	Tree
Cocos nucifera	Coconut	Arecaceae	Tree
Phoenix loureiroi	mountain date palm	Arecaceae	Shrub
Phoenix pusilla	-	Arecaceae	Shrub
Phoenix spp.	Khajur	Arecaceae	Tree
Phoenix sylvestris	Khajur	Arecaceae	Tree
Calotropis procera	Madar	Asclepiadaceae	Shrub
Cryptolepis buchanani	-	Asclepiadaceae	Climber
Tylophora indica	-	Asclepiadaceae	Herb
Cryptolepis buchananni	-	Asclepiadaceae	Climber
Calotropis gigantea	Madar	Asclepidiaceae	Shrub
Hemidesmus indicus	Anantamul	Asclepidiaceae	Herb
Ageratum conyzoides	Goat weed	Asteraceae	Herb
Bidens pilosa	-	Asteraceae	Herb
Chromolaena odorata	-	Asteraceae	Shrub
Conyza leucantha	-	Asteraceae	Herb
Crassocephalum crepidioides	-	Asteraceae	Herb
Eclipta alba	Mako	Asteraceae	Herb
Elephantopus scaber	Ban-tambakhu	Asteraceae	Herb
Emelia sonchifolia	-	Asteraceae	Herb
Glossocardia bosvallia	-	Asteraceae	Herb
Launaea sarmentosa	-	Asteraceae	Herb
Melanthera biflora	Bhringaraaja	Asteraceae	Herb
Parthanium hysterophorus	-	Asteraceae	Herb
Sphaeranthus indicus	-	Asteraceae	Herb
Synedrella nodiflora	-	Asteraceae	Herb
Tridax procumbens	Khal-muriya,	Asteraceae	Herb
Vernonia cinrea	-	Asteraceae	Herb
Xanthium indicum	-	Asteraceae	Herb
Impatiens balsamina	-	Balsaminaceae	Herb
Hydnocarpus wightiana	-	Bixaceae	Tree
Bombax ceiba	Semal	Bombacaceae	Tree
Ceiba pentandra	Safed semal	Bombacaceae	Tree
Cordia myxa	-	Boraginaceae	Tree
Heliotropium marifolium	-	Boraginaceae	Herb
Garunga pinnata	Kharpat	Burseraceae	Tree
Protium serratum	Khasi	Burseraceae	Tree

Botanical Name	Common Name	Family	Habit
Boswellia serrata	Shallaki,	Burseraceae	Tree
Canarium strictum		Burseraceaea	Tree
Bauhina purpuria	Kachnar	Caesalpiniaceae	Tree
Caesalpinia sp.	-	Caesalpiniaceae	Shrub
Cassia siamea	-	Caesalpiniaceae	Tree
Cassia auriculata	Avaram senna	Caesalpiniaceae	Shub
Cassia fistula	Amaltas	Caesalpiniaceae	Tree
Cassia montana	-	Caesalpiniaceae	Shrub
Cassia pumila	-	Caesalpiniaceae	Herb
Cassia tora	-	Caesalpiniaceae	Herb
Cassia uniflora	-	Caesalpiniaceae	Herb
Ceasalpinia crista	Latakaranja	Caesalpiniaceae	Tree
Chamaecrista absus	-	Caesalpiniaceae	Herb
Delonix regia	Gulmohar	Caesalpiniaceae	Tree
Moullava spicata	Candy Corn Plant	Caesalpiniaceae	Shrub
Senna alata	-	Caesalpiniaceae	Shrub
Senna auriculata	Tarwar	Caesalpiniaceae	Shrub
Senna nigricans	-	Caesalpiniaceae	Shrub
Senna occidentalis	-	Caesalpiniaceae	Shrub
Wagatea spicata	Candy Corn Plant	Caesalpiniaceae	Climber
Calaphyllus inophyllum	Sultan Champa	Calophyllaceae	Tree
Lobelia nicotianaefolia	Dhawal, Narasala	Campanulaceae	Shrub
Capparis sepiaria	-	Capparaceae	Shrub
Capparis zeylanica	-	Capparaceae	Climber
Carica papaya	Papita	Caricaceae	Tree
Bauhinia racemosa	Bidi leaf	Casesalpinae	Tree
Casuarina equisetifolia	Junglisaru	Casuarinaceae	Tree
Maytenus senegalensis	-	Celastraceae	Shrub
Arthrocnemum indicum	Shnaan	Chenopodiaceae	Herb
Chenopodium album	-	Chenopodiaceae	Herb
Cleome aspera	-	Cleomaceae	Herb
Cleome viscosa	Bagra	Cleomaceae	Herb
Garcinia indica	Kokum	Clusiaceae	Tree
Anogesissus latifolia	dhawa,	Combretaceae	Tree
Calycopteris floribunda	Kokoray	Combretaceae	Shrub
Combretum roxburghii	-	Combretaceae	Shrub
Quisqualis indica	-	Combretaceae	Climber
Terminalia arjuna	Arjuna	Combretaceae	Tree
Terminalia bellirica	Bahada	Combretaceae	Tree
Terminalia chebula	Harida	Combretaceae	Tree
Terminalia crenulata	Maretha	Combretaceae	Tree
Terminalia paniculata	Quinzol	Combretaceae	Tree
Commelina longifolia	-	Commelinaceae	Herb
Cyanotis axillaris	Kana	Commelinaceae	Herb

Botanical Name	Common Name	Family	Habit
Cynotis cristata	-	Commelinaceae	Herb
Evolvulus numlaria	-	Convolvulaceae	Herb
Ipomea pes- caprae	Railroad vine,	Convolvulaceae	Herb
Ipomoea alba	-	Convolvulaceae	Climber
Ipomoea aquatica	-	Convolvulaceae	Climber
Ipomoea biloba	-	Convolvulaceae	Climber
Ipomoea carnea	-	Convolvulaceae	Shrub
Ipomoea muricata	-	Convolvulaceae	Climber
Ipomoea pescarpae	-	Convolvulaceae	Climber
Costos speciosus	-	Costaceae	Herb
Mukia maderaspatana	-	Cucurbitacea	Climber
Coccinia grandis	-	Cucurbitaceae	Climber
Corallocarpus epigaeus	-	Cucurbitaceae	Climber
Melothria heterophylla	Ban kundri	Cuscutaceae	Climber
Bulbostylis barbata	-	Cyperaceae	Sedge
Cyperus arenarius	-	Cyperaceae	Sedge
Cyperus articulatus	-	Cyperaceae	Sedge
Cyperus cyperoides	-	Cyperaceae	Sedge
Cyperus difformis	-	Cyperaceae	Sedge
Cyperus distans	-	Cyperaceae	Sedge
Cyperus nutans	-	Cyperaceae	Sedge
Cyperus pangorei	-	Cyperaceae	Sedge
Cyperus rotundus	-	Cyperaceae	Sedge
Fimbristylis dichotoma	-	Cyperaceae	Sedge
Fimbristylis ferruginea	-	Cyperaceae	Sedge
Fimbristylis monostachya	-	Cyperaceae	Sedge
Fimbristylis ovata	-	Cyperaceae	Sedge
Kyllinga nemoralis	White water sedge	Cyperaceae	Sedge
Mariscus squarossus	-	Cyperaceae	Herb
Dellenia pentgyna	Kadkanagan, Kanigalu	Dilleniaceae	Tree
Dillenia pentagyna	Karmal	Dilleniaceae	Tree
Dllenia pentagyana	karmal	Dilleniaceae	Tree
Dioscorea sp	-	Dioscoriaceae	Climber
Hopea wightiana	-	Dipterocarpaceae	Tree
Dipterocarpus indicus	Dhuma	Dipterocarpaceae	Tree
Hopea parviflora	White kongu	Dipterocarpaceae	Tree
Didspyros crumanata	Abnus, Kendu	Ebenaceae	Tree
Diospyros montana	Bistendu	Ebenaceae	Tree
Equisetum sp	-	Equisetaceae	Fern
Phyllanthus emblica	Amla	Euphorbaceae	Tree
Mallotus phillipinensis	Sinduri	Euphorbiacea	Tree
Trewia nudiflora	Bomovaro petari	Euphorbiacea	Tree
Acalypha fruticosa		Euphorbiaceae	Herb
Acalypha indica	-	Euphorbiaceae	Herb
Cleistanthus collinus	Garari/Kara	Euphorbiaceae	Tree

Botanical Name	Common Name	Family	Habit
Croton bonplandianum	-	Euphorbiaceae	Herb
Croton caudatus	Putla	Euphorbiaceae	Tree
Croton hirtum	-	Euphorbiaceae	Herb
Euphorbia antiquorum	-	Euphorbiaceae	Shrub
Euphorbia geniculata	-	Euphorbiaceae	Herb
Euphorbia hirta	Garden spurge	Euphorbiaceae	Herb
Flueggea leucopyrus	-	Euphorbiaceae	Shrub
Glochidion lanceolarium	Ganda	Euphorbiaceae	Tree
Homonoia riparia	Sherni	Euphorbiaceae	Shrub
Jatropha gossipifolia	Jatropa	Euphorbiaceae	Shrub
Micrococca mercurialis	-	Euphorbiaceae	Herb
Phyllanthus maderaspatensis	-	Euphorbiaceae	Herb
Phyllanthus urinaria	-	Euphorbiaceae	Herb
Phyllanthus virgatus		Euphorbiaceae	Herb
Macaranga indica	Ramalo	Euphorbiaceae	Tree
Bridelia retusa	Kaji, Khaja, kassi	Euphoribaceae	Tree
Abrus precatorius	Crabs eye	Fabaceae	Climber
Adenanthera pavonia	Gunj	Fabaceae	Tree
Alysicarpus monilifer	-	Fabaceae	Herb
Alysicarpus rugosus	-	Fabaceae	Herb
Alysicarpus vaginalis	-	Fabaceae	Herb
Atylosia scarabaeoides	-	Fabaceae	Climber
Butea superba	Latapalas	Fabaceae	Tree
Cajanus scarabaeoides	-	Fabaceae	Herb
Clitoria ternata	-	Fabaceae	Climber
Clotoria ternatea	-	Fabaceae	Climber
Crotalaria angulata	-	Fabaceae	Herb
Crotalaria mysorensis	-	Fabaceae	Herb
Crotalaria pallida	-	Fabaceae	Herb
Crotalaria retusa	-	Fabaceae	Herb
Dalbergla latifolia	Sisso	Fabaceae	Tree
Derris heterophylla	panlata	Fabaceae	Shrub
Desmodium sp	-	Fabaceae	Herb
Desmodium triflorum	-	Fabaceae	Herb
Erithrina stricta	Pangara	Fabaceae	Tree
Erythrina suberosa	Dhaul dhak	Fabaceae	Tree
Flemingia strobilifera	-	Fabaceae	Shrub
Fleminhia congesta	-	Fabaceae	Shrub
Indigofera hirsuta	-	Fabaceae	Herb
Indigofera linifolia	-	Fabaceae	Herb
Indigofera linnaei	-	Fabaceae	Herb
Indigofera tirunelvelica	-	Fabaceae	Herb
Indigofera trifoliata	-	Fabaceae	Herb
Millettia sp	Bakar	Fabaceae	Climber
Mucuna artopururea	-	Fabaceae	Climber

Botanical Name	Common Name	Family	Habit
Mucuna pruriens	Alkushi	Fabaceae	Climber
Ougeinia dalbergioides	-	Fabaceae	Tree
Ougeinia oojeinensis	Bandhan	Fabaceae	Tree
Pongamia pinnata	Karanji	Fabaceae	Tree
Pterocarpus marsupium	Asan	Fabaceae	Tree
Pterolobium hexapetalum	-	Fabaceae	Shrub
Tephrosia pumila	-	Fabaceae	Herb
Tephrosia purpurea	-	Fabaceae	Shrub
Tephrosia purpurea	Sarphonka	Fabaceae	Shrub
Zornia diphylla	-	Fabaceae	Herb
Casearia tomentosa	Chhilla	Flacourticeae	Tree
Flacourbia montana	Mountain Sweet Thorn	Flacouticeae	Tree
Mesua ferrea	-	Guttiferae	Tree
Halophila beccarii	-	Hydrocharitaceae	Herb
Curculigo orchioides	-	Hypoxidaceae	Herb
Anisomeles ovata	-	Lamiaceae	Herb
Hygrophila spinosa	-	Lamiaceae	Herb
Hyptis suaveolens	Vilaiti tulsi	Lamiaceae	Herb
Leonotis nepataiefolia	-	Lamiaceae	Herb
Leucas aspera	Chhota halkusa	Lamiaceae	Herb
Ocimum omericanum	Ramtulasi	Lamiaceae	Herb
Ocimum tenuiflorum	Tulsi	Lamiaceae	Herb
Orthosiphon glabratus	-	Lamiaceae	Herb
Pogostemon benghalense	-	Lamiaceae	Shrub
Pogostemone sp	-	Lamiaceae	Shrub
Colebrookea oppositifolia	-	Lamiateae	Shub
Cinnamomum zeylanicum	Dalchinni	Lauraceae	Tree
Litsaea zeylanica	-	Lauraceae	Tree
Machilus macaranatha	-	Lauraceae	Tree
Careya arborea	Kumbhi	Lecethidaceae	Tree
Leea indica	Kukur jihwa	Leeaceae	Shrub
Asparagus recemosus	Satabari	Liliaceae	Shrub
Chlorophytum sp.	-	Liliaceae	Herb
Gloriosa superba	-	Liliaceae	Herb
Scilla hyacinthina	-	Liliaceae	Herb
Strychnos patatorum	Nirmala	Loganiaceae	Tree
Loranthus longiflorus	-	Loranthacaea	Parasite
Woodfordia floriabunda	Dhawai	Lythraceae	Shrub
Lagerstroemia lanceolata	-	Lythraceae	Tree
Abutilon indicum	Ati bala	Malvaceae	Shrub
Hibiscus lobatus	-	Malvaceae	Herb
Hibiscus tiliaceus	Wild cotton tree	Malvaceae	Tree
Justicia simplex	Water-willow	Malvaceae	Herb
Malvastrum coromandelianum	-	Malvaceae	Herb
Microcos paniculata	Shiral	Malvaceae	Shrub

Botanical Name	Common Name	Family	Habit
Pavonia odorata	-	Malvaceae	Herb
Sida acuta	Bala, /Chikna	Malvaceae	Herb
Sida cordata	bhuinii	Malvaceae	Herb
Sida mysorensis	-	Malvaceae	Herb
Sida rhombifolia	Karunthatti	Malvaceae	Herb
Thespecia lampa	Common mellow	Malvaceae	Shrub
Thespecia populinea	Bhendi	Malvaceae	Tree
Urena lobatta	-	Malvaceae	Shrub
Kydia calyenia	Bharanga	Malvaceae	Tree
Martynia annua	-	Martyniacaea	Herb
Melastoma malabathrum	-	Melastomataceae	Herb
Memecylon edule	-	Melastomataceae	Shrub
Cipadessa baccifera	-	Meliaceae	Shrub
Xylocarpus moluccansis	Nayireh batu	Meliaceae	Tree
Aglaia roxburghiana	Priyangu	Meliaceae	Tree
Azadirachta indica	Neem	Meliaceae	Tree
Cipadessa fruticose	-	Meliaceae	Tree
Dysoxylum malabaricum	-	Meliaceae	Tree
Someday febrifunga	-	Meliaceae	Tree
Cissampelos pareira	-	Menispermaceae	Climber
Cocculus hirsutus	-	Menispermaceae	Climber
Cyclea peltata	-	Menispermaceae	Climber
Stephania japonica	-	Menispermaceae	Climber
Acaci arabica	Jali	Mimosaceae	Tree
Acacia caesia	-	Mimosaceae	Shrub
Acacia catechu	Khair	Mimosaceae	Tree
Acacia feruginea	Banni	Mimosaceae	Tree
Acacia leucophloea	Ronjh	Mimosaceae	Tree
Acacia pinnata		Mimosaceae	Tree
Albezia procera	Belati	Mimosaceae	Tree
Albizia amara	Krishna Siris	Mimosaceae	Tree
Albizzia lebbek	Siras	Mimosaceae	Tree
Albizzia odoratissima	Kala Siras	Mimosaceae	Tree
Dichrostachys cinerea	Kunali	Mimosaceae	Shrub
Mimosa rubicaulis	-	Mimosaceae	Shrub
Prosopis juliflora	Kanta babul	Mimosaceae	Shrub
Tamarindus indica	Tentuli	Mimosaceae	Tree
Xylia xylocarpa	Jambu	Mimosaceae	Tree
Mimoasa pudica	Chui-mui	Mimoseae	Herb
Mollugo nudicaulis	-	Molluginaceae	Herb
Mollugo oppositifolia	-	Molluginaceae	Herb
Ficus bengalensis	Vad	Moracea	Tree
Ficus hispida	Nirgaragatti	Moracea	Tree
Ficus racemosa	Goolar	Moracea	Tree
Ficus religiosa	Pipal	Moracea	Tree
Artocarpus heterophyllus	Phanas	Moraceae	Tree
Ficus semicordata	-	Moraceae	Tree

Botanical Name	Common Name	Family	Habit
Cardiospermum halicacabum	-	Mudakkathan	Climber
Myristica magnifica	-	Myristicaceae	Tree
Ardisia solanacea	-	Myrsinaceae	Shrub
Barringtonia acutangula	Hinjal	Myrtaceae	Tree
Eucalyptus	-	Myrtaceae	Tree
Syzgium caryophyllatum	Bhedas	Myrtaceae	Tree
Syzgium cumini	Jamun	Myrtaceae	Tree
Syzygium zeylanicum	Marungi	Myrtaceae	Tree
Eugenia zeylanica	Kath jamun	Myrtaceaea	Tree
Boerhavia diffusa	Punnarva	Nyctaginaceae	Herb
Nymphaea nouchali	Kasturi Salak	Nymphaeaceae	Herb
Nymphaea pubescens	KamalSalak	Nymphaeaceae	Herb
Ludwigia parviflora	-	Onagraceae	Herb
Ludwigia peruviana	-	Onagraceae	Herb
Biophytum reinwarrdtii	-	Oxalidaceae	Herb
Pandanus tectorius	Kia Ketaki	Pandanaceae	Shrub
Argemone mexicana	-	Papaveraceae	Herb
Passiflora edulis	-	Passifloraceae	Climber
Passiflora foetida	Running pop	Passifloraceae	Climber
Piper longum	-	Piperaceae	Climber
Piper nigrum	-	Piperaceae	Climber
Digitalis purpurea	-	Plantaginaceae	Herb
Apluda mutica	-	Poaceae	Grass
Aristida adscensionis	-	Poaceae	Grass
Aristida funiculata	-	Poaceae	Grass
Aristida setacea	-	Poaceae	Grass
Arthraxon hispidus	-	Poaceae	Grass
Bambusa arundinacea	-	Poaceae	Thorny bamboo
Bothriochloa pertusa	-	Poaceae	Grass
Brachiaria reptans	-	Poaceae	Grass
Cenchrus ciliaris	-	Poaceae	Grass
Chloris barbata	-	Poaceae	Grass
Cymbopogon sp.	-	Poaceae	Grass
Cynodon dactylon	Haryali	Poaceae	Grass
Dactyloctenium aegyptium	Beach wiregrass	Poaceae	Grass
Dendrocalamus strictus	Bamboo	Poaceae	Bamboo
Digitaria adscendens	-	Poaceae	Grass
Digitaria ciliaris	-	Poaceae	Grass
Eragrostis tenella	-	Poaceae	Grass
Eragrostis uniloides	Lovegrass or canegrass	Poaceae	Grass
Eulaliopsis binata	Sabai grass	Poaceae	Grass
Heteropogon contortus	-	Poaceae	Grass
Kyllinga brevifolia	-	Poaceae	Grass
Paspalidium flavidum	-	Poaceae	Grass

Botanical Name	Common Name	Family	Habit
Perotis indica	-	Poaceae	Grass
Phragmites karka	-	Poaceae	Grass
Saccharum spontaneum	Kans	Poaceae	Grass
Spinifex littoreus	Littoral Spinegrass	Poaceae	Grass
Sporobolus diander	-	Poaceae	Grass
Themeda triandra	Kangaroo Grass	Poaceae	Grass
Polygala arvensis	-	Polygalaceae	Herb
Polygala chinensis	-	Polygalaceae	Herb
Persicarea barbata	-	Polygonaceae	Herb
Eichhornia crassipes	Jal Kumbhi	Pontederiaceae	Herb
Portulaca quadrifida	-	Portulacaceae	Herb
Portulaca tuberosa	-	Portulacaceae	Herb
Adiantum lunulatum	-	Pterisaceae	Fern
Colubrina asiatca	latherleaf	Rhamnaceae	Shrub
Ziziphus jujuba	Ber	Rhamnaceae	Tree
Ziziphus mauritiana	Ber	Rhamnaceae	Shrub
Ziziphus oenoplia	-	Rhamnaceae	Shrub
Adina cordifolia	Haldu	Rubiaceae	Tree
Catunaregam spinosa	-	Rubiaceae	Shrub
Coffea wightiana	-	Rubiaceae	Shrub
Hedyotis corymbosa	-	Rubiaceae	Herb
Hedyotis herbacea	Chayaparpatika.	Rubiaceae	Herb
Ixora coccinea	Pitkoli	Rubiaceae	Shrub
Morinda citrifolia	Bartundi	Rubiaceae	Tree
Randia deumatorum	Kaarai	Rubiaceae	Shrub
Spermacoce ocymoides	-	Rubiaceae	Herb
Tarenna asiatica	-	Rubiaceae	Shrub
Gardenia gummifera	-	Rubiaceae	Tree
Anthocephalus cadaurba	Neerubale	Rubiceae	Tree
Mitragyna parvifolia	Kaim	Rubiceae	Tree
Pavetta indica	Kankara	Rubiceae	Tree
Aegal marmelos	Bel	Rutaceae	Tree
Glycosmis pentaphylla	-	Rutaceae	Shrub
Murraya koenigii	Karipatha	Rutaceae	Shrub
Toddalia asiatica	-	Rutaceae	Shrub
Santala album	Chandan	Santalaceae	Tree
Saraca indica	Asoka	Sapindaceae	Tree
Schleichera oleosa	Kusum	Sapindaceae	Tree
Dodonia visscosa	-	Sapindaceae	Shub
Madhuca indica	Mahula	Sapotaceae	Tree
Manilkara hexandra	Kirni	Sapotaceae	Tree
Mimusops elengi	Maulsari	Sapotaceae	Tree
Palaquium ellipticum	-	Sapotaceae	Tree
Scoparia dulcis	-	Scrophulariaaceae	Herb
Bacopa monnieri	Brahmi	Scrophulariaceae	Herb

Botanical Name	**Common Name**	**Family**	**Habit**
Lindernia antipoda	-	Scrophulariaceae	Herb
Lindernia oppositifolia	-	Scrophulariaceae	Herb
Majus rugosus	-	Scrophulariaceae	Herb
Selaginella sp	-	Selaginacaea	Fern
Smilax zeylanica	Ghot vel	Smilacaceae	Climber
Datura innoxia	Datura	Solanaceae	Herb
Physalis minima	-	Solanaceae	Herb
Solanum nigrum	Makoi	Solanaceae	Herb
Solanum surattense	-	Solanaceae	Herb
Helicteris isora	-	Sterculiaceae	Shrub
Sterculia villosa	Aployo suplo	Sterculiaceae	Tree
Helictreres isora	Maror phali	Sterculiaceae	Shrub
Sterculia foetiada	Wild almond	Sterculiaceae	Tree
Symplocos recemosa	Lodha	Symplocaceae	Tree
Lasiosiphon eriocephalus	-	Thyimeleaeceae	Tree
Corchorus aestuans	Chonch	Tiliaceae	Herb
Grewia tillifolia	Dhamani	Tiliaceae	Tree
Triumfetta rhomboidea	Chikti	Tiliaceae	Herb
Elaeocarpus seratus	Malayalam	Tiliaceae	Tree
Typha angustata	Elephant grass	Typhaceae	Herb
Holoptelia integrifolia	Indian Elm	Ulmaceae	Tree
Artocarpus integrifolia	Katahal	Urticaceae	Tree
Clerodendron inermi	Chhoti-ari	Verbenaceae	Shrub
Gmelina arborea	Gamhar	Verbenaceae	Tree
Lantana camara	Lantana	Verbenaceae	Shrub
Phyla nudiflora	Bukkan	Verbenaceae	Herb
Vitex altissima	Bavalgi	Verbenaceae	Shrub
Vitex negundo	Nirgundi	Verbenaceae	Shrub
Tectona grandis	Teak	Verbinaceae	Tree
Ampelocissus latifolia	-	Vitaceae	Climber
Hedychium coronarium	-	Zingiberaceae	Herb
Tribulus terrestris	-	Zygophyllaceae	Herb

Annexure VI

List of Mammalian Species reported in East Flowing Rivers of Peninsular India Sub-basin Area

Common Name	Scientific Name	IUCN status	IWPA (1972)
Chital	*Axis axis*	LC	III
Lesser Bandicoot-rat	*Bandicota bengalensis*	LC	V
Indian bison	*Bos gaurus*	VU	I
Nilgai/Blue Bull	*Boselaphus tragocamelus*	LC	III
Jackal	*Canis aureus*	LC	II
Sambar deer	*Cervus unicolor*	VU	III
Jungle Cat	*Felis chaus*	LC	II
Common Palm Squirrel	*Funambulus palmaram*	LC	IV
Five-striped Palm Squirrel	*Funambulus pennanti*	LC	IV
Common mongoose	*Herpestes edwardsii*	LC	IV
Ruddy mongoose	*Herpestes smithii*	LC	IV
Striped Hyena	*Hyaena hyaena*	NT	III
Porcupine	*Hystrix indica*	LC	IV
Black-naped Hare	*Lepus nigricollis*	LC	IV
Common Otter	*Lutra lutra*	NT	II
Smooth Coated Otter	*Lutrogale perspicillata*	VU	II
Rhesus Macaque	*Macaca mulatta*	LC	II
Bonnet Macaque	*Macaca radiata*	LC	II
Sloth bear	*Melarsus ursinus*	VU	I
Ratel/Honey Badger	*Mellivora capensis*	LC	I
Barking Deer	*Muntiacus muntjak*	LC	III
Indian Field Mouse	*Mus booduga*	LC	V
House Mouse	*Mus musculus*	LC	V
Leopard	*Panthera pardus*	VU	I
Asian palm civet	*Paradoxurus hermaphroditus*	LC	II
Leopard cat	*Parionailurus bengalensis*	LC	II
Indian Flying Squirrel	*Petaurista philippensis*	LC	IV
Indian Pygmy Bat	*Pipistrellus tenuis*	LC	V
Indian flying fox	*Pteropus giganteus*	LC	III
Black Rat	*Rattus rattus*	LC	V
Common Langur	*Semnopithecus entellus*	LC	II
House shrew	*Suncus murinus*	LC	IV
Wild Boar	*Sus scrofa*	LC	III
Tree Shrew	*Tupia sp.*	-	-

Common Name	Scientific Name	IUCN status	IWPA (1972)
Small Indian Civet	*Viverricula indica*	LC	II
Indian fox	*Vulpes bengalensis*	NT	I

Note: LC-Least Concerned, NT-Near Thereatend, VU-Vulnerable, EN-Endangered

Annexure VII

List of Reptile species reported in the East Flowing Rivers of Peninsular India Sub-basin Area

Common Name	**Scientific Name**	**IUCN Status**	**IWPA Status**
Vine Snake	*Ahaetulla nasutus*	LC	NA
Buff striped keel back	*Amphiesma stolatum*	NE	NA
Forsten's Cat Snake.	*Boiga forsteni*	LC	NA
Common Indian Cat Snake.	*Boiga trigonata*	LC	NA
Common Indian Krait	*Bungarus caeruleus*	VU	SCH IV
Banded Krait	*Bungarus fasciatus*	LC	SCH IV
Rouxii lizard	*Calotes rouxii*	LC	NA
Indian Garden Lizard	*Calotes versicolor*	LC	NA
Dogfaced water Snake	*Cerberus rhynchops*	LC	NA
Indian Chameleon	*Chamaeleo zeylanicus*	LC	NA
Golden back tree Snake	*Chrysopelea ornata*	LC	NA
The Mugger	*Crocodylus palustris*	VU	NA
Russell's Viper	*Daboia russelii*	LC	SCH II
The Common Green Snake	*Dendrelaphis punctulata*	LC	NA
Bronzeback tree Snake	*Dendrelaphis tristis*	LC	NA
Flying lizard	*Draco dussumieri*	LC	NA
Saw scaled Viper	*Echis carinatus*	LC	SCH IV
Indian Egg Eater Snake	*Elachistodon westermanni*	NA	SCH I
Hook-nosed Sea Snake	*Enhydrina schistosa*	LC	NA
Russell's Earth Boa	*Eryx conicus*	NA	SCH IV
Johns sand boa	*Eryx johnii*	LC	NA
Brahminy Skink	*Eutropis carinata*	LC	NA
Common Sand Boa	*Gongylophis conicus*	DD	NA
Beaked worm snake	*Grypotyphlops acutus*	LC	SCH IV
Brook's Gecko	*Hemidactylus brookii*	NA	NA
Indian House Gecko	*Hemidactylus flaviviridis*	LC	NA
Southern House Gecko	*Hemidactylus frenatus*	LC	NA
Common Wolf snake	*Lycodon aulicus*	NE	NA
Snake Skink	*Lygosoma punctatus*	NE	NA
Common Indian Skink	*Mabuya carinata*	LC	NA
Bronze skink	*Mabuya macularia*	LC	NA
Green keelback.	*Macropisthodon plumbicolor*	LC	NA
Monocled Cobra	*Naja kaouthia*	LC	SCH II
Binocled Cobra	*Naja naja*	LC	SCH IV
The cobra	*Naja tripudians*	VU	NA
Common Kukri snake	*Oligodon arnensis*	LC	SCH IV
Variegated Kukri Snake	*Oligodon taeniolatus*	LC	NA
King Kobra	*Ophiophagus hannah*	VU	SCH II
Blanford's Rock Agama	*Psammophilus blanfordanus*	LC	NA

Common Name	Scientific Name	IUCN Status	IWPA Status
Rock Agama	*Psammophilus dorsalis*	LC	SCH IV
Peninsular Rock Agama	*Psammophilus dorsalis*	LC	SCH IV
Indian Rat Snake	*Ptyas mucosa*	LC	NA
Indian Rat Snake	*Ptyas mucosus*	NA	SCH II
Indian Rock Python	*Python molurus*	VU	NA
Brahminy worm snake	*Ramphotyphlops braminus*	LC	NA
The land Tortoise	*Testudo elegans*	VU	NA
Bamboo Pit Viper	*Trimeresurus gramineus*	LC	NA
Malabar Pit Viper	*Trimeresurus malabaricus*	LC	NA
Bombay shield tail	*Uropeltis macrolepis macrolepis*	LC	NA
Indian Monitor Lizard	*Varanus bengalensis*	NT	SCH II
Russels Viper	*Vipera russelii*	LC	NA
Checkered Keel Back	*Xenochrophis piscator*	LC	SCH II

Note: LC-Least Concerned, NT-Near Thereatend, VU-Vulnerable, NA-Not Assessed

Annexure VIII

List of Amphibians reported in East Flowing Rivers of Peninsular India Sub-basin Area

Common Name	Scientific Name	IUCN Status	IWPA Status
Indian Toad	*Cacopes systoma*	LC	NA
Indian Skipper frog	*Duttaphrynus melanostictus*	LC	SCH IV
Ferguson's Toad	*Duttaphrynus scaber*	LC	SCH IV
Marbled Toad	*Duttaphrynus stomaticus*	LC	NA
Skittering Frog	*Euphlyctis cyanophlyctis*	LC	SCH IV
Indian Pond Frog	*Euphlyctis hexadactylus*	LC	SCH IV
Aloyi Skittering Frog	*Euphlytic aloysii*	NA	NA
Green Pond Frog	*Euphlytic haxadactylus*	NA	NA
Small Cricket Frog	*Fejarvarya syhadrensis*	NA	NA
Peter's frog	*Fejervarya brevipalmata*	DD	NA
Indian Cricket Frog	*Fejervarya limnocharis*	LC	SCH IV
Indian Bull Frog	*Hoplobatrachus tigerinus*	LC	SCH IV
Plantain Frog	*Kalloula spp.*	LC	NA
-	*Microhoaornata*	LC	NA
Ornate Microhylid	*Microhyla ornata*	LC	SCH IV
-	*Microhylarubra*	LC	NA
Common Tree Frog	*Polypedates maculatus*	LC	SCH IV
Narrow-mouthed Frog	*Ramanella variegata*	LC	SCH IV
The Concer Frog	*Rana cyanophlyctis*	LC	NA
Fungoid frog	*Rana malabarica*	LC	NA
The Bull Frog	*Rana tigrina*	LC	NA
-	*Rana verrucosa*	LC	NA
-	*Rang curupes*	LC	NA
Malabar gliding frog	*Rhacophorus malabaricus*	LC	NA
Tree Frog	*Rhacophorus pleurostictus*	LC	NA
Indian Burrowing Frog	*Sphaerotheca breviceps*	LC	SCH IV
Ballon Frog	*Uperodon globulosus*	LC	NA

Note: LC-Least Concerned, NA-Not Assessed

Annexure IX

The list of avi-fauna reported from the East Flowing Rivers of Peninsular India Sub-basin Area alongwith their Conservation Status

Common Name	Scientific Name	IUCN status	IWPA 1972
Shikra	*Accipiter badius*	VU	Sch-IV
Crested Goshawk	*Accipiter trivirgatus*	LC	Sch-IV
Jungle Myna	*Acridotheres fuscus*	LC	Sch-IV
Common Myna	*Acridotheres tristis*	LC	Sch-IV
Yellow-browed Bulbul	*Acritillas indica*	LC	Sch-IV
Greater Spotted Eagle	*Aquila clanga*	VU	Sch-IV
Black-Headed Ibis	*Threskiornis melanocephalus*	NT	Sch-IV
Thick billed Warbler	*Acrocephalus aedon*	LC	Sch-IV
Paddyfield Warbler	*Acrocephalus agricola*	LC	Sch-IV
Common Iora	*Aegithina tiphia*	LC	Sch-IV
Indian Swiftlet	*Aerodramus unicolor*	LC	Sch-IV
Common Kingfisher	*Alcedo atthis*	LC	Sch-IV
Blue-eared Kingfisher	*Alcedo meninting*	LC	Sch-IV
White-breasted Waterhen	*Amaurornis phoenicurus*	LC	Sch-IV
Northern Pintail	*Anas acuta*	LC	Sch-IV
Northern Shoveler	*Anas clypeata*	LC	Sch-IV
Common Teal	*Anas crecca*	LC	Sch-IV
Spot-billed	*Anas poecilorhyncha*	LC	Sch-IV
Garganey	*Anas querquedula*	LC	Sch-IV
Asian Openbill	*Anastomus oscitans*	LC	Sch-IV
Darter or Snake-bird	*Anhinga melanogaster*	NT	Sch-IV
Richards Pipit	*Anthus richardi*	LC	Sch-IV
Paddy field Pipit	*Anthus rufulus*	LC	Sch-IV
Large White Rumped Swift	*Apus pacificus*	LC	Sch-IV
Lesser Spotted Eagle	*Aquila pomarina*	NT	Sch-IV
Grey Heron	*Ardea cinerea*	LC	Sch-IV
Eastern Great Egret	*Ardea modesta*	LC	Sch-IV
Purple Heron	*Ardea purpurea*	LC	Sch-IV
Indian Pond-Heron	*Ardeola grayii*	LC	Sch-IV
Sri Lanka Frogmouth	*Batrachostomus moniliger*	LC	Sch-IV
Spot-bellied Eagle-Owl	*Bubo nipalensis*	LC	Sch-IV
Cattle Egret	*Bubulcus ibis*	LC	Sch-IV
Common Buzzard	*Buteo buteo*	LC	Sch-IV
Grey-bellied Cuckoo	*Cacomantis passerinus*	LC	Sch-IV
Greater Short-toed Lark	*Calandrella brachydactyla*	LC	Sch-IV
Little Stint	*Calidris minuta*	LC	Sch-IV
Temminck's Stint	*Calidris temminckii*	LC	Sch-IV
Jerdon's Nightjar	*Caprimulgus atripennis*	LC	Sch-IV

Common Name	Scientific Name	IUCN status	IWPA 1972
Large Egret	*Casmerodius albus*	LC	Sch-IV
Red-rumped Swallow	*Cecropis daurica*	LC	Sch-IV
Rufous woodpecker	*Celeus brachyyurus*	LC	Sch-IV
Greater Coucal	*Centropus sinensis*	LC	Sch-IV
Pied Kingfisher	*Ceryle rudis*	LC	Sch-IV
Emerald Dove	*Chalcophaps indica*	LC	Sch-IV
Little Ringed Plover	*Charadrius dubius*	LC	Sch-IV
Kentish plover	*Charadrius alexandrinus*	LC	Sch-IV
Little ringed plover	*Charadrius dubius*	LC	Sch-IV
Whiskered Tern	*Chlidonias hybrida*	LC	Sch-IV
Greater Goldenback	*Chrysocolaptes lucidus*	LC	Sch-IV
Short-toed Snake-Eagle	*Circaetus gallicus*	LC	Sch-IV
Western Marsh Harrier	*Circus aeruginosus*	LC	Sch-IV
Nilgiri Wood-Pigeon	*Columba elphinstonii*	VU	Sch-IV
Rock Pigeon	*Columba livia*	LC	Sch-IV
White-rumped Shama	*Copsychus malabaricus*	LC	Sch-IV
Oriental Magpie-Robin	*Copsychus saularis*	LC	Sch-IV
Magpie robin	*Copsychus saularis*	LC	Sch-IV
Indian Roller	*Coracias benghalensis*	LC	Sch-IV
Black headed cuckoo shrike	*Coracina mealnoptera*	LC	Sch-IV
Jungle crow	*Corvus macrorhynchos*	LC	Sch-IV
House Crow	*Corvus splendens*	LC	Sch-IV
Common Hawk-Cuckoo	*Cuculus varius*	LC	Sch-IV
White-bellied Blue Flycatcher	*Cyornis pallipes*	LC	Sch-IV
Blue-throated Blue Flycatcher	*Cyornis rubeculoides*	LC	Sch-IV
Tickell's blue flycatcher	*Cyornis tickelliae*	LC	Sch-IV
Palm Swift	*Cypsirus Parvus*	LC	Sch-IV
Asian Palm Swift	*Cypsiurus balasiensis*	LC	Sch-IV
White-bellied Treepie	*Dendrocitta leucogastra*	LC	Sch-IV
Indian tree pie	*Dendrocitta vagabunda*	LC	Sch-IV
Yellow-crowned Woodpecker	*Dendrocopos mahrattensis*	LC	Sch-IV
Brown-capped Pygmy Woodpecker	*Dendrocopos nanus*	LC	Sch-IV
Lesser Whistling teal	*Dendrocygna javanica*	LC	Sch-IV
Forest Wagtail	*Dendronanthus indicus*	LC	Sch-IV
Thick billed Flowerpecker	*Dicaeum agile*	LC	Sch-IV
Nilgiri Flowerpecker	*Dicaeum concolor*	LC	Sch-IV

Common Name	Scientific Name	IUCN status	IWPA 1972
Tickell's Flowerpecker	*Dicaeum erythrorhynchos*	LC	Sch-IV
Bronzed Drongo	*Dicrurus aeneus*	LC	Sch-IV
White bellied Drongo	*Dicrurus caerulescens*	LC	Sch-IV
Hair crested Drongo	*Dicrurus hottentottus*	LC	Sch-IV
Ashy Drongo	*Dicrurus leucophaeus*	LC	Sch-IV
Black Drongo	*Dicrurus macrocercus*	LC	Sch-IV
Greater racket tailed drongo	*Dicrurus paradiseus*	LC	Sch-IV
Golden back woodpecker	*Dinopium benghalense*	LC	Sch-IV
White-bellied Woodpecker	*Dryocopus javensis*	LC	Sch-IV
Green Imperial Pigeon	*Ducula aenea*	LC	Sch-IV
Mountain Imperial-Pigeon	*Ducula badia*	LC	Sch-IV
White throated Babbler	*Dumetia hyperythra*	LC	Sch-IV
Little Egret	*Egretta garzetta*	LC	Sch-IV
Western Reef-Egret	*Egretta gularis*	LC	Sch-IV
Yellow-billed Egret	*Egretta intermedia*	LC	Sch-IV
Black-winged Kite	*Elanus caeruleus*	LC	Sch-IV
Ashy-crowned Sparrow-Lark	*Eremopterix grisea*	LC	Sch-IV
Asian Koel	*Eudynamys scolopaceus*	LC	Sch-IV
Verditer flycatcher	*Eumyias thalassina*	LC	Sch-IV
Great Eared Nightjar	*Eurostopodus macrotis*	LC	Sch-IV
Common Coot	*Fulica atra*	LC	Sch-IV
Watercock	*Gallicrex cinerea*	LC	Sch-IV
Common Moorhen	*Gallinula chloropus*	LC	Sch-IV
Red Spurfowl	*Galloperdix spadicea*	LC	Sch-IV
Grey Junglefowl	*Gallus sonneratii*	LC	Sch-IV
Wynaad Laughingthrush	*Garrulax delesserti*	LC	Sch-IV
Small Pratincole	*Glareola lactea*	LC	Sch-IV
Jungle Owlet	*Glaucidium radiatum*	LC	Sch-IV
Malayan Night Heron	*Gorsachius melanolophus*	LC	Sch-IV
Southern Hill Myna	*Gracula indica*	LC	Sch-IV
Black-capped Kingfisher	*Halcyon pileata*	LC	Sch-IV
White-throated Kingfisher	*Halcyon smyrnensis*	LC	Sch-IV
White-bellied Fish-Eagle	*Haliaeetus leucogaster*	LC	Sch-IV
Brahminy Kite	*Haliastur indus*	LC	Sch-IV
Malabar Trogon	*Harpactes fasciatus*	LC	Sch-IV
Heart-spotted Woodpecker	*Hemicircus canente*	LC	Sch-IV

Common Name	Scientific Name	IUCN status	IWPA 1972
Crested tree swift	*Hemiprocene longipennis*	LC	Sch-IV
Crested Treeswift	*Hemiprocne coronate*	LC	Sch-IV
Pied flycathcher shrike	*Hemipus picatus*	LC	Sch-IV
Booted Eagle	*Hieraaetus pennatus*	LC	Sch-IV
Common Hawk-Cuckoo	*Hierococcyx varius*	LC	Sch-IV
Black-winged Stilt	*Himantopus himantopus*	LC	Sch-IV
Brown-backed Needletail	*Hirundapus giganteus*	LC	Sch-IV
Dusky Crag Martin	*Hirundo concolor*	LC	Sch-IV
Red rumped Swallow	*Hirundo daurica*	LC	Sch-IV
Barn Swallow	*Hirundo rustica*	LC	Sch-IV
Wire tailed Swallow	*Hirundo smithii*	LC	Sch-IV
Black-naped Monarch	*Hypothymis azurea*	LC	Sch-IV
Black Eagle	*Ictinaetus malayensis*	LC	Sch-IV
Yellow-browed Bulbul	*Iole indica*	LC	Sch-IV
Asian Fairy-bluebird	*Irena puella*	LC	Sch-IV
Long tailed Shrike	*Lanius schach*	LC	Sch-IV
Purple-rumped Sunbird	*Leptocoma zeylonica*	LC	Sch-IV
Lesser Adjutant	*Leptoptilos javanicus*	LC	Sch-IV
Black-throated Munia	*Lonchura kelaarti*	LC	Sch-IV
Black headed Munia	*Lonchura malacca*	LC	Sch-IV
White Rumped Munia	*Lonchura striata*	LC	Sch-IV
Vernal Hanging Parrot	*Loriculus vernalis*	LC	Sch-IV
Indian Blue Robin	*Luscinia brunnea*	LC	Sch-IV
Crimson breasted Barbet	*Megalaima haemacephala*	LC	Sch-IV
Malabar Barbet	*Megalaima malabarica*	LC	Sch-IV
White cheeked Barbet	*Megalaima viridis*	LC	Sch-IV
Blue-tailed Bee-eater	*Merops philippinus*	LC	Sch-IV
Painted Stork	*Mycteria leucocephala*	NT	Sch-IV
Little Green Bee-eater	*Merops orientalis*	LC	Sch-IV
Blue-tailed Bee-eater	*Merops philippinus*	LC	Sch-IV
Intermediate Egret	*Mesophoyx intermedia*	LC	Sch-IV
Bronze-winged Jacana	*Metopidius indicus*	LC	Sch-IV
Black Kite	*Milvus migrans*	LC	Sch-IV
Large Pied Wagtail	*Motacilla maderaspatensis*	LC	Sch-IV
Citrine Wagtail	*Motacilla citreola*	LC	Sch-IV
Large Pied wagtail	*Motacilla madaraspatensis*	LC	Sch-IV
Asian Brown Flycatcher	*Muscicapa dauurica*	LC	Sch-IV
Brown-breasted	*Muscicapa muttui*	LC	Sch-IV

Common Name	Scientific Name	IUCN status	IWPA 1972
Flycatcher			
Rusty-tailed Flycatcher	*Muscicapa ruficauda*	LC	Sch-IV
Malabar Whistling-Thrush	*Myiophonus horsfieldii*	LC	Sch-IV
Purple Sunbird	*Nectarinia asiatica*	LC	Sch-IV
Loten's Sunbird	*Nectarinia lotenia*	LC	Sch-IV
Purple rumped Sunbird	*Nectarinia zeylonica*	LC	Sch-IV
Brown Hawk-Owl	*Ninox scutulata*	LC	Sch-IV
Black-crowned Night-Heron	*Nycticorax nycticorax*	LC	Sch-IV
Blue bearded bee-eater	*Nyctyornis athertoni*	LC	Sch-IV
Malabar Grey Hornbill	*Ocyceros griseus*	NT	Sch-IV
Golden oriole	*Oriole oriolus*	LC	Sch-IV
Indian Golden Oriole	*Oriolus kundoo*	LC	Sch-IV
Black headed oriole	*Oriolus xanthornus*	LC	Sch-IV
Common Tailor bird	*Orthotomus sutorius*	LC	Sch-IV
Indian Scops Owl	*Otus bakkamoena*	LC	Sch-IV
Pied Cuckoo	*Oxylophus jacobinus*	LC	Sch-IV
Osprey	*Pandion haliaetus*	LC	Sch-IV
House Sparrow	*Passer domesticus*	LC	Sch-IV
Indian Peafowl	*Pavo cristatus*	LC	Sch-IV
Stork-billed Kingfisher	*Pelargopsis capensis*	NT	Sch-IV
Spotted Babbler	*Pellorneum ruficeps*	LC	Sch-IV
Jungle Bush-Quail	*Perdicula asiatica*	LC	Sch-IV
Small minivet	*Pericrocotus cinnamomeus*	LC	Sch-IV
Small Minivet	*Pericrocotus cinnamomeus*	LC	Sch-IV
Scarlet Minivet	*Pericrocotus flammeus*	LC	Sch-IV
Crested Honey Buzzard	*Pernis ptilorhynchus*	LC	Sch-IV
Indian Shag	*Phalacrocorax fusicollis*	LC	Sch-IV
Little Cormorant	*Phalacrocorax niger*	LC	Sch-IV
Sri Lanka Bay Owl	*Phodilus assimilis*	LC	Sch-IV
Large-billed Leaf Warbler	*Phylloscopus magnirostris*	LC	Sch-IV
Greenish Warbler	*Phylloscopus trochiloides*	LC	Sch-IV
Speckled Piculet	*Picumnus innominatus*	LC	Sch-IV
Streak-throated Woodpecker	*Picus xanthopygaeus*	LC	Sch-IV
Indian Pitta	*Pitta brachyura*	LC	Sch-IV
Indian Baya	*Ploceus philippinus*	LC	Sch-IV
Indian Scimitar-Babbler	*Pomatorhinus horsfieldii*	LC	Sch-IV
Purple Swamphen	*Porphyrio porphyrio*	LC	Sch-IV

Common Name	Scientific Name	IUCN status	IWPA 1972
Ruddy-breasted Crake	*Porzana fusca*	LC	Sch-IV
Grey-breasted Prinia	*Prinia hodgsonii*	LC	Sch-IV
Plain Prinia	*Prinia inornata*	LC	Sch-IV
Ashy Prinia	*Prinia socialis*	LC	Sch-IV
Alexandrine Parakeet	*Psittacula eupatria*	NT	Sch-IV
Plum-headed Parakeet	*Psittacula cyanocephala*	LC	Sch-IV
Rose ringed parakeet	*Psittacula krameri*	LC	Sch-IV
Blossom headed parakeet	*Psittacula kyanocephala*	LC	Sch-IV
Dusky Crag Martin	*Ptyonoprogne concolor*	LC	Sch-IV
Red vented Bulbul	*Pycnonotus cafer*	LC	Sch-IV
Flame-throated Bulbul	*Pycnonotus gularis*	LC	Sch-IV
Red whiskered Bulbul	*Pycnonotus jocosus*	LC	Sch-IV
White browed Bulbul	*Pycnonotus luteolus*	LC	Sch-IV
Grey-headed Bulbul	*Pycnonotus priocephalus*	LC	Sch-IV
White throated fantail flycatcher	*Rhipidura albicollis*	LC	Sch-IV
Dark-fronted Babbler	*Rhopocichla atriceps*	LC	Sch-IV
Pied bush chat	*Saxicola caprata*	LC	Sch-IV
Indian Robin	*Saxicoloides fulicata*	LC	Sch-IV
Velvet-fronted Nuthatch	*Sitta frontalis*	LC	Sch-IV
Crested Serpent-Eagle	*Spilornis cheela*	LC	Sch-IV
Changeable Hawk-Eagle	*Spizaetus cirrhatus*	LC	Sch-IV
Legge's Hawk-Eagle	*Spizaetus kelaarti*	LC	Sch-IV
Common Tern	*Sterna hirundo*	LC	Sch-IV
River Tern	*Sterna aurantia*	NT	Sch-IV
Lesser Crested-Tern	*Sterna bengalensis*	LC	Sch-IV
Gull-billed Tern	*Sterna nilotica*	LC	Sch-IV
Spotted Dove	*Streptopelia chinensis*	LC	Sch-IV
Mottled Wood Owl	*Strix ocellata*	LC	Sch-IV
Malabar Starling	*Sturnus blythii*	LC	Sch-IV
Brahminy Myna	*Sturnus pagodarum*	LC	Sch-IV
Rosy Starling	*Sturnus roseus*	LC	Sch-IV
Fork-tailed Drongo-Cuckoo	*Surniculus dicruroides*	LC	Sch-IV
Little Grebe	*Tachybaptus ruficollis*	LC	Sch-IV
Malabar Woodshrike	*Tephrodornis sylvicola*	LC	Sch-IV
Paradise flycatcher	*Terpsiphone paradisi*	LC	Sch-IV
Oriental White Ibis	*Threskiornis melanocephalus*	LC	Sch-IV
Pompadour Green-	*Treron pompadora*	LC	Sch-IV

Common Name	Scientific Name	IUCN status	IWPA 1972
Pigeon			
Marsh Sandpiper	*Tringa stagnatilis*	LC	Sch-IV
Terek Sandpiper	*Tringa cinerea*	LC	Sch-IV
Spotted Redshank	*Tringa erythropus*	LC	Sch-IV
Wood Sandpiper	*Tringa glareola*	LC	Sch-IV
Common Sandpiper	*Tringa hypoleucos*	LC	Sch-IV
Common Greenshank	*Tringa nebularia*	LC	Sch-IV
Jungle Babbler	*Turdoides striatus*	LC	Sch-IV
Rufous Babbler	*Turdoides subrufa*	LC	Sch-IV
Orange-Billed Babbler	*Turdoides rufescens*	NT	Sch-IV
Eurasian Blackbird	*Turdus merula*	LC	Sch-IV
Indian Blackbird	*Turdus simillimus*	LC	Sch-IV
Hoopoe	*Upupa epops*	LC	Sch-IV
Yellow-wattled Labwing	*Vanellus malabaricus*	LC	Sch-IV
River Lapwing	*Vanellus duvaucelii*	NT	Sch-IV
Red-wattled Lapwing	*Vanellus indicus*	LC	Sch-IV
Yellow-wattled Lapwing	*Vanellus malabaricus*	LC	Sch-IV
Pandion haliaetus	*Osprey*	LC	SCH I
Orange-headed Thrush	*Zoothera citrina*	LC	Sch-IV

Note- LC =Least Concern, EN= Endangered, NT = Near Threatened; VU = Vulnerable

Annexure X

Butterflies reported from the East Flowing Rivers of Peninsular India Sub-basin Area

Common Name	Scientific Name	Status IUCN	Status IWPA 1972
Yellow Castor	*Acraea issoria*	NE	NA
Tawny Costar	*Acraea terpsicore*	NE	NA
Chocolate Albastross	*Appias lyncida*	SCH II	NA
Comon Cator	*Ariadne merione*	NE	NA
Common Sargent	*Athyma perius*	NE	NA
Pioneer white	*Belenois aurota*	NE	NA
Common Flash	*Bidaspa nissa*	NE	NA
Common Pierrot	*Castalius rosimon*	SCH I	NA
Forget Me Not	*Catachrysops strabo*	NE	NA
Common Emigrant	*Catopsilia pomona*	NE	NA
Mottled Emigrant	*Catopsilia pyranthe*	NE	NA
Common Gull	*Cepora nerissa*	SCH II	NA
Common Mime	*Chilasa clytia*	SCH I	NA
Rustic	*Cupha erymanthis*	NE	NA
Plain Tiger	*Danaus chrysippus*	NE	NA
Striped Tiger	*Danus genutia*	NE	NA
Common Jezebel	*Delias eucharis*	NE	NA
Gram Blue	*Enchrysops cnejus*	SCH II	NA
Common Indian Crow	*Euploea core*	SCH IV	NA
Three Spot Grass Yellow	*Eurema blanda*	NE	NA
Small Grass Yellow	*Eurema brigitta*	NE	NA
Common grass Yellow	*Eurema hecabe*	NE	NA
Tailed Jay	*Graphium Agamemnon*	NE	NA
Common Jay	*Graphium doson*	NE	NA
Common Bluebottle	*Graphium sarpedon*	NA	NA
Common Banded Awl	*Hasora Chromus*	NA	NA
Purple Sapphire	*Heliophorus epicles*	NA	NA
Great Eggfly	*Hypolimnas bolina*	NA	NA
Danaid Eggfly	*Hypolimnas misippus*	SCH I	NA
Chestnut Bob	*Imabrix salsala*	NE	NA
White Orange Tip	*Ixias marianne*	NE	NA
Common Cerulean	*Jamides celeno*	NE	NA
Peacock Pansy	*Junonia almanac*	NE	NA
Grey pansy	*Junonia atlites*	NE	NA
Chocolate Pansy	*Junonia iphita*	NA	NA
Lemon Pansy	*Junonia lemonias*	NA	NA
Blue Pansy	*Junonia orithya*	NA	NA
Pea Blue	*Lampides boeticus*	SCH II	NA
Psyche	*Leptosia nina*	NE	NA
Common Evening Brown	*Melanitis leda*	NE	NA

Common Name	Scientific Name	Status IUCN	Status IWPA 1972
Dark Evening Brown	*Melanitis phedima*	NE	NA
Common Bush Brown	*Mycalesis perseus*	NE	NA
Common Sailor	*Neptis hylas*	NE	NA
Common Rose	*Pachliopta aristolochiae*	NE	NA
Crimson Rose	*Pachliopta hector*	SCH I	NA
Lime Butterfly	*Papilio demoleus*	NE	NA
Common Mormon	*Papilio poytes*	NE	NA
Red Helen	*Paplio helenus*	NE	NA
Common Mormon	*Paplio polytes*	NE	NA
Glassy Tiger	*Parantica aglea*	NE	NA
Common Wanderer	*Pareronia valeria*	NE	NA
Oriental straight swift	*Parnara guttatus*	NE	NA
Small Branded Swift	*Pelopidas mathias*	NE	NA
Common Leopard	*Phalanta phalantha*	NE	NA
Indian Cabbage White	*Pieris canidia indica*	NE	NA
Common Silver line	*Spindasis vulcanus*	NE	NA
Common Grass Dart	*Taractrocera maevius*	NE	NA
Blue Tiger	*Tirumala limniace*	NE	NA
Common Birdwing	*Troides halena*	NE	NA
Southem Birdwing	*Troides minos Cramer*	NE	NA
Grass Demon	*Udaspes folus*	NE	NA
Common Four Ring	*Ypthima huebneri*	NE	NA
Red spot	*Zesius chrysomallus*	NE	NA
Dark Grass blue	*Zizeeria karsandra*	NE	NA
Tiny Grass Blue	*Zizula hylax*	NE	NA

Note- NE-Not Evaluated, NA=Not Assessed

Annexure XI

List of major fish species reported from the East Flowing Rivers of Peninsular India Sub-basin Area

Scientific Name	Common Name	Family	Staus	IUCN Status
Acanthocobitis rubidipinnis	-	Nemacheilidae	Native	LC
Ailia coila	Gangetic ailia	Schilbeidae	Native	NE
Ambassis ambassis	Commerson's glassy	Ambassidae	Native	LC
Ambassis gymnocephalus	Bald glassy	Ambassidae	Native	LC
Ambassis nalua	Scalloped perchlet	Ambassidae	Native	LC
Amblyceps accari	Nikhil's torrent catfish	Amblycipitidae	Endemic	LC
Amblyceps mangois	Indian torrent catfish	Amblycipitidae	Native	LC
Amblypharyngodon microlepis	Indian carplet	Cyprinidae	Native	LC
Amblypharyngodon mola	Mola carplet	Cyprinidae	Native	LC
Anabas cobojius	Gangetic koi	Anabantidae	Native	NE
Anguilla bengalensis	Indian mottled eel	Anguillidae	Native	NE
Anguilla bicolor	Indonesian shortfin eel	Anguillidae	Native	LC
Aplocheilus lineatus	Striped panchax	Aplocheilidae	Native	LC
Aplocheilus panchax	Blue panchax	Aplocheilidae	Native	LC
Balitora mysorensis	Slender stone loach	Balitoridae	Native	LC
Bangana ariza	Reba	Cyprinidae	Native	LC
Bangana dero	Kalabans	Cyprinidae	Native	LC
Barbodes carnaticus	Carnatic carp	Cyprinidae	Native	LC
Barilius gatensis	-	Cyprinidae	Native	LC
Bhavania australis	Western Ghat loach	Balitoridae	Native	LC
Botia striata	Zebra loach	Cobitidae	Native	VU
Cabdio morar	Morari	Cyprinidae	Native	LC
Cara nana	Elongate glass-perchlet	Ambassidae	Native	LC
Catla catla	Catla	Chanidae	Native	NE
Channa punctata	Spotted snakehead	Channidae	Native	LC
Chanos chanos	Milkfish	Chanidae	Native	LC
Chela cachius	-	Cyprinidae	Native	LC
Chelon planiceps	Tade gray mullet	Mugilidae	Native	LC
Cirrhinus fulungee	Deccan white	Cyprinidae	Native	LC

Scientific Name	Common Name	Family	Staus	IUCN Status
	carp			
Cirrhinus macrops	Hora white carp	Cyprinidae	Endemic	LC
Clarias dussumieri	-	Clariidae	Native	LC
Crossocheilus latius	Stone roller	Cyprinidae	Native	LC
Ctenopharyngodon idella	Grass carp	Cyprinidae	Introduced	LC
Cyprinus carpio	Common carp	Cyprinidae	Introduced	LC
Danio rerio	Zebra danio	Cyprinidae	Native	LC
Dawkinsia filamentosa	Blackspot barb	Cyprinidae	Native	LC
Dawkinsia rubrotinctus	-	Cyprinidae	Native	LC
Devario aequipinnatus	Giant danio	Cyprinidae	Native	LC
Devario devario	Sind danio	Cyprinidae	Native	LC
Devario fraseri	-	Cyprinidae	Native	LC
Devario malabaricus	Malabar danio	Cyprinidae	Native	LC
Dichotomyctere fluviatilis	Green pufferfish	Tetraodontidae	Native	LC
Esomus barbatus	South Indian flying barb	Cyprinidae	Native	LC
Esomus danrica	Flying barb	Cyprinidae	Native	LC
Esomus danrica	Flying barb	Cyprinidae	Native	NT
Esomus thermoicos	-	Cyprinidae	Native	LC
Etroplus maculatus	Orange chromide	Cichlidae	Native	LC
Etroplus suratensis	Pearlspot	Cichlidae	Native	NE
Eutropiichthys goongwaree	-	Schilbeidae	Native	LC
Eutropiichthys vacha	Batchwa vacha	Schilbeidae	Native	LC
Favonigobius reichei	Indo-Pacific tropical sand goby	Gobiidae	Native	LC
Gagata itchkeea	-	Sisoridae	Native	LC
Garra bicornuta	-	Cyprinidae	Native	NE
Garra mcclellandi	-	Cyprinidae	Native	LC
Garra mullya	Sucker fish	Cyprinidae	Native	LC
Garra platycephala	-	Cyprinidae	Native	LC
Garra stenorhynchus	-	Cyprinidae	Native	LC
Glossogobius giuris	Tank goby	Gobiidae	Native	NT
Glyptothorax sinensis	-	Sisoridae	Native	LC
Glyptothorax trewavasae	-	Sisoridae	Native	LC
Gudusia chapra	Indian river shad	Clupeidae	Native	LC
Haludaria fasciata	Melon barb	Cyprinidae	Native	LC
Hemibagrus menoda	Menoda catfish	Bagridae	Native	LC

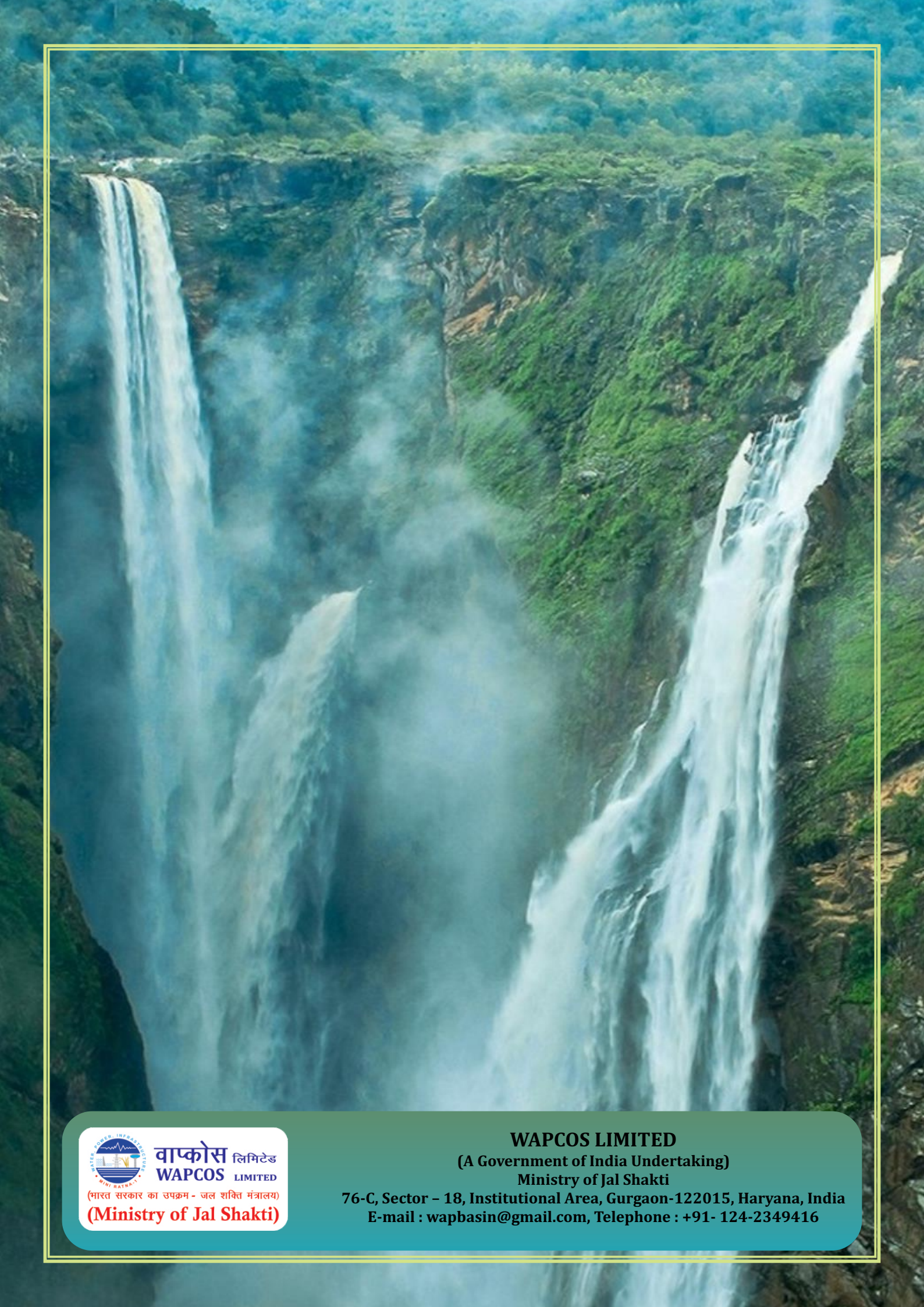
Scientific Name	Common Name	Family	Staus	IUCN Status
Hemibagrus punctatus	-	Bagridae	Native	NE
Heteropneustes fossilis	Stinging catfish	Heteropneustidae	Native	LC
Hilsa kelee	Kelee shad	Clupeidae	Native	LC
Hypophthalmichthys molitrix	Silver carp	Cyprinidae	Introduced	LC
Hypophthalmichthys nobilis	Bighead carp	Cyprinidae	Native	NE
Hyporhamphus limbatus	Congaturi halfbeak	Hemiramphidae	Native	LC
Hypselobarbus curmuca	Curmuca barb	Cyprinidae	Native	LC
Hypselobarbus dobsoni	Krishna carp	Cyprinidae	Native	LC
Hypselobarbus dubius	Nilgiris barb	Cyprinidae	Native	LC
Hypselobarbus kolus	Kolus	Cyprinidae	Native	LC
Hypselobarbus micropogon	Korhi barb	Cyprinidae	Endemic	LC
Hypselobarbus pulchellus	-	Cyprinidae	Native	LC
Ilisha megaloptera	Bigeye ilisha	Pristigasteridae	Native	LC
Indoreonectes evezardi	-	Nemacheilidae	Native	NE
Labeo bata	Bata	Cyprinidae	Native	LC
Labeo boga	-	Cyprinidae	Native	LC
Labeo boggut	Boggut labeo	Cyprinidae	Native	LC
Labeo calbasu	Orangefin labeo	Cyprinidae	Native	LC
Labeo fimbriatus	Fringed-lipped peninsula carp	Cyprinidae	Native	LC
Labeo gonius	Kuria labeo	Cyprinidae	Native	LC
Labeo kontius	Pigmouth carp	Cyprinidae	Endemic	LC
Labeo pangusia	-	Cyprinidae	Native	LC
Labeo rohita	Roho labeo	Cyprinidae	Native	LC
Laubuka laubuca	Indian glass barb	Cyprinidae	Native	LC
Lepidocephalichthys thermalis	Common spiny loach	Cobitidae	Native	LC
Macrognathus pancalus	Barred spiny eel	Mastacembelidae	Native	NT
Mastacembelus armatus	Zig-zag eel	Mastacembelidae	Native	LC
Mystus bleekeri	Day's mystus	Bagridae	Native	LC
Mystus cavasius	Gangetic mystus	Bagridae	Native	NE
Mystus gulio	Long whiskers catfish	Bagridae	Native	LC

Scientific Name	Common Name	Family	Staus	IUCN Status
Mystus malabaricus	-	Bagridae	Native	LC
Mystus seengtee	-	Bagridae	Native	NE
Mystus vittatus	Striped dwarf catfish	Bagridae	Native	LC
Nemacheilus anguilla	-	Nemacheilidae	Native	LC
Nemacheilus guentheri	-	Nemacheilidae	Native	NT
Nemacheilus pulchellus	-	Nemacheilidae	Endemic	LC
Nemacheilus rueppelli	-	Nemacheilidae	Native	DD
Neolissochilus bovanicus	Bowany barb	Cyprinidae	Native	LC
Notopterus notopterus	Bronze featherback	Notopteridae	Native	LC
Ompok bimaculatus	Butter catfish	Siluridae	Native	LC
Ompok pabda	Pabdah catfish	Siluridae	Native	NT
Opsarius barna	-	Cyprinidae	Native	LC
Oreichthys coorgensis	-	Cyprinidae	Native	LC
Oreichthys cosuatis	-	Cyprinidae	Native	LC
Oreochromis mossambicus	Mozambique tilapia	Cichlidae	Introduced	LC
Osteobrama belangeri	-	Cyprinidae	Native	LC
Osteobrama cunma	-	Cyprinidae	Native	LC
Osteobrama vigorsii	-	Cyprinidae	Native	NE
Osteochilichthys brevidorsalis	Kantaka barb	Cyprinidae	Native	LC
Osteochilichthys thomassi	Konti barb	Cyprinidae	Native	NE
Osteochilus nashii	Nash's barb	Cyprinidae	Native	LC
Pachypterus khavalchor	Khavalchor catfish	Schilbeidae	Native	LC
Parambassis ranga	Indian glassy fish	Ambassidae	Native	LC
Parapsilorhynchus prateri	Deolali minnow	Cyprinidae	Native	LC
Parapsilorhynchus tentaculatus	Khandalla minnow	Cyprinidae	Native	LC
Paraschistura montana	-	Nemacheilidae	Endemic	LC
Pethia conchonius	Rosy barb	Cyprinidae	Native	LC
Pethia guganio	Glass-barb	Cyprinidae	Native	LC
Pethia narayani	Narayan barb	Cyprinidae	Native	LC
Pethia ticto	Ticto barb	Cyprinidae	Native	LC
Planiliza macrolepis	Largescale mullet	Mugilidae	Native	LC
Proeutropiichthys taakree	-	Schilbeidae	Native	LC
Pseudogobius javanicus	-	Gobiidae	Native	NE

Scientific Name	Common Name	Family	Staus	IUCN Status
Pseudosphromenus cupanus	Spiketail paradisefish	Osphronemidae	Native	LC
Pterocryptis wynaadensis	-	Siluridae	Native	NE
Puntius amphibius	Scarlet-banded barb	Cyprinidae	Native	DD
Puntius cauveriensis	-	Cyprinidae	Native	LC
Puntius chola	Swamp barb	Cyprinidae	Native	LC
Puntius dorsalis	Long snouted barb	Cyprinidae	Native	LC
Puntius parrah	-	Cyprinidae	Endemic	LC
Puntius sophore	Pool barb	Cyprinidae	Native	LC
Puntius vittatus	Greenstripe barb	Cyprinidae	Native	LC
Rasbora caverii	Cauvery rasbora	Cyprinidae	Native	LC
Rasbora daniconius	Slender rasbora	Cyprinidae	Native	NE
Rasbora labiosa	-	Cyprinidae	Native	LC
Rasbora rasbora	Gangetic scissortail rasbora	Cyprinidae	Native	LC
Rita gogra	-	Bagridae	Native	LC
Rohtee ogilbii	Vatani rohtee	Cyprinidae	Native	LC
Salmostoma acinaces	Silver razorbelly minnow	Cyprinidae	Native	LC
Salmostoma balookee	Bloch razorbelly minnow	Cyprinidae	Native	NE
Salmostoma belachi	-	Cyprinidae	Endemic	LC
Salmostoma horai	Hora razorbelly minnow	Cyprinidae	Native	LC
Salmostoma novacula	Novacula razorbelly minnow	Cyprinidae	Native	LC
Salmostoma phulo	Finescale razorbelly minnow	Cyprinidae	Native	LC
Salmostoma untrahi	Mahanadi razorbelly minnow	Cyprinidae	Native	LC
Scatophagus argus	Spotted scat	Scatophagidae	Native	LC
Schismatorhynchos nukta	Nukta	Cyprinidae	Native	EN
Schistura kodaguensis	-	Nemacheilidae	Native	LC
Schistura semiarmata	-	Nemacheilidae	Native	LC
Schistura striata	-	Nemacheilidae	Native	LC
Silonia childreni	-	Schilbeidae	Native	LC
Sperata aor	Long-whiskered catfish	Bagridae	Native	LC

Scientific Name	Common Name	Family	Staus	IUCN Status
Sperata seenghala	Giant river-catfish	Bagridae	Native	LC
Stigmatogobius sadanundio	-	Gobiidae	Native	NE
Systomus sarana	Olive barb	Cyprinidae	Native	LC
Tenualosa ilisha	Hilsa shad	Clupeidae	Native	NE
Terapon jarbua	Jarbua terapon	Terapontidae	Native	LC
Thynnichthys sandkhol	Sandkhol carp	Cyprinidae	Native	LC
Tor khudree	Deccan mahseer	Cyprinidae	Native	EN
Wallago attu	Wallago	Siluridae	Native	NT

Note- LC=Least Concern, EN=Endangered, NT=Near Threatened;
VU=Vulnerable, NE=Not Evaluted, DD= Data Deficient.



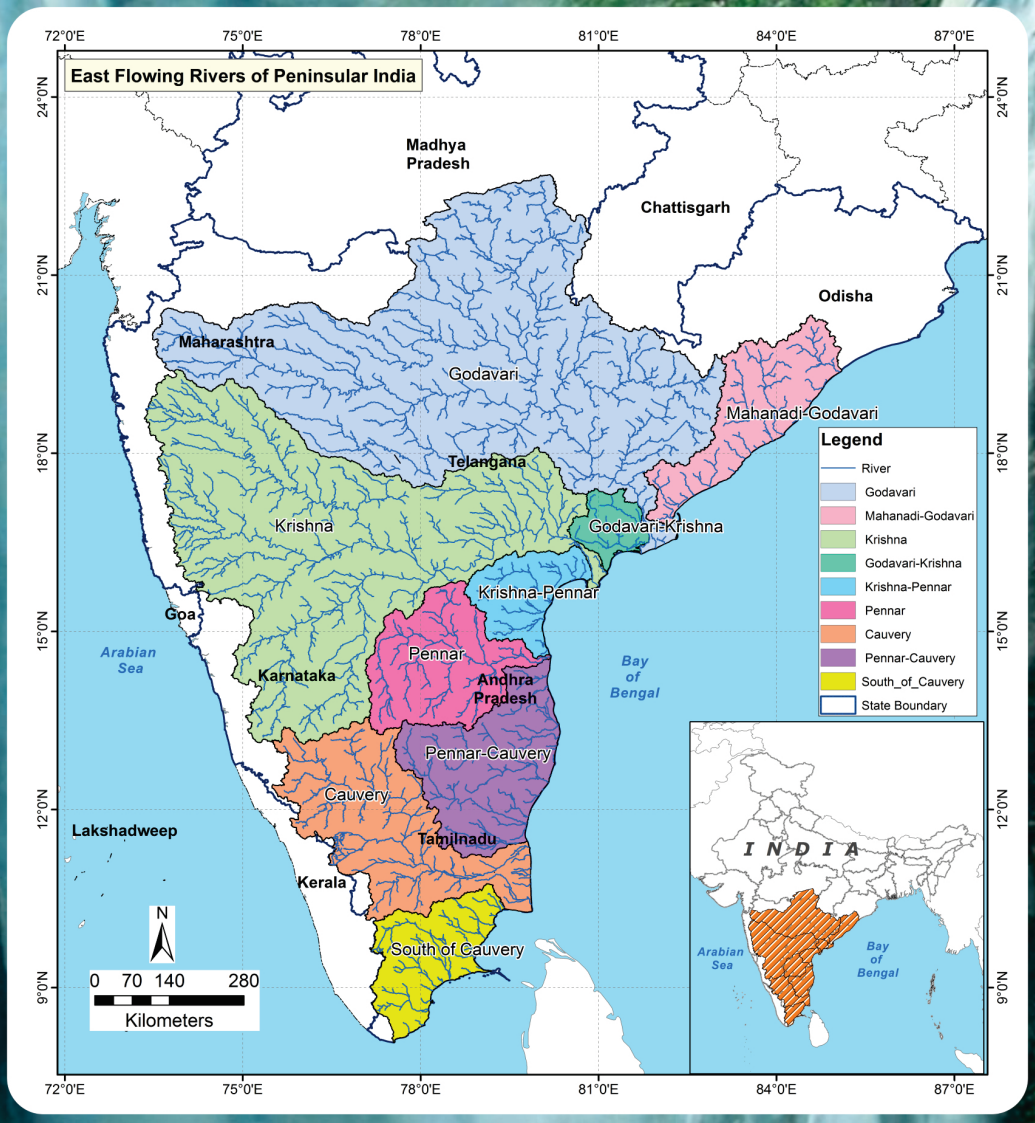
वाप्कोस लिमिटेड
WAPCOS LIMITED
(भारत सरकार का उपक्रम - जल शक्ति मंत्रालय)
(Ministry of Jal Shakti)

WAPCOS LIMITED
(A Government of India Undertaking)
Ministry of Jal Shakti
76-C, Sector – 18, Institutional Area, Gurgaon-122015, Haryana, India
E-mail : wapbasin@gmail.com, Telephone : +91- 124-2349416

सत्यमेव जयते

Government of India
Ministry of Power
Central Electricity Authority

BASIN-WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN INDIA
EAST FLOWING RIVERS OF PENINSULAR INDIA
(LARGE HYDROELECTRIC PROJECTS EXCLUDING PUMPED STORAGE)



VOLUME-II

January-2021

प्रकाश मस्के
अध्यक्ष तथा पदेन सचिव भारत सरकार
Prakash Mhaske
Chairperson & Ex-officio Secretary
to the Government of India

सत्यमेव जयते

केन्द्रीय विद्युत प्राधिकरण
विद्युत मंत्रालय
सेवा भवन, आर. के. पुरम
नई दिल्ली–110066
Central Electricity Authority
Ministry of Power
Sewa Bhawan, R. K. Puram
New Delhi-110066

FOREWORD

India, being one of the fastest growing economy on the Globe, needs to develop adequate, sustainable, economic, reliable and power system friendly energy sources for meeting rising demand as well as for future energy security. Harnessing potential Hydro power is important not only as a vital source of renewable electricity but also as most flexible resource, to play a crucial role in optimum utilisation of other renewable energy as well as conventional energy sources.

With an objective of identification of exploitable hydro potential and taking up the development of it in a systematic manner Central Electricity Authority (CEA) took up a study namely "Reassessment of Hydroelectric Potential in the country" in March' 2017. Under this comprehensive study, the reassessment of hydroelectric potential for all the six basins namely Ganga, Indus, Brahmaputra, West Flowing and East Flowing Rivers of Peninsular India and Central Indian River has been taken up.

This document on " East Flowing Rivers of Peninsular India" contains details of the basin characteristics along with status of hydro power development in the basin and basin states It will facilitate developers / States in taking advance action and in preparation of detailed project reports based on adequate investigations, in a phased manner, which would eliminate the causes of delay in the implementation of hydroelectric projects.

I am confident that this document will be useful in effective hydro development planning and speedy development of hydro projects in the Country.

(PRAKASH MHASKE)

6 Jan 2021

दूरभाष / Telephone: 011-26102583, 26732222, फैक्स / Fax: 011-26109212, ईमेल / Email: chair@nic.in, वेबसाइट / Website: www.cea.nic.in

दिनेश चन्द्रा
सदस्य
तथा पदेन अपर सचिव
भारत सरकार
DINESH CHANDRA
MEMBER &
EX-OFFICIO ADDL. SECRETARY
TO THE GOVERNMENT OF INDIA

दूरभाष (का.) Telephone (O) : 26732701
टेलिफैक्स Telefax : 26172942
केन्द्रीय विद्युत प्राधिकरण
सेवा भवन, आर. के. पुरम,
नई दिल्ली - 110066
CENTRAL ELECTRICITY AUTHORITY
SEWA BHAWAN, R.K. PURAM
NEW DELHI - 110066

PREFACE

The first systematic Hydroelectric Survey of India was undertaken by Central Water & Power Commission (CW&PC) during 1953-59. According to this survey, hydroelectric potential of the country was assessed as about 42,000 MW. This very first attempt of country's hydroelectric potential assessment was extremely useful for hydro planning in the country for about three decades.

During this long period, however, there had been major changes and important developments. Hence, the need was felt by the Central Electricity Authority for a second exercise to reassess the country's hydroelectric potential and accordingly, the Authority undertook the study in 1978 and completed it in 1987. As per this study, the Hydroelectric Power Potential of the country was estimated as 1,45,320 MW consisting of hydroelectric schemes having installed capacity above 25 MW.

Again, after three decades, fresh Basin wise reassessment of Hydroelectric Power Potential has been carried out to arrive at realistic exploitable potential taking into consideration updated high resolution Survey of India maps, hydrological data, hydro-meteorological data, ecological data, new norms relating to environmental flows, free flow stretch, inter-state issues & tribunal awards etc.

I hope that this re-assessment of hydroelectric potential would prove useful not only in assigning proper priorities in investigation and construction of hydro power projects but also help in placing the hydro developmental efforts in proper perspective.

(Dinesh Chandra)

प्रदीप कुमार शुक्ल
मुख्य अभियंता
PARDEEP KUMAR SHUKLA
CHIEF ENGINEER

सत्मेव जयते

दुरभाष (का.) Telephone (O) : 26732773
टेलिफैक्स Telefax : 26109610
केन्द्रीय विद्युत प्राधिकरण
सेवा भवन, आर. के. पुरम,
नई दिल्ली-110066
CENTRAL ELECTRICITY AUTHORITY
SEWA BHAWAN, R.K. PURAM
NEW DELHI - 110066

ACKNOWLEDGEMENT

The "Reassessment of Hydroelectric Potential in the country" involves preparation of Basin Reports for all the six basins namely Ganga, Indus, Brahmaputra, West Flowing and East Flowing Rivers of Peninsular India and Central Indian River System.

The present report of East Flowing Rivers of Peninsular India (EFR) Basin is being brought out in two volumes. The volume-I contains the general description of the study, the methodology adopted, Project Profiles and Environmental aspects of Projects while volume-II contains Hydrological & Power Potential Studies. The work has been carried out by CEA in association with WAPCOS Limited and periodical monitoring of the work along with getting inputs from CWC, MOEF & CC, GSI, SOI and NRSC. I am grateful to following officers of these Organizations for their co-operation and assistance in accomplishing this important and difficult task:

CWC

1. Dr.R.K.Gupta, Member (D&R)
2. Shri C. Lal, Chief Engineer (Hydrology)
3. Sh. S.K.Sinha, Director (Hydrology)

MOEF&CC

1. Dr.S.Kerketta, Director (IA)
2. Sh. Manmeet Singh, Consultant

GSI

1. Dr. Saibal Ghosh , Director
2. Sh. Dharmendra Kumar, Sr. Geologist

SOI

1. Sh. D.N. Pathak, Director

NRSC

1. Dr. V.V. Rao, Director
2. Dr. V.M. Chowdhary, Scientist 'SG'

I express my sincere thanks to Shri J.S. Bawa, Chief Engineer (HPP&I), CEA for providing support and guidance in completing this complex task in a highly systematic way. I am also thankful to Officers/ Staff of HEPR Division, CEA and WAPCOS who have rendered active assistance in the study and preparation of the reports. The work could not have been possible without their sincere and sustained effort.

I am also thankful to all the officers of concerned State Governments /CPSUs/SPSUs and private developers for providing information regarding their hydro projects in the EFR Basin.

(Pradeep Kumar Shukla)

CONTENTS

S.No.	Table of Contents	Page No.
	Volume-I	
	Abbreviations	1
	Members of the Monitoring Committee	3
	Chapter-1: Introduction	
1.0	Background	5
1.1	Objectives of Reassessment study	7
1.2	Need for Reassessment Study	8
1.3	General Methodology	9
1.4	Data Layers – Sources & Uses	13
1.5	East Flowing Rivers of Peninsular India (EFR) Basin	14
1.6	Hydroelectric Projects (above 25 MW) in EFR Basin as per 1978-87 studies	18
1.7	Hydroelectric Projects (above 25 MW) in EFR Basin and their status (Present Study)	19
1.8	Hydroelectric Projects in EFR Basin having Environmental/ Forest Issues	26
1.9	Hydroelectric Projects in EFR Basin having Inter-State Issues	27
1.9.1	International Treaties and Interstate Tribunals on rivers of EFR Basin	33
1.9.1.1	Cauvery Water Disputes Tribunal (June 1990)	34
1.9.1.2	Godavari Water Disputes Tribunal (April 1969)	41
1.9.1.3	Krishna Water Disputes Tribunal	42
1.9.1.4	Vansadhara Water Disputes Tribunal	43
1.10	Hydroelectric Projects (above 25 MW) in EFR Basin having no major constraints which have been taken up for further studies	46
1.11	Hydroelectric Projects in EFR Basin Projects not feasible	47
1.12	Final Outcome of Reassessment studies	48
	A. Hydro Potential at a glance in EFR Basin	48
	B. State wise Hydro Potential at a glance in EFR Basin	48
	Annexure I	52
	Annexure II	56

S.No.	Table of Contents	Page No.
	Annexure III	60
	Annexure IV	66
	Chapter-2: Sub-Basins	
2.1	**Godavari Sub-Basin**	73
2.1.1	Physiographic status of Godavari Sub-Basin	76
2.1.2	River Profile	87
2.1.2.1	Godavari River	87
2.1.2.2	Pranitha River	91
2.1.2.3	Indravati River	95
2.1.2.4	Sabari River	99
2.2	**Krishna Sub-Basin**	102
2.2.1	Physiographic status of Krishna Sub-Basin	104
2.2.2	River Profile	114
2.2.2.1	Krishna River	114
2.2.2.2	Indrayani River	118
2.2.2.3	Tungabhadra River	121
2.3	**Cauvery Sub-Basin**	124
2.3.1	Physiographic status of Cauvery Sub-Basin	126
2.3.2	River Profile	138
2.3.2.1	Cauvery River	138
2.3.2.2	Bhavani River	142
2.4	**South of Cauvery Sub-Basin**	146
2.4.1	Physiographic status of South of Cauvery Sub-Basin	146
2.4.2	River Profile	154
2.4.2.1	Suruli River	154
2.4.2.2	Thamirabarani River	157

S.No.	Table of Contents	Page No.
	Chapter-3: Project Profiles of Projects except those taken up for further studies	
A	**Projects In Operation**	
3.1	Bhandardara St-II Hydroelectric Project	161
3.2	Pench Hydroelectric Project	167
3.3	Pochampad Hydroelectric Project	171
3.4	Upper Indravati Hydroelectric Project	175
3.5	Upper Kolab Hydroelectric Project	179
3.6	Machkund Hydroelectric Project	183
3.7	Balimela Hydroelectric Project	189
3.8	Upper Sileru I & II Hydroelectric Project	193
3.9	Lower Sileru Hydroelectric Project	197
3.10	Bhivpuri Hydroelectric Project	201
3.11	Khopoli Hydroelectric Project	205
3.12	Bhira Hydroelectric Project	211
3.13	Koyna DPH Hydroelectric Project	215
3.14	Koyna St. I & II Hydroelectric Project	219
3.15	Koyna St. III Hydroelectric Project	223
3.16	Koyna St. IV Hydroelectric Project	227
3.17	Ghatprabha Hydroelectric Project	231
3.18	Almatti Hydroelectric Project	235
3.19	Priyadarshini Jurala Hydroelectric Project	239
3.20	Lower Jurala Hydroelectric Project	245
3.21	Srisailam Hydroelectric Project	249
3.22	Nagarjunasagar RBC & Ext Hydroelectric Project	255
3.23	Nagarjunasagar TPD Hydroelectric Project	259
3.24	Nagarjunasagar LBC Hydroelectric Project	263
3.25	Nagarjunasagar Hydroelectric Project	267
3.26	T B Dam Hydroelectric Project	273

S.No.	Table of Contents	Page No.
3.27	Hampi Hydroelectric Project	277
3.28	Munirabad Hydroelectric Project	283
3.29	Bhadra Hydroelectric Project	287
3.30	Pulichintala Hydroelectric Project	291
3.31	Mettur Dam Hydroelectric Project	295
3.32	Mettur Tunnel Hydroelectric Project	301
3.33	Lower Mettur-I Hydroelectric Project	307
3.34	Lower Mettur-II Hydroelectric Project	311
3.35	Lower Mettur-III Hydroelectric Project	315
3.36	Lower Mettur-IV Hydroelectric Project	319
3.37	Bhavani Kattalai Barrage-I Hydroelectric Project	323
3.38	Bhavani Kattalai Barrage-II Hydroelectric Project	327
3.39	Bhavani Kattalai Barrage-III Hydroelectric Project	331
3.40	Pykara Hydroelectric Project	335
3.41	Pykara Ultimate Hydroelectric Project	341
3.42	Kundah-I Hydroelectric Project	347
3.43	Kundah-II Hydroelectric Project	353
3.44	Kundah-III Hydroelectric Project	357
3.45	Kundah-IV Hydroelectric Project	363
3.46	Kundah-V Hydroelectric Project	367
3.47	Parson's Valley Hydroelectric Project	371
3.48	Shivasamudram Hydroelectric Project	377
3.49	Moyar Hydroelectric Project	383
3.50	Suruliyar Hydroelectric Project	387
3.51	Papanasam Hydroelectric Project	393
B	**Project Under Construction**	
3.52	Polavaram Hydroelectric Project	399
C	**Project Concurred/ Approved By State Governments**	
3.53	Matnar Hydroelectric Project	403

S.No.	Table of Contents	Page No.
D	**Projects having Environmental/ Forest Issues**	
3.54	Nugur-II Hydroelectric Project	407
3.55	Bhopalpatnam Hydroelectric Project	411
3.56	Lower Moyar Hydroelectric Project	415
E	**Projects having Inter-State Issues**	
3.57	Middle Kolab Hydroelectric Project	417
3.58	Lower Kolab Hydroelectric Project	423
3.59	Sivasamudram Hydroelectric Project	427
3.60	Mekadatu Hydroelectric Project	431
3.61	Rasimanal Hydroelectric Project	435
3.62	Hogenekkal Hydroelectric Project	439
3.63	Nellithorai Hydroelectric Project	443
3.64	Mananthavady Hydroelectric Project	445
	Chapter-4: Environmental Aspects	
4.1	General	449
4.2	Protected Areas	449
4.3	Assessment of Projects	451
4.3.1	Godavari Sub-Basin	451
4.3.2	Krishna Sub-Basin	460
4.3.3	Cauvery Sub-Basin	461
4.3.4	South of Cauvery Sub-Basin	463
4.4	Ecological Aspects	463
4.4.1	Flora	463
4.4.2	Fauna	468
4.4.2.1	Mammals	468
4.4.2.2	Reptiles	469
4.4.2.3	Amphibians	469
4.4.2.4	Avi-fauna	469
4.4.2.5	Butterflies	470

S.No.	Table of Contents	Page No.
4.4.2.6	Fish & Fisheries	471
4.5	Environmental Flows	471
	Annexure V	487
	Annexure VI	497
	Annexure VII	499
	Annexure VIII	501
	Annexure IX	502
	Annexure X	509
	Annexure XI	511
Volume-II		
	Chapter-5: Hydrological Studies	
5.0	General	517
5.1	Tupakulagudem Hydroelectric Project	522
5.2	Dummugudem Hydroelectric Project	547
5.3	Bodhghat Hydroelectric Project	567
5.4	Kutru-I Hydroelectric Project	588
5.5	Kutru-II Hydroelectric Project	608
5.6	Nugur-I Hydroelectric Project	627
5.7	Kotri Hydroelectric Project	649
5.8	Wainganga Hydroelectric Project	668
5.9	Samda Hydroelectric Project	689
5.10	Kunghara Hydroelectric Project	709
5.11	Pranhita Hydroelectric Project	729
5.12	Balimela Hydroelectric Project	750
5.13	Konta Hydroelectric Project	767
5.14	Tamankal Hydroelectric Project	792
5.15	Jaldurg Hydroelectric Project	818
	Chapter-6: Power Potential Studies	
6.0	Introduction	851

S.No.	Table of Contents	Page No.
6.1	Tupakulagudem Hydroelectric Project	851
6.2	Dummugudem Hydroelectric Project	865
6.3	Bodhghat Hydroelectric Project	873
6.4	Kutru-I Hydroelectric Project	881
6.5	Kutru-II Hydroelectric Project	888
6.6	Nugur-I Hydroelectric Project	898
6.7	Kotri Hydroelectric Project	906
6.8	Wainganga Hydroelectric Project	915
6.9	Samda Hydroelectric Project	923
6.10	Kunghara Hydroelectric Project	932
6.11	Pranhita Hydroelectric Project	940
6.12	Balimela Hydroelectric Project	947
6.13	Konta Hydroelectric Project	954
6.14	Tamankal Hydroelectric Project	964
6.15	Jaldurg Hydroelectric Project	969
6.16	Possibility of developing Hydroelectric Projects having environmental issues with adjustment of project components	975
	Chapter-7: Project Profiles of Projects Taken for Further Studies	
7.1	Tupakulagudem Hydroelectric Project	977
7.2	Dummugudem Hydroelectric Project	981
7.3	Bodhghat Hydroelectric Project	985
7.4	Kutru-I Hydroelectric Project	989
7.5	Kutru-II Hydroelectric Project	991
7.6	Nugur-I Hydroelectric Project	995
7.7	Kotri Hydroelectric Project	999
7.8	Wainganga Hydroelectric Project	1003
7.9	Samda Hydroelectric Project	1007
7.10	Kunghara Hydroelectric Project	1011
7.11	Pranhita Hydroelectric Project	1015

S.No.	Table of Contents	Page No.
7.12	Balimela Hydroelectric Project	1019
7.13	Konta Hydroelectric Project	1021
7.14	Tamankal Hydroelectric Project	1023
7.15	Jaldurg Hydroelectric Project	1027
	Chapter-8	
8.1	Exploration of river profiles for identifying new potential sites for Hydroelectric Projects development	1031
8.2	Outcome of river profile exploration	1088

LIST OF FIGURES

Figure No.	Details	Page No.
Figure 1.1	River basins of India	6
Figure 1.2	General Methodology	11
Figure 1.3	Catchment Delineation Process	13
Figure 1.4	Sub-Basins of East Flowing Rivers of Peninsular India	17
Figure 1.5	Hydroelectric Projects in East Flowing Rivers of Peninsular India Basin	22
Figure 2.1	Hydroelectric Projects in Godavari sub-basin	81
Figure 2.2	Topographical (Elevation Data) Map of Godavari sub-basin	82
Figure 2.3	Ecologically Sensitive Area Map of Godavari sub-basin	83
Figure 2.4	Geological Map of Godavari sub-basin	84
Figure 2.5	Seismic Map of Godavari sub-basin	85
Figure 2.6	CWC Gauge Discharge sites & IMD Rain Gauge sites of Godavari sub-basin	86
Figure 2.7	Hydroelectric Project on Godavari River	89
Figure 2.8	Geological Features of Godavari River	90
Figure 2.9	Hydroelectric Project on Pranhita River	93
Figure 2.10	Geological Features of Pranhita River	94
Figure 2.11	Hydroelectric Project on Indravati River	97
Figure 2.12	Geological Features of Indravati River	98
Figure 2.13	Hydroelectric Project on Sabari River	100

Figure No.	Details	Page No.
Figure 2-14	Geological Features of Sabari River	101
Figure 2.15	Hydroelectric Projects in Krishna sub-basin	108
Figure 2.16	Topographical (Elevation Data) Map of Krishna sub-basin	109
Figure 2.17	Ecologically Sensitive Area Map of Krishna sub-basin	110
Figure 2.18	Geological Map of Krishna sub-basin	111
Figure 2.19	Seismic Map of Krishna sub-basin	112
Figure 2.20	CWC Gauge Discharge sites & IMD Rain Gauge sites of Krishna sub-basin	113
Figure 2.21	Hydroelectric Project on Krishna River	116
Figure 2.22	Geological Features of Krishna River	117
Figure 2.23	Hydroelectric Project on Indrayani River	119
Figure 2.24	Geological Features of Indrayani River	120
Figure 2.25	Hydroelectric Project on Tungbhadra River	122
Figure 2.26	Geological Features of Tungbhadra River	123
Figure 2.27	Hydroelectric Projects in Cauvery sub-basin	132
Figure 2.28	Topographical (Elevation Data) Map of Cauvery sub-basin	133
Figure 2.29	Ecologically Sensitive Area Map of Cauvery sub-basin	134
Figure 2.30	Geological Map of Cauvery sub-basin	135
Figure 2.31	Seismic Map of Cauvery sub-basin	136
Figure 2.32	CWC Gauge Discharge sites & IMD Rain Gauge sites of Cauvery sub-basin	137
Figure 2.33	Hydroelectric Project on Cauvery River	140
Figure 2.34	Geological Features of Cauvery River	141
Figure 2.35	Hydroelectric Project on Bhavani River	144
Figure 2.36	Geological Features of Bhavani River	145
Figure 2.37	Hydroelectric Projects in South of Cauvery sub-basin	148
Figure 2.38	Topographical (Elevation Data) Map of South of Cauvery sub-basin	149
Figure 2.39	Ecologically Sensitive Area Map of South of Cauvery sub-basin	150

Figure No.	Details	Page No.
Figure 2.40	Geological Map of South of Cauvery sub-basin	151
Figure 2.41	Seismic Map of South of Cauvery sub-basin	152
Figure 2.42	CWC Gauge Discharge sites & IMD Rain Gauge sites of South of Cauvery sub-basin	153
Figure 2.43	Hydroelectric Project on Suruli River	155
Figure 2.44	Geological Features of Suruli River	156
Figure 2.45	Hydroelectric Project on Thamirabarani River	158
Figure 2.46	Geological Features of Thamirabarani River	159
Figure 4.1	Location of Dam site, Powerhouse Site of Dummugudem H.E. Project with respect to Kinnerasani and Eturnagram Eco-Sensitive	457
Figure 4.2	Location of Dam and Powerhouse Site of Nugur- II H.E. Project with respect to Indravati National Park	458
Figure 4.3	Location of Dam and Powerhouse Site of Bhopalapatnam H.E. Project with respect to Indravati National Park	458
Figure 4.4	Location of Dam and Powerhouse Site of Nugur-I H.E. Project with respect to Indravati National Park	459
Figure 4.5	Location of Dam and Powerhouse Site of Kunghara H.E. Project with respect to Chaprala Wildlife Sanctuary	459
Figure 4.6	Location of Dam and powerhouse site of Lower Moyar H.E. Project, Nilgiri, Tamil Nadu	463
Figure 5.1	Specific Flow at Polavaram	524
Figure 5.2	Specific Flow at Koida	524
Figure 5.3	Specific Flow at Perur	524
Figure 5.4	Specific Flow at Somanpally	525
Figure 5.5	Specific Flow at Mancherial	525
Figure 5.6	Specific Flow at all sites	525
Figure 5.7	Koida-Flood frequency estimates by different methods	528
Figure 5.8	Pathagudem-Flood frequency estimates by different methods	529
Figure 5.9	Mancherial-Flood frequency estimates by different methods	529
Figure 5.10	Perur-Flood frequency estimates by different methods	529
Figure 5.11	Polavaram-Flood frequency estimates by different methods	530
Figure 5.12	Flood frequency estimate at Tupakulagudem barrage site	531
Figure 5.13	Diagram of the Godavari river system showing Raingauge stations	544

Figure No.	Details	Page No.
Figure 5.14	Diagram of the Godavari river system showing Isohyetal map of Normal rainfall	545
Figure 5.15	Diagram the Godavari river system showing Gauge and Discharge stations	546
Figure 5.16	Catchment Area of Project and Locations of Dam and G&D site	548
Figure 5.17	IMD Grid Rainfall Data for Dummugudem Project site and G&D site	550
Figure 5.18	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Perur G&D site	554
Figure 5.19	Plot of runoff coefficient at Perur G&D Site	555
Figure 5.20	EAC curve of Dummugudem Dam	562
Figure 5.21	Catchment Area of Project and Locations of Dam and G&D site	569
Figure 5.22	IMD Grid Rainfall Data for Bodhghat Project site and G&D site	571
Figure 5.23	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site	575
Figure 5.24	Plot of Runoff Coefficient at G&D site	576
Figure 5.25	EAC curve of Bodhghat Dam	583
Figure 5.26	Catchment Area of Project and Locations of Dam and G&D site	589
Figure 5.27	IMD Grid Rainfall Data for Kutru-I Project site and G&D site	591
Figure 5.28	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site	595
Figure 5.29	Plot of Runoff Coefficient at G&D site	596
Figure 5.30	EAC curve of Kutru-I Dam	603
Figure 5.31	Catchment Area of Project and Locations of Dam and G&D site	609
Figure 5.32	IMD Grid Rainfall Data for Kutru-II Project site and G&D site	611
Figure 5.33	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site	615
Figure 5.34	Plot of Runoff Coefficient at G&D site	616
Figure 5.35	EAC curve of Kutru-II Dam	623
Figure 5.36	Catchment Area of Project and Locations of Dam and G&D site	629
Figure 5.37	IMD Grid Rainfall Data for Nugur-I Project site and G&D site	631
Figure 5.38	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tumnar G&D site	635

Figure No.	Details	Page No.
Figure 5.39	Plot of Runoff Coefficient at G&D site	636
Figure 5.40	Daily Rainfall-Runoff Correlation at Tumnar G&D Site	637
Figure 5.41	EAC curve of Nugur-I Dam	645
Figure 5.42	Catchment Area of Project and Locations of Dam and G&D site	650
Figure 5.43	IMD Grid Rainfall Data for Kotri Project site and G&D site	652
Figure 5.44	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tumnar G&D site	656
Figure 5.45	Plot of Runoff coefficient at G&D site	657
Figure 5.46	EAC curve of Kotri Dam	664
Figure 5.47	Catchment Area of Project and Locations of Dam and G&D site	670
Figure 5.48	IMD Grid Rainfall Data for Wainganga Project site and G&D site	672
Figure 5.49	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site	676
Figure 5.50	Plot of Runoff Coefficient at G&D site	677
Figure 5.51	EAC curve of Wainganga Dam	684
Figure 5.52	Catchment Area of Project and Locations of Dam and G&D site	691
Figure 5.53	IMD Grid Rainfall Data for Samda Project site and G&D site	693
Figure 5.54	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site	697
Figure 5.55	Plot of Runoff Coefficient at G&D site	698
Figure 5.56	EAC curve of Samda Dam	705
Figure 5.57	Catchment Area of Project and Locations of Dam and G&D site	711
Figure 5.58	IMD Grid Rainfall Data for Kunghara Project site and G&D site	713
Figure 5.59	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site	717
Figure 5.60	Plot of Runoff Coefficient at G&D site	718
Figure 5.61	EAC curve of Kunghara Dam	725
Figure 5.62	Catchment Area of Project and Locations of Dam and G&D site	731
Figure 5.63	IMD Grid Rainfall Data for Pranhita Project site and G&D site	733
Figure 5.64	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tekra G&D site	737
Figure 5.65	Plot of Runoff coefficient at the G&D	738

Figure No.	Details	Page No.
Figure 5.66	EAC curve of Pranhita Dam	745
Figure 5.67	Catchment Area of the Project and Locations of Dam Site	751
Figure 5.68	IMD Grid Rainfall Data for Balimela Project site	753
Figure 5.69	Comparison of Annual Rainfall and Annual Runoff in mm at Balimela Dam site	756
Figure 5.70	EAC curve of Balimela Dam	763
Figure 5.71	Catchment Area of Project and Locations of Dam and G&D site	768
Figure 5.72	IMD Grid Rainfall Data for Konta Project site and G&D site	770
Figure 5.73	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tekra G&D site	775
Figure 5.74	Plot of Runoff coefficient at the G&D	776
Figure 5.75	EAC curve of Sabari Dam	785
Figure 5.76	EAC curve of Sileru Dam	786
Figure 5.77	Catchment Area of Project Locations of Dams and G&D site	794
Figure 5.78	IMD GRID Rainfall Data for Project site and Dam site	796
Figure 5.79	Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Huvinhedgi G&D site	801
Figure 5.80	Plot of Runoff Coefficient at G&D Site	802
Figure 5.81	Plot of Runoff Coefficient at Narayanpur Dam site	802
Figure 5.82	EAC curve of Tamankal Dam	813
Figure 5.83	Catchment Area of Project and Locations of Dam site	820
Figure 5.84	IMD GRID Rainfall Data for Jaldurg Diversion Site & Dam site	822
Figure 5.85	Plot of Monthly Rainfall (mm) and Monthly Runoff (mm) at Huvinhedgi G&D site	829
Figure 5.86	Plot of Runoff Coefficient at G&D Site	829
Figure 5.87	Plot of Runoff Coefficient at Narayanpur Dam site	830
Figure 5.88	EAC curve of Jaldurg Diversion	845

CHAPTER – 5
HYDROLOGICAL STUDIES

5.0 General

5.0.1 Introduction

5.0.1.1 Objective of the Study

Hydrological inputs play a vital role in planning, execution and operation of any hydropower development project.

The overall objective of the hydrological study is enumerated as follows

1. Developing flow series on 10-daily/monthly basis for assessment of water availability at the present project site based on hydrological data.
2. Computation of 90% and 50% dependable year flows.
3. Designing flood studies for various return periods at the proposed project site.
4. Assessment of submergence area and preparation of area-elevation-capacity curves for the proposed project site.

All projects which are under planning/ DPR stage have been taken up for hydrological studies.

5.0.1.2 Present Study

Hydrological study has to be carried out to assess the hydro potential from the project & the basin for overall estimation of hydro-potential for the country. As such the study would be largely broad based due to limitations of data availability and would be similar to feasibility/prefeasibility study presenting a holistic view of hydro potential in the river basin & country as a whole. However a detailed study would be carried out later during detailed project stage.

Hydrological studies have not been carried out for the following projects as they have been found to be environmentally not feasible as mentioned in **Chapter-4**:

- Lower Moyar
- Nugur-II
- Bhopalpatnam

5.0.1.3 Methodology for Generating Flow Series

Long-term runoff data at the project sites are generally not available. As such, the rainfall-runoff correlation method has been used to develop the flow series or the observed runoff data of G&D site to be transposed to proposed project site in catchment area proportion together with corresponding long term annual rainfall at the project site. The correlation is developed between 10 daily rainfall (in mm) and 10 daily runoff at the G&D Site for monsoon season (Jun-Nov). The correlation equation thus developed, is used at the project site to generate 10 daily flow series for monsoon period (Jun-Nov). For, non-monsoon period, discharge data is missing for majority of the years at some of the G&D sites, since the river is non-perennial at those sites.

5.0.1.4 Methodology for Estimating Design Flood

As no observed flood peak data are available at the project sites, the flood peaks available at the G&D site location has been used to estimate the project design flood. The Gumbel distribution method has been used to derive the different return period flood at the project site.

5.0.2 Catchment and the River System

5.0.2.1 General

GIS processing of SRTM Digital Elevation Model (DEM) of 30 m resolution has been used to estimate catchment area of the Dam and G&D sites.

5.0.3 Water Availability Studies

5.0.3.1 Data Availability

Data relevant to hydrological assessment of the project is not generally available at present. However, discharge data at the CWC G&D site is available and can be downloaded from India WRIS site. In addition to this, IMD rainfall data with a resolution of 0.25 degree x 0.25 degree is available for the entire country, which can be used for the development of flow series at the project site.

5.0.3.2 Rainfall and Runoff Data at G&D Site

Detailed calculations on water availability and flood magnitude will lead to selecting the design features of the project (installed capacity, turbine flow, spillway capacity, etc.). These features will directly reflect on the project cost and on the quantity and value of energy produced.

Thus, a gross consistency check has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the time for the Hydrological years to assess the consistency and reliability of data.

5.0.3.3 Rainfall Data

a) Methodology for Estimation of Rainfall Data

IMD daily rainfall grid data with a resolution of 0.25 degree x 0.25 degree for the Hydrological year were collected for the influencing grid points lying in the catchment area of proposed Hydroelectric Project and G&D site. Subsequently daily rainfall (in mm) as per the basin boundary was estimated. Average of daily rainfall for the entire IMD grid data falling in basin boundary is calculated to find the average daily rainfall of the catchment area. However, if in any case, no grid data point falls inside the basin boundary, nearest grid data points are used to find the average rainfall for the basin. After daily rainfall, 10-daily rainfall and monthly average rainfall is estimated for the G&D and dam catchments.

b) Average Annual Rainfall

Catchment area rainfalls for the Hydrological years have been considered to derive the rainfall factor at different dam sites. Average Annual rainfall for the G&D site and dam sites are given in respective project details. Also, 10 daily rainfall variations for the G&D site and the dam sites are also provided.

c) Methodology for Estimation of Runoff

The daily runoff data from INDIA WRIS site was downloaded and converted into 10 daily runoff for the entire data availability period and same has been utilized in the present study. Since CWC before uploading the discharge data, carryout relevant consistency checks as such, at present the checks have not been carried out in detail.

5.0.4 Flow Series Computation

It is proposed to use 10 daily rainfall-10 daily runoff correlations in mm for monsoon period for deriving the flow series at the project site. As there is no observed discharge data at the project site, the rainfall-runoff correlation has been developed at the CWC G&D Site. The correlation thus developed has been used to derive the flow series at

the project site. The Rainfall-Runoff (R-R) relationship was attempted for each monsoon month using the observed Rainfall-Runoff data on 10 Daily basis at the G&D site. However, it was noticed that the correlation coefficient in respect of each monsoon month was very weak. As such, attempt was made to develop relationship between the entire monsoon period rainfall and runoff. Since large number of values exists (even after deleting the outliers), the correlation coefficient improved. As such the same has been considered in the present study.

Wherever the proposed project site is within the same Hydro-Metrological region of G&D site and wide variation in catchment area do not exist, then G&D site data is transposed to proposed project site in catchment area and rainfall proportion.

5.0.5 90% & 50% Dependable Flows

Having prepared the long term 10-daily flow series at the proposed hydropower sites, the 90% and 50% dependable year flows have been found out using Weibull's plotting positions. The computation of 90% and 50% dependable year and the corresponding year flows are given in the respective project details.

5.0.6 Elevation Area Capacity Curve

Reservoir elevation-area-capacity (EAC) is important for planning and operation purposes. The original reservoir elevation-area-capacity curve at a dam site can be prepared from the available topographical maps. The incremental volume between any two contour elevations has been found out by the following formula

$$\Delta V_i = \Delta h\left(A_i + A_{i+1} + \sqrt{A_i A_{i+1}}\right)/3$$

Where,

ΔV_i = Volume between contour elevations i and i+1,

Δh = Contour interval,

A_i = Area at contour elevation i,

A_{i+1}= Area at contour elevation 1+i,

For the projects the contours are generated from the SRTM 30 m DEM and the area against the corresponding elevation has been extracted for developing the EAC curves of a particular dam site.

5.0.7 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important as an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value will place the structure and population at risk.

5.0.7.1 Computation of Design Flood

Since no short interval rainfall runoff data is available either at G&D site or proposed project site, as such Hydro-Metrological approach for estimation of design flood could not be attempted. Accordingly frequency approach is used to estimate the design flood.

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the G&D site. Therefore, it has been proposed to estimate the return period flood using Gumbel distribution and then transposed the flood peak to the project site based on Dicken's formula which will then be subjected to frequency analysis.

5.0.8 Limitations and Recommendations

The hydrological studies have been carried out with limited available data & Data constraints. For more accurate estimate, data at project site as per accepted norms to be measured.

For preliminary planning purpose the present hydrological studies may be carefully utilized until the site specific data is made available. Once the site specific data is available hydrological studies would need review.

5.1 Hydrology of Tupakulagudem Hydroelectric Project

5.1.1 General

The Tupakulagudem project proposed across Godavari River at Thupakulagudem, envisages construction of barrage for lifting water for Kaleshwaram Lift Irrigation and also for stabilizing the Devadula Lift Irrigation Scheme sticking to the provision as per the Godavari Water Dispute Tribunal Award. As far as the diversion potential is concerned, it is function of many factors including magnitude and pattern of river flow, storage available at the site, capacity of the diversion canal (or capacity of pumps), besides U/S and D/S water allocations for existing and future projects for irrigation and other uses. Where little or no storage is available on the river day-to-day availability of river flow at the site and diversion canal capacity assumes greater importance. The portion of diverted quantity that can be put to actual use is further governed by the magnitude and pattern of project requirements, the storage, and conveyance and distribution capacity of the water resources system.

5.1.2 Methodology adopted to arrive at the net availability of water at Tupakulagudem barrage site

The Proposed Tupakulagudem Barrage site (Latitude: 18°35'9.24"N, Longitude: 80°23'35.57"E) on Godavari River is located about 3km upstream of Perur G&D site maintained by Central Water Commission. The sub-basins up to Perur on main Godavari are as under:

Table 5.1: Sub-basin classification upto Perur

Sl. No.	Sub-Basin	Description
1	Upper Godavari	The river Godavari from source to confluence with Manjra excluding Pravara, Purna & Manjra
2	Pravara	Pravara up to confluence with Godavari
3	Purna	The entire catchment of Purna
4	Manjra	The entire catchment of Manjra
5	Middle Godavari	The Catchment from confluence with Manjra to its confluence with Pranahita
6	Manair	The Manair from source to confluence with Godavari
7	Penganga	The catchment of Penganga from source to confluence with Wardha

8	Wardha	Catchment of Wardha up to confluence with Pranahita
9	Pranahita	Catchment of Pranahita up to confluence with Godavari
10	Indravati	Catchment of Indravati up to confluence with Godavari

The Godavari basin marking the sub-basins as shown in **Figure 5.13**. The Schematic diagram of the Godavari river system showing Raingauge stations, Isohyetal map of Normal rainfall of Godavari basin and Map of Gauge and Discharge stations in the basin are given in **Figure 5.14** and **Figure 5.15** respectively. The rain gauges and hydrological observation stations that can be considered for carrying out the studies are given in **Table 5.8** and **Table 5.9** respectively. The observed flow data at Perur is being used for assessing the availability of water at Tupakulagudem Barrage site. The observed flow (monthly) data at Perur for the period from 1966-67 to 2012-13(47 years) is given in **Table 5.10.**

5.1.2.1 Water Availability at Tupakulagudem Barrage Site

5.1.2.1.1 Data Consistency

For this study, the flow data of the CWC hydrological observation station namely Polavarm, Koida, Perur, Somanpally and Mancherial are used. The consistency check has been carried out by specific flow analysis and results are as under.

Table 5.2: Specific Flows at Perur and adjoining sites on Godavari (ltrs/sec/sq.km)

Name of the Site	Polavaram	Koida	Perur	Somanpally	Mancherial
June	849063	1054733	741896	70863	744961
July	6028669	6389981	4842500	492870	4762343
August	11797621	13331942	9577856	1310953	9535893
September	8466875	8628774	6919188	1303360	6624625
October	3510786	3685957	2685605	728491	2542218
November	917938	985203	692229	131444	648804
December	520585	571369	297399	57205	292174
January	368891	418548	194261	36305	180408
February	307902	367431	156317	33347	148778
March	262016	323890	111149	31618	107964
April	239875	271049	70361	17825	66069
May	225242	272569	63085	11180	53632

The graphical representation of the results are given as **Fig 5.1 to Fig 5.6**

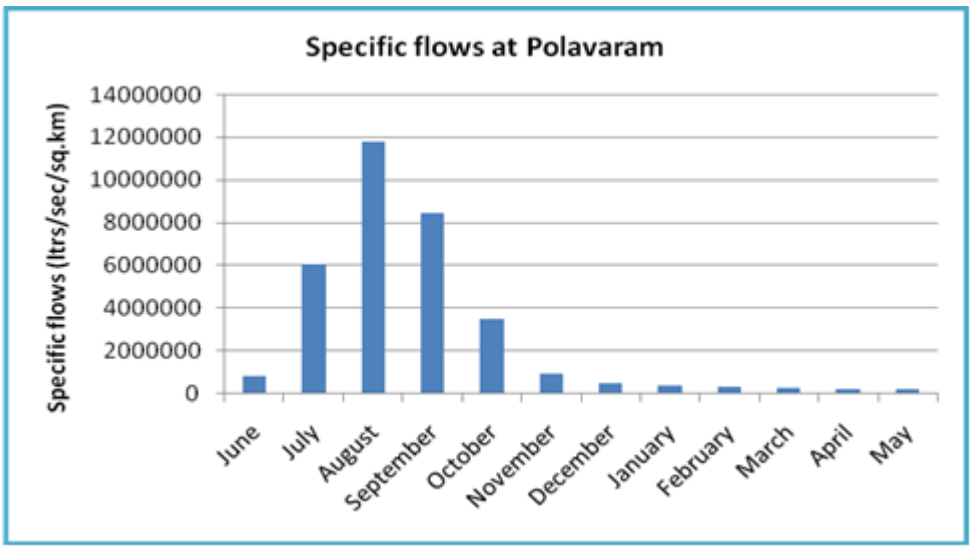


Fig 5.1

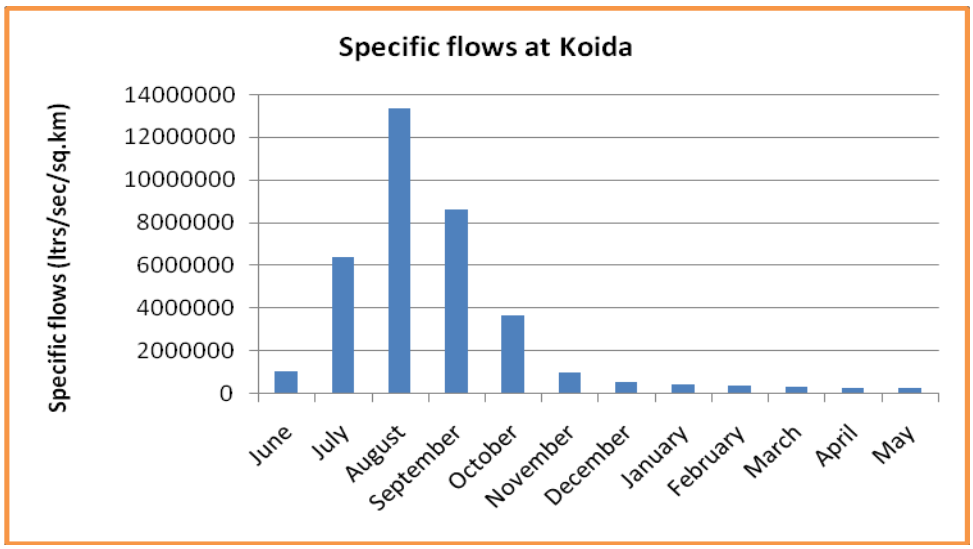


Fig 5.2

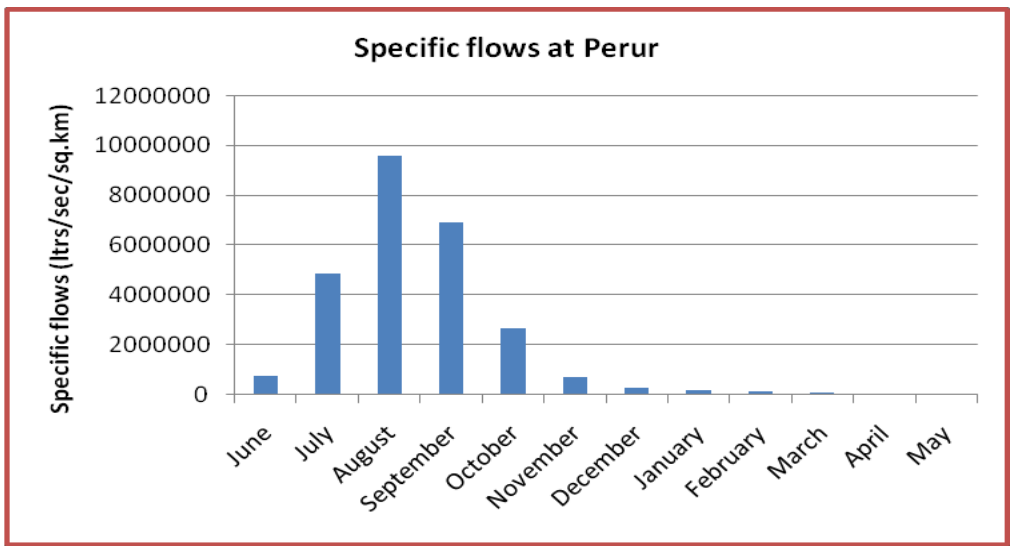


Fig 5.3

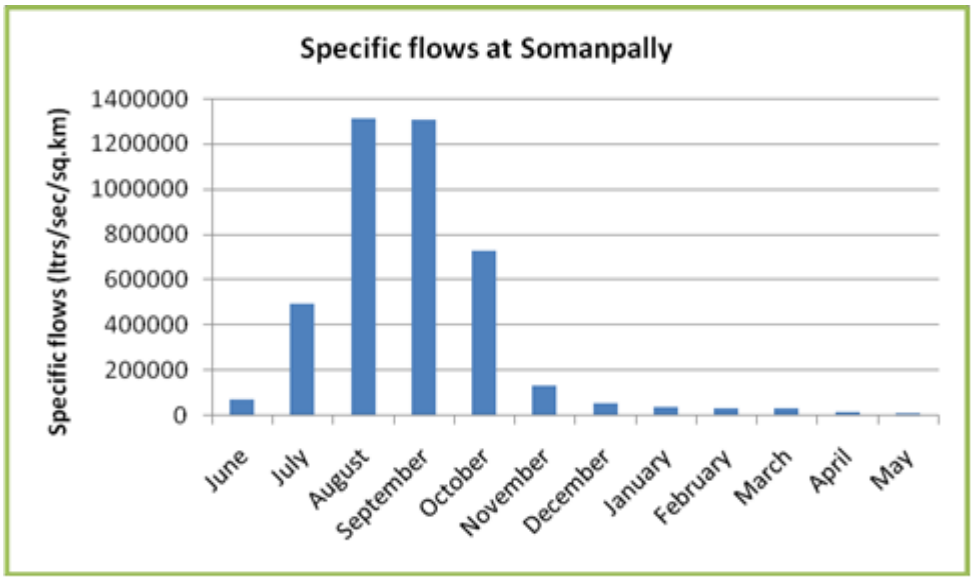


Fig 5.4

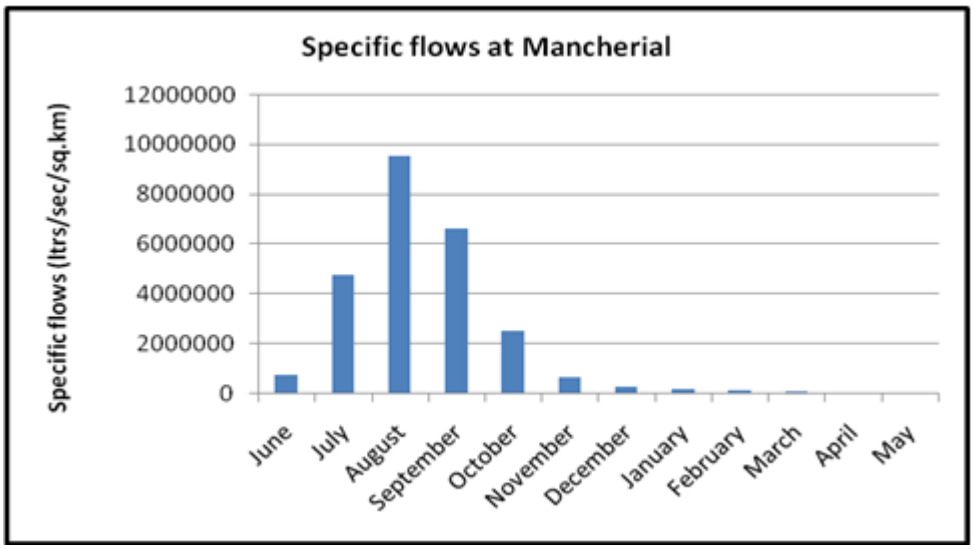


Fig 5.5

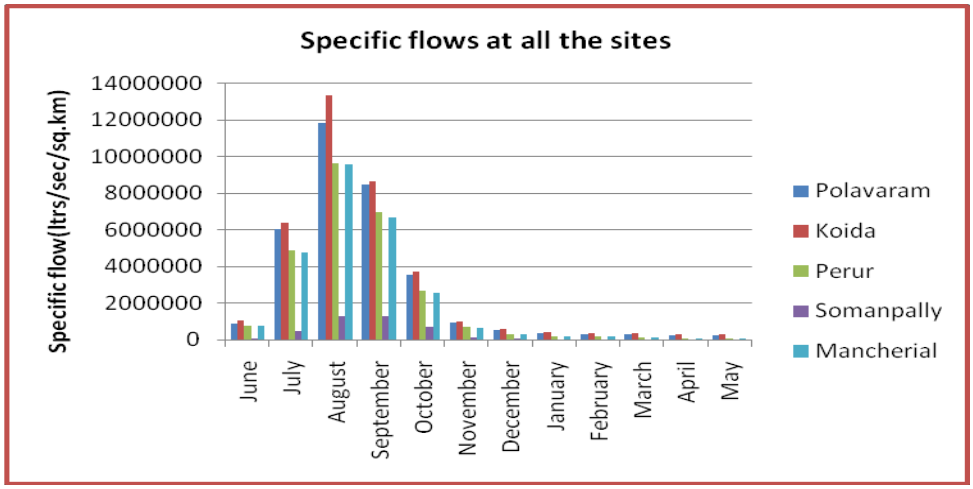


Fig 5.6

5.1.2.1.2 Net Water Availability at Tupakulagudem Site

As already mentioned the Perur G&D site maintained by Central Water Commission is very close to the proposed barrage at Tupakulagudem (approximately 3km upstream). It is decided to consider the data at Perur for assessing the net availability of water at the project site taking into account the utilization under ongoing and planned projects as the existing utilization is already reflected in the observed data at Perur. The utilization likely to take place under ongoing and planned in the sub - basins above perur are as under.

Table 5.3: Utilization in Sub-basin

Sub-basin	Proposed Utilisation for Ongoing Projects		Proposed Utilisation for Future Projects		Total Utilisation for Ongoing and Proposed projects	
	MCM	TMC	MCM	TMC	MCM	TMC
Indravati	255.0	9.0	9827.0	347.0	10082.0	356.0
Penganga	1664.7	58.8	1562.6	55.2	3227.3	114.0
Wardha	1643.0	58.0	515.5	18.2	2158.5	76.2
Pranahita	4940.0	174.4	7765.4	274.2	12705.4	448.6
Middle Godavari	1806.3	63.8	1927.9	68.1	3734.2	131.9
Maner	3.9	0.1	4.4	0.2	8.3	0.3
Sub Total	**10312.9**	**364.1**	**21602.8**	**763.0**	**31915.7**	**1127.1**

The observed flow data at Perur (CA – 2,68,200 sq.km) has been reduced pro rata at Tupakulagudem barrage site(CA-2,68,000 sq.km) and the 75% dependable flow at the barrage site is 1534.4 TMC (**Table 5.11**). The net water availability at Tupakulagudem barrage site for the present purpose considering utilization under ongoing and planned projects as mentioned above are given in the Tabular form given under.

Table 5.4 Net Availability of water at Tupakulagudem site

Units	75% dependable flow at Perur reduced pro rata	Utilization under ongoing	Utilization under planned	Net Availability at 75% dependability
MCM	43450.6	10312.9	21602.8	11535.0
TMC	1534.7	364.3	763.0	407.4*

* Excluding water requirement of Kaleshwaram Lift Project.

5.1.3 Design Flood

5.1.3.1 General

The design flood for the barrage at Tupakulagudem, is been determined keeping in view the criteria laid done in IS 6966 Part-I 1989 – "Hydraulic Design of Barrage and Weirs". According to this code the design flood for Barrages and Weirs should be 50 year flood. However, in this particular case 100 year flood is proposed to be considered as design flood for barrage. For, fixing the free board normally 500 year return period flood or Standard Project Flood (SPF) as the case may be can be considered. Since the catchment area intercepted by the barrage is quite large, estimation of standard project flood can be time consuming particularly with regard to collection of requisite hydro-meteorological data and keeping in view the urgency in the preparation of feasibility report it is decided to estimate the design flood by resorting to frequency approach utilizing the annual peak discharge data **(Table 5.12 & 5.13)** readily available at the CWC sites namely Polavaram, Koida, Perur, Somanpally and Mancherial on Godavari/Tributaries of Godavari.

5.1.3.2 Design Flood at Tupakulagudem Site

Frequency Analysis has been conducted using the data of the above mentioned sites and the flood values against various return periods viz: 50, 100 and 500 year have been arrived at. Before the annual peak data is subjected to frequency analysis as is customary Chi Square Test/ Kolmogorov-Smirnov (K-S) tests on the data have been carried out to decide up on the type of distribution to which the data fits. The software HYFA has been used for the study. The results of the study are given in the table below.

Table 5.5 Result of Flood Frequency Analysis for different distributions and return period

Site Name		Koida	Pathagudem	Mancherial	Perur	Polavaram
Catchment Area in Sq. km		305460	40000	102900	268200	307800
Years of Data		29	47	48	47	47
Gumbel Type I	50 Year	68353.5	30870.6	25892.4	67155.0	66860.3
	100 Year	77128.9	34380.5	29620.5	74918.8	74258.2
	500 Year	93571.2	42491.4	38235.7	92859.9	91353.7

Site Name		Koida	Pathagudem	Mancherial	Perur	Polavaram
Log Normal 2- Parameter	50 Year	70412.4	33321.6	32722.6	66040.4	63001.4
	100 Year	79052.9	37824.6	40863.3	74187.9	69756.6
	500 Year	99922.0	48886.8	64064.8	93884.4	85726.8
Log Normal 3- Parameter	50 Year	68236.5	32821.2	30613.8	61284.5	58265.3
	100 Year	75324.9	36907.0	35549.3	66461.7	62371.0
	500 Year	91601.4	46680.8	47420.5	77689.1	71039.0
Pearson type - III	50 Year	69726.6	33561.6	31547.1	61758.3	58528.7
	100 Year	77302.7	37809.0	36694.2	67068.2	62718.5
	500 Year	94484.5	47654.9	48672.6	78543.1	71568.1
Log Pearson type - III	50 Year	71480.0	33591.5	33053.6	64977.7	59884.2
	100 Year	80014.5	38115.1	37723.6	71179.7	64057.3
	500 Year	100217.0	49175.6	46649.0	84462.3	72329.9
2 Parameter Gamma	50 Year	66277.0	30699.9	32472.4	63706.1	61008.8
	100 Year	72523.8	33769.2	38299.9	69945.5	66312.2
	500 Year	86344.2	40594.2	52146.8	83794.3	77969.1
Accepted values	50 Year	**66277**	**30871**	**25892**	**63706**	**58265**
	100 Year	**77129**	**34381**	**29621**	**74919**	**66312**
	500 Year	**93571**	**42491**	**38236**	**92860**	**77969**

The return period versus flood peaks plot using the results in the table above is given under:

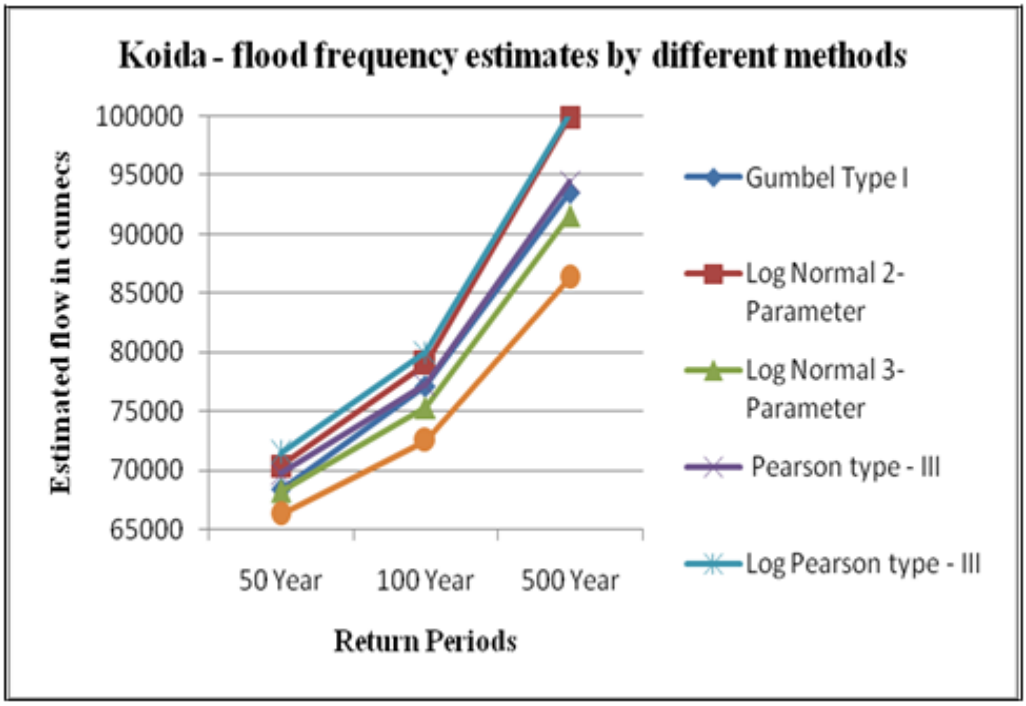


Fig 5.7

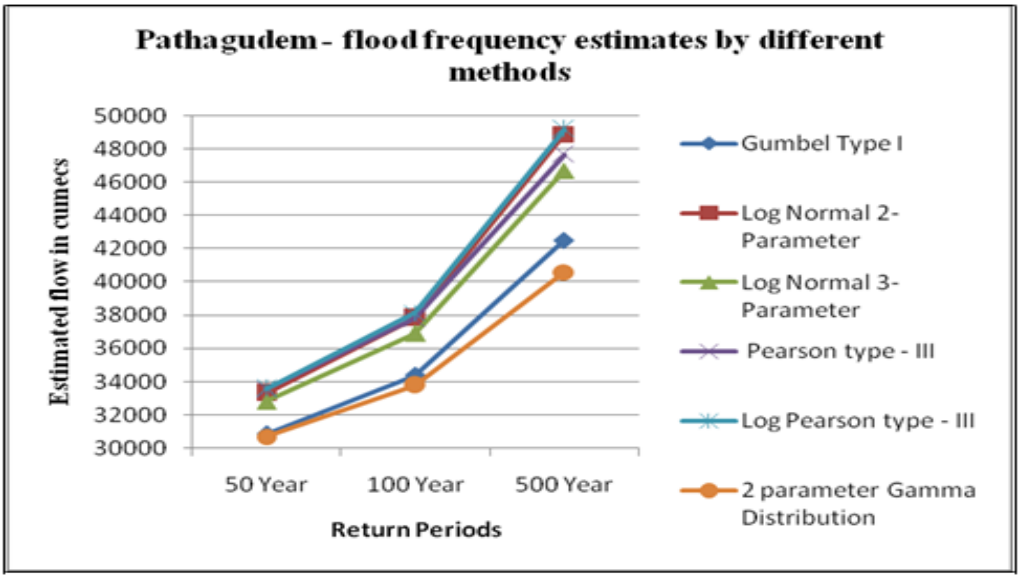


Fig 5.8

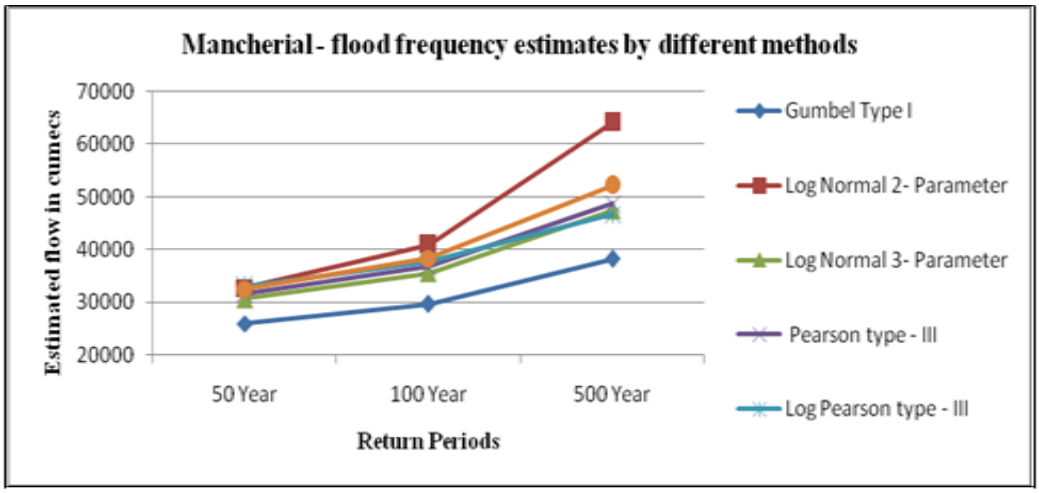


Fig 5.9

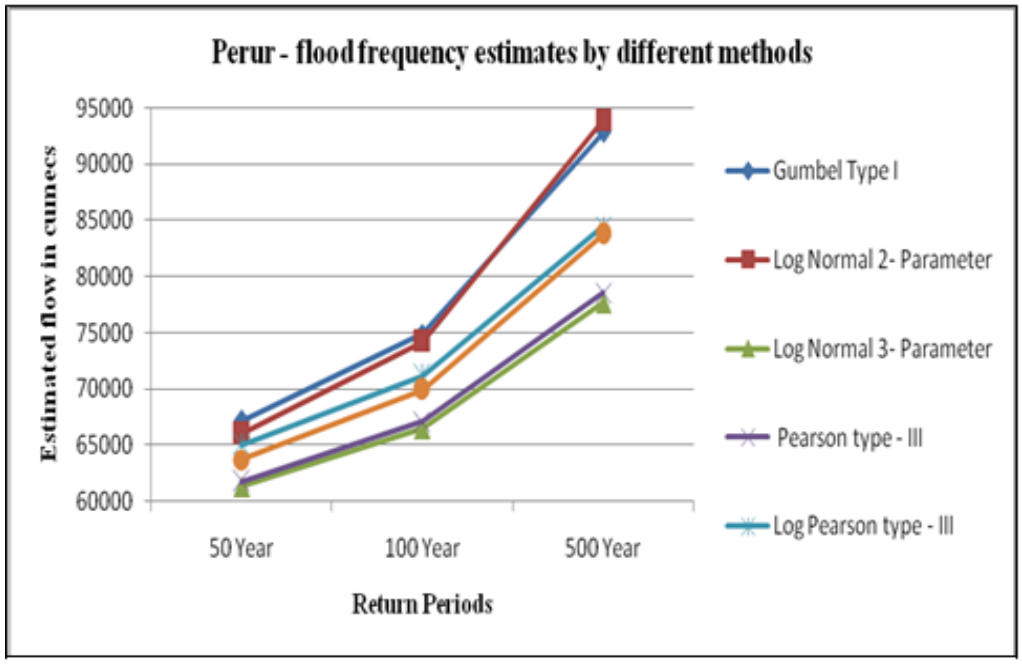


Fig 5.10

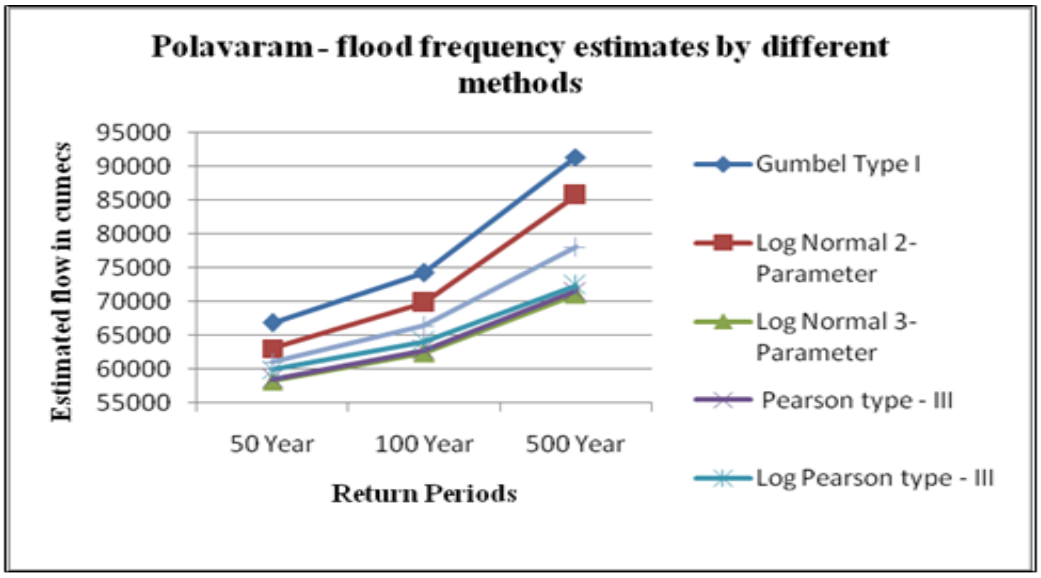


Fig 5.11

The weighted average value of C pertaining to each return period on the basis of data length has been worked out and presented in the **Table 5.6**. The flood values for the various return periods for barrage at Tupakulagudem, have been worked out using the weighted average value of C as mentioned for the respective return periods and the results are furnished in the **Table 5.7**.

Table 5.6 Dicken's C calculation

Dicken's C calculation					
Site Name	**Catchment Area in Sq.Km**	**Years of Data**	**Dicken's 'C' in Q=C (A^0.75 for the accepted values)**		
			50 Year	**100 Year**	**500 Year**
Koida	305460	29	5.101	5.936	7.202
Pathagudem	40000	47	10.914	12.155	15.023
Mancherial	102900	48	4.507	5.156	6.655
Perur	268200	47	5.406	6.357	7.879
Polavaram	307800	47	4.459	5.074	5.967
Average weighted by data length			**6.151**	**7.010**	**8.647**

Table 5.7 Design Flood at Tupakulagudem

Site Name	Catchment Area in Sq.Km	Q = C*A$^{0.75}$ m^3/s		
		50 Year	100 Year	500 Year
At Tupakulagudem Barrage Site	268000	72488	82616	101912

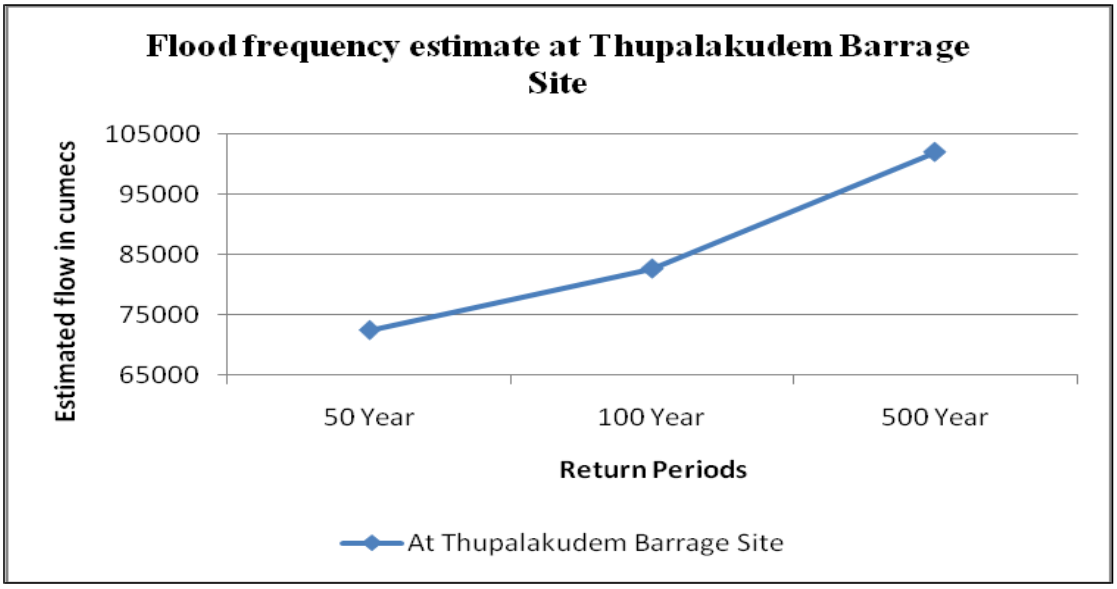


Fig 5.12

The 100 year return period flood of say 85,000 cumecs is proposed to be adopted as the design flood for the Tupakulagudem barrage. The 500 year flood of magnitude 1, 02,000 cumecs is proposed to be considered for fixing the free board.

5.1.4 Sedimentation

Since the proposed structure at Tupakulagudem is only barrage, the chance of facing any problem on account of sedimentation is quite remote and if at all encountered it is going to be quite insignificant. Therefore, detailed sedimentation study is perhaps not needed.

Table 5.8 : Details of CWC G&D sites in Godavari Basin

Sl.No.	Site Name	Code	Data Available		In between missing years	
			From	To	From	To
1	Amabal	AGC90C8	1994-95	1997-98	-	-
2	Ashti	AGH40A4	1965-66	1997-98	-	-
3	Ashwi	AGU00N3	1972-73	1995-96	-	-
4	Babli	NA	1965-66	1977-78	-	-
5	Badegaon	AGG30S1	1989-90	1991-92	-	-
6	Bamni	AGH30E2	1965-66	1997-98	-	-
7	Basar	NA	1967-68	1981-82	-	-
8	Bhatpalli	AGH10L0	1991-92	1997-98	-	-
9	Betmogra	AGP10F7	1987-88	1997-98	-	-
10	Bhatkheda	AGP00R7	1991-92	1997-98	-	-
11	Bhisnur	AGH30S9	1988-89	1997-98	-	-
12	Chass	AG000Y5	1972-73	1997-98	-	-
13	Cherla	AGE00C6	1967-68	1988-89	-	-
14	Cherribeda	NA	1997-98	1997-98	-	-
15	Chindnar	AGG00N7	1971-72	1997-98	-	-
16	Degloor	AGP20F4	1987-88	1997-98	-	-
17	Dhalegaon	AG000S9	1965-66	1997-98	-	-
18	G.R.Bridge	AG000R6	1976-77	1997-98	-	-
19	Gandlapet	AGM00G6	1987-88	1997-98	-	-
20	Ghargaon	AGU10R6	1994-95	1997-98	-	-
21	Ghugus	AGH30F6	1965-66	1997-98	-	-
22	Hivra	AGH30Q1	1988-89	1997-98	-	-
23	Injaram	AGC00D2	1965-66	1997-98	-	-
24	Jagdalpur	AGG00R9	1965-67	1997-99	-	-
25	Jalaput	NA	1966-67	1973-74	-	-
26	Kaigaon	NA	1965-66	1966-67	-	-
27	Kanhargaon	AGH32R8	1992-93	1997-98	-	-
28	Karodi	AGH32P3	1968-69	1991-92	-	-
29	Keolari	AGH40V3	1988-89	1997-98	-	-
30	Koida	AG000C7	1977-78	1997-98	-	-
31	Konta	AGC00C5	1965-66	1997-98	1977-78	1977-78
32	Kosagumda	NA	1997-98	1997-98	-	-
33	Kotta	AGC00V6	1969-70	1990-91	-	-
34	Kumhari	AGH40R6	1988-89	1997-98	-	-
35	Mancherial	AG000J3	1966-67	1997-98	-	-
36	Mangrul (Taroda)	AGH35G0	1992-93	1997-98	-	-
37	Manjlegaon	AGS00C5	1965-66	1995-96	-	-
38	Marlegaon	AGH32N7	1965-66	1997-98	-	-
39	Medadapalli	AGG00F2	1973-74	1997-98	-	-
40	Medapalli	AGG40A7	1966-67	1997-98	-	-
41	Murthahandi	AGC40E9	1989-90	1997-98	-	-
42	Nandgaon	AGH3AF4	1988-89	1997-98	-	-
43	Nil Konda	NA	1969-70	1972-73	-	-
44	Nowrangpur	AGG00U7	1965-66	1997-98	-	-
45	Pachegaon	AGU00D3	1983-84	1997-98	-	-

			From	To	From	To
46	Pathagudam	AGG00B5	1965-66	1997-98	-	-
47	Pauni	AGH40I8	1965-66	1997-98	-	-
48	Penganga Bridge	AGH32D5	1965-66	1997-98	1987-88	1987-88
49	Perur	AG000G7	1965-66	1997-98	-	-
50	Phalla	NA	1966-67	1975-76	-	-
51	Pochavaram	NA	1965-66	1976-77	-	-
52	Polavaram	AG000C3	1965-66	1997-98	-	-
53	Potteru	AGC20H2	1997-98	1997-98	-	-
54	Purna	AGR00A5	1969-70	1997-98	-	-
55	Raipally	NA	1965-66	1986-87	-	-
56	Rajegaon	AGH4MC3	1988-89	1997-98	-	-
57	Rajoli	AGH41Q4	1988-89	1997-98	-	-
58	Ramakona	AGH4BQ3	1988-89	1997-98	-	-
59	Saigaon	AGP00N8	1967-68	1997-98	-	-
60	Salebardi	AGH49I1	1988-89	1997-98	-	-
61	Sardaput	AGC00N4	1970-71	1997-98	-	-
62	Satrapur(K.R.Brid	AGH4BF6	1988-89	1997-98	-	-
63	Sirpur	AGH30B6	1967-68	1997-98	1987-88	1987-88
64	Sirpur Kagaznaga	AGH10L0	1988-89	1990-91	-	-
65	Somanpally	AGI00C3	1966-67	1997-98	-	-
66	Sonarpal	AGG91F2	1994-95	1997-98	-	-
67	Sangam	NA	1996-97	1997-98	-	-
68	Tegada	NA	1970-71	1971-72	-	-
69	Tekra	AGH00C4	1965-66	1997-98	-	-
70	Toka	NA	1967-68	1974-75	-	-
71	Tumnar	AGG60B1	1993-94	1997-98	-	-
72	Umari	AGH4FE4	1988-89	1989-90	-	-
73	Wairagarh	AGH46D4	1992-93	1997-98	-	-
74	Yelli	AG000P3	1979-80	1997-98	-	-
75	Zari	AGR10C6	1987-88	1997-98	-	-

Table 5.9: List of Raingauge stations whose monthly rainfall data used in the study

IMD CAT NO.	STATE	DISTRICT	STATION NAME	SOURCE	FROM. YEAR	..TO.. YEAR
314	AP	ADILABAD	ADILABAD		1941	1970
314	AP	ADILABAD	ADILABAD	REV	1971	1994
313	AP	ADILABAD	ASIFABAD	PWD	1957	1994
313	AP	ADILABAD	ASIFABAD	REV	1941	1992
313	AP	ADILABAD	BOATH		1952	1970
313	AP	ADILABAD	BOATH	REV	1971	1994
313	AP	ADILABAD	CHINNUR		1951	1970
313	AP	ADILABAD	CHINNUR	REV	1971	1994
313	AP	ADILABAD	INDANAPALLI		1962	1970
313	AP	ADILABAD	INDANAPALLI	PWD	1971	1987
313	AP	ADILABAD	JOWLYNALLA		1941	1970
313	AP	ADILABAD	JOWLYNALLA	PWD	1971	1988
313	AP	ADILABAD	KADDAM		1957	1970
313	AP	ADILABAD	KADDAM	PWD	1971	1994
313	AP	ADILABAD	KHANAPUR		1957	1970
313	AP	ADILABAD	KHANAPUR	REV	1971	1994
313	AP	ADILABAD	LINGAPUR		1961	1970
313	AP	ADILABAD	LINGAPUR	PWD	1971	1990
313	AP	ADILABAD	LUXETTIPET		1952	1970
313	AP	ADILABAD	LUXETTIPET	REV	1971	1994
313	AP	ADILABAD	MANCHERIAL	PWD	1971	1994
313	AP	ADILABAD	MANCHERIAL		1951	1970
313	AP	ADILABAD	MUDHOLE		1951	1970
313	AP	ADILABAD	MUDHOLE	REV	1971	1994
313	AP	ADILABAD	OOTNOOR	REV	1971	1994
313	AP	ADILABAD	OOTNOOR		1951	1970
314	AP	ADILABAD	SIRPUR		1951	1970
314	AP	ADILABAD	SIRPUR	REV	1971	1994
313	AP	ADILABAD	SWARNA PROJECT		1968	1970
313	AP	ADILABAD	SWARNA PROJECT	PWD	1972	1992
318	AP	EAST GODAVARI	ANNAVARAM		1968	1970
318	AP	EAST GODAVARI	ANNAVARAM	PWD	1971	1994
318	AP	EAST GODAVARI	CHINTAPALLI		1951	1970
318	AP	EAST GODAVARI	CHINTAPALLI	PWD	1971	1994
317	AP	EAST GODAVARI	DOWLESHWARAM		1951	1970
317	AP	EAST GODAVARI	DOWLESHWARAM	PWD	1971	1994
317	AP	EAST GODAVARI	GOPALAPURAM		1951	1970
317	AP	EAST GODAVARI	GOPALAPURAM	PWD	1971	1994
318	AP	EAST GODAVARI	KOTHAPETA		1941	1970
318	AP	EAST GODAVARI	KOTHAPETA	REV	1971	1994
318	AP	EAST GODAVARI	MUMMIDIVARAM		1941	1970
318	AP	EAST GODAVARI	MUMMIDIVARAM	REV	1971	1994
318	AP	EAST GODAVARI	PEDDAPURAM		1941	1970
318	AP	EAST GODAVARI	PEDDAPURAM	REV	1971	1994
318	AP	EAST GODAVARI	PRATHIPADU		1941	1970
318	AP	EAST GODAVARI	PRATHIPADU	REV	1971	1994
318	AP	EAST GODAVARI	RALLI	PWD	1951	1994

IMD CAT NO.	STATE	DISTRICT	STATION NAME	SOURCE	FROM. YEAR	..TO.. YEAR
318	AP	EAST GODAVARI	RAMACHANDRAPURAM		1941	1970
318	AP	EAST GODAVARI	RAMACHANDRAPURAM	REV	1971	1989
318	AP	EAST GODAVARI	YELLAVARAM		1941	1970
318	AP	EAST GODAVARI	YELLAVARAM	REV	1971	1979
318	AP	WEST GODAVARI	BHIMAVARAM		1941	1970
318	AP	WEST GODAVARI	BHIMAVARAM	REV	1971	1994
318	AP	WEST GODAVARI	DUVVA		1951	1970
318	AP	WEST GODAVARI	DUVVA	PWD	1971	1993
317	AP	WEST GODAVARI	KOVVUR		1941	1970
317	AP	WEST GODAVARI	KOVVUR	REV	1971	1994
318	AP	WEST GODAVARI	LAKSHMIPALEM		1951	1970
318	AP	WEST GODAVARI	LAKSHMIPALEM	PWD	1971	1994
318	AP	WEST GODAVARI	NIDADAVOLE	OBSY	1956	1998
317	AP	WEST GODAVARI	POLAVARAM		1941	1970
317	AP	WEST GODAVARI	POLAVARAM	REV	1971	1994
318	AP	WEST GODAVARI	TANUKU		1941	1970
318	AP	WEST GODAVARI	TANUKU	REV	1972	1994
313	AP	KARIMNAGAR	AMBARIPET		1968	1970
313	AP	KARIMNAGAR	AMBARIPET	PWD	1971	1994
313	AP	KARIMNAGAR	HUZURABAD	PWD	1957	1994
313	AP	KARIMNAGAR	JACTIAL	REV	1971	1994
313	AP	KARIMNAGAR	JAGTIAL		1941	1970
313	AP	KARIMNAGAR	KARIMNAGAR	PWD	1957	1994
313	AP	KARIMNAGAR	KARIMNAGAR	REV	1941	1994
313	AP	KARIMNAGAR	KESHAVAPATNAMVAG		1968	1970
313	AP	KARIMNAGAR	KESHAVAPATNAMVAG	REV	1971	1994
313	AP	KARIMNAGAR	MAHADEVPUR		1968	1970
313	AP	KARIMNAGAR	MAHADEVPUR	PWD	1971	1993
313	AP	KARIMNAGAR	MANAIR		1957	1970
313	AP	KARIMNAGAR	MANAIR PROJ.	PWD	1971	1994
313	AP	KARIMNAGAR	MANTHANI		1952	1970
313	AP	KARIMNAGAR	MANTHANI	REV	1971	1994
313	AP	KARIMNAGAR	RAMGUNDAM	OBSY	1951	1998
313	AP	KARIMNAGAR	SHAMIGARAM		1968	1970
313	AP	KARIMNAGAR	SHAMIGARAM	PWD	1971	1994
313	AP	KARIMNAGAR	SIRICILLA		1951	1970
313	AP	KARIMNAGAR	SIRICILLA	REV	1971	1994
312	AP	KARIMNAGAR	SULTANABAD		1951	1970
312	AP	KARIMNAGAR	SULTANABAD	REV	1972	1994
317	AP	KHAMMAM	ALLIPALLI		1968	1970
317	AP	KHAMMAM	ALLIPALLI	PWD	1971	1994
317	AP	KHAMMAM	B'CHALAM/KOTHAGU	OBSY	1971	1998
317	AP	KHAMMAM	BHADRACHALAM		1941	1970
317	AP	KHAMMAM	BHADRACHALAM	OBSY	1952	1970
317	AP	KHAMMAM	BHADRACHALAM	REV	1971	1998
317	AP	KHAMMAM	BURGAMPAD		1957	1970
317	AP	KHAMMAM	BURGAMPAD	REV	1971	1994
	AP	KHAMMAM	CHERLA	REV	1991	1994
317	AP	KHAMMAM	GUNDALA		1968	1970
317	AP	KHAMMAM	GUNDALA	PWD	1971	1994
317	AP	KHAMMAM	KINNERASAMI	PWD	1971	1990

IMD CAT NO.	STATE	DISTRICT	STATION NAME	SOURCE	FROM. YEAR	..TO.. YEAR
317	AP	KHAMMAM	KINNERASAMI		1968	1970
317	AP	KHAMMAM	KOTHAPALANCHA		1968	1976
317	AP	KHAMMAM	NUGURU		1941	1970
317	AP	KHAMMAM	NUGURU	REV	1971	1988
317	AP	KHAMMAM	PALANCHA		1951	1966
317	AP	KHAMMAM	PALANCHA	PWD	1977	1994
317	AP	KHAMMAM	SINGABUPALAYAM		1943	1970
317	AP	KHAMMAM	SINGABUPALAYAM	PWD	1971	1994
317	AP	KHAMMAM	THANIKALLA		1951	1970
317	AP	KHAMMAM	THANIKALLA	PWD	1971	1990
318	AP	KRISHNA	KAIKALUR		1941	1970
318	AP	KRISHNA	KAIKALUR	REV	1971	1994
313	AP	MADAK	ANANTAGIRI		1943	1973
312	AP	MADAK	ANDOLE	REV	1971	1994
312	AP	MADAK	ANDOLE		1951	1970
313	AP	MADAK	GAJWEL		1957	1970
313	AP	MADAK	GAJWEL	REV	1971	1994
312	AP	MADAK	MEDAK		1941	1970
312	AP	MADAK	MEDAK	REV	1971	1994
312	AP	MADAK	NAGASANIPALLI		1952	1970
312	AP	MADAK	NAGASANIPALLI	PWD	1971	1990
312	AP	MADAK	NARASAPUR		1957	1970
312	AP	MADAK	NARASAPUR	REV	1971	1994
312	AP	MADAK	RAYANAPALLY		1941	1970
312	AP	MADAK	RAYANAPALLY	PWD	1971	1994
312	AP	MADAK	SANGAREDDI	REV	1941	1994
313	AP	MADAK	SIDDIPET		1951	1970
313	AP	MADAK	SIDDIPET	REV	1971	1994
312	AP	MADAK	ZAHIRABAD		1957	1970
312	AP	MADAK	ZAHIRABAD	REV	1971	1994
312	AP	NIZAMABAD	ALISAGAR		1941	1970
312	AP	NIZAMABAD	ALISAGAR	PWD	1971	1993
313	AP	NIZAMABAD	ANKASPUR		1951	1970
313	AP	NIZAMABAD	ANKASPUR	PWD	1971	1989
313	AP	NIZAMABAD	ARMOOR	REV	1971	1994
313	AP	NIZAMABAD	ARMOOR		1941	1970
312	AP	NIZAMABAD	BANSWADA		1951	1970
312	AP	NIZAMABAD	BANSWADA	REV	1971	1994
313	AP	NIZAMABAD	BARIDPUR		1941	1970
313	AP	NIZAMABAD	BARIDPUR	PWD	1971	1991
312	AP	NIZAMABAD	BHOMENDRAPALLI		1941	1970
312	AP	NIZAMABAD	BHOMENDRAPALLI	PWD	1971	1994
312	AP	NIZAMABAD	BODHAN	REV	1943	1994
312	AP	NIZAMABAD	BORLAM		1941	1970
312	AP	NIZAMABAD	BORLAM	PWD	1971	1994
313	AP	NIZAMABAD	DOODGAON		1941	1970
313	AP	NIZAMABAD	DOODGAON	PWD	1971	1992
312	AP	NIZAMABAD	GUNKAL		1951	1970
312	AP	NIZAMABAD	GUNKAL	PWD	1971	1994
313	AP	NIZAMABAD	KAMAREDDY		1941	1970
313	AP	NIZAMABAD	KAMAREDDY	REV	1971	1994

IMD CAT NO.	STATE	DISTRICT	STATION NAME	SOURCE	FROM. YEAR	..TO.. YEAR
312	KAR	BIDAR	BHALKI T.O.		1971	1993
312	KAR	BIDAR	BIDAR	OBSY	1941	1999
312	KAR	BIDAR	SANTHPUR		1971	1993
312	KAR	BIDAR	SANTHPUR		1956	1970
315	MP	BALAGHAT	BALAGHAT		1941	1995
315	MP	BALAGHAT	DHUTI		1941	1994
315	MP	BALAGHAT	DONGARGAON		1941	1994
315	MP	BALAGHAT	JAMUNIA		1941	1994
315	MP	BALAGHAT	KATTANJHIRI		1941	1994
315	MP	BALAGHAT	LANJI		1941	1995
315	MP	BALAGHAT	WARA MAIN		1941	1970
315	MP	BALAGHAT	WARAMAIN		1971	1994
315	MP	BALAGHAT	WARASEONI		1941	1995
316	MP	BASTER	ANTAGARH		1941	1995
316	MP	BASTER	BHANUPRATAPPUR		1941	1995
316	MP	BASTER	BHOPALPATNAM		1941	1995
316	MP	BASTER	BIJAPUR		1941	1995
316	MP	BASTER	JAGDALPUR	OBSY	1941	1999
316	MP	BASTER	KESKAL		1941	1995
316	MP	BASTER	KONDAGAON		1941	1995
317	MP	BASTER	KONTA		1941	1995
316	MP	BASTER	NARAYANPUR		1941	1995
317	MP	BASTER	SUKMA		1941	1995
103	MP	BETUL	ATNER		1941	1995
103	MP	BETUL	MULTAI		1941	1995
315	MP	CHINDWARA	AMARWARA		1941	1995
315	MP	CHINDWARA	CHAURAI		1941	1995
315	MP	CHINDWARA	CHINDWARA		1941	1995
315	MP	CHINDWARA	CHINDWARA	OBSY	1949	1999
315	MP	CHINDWARA	SAUSAR		1941	1995
315	MP	SEONI	BORI		1941	1994
315	MP	SEONI	CHINCHBUND		1951	1994
315	MP	SEONI	KEOLARI		1941	1995
315	MP	SEONI	ROOMAL		1941	1994
315	MP	SEONI	SEONI	OBSY	1941	1999
311	MAH	AHMEDNAGAR	AKOLA		1941	1996
311	MAH	AHMEDNAGAR	KOPARGAON		1941	1996
311	MAH	AHMEDNAGAR	NEVASA		1941	1996
311	MAH	AHMEDNAGAR	PATHARDI		1941	1996
311	MAH	AHMEDNAGAR	RAHURI		1941	1996
311	MAH	AHMEDNAGAR	SANGAMNER		1941	1996
311	MAH	AHMEDNAGAR	SHEVGAON		1941	1996
311	MAH	AHMEDNAGAR	SHRIRAMPUR		1955	1996
103	MAH	AKOLA	AKOLA	OBSY	1941	1999
314	MAH	AKOLA	MANGRULPIR		1941	1996
103	MAH	AKOLA	MURTAJAPUR		1941	1996
314	MAH	AKOLA	RISOD		1941	1996
103	MAH	AKOLA	SIRPUR		1941	1969
314	MAH	AKOLA	WASHIM		1941	1996
103	MAH	AMRAOTI	AMRAOTI	OBSY	1941	1999
103	MAH	AMRAOTI	BADNERA		1941	1993

IMD CAT NO.	STATE	DISTRICT	STATION NAME	SOURCE	FROM. YEAR	..TO.. YEAR
314	MAH	AMRAOTI	BARUD		1941	1996
103	MAH	AMRAOTI	CHANDUR BAZAR		1941	1996
314	MAH	AMRAOTI	CHANDUR RAILWAY		1941	1996
103	MAH	AMRAOTI	KHOLAPUR		1941	1990
314	MAH	AMRAOTI	MORSI		1941	1996
314	MAH	AMRAOTI	TALEGAON		1941	1984
311	MAH	AURANGABAD	AURANGABAD	OBSY	1941	1983
311	MAH	AURANGABAD	GANGAPUR		1951	1996
311	MAH	AURANGABAD	KANNAD		1951	1996
311	MAH	AURANGABAD	KHALDABAD		1951	1996
311	MAH	AURANGABAD	PAITHAN		1957	1996
311	MAH	AURANGABAD	SILLOD		1951	1996
311	MAH	AURANGABAD	VIJAPUR		1971	1996
311	MAH	AURANGABAD	VIJAPUR(VAIJAPUR		1951	1970
315	MAH	BHANDARA	BHANDARA		1941	1996
315	MAH	BHANDARA	BODALKASA		1941	1996
315	MAH	BHANDARA	CHANDPUR		1941	1990
315	MAH	BHANDARA	CHORKHAMARA		1941	1996
315	MAH	BHANDARA	DEORI		1944	1996
315	MAH	BHANDARA	GONDIA	OBSY	1951	1999
315	MAH	BHANDARA	KHYRBUND		1941	1996
315	MAH	BHANDARA	PAONI		1945	1995
315	MAH	BHANDARA	SAKOLI		1941	1996
311	MAH	BHIR	BHIR	OBSY	1961	1997
312	MAH	BHIR	CHOWSALA		1943	1996
311	MAH	BHIR	GEORAI		1951	1970
311	MAH	BHIR	GUORAI		1972	1996
311	MAH	BHIR	MANJLEGAON		1951	1996
311	MAH	BHIR	MOMINABAD		1951	1970
312	MAH	BHIR	PATODA		1951	1996
103	MAH	BULDANA	BULDANA		1971	1996
103	MAH	BULDANA	BULDHANA		1941	1970
314	MAH	BULDANA	CHIKHLI		1941	1995
311	MAH	BULDANA	DEOLGAON RAJA		1941	1996
103	MAH	BULDANA	DHAMANGAON		1941	1989
314	MAH	BULDANA	DONEGAON		1941	1992
103	MAH	BULDANA	KHAMGAON		1941	1996
311	MAH	BULDANA	LONAR		1990	1996
315	MAH	CHANDRAPUR	ASOLA		1941	1996
315	MAH	CHANDRAPUR	BRAMHAPURI	OBSY	1956	1999
314	MAH	CHANDRAPUR	CHANDRAPUR	OBSY	1941	1999
315	MAH	CHANDRAPUR	CHIMUR		1941	1996
315	MAH	CHANDRAPUR	KHAIREE		1941	1996
315	MAH	CHANDRAPUR	NALESAR		1941	1996
315	MAH	CHANDRAPUR	SINDEWAHI		1946	1996
314	MAH	CHANDRAPUR	WARORA		1941	1996
103	MAH	JALGAON	CHALISGAON		1941	1996
103	MAH	JALGAON	JAMNER		1941	1996
103	MAH	JALGAON	PACHORA		1941	1996
315	MAH	NAGPUR	NAGPUR MEYO HOSP	OBSY	1941	1999
315	MAH	NAGPUR	PERSEONI		1941	1996

IMD CAT NO.	STATE	DISTRICT	STATION NAME	SOURCE	FROM. YEAR	..TO.. YEAR
315	MAH	NAGPUR	RAMTEK		1941	1996
315	MAH	NAGPUR	SAONER		1941	1996
315	MAH	NAGPUR	THARSA		1941	1990
315	MAH	NAGPUR	UMRER		1941	1996
311	MAH	NANDED	BILLOLI		1951	1996
312	MAH	NANDED	DEGLOOR		1951	1996
311	MAH	NANDED	KANDHAR		1951	1996
311	MAH	NANDED	NANDED		1941	1996
311	MAH	NASIK	BOLTHAN		1941	1994
311	MAH	NASIK	CHANDOR		1941	1996
311	MAH	NASIK	DINDORI		1941	1996
311	MAH	NASIK	IGATPURI		1941	1996
103	MAH	NASIK	KALVAN		1941	1996
311	MAH	NASIK	KOLEGAON MAL		1955	1996
103	MAH	NASIK	MALEGAON	OBSY	1941	1999
103	MAH	NASIK	NANDGAON		1941	1996
311	MAH	NASIK	NASIK		1941	1996
311	MAH	NASIK	NASIK	OBSY	1941	1990
311	MAH	NASIK	NIPHAD		1941	1996
311	MAH	NASIK	OZAR AERO	OBSY	1965	1970
311	MAH	NASIK	OZAR AERODROME	OBSY	1971	1999
311	MAH	NASIK	PIMPALGAON		1941	1994
311	MAH	NASIK	SINNAR		1941	1996
311	MAH	NASIK	TRIMBAK		1941	1996
311	MAH	NASIK	YEOLA		1941	1996
312	MAH	OSMANABAD	KALLAM		1951	1996
314	MAH	PARBHANI	HINGOLI		1941	1996
314	MAH	PARBHANI	KALMANOORI		1951	1996
311	MAH	PARBHANI	PARBHANI	OBSY	1941	1999
311	MAH	PARBHANI	SIDHESHWAR CAMP		1959	1996
314	MAH	YEOTMAL	DARWHA		1941	1996
314	MAH	YEOTMAL	DIGRAS		1941	1996
314	MAH	YEOTMAL	NER		1941	1996
314	MAH	YEOTMAL	PANDHERIKAWARA		1941	1994
314	MAH	YEOTMAL	PUSAD		1941	1996
314	MAH	YEOTMAL	UMERKHED		1941	1996
314	MAH	YEOTMAL	WANI		1941	1996
314	MAH	YEOTMAL	YEOTMAL		1941	1996
314	MAH	WARDHA	ARVI		1941	1996
314	MAH	WARDHA	HINGANGHAT		1941	1996
315	MAH	WARDHA	KHARANGHA		1967	1996
314	MAH	WARDHA	WARDHA		1941	1996
314	MAH	WARDHA	WARDHA	OBSY	1966	1999
316	ORISS	KALAHANDI	KASIPUR		1954	1958
317	ORISS	KORAPUT	JEYPORE		1941	1992
316	ORISS	KORAPUT	KORAPUT		1941	1992
316	ORISS	KORAPUT	KORAPUT	OBSY	1950	1984
317	ORISS	KORAPUT	MALKANGIRI		1941	1992
316	ORISS	KORAPUT	NAWARANGPUR		1941	1992
317	ORISS	KORAPUT	POTTANGI		1941	1992

Table 5.10: Monthly water availability at Perur G&D site

CA at Perur 268200 sq.km

Unit:MCM

Water Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total Monsoon (MCM)	Total Monsoon (TMC)	Total NonMonsoon (MCM)	Total NonMonsoon (TMC)	Total Annual (MCM)	Total Annual (TMC)
1966-67	605.0	12753.4	22206.6	25762.6	3371.2	1896.8	1692.6	412.9	222.0	653.5	367.0	94.5	64698.8	2284.8	5339.2	188.6	70038.0	2473.4
1967-68	3028.8	18962.9	32195.8	13206.2	5778.1	948.4	2392.4	994.5	459.0	1007.3	202.1	179.7	73171.8	2584.0	6183.5	218.4	79355.3	2802.4
1968-69	1090.5	8224.5	19517.9	14076.8	7085.7	1387.1	612.1	430.7	252.0	194.8	192.6	194.6	49995.4	1765.6	3263.8	115.3	53259.2	1880.8
1969-70	224.9	15780.9	27316.9	38613.9	4253.7	1924.0	724.1	390.4	268.4	234.6	137.4	97.3	86190.3	3043.8	3776.2	133.4	89966.5	3177.1
1970-71	5211.0	11429.1	50430.8	34364.7	6655.6	1549.0	777.5	530.6	336.9	331.0	217.3	335.2	108091.2	3817.2	4077.4	144.0	112168.7	3961.2
1971-72	3495.2	4892.1	9006.1	14939.1	8860.0	1508.5	588.0	366.6	209.7	138.7	75.1	48.2	41192.4	1454.7	2934.9	103.6	44127.3	1558.3
1972-73	682.7	13319.0	9043.5	8638.7	1719.9	899.2	424.4	174.1	97.4	74.8	55.0	39.5	33403.7	1179.6	1764.4	62.3	35168.1	1241.9
1973-74	297.5	29384.7	35071.5	18059.3	22579.2	5282.3	1213.4	679.8	428.4	272.9	175.0	187.7	105392.2	3721.9	8239.4	291.0	113631.5	4012.9
1974-75	600.3	2378.9	14646.6	2976.1	6976.1	1893.1	702.6	337.9	303.6	237.6	110.8	74.0	27577.9	973.9	3659.6	129.2	31237.5	1103.1
1975-76	4123.9	14232.5	28768.8	37769.7	14480.7	3686.3	929.2	553.5	337.5	227.3	165.7	123.8	99375.7	3509.4	6023.2	212.7	105398.9	3722.1
1976-77	175.5	24331.5	25361.3	28036.1	1764.8	883.5	554.2	311.5	227.5	181.2	139.8	241.2	79669.1	2813.5	2538.9	89.7	82208.0	2903.1
1977-78	1018.7	13410.1	22852.7	19332.9	3571.4	1666.9	1875.9	683.6	518.7	313.6	192.7	225.3	59185.9	2090.1	5476.7	193.4	64662.6	2283.5
1978-79	3781.8	26533.9	42776.5	16411.1	3584.1	1713.2	1136.7	640.5	1199.1	570.8	190.5	137.0	93087.6	3287.4	5587.9	197.3	98675.4	3484.7
1979-80	6442.0	7843.9	31825.6	7680.8	5439.4	974.5	938.5	529.5	383.4	405.2	229.8	174.8	59231.6	2091.7	3635.8	128.4	62867.4	2220.1
1980-81	3388.4	13064.0	37551.8	21859.5	2688.1	1005.5	513.0	539.9	358.0	319.0	217.4	232.5	78551.8	2774.0	3185.2	112.5	81736.9	2886.5
1981-82	1075.6	11588.9	36732.0	20774.1	10250.4	2138.8	799.9	613.7	499.3	248.6	143.3	122.7	80421.0	2840.0	4566.2	161.3	84987.2	3001.3
1982-83	953.1	6698.1	17396.9	8824.5	3982.7	1792.8	621.7	378.5	395.1	290.4	79.0	61.2	37855.3	1336.8	3618.6	127.8	41473.9	1464.6
1983-84	1797.1	10384.4	42429.1	42209.4	21898.6	1929.0	1022.1	815.9	450.9	608.9	380.2	287.9	118717.6	4192.5	5494.8	194.0	124212.4	4386.5
1984-85	1083.7	6791.6	18766.6	4195.0	2764.6	1068.2	516.6	458.8	340.6	262.8	192.6	102.4	33601.5	1186.6	2942.1	103.9	36543.6	1290.5
1985-86	1473.6	8444.0	18728.3	5580.4	5938.4	1163.3	463.8	370.1	482.6	452.8	216.6	169.2	40164.7	1418.4	3318.4	117.2	43483.1	1535.6
1986-87	2034.4	19648.2	40335.3	4791.0	1965.1	1082.3	389.8	469.2	260.7	200.5	91.4	67.8	68773.9	2428.7	2561.8	90.5	71335.7	2519.2
1987-88	388.2	5624.1	8326.4	5298.9	2015.8	1074.2	559.2	293.2	203.5	239.4	100.7	91.1	21653.4	764.7	2561.3	90.5	24214.7	855.1
1988-89	1210.2	25840.6	34619.5	30194.6	16383.5	1484.3	699.8	440.5	285.9	302.6	200.0	90.4	106248.4	3822.8	3503.4	123.7	111751.8	3946.5
1989-90	1352.1	20161.5	21137.0	15635.0	4403.8	828.8	448.3	437.5	269.8	255.8	121.0	794.1	62689.4	2213.9	3155.2	111.4	65844.6	2325.3
1990-91	8531.2	18770.5	54219.1	27270.6	20025.7	5050.2	1053.7	694.0	408.3	331.6	248.6	142.6	128817.0	4549.1	7928.8	280.0	136745.8	4829.1
1991-92	1121.4	10971.1	23123.4	4706.2	2347.9	1356.4	527.1	315.3	205.5	152.5	79.9	55.0	42270.0	1492.8	2691.7	95.1	44961.7	1587.8
1992-93	1955.9	6563.1	34484.9	14908.5	2218.5	962.6	476.1	291.6	221.5	238.2	109.9	59.6	60130.9	2123.5	2359.6	83.3	62490.5	2206.8
1993-94	431.7	7713.6	12414.1	8639.9	4611.6	1212.6	519.8	359.6	329.8	198.0	70.6	39.1	34010.9	1201.1	2729.5	96.4	36740.4	1297.5
1994-95	875.6	32042.5	26611.5	39201.2	6036.2	1806.1	1070.4	1350.8	637.9	619.2	446.4	432.8	104766.9	3699.8	6363.7	224.7	111130.6	3924.5
1995-96	772.9	15009.8	12303.1	19281.9	13234.2	2002.5	839.9	629.8	440.1	394.0	252.2	164.8	60601.9	2140.1	4723.4	166.8	65325.3	2306.9
1996-97	1334.0	4941.2	15892.4	12255.8	4232.8	1332.2	522.7	410.8	279.9	398.8	453.2	165.3	38656.1	1365.1	3563.0	125.8	42219.1	1491.0
1997-98	114.7	3523.2	13905.6	10701.8	2428.8	1865.4	2880.1	1502.9	992.4	302.0	170.0	205.5	30674.1	1083.2	7918.4	279.6	38592.5	1362.9
1998-99	945.5	7378.2	17641.7	21579.7	13062.8	3827.0	822.6	517.5	379.0	283.7	214.3	168.9	60607.8	2140.3	6212.9	219.4	66820.8	2359.8
1999-2000	3972.8	5884.6	21015.5	24928.5	12841.7	2088.4	794.3	507.3	395.6	334.6	179.8	116.7	68643.2	2424.1	4416.7	156.0	73059.9	2580.1
2000-01	2260.5	21995.3	24809.7	10899.0	2063.1	747.7	340.7	235.8	162.9	157.7	168.5	77.5	62027.7	2190.5	1890.7	66.8	63918.4	2257.3
2001-02	9008.6	12985.7	30335.3	4568.1	5619.0	1020.9	472.8	348.9	220.7	155.8	80.2	40.7	62516.7	2207.8	2340.1	82.6	64856.8	2290.4
2002-03	4236.5	2337.8	20938.3	13145.3	1819.6	595.9	363.5	224.2	148.0	108.7	69.3	39.8	42477.5	1500.1	1549.3	54.7	44026.8	1554.8
2003-04	157.6	17884.5	22813.0	13072.3	8012.1	1692.5	699.7	427.2	476.1	173.5	97.8	97.2	61939.6	2187.4	3664.0	129.4	65603.5	2316.8
2004-05	2670.0	2527.2	20055.4	3814.0	2207.8	522.0	236.7	165.8	698.4	158.0	96.0	70.3	31274.5	1104.4	1937.1	68.4	33211.6	1172.9
2005-06	95.1	18734.1	25786.2	25794.5	9327.2	2476.1	657.2	375.4	226.6	255.3	222.1	189.0	79737.2	2815.9	4401.7	155.4	84138.8	2971.3
2006-07	135.4	13654.6	49749.3	29620.5	10735.0	2980.1	813.9	492.2	289.4	171.4	137.3	106.6	103894.9	3669.0	4990.9	176.3	108885.8	3845.3
2007-08	554.3	14347.8	21207.5	18737.6	7256.0	1223.4	474.2	293.1	330.7	258.3	221.5	18.7	62103.1	2193.2	2819.9	99.6	64923.0	2292.7
2008-09	300.8	4872.8	23816.8	8388.4	1963.0	835.7	445.4	184.7	134.0	84.4	52.4	18.5	39341.7	1389.3	1755.1	62.0	41096.9	1451.3
2009-10	16.3	7801.1	6475.4	6149.5	1373.2	677.8	338.0	224.6	136.0	97.0	38.0	22.9	21815.4	770.4	1534.4	54.2	23349.7	824.6
2010-11	186.7	11962.3	35298.5	41049.1	6481.5	2846.8	1057.4	471.3	293.7	312.0	167.4	102.8	94978.1	3354.1	5251.3	185.4	100229.4	3539.6
2011-12	253.6	4532.7	14027.1	29556.1	2367.1	795.8	387.5	341.5	193.2	63.1	33.1	16.9	50736.5	1791.7	1831.1	64.7	52567.6	1856.4
2012-13	398.8	9467.6	31643.5	30172.2	5744.4	1529.4	581.8	371.1	274.9	246.4	108.1	52.3	77426.3	2734.3	3164.0	111.7	80590.3	2846.0
Average	2014.8	13022.6	25477.9	16636.0	7279.6	1752.3	755.7	492.9	380.9	278.2	172.5	147.6	64430.9	2275.4	3980.2	140.6	68411.1	2415.9
												50% Dependable flow			65325 MCM		2306.9 TMC	
												75% Dependable flow			43483 MCM		1535.6 TMC	
												90% Dependable flow			34777 MCM		1228.1 TMC	

Table 5.11: Monthly water availability at Tupakulagudem project site

CA at Thupalakudem 268000 sq.km
Catchment Factor 0.999254

Unit:MCM

Water Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total Monsoon (MCM)	Total Monsoon (TMC)	Total NonMonsoon (MCM)	Total NonMonsoon (TMC)	Total Annual (MCM)	Total Annual (TMC)
1966-67	604.5	12743.9	22190.1	25743.4	3368.7	1895.4	1691.3	412.6	221.8	653.0	366.7	94.5	64650.5	2283.1	5335.3	188.4	69985.8	2471.5
1967-68	3026.6	18948.8	32171.8	13196.4	5773.8	947.7	2390.7	993.8	458.7	1006.6	201.9	179.5	73117.3	2582.1	6178.9	218.2	79296.1	2800.3
1968-69	1089.7	8218.4	19503.4	14066.3	7080.4	1386.1	611.7	430.4	251.8	194.6	192.4	194.4	49958.1	1764.3	3261.4	115.2	53219.5	1879.4
1969-70	224.8	15769.1	27296.5	38585.1	4250.6	1922.5	723.5	390.2	268.2	234.5	137.3	97.2	86126.0	3041.5	3773.4	133.3	89899.4	3174.8
1970-71	5207.2	11420.6	50393.2	34339.0	6650.7	1547.8	776.9	530.2	336.6	330.7	217.1	335.0	108010.6	3814.4	4074.4	143.9	112085.0	3958.2
1971-72	3492.6	4888.4	8999.4	14927.9	8853.3	1507.4	587.6	366.3	209.6	138.6	75.1	48.2	41161.7	1453.6	2932.7	103.6	44094.4	1557.2
1972-73	682.2	13309.0	9036.7	8632.3	1718.6	898.5	424.1	174.0	97.4	74.7	54.9	39.5	33378.8	1178.8	1763.1	62.3	35141.9	1241.0
1973-74	297.3	29362.8	35045.3	18045.8	22562.3	5278.3	1212.5	679.3	428.1	272.7	174.8	187.5	105313.6	3719.1	8233.2	290.8	113546.8	4009.9
1974-75	599.8	2377.1	14635.7	2973.8	6970.9	1891.7	702.0	337.7	303.4	237.5	110.7	73.9	27557.4	973.2	3656.9	129.1	31214.2	1102.3
1975-76	4120.8	14221.9	28747.4	37741.6	14469.9	3683.5	928.5	553.1	337.2	227.1	165.6	123.7	99301.5	3506.8	6018.7	212.5	105320.3	3719.4
1976-77	175.4	24313.3	25342.4	28015.2	1763.5	882.8	553.8	311.3	227.4	181.1	139.7	241.1	79609.7	2811.4	2537.1	89.6	82146.7	2901.0
1977-78	1017.9	13400.1	22835.7	18319.3	3568.7	1665.6	1874.5	683.1	518.3	313.4	192.6	225.1	59141.7	2088.6	5472.6	193.3	64614.3	2281.8
1978-79	3779.0	26514.2	42744.6	16398.9	3581.4	1712.0	1135.9	640.0	1198.2	570.4	190.4	136.9	93018.1	3284.9	5583.7	197.2	98601.8	3482.1
1979-80	6437.2	7838.1	31801.8	7675.1	5435.3	973.8	937.8	529.1	383.1	404.9	229.7	174.7	59187.5	2090.2	3633.1	128.3	62820.5	2218.5
1980-81	3385.9	13054.2	37523.8	21843.2	2686.1	1004.8	512.6	539.5	357.7	318.7	217.2	232.3	78493.2	2772.0	3182.8	112.4	81676.0	2884.4
1981-82	1074.8	11580.3	36704.6	20758.6	10242.8	2137.2	799.4	613.2	498.9	248.4	143.2	122.6	80361.0	2837.9	4562.8	161.1	84923.8	2999.1
1982-83	952.4	6693.1	17383.9	8817.9	3979.7	1791.4	621.2	378.2	394.8	290.1	78.9	61.2	37827.1	1335.9	3615.9	127.7	41443.0	1463.5
1983-84	1795.8	10376.7	42396.4	42177.9	21882.3	1927.6	1021.3	815.3	450.6	608.4	379.9	287.7	116629.0	4189.3	5490.8	193.9	124119.8	4383.2
1984-85	1082.9	6786.5	18752.6	4191.9	2762.6	1067.4	516.2	458.5	340.4	262.6	192.5	102.3	33576.4	1185.7	2939.9	103.8	36516.3	1289.6
1985-86	1472.5	8437.7	18714.3	5576.2	5934.0	1162.4	463.5	369.8	482.3	452.4	216.5	169.0	40134.7	1417.3	3315.9	117.1	43450.6	1534.4
1986-87	2032.8	19633.5	40305.2	4787.4	1963.6	1081.5	389.5	468.9	260.5	200.4	91.3	67.8	68722.6	2426.9	2559.9	90.4	71282.5	2517.3
1987-88	387.9	5619.9	8320.2	5295.0	2014.3	1073.4	558.7	293.0	203.3	239.2	100.7	91.0	21637.2	764.1	2559.4	90.4	24196.6	854.5
1988-89	1209.3	25821.3	34593.7	30172.1	16371.3	1483.2	699.3	440.1	285.7	302.4	199.8	90.3	108167.7	3819.9	3500.8	123.6	111668.4	3943.5
1989-90	1351.1	20146.4	21121.3	15623.3	4400.5	828.2	447.9	437.1	269.6	255.6	120.9	793.5	62642.7	2212.2	3152.8	111.3	65795.5	2323.5
1990-91	8524.8	18756.5	54178.7	27250.2	20010.7	5046.4	1052.9	693.5	408.0	331.3	248.4	142.4	128720.9	4545.7	7922.9	279.8	136643.8	4825.5
1991-92	1120.6	10962.9	23106.1	4702.7	2346.2	1355.4	526.7	315.1	205.3	152.4	79.8	54.9	42236.5	1491.6	2689.7	95.0	44928.2	1586.6
1992-93	1954.4	6558.2	34459.2	14897.4	2216.8	961.9	475.8	291.4	221.3	238.0	109.8	59.6	60086.0	2121.9	2357.8	83.3	62443.9	2205.2
1993-94	431.4	7707.9	12404.8	8833.3	4608.2	1211.7	519.4	359.4	329.5	197.8	70.6	39.1	33985.5	1200.2	2727.5	96.3	36713.0	1296.5
1994-95	875.0	32018.6	26591.6	39171.9	6031.7	1804.8	1069.6	1349.8	637.5	618.7	446.0	432.5	104688.8	3697.1	6358.9	224.6	111047.7	3921.6
1995-96	772.3	14998.6	12293.9	19267.5	13224.3	2001.0	839.3	629.3	439.8	393.7	252.0	164.7	60556.7	2138.5	4719.9	166.7	65276.6	2305.2
1996-97	1333.0	4937.5	15880.5	12246.7	4229.6	1331.2	522.3	410.5	279.7	398.6	452.9	165.2	38627.3	1364.1	3560.3	125.7	42187.6	1489.8
1997-98	114.6	3520.6	13895.2	10693.8	2427.0	1864.0	2878.0	1501.8	991.7	301.8	169.9	205.3	30651.2	1082.4	7912.5	279.4	38563.7	1361.9
1998-99	944.8	7372.7	17628.5	21563.6	13053.1	3824.1	822.0	517.1	378.8	283.5	214.2	168.7	60562.6	2138.7	6208.3	219.2	66771.0	2358.0
1999-2000	3969.9	5880.2	20999.9	24909.9	12832.2	2086.9	793.7	506.9	395.3	334.4	179.7	116.6	68592.0	2422.3	4413.5	155.9	73005.4	2578.2
2000-01	2258.9	21978.9	24791.2	10890.8	2061.6	747.2	340.4	235.6	162.8	157.6	168.3	77.4	61981.5	2188.9	1889.3	66.7	63870.8	2255.6
2001-02	9001.9	12976.0	30312.7	4564.7	5614.8	1020.1	472.4	348.7	220.5	155.7	80.1	40.7	62470.1	2206.1	2338.3	82.6	64808.4	2288.7
2002-03	4233.3	2336.1	20922.7	13135.5	1818.2	595.4	363.2	224.0	147.9	108.6	69.2	39.7	42445.8	1499.0	1548.1	54.7	43993.9	1553.6
2003-04	157.5	17871.1	22796.0	13062.6	8006.2	1691.2	699.1	426.9	475.7	173.4	97.7	97.1	61893.4	2185.7	3661.2	129.3	65554.6	2315.0
2004-05	2668.0	2525.3	20040.5	3811.2	2206.1	521.6	236.5	165.7	697.9	157.9	85.9	70.2	31251.1	1103.6	1935.7	68.4	33186.8	1172.0
2005-06	95.1	18720.1	25767.0	25775.3	9320.2	2474.2	656.7	375.1	226.4	255.1	222.0	188.9	79677.7	2813.8	4398.4	155.3	84076.1	2969.1
2006-07	135.3	13644.4	49712.2	29598.4	10727.0	2977.9	813.3	491.8	289.2	171.3	137.2	106.5	103817.4	3666.3	4987.2	176.1	108804.6	3842.4
2007-08	553.9	14337.1	21191.6	18723.6	7250.6	1222.5	473.9	292.9	330.5	258.1	221.3	18.7	62056.8	2191.5	2817.8	99.5	64874.6	2291.0
2008-09	300.5	4869.1	23799.0	8382.1	1961.6	835.1	445.1	184.6	133.9	84.4	52.4	18.5	39312.4	1388.3	1753.8	61.9	41066.2	1450.2
2009-10	16.3	7795.2	6470.6	6144.9	1372.1	677.3	337.8	224.4	135.9	97.0	37.9	22.9	21799.1	769.8	1533.2	54.1	23332.3	824.0
2010-11	186.6	11953.4	35272.2	41018.5	6476.7	2844.7	1056.6	470.9	293.5	311.8	167.2	102.7	94907.3	3351.6	5247.4	185.3	100154.7	3536.9
2011-12	253.4	4529.3	14016.6	29534.1	2365.4	795.2	387.2	341.2	193.1	63.0	33.1	16.9	50698.7	1790.4	1829.7	64.6	52528.4	1855.0
2012-13	398.5	9460.5	31619.9	30149.7	5740.1	1528.3	581.4	370.8	274.7	246.2	108.0	52.2	77368.6	2732.2	3161.6	111.7	80530.2	2843.9
Average	1825.5	12493.3	25632.1	18217.7	6684.8	1684.4	786.0	480.3	354.3	287.4	167.9	139.8	64382.8	2273.7	3977.3	140.5	68753.7	2414.1

50% Dependable flow	65277 MCM	2305.2 TMC
75% Dependable flow	43451 MCM	1534.4 TMC
90% Dependable flow	34751 MCM	1227.2 TMC

Table 5.12: Annual Maximum discharge with corresponding water level (m.s.l)

Annual Maximum discharge with corresponding Water Level (m.s.l)

Site: Koida

Year	Q (cumecs)	WL (m)	Date
1977	27489	35.660	8/25/1977
1978	42494	37.510	9/2/1978
1979	32421	36.515	8/6/1979
1980	31368	34.165	8/5/1980
1981	41024	38.860	8/13/1981
1982	19049	29.075	8/19/1982
1983	57978	41.238	8/15/1983
1984	24911	31.000	8/4/1984
1985	16850	29.060	8/15/1985
1986	70793	47.120	8/17/1986
1987	15004	29.040	7/11/1987
1988	43730	38.530	8/2/1988
1989	33324	35.500	7/27/1989
1990	60120	44.320	8/25/1990
1991	28468	33.400	8/19/1991
1992	34603	37.060	8/17/1992
1993	19818	29.155	8/6/1993
1994	42628	40.400	9/7/1994
1995	33474	36.950	10/23/1995
1996	12023	26.040	8/26/1996
1997	15124	27.500	8/30/1997
1998	18474	29.330	9/18/1998
1999	21933	31.390	8/9/1999
2000	35110	37.990	8/30/2000
2001	32246	36.550	8/23/2001
2002	27109	34.195	8/27/2002
2003	32544	35.010	7/28/2003
2004	17974	29.645	8/7/2004
2005	46191	39.280	9/21/2005

Site: Mancherial

Year	Q (cumecs)	WL (m)	Date
1966	18538	134.226	9/5/1966
1967	9460	131.721	7/25/1967
1968	4740	129.906	8/12/1968
1969	18138	133.621	9/9/1969
1970	26537	136.486	8/20/1970
1971	6306	130.336	8/28/1971
1972	1490	128.206	7/4/1972
1973	14136	133.111	8/24/1973
1974	4767	130.021	10/25/1974
1975	11804	132.476	9/11/1975
1976	10527	132.206	9/3/1976
1977	5786	130.196	9/3/1977
1978	5670	130.206	8/17/1978
1979	6860	130.836	8/4/1979
1980	9000	131.526	9/5/1980
1981	5140	130.166	9/28/1981
1982	1698	128.191	10/22/1982
1983	29531	137.846	8/12/1983
1984	377.7	127.261	9/13/1984
1985	871.5	127.666	8/3/1985
1986	10982	131.976	8/13/1986
1987	1694	128.441	7/9/1987
1988	20944	135.191	7/31/1988
1989	24900	136.876	7/25/1989
1990	23846	136.211	8/31/1990
1991	6463	130.759	7/13/1991
1992	5066	129.781	9/5/1992
1993	2257	128.641	8/4/1993
1994	2317	128.549	7/12/1994
1995	31820	137.386	10/20/1995
1996	4618	129.821	9/17/1996
1997	552.7	126.961	10/29/1997
1998	8209	131.896	10/18/1998
1999	8340	131.061	9/9/1999
2000	15840	133.336	8/28/2000
2001	2805	128.591	10/12/2001
2002	4252	129.331	8/25/2002
2003	4475	129.506	8/8/2003
2004	122.6	125.966	7/14/2004
2005	7376	131.511	9/23/2005
2006	9901	132.791	8/7/2006
2007	611.5	127.106	10/2/2007
2008	2560	128.331	9/25/2008
2009	296.8	126.716	9/4/2009
2010	7085	131.301	9/8/2010
2011	2133	127.676	8/30/2011
2012	1181	127.376	9/11/2012

Site: Pathagudem

Year	Q (cumecs)	WL (m)	Date
1965	7587	94.465	9/2/1965
1966	19718	99.810	9/5/1966
1967	16293	97.620	8/4/1967
1968	9340	95.085	9/15/1968
1969	17960	98.960	8/1/1969
1970	12182	96.400	8/29/1970
1971	6563	93.460	9/5/1971
1972	15155	97.638	7/5/1972
1973	13930	97.275	7/14/1973
1974	10302	95.490	8/11/1974
1975	15036	97.230	9/10/1975
1976	24862	101.958	7/21/1976
1977	14517	97.475	8/23/1977
1978	18461	98.880	8/16/1978
1979	16606	98.698	8/4/1979
1980	11190	95.915	8/2/1980
1981	18015	98.735	8/10/1981
1982	10045	94.940	8/14/1982
1983	12062	96.850	8/20/1983
1984	12706	96.430	8/2/1984
1985	5880	94.080	8/8/1985
1986	32831	102.900	8/15/1986
1987	7297	94.490	8/29/1987
1988	9227	95.525	7/30/1988
1989	11316	96.775	8/23/1989
1990	31462	103.350	8/23/1990
1991	9081	96.400	7/31/1991
1992	14075	98.010	8/16/1992
1993	5183	93.380	8/4/1993
1994	20800	101.440	7/12/1994
1995	15679	99.175	7/25/1995
1996	4564	92.830	7/23/1996
1997	10803	96.090	8/23/1997
1998	5063	93.265	9/14/1998
1999	7969	94.630	9/2/1999
2000	9842	95.310	8/30/2000
2001	25077	101.150	8/21/2001
2002	11343	96.690	8/25/2002
2003	14072	97.010	8/24/2003
2004	12862	97.830	8/23/2004
2005	13753	97.550	9/14/2005
2006	35392	103.500	8/5/2006
2007	16810	99.010	8/8/2007
2008	12703	96.185	7/30/2008
2009	10446	95.235	8/28/2009
2010	25504	102.450	8/7/2010
2011	10853	96.160	9/2/2011
2012	13358	97.160	8/20/2012

Table 5.13: Annual Maximuum discharge with corresponding water level (m.s.l)

Site Perur

Year	Q (cumecs)	WL (m)	Date
1966	44418	85.455	9/6/1966
1967	30194	82.465	8/4/1967
1968	20662	80.045	8/18/1968
1969	33577	82.680	9/21/1969
1970	46078	83.875	8/20/1970
1971	18005	79.310	9/2/1971
1972	22129	80.355	7/6/1972
1973	32738	81.990	8/26/1973
1974	15559	79.760	8/12/1974
1975	34115	82.675	9/12/1975
1976	39427	84.040	7/22/1976
1977	27766	81.765	8/24/1977
1978	38329	83.230	9/1/1978
1979	36269	82.760	8/5/1979
1980	26480	82.015	8/3/1980
1981	51496	84.025	8/11/1981
1982	11750	77.750	8/18/1982
1983	43879	85.080	8/13/1983
1984	14784	79.510	8/22/1984
1985	12986	78.120	8/13/1985
1986	62889	87.420	8/15/1986
1987	11809	78.515	7/10/1987
1988	39623	83.450	8/1/1988
1989	31414	82.750	7/25/1989
1990	62800	87.020	8/24/1990
1991	24830	81.655	8/18/1991
1992	35140	82.920	8/16/1992
1993	17642	80.070	8/5/1993
1994	41042	83.980	7/13/1994
1995	40205	83.750	10/21/1995
1996	8996	77.170	8/25/1996
1997	12350	78.270	8/23/1997
1998	18132	79.380	9/17/1998
1999	19223	80.280	8/12/1999
2000	40942	83.340	7/21/2000
2001	36288	82.730	8/22/2001
2002	24840	81.540	8/26/2002
2003	20116	80.160	7/27/2003
2004	16746	79.120	8/23/2004
2005	24436	81.130	9/18/2005
2006	51917	85.600	8/6/2006
2007	37378	82.810	8/9/2007
2008	25946	81.970	8/6/2008
2009	12393	77.750	8/28/2009
2010	44201	83.670	8/7/2010
2011	26113	80.930	9/2/2011
2012	27119	81.480	8/22/2012

Site Polavaram

Year	Q (cumecs)	WL (m)	Date
1966	29760	25.217	9/6/1966
1967	35161	24.687	8/5/1967
1968	26189	22.427	8/19/1968
1969	35462	25.142	9/23/1969
1970	38701	26.297	8/23/1970
1971	16881	21.745	9/3/1971
1972	27949	23.870	7/7/1972
1973	30564	24.417	8/28/1973
1974	18110	22.270	8/13/1974
1975	39364	25.192	9/11/1975
1976	46299	26.517	7/23/1976
1977	34964	24.442	8/25/1977
1978	38229	25.542	8/18/1978
1979	32864	24.897	8/7/1979
1980	29468	24.075	8/5/1980
1981	43841	25.922	8/13/1981
1982	15247	21.817	8/19/1982
1983	40716	26.627	8/15/1983
1984	19943	22.702	8/4/1984
1985	16442	21.957	8/15/1985
1986	57311	28.017	8/16/1986
1987	15169	21.705	7/11/1987
1988	43506	25.525	7/30/1988
1989	35936	24.477	7/27/1989
1990	61658	27.277	8/25/1990
1991	29469	23.637	8/19/1991
1992	39003	24.967	8/17/1992
1993	19062	21.832	8/6/1993
1994	43105	26.002	9/7/1994
1995	35259	24.912	10/23/1995
1996	11290	20.317	7/23/1996
1997	13266	21.117	8/3/1997
1998	16477	22.082	9/18/1998
1999	22714	22.987	8/9/1999
2000	35217	25.297	8/31/2000
2001	33764	24.967	8/23/2001
2002	29786	24.127	8/27/2002
2003	25862	24.342	7/28/2003
2004	18725	21.742	8/4/2004
2005	43703	25.897	9/21/2005
2006	52811	27.297	8/7/2006
2007	47249	24.712	8/10/2007
2008	26975	23.957	8/8/2008
2009	11249	20.217	8/29/2009
2010	39047	25.707	8/9/2010
2011	23943	23.502	9/3/2011
2012	26290	23.692	9/7/2012

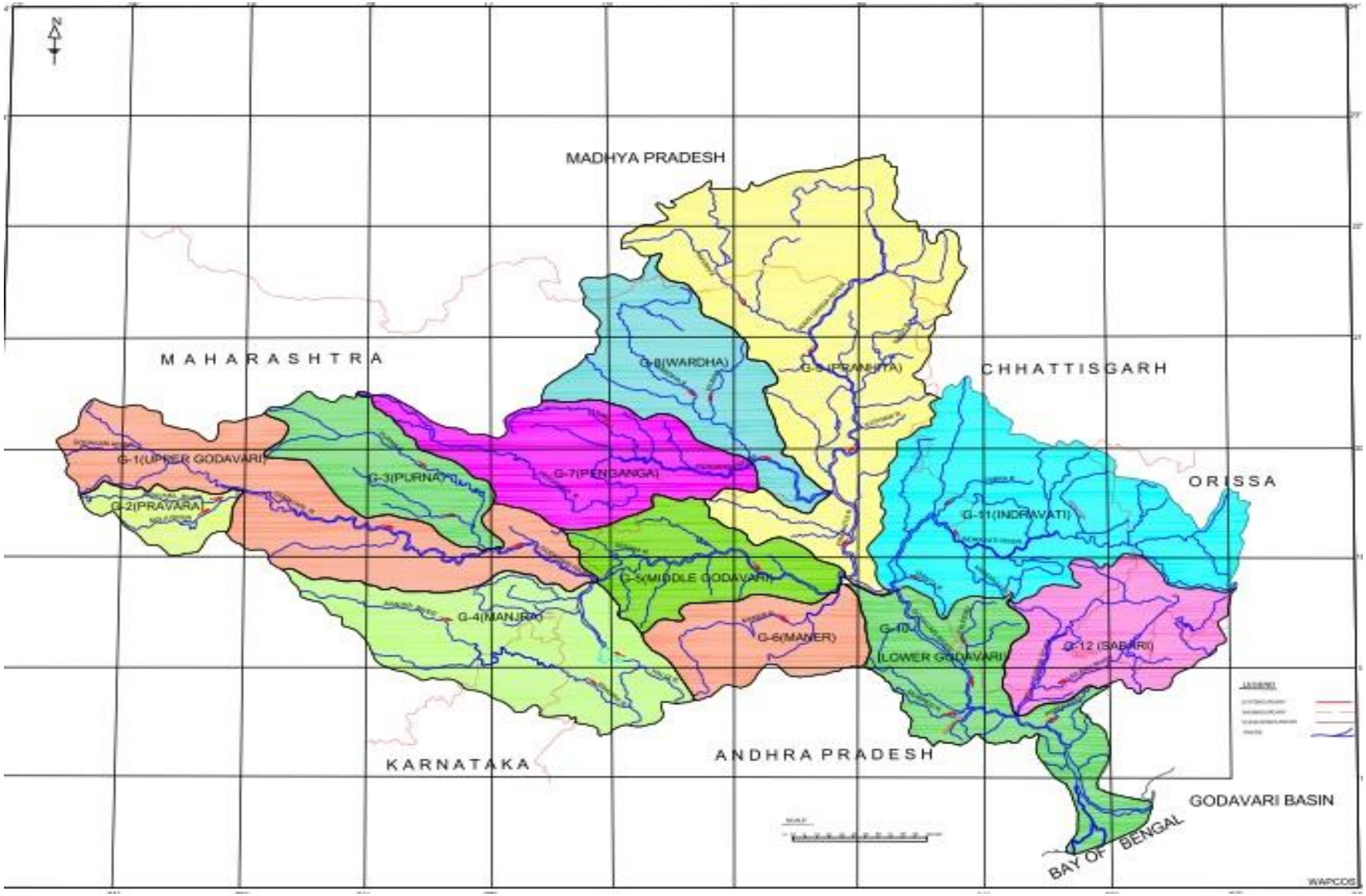


Fig 5.13 Diagram of the Godavari river system showing Raingauge stations



Fig 5.14 Diagram of the Godavari river system showing Isohyetal map of Normal rainfall

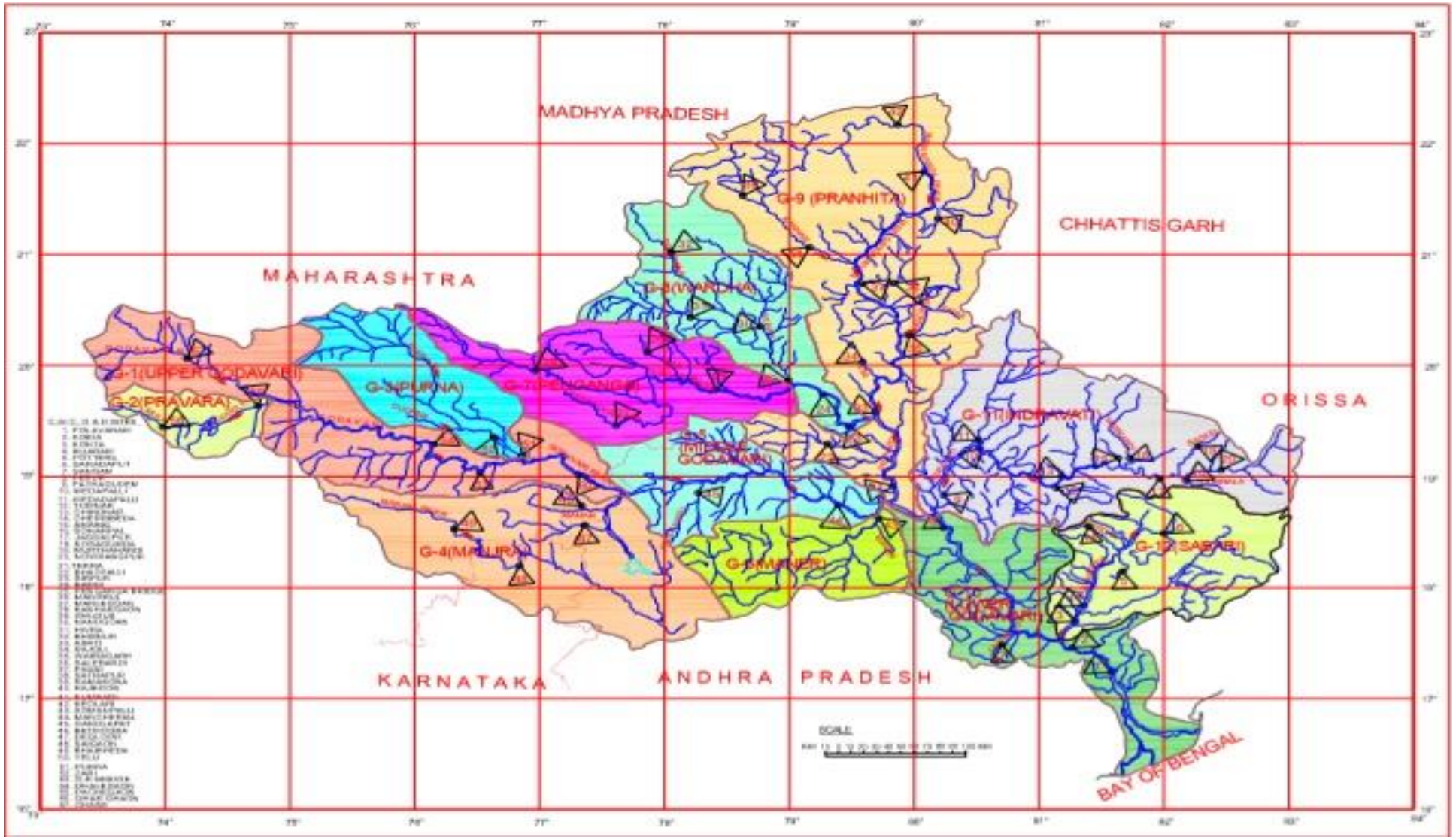


Fig 5.15 Diagram the Godavari river system showing Gauge and Discharge stations

5.2 Hydrology of Dummugudem Hydroelectric Project

5.2.1 General

The present project, Dummugudem, envisages harnessing water from the River Godavari. It is situated in Khamman district of the Indian state of Telangana. It is located in Dummugudem mandal of Bhadrachalam revenue division. The project is proposed to be of RoR type with the multifunction of irrigation and power.

5.2.1.1 Description of Dam Sites

The catchment area of the dam site which comes out to be 2,77,001 km^2. The dam site is located in Khamman district of Telangana at 17°52'25.3"N, 80°53'07.6"E. Locations of the dam site and catchment area are shown in **Figure 5.16**.

5.2.1.2 Description of G&D Site

Perur G&D site is situated in the Khamman district of Telangana at 80° 23' 10" E, 18° 32' 52" N. Catchment area of the G&D site is around 2,68,200 km^2 .

5.2.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Telangana. It flows east for about 1,465 kilometres draining the states of Telangana (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2 , it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sealevels.



Figure 5.16: Catchment Area of Project and Locations of Dam and G&D site

5.2.2 Water Availability Studies

5.2.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Perur (Catchment Area=2,68,200 km^2) which is upstream of the project site along the Godavari River, is available and can be downloaded from India WRIS site. The G&D site lies in the Khamman district of Telangana.

Generally, 15-year flow series data is required for a RoR project. Thus, flow series for the period 2000-2015 has been considered for generating the flow at the present project site.

5.2.2.2 Rainfall data

Average daily rainfall (in mm) have been calculated at each grid point (as can been seen from **Figure 5.17**) within the boundary of the Perur G&D site and Dummugudem dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.17**, 371 grid points is considered to assess the catchment rainfall for Perur G&D site and Similarly, for Dummugudem proposed dam, 384 grid points have been considered for the assessment of rainfall in site. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations

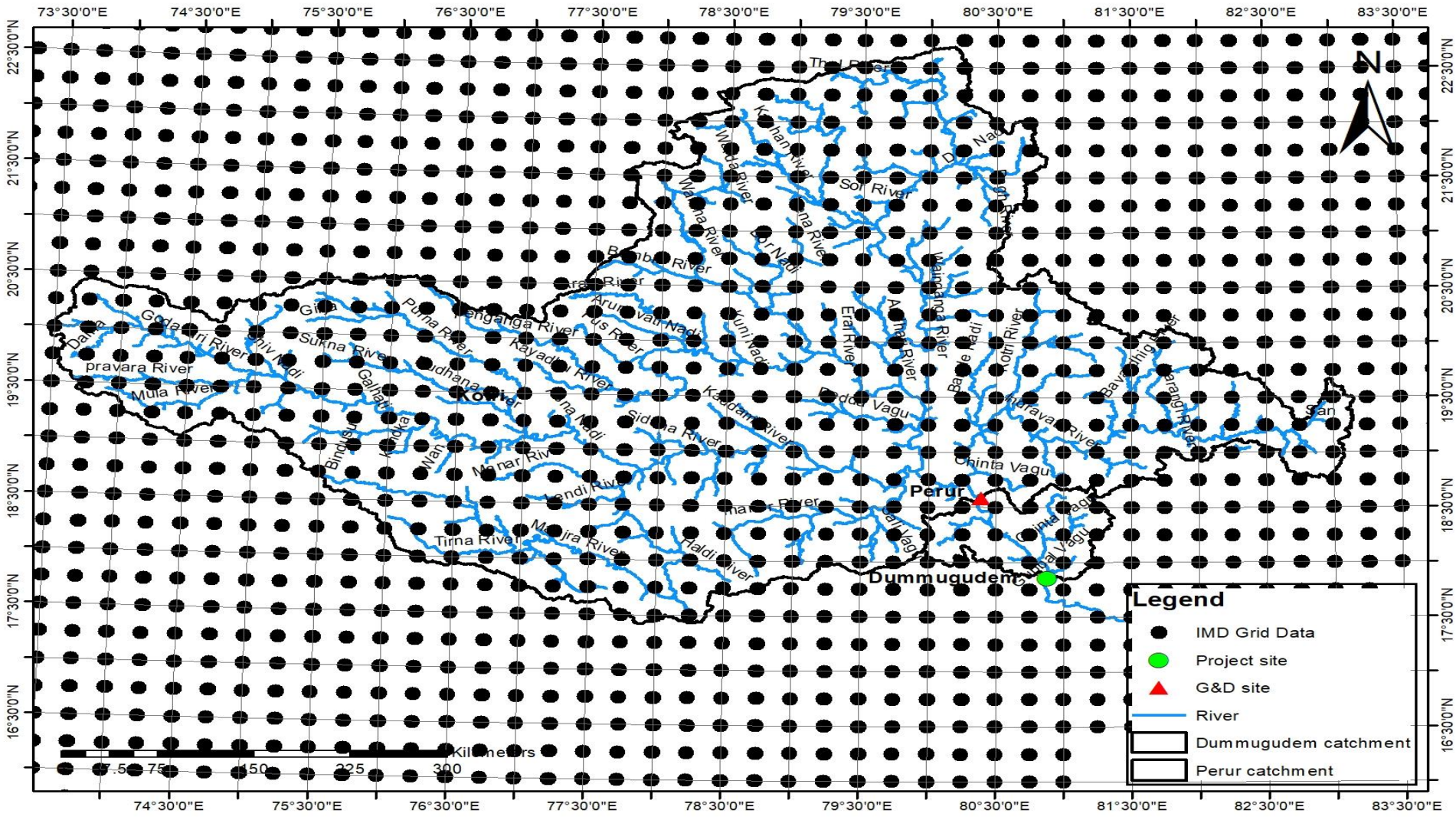


Figure 5.17: IMD Grid Rainfall Data for Dummugudem Project site and G&D site

a. Average Annual Rainfall

Catchment area rainfalls for the last 15 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site is given in **Table 5.14**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.15** and **Table 5.16** respectively.

Table 5.14: Average Annual Rainfall

	Rainfall (in mm)	
Year	**Perur**	**Dummugudem Dam**
2000-01	936	999
2001-02	983	1104
2002-03	870	889
2003-04	1019	1159
2004-05	831	919
2005-06	1282	1301
2006-07	1036	1175
2007-08	950	1078
2008-09	875	954
2009-10	823	867
2010-11	1246	1325
2011-12	804	874
2012-13	949	1070
2013-14	1424	1474
2014-15	844	935
AVERAGE (mm)	1030	1075

Table 5.15: 10 Daily Rainfall (in mm) of Perur G&D Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	10.43	5.85	2.21	0.16	2.39	0.35	1.3	3.03	3.28	1.44	0.53	2.64	0.73	4.94	0.73
	II	6.71	17.04	3.78	5.39	7.51	2.04	1.67	5.78	3.58	1.19	7.15	2.98	7.42	12.61	4.14
	III	5.08	1.6	18.66	7.36	2.42	15.84	9.18	11.62	6.34	5.53	5.23	5.02	2.35	9.58	1.45
JUL	I	8.58	6.02	0.6	11.88	3.95	13.29	11.02	9.38	5.4	9.78	15.3	7.44	8.16	8.95	3.37
	II	18.36	5.73	5.28	12.14	6.54	7.3	3.94	6.19	2.18	9.68	7.2	9.85	7.45	23.09	7.73
	III	2.21	5.44	2.27	12.72	11.21	21.32	10.64	6.07	12.45	6.3	15.53	7.43	11.83	15.44	12.15
AUG	I	4.9	13.9	12.32	9.01	9.94	11.03	24.7	11.25	17.52	0.93	12.92	7.41	7.17	11.68	5.46
	II	10.92	11.45	8.4	3.92	4.5	6.81	7.44	2.34	5.06	6.16	9.06	6.49	7.39	10.01	2.03
	III	13.59	5.05	12.55	12	2.99	2.37	3.76	7.4	3.93	10.29	11.43	11.45	8.61	4.8	11.56
SEP	I	0.81	1.71	9.6	3.65	5.42	6.33	3.95	10.24	8.74	8.85	14.18	9.56	12.32	1.84	12.99
	II	1.39	2.75	1.17	2.14	2.76	12.53	12.22	7.28	9.31	0.94	6.2	4.64	3.32	8.36	2.4
	III	2.79	2.7	0.61	7.67	4.56	7.4	5.23	5.34	1.93	2.59	2.81	0.75	4.47	3.72	0.4
OCT	I	1.07	11.44	0.19	2.09	3.32	0.18	3.62	1.74	2.4	5.05	0.94	0.62	5.35	8.97	0.54
	II	0.66	2.89	4.13	0.11	1.02	8	0.08	0.04	0.5	0.02	2.69	0.74	0	1.85	1.21
	III	0.03	0	0	2.75	0.13	1.05	0.22	0.01	0.13	0	2.89	0	0.25	2.83	0.38
NOV	I	0.04	0.03	0.05	0.22	0.78	0.02	1.63	0.65	0	0.87	1.14	0.04	1.39	0.01	0.06
	II	0	0.31	0.13	0	0.34	0	0	0	0.22	6.45	3.13	0	0	0	1.56
	III	0	0	0	0	0	0	0.12	0	0.09	0	0.64	0	0	0.59	0
DEC	I	0.01	0.01	0	0	0	0	0.04	0	0.04	0	0.47	0	0	0.41	0
	II	0	0	0	0.05	0	0	0	0	0	0.41	0.03	0	0.02	0	0.34
	III	0.04	0	0.01	0.12	0	0.7	0	0	0	0.15	0	0	0	0	0
JAN	I	0.65	0.85	0.03	0.03	0.01	0	0.02	0	0.02	0	0.02	0.65	0.26	0.03	1.83
	II	0.03	0.01	0.01	0	0.04	0	0	0	0	1.02	0.01	0	0	0.11	0
	III	0	0.06	0	1.29	5.93	0	0	0	0	0	0	0.26	0.18	0.09	0.02
FEB	I	0	0.24	0.64	0.56	0.98	0	0	0.16	0.01	0.25	0	0.01	0.2	0	0.07
	II	0	0.17	0.68	0	0.01	0	0.1	0.38	0	0.41	0.08	0.03	1.54	0.02	0.3
	III	0	0.07	0.04	0	0.09	0	0	0	0	0.4	0.35	0	0.4	1.91	0.04
MAR	I	0.58	0.01	0.01	0.14	1.62	2.62	0.02	0	0	0	0.02	0	0	5.44	4.29
	II	0.33	0.03	0.48	0	0.09	1.67	0.1	0.11	0.19	0.75	0	0	0.25	0.66	1.06
	III	0.04	0.08	0.12	0.21	0	0	0.02	3.43	0.09	0.11	0.07	0	0.09	0	0.18
APR	I	0.36	0.42	0.32	0.45	0.09	0.01	0.04	0.44	0.38	0	0.25	0.11	0.41	0.05	0.54
	II	1.77	0.03	0.18	0.02	0.86	1.71	0.4	0	0	0.05	0.59	0.06	0.27	0.49	3.07
	III	0.04	0.04	0.17	0.55	0.7	0.01	0.11	0	0	0.25	0.41	0.15	0.63	0.24	0.34
MAY	I	0.01	0.12	0.01	0.94	0.55	0.44	0.22	0.11	0.08	0.27	0.09	0.04	0.04	1.19	0.62
	II	0.19	0.77	0.87	1.16	0	0.71	0.11	0.05	1.33	0.14	0.06	0.08	0.05	0.3	1.08
	III	0.31	0.38	0.01	0.26	0.3	1.74	0.2	0.23	0.56	0.35	0.19	0.03	0.34	0.26	0.06
Yearly Rainfall (mm)		936	983	870	1019	831	1282	1036	950	875	823	1246	804	949	1424	844

Table 5.16: 10 Daily Rainfall (in mm) of Dummugudem Dam Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	10.34	6.05	2.44	0.19	2.36	0.47	1.70	2.73	4.38	1.70	0.62	2.72	0.87	5.06	0.84
	II	7.08	19.27	3.87	5.36	9.81	2.02	1.65	5.91	3.89	1.27	6.97	3.28	7.51	14.19	4.32
	III	5.37	2.01	17.50	7.09	2.35	15.70	8.62	14.23	6.84	5.31	5.01	5.33	3.12	10.08	1.86
JUL	I	8.76	9.61	0.70	12.05	4.29	12.85	14.00	9.10	6.08	10.02	14.70	7.62	8.77	8.72	3.36
	II	19.36	6.38	6.20	13.28	7.31	6.97	4.59	7.34	2.48	11.81	7.81	9.70	8.10	22.55	9.38
	III	2.43	6.05	2.69	14.66	11.71	20.35	11.79	6.09	13.08	6.64	16.63	7.59	13.17	15.95	13.85
AUG	I	5.48	14.60	12.71	10.69	11.64	10.93	26.64	14.01	19.63	1.34	14.22	7.74	9.62	12.16	6.59
	II	11.92	14.07	8.67	4.72	5.92	7.48	8.89	4.00	5.92	6.53	9.31	7.32	9.16	11.18	2.64
	III	14.35	5.37	12.74	14.49	4.14	2.48	5.18	7.71	4.35	11.00	11.88	11.81	8.95	4.67	11.73
SEP	I	1.19	1.90	9.39	4.67	5.30	6.42	4.26	11.58	8.97	8.33	15.64	11.16	13.61	2.21	14.26
	II	1.62	3.02	1.35	2.63	2.91	14.44	14.39	6.94	9.38	0.86	7.45	5.82	3.99	8.15	3.48
	III	3.21	2.94	0.53	7.80	4.49	6.72	6.30	6.62	1.95	2.66	2.56	1.09	4.83	4.21	0.66
OCT	I	1.11	10.30	0.24	3.97	3.87	0.32	3.18	3.62	2.30	4.90	1.11	0.73	4.99	8.65	0.53
	II	0.58	2.79	4.44	0.15	1.07	7.58	0.09	0.19	0.47	0.02	3.66	0.84	0.20	1.85	2.30
	III	0.02	0.00	0.02	3.41	0.20	2.02	0.28	0.04	0.15	0.00	2.88	0.04	0.21	4.09	0.44
NOV	I	0.04	0.04	0.04	0.21	0.71	0.33	2.17	0.54	0.00	0.78	1.31	0.03	2.22	0.01	0.05
	II	0.00	1.01	0.11	0.00	0.32	0.00	0.01	0.00	0.20	5.63	2.77	0.00	0.00	0.00	1.46
	III	0.01	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.08	0.00	0.63	0.00	0.00	0.50	0.00
DEC	I	0.05	0.01	0.00	0.00	0.00	0.00	0.07	0.00	0.04	0.00	0.88	0.00	0.00	0.34	0.00
	II	0.00	0.00	0.00	0.47	0.00	0.00	0.01	0.00	0.00	0.34	0.08	0.00	0.02	0.00	0.28
	III	0.04	0.00	0.01	0.13	0.00	0.67	0.00	0.00	0.00	0.13	0.00	0.02	0.00	0.00	0.01
JAN	I	0.56	0.91	0.03	0.02	0.01	0.00	0.02	0.00	0.02	0.00	0.02	0.76	0.22	0.03	1.73
	II	0.03	0.01	0.01	0.05	0.04	0.00	0.00	0.00	0.00	0.99	0.01	0.07	0.00	0.09	0.00
	III	0.00	0.19	0.00	1.72	5.79	0.00	0.00	0.14	0.00	0.00	0.01	0.25	0.16	0.08	0.01
FEB	I	0.00	0.21	0.54	0.76	0.97	0.00	0.00	0.22	0.01	0.22	0.00	0.00	0.17	0.00	0.06
	II	0.00	0.15	0.62	0.00	0.01	0.00	0.13	0.37	0.00	0.37	0.08	0.02	1.44	0.02	0.25
	III	0.00	0.07	0.08	0.00	0.07	0.00	0.00	0.00	0.00	0.40	0.51	0.00	0.33	1.59	0.04
MAR	I	0.51	0.01	0.02	0.12	1.35	2.34	0.01	0.00	0.00	0.00	0.02	0.02	0.00	5.08	3.71
	II	0.29	0.03	0.59	0.00	0.08	1.80	0.09	0.16	0.16	0.64	0.00	0.00	0.22	0.61	0.89
	III	0.05	0.09	0.24	0.17	0.00	0.01	0.02	3.46	0.23	0.17	0.10	0.06	0.08	0.00	0.19
APR	I	0.37	0.50	0.37	0.46	0.11	0.04	0.03	0.47	0.36	0.00	0.31	0.13	0.36	0.06	0.47
	II	2.12	0.13	0.23	0.03	0.80	2.01	0.52	0.00	0.00	0.10	0.72	0.07	0.66	0.64	2.97
	III	0.12	0.07	0.21	0.84	0.84	0.02	0.13	0.01	0.00	0.61	0.84	0.43	1.07	0.32	0.69
MAY	I	0.14	0.10	0.01	0.89	0.68	0.52	0.40	0.12	0.24	0.55	0.21	0.36	0.04	1.33	0.75
	II	0.31	0.77	0.72	1.10	0.00	0.93	0.19	0.04	1.37	0.17	0.16	0.32	0.13	0.36	1.06
	III	0.68	0.51	0.02	0.27	0.53	1.89	0.29	0.34	0.91	1.33	0.30	0.05	0.53	0.41	0.05
Yearly Rainfall (mm)		999	1104	889	1159	919	1301	1175	1078	954	867	1325	874	1070	1474	935

5.2.2.3 Rainfall and Runoff Data at Perur G&D Site

Detailed calculations on water availability and flood magnitude will help select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of the observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) for the entire period ranging from 2000 to 2015. The plot between monthly runoff depth and monthly rainfall data in "mm" at Perur G&D site is shown in **Figure 5.18**. The basic comparison between rainfall and runoff in **Figure 5.18** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.19** shows the plot of runoff coefficient at G&D site. It can be seen that annual runoff depth is less than annual rainfall. The difference might arise due to presence of dams, barrages, etc present at the upstream of G&D sites which might affect the flow series generated at the G&D site.

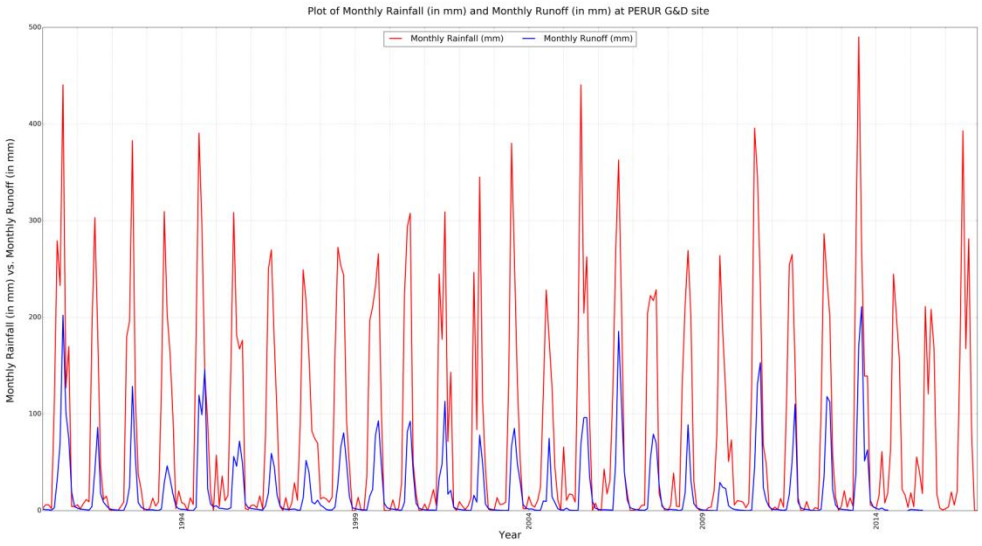


Figure 5.18: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Perur G&D site

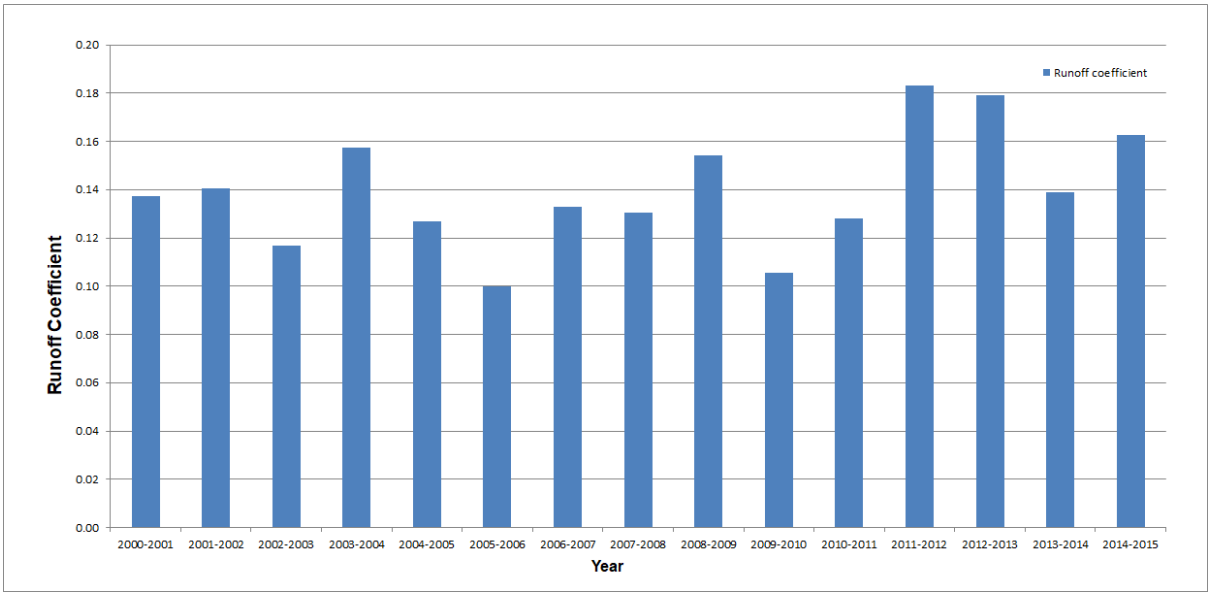


Figure 5.19: Plot of runoff coefficient at Perur G&D Site

5.2.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Perur is around 2,68,200 km^2 as mentioned on India WRIS site. Daily discharge data for Perur site is available for period from 2000 to 2015. After finalizing the flow series at the G&D site of Perur, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Perur G&D and the dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Perur G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Dummugudem}}{CA_{Perur}} = \frac{277001}{268200} = 1.03$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Dummugudem}}{\text{Average Annual Rainfall}_{Perur}} = \frac{1075}{1030} = 1.04$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Dummugudem}} = Q_{\text{Perur G\&D } Site} \text{X } 1.03 \text{ X } 1.04$$

Table 5.19 shows 10-daily average flow series at G&D site. **Table 5.17** and **Table 5.18** give 10-daily average flow series and 10-daily inflow series developed for Dummugudem dam site.

Table 5.17: 10-Daily Average Flow Series (m^3/s) at Perur

Catchment Area =2,68,200 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	30.59	53.45	18.31	15.51	28.93	15.57	51.79	25.15	16.31	31.08	14.60	29.58	3.34	11.40	24.69
	II	32.37	57.60	26.20	26.45	26.23	3.78	53.93	84.61	56.31	64.95	17.60	40.46	48.17	73.00	43.69
	III	263.97	301.55	358.80	150.49	421.13	100.78	251.04	231.84	185.50	118.28	183.94	223.44	250.01	254.75	235.39
Jul	I	1212.91	798.76	954.89	873.09	1246.14	1599.11	1805.45	1362.84	719.89	344.85	780.59	615.37	697.52	722.42	980.99
	II	1988.24	1721.13	1190.89	2036.27	1596.26	2938.09	2446.78	2984.08	2720.76	1132.98	1389.61	1381.27	1177.03	1393.83	1864.09
	III	2219.75	2918.06	1418.21	2900.24	1893.29	2141.64	2047.04	2326.68	3817.40	2046.52	2250.02	2954.11	2530.26	2173.17	2402.60
Aug	I	2968.14	3060.26	2381.56	3107.60	3732.61	3054.24	2472.55	2524.53	4460.48	2987.29	3105.22	3105.40	3137.62	3204.72	3093.02
	II	4427.45	4836.04	4371.54	4327.68	4994.93	4278.51	3755.99	3405.73	6177.91	4211.17	4967.04	4932.46	4356.51	5209.71	4589.48
	III	5638.29	4830.95	5073.71	5789.70	5804.33	5829.50	6501.56	4286.74	6661.21	4814.73	5893.17	5451.99	5572.99	5436.65	5541.82
Sep	I	5062.83	5512.70	5933.92	7017.88	3608.35	3050.22	5253.88	4442.63	4675.35	4981.07	5841.18	7116.93	7208.20	4176.69	5277.27
	II	3883.83	5605.47	4174.28	4982.21	2598.94	2577.68	3364.41	3289.38	4574.00	1604.85	6463.98	8983.57	9687.15	3612.56	4671.59
	III	2417.31	3169.04	1106.24	4129.91	1207.11	2226.85	2664.72	3155.00	2459.40	531.50	4205.35	5107.96	7026.14	8161.79	3397.74
Oct	I	2406.35	2748.11	570.36	4105.14	1339.24	2929.70	2745.53	3198.95	974.06	699.73	2806.17	1169.70	4221.97	8950.06	2776.08
	II	1811.76	2865.06	530.58	2247.11	792.72	1939.08	2496.00	2035.57	743.12	574.35	1831.56	966.81	1490.47	6583.45	1921.97
	III	1234.77	809.32	913.68	2655.52	384.85	1569.60	1075.66	1057.82	504.42	286.57	2603.63	548.38	851.02	3610.89	1293.30
Nov	I	690.48	442.06	290.77	1072.18	246.02	1044.78	1047.07	742.34	407.42	178.31	1234.35	391.93	800.69	1723.85	736.59
	II	500.80	413.03	231.42	540.26	210.89	747.28	861.94	503.89	315.63	164.28	1208.17	301.41	611.37	865.03	533.96
	III	333.60	326.51	167.49	346.49	147.24	473.74	540.15	169.74	244.18	441.88	852.42	227.71	358.11	659.33	377.76
Dec	I	254.42	235.13	161.49	340.51	106.51	301.72	381.15	209.63	234.70	179.22	513.42	176.13	283.75	503.53	277.24
	II	191.13	174.33	140.59	224.56	86.93	223.41	296.93	174.38	161.49	123.84	377.22	148.95	211.48	341.54	205.48
	III	163.79	125.22	107.86	222.48	73.16	214.08	239.95	149.86	108.47	80.16	302.90	112.20	161.96	312.34	169.60
Jan	I	143.38	127.64	103.80	185.07	66.39	173.00	204.39	128.39	70.60	88.20	216.71	121.88	142.62	236.35	143.46
	II	127.27	158.97	80.38	145.09	58.06	137.04	184.06	112.62	69.75	87.05	179.23	164.15	156.93	212.97	133.83
	III	110.61	106.59	68.46	149.34	61.37	113.11	164.76	89.28	66.77	76.99	135.91	99.29	118.14	199.74	111.45
Feb	I	209.88	91.33	62.53	301.60	558.21	97.89	147.70	115.29	60.85	62.02	111.37	88.78	101.75	184.15	156.67
	II	121.26	92.14	64.13	174.35	179.32	92.88	124.76	155.47	55.38	59.38	111.49	86.69	106.03	148.26	112.25
	III	82.62	89.95	55.83	93.83	88.57	89.37	78.16	139.99	48.52	45.05	146.30	60.17	138.01	131.98	92.02
Mar	I	72.31	70.38	51.77	82.87	67.35	85.52	75.94	101.62	39.78	50.52	158.32	33.16	118.61	171.01	84.23
	II	63.75	57.69	36.46	62.37	59.26	103.09	63.61	95.87	29.62	33.22	103.55	24.34	93.21	388.06	86.72
	III	55.68	47.56	34.13	50.55	51.12	97.19	53.51	92.27	25.75	25.96	90.27	14.11	66.68	247.97	68.05
Apr	I	43.59	37.48	34.05	43.02	41.81	50.87	54.29	109.51	24.73	20.99	69.95	12.09	50.34	93.73	49.03
	II	43.58	31.40	25.39	38.24	31.63	85.75	49.05	100.13	20.38	13.34	49.61	14.91	39.34	61.66	43.17
	III	46.45	23.92	20.72	31.97	26.06	120.46	55.59	46.71	15.54	19.62	74.14	11.36	35.43	59.43	41.96
May	I	39.04	15.78	17.12	35.49	28.77	88.77	48.30	11.47	19.69	17.07	50.41	7.61	29.37	49.21	32.72
	II	35.79	15.77	15.26	45.04	28.17	70.03	40.49	12.71	15.13	16.18	37.09	16.18	21.25	56.98	30.43
	III	27.29	14.19	12.41	29.02	22.17	54.53	31.43	16.76	16.02	12.10	28.63	15.24	8.97	64.62	25.24
Inflow (MCM) =		34460	37024	27265	42975	28275	34303	36915	33232	36207	23285	42773	39453	45633	53106	36779

Table 5.18: 10-Daily Average Flow Series (m^3/s) at Dummugudem Dam

Catchment Area =2,77,001km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	32.87	57.43	19.67	16.67	31.09	16.73	55.65	27.02	17.53	33.40	15.69	31.78	3.59	12.25	26.53
	II	34.78	61.89	28.15	28.42	28.18	4.06	57.95	90.91	60.51	69.79	18.91	43.47	51.76	78.44	46.94
	III	283.63	324.02	385.53	161.70	452.50	108.29	269.74	249.11	199.32	127.09	197.64	240.09	268.64	273.73	252.93
Jul	I	1303.27	858.27	1026.03	938.14	1338.98	1718.25	1939.96	1464.37	773.52	370.54	838.74	661.22	749.49	776.24	1054.07
	II	2136.36	1849.36	1279.61	2187.97	1715.18	3156.98	2629.07	3206.40	2923.46	1217.39	1493.14	1484.18	1264.72	1497.67	2002.96
	III	2385.12	3135.46	1523.87	3116.31	2034.34	2301.19	2199.55	2500.02	4101.80	2198.99	2417.65	3174.19	2718.77	2335.07	2581.59
Aug	I	3189.27	3288.25	2558.99	3339.12	4010.69	3281.78	2656.76	2712.61	4792.79	3209.85	3336.56	3336.76	3371.38	3443.47	3323.45
	II	4757.30	5196.33	4697.22	4650.10	5367.06	4597.26	4035.81	3659.46	6638.17	4524.91	5337.09	5299.93	4681.07	5597.84	4931.40
	III	6058.35	5190.86	5451.71	6221.04	6236.76	6263.80	6985.93	4606.11	7157.48	5173.43	6332.22	5858.17	5988.18	5841.69	5954.69
Sep	I	5440.01	5923.40	6376.00	7540.72	3877.18	3277.46	5645.30	4773.61	5023.67	5352.16	6276.35	7647.15	7745.22	4487.86	5670.43
	II	4173.18	6023.08	4485.27	5353.39	2792.56	2769.72	3615.06	3534.44	4914.77	1724.41	6945.55	9652.85	10408.85	3881.70	5019.63
	III	2597.40	3405.14	1188.66	4437.59	1297.04	2392.75	2863.24	3390.05	2642.63	571.10	4518.65	5488.51	7549.59	8769.85	3650.87
Oct	I	2585.62	2952.85	612.85	4410.98	1439.01	3147.97	2950.07	3437.27	1046.63	751.86	3015.23	1256.84	4536.51	9616.85	2982.90
	II	1946.74	3078.51	570.11	2414.52	851.78	2083.54	2681.95	2187.22	798.48	617.14	1968.01	1038.84	1601.51	7073.92	2065.16
	III	1326.76	869.62	981.75	2853.36	413.52	1686.54	1155.80	1136.63	542.00	307.92	2797.60	589.23	914.42	3879.90	1389.65
Nov	I	741.92	474.99	312.43	1152.06	264.35	1122.62	1125.08	797.64	437.77	191.59	1326.31	421.13	860.34	1852.28	791.47
	II	538.11	443.80	248.66	580.51	226.60	802.95	926.16	541.43	339.14	176.52	1298.18	323.87	656.92	929.48	573.74
	III	358.46	350.84	179.97	372.30	158.21	509.03	580.39	182.39	262.37	474.80	915.93	244.67	384.79	708.45	405.90
Dec	I	273.37	252.65	173.52	365.88	114.45	324.20	409.55	225.25	252.19	192.57	551.67	189.25	304.89	541.04	297.89
	II	205.36	187.32	151.06	241.29	93.41	240.05	319.05	187.37	173.52	133.07	405.32	160.05	227.24	366.99	220.79
	III	175.99	134.55	115.90	239.05	78.61	230.03	257.83	161.02	116.55	86.13	325.47	120.56	174.03	335.61	182.24
Jan	I	154.06	137.15	111.53	198.86	71.34	185.89	219.62	137.96	75.86	94.77	232.86	130.96	153.25	253.96	154.15
	II	136.75	170.81	86.37	155.90	62.39	147.25	197.77	121.01	74.95	93.54	192.58	176.38	168.62	228.84	143.80
	III	118.85	114.53	73.56	160.47	65.94	121.54	177.03	95.93	71.74	82.73	146.04	106.69	126.94	214.62	119.76
Feb	I	225.51	98.13	67.19	324.07	599.80	105.18	158.70	123.88	65.38	66.64	119.67	95.39	109.33	197.87	168.34
	II	130.30	99.00	68.91	187.34	192.68	99.80	134.05	167.05	59.51	63.80	119.80	93.15	113.93	159.31	120.62
	III	88.77	96.65	59.99	100.82	95.17	96.03	83.98	150.42	52.13	48.41	157.20	64.65	148.29	141.81	98.88
Mar	I	77.69	75.62	55.63	89.04	72.37	91.89	81.60	109.19	42.74	54.28	170.11	35.63	127.45	183.75	90.50
	II	68.50	61.99	39.18	67.02	63.67	110.77	68.35	103.01	31.83	35.69	111.26	26.15	100.15	416.97	93.18
	III	59.82	51.10	36.67	54.32	54.93	104.43	57.50	99.14	27.67	27.89	97.00	15.16	71.65	266.44	73.12
Apr	I	46.83	40.27	36.59	46.23	44.92	54.66	58.33	117.67	26.57	22.55	75.16	12.99	54.09	100.71	52.68
	II	46.82	33.74	27.28	41.09	33.99	92.14	52.70	107.59	21.90	14.33	53.31	16.02	42.27	66.25	46.39
	III	49.91	25.70	22.26	34.35	28.00	129.43	59.73	50.19	16.70	21.08	79.66	12.21	38.07	63.86	45.08
May	I	41.95	16.96	18.40	38.13	30.91	95.38	51.90	12.32	21.16	18.34	54.17	8.18	31.56	52.88	35.16
	II	38.46	16.94	16.40	48.40	30.27	75.25	43.51	13.66	16.26	17.39	39.85	17.39	22.83	61.23	32.70
	III	29.32	15.25	13.33	31.18	23.82	58.59	33.77	18.01	17.21	13.00	30.76	16.38	9.64	69.43	27.12
Inflow (MCM) =		37027	39782	29296	46177	30381	36859	39665	35708	38905	25020	45960	42392	49033	57062	39519

Table 5.19: 10-Daily Inflow Series (MCM) at Dummugudem Project Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	28.40	49.62	17.00	14.40	26.86	14.45	48.08	23.35	15.14	28.86	13.55	27.46	3.10	10.58	22.92
	II	30.05	53.47	24.32	24.56	24.35	3.51	50.07	78.55	52.28	60.30	16.34	37.56	44.72	67.77	40.56
	III	245.06	279.95	333.10	139.71	390.96	93.56	233.06	215.23	172.21	109.81	170.76	207.43	232.10	236.50	218.53
Jul	I	1126.02	741.54	886.49	810.55	1156.88	1484.56	1676.12	1265.22	668.32	320.15	724.68	571.29	647.56	670.67	910.72
	II	1845.82	1597.84	1105.59	1890.41	1481.92	2727.63	2271.51	2770.33	2525.87	1051.82	1290.07	1282.33	1092.72	1293.99	1730.56
	III	2266.82	2979.94	1448.28	2961.74	1933.44	2187.05	2090.45	2376.02	3898.35	2089.92	2297.73	3016.75	2583.92	2219.25	2453.55
Aug	I	2755.53	2841.05	2210.97	2885.00	3465.24	2835.46	2295.44	2343.69	4140.97	2773.31	2882.79	2882.96	2912.87	2975.16	2871.46
	II	4110.30	4489.63	4058.40	4017.68	4637.14	3972.03	3486.94	3161.77	5735.38	3909.52	4611.24	4579.14	4044.45	4836.53	4260.73
	III	5757.86	4933.39	5181.30	5912.47	5927.41	5953.12	6639.43	4377.64	6802.47	4916.83	6018.14	5567.60	5691.17	5551.94	5659.34
Sep	I	4700.17	5117.82	5508.87	6515.18	3349.88	2831.73	4877.54	4124.40	4340.45	4624.27	5422.77	6607.14	6691.87	3877.51	4899.26
	II	3605.63	5203.94	3875.27	4625.33	2412.77	2393.04	3123.41	3053.76	4246.36	1489.89	6000.96	8340.07	8993.25	3353.79	4336.96
	III	2244.16	2942.04	1027.00	3834.08	1120.64	2067.34	2473.84	2929.00	2283.23	493.43	3904.12	4742.07	6522.85	7577.15	3154.35
Oct	I	2233.98	2551.26	529.50	3811.08	1243.31	2719.84	2548.86	2969.81	904.29	649.61	2605.16	1085.91	3919.55	8308.96	2577.22
	II	1681.98	2659.83	492.57	2086.15	735.94	1800.18	2317.21	1889.76	689.89	533.21	1700.36	897.56	1383.71	6111.87	1784.30
	III	1260.96	826.48	933.06	2711.83	393.01	1602.88	1098.47	1080.25	515.12	292.65	2658.84	560.01	869.07	3687.46	1320.72
Nov	I	641.02	410.39	269.94	995.38	228.40	969.94	972.07	689.17	378.24	165.54	1145.93	363.86	743.34	1600.37	683.83
	II	464.93	383.44	214.84	501.56	195.78	693.75	800.20	467.80	293.02	152.51	1121.63	279.82	567.58	803.07	495.71
	III	309.71	303.12	155.49	321.67	136.69	439.81	501.46	157.58	226.69	410.23	791.36	211.40	332.46	612.10	350.70
Dec	I	236.19	218.29	149.92	316.12	98.88	280.11	353.85	194.61	217.89	166.38	476.64	163.51	263.42	467.46	257.38
	II	177.43	161.84	130.52	208.47	80.70	207.41	275.66	161.89	149.92	114.97	350.20	138.28	196.33	317.08	190.76
	III	167.26	127.88	110.15	227.20	74.71	218.62	245.04	153.04	110.77	81.86	309.32	114.58	165.39	318.96	173.20
Jan	I	133.11	118.50	96.36	171.81	61.63	160.61	189.75	119.19	65.54	81.88	201.19	113.15	132.40	219.42	133.18
	II	118.15	147.58	74.62	134.70	53.90	127.22	170.88	104.55	64.75	80.81	166.39	152.39	145.69	197.71	124.24
	III	112.95	108.85	69.91	152.51	62.67	115.51	168.25	91.17	68.19	78.62	138.79	101.40	120.65	203.98	113.82
Feb	I	194.84	84.79	58.05	280.00	518.22	90.88	137.12	107.03	56.49	57.58	103.39	82.42	94.46	170.96	145.45
	II	112.58	85.54	59.54	161.86	166.48	86.23	115.82	144.33	51.41	55.13	103.50	80.48	98.43	137.64	104.21
	III	61.36	66.81	41.46	69.69	65.78	66.37	58.05	103.97	36.04	33.46	108.66	44.69	102.50	98.02	68.35
Mar	I	67.13	65.34	48.06	76.93	62.53	79.39	70.50	94.34	36.93	46.90	146.98	30.78	110.11	158.76	78.19
	II	59.18	53.56	33.85	57.90	55.02	95.71	59.05	89.00	27.50	30.84	96.13	22.60	86.53	360.26	80.51
	III	56.86	48.57	34.85	51.62	52.20	99.25	54.64	94.23	26.30	26.51	92.18	14.41	68.09	253.23	69.50
Apr	I	40.46	34.80	31.61	39.94	38.82	47.23	50.40	101.67	22.96	19.49	64.94	11.22	46.73	87.02	45.52
	II	40.46	29.15	23.57	35.50	29.36	79.61	45.54	92.96	18.92	12.38	46.06	13.84	36.52	57.24	40.08
	III	43.13	22.21	19.24	29.68	24.19	111.83	51.61	43.36	14.43	18.21	68.83	10.55	32.89	55.17	38.95
May	I	36.24	14.65	15.89	32.95	26.71	82.41	44.84	10.65	18.28	15.85	46.80	7.06	27.27	45.69	30.38
	II	33.23	14.64	14.17	41.81	26.15	65.01	37.59	11.80	14.05	15.02	34.43	15.02	19.73	52.90	28.25
	III	27.87	14.49	12.67	29.64	22.64	55.69	32.10	17.12	16.36	12.36	29.24	15.56	9.16	65.99	25.78
Inflow (MCM) =		37027	39782	29296	46177	30381	36859	39665	35708	38905	25020	45960	42392	49033	57062	39519

5.2.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.20** and **Table 5.21** respectively.

Table 5.20: Computation of 90% and 50% Dependable Year for Dummugudem Project

m	m/(n+1)	Runoff in descending order (in MCM)	Dependable Year	
1	0.06	57062	2013-2014	
2	0.13	49033	2012-2013	
3	0.19	46177	2003-2004	
4	0.25	45960	2010-2011	
5	0.31	42392	2011-2012	
6	0.38	39782	2001-2002	
7	0.44	39665	2006-2007	
8	**0.50**	**39519**	**2014-2015**	**50% Dependable**
9	0.56	38905	2008-2009	
10	0.63	37027	2000-2001	
11	0.69	36859	2005-2006	
12	0.75	35708	2007-2008	
13	0.81	30381	2004-2005	
14	**0.88**	**29296**	**2002-2003**	**90% Dependable**
15	0.94	25020	2009-2010	

Table 5.21: 90% and 50% Dependable year flows for Dummugudem Project

Period		90% Dependable 2002-2003	50% Dependable 2014-2015
Jun	I	19.67	26.53
	II	28.15	46.94
	III	385.53	252.93
Jul	I	1026.03	1054.07
	II	1279.61	2002.96
	III	1523.87	2581.59
Aug	I	2558.99	3323.45
	II	4697.22	4931.40
	III	5451.71	5954.69
Sep	I	6376.00	5670.43
	II	4485.27	5019.63
	III	1188.66	3650.87
Oct	I	612.85	2982.90
	II	570.11	2065.16
	III	981.75	1389.65
Nov	I	312.43	791.47
	II	248.66	573.74
	III	179.97	405.90
Dec	I	173.52	297.89
	II	151.06	220.79
	III	115.90	182.24
Jan	I	111.53	154.15
	II	86.37	143.80
	III	73.56	119.76
Feb	I	67.19	168.34
	II	68.91	120.62
	III	59.99	98.88
Mar	I	55.63	90.50
	II	39.18	93.18
	III	36.67	73.12
Apr	I	36.59	52.68
	II	27.28	46.39
	III	22.26	45.08
May	I	18.40	35.16
	II	16.40	32.70
	III	13.33	27.12
Inflow (MCM) =		29296	39519

5.2.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam sites of Dummugudem, is given in the following section.

5.2.5.1 EAC of Dummugudem Dam

The EAC curve and the table showing the different values are given in **Figure 5.20** and **Table 5.22** respectively.

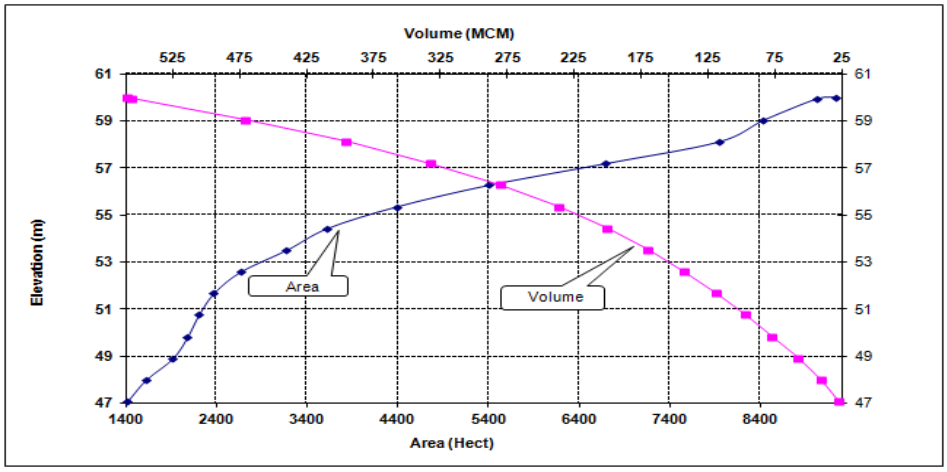


Figure 5.20: EAC curve of Dummugudem Dam

Table 5.22: EAC data of Dummugudem Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
47.08	14218167.59	1421.82	27081689.98	27.08
48.00	16258167.59	1625.82	40162378.14	40.16
48.92	19245627.49	1924.56	57868320.19	57.87
49.84	20859449.63	2085.94	76929946.50	76.93
50.76	22093769.94	2209.38	97058683.33	97.06
51.68	23739530.35	2373.95	118504113.10	118.50
52	26727637.59	2672.76	142137297.3	120.61
53.52	31791732.56	3179.17	169360108.60	169.36
54.44	36259333.32	3625.93	200574182.60	200.57
55.36	43886005.01	4388.60	236678447.60	236.68
56.28	54111888.49	5411.19	279916726.80	279.92
57.20	66994284.79	6699.43	332276260.60	332.28
58.12	79429964.70	7943.00	395523147.20	395.52
59.04	84311002.21	8431.10	469994126.60	469.99
59.96	90311002.21	9031.10	554920079.6	554.92
60.00	92311002.21	9231.10	558612604.2	558.61

5.2.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.2.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Perur G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Perur G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{Dummugudem}}{A_{Perur}}\right)^{\frac{3}{4}} = 1.02$$

Using the above multiplying factors to the peak flows at the Perur G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.23**. Flood peak at G&D site for year 2014 is not available and thus not used to estimate statistical parameters.

Table 5.23: Final Peak Flows at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2000	40942	53225	54530
2001	36288	47174	48330
2002	24840	32292	33083
2003	20116	26151	26792
2004	16746	21769	22303
2005	24436	31767	32546

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2006	51917	67492	69146
2007	37378	48591	49782
2008	25946	33730	34557
2009	12393	16111	16506
2010	44201	57461	58869
2011	26113	33947	34780
2012	27119	35255	36119
2013	57245	74418	76242

5.2.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.24**.

Table 5.24: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean (X_m)	42398.96
Variance	309974404.66
SD (Sx)	17606.09
Skewness	0.54
Kurtosis	-0.50
No. of Data	14

5.2.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.25**.

The detailed procedure for Gumbel distribution method for Dummugudem dam site has been shown in **Annexure-1**.

Table 5.25: Detail of different year Return Period Flood (m^3/s) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	39897
2	5	58374
3	10	70607
4	20	82342
5	25	86064
6	50	97531
7	100	108913
8	500	135216

Annexure -1 (Flood Frequency Analysis for Dummugudem Dam)

DESIGN FLOOD-Dummugudem

CA at G&D = 268200 | CA = 277001

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	2000	40942	53225	54530	7.21
2	2001	36288	47174	48330	6.86
3	2002	24840	32292	33083	6.59
4	2003	20116	26151	26792	6.93
5	2004	16746	21769	22303	6.75
6	2005	24436	31767	32546	7.01
7	2006	51917	67492	69146	6.86
8	2007	37378	48591	49782	6.59
9	2008	25946	33730	34557	7.40
10	2009	12393	16111	16506	4.89
11	2010	44201	57461	58869	6.92
12	2011	26113	33947	34780	6.85
13	2012	27119	35255	36119	6.48
14	2013	57245	74418	76242	6.53

Conversion factor = 1.02

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	42398.96	6.71
Variance	309974404.66	0.338
SD (Sx)	17606.09	0.581
Skewness	0.54	-2.49484
Kurtosis	-0.50	8.08409
No. of Data	14	

Parameters	Values

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 14

Reduced mean = Y_n = 0.520 (From Table) $f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Std. Dev = S_n = 1.08 (From Table)

Reduced Variate = Y_T = $-(\ln(\ln(T/T-1)))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

90% CONFIDENCE INTERVAL (X_{cl})

Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	**39897**	0.367	-0.142	0.915	4306.079	7083.501	32813	46980
2	5	**58374**	1.500	0.907	1.756	8264.921	13595.795	44778	71970
3	10	**70607**	2.250	1.602	2.430	11435.801	18811.893	51795	89419
4	20	**82342**	2.970	2.269	3.100	14587.582	23996.572	58345	106338
5	25	**86064**	3.199	2.480	3.315	15599.234	25660.740	60404	111725
6	50	**97531**	3.902	3.131	3.982	18737.554	30823.277	66708	128354
7	100	**108913**	4.600	3.778	4.649	21874.513	35983.573	72930	144897
8	500	**135216**	6.214	5.272	6.199	29168.005	47981.369	87234	183197

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	39897
2	5	58374
3	10	70607
4	20	82342
5	25	86064
6	50	97531
7	100	108913
8	500	135216

5.3 Hydrology of Bodhghat Hydroelectric Project

5.3.1 General

The present project, Bodhghat, envisages harnessing water from the River Indravati and other small rivers. Indravati River is a stream of the river Godavari. Its starting point is at the Ghats of Dandakaranya range from a hilltop village Mardiguda of Thuamula Rampur Block in the Kalahandi district of the state of Odisha due to the amalgamation of three streams. The project is proposed to be of storage type with the multifunction of irrigation and power.

5.3.1.1 Description of Dam Site

The catchment area of the dam site which comes out to be 15,719 km^2. The dam site is located in Dantewada district of Chattisgarh at 81°24' 08"E, 19°11'19.3"N. Locations of the dam site and of G&D site are shown in **Figure 5.21**.

5.3.1.2 Description of G&D Site

Chindnar G&D site is situated in the Dantewada district of Chattisgarh at 81°18'10" E, 19°4'50"N. Catchment area of the G&D site is around 17,270 km^2.

5.3.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometers draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/ km^2 –

nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

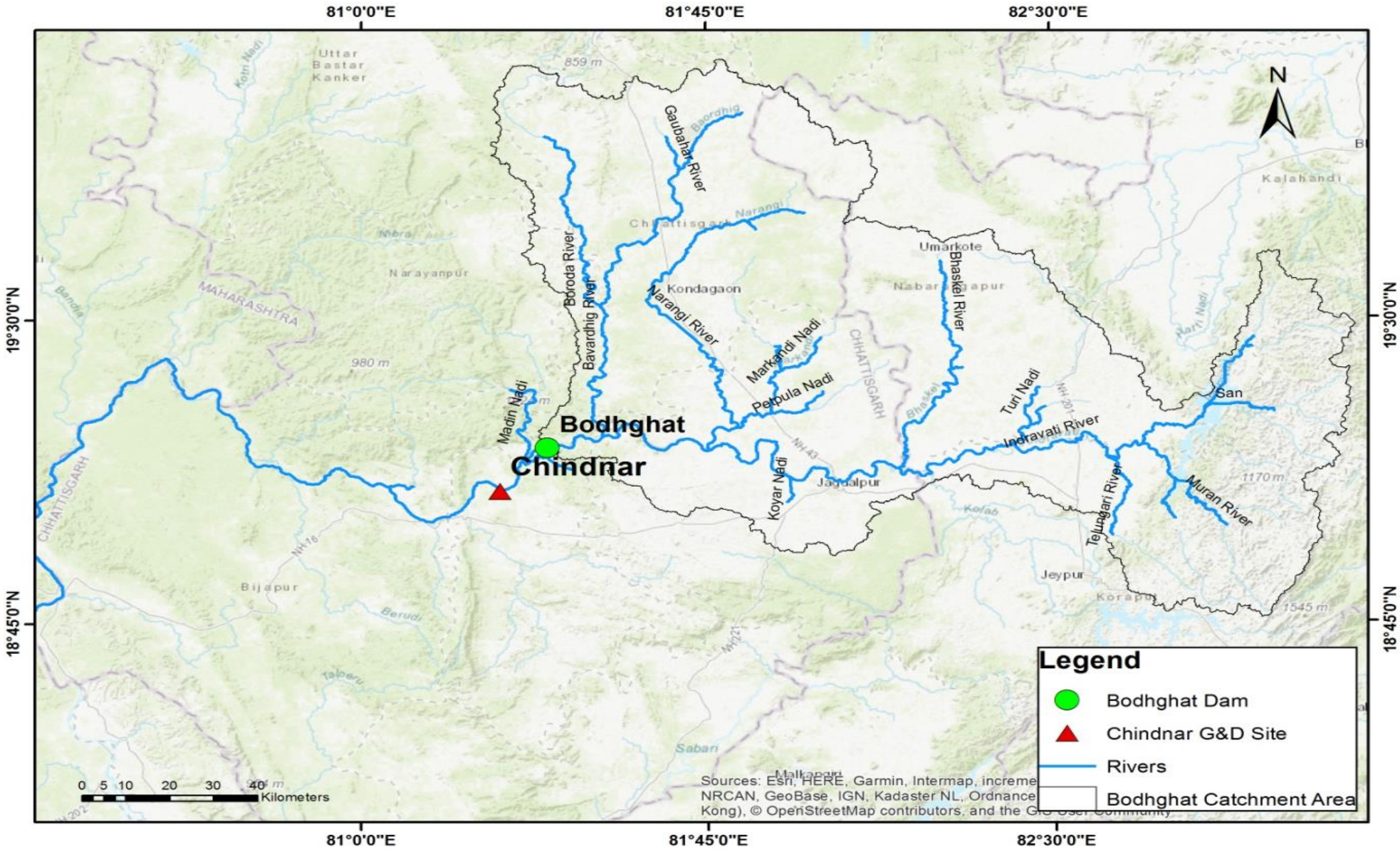


Figure 5.21: Catchment Area of Project and Locations of Dam and G&D site

5.3.2 Water Availability Studies

5.3.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Chindnar (Catchment Area=17,270 km^2), which is downstream of the project site along the Indravati River, is available and can be downloaded from India WRIS site. The G&D site lies in the Dantewada district of Chattisgarh.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.3.2.2 Rainfall data

Average of daily rainfall data generated at each grid point (as can be seen from **Figure 5.22**) within the boundary of the Chindnar G&D site and Bodhghat dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.22**, 24 grid point is considered to assess the catchment rainfall for Chindnar G&D site. Similarly, for Bodhghat proposed dam site, 21 grid points have been considered for the assessment of catchment rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

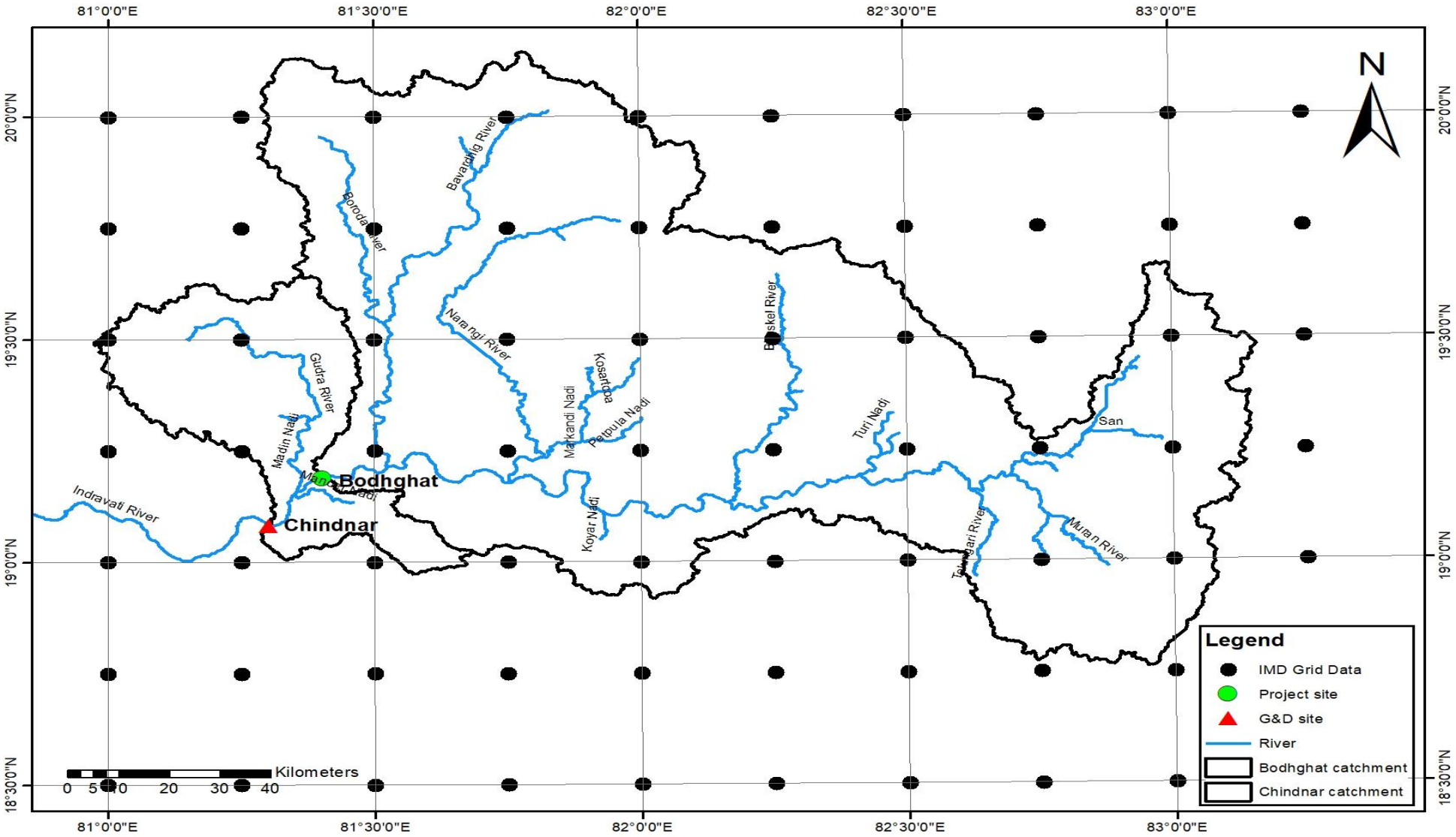


Figure 5.22: IMD Grid Rainfall Data for Bodhghat Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfall for the last 25 years has been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.26**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.27** and **Table 5.28** respectively.

Table 5.26: Average Annual Rainfall (in mm)

Year	Chindnar	Bodhghat
1990-1991	1687	1684
1991-1992	1375	1391
1992-1993	1509	1536
1993-1994	1298	1315
1994-1995	1918	1909
1995-1996	1401	1412
1996-1997	1353	1365
1997-1998	1255	1289
1998-1999	1109	1098
1999-2000	1247	1226
2000-2001	1238	1269
2001-2002	1668	1670
2002-2003	974	974
2003-2004	1725	1717
2004-2005	1457	1464
2005-2006	1512	1532
2006-2007	1983	2046
2007-2008	1793	1814
2008-2009	1550	1618
2009-2010	1303	1334
2010-2011	1757	1807
2011-2012	1203	1186
2012-2013	1576	1580
2013-2014	1588	1607
2014-2015	1474	1489
AVERAGE (mm)	1478	1493

Table 5.27: 10 Daily Rainfall (in mm) of Chindnar G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	6.68	3.18	2.83	1.89	1.04	0.32	2.00	0.46	0.58	1.18	7.30	7.84	4.03	0.42	4.28	1.66	5.88	1.98	11.80	3.20	1.77	2.96	1.36	4.79	2.69
	II	9.12	8.16	13.62	12.08	11.28	3.17	7.23	4.74	7.07	16.76	10.55	26.76	4.21	3.80	28.99	2.27	2.45	8.16	5.76	2.39	3.55	6.98	4.52	27.63	6.05
	III	8.41	6.33	3.60	5.40	9.91	8.14	3.61	6.19	6.48	3.40	7.83	5.73	10.45	3.68	1.46	18.36	6.75	40.46	10.11	6.87	4.33	4.06	9.20	13.91	7.40
JUL	I	6.23	10.69	5.51	7.92	25.11	5.38	5.59	5.68	13.73	3.38	8.59	30.93	1.53	11.16	7.09	5.97	38.59	5.88	7.39	10.88	11.60	7.11	10.45	5.19	2.96
	II	11.95	19.04	11.40	19.17	15.10	19.85	17.52	5.58	10.74	8.38	20.46	11.31	12.02	16.22	9.97	5.79	6.94	10.99	4.69	26.20	10.30	5.05	9.47	8.64	16.96
	III	9.38	20.65	29.04	11.41	14.17	23.83	17.89	21.21	7.49	8.24	2.81	7.55	5.94	20.33	14.17	12.55	15.65	5.94	14.69	12.10	19.22	9.70	20.09	15.28	24.30
AUG	I	8.69	10.14	13.77	8.26	9.79	14.15	12.75	5.90	8.57	20.15	7.19	18.50	9.77	17.13	14.80	10.89	35.59	29.91	31.62	5.95	24.77	7.33	25.98	12.39	15.92
	II	17.12	13.49	22.27	6.36	12.18	3.73	19.34	14.75	8.82	4.68	11.12	20.13	9.47	10.14	12.50	13.32	16.74	14.78	12.56	9.77	7.34	10.67	16.71	10.60	8.44
	III	20.09	9.99	9.14	4.78	17.77	14.50	8.81	14.62	4.78	17.60	17.53	5.40	13.39	23.92	9.81	2.39	16.26	7.98	9.88	17.55	12.29	14.36	7.82	3.83	10.17
SEP	I	11.81	4.43	19.31	17.66	22.28	8.04	5.99	6.50	8.18	11.08	3.70	3.78	8.14	12.35	6.56	5.66	5.93	17.47	13.31	3.74	18.01	19.04	14.21	5.61	16.21
	II	9.45	8.34	0.59	4.28	8.68	6.58	5.63	11.60	5.26	7.21	2.99	6.22	3.69	5.78	4.71	33.43	14.70	4.76	16.60	0.70	16.52	13.83	5.41	5.50	9.49
	III	5.67	3.53	1.47	9.77	3.23	4.79	6.46	5.05	3.23	5.55	7.31	3.79	0.36	9.44	3.46	1.35	16.44	12.00	2.66	5.07	1.17	3.91	5.29	7.89	2.13
OCT	I	22.49	6.12	2.27	2.22	3.22	2.38	2.42	0.70	4.80	3.44	1.25	3.36	0.56	15.63	11.30	1.67	1.06	9.39	2.76	4.21	2.45	1.04	2.30	7.95	0.49
	II	5.42	1.68	1.04	6.00	1.66	6.72	0.66	0.78	4.55	1.37	0.26	2.58	6.20	0.19	2.53	5.05	0.22	1.14	0.17	0.06	12.67	0.79	3.12	2.04	8.38
	III	0.78	0.11	0.00	0.71	1.30	3.50	1.25	1.68	0.58	2.21	0.00	0.03	0.26	5.24	0.57	8.12	0.78	0.26	0.23	0.00	3.84	0.42	0.00	10.87	0.73
NOV	I	3.08	2.93	0.31	0.03	0.87	2.29	0.21	0.34	3.38	0.54	0.01	0.09	0.00	0.08	0.81	2.25	3.87	0.05	0.00	0.54	1.85	0.00	7.43	0.00	0.00
	II	0.06	0.25	0.26	0.00	0.04	0.09	0.50	1.90	2.81	0.00	0.00	3.34	0.00	0.00	0.12	0.00	0.03	0.00	0.03	1.15	1.37	0.00	0.00	0.00	0.33
	III	0.00	0.17	1.67	0.00	0.12	0.00	0.02	0.98	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.26	0.00	0.00	0.19	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.02	0.09	2.26	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	3.27	0.03	0.00	0.00	0.00
	II	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	4.59	0.01	0.00	0.05	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.60	0.00	0.13	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.22	0.00	0.00	0.04
JAN	I	0.18	0.29	0.00	0.00	4.91	0.12	0.05	0.05	0.00	0.07	0.09	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.06	0.00	0.46
	II	0.13	0.00	0.00	0.23	1.45	0.15	0.79	0.03	0.00	0.07	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.60	0.00	0.00	0.00
	III	0.00	0.04	0.00	0.00	0.00	0.07	0.10	0.02	0.00	0.00	0.00	0.76	0.00	2.54	4.08	0.00	0.00	1.42	0.00	0.00	0.12	0.57	0.00	0.00	0.00
FEB	I	0.00	0.18	0.00	0.24	0.03	0.19	0.03	1.22	0.14	0.05	0.00	0.01	0.02	0.61	0.53	0.00	0.00	0.23	0.00	0.08	0.00	0.00	0.02	0.00	0.00
	II	0.00	0.00	0.37	0.72	0.00	0.54	0.01	0.00	0.00	1.28	0.00	0.02	0.32	0.00	0.00	0.00	0.39	0.34	0.00	0.30	0.23	0.00	0.65	0.09	0.04
	III	0.00	0.27	0.03	0.00	0.19	0.00	0.15	0.05	0.00	0.89	0.00	0.05	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.38	2.65	0.00	0.00	0.00	0.05
MAR	I	0.92	0.00	0.34	0.14	0.10	1.80	0.00	1.44	0.00	0.00	0.21	0.00	0.10	0.11	0.00	1.95	0.01	0.00	0.00	0.00	0.00	0.17	0.00	3.00	0.16
	II	0.25	0.00	0.00	0.00	1.54	0.00	0.00	0.24	0.02	0.01	0.07	0.00	1.58	0.00	0.09	1.56	0.01	0.27	0.00	0.21	0.00	0.00	0.02	0.92	0.13
	III	0.04	0.14	0.07	0.08	0.51	0.00	3.00	0.78	0.00	0.00	0.16	0.13	0.60	0.04	0.02	0.02	0.00	2.30	0.98	0.47	0.01	0.66	0.00	0.00	0.41
APR	I	1.18	0.21	0.04	1.36	1.31	0.15	4.39	1.09	0.20	0.00	0.93	1.41	0.28	0.45	0.33	0.12	0.00	0.58	0.27	0.00	1.30	0.37	0.17	0.28	0.12
	II	0.52	0.02	1.65	0.15	0.48	1.48	1.02	0.00	0.09	0.85	4.21	1.43	1.27	0.27	0.40	4.42	1.04	0.04	0.00	0.55	2.83	0.12	2.87	1.96	2.38
	III	1.25	0.85	1.49	1.95	0.28	2.07	2.03	1.27	0.00	0.20	0.68	0.58	0.75	1.35	0.94	0.18	0.19	0.07	0.00	2.90	3.97	2.42	3.66	1.36	3.47
MAY	I	1.48	1.16	0.06	0.81	6.00	0.80	1.38	1.70	1.20	1.38	1.33	0.04	0.04	0.17	0.97	1.47	2.39	0.22	1.58	3.22	1.54	2.27	0.16	1.92	3.02
	II	0.81	0.41	2.15	1.08	12.88	0.00	0.81	1.00	2.01	0.37	1.39	0.56	0.00	1.09	0.01	2.34	1.51	0.01	2.05	0.27	1.59	1.49	1.00	0.68	0.87
	III	1.96	1.52	2.51	3.07	0.95	0.97	0.46	0.48	4.45	1.40	3.37	1.90	0.16	0.24	2.11	5.51	1.18	0.79	3.02	6.50	1.61	0.05	2.59	2.95	0.03
Yearly Rainfall (mm)		1687	1375	1509	1298	1918	1401	1353	1255	1109	1247	1238	1668	974	1725	1457	1512	1983	1793	1550	1303	1757	1203	1576	1588	1474

Table 5.28: 10 Daily Rainfall (in mm) of Bodhghat Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	6.86	3.17	2.82	2.05	1.01	0.36	2.14	0.53	0.65	1.30	7.30	7.53	4.17	0.45	4.73	1.62	6.35	1.99	12.34	3.11	1.85	2.97	1.33	4.70	2.78
	II	8.77	8.22	14.08	12.45	11.08	3.25	6.63	4.89	7.14	16.86	11.16	26.26	4.40	3.94	30.10	2.21	2.64	9.05	5.99	2.51	3.72	7.47	4.59	28.50	6.08
	III	8.27	6.65	3.65	5.44	8.93	7.81	3.89	6.17	6.71	3.23	7.85	5.92	10.42	3.63	1.12	18.70	7.15	42.53	10.80	7.42	4.61	3.74	9.42	14.33	8.14
JUL	I	5.88	10.73	6.19	7.27	24.53	5.63	5.60	5.87	13.12	3.63	8.80	31.97	1.65	11.29	7.00	5.78	38.25	5.33	7.04	10.60	11.67	6.98	10.09	4.93	3.14
	II	11.88	19.19	11.29	19.20	14.58	19.66	18.80	6.02	10.54	7.81	21.10	11.56	11.22	16.34	9.61	5.77	7.39	10.66	4.92	26.80	10.64	4.64	9.27	8.19	17.20
	III	8.78	20.61	28.73	11.91	13.68	23.38	17.84	20.77	7.57	7.30	2.85	7.49	6.23	19.66	13.63	12.65	16.42	6.11	14.86	12.52	19.82	9.68	20.37	15.11	24.23
AUG	I	8.78	10.24	13.83	8.07	10.11	13.77	12.60	6.11	7.89	19.32	7.28	18.05	9.45	17.61	14.15	10.97	37.52	29.84	32.88	6.16	25.83	7.07	26.14	12.15	15.75
	II	16.39	13.45	22.40	6.16	11.70	3.69	19.01	15.26	8.33	5.10	11.11	19.43	9.16	9.91	12.81	13.34	17.27	15.53	12.85	10.50	7.02	10.94	16.08	9.69	8.85
	III	20.25	9.94	8.45	4.32	17.13	14.40	8.46	13.81	4.83	17.70	18.20	5.48	13.58	23.41	10.07	2.49	16.74	7.88	10.27	17.47	11.93	14.06	7.51	4.05	10.14
SEP	I	11.41	4.67	19.95	17.92	22.72	7.83	5.97	6.71	8.16	10.62	4.05	3.98	7.84	12.76	6.65	5.65	5.90	17.03	13.80	3.85	18.59	18.68	13.87	6.22	15.85
	II	9.79	8.58	0.55	4.46	9.32	6.79	5.24	12.32	4.84	6.77	3.06	6.40	4.02	6.08	4.96	33.90	15.42	4.61	18.15	0.80	16.52	13.24	5.18	5.21	9.74
	III	5.63	3.49	1.55	9.72	3.55	5.43	6.63	5.42	2.77	5.74	7.79	3.87	0.41	9.34	3.40	1.22	16.66	12.03	2.64	5.45	1.11	3.88	5.32	8.12	2.15
OCT	I	22.94	5.79	2.49	2.21	3.31	2.42	2.70	0.75	4.57	3.15	1.30	3.15	0.62	16.05	12.64	1.77	1.19	8.87	3.09	4.55	2.63	0.80	2.28	8.23	0.42
	II	5.35	1.78	1.18	6.35	0.94	6.50	0.75	0.88	4.77	1.49	0.29	2.68	6.45	0.17	2.45	5.11	0.20	1.26	0.18	0.07	12.99	0.79	3.51	2.02	8.22
	III	0.71	0.12	0.00	0.74	1.46	3.73	0.89	1.72	0.56	1.94	0.00	0.04	0.30	4.65	0.52	7.54	0.79	0.30	0.26	0.00	4.11	0.48	0.00	11.53	0.68
NOV	I	3.30	3.17	0.35	0.03	1.00	2.62	0.24	0.35	3.81	0.62	0.01	0.10	0.00	0.09	0.92	2.40	3.79	0.05	0.00	0.57	2.04	0.00	8.28	0.00	0.00
	II	0.07	0.26	0.27	0.00	0.05	0.10	0.56	2.16	3.19	0.00	0.00	2.82	0.00	0.00	0.10	0.00	0.00	0.00	0.03	1.18	1.50	0.00	0.00	0.00	0.16
	III	0.00	0.20	1.91	0.00	0.13	0.00	0.00	0.94	0.01	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.24	0.00	0.00	0.21	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.02	0.08	2.58	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	3.51	0.03	0.00	0.00	0.00
	II	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	4.93	0.00	0.00	0.02	0.00	0.00	0.00	0.04	0.06	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.04	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.25	0.00	0.00	0.04
JAN	I	0.20	0.33	0.00	0.00	4.79	0.14	0.06	0.01	0.00	0.03	0.10	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.28	0.07	0.00	0.26
	II	0.14	0.00	0.00	0.26	1.47	0.18	0.90	0.01	0.00	0.03	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.68	0.00	0.00	0.00
	III	0.00	0.05	0.00	0.00	0.00	0.09	0.12	0.02	0.00	0.00	0.00	0.85	0.00	2.13	3.58	0.00	0.00	1.24	0.00	0.00	0.13	0.65	0.00	0.00	0.00
FEB	I	0.00	0.20	0.00	0.28	0.03	0.21	0.01	1.37	0.16	0.06	0.00	0.01	0.02	0.35	0.52	0.00	0.00	0.24	0.00	0.06	0.00	0.00	0.02	0.00	0.00
	II	0.00	0.00	0.42	0.82	0.00	0.62	0.00	0.00	0.00	1.46	0.00	0.01	0.26	0.00	0.00	0.00	0.36	0.35	0.00	0.31	0.26	0.00	0.58	0.10	0.04
	III	0.00	0.30	0.04	0.00	0.22	0.00	0.17	0.05	0.00	1.02	0.00	0.02	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.40	2.58	0.00	0.00	0.00	0.05
MAR	I	1.05	0.00	0.39	0.16	0.12	2.05	0.00	1.63	0.00	0.00	0.23	0.00	0.11	0.13	0.00	2.22	0.01	0.00	0.00	0.00	0.00	0.15	0.00	3.11	0.15
	II	0.28	0.00	0.00	0.00	1.61	0.00	0.01	0.28	0.02	0.01	0.08	0.00	1.77	0.00	0.10	1.52	0.01	0.29	0.00	0.24	0.00	0.00	0.01	1.05	0.15
	III	0.04	0.16	0.08	0.09	0.58	0.00	3.43	0.90	0.00	0.00	0.18	0.15	0.34	0.05	0.03	0.03	0.00	2.49	1.09	0.39	0.02	0.68	0.00	0.00	0.47
APR	I	1.34	0.23	0.04	1.56	1.49	0.18	4.85	1.24	0.23	0.00	1.05	1.51	0.29	0.51	0.35	0.05	0.00	0.64	0.30	0.00	1.43	0.39	0.19	0.32	0.14
	II	0.58	0.03	1.85	0.17	0.52	1.68	0.95	0.00	0.10	0.87	3.81	1.59	1.44	0.31	0.42	4.72	1.12	0.04	0.00	0.60	3.09	0.14	2.98	1.82	2.33
	III	1.43	0.95	1.70	2.23	0.32	2.35	1.98	1.35	0.00	0.23	0.78	0.65	0.79	1.10	0.70	0.18	0.21	0.08	0.00	2.62	4.31	2.57	3.69	1.50	3.91
MAY	I	1.69	1.32	0.07	0.91	6.65	0.91	1.51	1.84	1.31	1.57	1.45	0.05	0.04	0.16	0.83	1.65	2.61	0.23	1.74	3.25	1.70	2.35	0.18	2.14	3.30
	II	0.93	0.47	2.45	1.18	13.65	0.00	0.85	1.08	1.99	0.42	1.57	0.62	0.00	1.17	0.01	2.57	1.72	0.01	2.26	0.27	1.80	1.36	1.14	0.75	0.97
	III	2.18	1.64	2.86	3.50	0.86	1.11	0.49	0.55	4.69	1.60	2.98	2.15	0.18	0.27	2.04	6.26	1.27	0.84	3.34	6.51	1.78	0.04	2.80	3.36	0.03
Yearly Rainfall (mm)		1684	1391	1536	1315	1909	1412	1364	1288	1097	1226	1269	1670	974	1717	1464	1532	2046	1814	1618	1334	1807	1186	1580	1607	1489

5.3.2.3 Rainfall and Runoff Data at Chindnar G&D Site

Detailed calculations on water availability and flood magnitude will help to select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the monthly runoff and monthly rainfall for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Chindnar G&D site is shown in **Figure 5.23**, which shows that there is no major error in the downloaded data from WRIS site. However, similarity in trends between monthly rainfall and monthly runoff show that there is no major error in the downloaded data from the WRIS site. The basic comparison between rainfall and runoff in **Figure 5.23** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.24** shows plot of runoff coefficient at G&D site.

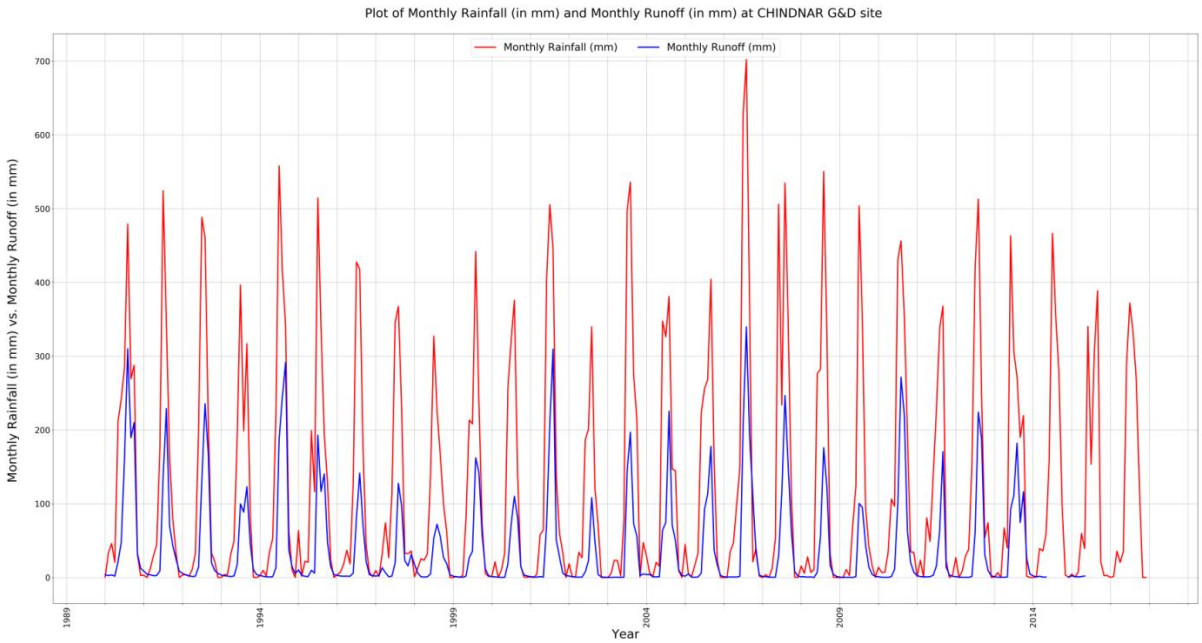


Figure 5.23: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site

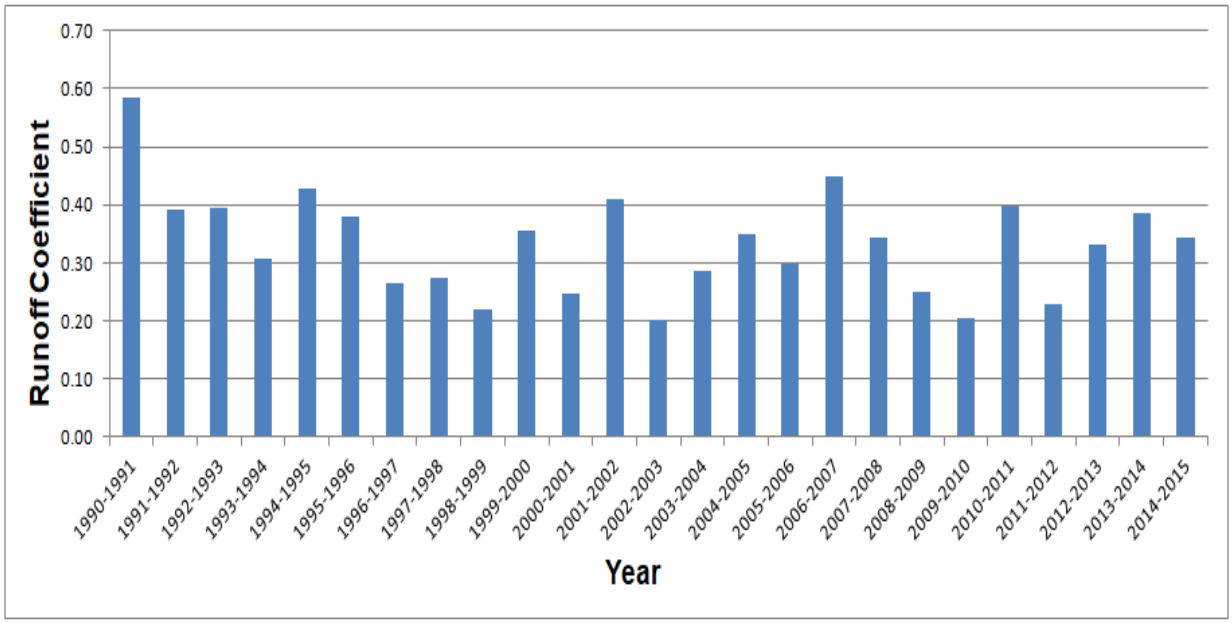


Figure 5.24: Plot of Runoff Coefficient at G&D site

5.3.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Chindnar is around 17,270 km^2 as mentioned on India WRIS site. Daily discharge data for Chindnar site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Chindnar, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Chindnar G&D and the Bodhghat dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Chindnar G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Bodhghat}}{CA_{Chindnar}} = \frac{15719}{17270} = 0.91$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Bodhghat}}{\text{Average Annual Rainfall}_{Chindnar}} = \frac{1493}{1478} = 1.01$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Bodhghat}} = Q_{\text{Chindnar G\&}D\ Site} \text{X } 0.91 \text{ X } 1.01$$

Table 5.29 shows 10-daily average flow series for G&D site. **Table 5.30** and **Table 5.31** show 10-daily average flow series (m^3/s) and inflow series (MCM) respectively for Bodhghat Dam.

Table 5.29: 10-Daily Average Flow Series (m^3/s) at Chindnar

Catchment Area =17,270 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	200.37	24.19	15.30	24.19	9.27	10.96	16.45	16.45	16.45	14.32	31.24	21.37	22.31	22.31	22.31	22.17	12.22	21.00	23.15	22.66	24.99	17.86	21.14	25.92	27.44
	II	370.10	54.47	86.48	162.60	83.11	11.43	96.74	7.42	16.96	284.74	90.43	1313.81	2.34	1.55	1270.28	2.37	7.43	9.42	102.72	3.77	58.64	20.14	8.36	1023.30	212.03
	III	383.67	103.25	182.66	170.62	170.79	98.55	23.76	30.76	80.48	239.33	248.84	97.67	147.91	9.48	10.42	116.29	16.70	564.44	34.76	19.83	155.36	23.56	20.70	816.72	156.94
JUL	I	406.29	147.02	108.96	202.92	632.03	112.62	65.84	53.52	191.88	61.66	244.70	1666.49	7.87	191.03	31.86	460.44	3274.86	1031.54	68.83	91.33	201.94	77.78	144.50	328.62	408.52
	II	989.10	981.60	245.51	1097.78	2065.12	421.20	245.61	15.04	540.96	175.41	683.54	1407.96	317.92	606.83	339.23	523.66	198.00	878.74	64.85	526.61	357.17	119.22	108.12	674.80	566.00
	III	1660.33	1465.50	2071.02	630.99	958.53	3020.33	1201.09	298.78	308.41	432.52	462.99	983.31	114.47	1897.71	1017.84	782.77	585.93	345.70	908.37	1263.23	1300.85	110.94	881.16	1107.66	992.10
AUG	I	642.57	1635.27	1167.43	887.16	960.81	896.76	787.01	729.79	347.78	1487.64	166.00	1574.68	293.10	1202.87	1187.15	1091.14	2969.87	2576.27	1218.96	247.05	3727.52	252.29	1721.21	1719.81	1228.76
	II	1973.50	1663.73	1933.71	333.23	1308.66	727.31	949.32	390.64	588.43	532.33	780.06	1829.67	516.23	926.39	1469.88	570.36	2237.89	1374.88	1532.54	340.29	730.28	216.18	1289.32	1184.39	1058.30
	III	3257.01	1163.00	1461.39	500.58	2390.64	644.04	994.90	1299.68	459.43	1111.25	1139.33	2530.97	1229.71	1641.44	1680.53	543.26	1438.02	890.43	696.18	1193.93	883.34	751.07	1336.16	669.07	1246.06
SEP	I	1963.63	550.45	2231.34	911.31	4091.60	1857.71	619.20	607.65	401.58	1262.65	954.04	391.30	526.18	868.84	566.31	273.14	1454.38	1439.59	985.12	668.11	2192.68	1645.21	1561.76	345.04	1182.03
	II	1292.45	527.98	897.40	516.57	1131.10	603.32	496.05	820.05	396.14	943.20	311.49	409.15	389.12	251.86	465.22	2429.57	1132.87	661.49	953.70	126.01	1645.85	1054.79	1203.33	519.87	799.11
	III	529.62	327.86	245.97	1034.66	606.87	345.46	348.43	527.63	317.07	639.08	361.60	225.69	63.74	346.54	378.61	849.22	1265.61	882.62	497.12	82.13	595.28	710.09	998.36	625.43	533.53
OCT	I	2584.66	299.19	176.46	289.24	330.02	224.42	264.08	207.50	197.66	533.15	152.66	241.37	28.25	671.69	591.00	189.31	1858.79	815.16	170.22	196.90	228.02	133.44	397.50	967.57	489.51
	II	1184.23	384.71	130.72	351.26	198.21	319.51	82.12	92.94	199.18	361.32	92.74	210.81	30.51	182.29	250.52	167.34	222.42	259.66	103.48	64.48	666.69	106.17	132.13	662.91	269.01
	III	390.38	160.00	82.53	268.02	204.80	376.97	86.30	142.67	130.25	232.85	41.82	96.03	20.42	248.80	144.09	342.45	123.34	135.89	52.91	28.10	316.79	41.43	88.22	630.49	182.73
NOV	I	323.71	287.26	71.84	105.71	134.96	123.42	40.88	95.96	107.81	136.47	28.21	47.58	7.28	46.03	75.05	214.61	447.74	80.64	33.98	17.47	151.25	29.87	85.63	280.21	123.90
	II	199.97	121.63	60.94	67.57	96.48	106.67	24.83	82.69	183.43	62.00	21.95	39.70	4.72	5.92	93.53	77.39	176.17	51.54	28.49	32.36	161.93	23.74	70.22	141.65	80.65
	III	130.16	91.56	58.99	45.65	66.91	63.77	12.55	135.73	87.10	32.47	16.29	36.93	2.73	0.47	38.07	43.13	65.56	31.13	21.83	36.79	79.19	17.24	34.75	93.42	51.77
DEC	I	95.47	66.76	44.94	31.32	45.24	31.71	19.64	197.38	32.57	20.62	12.80	19.87	5.46	35.47	26.70	24.80	27.97	17.23	17.21	14.20	45.97	11.77	22.18	43.98	37.97
	II	79.18	52.89	35.74	25.28	32.95	26.06	16.16	215.05	22.75	14.67	15.24	15.26	2.96	68.77	16.27	14.32	19.78	13.59	9.60	10.28	63.08	11.09	15.62	27.54	34.34
	III	69.96	47.63	29.04	22.11	28.43	22.06	13.21	192.57	17.61	12.21	12.48	13.65	1.42	55.57	13.07	13.24	16.17	9.62	5.00	6.50	26.38	9.51	9.76	20.10	17.77
JAN	I	64.89	42.36	25.71	20.09	37.02	20.20	11.75	164.44	14.25	10.35	9.42	14.56	1.10	33.47	11.03	9.51	12.73	7.49	4.10	6.13	19.64	8.51	8.80	17.37	18.99
	II	55.18	35.91	22.97	17.27	122.78	19.93	13.16	102.85	12.48	8.63	8.42	15.42	0.62	21.98	8.97	6.71	10.75	6.10	3.70	9.28	17.16	9.84	8.97	15.03	15.85
	III	47.97	31.92	18.80	15.94	42.55	16.63	13.85	82.32	10.51	6.92	7.37	10.68	0.55	24.71	15.18	6.51	8.33	6.13	3.03	6.52	13.27	7.14	4.77	11.87	11.97
FEB	I	36.27	26.66	18.20	12.71	25.29	15.19	9.01	83.99	8.88	5.31	6.50	9.77	0.41	53.12	75.21	5.27	6.40	7.32	2.37	3.94	10.44	4.23	3.29	7.53	10.37
	II	30.36	24.89	17.95	13.62	19.57	14.80	7.04	30.24	8.03	6.24	5.80	8.28	0.73	17.98	16.10	4.35	9.77	9.95	2.18	2.85	7.79	3.04	2.72	6.98	8.97
	III	26.13	21.65	15.22	11.92	16.16	13.28	46.14	12.18	6.19	8.67	4.77	7.31	0.55	11.93	6.47	3.78	9.14	6.53	1.65	2.34	11.33	2.70	2.41	7.00	6.69
MAR	I	23.39	19.68	14.80	8.67	13.28	12.46	85.15	9.19	4.98	5.98	4.22	6.07	2.58	8.18	3.73	3.11	6.20	2.84	1.85	1.69	10.23	2.48	1.67	8.17	6.38
	II	29.31	15.46	13.96	7.04	10.87	12.52	84.28	7.87	4.27	2.40	3.77	3.19	2.51	4.64	3.18	6.19	2.43	2.72	1.00	1.56	5.69	1.95	2.90	20.64	5.77
	III	18.94	12.96	10.44	5.63	10.13	10.81	89.92	6.37	3.41	1.41	3.03	1.83	3.12	4.14	2.54	6.04	2.81	4.64	1.28	1.60	4.60	1.66	1.45	7.46	5.12
APR	I	16.90	11.90	10.20	5.15	11.04	10.30	85.11	5.45	2.82	0.82	2.39	1.87	3.32	7.76	1.44	2.83	1.47	11.20	1.07	1.04	4.58	1.31	0.94	4.30	7.40
	II	19.17	9.00	9.13	5.81	10.64	12.10	29.45	5.56	2.40	0.68	7.87	4.82	2.79	5.88	2.97	4.65	2.85	5.32	1.00	1.01	4.92	1.71	0.99	3.92	9.85
	III	13.32	8.69	10.51	4.37	5.76	16.18	12.81	2.80	2.45	0.89	17.17	4.63	2.85	5.41	3.63	8.01	5.08	2.03	0.52	1.40	9.54	1.63	5.91	4.84	13.05
MAY	I	13.20	13.00	13.41	7.33	26.49	13.48	13.92	8.47	2.03	0.74	4.30	3.55	2.01	8.33	7.18	4.58	2.74	0.49	0.18	7.13	9.94	1.62	7.81	2.93	15.85
	II	13.44	12.43	9.48	4.21	134.35	10.56	6.82	8.86	6.35	0.70	3.35	3.52	0.68	3.23	5.58	4.11	2.50	0.29	0.09	4.00	7.40	1.52	2.87	5.42	16.36
	III	24.58	10.75	16.97	11.16	32.62	9.72	3.70	3.49	30.03	2.40	3.91	5.11	0.74	9.07	2.20	4.96	1.24	0.06	1.79	15.74	6.59	1.55	2.87	4.54	8.62
Inflow (MCM) =		*17022*	*9278*	*10309*	*6888*	*14194*	*9210*	*6175*	*5957*	*4197*	*7629*	*5294*	*11782*	*3366*	*8543*	*8761*	*7777*	*15424*	*10629*	*6671*	*4587*	*12104*	*4775*	*9021*	*10610*	*8731*

Table 5.30: 10-Daily Average Flow Series (m^3/s) at Bodhghat Dam

Catchment Area =15,719 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	184.23	22.24	14.07	22.24	8.52	10.08	15.12	15.12	15.12	13.17	28.72	19.65	20.51	20.51	20.51	20.38	11.24	19.31	21.28	20.83	22.98	16.42	19.44	23.83	25.23
	II	340.28	50.08	79.51	149.50	76.41	10.51	88.95	6.82	15.59	261.80	83.14	1207.95	2.15	1.43	1167.93	2.18	6.83	8.66	94.44	3.47	53.92	18.52	7.69	940.85	194.94
	III	352.76	94.93	167.94	156.87	157.03	90.61	21.85	28.28	74.00	220.05	228.79	89.80	135.99	8.72	9.58	106.92	15.35	518.96	31.96	18.23	142.84	21.66	19.03	750.92	144.29
JUL	I	373.55	135.17	100.18	186.57	581.11	103.55	60.54	49.21	176.42	56.69	224.98	1532.22	7.24	175.64	29.29	423.34	3011.00	948.43	63.28	83.97	185.67	71.51	132.86	302.14	375.61
	II	909.41	902.51	225.73	1009.33	1898.73	387.26	225.82	13.83	497.37	161.28	628.47	1294.52	292.30	557.94	311.90	481.47	182.05	807.94	59.62	484.18	328.39	109.61	99.41	620.43	520.40
	III	1526.55	1347.42	1904.15	580.15	881.30	2776.98	1104.32	274.71	283.56	397.67	425.69	904.08	105.25	1744.81	935.83	719.70	538.72	317.85	835.18	1161.45	1196.04	102.00	810.16	1018.41	912.17
AUG	I	590.80	1503.51	1073.37	815.68	883.40	824.51	723.60	670.99	319.76	1367.78	152.63	1447.81	269.48	1105.95	1091.50	1003.23	2730.58	2368.70	1120.75	227.14	3427.19	231.96	1582.53	1581.24	1129.75
	II	1814.49	1529.68	1777.91	306.38	1203.22	668.71	872.83	359.17	541.02	489.44	717.21	1682.25	474.64	851.75	1351.45	524.41	2057.58	1264.10	1409.06	312.87	671.44	198.76	1185.44	1088.96	973.03
	III	2994.59	1069.30	1343.64	460.25	2198.02	592.15	914.74	1194.96	422.41	1021.71	1047.53	2327.05	1130.63	1509.19	1545.13	499.49	1322.16	818.69	640.09	1097.73	812.17	690.56	1228.50	615.16	1145.66
SEP	I	1805.42	506.10	2051.56	837.88	3761.93	1708.03	569.31	558.69	369.22	1160.92	877.17	359.77	483.78	798.84	520.68	251.13	1337.20	1323.60	905.75	614.28	2016.01	1512.65	1435.93	317.24	1086.80
	II	1188.32	485.44	825.10	474.95	1039.97	554.71	456.08	753.98	364.22	867.20	286.39	376.18	357.77	231.57	427.74	2233.82	1041.59	608.19	876.86	115.86	1513.24	969.80	1106.38	477.98	734.72
	III	486.95	301.44	226.15	951.30	557.97	317.63	320.36	485.12	291.52	587.59	332.47	207.51	58.60	318.62	348.10	780.80	1163.64	811.51	457.07	75.51	547.32	652.88	917.92	575.04	490.54
OCT	I	2376.41	275.08	162.24	265.94	303.43	206.34	242.80	190.78	181.73	490.19	140.36	221.92	25.97	617.57	543.38	174.06	1709.02	749.48	156.51	181.04	209.65	122.69	365.47	889.61	450.07
	II	1088.81	353.71	120.19	322.96	182.24	293.77	75.50	85.45	183.13	332.21	85.27	193.82	28.05	167.60	230.34	153.86	204.50	238.74	95.14	59.28	612.97	97.62	121.48	609.50	247.34
	III	358.93	147.11	75.88	246.43	188.30	346.60	79.35	131.17	119.76	214.09	38.45	88.29	18.77	228.75	132.48	314.86	113.40	124.94	48.65	25.84	291.27	38.09	81.11	579.69	168.01
NOV	I	297.63	264.12	66.05	97.19	124.09	113.48	37.59	88.23	99.12	125.47	25.94	43.75	6.69	42.32	69.00	197.32	411.66	74.14	31.24	16.06	139.06	27.46	78.73	257.63	113.92
	II	183.86	111.83	56.03	62.13	88.71	98.08	22.83	76.03	168.65	57.00	20.18	36.50	4.34	5.44	85.99	71.15	161.98	47.39	26.19	29.75	148.88	21.83	64.56	130.24	74.15
	III	119.67	84.18	54.24	41.97	61.52	58.63	11.54	124.79	80.08	29.85	14.98	33.95	2.51	0.43	35.00	39.65	60.28	28.62	20.07	33.83	72.81	15.85	31.95	85.89	47.60
DEC	I	87.78	61.38	41.32	28.80	41.59	29.16	18.06	181.48	29.95	18.96	11.77	18.27	5.02	32.61	24.55	22.80	25.72	15.84	15.82	13.06	42.27	10.82	20.39	40.44	34.91
	II	72.80	48.63	32.86	23.24	30.30	23.96	14.86	197.72	20.92	13.49	14.01	14.03	2.72	63.23	14.96	13.17	18.19	12.50	8.83	9.45	58.00	10.20	14.36	25.32	31.57
	III	64.32	43.79	26.70	20.33	26.14	20.28	12.15	177.05	16.19	11.23	11.47	12.55	1.31	51.09	12.02	12.17	14.87	8.84	4.60	5.98	24.25	8.74	8.97	18.48	16.34
JAN	I	59.66	38.95	23.64	18.47	34.04	18.57	10.80	151.19	13.10	9.52	8.66	13.39	1.01	30.77	10.14	8.74	11.70	6.89	3.77	5.64	18.06	7.82	8.09	15.97	17.46
	II	50.73	33.02	21.12	15.88	112.89	18.32	12.10	94.56	11.47	7.93	7.74	14.18	0.57	20.21	8.25	6.17	9.88	5.61	3.40	8.53	15.78	9.05	8.25	13.82	14.57
	III	44.10	29.35	17.29	14.66	39.12	15.29	12.73	75.69	9.66	6.36	6.78	9.82	0.51	22.72	13.96	5.99	7.66	5.64	2.79	5.99	12.20	6.56	4.39	10.91	11.01
FEB	I	33.35	24.51	16.73	11.69	23.25	13.97	8.28	77.22	8.16	4.88	5.98	8.98	0.38	48.84	69.15	4.85	5.88	6.73	2.18	3.62	9.60	3.89	3.02	6.92	9.53
	II	27.91	22.88	16.50	12.52	17.99	13.61	6.47	27.80	7.38	5.74	5.33	7.61	0.67	16.53	14.80	4.00	8.98	9.15	2.00	2.62	7.16	2.80	2.50	6.42	8.25
	III	24.02	19.91	13.99	10.96	14.86	12.21	42.42	11.20	5.69	7.97	4.39	6.72	0.51	10.97	5.95	3.48	8.40	6.00	1.52	2.15	10.42	2.48	2.22	6.44	6.15
MAR	I	21.51	18.09	13.61	7.97	12.21	11.46	78.29	8.45	4.58	5.50	3.88	5.58	2.37	7.52	3.43	2.86	5.70	2.61	1.70	1.55	9.41	2.28	1.54	7.51	5.87
	II	26.95	14.21	12.84	6.47	9.99	11.51	77.49	7.24	3.93	2.21	3.47	2.93	2.31	4.27	2.92	5.69	2.23	2.50	0.92	1.43	5.23	1.79	2.67	18.98	5.31
	III	17.41	11.92	9.60	5.18	9.31	9.94	82.68	5.86	3.14	1.30	2.79	1.68	2.87	3.81	2.34	5.55	2.58	4.27	1.18	1.47	4.23	1.53	1.33	6.86	4.71
APR	I	15.54	10.94	9.38	4.74	10.15	9.47	78.25	5.01	2.59	0.75	2.20	1.72	3.05	7.13	1.32	2.60	1.35	10.30	0.98	0.96	4.21	1.20	0.86	3.95	6.80
	II	17.63	8.27	8.39	5.34	9.78	11.13	27.08	5.11	2.21	0.63	7.24	4.43	2.57	5.41	2.73	4.28	2.62	4.89	0.92	0.93	4.52	1.57	0.91	3.60	9.06
	III	12.25	7.99	9.66	4.02	5.30	14.88	11.78	2.57	2.25	0.82	15.79	4.26	2.62	4.97	3.34	7.36	4.67	1.87	0.48	1.29	8.77	1.50	5.43	4.45	12.00
MAY	I	12.14	11.95	12.33	6.74	24.36	12.39	12.80	7.79	1.87	0.68	3.95	3.26	1.85	7.66	6.60	4.21	2.52	0.45	0.17	6.56	9.14	1.49	7.18	2.69	14.57
	II	12.36	11.43	8.72	3.87	123.53	9.71	6.27	8.15	5.84	0.64	3.08	3.24	0.63	2.97	5.13	3.78	2.30	0.27	0.08	3.68	6.80	1.40	2.64	4.98	15.04
	III	22.60	9.88	15.60	10.26	29.99	8.94	3.40	3.21	27.61	2.21	3.59	4.70	0.68	8.34	2.02	4.56	1.14	0.06	1.65	14.47	6.06	1.43	2.64	4.17	7.93
Inflow (MCM) =		15650	8530	9479	6333	13051	8468	5678	5477	3859	7015	4867	10833	3095	7854	8055	7150	14181	9772	6134	4218	11129	4390	8294	9755	8027

Table 5.31: Inflow Series (MCM) at Bodhghat Project Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	159.17	19.22	12.15	19.22	7.36	8.71	13.07	13.07	13.07	11.38	24.82	16.98	17.72	17.72	17.72	17.61	9.71	16.68	18.39	18.00	19.85	14.19	16.79	20.59	21.80
	II	294.00	43.27	68.70	129.17	66.02	9.08	76.85	5.89	13.47	226.19	71.84	1043.67	1.86	1.23	1009.09	1.88	5.90	7.48	81.60	2.99	46.58	16.00	6.64	812.90	168.43
	III	304.78	82.02	145.10	135.54	135.67	78.29	18.87	24.44	63.93	190.12	197.68	77.59	117.50	7.53	8.28	92.38	13.27	448.38	27.61	15.75	123.42	18.72	16.44	648.79	124.67
JUL	I	322.75	116.79	86.56	161.20	502.08	89.46	52.30	42.52	152.43	48.98	194.39	1323.84	6.25	151.75	25.31	365.77	2601.50	819.44	54.68	72.55	160.42	61.79	114.79	261.05	324.52
	II	785.73	779.77	195.03	872.06	1640.50	334.60	195.11	11.95	429.73	139.34	542.99	1118.46	252.55	482.06	269.48	415.99	157.29	698.06	51.52	418.33	283.73	94.71	85.89	536.05	449.62
	III	1450.84	1280.59	1809.71	551.37	837.59	2639.24	1049.54	261.08	269.50	377.95	404.57	859.24	100.03	1658.27	889.41	684.00	512.00	302.08	793.76	1103.84	1136.72	96.94	769.98	967.90	866.92
AUG	I	510.45	1299.04	927.39	704.75	763.25	712.37	625.19	579.74	276.27	1181.76	131.87	1250.90	232.83	955.54	943.06	866.79	2359.22	2046.55	968.33	196.25	2961.09	200.42	1367.31	1366.19	976.11
	II	1567.72	1321.64	1536.11	264.71	1039.58	577.77	754.13	310.32	467.44	422.88	619.67	1453.46	410.09	735.91	1167.65	453.09	1777.75	1092.19	1217.43	270.32	580.12	171.73	1024.22	940.86	840.70
	III	2846.06	1016.26	1277.00	437.42	2089.00	562.78	869.37	1135.69	401.46	971.04	995.57	2211.62	1074.55	1434.33	1468.49	474.71	1256.58	778.08	608.34	1043.29	771.88	656.30	1167.57	584.65	1088.84
SEP	I	1559.88	437.27	1772.55	723.93	3250.31	1475.74	491.88	482.71	319.01	1003.03	757.88	310.84	417.99	690.19	449.87	216.98	1155.34	1143.59	782.57	530.74	1741.83	1306.93	1240.64	274.10	938.99
	II	1026.70	419.42	712.88	410.36	898.53	479.27	394.06	651.44	314.69	749.27	247.44	325.02	309.11	200.07	369.56	1930.02	899.94	525.48	757.61	100.10	1307.44	837.91	955.91	412.98	634.80
	III	420.72	260.45	195.40	821.92	482.09	274.43	276.79	419.14	251.88	507.68	287.25	179.29	50.63	275.29	300.76	674.61	1005.38	701.14	394.91	65.24	472.88	564.09	793.08	496.83	423.83
OCT	I	2053.22	237.67	140.18	229.77	262.16	178.28	209.78	164.84	157.02	423.53	121.27	191.74	22.44	533.58	469.48	150.39	1476.60	647.55	135.22	156.41	181.14	106.00	315.77	768.62	388.86
	II	940.74	305.61	103.84	279.04	157.46	253.81	65.23	73.83	158.23	287.03	73.67	167.46	24.24	144.81	199.01	132.93	176.69	206.27	82.20	51.22	529.61	84.34	104.96	526.61	213.70
	III	341.12	139.81	72.12	234.20	178.96	329.41	75.41	124.67	113.82	203.47	36.54	83.91	17.84	217.41	125.91	299.24	107.78	118.74	46.23	24.55	276.82	36.20	77.09	550.94	159.68
NOV	I	257.15	228.20	57.07	83.97	107.21	98.04	32.47	76.23	85.64	108.41	22.41	37.80	5.78	36.57	59.62	170.48	355.68	64.06	26.99	13.88	120.15	23.73	68.02	222.59	98.42
	II	158.85	96.62	48.41	53.68	76.64	84.74	19.72	65.69	145.71	49.25	17.44	31.54	3.75	4.70	74.30	61.48	139.95	40.94	22.63	25.71	128.63	18.86	55.78	112.52	64.06
	III	103.40	72.73	46.86	36.26	53.15	50.66	9.97	107.82	69.19	25.79	12.94	29.34	2.17	0.37	30.24	34.26	52.08	24.73	17.34	29.23	62.91	13.70	27.60	74.21	41.12
DEC	I	75.84	53.03	35.70	24.88	35.94	25.19	15.60	156.80	25.87	16.38	10.17	15.78	4.34	28.18	21.21	19.70	22.22	13.69	13.67	11.28	36.52	9.35	17.62	34.94	30.16
	II	62.90	42.02	28.39	20.08	26.18	20.70	12.84	170.83	18.07	11.65	12.11	12.12	2.35	54.63	12.92	11.38	15.71	10.80	7.63	8.17	50.11	8.81	12.41	21.88	27.28
	III	61.13	41.62	25.38	19.32	24.84	19.28	11.54	168.27	15.39	10.67	10.91	11.93	1.24	48.56	11.42	11.57	14.13	8.41	4.37	5.68	23.05	8.31	8.53	17.56	15.53
JAN	I	51.55	33.65	20.42	15.96	29.41	16.05	9.33	130.63	11.32	8.22	7.48	11.57	0.87	26.59	8.76	7.55	10.11	5.95	3.26	4.87	15.60	6.76	6.99	13.80	15.09
	II	43.83	28.53	18.25	13.72	97.53	15.83	10.45	81.70	9.91	6.86	6.69	12.25	0.49	17.46	7.13	5.33	8.54	4.85	2.94	7.37	13.63	7.82	7.13	11.94	12.59
	III	41.92	27.89	16.43	13.93	37.18	14.53	12.10	71.93	9.18	6.05	6.44	9.33	0.48	21.59	13.26	5.69	7.28	5.36	2.65	5.70	11.60	6.24	4.17	10.37	10.46
FEB	I	28.81	21.18	14.46	10.10	20.09	12.07	7.16	66.72	7.05	4.22	5.16	7.76	0.33	42.20	59.75	4.19	5.08	5.81	1.88	3.13	8.29	3.36	2.61	5.98	8.24
	II	24.12	19.77	14.26	10.82	15.55	11.76	5.59	24.02	6.38	4.96	4.61	6.58	0.58	14.28	12.79	3.46	7.76	7.90	1.73	2.26	6.19	2.41	2.16	5.54	7.13
	III	16.61	13.76	9.67	7.58	10.27	8.44	29.32	7.74	3.93	5.51	3.03	4.65	0.35	7.58	4.11	2.40	5.81	4.15	1.05	1.49	7.20	1.72	1.53	4.45	4.25
MAR	I	18.58	15.63	11.76	6.89	10.55	9.90	67.64	7.30	3.96	4.75	3.35	4.82	2.05	6.50	2.96	2.47	4.93	2.26	1.47	1.34	8.13	1.97	1.33	6.49	5.07
	II	23.28	12.28	11.09	5.59	8.63	9.95	66.95	6.25	3.39	1.91	2.99	2.53	1.99	3.69	2.53	4.92	1.93	2.16	0.79	1.24	4.52	1.55	2.30	16.40	4.58
	III	16.55	11.32	9.12	4.92	8.85	9.45	78.57	5.57	2.98	1.23	2.65	1.60	2.73	3.62	2.22	5.28	2.46	4.05	1.12	1.40	4.02	1.45	1.27	6.52	4.47
APR	I	13.43	9.45	8.10	4.09	8.77	8.18	67.61	4.33	2.24	0.65	1.90	1.49	2.64	6.16	1.14	2.25	1.17	8.90	0.85	0.83	3.64	1.04	0.75	3.42	5.88
	II	15.23	7.15	7.25	4.62	8.45	9.61	23.39	4.42	1.91	0.54	6.25	3.83	2.22	4.67	2.36	3.69	2.26	4.23	0.79	0.80	3.91	1.36	0.79	3.11	7.82
	III	10.58	6.90	8.35	3.47	4.58	12.85	10.18	2.22	1.95	0.71	13.64	3.68	2.26	4.30	2.88	6.36	4.04	1.61	0.41	1.11	7.58	1.29	4.69	3.84	10.37
MAY	I	10.49	10.33	10.65	5.82	21.04	10.71	11.06	6.73	1.61	0.59	3.42	2.82	1.60	6.62	5.70	3.64	2.18	0.39	0.14	5.66	7.90	1.29	6.20	2.33	12.59
	II	10.68	9.87	7.53	3.34	106.73	8.39	5.42	7.04	5.04	0.56	2.66	2.80	0.54	2.57	4.43	3.26	1.99	0.23	0.07	3.18	5.88	1.21	2.28	4.31	13.00
	III	21.48	9.39	14.83	9.75	28.50	8.49	3.23	3.05	26.24	2.10	3.42	4.47	0.65	7.93	1.92	4.33	1.08	0.05	1.56	13.75	5.76	1.35	2.51	3.97	7.53
Total Inflow (MCM) =		15650	8530	9479	6333	13051	8468	5678	5477	3859	7015	4867	10833	3095	7854	8055	7150	14181	9772	6134	4218	11129	4390	8294	9755	8027

5.3.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.32** and **Table 5.33**

Table 5.32: Computation of 90% and 50% Dependable Year for Bodhghat Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.04	15650	1990-1991	
2	0.08	14181	2006-2007	
3	0.12	13051	1994-1995	
4	0.15	11129	2010-2011	
5	0.19	10833	2001-2002	
6	0.23	9772	2007-2008	
7	0.27	9755	2013-2014	
8	0.31	9479	1992-1993	
9	0.35	8530	1991-1992	
10	0.38	8468	1995-1996	
11	0.42	8294	2012-2013	
12	0.46	8055	2004-2005	
13	**0.50**	**8027**	**2014-2015**	**50% Dependable**
14	0.54	7854	2003-2004	
15	0.58	7150	2005-2006	
16	0.62	7015	1999-2000	
17	0.65	6333	1993-1994	
18	0.69	6134	2008-2009	
19	0.73	5678	1996-1997	
20	0.77	5477	1997-1998	
21	0.81	4867	2000-2001	
22	0.85	4390	2011-2012	
23	**0.88**	**4218**	**2009-2010**	**90% Dependable**
24	0.92	3859	1998-1999	
25	0.96	3095	2002-2003	

Table 5.33: 90% and 50% dependable flows for the dam site (cumec)

Period		50% Dependable 2014-2015	90% Dependable 2009-2010
Jun	I	25.23	20.83
	II	194.94	3.47
	III	144.29	18.23
Jul	I	375.61	83.97
	II	520.40	484.18
	III	912.17	1161.45
Aug	I	1129.75	227.14
	II	973.03	312.87
	III	1145.66	1097.73
Sep	I	1086.80	614.28
	II	734.72	115.86
	III	490.54	75.51
Oct	I	450.07	181.04
	II	247.34	59.28
	III	168.01	25.84
Nov	I	113.92	16.06
	II	74.15	29.75
	III	47.60	33.83
Dec	I	34.91	13.06
	II	31.57	9.45
	III	16.34	5.98
Jan	I	17.46	5.64
	II	14.57	8.53
	III	11.01	5.99
Feb	I	9.53	3.62
	II	8.25	2.62
	III	6.15	2.15
Mar	I	5.87	1.55
	II	5.31	1.43
	III	4.71	1.47
Apr	I	6.80	0.96
	II	9.06	0.93
	III	12.00	1.29
May	I	14.57	6.56
	II	15.04	3.68
	III	7.93	14.47
Inflow (MCM) =		8027	4218

5.3.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Bodhghat, is given in the following section.

5.3.5.1 EAC of Bodhghat Dam

The EAC curve and the table showing the different values are given in **Figure 5.25** and **Table 5.34** respectively.

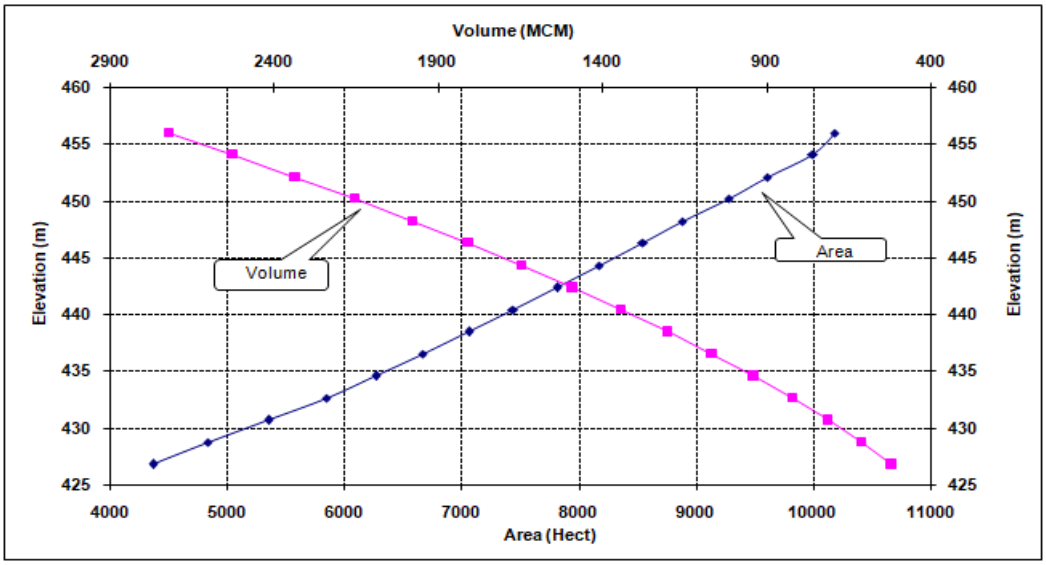


Figure 5.25: EAC curve of Bodhghat Dam

Table 5.34: EAC data of Bodhghat Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
426.80	43703142.82	4370.31	518705380.48	518.71
428.75	48334710.58	4833.47	609785055.37	609.79
430.70	53527851.23	5352.79	710422294.99	710.42
432.65	58472134.33	5847.21	820579959.13	820.58
434.60	62731824.39	6273.18	939347121.36	939.35
436.55	66646870.21	6664.69	1065847168.84	1065.85
438.50	70611687.54	7061.17	1199951683.73	1199.95
440.45	74413104.07	7441.31	1341184418.95	1341.18
442.40	78180713.53	7818.07	1489732962.70	1489.73
444.35	81739846.09	8173.98	1645313014.02	1645.31
446.30	85502760.12	8550.28	1807498043.37	1807.50
448.25	88806461.54	8880.65	1976745747.90	1976.75
450.20	92790060.57	9279.01	2152854497.19	2152.85
452.15	96102213.75	9610.22	2335902628.16	2335.90
454.10	99983452.51	9998.35	2525817354.35	2525.82
456.00	101834389.26	10183.44	2717636240.62	2717.64

5.3.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.3.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Chindnar G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Chindnar G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{\text{Bodhghat}}}{A_{\text{Chindnar}}}\right)^{\frac{3}{4}} = 0.93$$

Using the above multiplying factors to the peak flows at the Chindnar G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.35**.

Table 5.35: Final Peak Flows (cumec) at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1990	7464.38	9703.69	9042.46
1991	6147.00	7991.10	7446.57
1992	6291.00	8178.30	7621.01
1993	2614.00	3398.20	3166.64
1994	7418.00	9643.40	8986.27
1995	12223.00	15889.90	14807.12
1996	2352.00	3057.60	2849.25
1997	3069.62	3990.51	3718.58
1998	1507.85	1960.21	1826.63
1999	3003.38	3904.39	3638.34
2000	3247.50	4221.75	3934.07
2001	9820.18	12766.23	11896.31
2002	5273.50	6855.55	6388.39
2003	4310.71	5603.92	5222.06
2004	5008.05	6510.47	6066.82

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2005	7127.40	9265.62	8634.24
2006	13350.59	17355.77	16173.10
2007	10073.46	13095.50	12203.14
2008	4820.78	6267.01	5839.96
2009	4059.34	5277.14	4917.54
2010	11335.00	14735.50	13731.38
2011	2898.76	3768.39	3511.60
2012	4847.33	6301.53	5872.13
2013	3995.40	5194.02	4840.09

5.3.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.36**.

Table 5.36: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	7180.57
Variance	16104136.66
SD (Sx)	4013.00
Skewness	0.87
Kurtosis	-0.16
No. of Data	24

5.3.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.37**.

The detailed procedure for Gumbel distribution method for Bodhghat dam site has been shown in **Annexure-2**.

Table 5.37: Detail of different year Return Period Flood (cumec) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	6578
2	5	10765
3	10	13537
4	20	16196
5	25	17039

Sl No.	Return Period (Years)	Flood (cumec)
6	50	19637
7	100	22217
8	500	28176

Annexure-2 (Flood Frequency Analysis for Bodhghat Dam)

DESIGN FLOOD-Bodhghat

CA at G&D = 17270 | CA = 15719

Sl.No.	Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	1990	7464.38	9703.69	9042.46	9.11
2	1991	6147.00	7991.10	7446.57	8.92
3	1992	6291.00	8178.30	7621.01	8.94
4	1993	2614.00	3398.20	3166.64	8.06
5	1994	7418.00	9643.40	8986.27	9.10
6	1995	12223.00	15889.90	14807.12	9.60
7	1996	2352.00	3057.60	2849.25	7.95
8	1997	3069.62	3990.51	3718.58	8.22
9	1998	1507.85	1960.21	1826.63	7.51
10	1999	3003.38	3904.39	3638.34	8.20
11	2000	3247.50	4221.75	3934.07	8.28
12	2001	9820.18	12766.23	11896.31	9.38
13	2002	5273.50	6855.55	6388.39	8.76
14	2003	4310.71	5603.92	5222.06	8.56
15	2004	5008.05	6510.47	6066.82	8.71
16	2005	7127.40	9265.62	8634.24	9.06
17	2006	13350.59	17355.77	16173.10	9.69
18	2007	10073.46	13095.50	12203.14	9.41
19	2008	4820.78	6267.01	5839.96	8.67
20	2009	4059.34	5277.14	4917.54	8.50
21	2010	11335.00	14735.50	13731.38	9.53
22	2011	2898.76	3768.39	3511.60	8.16
23	2012	4847.33	6301.53	5872.13	8.68
24	2013	3995.40	5194.02	4840.09	8.48

Conversion factor = 0.93

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	7180.57	8.73
Variance	16104136.66	0.323
SD (Sx)	4013.00	0.569
Skewness	0.87	-0.08743
Kurtosis	-0.16	-0.53775
No. of Data	24	

Parameters	Values
Mean(Xm)	7180.57
Variance	16104136.66
SD (Sx)	4013.00
Skewness	0.87
Kurtosis	-0.16
No. of Data	24

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 24

Reduced mean = Y_n = 0.530 } From Table (Interpolated) $f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Std. Dev = S_n = 1.09 }

Reduced Variate = Y_T = $-(\ln(\ln(T/T-1)))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	90% CONFIDENCE INTERVAL (X_{cl} Values in cumec) Lower Confidence Limit	Upper Confidence Limit
1	2	**6578**	0.367	-0.150	0.911	746.117	1227.363	5351	7806
2	5	**10765**	1.500	0.893	1.743	1427.918	2348.926	8416	13114
3	10	**13537**	2.250	1.584	2.412	1975.961	3250.457	10286	16787
4	20	**16196**	2.970	2.246	3.078	2521.048	4147.124	12049	20343
5	25	**17039**	3.199	2.457	3.291	2696.043	4434.991	12604	21474
6	50	**19637**	3.902	3.104	3.954	3238.971	5328.108	14309	24966
7	100	**22217**	4.600	3.747	4.617	3781.723	6220.935	15996	28437
8	500	**28176**	6.214	5.232	6.157	5043.750	8296.968	19879	36473

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	6578
2	5	10765
3	10	13537
4	20	16196
5	25	17039
6	50	19637
7	100	22217
8	500	28176

5.4 Hydrology of Kutru-I Hydroelectric Project

5.4.1 General

The present project, Kutru-I, envisages harnessing water from the River Indravati and other small rivers. Indravati River is a stream of the river Godavari. Its starting point is at the Ghats of Dandakaranya range from a hilltop village Mardiguda of Thuamula Rampur Block in the Kalahandi district of the state of Odisha. The project is proposed to be of storage type with the multifunction of irrigation and power.

5.4.1.1 Description of Dam Site

The catchment area of the dam site which comes out to be 18,309 km^2. The dam site is located in Bastar district of Chattisgarh at 81°14'00" E, 19°03'15" N. Catchment area of dam site and locations of the dam site and of G&D site are shown in **Figure 5.26**.

5.4.1.2 Description of G&D Site

Chindnar G&D site is situated in the Dantewada district of Chattisgarh at 81°18'10"E, 19°4'50"N. Catchment area of the G&D site is around 17,270 km^2 .

5.4.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometers draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/ km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

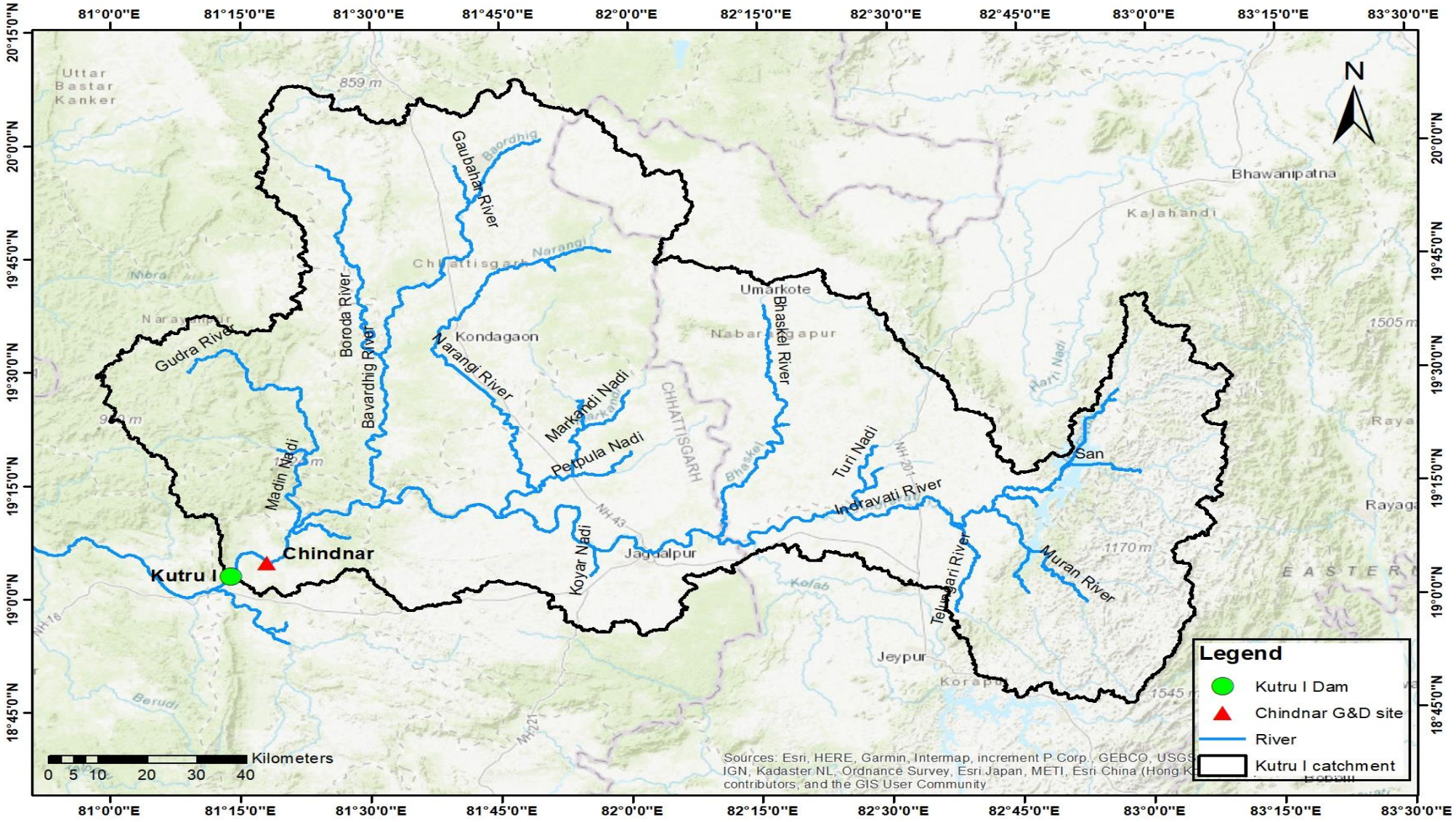


Figure 5.26: Catchment Area of Project and Locations of Dam and G&D site

5.4.2 Water Availability Studies

5.4.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Chindnar (Catchment Area=17,270 km^2), which is upstream of the project site along the Indravati River, is available and can be downloaded from India WRIS site. The G&D site lies in the Dantewada district of Chattisgarh.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.4.2.2 Rainfall data

Average of daily rainfall data generated at each grid point (as can be seen from **Figure 5.27**) within the boundary of the Chindnar G&D site and Kutru-I dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.27**, 24 grid point is considered to assess the catchment rainfall for Chindnar G&D site. Similarly, for Kutru-I proposed dam site, 24 grid points have been considered for the assessment of catchment rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

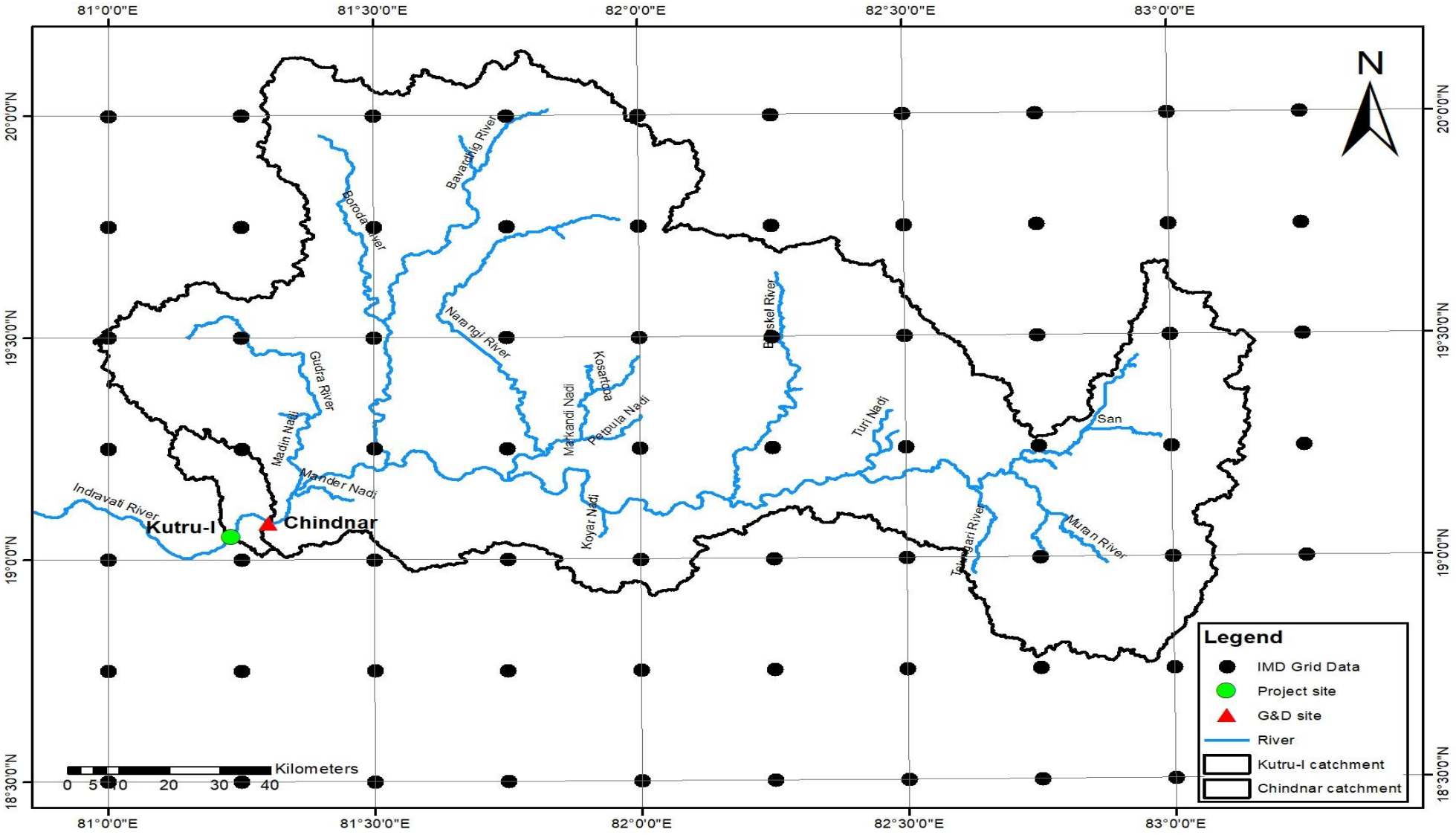


Figure 5.27: IMD Grid Rainfall Data for Kutru-I Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfall for the last 25 years has been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.38**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.39** and **Table 5.40** respectively.

Table 5.38: Average Annual Rainfall (in mm)

Year	Chindnar	Kutru-I
1990-1991	1687	1687
1991-1992	1375	1375
1992-1993	1509	1509
1993-1994	1298	1298
1994-1995	1918	1918
1995-1996	1401	1401
1996-1997	1353	1353
1997-1998	1255	1255
1998-1999	1109	1109
1999-2000	1247	1247
2000-2001	1238	1238
2001-2002	1668	1668
2002-2003	974	974
2003-2004	1725	1725
2004-2005	1457	1457
2005-2006	1512	1512
2006-2007	1983	1983
2007-2008	1793	1793
2008-2009	1550	1550
2009-2010	1303	1303
2010-2011	1757	1757
2011-2012	1203	1203
2012-2013	1576	1576
2013-2014	1588	1588
2014-2015	1474	1474
AVERAGE (mm)	1478	1478

Table 5.39: 10 Daily Rainfall (in mm) of Chindnar G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	6.68	3.18	2.83	1.89	1.04	0.32	2.00	0.46	0.58	1.18	7.30	7.84	4.03	0.42	4.28	1.66	5.88	1.98	11.80	3.20	1.77	2.96	1.36	4.79	2.69
	II	9.12	8.16	13.62	12.08	11.28	3.17	7.23	4.74	7.07	16.76	10.55	26.76	4.21	3.80	28.99	2.27	2.45	8.16	5.76	2.39	3.55	6.98	4.52	27.63	6.05
	III	8.41	6.33	3.60	5.40	9.91	8.14	3.61	6.19	6.48	3.40	7.83	5.73	10.45	3.68	1.46	18.36	6.75	40.46	10.11	6.87	4.33	4.06	9.20	13.91	7.40
JUL	I	6.23	10.69	5.51	7.92	25.11	5.38	5.59	5.68	13.73	3.38	8.59	30.93	1.53	11.16	7.09	5.97	38.59	5.88	7.39	10.88	11.60	7.11	10.45	5.19	2.96
	II	11.95	19.04	11.40	19.17	15.10	19.85	17.52	5.58	10.74	8.38	20.46	11.31	12.02	16.22	9.97	5.79	6.94	10.99	4.69	26.20	10.30	5.05	9.47	8.64	16.96
	III	9.38	20.65	29.04	11.41	14.17	23.83	17.89	21.21	7.49	8.24	2.81	7.55	5.94	20.33	14.17	12.55	15.65	5.94	14.69	12.10	19.22	9.70	20.09	15.28	24.30
AUG	I	8.69	10.14	13.77	8.26	9.79	14.15	12.75	5.90	8.57	20.15	7.19	18.50	9.77	17.13	14.80	10.89	35.59	29.91	31.62	5.95	24.77	7.33	25.98	12.39	15.92
	II	17.12	13.49	22.27	6.36	12.18	3.73	19.34	14.75	8.82	4.68	11.12	20.13	9.47	10.14	12.50	13.32	16.74	14.78	12.56	9.77	7.34	10.67	16.71	10.60	8.44
	III	20.09	9.99	9.14	4.78	17.77	14.50	8.81	14.62	4.78	17.60	17.53	5.40	13.39	23.92	9.81	2.39	16.26	7.98	9.88	17.55	12.29	14.36	7.82	3.83	10.17
SEP	I	11.81	4.43	19.31	17.66	22.28	8.04	5.99	6.50	8.18	11.08	3.70	3.78	8.14	12.35	6.56	5.66	5.93	17.47	13.31	3.74	18.01	19.04	14.21	5.61	16.21
	II	9.45	8.34	0.59	4.28	8.68	6.58	5.63	11.60	5.26	7.21	2.99	6.22	3.69	5.78	4.71	33.43	14.70	4.76	16.60	0.70	16.52	13.83	5.41	5.50	9.49
	III	5.67	3.53	1.47	9.77	3.23	4.79	6.46	5.05	3.23	5.55	7.31	3.79	0.36	9.44	3.46	1.35	16.44	12.00	2.66	5.07	1.17	3.91	5.29	7.89	2.13
OCT	I	22.49	6.12	2.27	2.22	3.22	2.38	2.42	0.70	4.80	3.44	1.25	3.36	0.56	15.63	11.30	1.67	1.06	9.39	2.76	4.21	2.45	1.04	2.30	7.95	0.49
	II	5.42	1.68	1.04	6.00	1.66	6.72	0.66	0.78	4.55	1.37	0.26	2.58	6.20	0.19	2.53	5.05	0.22	1.14	0.17	0.06	12.67	0.79	3.12	2.04	8.38
	III	0.78	0.11	0.00	0.71	1.30	3.50	1.25	1.68	0.58	2.21	0.00	0.03	0.26	5.24	0.57	8.12	0.78	0.26	0.23	0.00	3.84	0.42	0.00	10.87	0.73
NOV	I	3.08	2.93	0.31	0.03	0.87	2.29	0.21	0.34	3.38	0.54	0.01	0.09	0.00	0.08	0.81	2.25	3.87	0.05	0.00	0.54	1.85	0.00	7.43	0.00	0.00
	II	0.06	0.25	0.26	0.00	0.04	0.09	0.50	1.90	2.81	0.00	0.00	3.34	0.00	0.00	0.12	0.00	0.03	0.00	0.03	1.15	1.37	0.00	0.00	0.00	0.33
	III	0.00	0.17	1.67	0.00	0.12	0.00	0.02	0.98	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.26	0.00	0.00	0.19	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.02	0.09	2.26	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	3.27	0.03	0.00	0.00	0.00
	II	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	4.59	0.01	0.00	0.05	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.60	0.00	0.13	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.22	0.00	0.00	0.04
JAN	I	0.18	0.29	0.00	0.00	4.91	0.12	0.05	0.05	0.00	0.07	0.09	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.06	0.00	0.46
	II	0.13	0.00	0.00	0.23	1.45	0.15	0.79	0.03	0.00	0.07	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.60	0.00	0.00	0.00
	III	0.00	0.04	0.00	0.00	0.00	0.07	0.10	0.02	0.00	0.00	0.00	0.76	0.00	2.54	4.08	0.00	0.00	1.42	0.00	0.00	0.12	0.57	0.00	0.00	0.00
FEB	I	0.00	0.18	0.00	0.24	0.03	0.19	0.03	1.22	0.14	0.05	0.00	0.01	0.02	0.61	0.53	0.00	0.00	0.23	0.00	0.08	0.00	0.00	0.02	0.00	0.00
	II	0.00	0.00	0.37	0.72	0.00	0.54	0.01	0.00	0.00	1.28	0.00	0.02	0.32	0.00	0.00	0.00	0.39	0.34	0.00	0.30	0.23	0.00	0.65	0.09	0.04
	III	0.00	0.27	0.03	0.00	0.19	0.00	0.15	0.05	0.00	0.89	0.00	0.05	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.38	2.65	0.00	0.00	0.00	0.05
MAR	I	0.92	0.00	0.34	0.14	0.10	1.80	0.00	1.44	0.00	0.00	0.21	0.00	0.10	0.11	0.00	1.95	0.01	0.00	0.00	0.00	0.00	0.17	0.00	3.00	0.16
	II	0.25	0.00	0.00	0.00	1.54	0.00	0.00	0.24	0.02	0.01	0.07	0.00	1.58	0.00	0.09	1.56	0.01	0.27	0.00	0.21	0.00	0.00	0.02	0.92	0.13
	III	0.04	0.14	0.07	0.08	0.51	0.00	3.00	0.78	0.00	0.00	0.16	0.13	0.60	0.04	0.02	0.02	0.00	2.30	0.98	0.47	0.01	0.66	0.00	0.00	0.41
APR	I	1.18	0.21	0.04	1.36	1.31	0.15	4.39	1.09	0.20	0.00	0.93	1.41	0.28	0.45	0.33	0.12	0.00	0.58	0.27	0.00	1.30	0.37	0.17	0.28	0.12
	II	0.52	0.02	1.65	0.15	0.48	1.48	1.02	0.00	0.09	0.85	4.21	1.43	1.27	0.27	0.40	4.42	1.04	0.04	0.00	0.55	2.83	0.12	2.87	1.96	2.38
	III	1.25	0.85	1.49	1.95	0.28	2.07	2.03	1.27	0.00	0.20	0.68	0.58	0.75	1.35	0.94	0.18	0.19	0.07	0.00	2.90	3.97	2.42	3.66	1.36	3.47
MAY	I	1.48	1.16	0.06	0.81	6.00	0.80	1.38	1.70	1.20	1.38	1.33	0.04	0.04	0.17	0.97	1.47	2.39	0.22	1.58	3.22	1.54	2.27	0.16	1.92	3.02
	II	0.81	0.41	2.15	1.08	12.88	0.00	0.81	1.00	2.01	0.37	1.39	0.56	0.00	1.09	0.01	2.34	1.51	0.01	2.05	0.27	1.59	1.49	1.00	0.68	0.87
	III	1.96	1.52	2.51	3.07	0.95	0.97	0.46	0.48	4.45	1.40	3.37	1.90	0.16	0.24	2.11	5.51	1.18	0.79	3.02	6.50	1.61	0.05	2.59	2.95	0.03
Yearly Rainfall (mm)		1687	1375	1509	1298	1918	1401	1353	1255	1109	1247	1238	1668	974	1725	1457	1512	1983	1793	1550	1303	1757	1203	1576	1588	1474

Table 5.40: 10 Daily Rainfall (in mm) of Kutru-I Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	6.68	3.18	2.83	1.89	1.04	0.32	2.00	0.46	0.58	1.18	7.30	7.84	4.03	0.42	4.28	1.66	5.88	1.98	11.80	3.20	1.77	2.96	1.36	4.79	2.69
	II	9.12	8.16	13.62	12.08	11.28	3.17	7.23	4.74	7.07	16.76	10.55	26.76	4.21	3.80	28.99	2.27	2.45	8.16	5.76	2.39	3.55	6.98	4.52	27.63	6.05
	III	8.41	6.33	3.60	5.40	9.91	8.14	3.61	6.19	6.48	3.40	7.83	5.73	10.45	3.68	1.46	18.36	6.75	40.46	10.11	6.87	4.33	4.06	9.20	13.91	7.40
JUL	I	6.23	10.69	5.51	7.92	25.11	5.38	5.59	5.68	13.73	3.38	8.59	30.93	1.53	11.16	7.09	5.97	38.59	5.88	7.39	10.88	11.60	7.11	10.45	5.19	2.96
	II	11.95	19.04	11.40	19.17	15.10	19.85	17.52	5.58	10.74	8.38	20.46	11.31	12.02	16.22	9.97	5.79	6.94	10.99	4.69	26.20	10.30	5.05	9.47	8.64	16.96
	III	9.38	20.65	29.04	11.41	14.17	23.83	17.89	21.21	7.49	8.24	2.81	7.55	5.94	20.33	14.17	12.55	15.65	5.94	14.69	12.10	19.22	9.70	20.09	15.28	24.30
AUG	I	8.69	10.14	13.77	8.26	9.79	14.15	12.75	5.90	8.57	20.15	7.19	18.50	9.77	17.13	14.80	10.89	35.59	29.91	31.62	5.95	24.77	7.33	25.98	12.39	15.92
	II	17.12	13.49	22.27	6.36	12.18	3.73	19.34	14.75	8.82	4.68	11.12	20.13	9.47	10.14	12.50	13.32	16.74	14.78	12.56	9.77	7.34	10.67	16.71	10.60	8.44
	III	20.09	9.99	9.14	4.78	17.77	14.50	8.81	14.62	4.78	17.60	17.53	5.40	13.39	23.92	9.81	2.39	16.26	7.98	9.88	17.55	12.29	14.36	7.82	3.83	10.17
SEP	I	11.81	4.43	19.31	17.66	22.28	8.04	5.99	6.50	8.18	11.08	3.70	3.78	8.14	12.35	6.56	5.66	5.93	17.47	13.31	3.74	18.01	19.04	14.21	5.61	16.21
	II	9.45	8.34	0.59	4.28	8.68	6.58	5.63	11.60	5.26	7.21	2.99	6.22	3.69	5.78	4.71	33.43	14.70	4.76	16.60	0.70	16.52	13.83	5.41	5.50	9.49
	III	5.67	3.53	1.47	9.77	3.23	4.79	6.46	5.05	3.23	5.55	7.31	3.79	0.36	9.44	3.46	1.35	16.44	12.00	2.66	5.07	1.17	3.91	5.29	7.89	2.13
OCT	I	22.49	6.12	2.27	2.22	3.22	2.38	2.42	0.70	4.80	3.44	1.25	3.36	0.56	15.63	11.30	1.67	1.06	9.39	2.76	4.21	2.45	1.04	2.30	7.95	0.49
	II	5.42	1.68	1.04	6.00	1.66	6.72	0.66	0.78	4.55	1.37	0.26	2.58	6.20	0.19	2.53	5.05	0.22	1.14	0.17	0.06	12.67	0.79	3.12	2.04	8.38
	III	0.78	0.11	0.00	0.71	1.30	3.50	1.25	1.68	0.58	2.21	0.00	0.03	0.26	5.24	0.57	8.12	0.78	0.26	0.23	0.00	3.84	0.42	0.00	10.87	0.73
NOV	I	3.08	2.93	0.31	0.03	0.87	2.29	0.21	0.34	3.38	0.54	0.01	0.09	0.00	0.08	0.81	2.25	3.87	0.05	0.00	0.54	1.85	0.00	7.43	0.00	0.00
	II	0.06	0.25	0.26	0.00	0.04	0.09	0.50	1.90	2.81	0.00	0.00	3.34	0.00	0.00	0.12	0.00	0.03	0.00	0.03	1.15	1.37	0.00	0.00	0.00	0.33
	III	0.00	0.17	1.67	0.00	0.12	0.00	0.02	0.98	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.26	0.00	0.00	0.19	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.02	0.09	2.26	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	3.27	0.03	0.00	0.00	0.00
	II	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	4.59	0.01	0.00	0.05	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.60	0.00	0.13	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.22	0.00	0.00	0.04
JAN	I	0.18	0.29	0.00	0.00	4.91	0.12	0.05	0.05	0.00	0.07	0.09	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.06	0.00	0.46
	II	0.13	0.00	0.00	0.23	1.45	0.15	0.79	0.03	0.00	0.07	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.60	0.00	0.00	0.00
	III	0.00	0.04	0.00	0.00	0.00	0.07	0.10	0.02	0.00	0.00	0.00	0.76	0.00	2.54	4.08	0.00	0.00	1.42	0.00	0.00	0.12	0.57	0.00	0.00	0.00
FEB	I	0.00	0.18	0.00	0.24	0.03	0.19	0.03	1.22	0.14	0.05	0.00	0.01	0.02	0.61	0.53	0.00	0.00	0.23	0.00	0.08	0.00	0.00	0.02	0.00	0.00
	II	0.00	0.00	0.37	0.72	0.00	0.54	0.01	0.00	0.00	1.28	0.00	0.02	0.32	0.00	0.00	0.00	0.39	0.34	0.00	0.30	0.23	0.00	0.65	0.09	0.04
	III	0.00	0.27	0.03	0.00	0.19	0.00	0.15	0.05	0.00	0.89	0.00	0.05	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.38	2.65	0.00	0.00	0.00	0.05
MAR	I	0.92	0.00	0.34	0.14	0.10	1.80	0.00	1.44	0.00	0.00	0.21	0.00	0.10	0.11	0.00	1.95	0.01	0.00	0.00	0.00	0.00	0.17	0.00	3.00	0.16
	II	0.25	0.00	0.00	0.00	1.54	0.00	0.00	0.24	0.02	0.01	0.07	0.00	1.58	0.00	0.09	1.56	0.01	0.27	0.00	0.21	0.00	0.00	0.02	0.92	0.13
	III	0.04	0.14	0.07	0.08	0.51	0.00	3.00	0.78	0.00	0.00	0.16	0.13	0.60	0.04	0.02	0.02	0.00	2.30	0.98	0.47	0.01	0.66	0.00	0.00	0.41
APR	I	1.18	0.21	0.04	1.36	1.31	0.15	4.39	1.09	0.20	0.00	0.93	1.41	0.28	0.45	0.33	0.12	0.00	0.58	0.27	0.00	1.30	0.37	0.17	0.28	0.12
	II	0.52	0.02	1.65	0.15	0.48	1.48	1.02	0.00	0.09	0.85	4.21	1.43	1.27	0.27	0.40	4.42	1.04	0.04	0.00	0.55	2.83	0.12	2.87	1.96	2.38
	III	1.25	0.85	1.49	1.95	0.28	2.07	2.03	1.27	0.00	0.20	0.68	0.58	0.75	1.35	0.94	0.18	0.19	0.07	0.00	2.90	3.97	2.42	3.66	1.36	3.47
MAY	I	1.48	1.16	0.06	0.81	6.00	0.80	1.38	1.70	1.20	1.38	1.33	0.04	0.04	0.17	0.97	1.47	2.39	0.22	1.58	3.22	1.54	2.27	0.16	1.92	3.02
	II	0.81	0.41	2.15	1.08	12.88	0.00	0.81	1.00	2.01	0.37	1.39	0.56	0.00	1.09	0.01	2.34	1.51	0.01	2.05	0.27	1.59	1.49	1.00	0.68	0.87
	III	1.96	1.52	2.51	3.07	0.95	0.97	0.46	0.48	4.45	1.40	3.37	1.90	0.16	0.24	2.11	5.51	1.18	0.79	3.02	6.50	1.61	0.05	2.59	2.95	0.03
Yearly Rainfall (mm)		1687	1375	1509	1298	1918	1401	1353	1255	1109	1247	1238	1668	974	1725	1457	1512	1983	1793	1550	1303	1757	1203	1576	1588	1474

5.4.2.3 Rainfall and Runoff Data at Chindnar G&D Site

Detailed calculations on water availability and flood magnitude will help to select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the monthly runoff and monthly rainfall for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Chindnar G&D site is shown in **Figure 5.28**. The basic comparison between rainfall and runoff in **Figure 5.28** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.29** shows plot of runoff coefficient at G&D site.

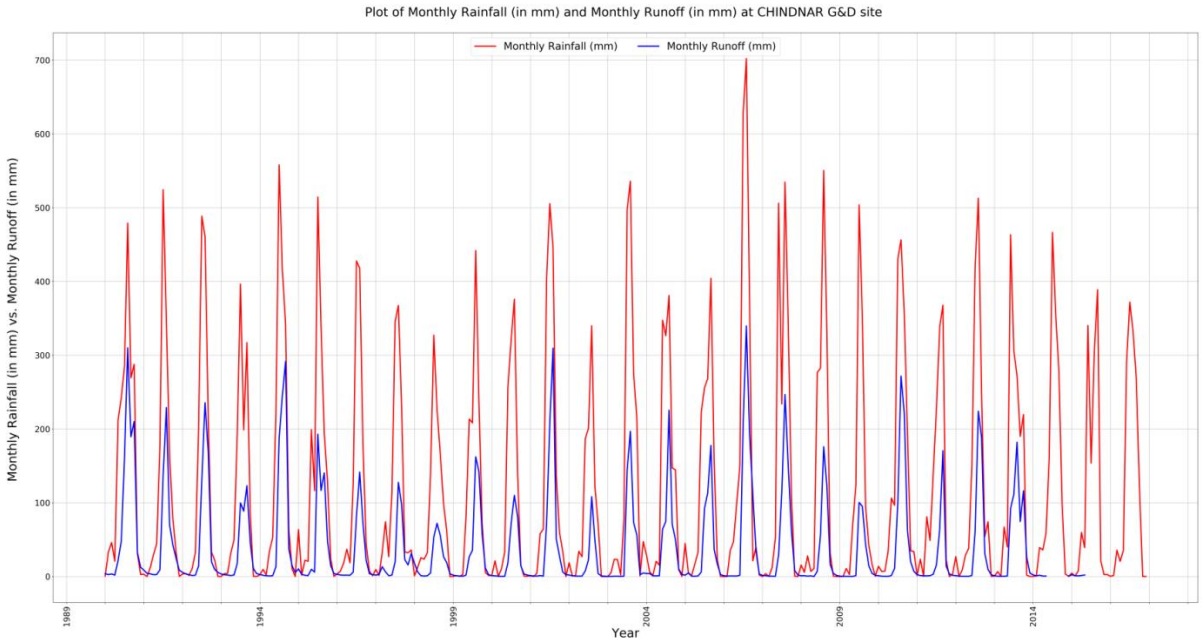


Figure 5.28: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site

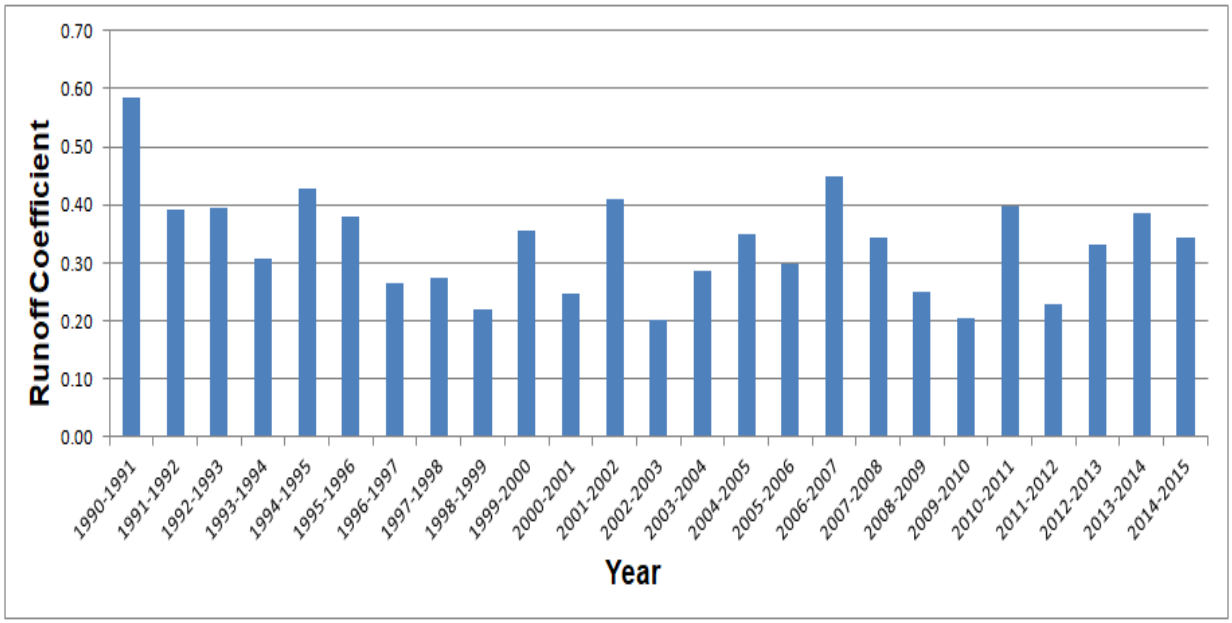


Figure 5.29: Plot of Runoff Coefficient at G&D site

5.4.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Chindnar is around 17,270 km^2 as mentioned on India WRIS site. Daily discharge data for Chindnar site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Chindnar, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Chindnar G&D and the Kutru-I dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Chindnar G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{\text{Kutru I}}}{CA_{\text{Chindnar}}} = \frac{18309}{17270} = 1.06$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{\text{Kutru-I}}}{\text{Average Annual Rainfall}_{\text{Chindnar}}} = \frac{1478}{1478} = 1.00$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Kutru I}} = Q_{\text{Chindnar G\&D } Site} \text{X } 1.060 \text{ X } 1.00$$

Table 5.41 shows 10-daily average flow series for G&D site. **Table 5.42** and **Table 5.43** show 10-daily average flow series (m^3/s) and 10-daily inflow series (MCM) respectively for Kutru-I Dam.

Table 5.41: 10-Daily Average Flow Series (m^3/s) at Chindnar

Catchment Area =17,270 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	200.37	24.19	15.30	24.19	9.27	10.96	1.58	0.89	2.31	14.32	31.24	21.37	1.64	0.30	6.09	2.17	12.22	1.00	3.15	22.66	4.99	17.86	1.14	5.92	18.13
	II	370.10	54.47	86.48	162.60	83.11	11.43	96.74	7.42	16.96	284.74	90.43	1313.81	2.34	1.55	1270.28	2.37	7.43	9.42	102.72	3.77	58.64	20.14	8.36	1023.30	212.03
	III	383.67	103.25	182.66	170.62	170.79	98.55	23.76	30.76	80.48	239.33	248.84	97.67	147.91	9.48	10.42	116.29	16.70	564.44	34.76	19.83	155.36	23.56	20.70	816.72	156.94
JUL	I	406.29	147.02	108.96	202.92	632.03	112.62	65.84	53.52	191.88	61.66	244.70	1666.49	7.87	191.03	31.86	460.44	3274.86	1031.54	68.83	91.33	201.94	77.78	144.50	328.62	408.52
	II	989.10	981.60	245.51	1097.78	2065.12	421.20	245.61	15.04	540.96	175.41	683.54	1407.96	317.92	606.83	339.23	523.66	198.00	878.74	64.85	526.61	357.17	119.22	108.12	674.80	566.00
	III	1660.33	1465.50	2071.02	630.99	958.53	3020.33	1201.09	298.78	308.41	432.52	462.99	983.31	114.47	1897.71	1017.84	782.77	585.93	345.70	908.37	1263.23	1300.85	110.94	881.16	1107.66	992.10
AUG	I	642.57	1635.27	1167.43	887.16	960.81	896.76	787.01	729.79	347.78	1487.64	166.00	1574.68	293.10	1202.87	1187.15	1091.14	2969.87	2576.27	1218.96	247.05	3727.52	252.29	1721.21	1719.81	1228.76
	II	1973.50	1663.73	1933.71	333.23	1308.66	727.31	949.32	390.64	588.43	532.33	780.06	1829.67	516.23	926.39	1469.88	570.36	2237.89	1374.88	1532.54	340.29	730.28	216.18	1289.32	1184.39	1058.30
	III	3257.01	1163.00	1461.39	500.58	2390.64	644.04	994.90	1299.68	459.43	1111.25	1139.33	2530.97	1229.71	1641.44	1680.53	543.26	1438.02	890.43	696.18	1193.93	883.34	751.07	1336.16	669.07	1246.06
SEP	I	1963.63	550.45	2231.34	911.31	4091.60	1857.71	619.20	607.65	401.58	1262.65	954.04	391.30	526.18	868.84	566.31	273.14	1454.38	1439.59	985.12	668.11	2192.68	1645.21	1561.76	345.04	1182.03
	II	1292.45	527.98	897.40	516.57	1131.10	603.32	496.05	820.05	396.14	943.20	311.49	409.15	389.12	251.86	465.22	2429.57	1132.87	661.49	953.70	126.01	1645.85	1054.79	1203.33	519.87	799.11
	III	529.62	327.86	245.97	1034.66	606.87	345.46	348.43	527.63	317.07	639.08	361.60	225.69	63.74	346.54	378.61	849.22	1265.61	882.62	497.12	82.13	595.28	710.09	998.36	625.43	533.53
OCT	I	2584.66	299.19	176.46	289.24	330.02	224.42	264.08	207.50	197.66	533.15	152.66	241.37	28.25	671.69	591.00	189.31	1858.79	815.16	170.22	196.90	228.02	133.44	397.50	967.57	489.51
	II	1184.23	384.71	130.72	351.26	198.21	319.51	82.12	92.94	199.18	361.32	92.74	210.81	30.51	182.29	250.52	167.34	222.42	259.66	103.48	64.48	666.69	106.17	132.13	662.91	269.01
	III	390.38	160.00	82.53	268.02	204.80	376.97	86.30	142.67	130.25	232.85	41.82	96.03	20.42	248.80	144.09	342.45	123.34	135.89	52.91	28.10	316.79	41.43	88.22	630.49	182.73
NOV	I	323.71	287.26	71.84	105.71	134.96	123.42	40.88	95.96	107.81	136.47	28.21	47.58	7.28	46.03	75.05	214.61	447.74	80.64	33.98	17.47	151.25	29.87	85.63	280.21	123.90
	II	199.97	121.63	60.94	67.57	96.48	106.67	24.83	82.69	183.43	62.00	21.95	39.70	4.72	5.92	93.53	77.39	176.17	51.54	28.49	32.36	161.93	23.74	70.22	141.65	80.65
	III	130.16	91.56	58.99	45.65	66.91	63.77	12.55	135.73	87.10	32.47	16.29	36.93	2.73	0.47	38.07	43.13	65.56	31.13	21.83	36.79	79.19	17.24	34.75	93.42	51.77
DEC	I	95.47	66.76	44.94	31.32	45.24	31.71	19.64	197.38	32.57	20.62	12.80	19.87	5.46	35.47	26.70	24.80	27.97	17.23	17.21	14.20	45.97	11.77	22.18	43.98	37.97
	II	79.18	52.89	35.74	25.28	32.95	26.06	16.16	215.05	22.75	14.67	15.24	15.26	2.96	68.77	16.27	14.32	19.78	13.59	9.60	10.28	63.08	11.09	15.62	27.54	34.34
	III	69.96	47.63	29.04	22.11	28.43	22.06	13.21	192.57	17.61	12.21	12.48	13.65	1.42	55.57	13.07	13.24	16.17	9.62	5.00	6.50	26.38	9.51	9.76	20.10	17.77
JAN	I	64.89	42.36	25.71	20.09	37.02	20.20	11.75	164.44	14.25	10.35	9.42	14.56	1.10	33.47	11.03	9.51	12.73	7.49	4.10	6.13	19.64	8.51	8.80	17.37	18.99
	II	55.18	35.91	22.97	17.27	122.78	19.93	13.16	102.85	12.48	8.63	8.42	15.42	0.62	21.98	8.97	6.71	10.75	6.10	3.70	9.28	17.16	9.84	8.97	15.03	15.85
	III	47.97	31.92	18.80	15.94	42.55	16.63	13.85	82.32	10.51	6.92	7.37	10.68	0.55	24.71	15.18	6.51	8.33	6.13	3.03	6.52	13.27	7.14	4.77	11.87	11.97
FEB	I	36.27	26.66	18.20	12.71	25.29	15.19	9.01	83.99	8.88	5.31	6.50	9.77	0.41	53.12	75.21	5.27	6.40	7.32	2.37	3.94	10.44	4.23	3.29	7.53	10.37
	II	30.36	24.89	17.95	13.62	19.57	14.80	7.04	30.24	8.03	6.24	5.80	8.28	0.73	17.98	16.10	4.35	9.77	9.95	2.18	2.85	7.79	3.04	2.72	6.98	8.97
	III	26.13	21.65	15.22	11.92	16.16	13.28	46.14	12.18	6.19	8.67	4.77	7.31	0.55	11.93	6.47	3.78	9.14	6.53	1.65	2.34	11.33	2.70	2.41	7.00	6.69
MAR	I	23.39	19.68	14.80	8.67	13.28	12.46	85.15	9.19	4.98	5.98	4.22	6.07	2.58	8.18	3.73	3.11	6.20	2.84	1.85	1.69	10.23	2.48	1.67	8.17	6.38
	II	29.31	15.46	13.96	7.04	10.87	12.52	84.28	7.87	4.27	2.40	3.77	3.19	2.51	4.64	3.18	6.19	2.43	2.72	1.00	1.56	5.69	1.95	2.90	20.64	5.77
	III	18.94	12.96	10.44	5.63	10.13	10.81	89.92	6.37	3.41	1.41	3.03	1.83	3.12	4.14	2.54	6.04	2.81	4.64	1.28	1.60	4.60	1.66	1.45	7.46	5.12
APR	I	16.90	11.90	10.20	5.15	11.04	10.30	85.11	5.45	2.82	0.82	2.39	1.87	3.32	7.76	1.44	2.83	1.47	11.20	1.07	1.04	4.58	1.31	0.94	4.30	7.40
	II	19.17	9.00	9.13	5.81	10.64	12.10	29.45	5.56	2.40	0.68	7.87	4.82	2.79	5.88	2.97	4.65	2.85	5.32	1.00	1.01	4.92	1.71	0.99	3.92	9.85
	III	13.32	8.69	10.51	4.37	5.76	16.18	12.81	2.80	2.45	0.89	17.17	4.63	2.85	5.41	3.63	8.01	5.08	2.03	0.52	1.40	9.54	1.63	5.91	4.84	13.05
MAY	I	13.20	13.00	13.41	7.33	26.49	13.48	13.92	8.47	2.03	0.74	4.30	3.55	2.01	8.33	7.18	4.58	2.74	0.49	0.18	7.13	9.94	1.62	7.81	2.93	15.85
	II	13.44	12.43	9.48	4.21	134.35	10.56	6.82	8.86	6.35	0.70	3.35	3.52	0.68	3.23	5.58	4.11	2.50	0.29	0.09	4.00	7.40	1.52	2.87	5.42	16.36
	III	24.58	10.75	16.97	11.16	32.62	9.72	3.70	3.49	30.03	2.40	3.91	5.11	0.74	9.07	2.20	4.96	1.24	0.06	1.79	15.74	6.59	1.55	2.87	4.54	8.62
Inflow (MCM) =		*17022*	*9278*	*10309*	*6888*	*14194*	*9210*	*6162*	*5943*	*4185*	*7629*	*5294*	*11782*	*3348*	*8524*	*8747*	*7759*	*15424*	*10611*	*6654*	*4570*	*12087*	*4775*	*9003*	*10593*	*8723*

Table 5.42: 10-Daily Average Flow Series (m^3/s) at Kutru-I Dam

Catchment Area =18,309 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	212.43	25.65	16.22	25.65	9.83	11.62	1.68	0.94	2.45	15.18	33.12	22.66	1.74	0.32	6.46	2.30	12.96	1.06	3.34	2.82	5.29	18.94	1.21	6.28	18.34
	II	392.38	57.75	91.69	172.39	88.11	12.12	102.56	7.87	17.98	301.88	95.87	1392.90	2.48	1.64	1346.75	2.51	7.88	9.99	108.90	4.00	62.17	21.35	8.86	1084.90	224.79
	III	406.77	109.47	193.66	180.89	181.07	104.48	25.19	32.61	85.32	253.74	263.82	103.55	156.81	10.05	11.05	123.29	17.71	598.42	36.85	21.02	164.71	24.98	21.95	865.89	166.39
JUL	I	430.75	155.87	115.52	215.14	670.08	119.40	69.80	56.74	203.43	65.37	259.43	1766.81	8.34	202.53	33.78	488.16	3472.01	1093.64	72.97	96.83	214.10	82.46	153.20	348.40	433.12
	II	1048.64	1040.69	260.29	1163.87	2189.44	446.56	260.40	15.95	573.53	185.97	724.69	1492.72	337.06	643.36	359.65	555.18	209.92	931.64	68.75	558.31	378.67	126.40	114.63	715.42	600.07
	III	1760.28	1553.72	2195.70	668.98	1016.23	3202.15	1273.40	316.77	326.98	458.56	490.86	1042.51	121.36	2011.95	1079.11	829.89	621.20	366.51	963.05	1339.28	1379.16	117.62	934.21	1174.34	1051.83
AUG	I	681.25	1733.71	1237.71	940.57	1018.65	950.74	834.39	773.72	368.72	1577.20	175.99	1669.48	310.74	1275.28	1258.62	1156.83	3148.66	2731.36	1292.34	261.92	3951.92	267.48	1824.83	1823.34	1302.73
	II	2092.30	1763.89	2050.12	353.29	1387.44	771.09	1006.47	414.16	623.85	564.38	827.02	1939.82	547.31	982.16	1558.37	604.70	2372.61	1457.65	1624.80	360.78	774.24	229.19	1366.94	1255.69	1122.01
	III	3453.08	1233.01	1549.37	530.71	2534.56	682.81	1054.79	1377.92	487.09	1178.15	1207.92	2683.33	1303.74	1740.25	1781.70	575.96	1524.59	944.03	738.09	1265.80	936.52	796.28	1416.60	709.35	1321.07
SEP	I	2081.84	583.59	2365.67	966.17	4337.91	1969.54	656.48	644.23	425.76	1338.66	1011.47	414.86	557.86	921.14	600.40	289.58	1541.93	1526.25	1044.42	708.33	2324.68	1744.25	1655.78	365.81	1253.19
	II	1370.26	559.76	951.42	547.67	1199.19	639.64	525.91	869.42	419.99	999.98	330.24	433.78	412.55	267.02	493.23	2575.83	1201.07	701.31	1011.11	133.60	1744.93	1118.29	1275.77	551.17	847.21
	III	561.50	347.60	260.78	1096.95	643.40	366.26	369.41	559.39	336.16	677.55	383.37	239.28	67.58	367.40	401.40	900.34	1341.80	935.75	527.05	87.07	631.12	752.84	1058.46	663.08	565.65
OCT	I	2740.26	317.20	187.08	306.65	349.89	237.93	279.98	219.99	209.56	565.25	161.85	255.90	29.95	712.13	626.58	200.71	1970.69	864.23	180.47	208.75	241.75	141.47	421.43	1025.82	518.98
	II	1255.52	407.87	138.59	372.41	210.14	338.74	87.06	98.53	211.17	383.07	98.32	223.50	32.35	193.26	265.60	177.41	235.81	275.29	109.71	68.36	706.82	112.56	140.08	702.82	285.21
	III	413.88	169.63	87.50	284.15	217.13	399.66	91.50	151.26	138.09	246.87	44.34	101.81	21.65	263.78	152.76	363.07	130.77	144.07	56.10	29.79	335.86	43.92	93.53	668.45	193.73
NOV	I	343.20	304.55	76.16	112.07	143.08	130.85	43.34	101.74	114.30	144.69	29.91	50.44	7.72	48.80	79.57	227.53	474.69	85.49	36.03	18.52	160.36	31.67	90.78	297.08	131.36
	II	212.01	128.95	64.61	71.64	102.29	113.09	26.32	87.67	194.47	65.73	23.27	42.09	5.00	6.28	99.16	82.05	186.78	54.64	30.21	34.31	171.68	25.17	74.45	150.18	85.50
	III	138.00	97.07	62.54	48.40	70.94	67.61	13.31	143.90	92.34	34.42	17.27	39.15	2.89	0.50	40.36	45.73	69.51	33.00	23.14	39.00	83.96	18.28	36.84	99.04	54.88
DEC	I	101.22	70.78	47.65	33.21	47.96	33.62	20.82	209.26	34.53	21.86	13.57	21.07	5.79	37.61	28.31	26.29	29.65	18.27	18.25	15.05	48.74	12.48	23.52	46.63	40.26
	II	83.95	56.07	37.89	26.80	34.93	27.63	17.13	228.00	24.12	15.55	16.16	16.18	3.14	72.91	17.25	15.18	20.97	14.41	10.18	10.90	66.88	11.76	16.56	29.20	36.41
	III	74.17	50.50	30.79	23.44	30.14	23.39	14.01	204.16	18.67	12.95	13.23	14.47	1.51	58.92	13.86	14.04	17.14	10.20	5.30	6.89	27.97	10.08	10.35	21.31	18.84
JAN	I	68.80	44.91	27.26	21.30	39.25	21.42	12.46	174.34	15.11	10.97	9.99	15.44	1.17	35.48	11.69	10.08	13.50	7.94	4.35	6.50	20.82	9.02	9.33	18.42	20.13
	II	58.50	38.07	24.35	18.31	130.17	21.13	13.95	109.04	13.23	9.15	8.93	16.35	0.66	23.30	9.51	7.11	11.40	6.47	3.92	9.84	18.19	10.43	9.51	15.93	16.80
	III	50.86	33.84	19.93	16.90	45.11	17.63	14.68	87.28	11.14	7.34	7.81	11.32	0.58	26.20	16.09	6.90	8.83	6.50	3.21	6.91	14.07	7.57	5.06	12.58	12.69
FEB	I	38.45	28.26	19.30	13.48	26.81	16.10	9.55	89.05	9.41	5.63	6.89	10.36	0.43	56.32	79.74	5.59	6.79	7.76	2.51	4.18	11.07	4.48	3.49	7.98	10.99
	II	32.19	26.39	19.03	14.44	20.75	15.69	7.46	32.06	8.51	6.62	6.15	8.78	0.77	19.06	17.07	4.61	10.36	10.55	2.31	3.02	8.26	3.22	2.88	7.40	9.51
	III	27.70	22.95	16.14	12.64	17.13	14.08	48.92	12.91	6.56	9.19	5.06	7.75	0.58	12.65	6.86	4.01	9.69	6.92	1.75	2.48	12.01	2.86	2.56	7.42	7.09
MAR	I	24.80	20.86	15.69	9.19	14.08	13.21	90.28	9.74	5.28	6.34	4.47	6.44	2.74	8.67	3.95	3.30	6.57	3.01	1.96	1.79	10.85	2.63	1.77	8.66	6.76
	II	31.07	16.39	14.80	7.46	11.52	13.27	89.35	8.34	4.53	2.54	4.00	3.38	2.66	4.92	3.37	6.56	2.58	2.88	1.06	1.65	6.03	2.07	3.07	21.88	6.12
	III	20.08	13.74	11.07	5.97	10.74	11.46	95.33	6.75	3.62	1.49	3.21	1.94	3.31	4.39	2.69	6.40	2.98	4.92	1.36	1.70	4.88	1.76	1.54	7.91	5.43
APR	I	17.92	12.62	10.81	5.46	11.70	10.92	90.23	5.78	2.99	0.87	2.53	1.98	3.52	8.23	1.53	3.00	1.56	11.87	1.13	1.10	4.86	1.39	1.00	4.56	7.85
	II	20.32	9.54	9.68	6.16	11.28	12.83	31.22	5.89	2.54	0.72	8.34	5.11	2.96	6.23	3.15	4.93	3.02	5.64	1.06	1.07	5.22	1.81	1.05	4.16	10.44
	III	14.12	9.21	11.14	4.63	6.11	17.15	13.58	2.97	2.60	0.94	18.20	4.91	3.02	5.74	3.85	8.49	5.39	2.15	0.55	1.48	10.11	1.73	6.27	5.13	13.84
MAY	I	13.99	13.78	14.22	7.77	28.08	14.29	14.76	8.98	2.15	0.78	4.56	3.76	2.13	8.83	7.61	4.86	2.90	0.52	0.19	7.56	10.54	1.72	8.28	3.11	16.80
	II	14.25	13.18	10.05	4.46	142.44	11.20	7.23	9.39	6.73	0.74	3.55	3.73	0.72	3.42	5.92	4.36	2.65	0.31	0.10	4.24	7.85	1.61	3.04	5.75	17.34
	III	26.06	11.40	17.99	11.83	34.58	10.31	3.92	3.70	31.84	2.54	4.15	5.42	0.78	9.62	2.33	5.26	1.31	0.06	1.90	16.69	6.99	1.64	3.04	4.81	9.14
Inflow (MCM) =		*18046*	*9836*	*10930*	*7303*	*15049*	*9765*	*6533*	*6301*	*4437*	*8089*	*5612*	*12491*	*3550*	*9037*	*9273*	*8226*	*16353*	*11250*	*7055*	*4845*	*12814*	*5062*	*9545*	*11231*	*9247*

Table 5.43: 10- Daily Inflow Series (MCM) at Kutru-I Project Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	183.54	22.16	14.01	22.16	8.49	10.04	1.45	0.81	2.12	13.12	28.62	19.58	1.50	0.28	5.58	1.99	11.20	0.92	2.89	2.44	4.57	16.36	1.05	5.43	15.85
	II	339.02	49.90	79.22	148.94	76.13	10.47	88.61	6.80	15.53	260.82	82.83	1203.47	2.14	1.42	1163.59	2.17	6.81	8.63	94.09	3.46	53.71	18.45	7.66	937.35	194.22
	III	351.45	94.58	167.32	156.29	156.44	90.27	21.76	28.18	73.72	219.23	227.94	89.47	135.48	8.68	9.55	106.52	15.30	517.03	31.84	18.16	142.31	21.58	18.96	748.13	143.76
JUL	I	372.17	134.67	99.81	185.88	578.95	103.16	60.31	49.02	175.76	56.48	224.15	1526.52	7.21	174.99	29.19	421.77	2999.82	944.90	63.05	83.66	184.98	71.25	132.36	301.02	374.21
	II	906.02	899.16	224.89	1005.58	1891.68	385.83	224.99	13.78	495.53	160.68	626.13	1289.71	291.22	555.86	310.74	479.68	181.37	804.94	59.40	482.38	327.17	109.21	99.04	618.12	518.46
	III	1672.97	1476.66	2086.79	635.80	965.82	3043.32	1210.24	301.06	310.76	435.82	466.51	990.80	115.34	1912.16	1025.59	788.73	590.39	348.33	915.28	1272.85	1310.75	111.79	887.87	1116.09	999.66
AUG	I	588.60	1497.93	1069.38	812.65	880.11	821.44	720.91	668.49	318.57	1362.70	152.06	1442.43	268.48	1101.84	1087.45	999.50	2720.44	2359.90	1116.58	226.30	3414.46	231.10	1576.65	1575.37	1125.56
	II	1807.75	1524.00	1771.30	305.24	1198.75	666.22	869.59	357.83	539.01	487.62	714.55	1676.00	472.88	848.59	1346.43	522.46	2049.94	1259.41	1403.83	311.71	668.94	198.02	1181.04	1084.92	969.42
	III	3281.81	1171.85	1472.52	504.39	2408.85	648.94	1002.47	1309.58	462.93	1119.71	1148.01	2550.24	1239.07	1653.93	1693.33	547.39	1448.97	897.21	701.48	1203.02	890.07	756.78	1346.34	674.17	1255.54
SEP	I	1798.71	504.22	2043.94	834.77	3747.95	1701.68	567.20	556.61	367.86	1156.60	873.91	358.44	481.99	795.86	518.75	250.20	1332.23	1318.68	902.38	612.00	2008.52	1507.03	1430.59	316.06	1082.76
	II	1183.90	483.63	822.03	473.19	1036.10	552.65	454.39	751.18	362.87	863.98	285.33	374.79	356.44	230.71	426.15	2225.52	1037.72	605.93	873.60	115.43	1507.62	966.20	1102.27	476.21	731.99
	III	485.14	300.33	225.31	947.76	555.90	316.45	319.17	483.31	290.44	585.40	331.23	206.74	58.39	317.43	346.81	777.89	1159.32	808.49	455.37	75.23	545.29	650.45	914.51	572.90	488.72
OCT	I	2367.58	274.06	161.64	264.95	302.30	205.57	241.90	190.07	181.06	488.38	139.84	221.10	25.88	615.28	541.37	173.41	1702.68	746.69	155.93	180.36	208.87	122.23	364.12	886.31	448.40
	II	1084.77	352.40	119.74	321.76	181.56	292.67	75.22	85.13	182.45	330.97	84.95	193.10	27.95	166.98	229.48	153.28	203.74	237.85	94.79	59.06	610.69	97.25	121.03	607.24	246.42
	III	393.35	161.22	83.16	270.06	206.36	379.84	86.96	143.76	131.24	234.63	42.14	96.76	20.58	250.70	145.18	345.06	124.28	136.92	53.32	28.31	319.20	41.74	88.89	635.29	184.12
NOV	I	296.52	263.13	65.80	96.83	123.62	113.05	37.45	87.90	98.76	125.01	25.84	43.58	6.67	42.16	68.75	196.59	410.13	73.86	31.13	16.00	138.55	27.36	78.43	256.68	113.49
	II	183.18	111.41	55.82	61.90	88.38	97.71	22.74	75.75	168.02	56.79	20.11	36.37	4.32	5.43	85.67	70.89	161.38	47.21	26.10	29.64	148.33	21.75	64.32	129.76	73.87
	III	119.23	83.87	54.03	41.82	61.29	58.42	11.50	124.33	79.78	29.74	14.92	33.83	2.50	0.43	34.87	39.51	60.06	28.51	19.99	33.70	72.54	15.79	31.83	85.57	47.42
DEC	I	87.45	61.15	41.17	28.69	41.44	29.05	17.99	180.80	29.83	18.89	11.72	18.20	5.00	32.50	24.46	22.71	25.62	15.79	15.77	13.00	42.11	10.78	20.32	40.29	34.78
	II	72.53	48.44	32.74	23.16	30.18	23.87	14.80	196.99	20.84	13.44	13.96	13.98	2.71	62.99	14.90	13.12	18.12	12.45	8.80	9.42	57.78	10.16	14.31	25.23	31.46
	III	70.49	48.00	29.26	22.28	28.65	22.23	13.32	194.03	17.74	12.31	12.57	13.75	1.44	56.00	13.17	13.34	16.29	9.69	5.04	6.55	26.58	9.58	9.84	20.25	17.91
JAN	I	59.44	38.80	23.55	18.40	33.91	18.51	10.77	150.63	13.06	9.48	8.63	13.34	1.01	30.65	10.10	8.71	11.66	6.86	3.76	5.62	17.99	7.79	8.06	15.91	17.39
	II	50.54	32.89	21.04	15.82	112.47	18.26	12.05	94.21	11.43	7.91	7.72	14.13	0.57	20.13	8.22	6.14	9.85	5.59	3.39	8.50	15.72	9.01	8.22	13.76	14.52
	III	48.34	32.16	18.94	16.06	42.87	16.76	13.95	82.95	10.59	6.98	7.42	10.76	0.55	24.90	15.29	6.56	8.39	6.18	3.05	6.57	13.37	7.19	4.81	11.96	12.06
FEB	I	33.22	24.42	16.68	11.65	23.16	13.91	8.25	76.94	8.13	4.86	5.95	8.95	0.37	48.66	68.90	4.83	5.87	6.70	2.17	3.61	9.56	3.87	3.02	6.89	9.50
	II	27.81	22.80	16.44	12.48	17.93	13.56	6.45	27.70	7.35	5.72	5.31	7.59	0.67	16.47	14.75	3.98	8.95	9.12	2.00	2.61	7.14	2.78	2.49	6.39	8.22
	III	19.15	15.86	11.16	8.74	11.84	9.73	33.81	8.92	4.53	6.35	3.50	5.36	0.40	8.74	4.74	2.77	6.70	4.78	1.21	1.71	8.30	1.98	1.77	5.13	4.90
MAR	I	21.43	18.02	13.56	7.94	12.17	11.41	78.00	8.42	4.56	5.48	3.86	5.56	2.37	7.49	3.41	2.85	5.68	2.60	1.69	1.55	9.37	2.27	1.53	7.48	5.84
	II	26.84	14.16	12.79	6.45	9.95	11.47	77.20	7.21	3.91	2.19	3.46	2.92	2.30	4.25	2.91	5.67	2.23	2.49	0.92	1.43	5.21	1.79	2.65	18.90	5.29
	III	19.08	13.06	10.52	5.67	10.21	10.89	90.60	6.42	3.44	1.42	3.05	1.84	3.15	4.17	2.56	6.08	2.83	4.68	1.29	1.62	4.64	1.67	1.46	7.52	5.16
APR	I	15.48	10.90	9.34	4.72	10.11	9.43	77.96	4.99	2.58	0.75	2.19	1.71	3.04	7.11	1.32	2.59	1.35	10.26	0.98	0.95	4.20	1.20	0.86	3.94	6.78
	II	17.56	8.24	8.36	5.32	9.75	11.09	26.97	5.09	2.19	0.62	7.21	4.42	2.56	5.38	2.72	4.26	2.61	4.87	0.92	0.92	4.51	1.56	0.91	3.59	9.02
	III	12.20	7.96	9.62	4.00	5.28	14.82	11.73	2.57	2.25	0.81	15.72	4.24	2.61	4.96	3.33	7.34	4.66	1.86	0.48	1.28	8.74	1.49	5.42	4.43	11.96
MAY	I	12.09	11.91	12.29	6.71	24.26	12.35	12.75	7.76	1.86	0.67	3.94	3.25	1.84	7.63	6.58	4.20	2.51	0.45	0.16	6.53	9.11	1.49	7.15	2.69	14.52
	II	12.31	11.39	8.68	3.85	123.07	9.68	6.25	8.11	5.81	0.64	3.07	3.22	0.62	2.95	5.11	3.77	2.29	0.27	0.09	3.66	6.78	1.39	2.63	4.97	14.98
	III	24.77	10.83	17.10	11.24	32.86	9.80	3.73	3.52	30.26	2.41	3.94	5.15	0.74	9.14	2.21	5.00	1.25	0.06	1.81	15.86	6.64	1.56	2.89	4.57	8.69
Total Inflow (MCM)		*18046*	*9836*	*10930*	*7303*	*15049*	*9765*	*6533*	*6301*	*4437*	*8089*	*5612*	*12491*	*3550*	*9037*	*9273*	*8226*	*16353*	*11250*	*7055*	*4845*	*12814*	*5062*	*9545*	*11231*	*9247*

5.4.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.44** and **Table 5.45**

Table 5.44: Computation of 90% and 50% Dependable Year for Kutru-I Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.04	18046	1990-1991	
2	0.08	16353	2006-2007	
3	0.12	15049	1994-1995	
4	0.15	12814	2010-2011	
5	0.19	12491	2001-2002	
6	0.23	11250	2007-2008	
7	0.27	11231	2013-2014	
8	0.31	10930	1992-1993	
9	0.35	9836	1991-1992	
10	0.38	9765	1995-1996	
11	0.42	9545	2012-2013	
12	0.46	9273	2004-2005	
13	**0.50**	**9247**	**2014-2015**	**50% Dependable**
14	0.54	9037	2003-2004	
15	0.58	8226	2005-2006	
16	0.62	8089	1999-2000	
17	0.65	7303	1993-1994	
18	0.69	7055	2008-2009	
19	0.73	6533	1996-1997	
20	0.77	6301	1997-1998	
21	0.81	5612	2000-2001	
22	0.85	5062	2011-2012	
23	**0.88**	**4845**	**2009-2010**	**90% Dependable**
24	0.92	4437	1998-1999	
25	0.96	3550	2002-2003	

Table 5.45: 90% and 50% dependable flows for the dam site (cumec)

		90% Dependable	50% Dependable
Period		**2009-2010**	**2014-2015**
Jun	**I**	2.82	18.34
	II	4.00	224.79
	III	21.02	166.39
Jul	**I**	96.83	433.12
	II	558.31	600.07
	III	1339.28	1051.83
Aug	**I**	261.92	1302.73
	II	360.78	1122.01
	III	1265.80	1321.07
Sep	**I**	708.33	1253.19
	II	133.60	847.21
	III	87.07	565.65
Oct	**I**	208.75	518.98
	II	68.36	285.21
	III	29.79	193.73
Nov	**I**	18.52	131.36
	II	34.31	85.50
	III	39.00	54.88
Dec	**I**	15.05	40.26
	II	10.90	36.41
	III	6.89	18.84
Jan	**I**	6.50	20.13
	II	9.84	16.80
	III	6.91	12.69
Feb	**I**	4.18	10.99
	II	3.02	9.51
	III	2.48	7.09
Mar	**I**	1.79	6.76
	II	1.65	6.12
	III	1.70	5.43
Apr	**I**	1.10	7.85
	II	1.07	10.44
	III	1.48	13.84
May	**I**	7.56	16.80
	II	4.24	17.34
	III	16.69	9.14
Inflow (MCM) =		**4845**	**9247**

5.4.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Kutru-I, is given in the following section.

5.4.5.1 EAC of Kutru-I Dam

The EAC curve and the table showing the different values are given in **Figure 5.30** and **Table 5.46** respectively.

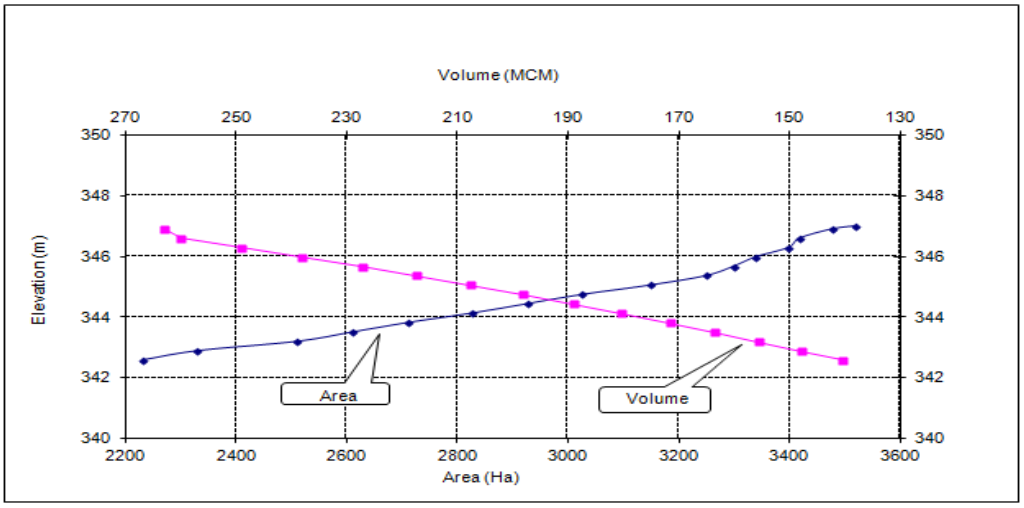


Figure 5.30: EAC curve of Kutru-I Dam

Table 5.46: EAC data of Kutru-I Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
342.57	22307004.88	2230.70	133441827.60	133.44
342.88	23307004.88	2330.70	140356944.70	140.36
343.19	25114754.81	2511.48	147805541.10	147.81
343.5	26114754.81	2611.48	155591053.70	155.59
343.81	27114754.81	2711.48	163376566.40	163.38
344.12	28265371.49	2826.54	171540137.70	171.54
344.43	29265371.49	2926.54	180302333.90	180.30
344.74	30265371.49	3026.54	189064530.00	189.06
345.05	31497712.58	3149.77	197988303.80	197.99
345.36	32497712.58	3249.77	207752517.80	207.75
345.67	32997712.58	3299.77	217517693.00	217.52
345.98	33397712.58	3339.77	227281907.00	227.28
346.29	33993158.62	3399.32	238117831.90	238.12
346.60	34193158.62	3419.32	249027625.20	249.03
346.91	34793158.62	3479.32	259937418.40	259.94
347.00	35193158.62	3519.32	263104673.80	263.10

5.4.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.4.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Chindnar G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Chindnar G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{\text{Kutru-I}}}{A_{\text{Chindnar}}}\right)^{\frac{3}{4}} = 1.04$$

Using the above multiplying factors to the peak flows at the Chindnar G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.47**.

Table 5.47: Final Peak Flows (cumec) at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1990	7464.38	9703.69	10138.33
1991	6147.00	7991.10	8349.03
1992	6291.00	8178.30	8544.61
1993	2614.00	3398.20	3550.41
1994	7418.00	9643.40	10075.33
1995	12223.00	15889.90	16601.62
1996	2352.00	3057.60	3194.55
1997	3069.62	3990.51	4169.24
1998	1507.85	1960.21	2048.00
1999	3003.38	3904.39	4079.27
2000	3247.50	4221.75	4410.84
2001	9820.18	12766.23	13338.04
2002	5273.50	6855.55	7162.61
2003	4310.71	5603.92	5854.93
2004	5008.05	6510.47	6802.07
2005	7127.40	9265.62	9680.63

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2006	13350.59	17355.77	18133.14
2007	10073.46	13095.50	13682.05
2008	4820.78	6267.01	6547.72
2009	4059.34	5277.14	5513.51
2010	11335.00	14735.50	15395.51
2011	2898.76	3768.39	3937.18
2012	4847.33	6301.53	6583.78
2013	3995.40	5194.02	5426.66

5.4.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.48**.

Table 5.48: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	8050.79
Variance	20244031.92
SD (Sx)	4499.34
Skewness	0.87
Kurtosis	-0.16
No. of Data	24

5.4.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.49**.

The detailed procedure for Gumbel distribution method for Kutru-I dam site has been shown in **Annexure-3** .

Table 5.49: Detail of different year Return Period Flood (cumec) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	7375
2	5	12069
3	10	15177
4	20	18159
5	25	19104
6	50	22017

Sl No.	Return Period (Years)	Flood (cumec)
7	100	24909
8	500	31591

Annexure-3 (Flood Frequency Analysis for Kutru-I Dam)

DESIGN FLOOD-Kutru1

CA at G&D = 17270 | CA = 18309

Conversion factor = 1.04

Instantaneous Peak = 30%

Sl.No.	Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	1990	7464.38	9703.69	10138.33	9.22
2	1991	6147.00	7991.10	8349.03	9.03
3	1992	6291.00	8178.30	8544.61	9.05
4	1993	2614.00	3398.20	3550.41	8.17
5	1994	7418.00	9643.40	10075.33	9.22
6	1995	12223.00	15889.90	16601.62	9.72
7	1996	2352.00	3057.60	3194.55	8.07
8	1997	3069.62	3990.51	4169.24	8.34
9	1998	1507.85	1960.21	2048.00	7.62
10	1999	3003.38	3904.39	4079.27	8.31
11	2000	3247.50	4221.75	4410.84	8.39
12	2001	9820.18	12766.23	13338.04	9.50
13	2002	5273.50	6855.55	7162.61	8.88
14	2003	4310.71	5603.92	5854.93	8.68
15	2004	5008.05	6510.47	6802.07	8.82
16	2005	7127.40	9265.62	9680.63	9.18
17	2006	13350.59	17355.77	18133.14	9.81
18	2007	10073.46	13095.50	13682.05	9.52
19	2008	4820.78	6267.01	6547.72	8.79
20	2009	4059.34	5277.14	5513.51	8.61
21	2010	11335.00	14735.50	15395.51	9.64
22	2011	2898.76	3768.39	3937.18	8.28
23	2012	4847.33	6301.53	6583.78	8.79
24	2013	3995.40	5194.02	5426.66	8.60

	X-STAT	Ln-STAT
Mean(X_m)	8050.79	8.84
Variance	20244031.92	0.323
SD (Sx)	4499.34	0.569
Skewness	0.87	-0.08743
Kurtosis	-0.16	-0.53775
No. of Data	24	

Parameters	Values
Mean(Xm)	8050.79
Variance	20244031.92
SD (Sx)	4499.34
Skewness	0.87
Kurtosis	-0.16
No. of Data	24

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 24

Reduced mean = Y_n = 0.530 (From Table (Interpolated))

Reduced Std. Dev = S_n = 1.09 (From Table (Interpolated))

$f_{(C.)}$ = 1.645 (90% confidence probability)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C.)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C.)}.Se$

90% CONFIDENCE INTERVAL (X_{cl} Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	**7375**	0.367	-0.150	0.911	836.540	1376.109	5999	8751
2	5	**12069**	1.500	0.893	1.743	1600.970	2633.596	9436	14703
3	10	**15177**	2.250	1.584	2.412	2215.431	3644.384	11533	18822
4	20	**18159**	2.970	2.246	3.078	2826.577	4649.720	13509	22808
5	25	**19104**	3.199	2.457	3.291	3022.781	4972.474	14132	24077
6	50	**22017**	3.902	3.104	3.954	3631.507	5973.829	16044	27991
7	100	**24909**	4.600	3.747	4.617	4240.036	6974.859	17934	31884
8	500	**31591**	6.214	5.232	6.157	5655.009	9302.490	22289	40894

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	7375
2	5	12069
3	10	15177
4	20	18159
5	25	19104
6	50	22017
7	100	24909
8	500	31591

5.5 Hydrology of Kutru-II Hydroelectric Project

5.5.1 General

The present project, Kutru-II, envisages harnessing water from the River Indravati and other small rivers. Indravati River is a stream of the river Godavari. Its starting point is at the Ghats of Dandakaranya range from a hilltop village Mardiguda of Thuamula Rampur Block in the Kalahandi district of the state of Odisha. The project is proposed to be of storage type with the multifunction of irrigation and power.

5.5.1.1 Description of Dam Site

The catchment area of the dam site which comes out to be 21,189 km^2. The dam site is located in Bastar district of Chattisgarh at 19° 06' 18.1" N, 80° 52' 5.5"E. Catchment area of dam site and locations of the dam site and of G&D site are shown in **Figure 5.31**.

5.5.1.2 Description of G&D Site

Chindnar G&D site is situated in the Dantewada district of Chattisgarh at 81° 18' 10" E, 19° 4' 50" N. Catchment area of the G&D site is around 17,270 km^2 .

5.5.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometers draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

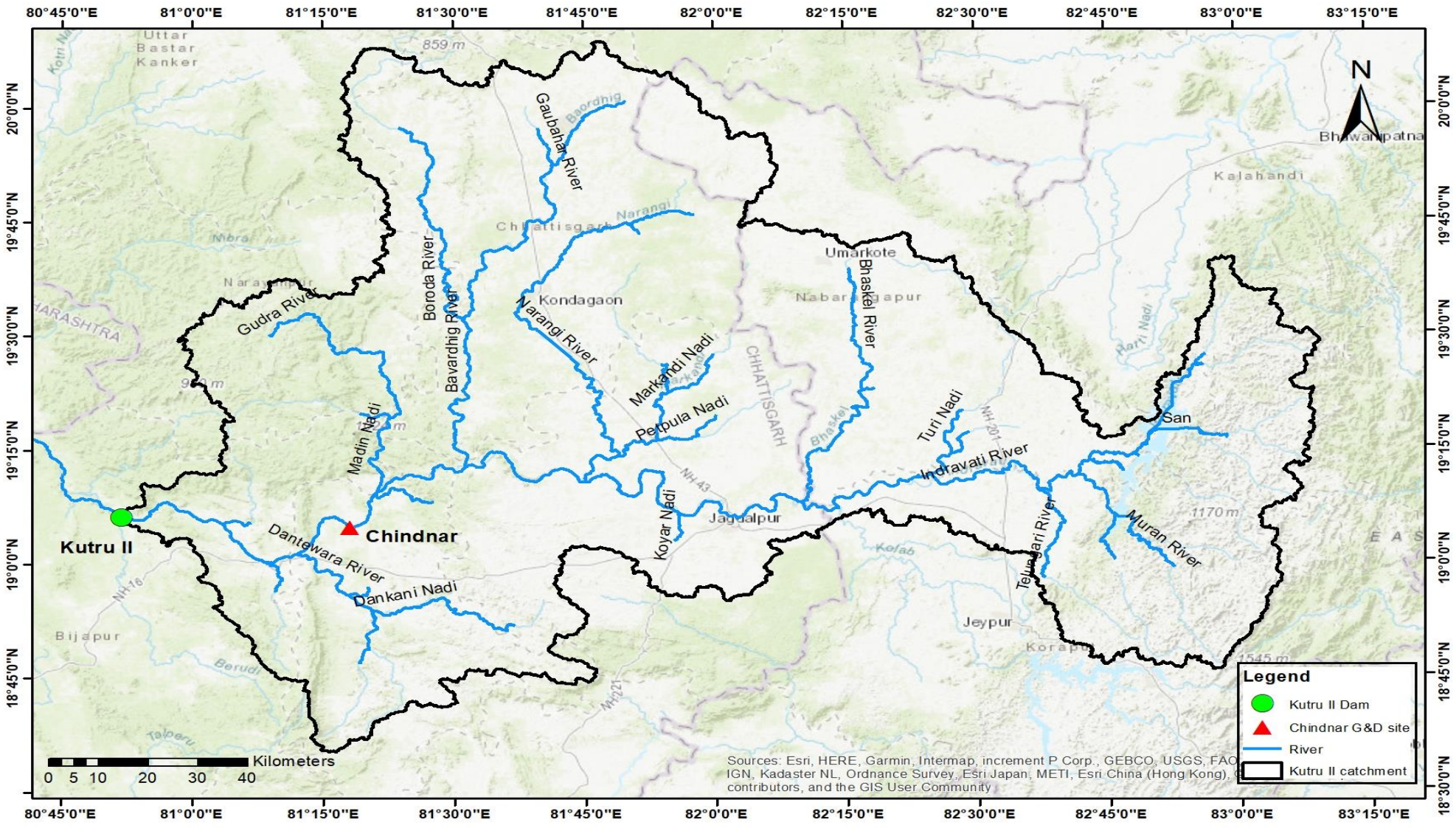


Figure 5.31: Catchment Area of Project and Locations of Dam and G&D site

5.5.2 Water Availability Studies

5.5.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Chindnar (Catchment Area=17,270 km^2), which is upstream of the project site along the Indravati River, is available and can be downloaded from India WRIS site. The G&D site lies in the Dantewada district of Chattisgarh.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.5.2.2 Rainfall data

Average of daily rainfall data generated at each grid point (as can be seen from **Figure 5.32**) within the boundary of the Chindnar G&D site and Kutru-II dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.32**, 23 grid point is considered to assess the catchment rainfall for Chindnar G&D site. Similarly, for Kutru-II proposed dam site, 29 grid points have been considered for the assessment of catchment rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

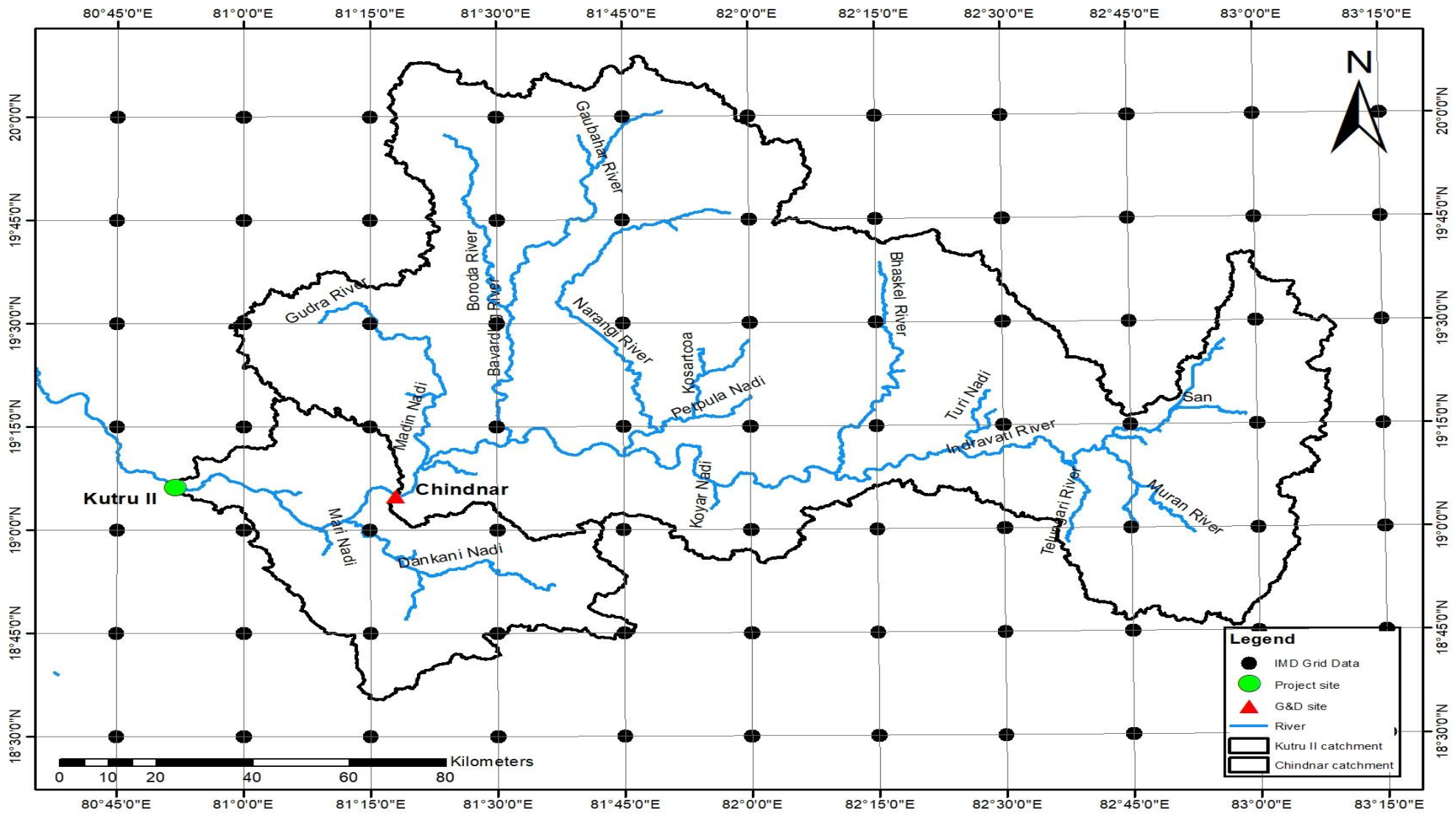


Figure 5.32: IMD Grid Rainfall Data for Kutru-II Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfall for the last 25 years has been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.50**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.51** and **Table 5.52** respectively.

Table 5.50: Average Annual Rainfall (in mm)

Year	Chindnar	Kutru-II
1990-1991	1687	1684
1991-1992	1375	1360
1992-1993	1509	1490
1993-1994	1298	1326
1994-1995	1918	1923
1995-1996	1401	1405
1996-1997	1353	1370
1997-1998	1255	1207
1998-1999	1109	1169
1999-2000	1247	1320
2000-2001	1238	1262
2001-2002	1668	1654
2002-2003	974	991
2003-2004	1725	1778
2004-2005	1457	1459
2005-2006	1512	1509
2006-2007	1983	1939
2007-2008	1793	1800
2008-2009	1550	1505
2009-2010	1303	1257
2010-2011	1757	1771
2011-2012	1203	1235
2012-2013	1576	1596
2013-2014	1588	1580
2014-2015	1474	1447
AVERAGE (mm)	1478	1481

Table 5.51: 10 Daily Rainfall (in mm) of Chindnar G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	6.68	3.18	2.83	1.89	1.04	0.32	2.00	0.46	0.58	1.18	7.30	7.84	4.03	0.42	4.28	1.66	5.88	1.98	11.80	3.20	1.77	2.96	1.36	4.79	2.69
	II	9.12	8.16	13.62	12.08	11.28	3.17	7.23	4.74	7.07	16.76	10.55	26.76	4.21	3.80	28.99	2.27	2.45	8.16	5.76	2.39	3.55	6.98	4.52	27.63	6.05
	III	8.41	6.33	3.60	5.40	9.91	8.14	3.61	6.19	6.48	3.40	7.83	5.73	10.45	3.68	1.46	18.36	6.75	40.46	10.11	6.87	4.33	4.06	9.20	13.91	7.40
JUL	I	6.23	10.69	5.51	7.92	25.11	5.38	5.59	5.68	13.73	3.38	8.59	30.93	1.53	11.16	7.09	5.97	38.59	5.88	7.39	10.88	11.60	7.11	10.45	5.19	2.96
	II	11.95	19.04	11.40	19.17	15.10	19.85	17.52	5.58	10.74	8.38	20.46	11.31	12.02	16.22	9.97	5.79	6.94	10.99	4.69	26.20	10.30	5.05	9.47	8.64	16.96
	III	9.38	20.65	29.04	11.41	14.17	23.83	17.89	21.21	7.49	8.24	2.81	7.55	5.94	20.33	14.17	12.55	15.65	5.94	14.69	12.10	19.22	9.70	20.09	15.28	24.30
AUG	I	8.69	10.14	13.77	8.26	9.79	14.15	12.75	5.90	8.57	20.15	7.19	18.50	9.77	17.13	14.80	10.89	35.59	29.91	31.62	5.95	24.77	7.33	25.98	12.39	15.92
	II	17.12	13.49	22.27	6.36	12.18	3.73	19.34	14.75	8.82	4.68	11.12	20.13	9.47	10.14	12.50	13.32	16.74	14.78	12.56	9.77	7.34	10.67	16.71	10.60	8.44
	III	20.09	9.99	9.14	4.78	17.77	14.50	8.81	14.62	4.78	17.60	17.53	5.40	13.39	23.92	9.81	2.39	16.26	7.98	9.88	17.55	12.29	14.36	7.82	3.83	10.17
SEP	I	11.81	4.43	19.31	17.66	22.28	8.04	5.99	6.50	8.18	11.08	3.70	3.78	8.14	12.35	6.56	5.66	5.93	17.47	13.31	3.74	18.01	19.04	14.21	5.61	16.21
	II	9.45	8.34	0.59	4.28	8.68	6.58	5.63	11.60	5.26	7.21	2.99	6.22	3.69	5.78	4.71	33.43	14.70	4.76	16.60	0.70	16.52	13.83	5.41	5.50	9.49
	III	5.67	3.53	1.47	9.77	3.23	4.79	6.46	5.05	3.23	5.55	7.31	3.79	0.36	9.44	3.46	1.35	16.44	12.00	2.66	5.07	1.17	3.91	5.29	7.89	2.13
OCT	I	22.49	6.12	2.27	2.22	3.22	2.38	2.42	0.70	4.80	3.44	1.25	3.36	0.56	15.63	11.30	1.67	1.06	9.39	2.76	4.21	2.45	1.04	2.30	7.95	0.49
	II	5.42	1.68	1.04	6.00	1.66	6.72	0.66	0.78	4.55	1.37	0.26	2.58	6.20	0.19	2.53	5.05	0.22	1.14	0.17	0.06	12.67	0.79	3.12	2.04	8.38
	III	0.78	0.11	0.00	0.71	1.30	3.50	1.25	1.68	0.58	2.21	0.00	0.03	0.26	5.24	0.57	8.12	0.78	0.26	0.23	0.00	3.84	0.42	0.00	10.87	0.73
NOV	I	3.08	2.93	0.31	0.03	0.87	2.29	0.21	0.34	3.38	0.54	0.01	0.09	0.00	0.08	0.81	2.25	3.87	0.05	0.00	0.54	1.85	0.00	7.43	0.00	0.00
	II	0.06	0.25	0.26	0.00	0.04	0.09	0.50	1.90	2.81	0.00	0.00	3.34	0.00	0.00	0.12	0.00	0.03	0.00	0.03	1.15	1.37	0.00	0.00	0.00	0.33
	III	0.00	0.17	1.67	0.00	0.12	0.00	0.02	0.98	0.01	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.26	0.00	0.00	0.19	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.02	0.09	2.26	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	3.27	0.03	0.00	0.00	0.00
	II	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00	0.00	4.59	0.01	0.00	0.05	0.00	0.00	0.00	0.10	0.05	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.60	0.00	0.13	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.22	0.00	0.00	0.04
JAN	I	0.18	0.29	0.00	0.00	4.91	0.12	0.05	0.05	0.00	0.07	0.09	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.47	0.06	0.00	0.46
	II	0.13	0.00	0.00	0.23	1.45	0.15	0.79	0.03	0.00	0.07	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.60	0.00	0.00	0.00
	III	0.00	0.04	0.00	0.00	0.00	0.07	0.10	0.02	0.00	0.00	0.00	0.76	0.00	2.54	4.08	0.00	0.00	1.42	0.00	0.00	0.12	0.57	0.00	0.00	0.00
FEB	I	0.00	0.18	0.00	0.24	0.03	0.19	0.03	1.22	0.14	0.05	0.00	0.01	0.02	0.61	0.53	0.00	0.00	0.23	0.00	0.08	0.00	0.00	0.02	0.00	0.00
	II	0.00	0.00	0.37	0.72	0.00	0.54	0.01	0.00	0.00	1.28	0.00	0.02	0.32	0.00	0.00	0.00	0.39	0.34	0.00	0.30	0.23	0.00	0.65	0.09	0.04
	III	0.00	0.27	0.03	0.00	0.19	0.00	0.15	0.05	0.00	0.89	0.00	0.05	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.38	2.65	0.00	0.00	0.00	0.05
MAR	I	0.92	0.00	0.34	0.14	0.10	1.80	0.00	1.44	0.00	0.00	0.21	0.00	0.10	0.11	0.00	1.95	0.01	0.00	0.00	0.00	0.00	0.17	0.00	3.00	0.16
	II	0.25	0.00	0.00	0.00	1.54	0.00	0.00	0.24	0.02	0.01	0.07	0.00	1.58	0.00	0.09	1.56	0.01	0.27	0.00	0.21	0.00	0.00	0.02	0.92	0.13
	III	0.04	0.14	0.07	0.08	0.51	0.00	3.00	0.78	0.00	0.00	0.16	0.13	0.60	0.04	0.02	0.02	0.00	2.30	0.98	0.47	0.01	0.66	0.00	0.00	0.41
APR	I	1.18	0.21	0.04	1.36	1.31	0.15	4.39	1.09	0.20	0.00	0.93	1.41	0.28	0.45	0.33	0.12	0.00	0.58	0.27	0.00	1.30	0.37	0.17	0.28	0.12
	II	0.52	0.02	1.65	0.15	0.48	1.48	1.02	0.00	0.09	0.85	4.21	1.43	1.27	0.27	0.40	4.42	1.04	0.04	0.00	0.55	2.83	0.12	2.87	1.96	2.38
	III	1.25	0.85	1.49	1.95	0.28	2.07	2.03	1.27	0.00	0.20	0.68	0.58	0.75	1.35	0.94	0.18	0.19	0.07	0.00	2.90	3.97	2.42	3.66	1.36	3.47
MAY	I	1.48	1.16	0.06	0.81	6.00	0.80	1.38	1.70	1.20	1.38	1.33	0.04	0.04	0.17	0.97	1.47	2.39	0.22	1.58	3.22	1.54	2.27	0.16	1.92	3.02
	II	0.81	0.41	2.15	1.08	12.88	0.00	0.81	1.00	2.01	0.37	1.39	0.56	0.00	1.09	0.01	2.34	1.51	0.01	2.05	0.27	1.59	1.49	1.00	0.68	0.87
	III	1.96	1.52	2.51	3.07	0.95	0.97	0.46	0.48	4.45	1.40	3.37	1.90	0.16	0.24	2.11	5.51	1.18	0.79	3.02	6.50	1.61	0.05	2.59	2.95	0.03
Yearly Rainfall (mm)		1687	1375	1509	1298	1918	1401	1353	1255	1109	1247	1238	1668	974	1725	1457	1512	1983	1793	1550	1303	1757	1203	1576	1588	1474

Table 5.52: 10 Daily Rainfall (in mm) of Kutru-II Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	6.20	2.93	2.84	1.79	0.87	0.29	2.26	0.46	0.59	1.16	8.78	7.55	4.24	0.35	3.85	1.68	5.28	1.84	11.42	2.99	1.76	2.79	1.50	5.23	2.45
	II	10.60	7.54	12.78	11.68	11.65	3.35	9.11	4.77	8.08	17.29	10.11	26.09	4.03	3.72	27.92	2.18	2.45	7.57	5.61	2.46	4.12	6.48	4.54	26.32	6.19
	III	9.07	6.30	3.94	5.03	10.07	8.10	3.17	6.01	6.41	3.68	7.91	5.28	10.74	3.51	2.19	17.75	6.61	36.87	9.87	6.15	4.37	4.56	9.33	13.69	6.99
JUL	I	7.16	11.31	5.11	8.53	25.58	5.24	5.36	5.74	14.76	3.26	9.38	29.98	1.44	11.28	7.69	6.49	35.01	6.25	8.17	12.14	11.53	7.69	10.75	6.45	3.18
	II	12.56	18.32	10.97	19.24	15.42	20.25	15.98	5.06	11.04	9.63	19.82	10.78	11.85	15.94	10.99	5.88	7.41	11.77	4.42	25.73	10.08	5.54	9.54	9.22	16.55
	III	10.09	19.22	28.71	11.81	14.49	23.84	19.12	20.66	7.88	10.61	3.55	7.72	5.64	21.02	15.27	12.84	15.34	5.43	14.69	11.17	20.29	9.48	19.97	15.08	23.23
AUG	I	8.27	11.07	13.04	9.69	10.09	14.34	13.69	5.51	9.04	21.48	8.09	18.70	10.99	17.30	15.42	10.69	35.73	28.61	29.85	5.33	24.56	7.90	26.04	12.19	14.38
	II	17.61	12.97	22.11	6.42	13.25	3.92	18.41	13.32	8.62	5.08	11.09	20.30	10.08	10.54	12.39	13.14	17.09	14.13	11.98	9.08	8.36	10.29	16.82	11.76	8.23
	III	18.79	10.09	9.65	5.53	18.65	14.94	9.64	14.34	4.70	17.69	16.93	5.33	13.54	25.87	8.69	2.34	14.65	8.60	9.24	16.43	12.57	15.42	8.33	3.51	11.00
SEP	I	10.71	4.16	19.96	17.47	21.61	8.10	6.20	6.16	8.77	11.41	4.18	3.64	8.03	11.54	6.21	6.02	5.59	17.82	13.73	3.87	17.76	17.94	14.42	5.41	15.53
	II	8.76	9.85	0.60	4.01	8.14	6.49	5.92	10.73	6.56	7.55	2.78	5.71	3.46	5.56	4.53	32.01	17.83	5.71	14.70	0.62	16.81	14.73	6.33	5.43	10.48
	III	5.76	3.29	1.79	10.43	2.78	4.38	5.98	4.85	3.55	5.75	6.91	4.35	0.31	9.41	3.77	2.01	14.67	12.58	2.35	4.86	1.55	3.65	5.47	7.44	2.07
OCT	I	22.10	5.93	1.99	2.65	3.56	2.36	2.34	0.66	5.93	3.56	1.13	3.88	0.49	16.15	10.06	1.70	0.92	12.29	2.44	3.80	2.32	1.50	2.40	7.33	0.46
	II	5.58	1.68	0.90	6.06	1.40	7.60	0.54	0.68	4.79	1.27	0.21	2.45	6.23	0.22	2.25	5.17	0.24	1.30	0.14	0.05	12.11	0.71	2.59	1.91	8.52
	III	0.96	0.09	0.10	0.82	1.43	3.31	1.11	1.52	0.59	2.26	0.00	0.03	0.22	5.18	0.67	9.02	0.75	0.29	0.21	0.00	3.52	0.35	0.00	11.06	0.65
NOV	I	2.69	2.94	0.26	0.03	0.87	1.91	0.21	0.48	3.26	0.46	0.06	0.09	0.00	0.13	0.68	2.39	4.09	0.05	0.00	0.49	1.76	0.00	6.92	0.00	0.00
	II	0.05	0.31	0.39	0.00	0.04	0.07	0.53	2.31	2.71	0.00	0.00	3.68	0.00	0.00	0.24	0.00	0.07	0.00	0.04	1.15	1.62	0.00	0.00	0.00	0.76
	III	0.00	0.14	1.39	0.00	0.14	0.00	0.05	0.89	0.01	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.01	0.00	0.39	0.00	0.00	0.20	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.01	0.11	2.10	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.23	0.00	0.00	0.00	3.04	0.02	0.00	0.00	0.00
	II	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	4.51	0.03	0.00	0.08	0.00	0.00	0.00	0.29	0.05	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.55	0.00	0.29	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.19	0.00	0.00	0.03
JAN	I	0.42	0.25	0.00	0.00	4.92	0.11	0.06	0.10	0.00	0.17	0.08	1.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.64	0.05	0.00	0.40
	II	0.12	0.00	0.00	0.19	1.28	0.13	0.72	0.07	0.00	0.18	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	1.29	0.00	0.51	0.00	0.00	0.00
	III	0.00	0.04	0.00	0.00	0.00	0.06	0.09	0.01	0.00	0.00	0.00	0.80	0.00	3.47	3.91	0.00	0.00	1.28	0.00	0.00	0.10	0.47	0.00	0.00	0.00
FEB	I	0.00	0.14	0.00	0.22	0.02	0.18	0.07	1.19	0.12	0.04	0.00	0.01	0.01	1.41	0.60	0.00	0.00	0.19	0.00	0.11	0.00	0.00	0.01	0.00	0.00
	II	0.00	0.00	0.31	0.67	0.00	0.45	0.03	0.00	0.00	1.10	0.00	0.05	0.44	0.00	0.00	0.00	0.44	0.38	0.00	0.27	0.19	0.00	0.62	0.08	0.03
	III	0.00	0.30	0.03	0.00	0.16	0.00	0.12	0.04	0.00	0.77	0.00	0.10	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.37	2.30	0.00	0.00	0.00	0.07
MAR	I	0.76	0.00	0.39	0.12	0.09	1.58	0.00	1.20	0.00	0.00	0.19	0.00	0.09	0.09	0.00	1.63	0.01	0.00	0.00	0.00	0.00	0.14	0.00	2.90	0.18
	II	0.21	0.00	0.00	0.00	1.47	0.00	0.00	0.20	0.02	0.00	0.09	0.00	1.46	0.00	0.09	1.53	0.01	0.33	0.00	0.17	0.00	0.00	0.06	0.77	0.11
	III	0.03	0.12	0.06	0.06	0.47	0.00	2.88	0.66	0.00	0.00	0.13	0.14	1.03	0.04	0.02	0.04	0.00	2.71	1.07	0.53	0.01	0.59	0.00	0.00	0.38
APR	I	0.99	0.19	0.04	1.16	1.18	0.14	4.08	1.03	0.17	0.01	0.85	1.39	0.47	0.53	0.32	0.22	0.00	0.60	0.30	0.00	1.16	0.52	0.21	0.24	0.10
	II	0.44	0.02	1.71	0.13	0.45	1.39	1.14	0.00	0.07	1.05	4.37	1.32	1.10	0.22	0.41	4.50	1.07	0.03	0.00	0.54	2.46	0.10	3.04	2.03	2.16
	III	1.07	0.76	1.31	1.73	0.37	2.04	2.08	1.22	0.00	0.17	0.61	0.48	0.75	2.14	1.24	0.21	0.15	0.07	0.00	3.21	4.01	3.15	3.84	1.26	3.41
MAY	I	1.25	1.01	0.05	1.02	5.44	0.79	1.49	1.92	1.22	1.37	1.44	0.04	0.03	0.23	1.16	1.35	2.27	0.30	1.77	2.94	1.60	2.31	0.14	2.05	2.82
	II	0.88	0.34	1.99	1.08	11.88	0.02	0.78	1.24	2.08	0.32	1.31	0.69	0.00	1.08	0.01	2.44	1.29	0.01	2.32	0.28	1.41	2.06	1.01	0.79	0.82
	III	1.81	1.63	2.44	2.92	0.97	0.83	0.43	0.46	4.17	1.32	3.66	2.00	0.15	0.24	2.19	4.78	1.26	1.03	3.36	6.24	1.73	0.07	2.54	2.48	0.02
Yearly Rainfall (mm)		1684	1360	1490	1326	1923	1405	1370	1207	1169	1320	1262	1654	991	1778	1459	1509	1939	1800	1505	1257	1771	1235	1596	1580	1447

5.5.2.3 Rainfall and Runoff Data at Chindnar G&D Site

Detailed calculations on water availability and flood magnitude will help to select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the monthly runoff and monthly rainfall for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Chindnar G&D site is shown in **Figure 5.33**. The basic comparison between rainfall and runoff in **Figure 5.33** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.34** shows plot of runoff coefficient at G&D site.

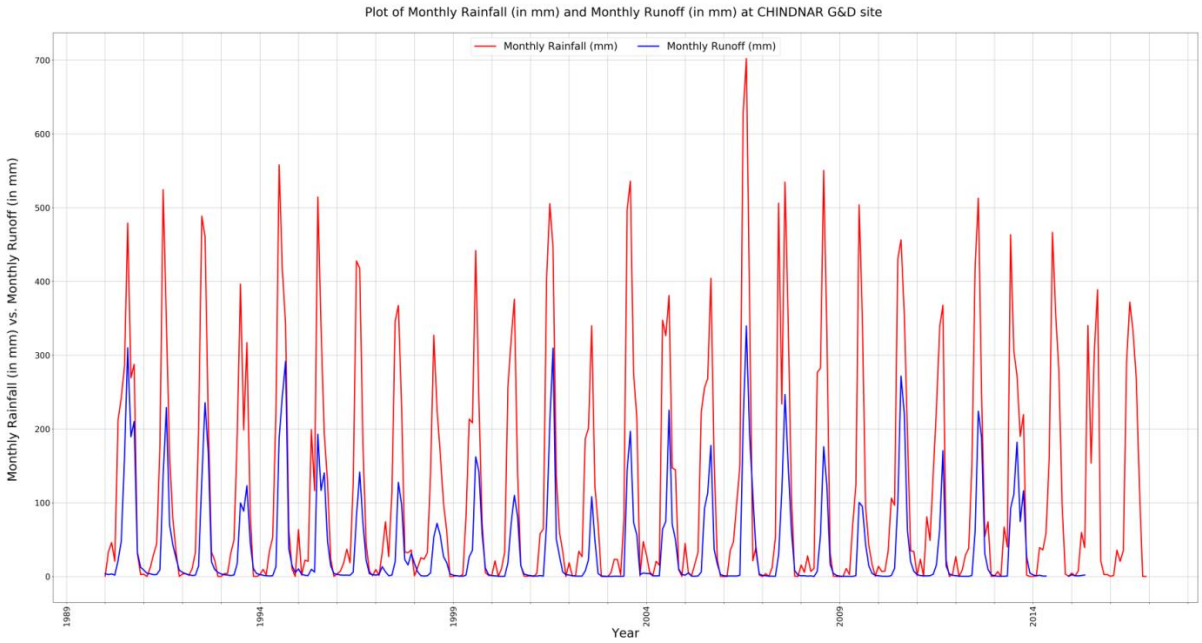


Figure 5.33: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Chindnar G&D site

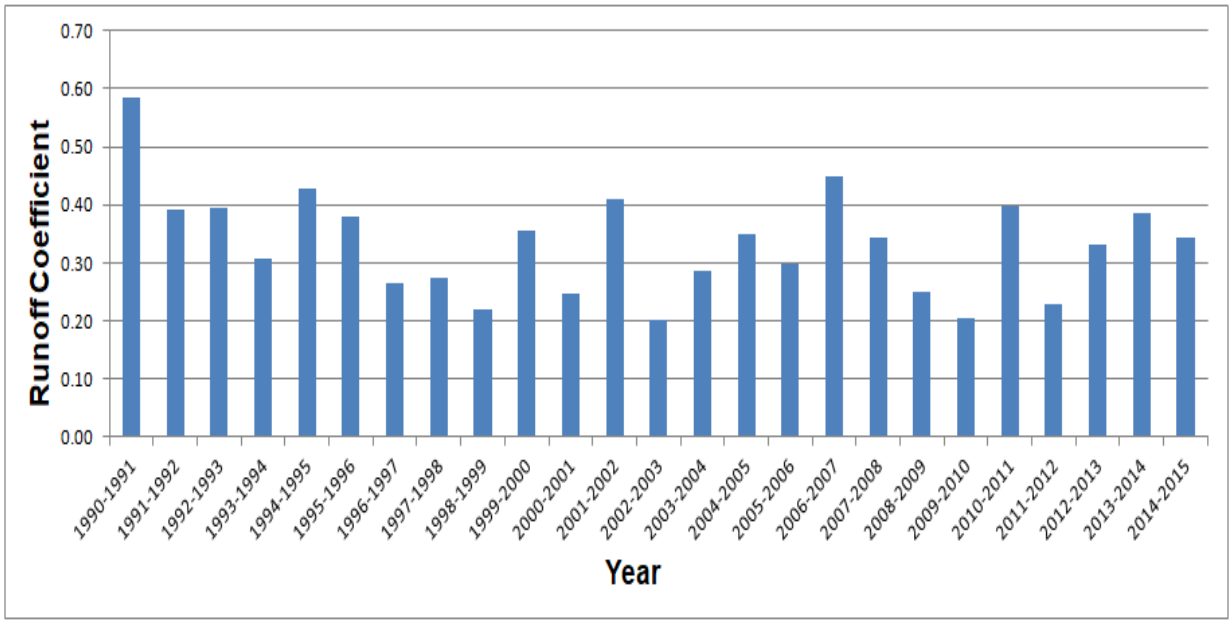


Figure 5.34: Plot of Runoff Coefficient at G&D site

5.5.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Chindnar is around 17,270 km^2 as mentioned on India WRIS site. Daily discharge data for Chindnar site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Chindnar, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Chindnar G&D and the Kutru-II dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Chindnar G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Kutru-II}}{CA_{Chindnar}} = \frac{21189}{17270} = 1.23$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Kutru-I}}{\text{Average Annual Rainfall}_{Chindnar}} = \frac{1481}{1478} = 1.002$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Kutru-II}} = Q_{\text{Chindnar G\&}D\ Site} \text{X } 1.23 \text{ X } 1.002$$

Table 5.53 shows 10-daily average flow series for G&D site. **Table 5.54** and **Table 5.55** show 10-daily average flow series (m^3/s) and 10-daily inflow series (MCM) respectively for Kutru-II Dam.

Table 5.53: 10-Daily Average Flow Series (m^3/s) at Chindnar

Catchment Area =17,270 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	200.37	24.19	15.30	24.19	9.27	10.96	1.58	0.89	2.31	14.32	31.24	21.37	1.64	0.30	6.09	2.17	12.22	1.00	3.15	22.66	4.99	17.86	1.14	5.92	18.13
	II	370.10	54.47	86.48	162.60	83.11	11.43	96.74	7.42	16.96	284.74	90.43	1313.81	2.34	1.55	1270.28	2.37	7.43	9.42	102.72	3.77	58.64	20.14	8.36	1023.30	212.03
	III	383.67	103.25	182.66	170.62	170.79	98.55	23.76	30.76	80.48	239.33	248.84	97.67	147.91	9.48	10.42	116.29	16.70	564.44	34.76	19.83	155.36	23.56	20.70	816.72	156.94
JUL	I	406.29	147.02	108.96	202.92	632.03	112.62	65.84	53.52	191.88	61.66	244.70	1666.49	7.87	191.03	31.86	460.44	3274.86	1031.54	68.83	91.33	201.94	77.78	144.50	328.62	408.52
	II	989.10	981.60	245.51	1097.78	2065.12	421.20	245.61	15.04	540.96	175.41	683.54	1407.96	317.92	606.83	339.23	523.66	198.00	878.74	64.85	526.61	357.17	119.22	108.12	674.80	566.00
	III	1660.33	1465.50	2071.02	630.99	958.53	3020.33	1201.09	298.78	308.41	432.52	462.99	983.31	114.47	1897.71	1017.84	782.77	585.93	345.70	908.37	1263.23	1300.85	110.94	881.16	1107.66	992.10
AUG	I	642.57	1635.27	1167.43	887.16	960.81	896.76	787.01	729.79	347.78	1487.64	166.00	1574.68	293.10	1202.87	1187.15	1091.14	2969.87	2576.27	1218.96	247.05	3727.52	252.29	1721.21	1719.81	1228.76
	II	1973.50	1663.73	1933.71	333.23	1308.66	727.31	949.32	390.64	588.43	532.33	780.06	1829.67	516.23	926.39	1469.88	570.36	2237.89	1374.88	1532.54	340.29	730.28	216.18	1289.32	1184.39	1058.30
	III	3257.01	1163.00	1461.39	500.58	2390.64	644.04	994.90	1299.68	459.43	1111.25	1139.33	2530.97	1229.71	1641.44	1680.53	543.26	1438.02	890.43	696.18	1193.93	883.34	751.07	1336.16	669.07	1246.06
SEP	I	1963.63	550.45	2231.34	911.31	4091.60	1857.71	619.20	607.65	401.58	1262.65	954.04	391.30	526.18	868.84	566.31	273.14	1454.38	1439.59	985.12	668.11	2192.68	1645.21	1561.76	345.04	1182.03
	II	1292.45	527.98	897.40	516.57	1131.10	603.32	496.05	820.05	396.14	943.20	311.49	409.15	389.12	251.86	465.22	2429.57	1132.87	661.49	953.70	126.01	1645.85	1054.79	1203.33	519.87	799.11
	III	529.62	327.86	245.97	1034.66	606.87	345.46	348.43	527.63	317.07	639.08	361.60	225.69	63.74	346.54	378.61	849.22	1265.61	882.62	497.12	82.13	595.28	710.09	998.36	625.43	533.53
OCT	I	2584.66	299.19	176.46	289.24	330.02	224.42	264.08	207.50	197.66	533.15	152.66	241.37	28.25	671.69	591.00	189.31	1858.79	815.16	170.22	196.90	228.02	133.44	397.50	967.57	489.51
	II	1184.23	384.71	130.72	351.26	198.21	319.51	82.12	92.94	199.18	361.32	92.74	210.81	30.51	182.29	250.52	167.34	222.42	259.66	103.48	64.48	666.69	106.17	132.13	662.91	269.01
	III	390.38	160.00	82.53	268.02	204.80	376.97	86.30	142.67	130.25	232.85	41.82	96.03	20.42	248.80	144.09	342.45	123.34	135.89	52.91	28.10	316.79	41.43	88.22	630.49	182.73
NOV	I	323.71	287.26	71.84	105.71	134.96	123.42	40.88	95.96	107.81	136.47	28.21	47.58	7.28	46.03	75.05	214.61	447.74	80.64	33.98	17.47	151.25	29.87	85.63	280.21	123.90
	II	199.97	121.63	60.94	67.57	96.48	106.67	24.83	82.69	183.43	62.00	21.95	39.70	4.72	5.92	93.53	77.39	176.17	51.54	28.49	32.36	161.93	23.74	70.22	141.65	80.65
	III	130.16	91.56	58.99	45.65	66.91	63.77	12.55	135.73	87.10	32.47	16.29	36.93	2.73	0.47	38.07	43.13	65.56	31.13	21.83	36.79	79.19	17.24	34.75	93.42	51.77
DEC	I	95.47	66.76	44.94	31.32	45.24	31.71	19.64	197.38	32.57	20.62	12.80	19.87	5.46	35.47	26.70	24.80	27.97	17.23	17.21	14.20	45.97	11.77	22.18	43.98	37.97
	II	79.18	52.89	35.74	25.28	32.95	26.06	16.16	215.05	22.75	14.67	15.24	15.26	2.96	68.77	16.27	14.32	19.78	13.59	9.60	10.28	63.08	11.09	15.62	27.54	34.34
	III	69.96	47.63	29.04	22.11	28.43	22.06	13.21	192.57	17.61	12.21	12.48	13.65	1.42	55.57	13.07	13.24	16.17	9.62	5.00	6.50	26.38	9.51	9.76	20.10	17.77
JAN	I	64.89	42.36	25.71	20.09	37.02	20.20	11.75	164.44	14.25	10.35	9.42	14.56	1.10	33.47	11.03	9.51	12.73	7.49	4.10	6.13	19.64	8.51	8.80	17.37	18.99
	II	55.18	35.91	22.97	17.27	122.78	19.93	13.16	102.85	12.48	8.63	8.42	15.42	0.62	21.98	8.97	6.71	10.75	6.10	3.70	9.28	17.16	9.84	8.97	15.03	15.85
	III	47.97	31.92	18.80	15.94	42.55	16.63	13.85	82.32	10.51	6.92	7.37	10.68	0.55	24.71	15.18	6.51	8.33	6.13	3.03	6.52	13.27	7.14	4.77	11.87	11.97
FEB	I	36.27	26.66	18.20	12.71	25.29	15.19	9.01	83.99	8.88	5.31	6.50	9.77	0.41	53.12	75.21	5.27	6.40	7.32	2.37	3.94	10.44	4.23	3.29	7.53	10.37
	II	30.36	24.89	17.95	13.62	19.57	14.80	7.04	30.24	8.03	6.24	5.80	8.28	0.73	17.98	16.10	4.35	9.77	9.95	2.18	2.85	7.79	3.04	2.72	6.98	8.97
	III	26.13	21.65	15.22	11.92	16.16	13.28	46.14	12.18	6.19	8.67	4.77	7.31	0.55	11.93	6.47	3.78	9.14	6.53	1.65	2.34	11.33	2.70	2.41	7.00	6.69
MAR	I	23.39	19.68	14.80	8.67	13.28	12.46	85.15	9.19	4.98	5.98	4.22	6.07	2.58	8.18	3.73	3.11	6.20	2.84	1.85	1.69	10.23	2.48	1.67	8.17	6.38
	II	29.31	15.46	13.96	7.04	10.87	12.52	84.28	7.87	4.27	2.40	3.77	3.19	2.51	4.64	3.18	6.19	2.43	2.72	1.00	1.56	5.69	1.95	2.90	20.64	5.77
	III	18.94	12.96	10.44	5.63	10.13	10.81	89.92	6.37	3.41	1.41	3.03	1.83	3.12	4.14	2.54	6.04	2.81	4.64	1.28	1.60	4.60	1.66	1.45	7.46	5.12
APR	I	16.90	11.90	10.20	5.15	11.04	10.30	85.11	5.45	2.82	0.82	2.39	1.87	3.32	7.76	1.44	2.83	1.47	11.20	1.07	1.04	4.58	1.31	0.94	4.30	7.40
	II	19.17	9.00	9.13	5.81	10.64	12.10	29.45	5.56	2.40	0.68	7.87	4.82	2.79	5.88	2.97	4.65	2.85	5.32	1.00	1.01	4.92	1.71	0.99	3.92	9.85
	III	13.32	8.69	10.51	4.37	5.76	16.18	12.81	2.80	2.45	0.89	17.17	4.63	2.85	5.41	3.63	8.01	5.08	2.03	0.52	1.40	9.54	1.63	5.91	4.84	13.05
MAY	I	13.20	13.00	13.41	7.33	26.49	13.48	13.92	8.47	2.03	0.74	4.30	3.55	2.01	8.33	7.18	4.58	2.74	0.49	0.18	7.13	9.94	1.62	7.81	2.93	15.85
	II	13.44	12.43	9.48	4.21	134.35	10.56	6.82	8.86	6.35	0.70	3.35	3.52	0.68	3.23	5.58	4.11	2.50	0.29	0.09	4.00	7.40	1.52	2.87	5.42	16.36
	III	24.58	10.75	16.97	11.16	32.62	9.72	3.70	3.49	30.03	2.40	3.91	5.11	0.74	9.07	2.20	4.96	1.24	0.06	1.79	15.74	6.59	1.55	2.87	4.54	8.62
Inflow (MCM) =		*17022*	*9278*	*10309*	*6888*	*14194*	*9210*	*6162*	*5943*	*4185*	*7629*	*5294*	*11782*	*3348*	*8524*	*8747*	*7759*	*15424*	*10611*	*6654*	*4570*	*12087*	*4775*	*9003*	*10593*	*8723*

Table 5.54: 10-Daily Average Flow Series (m^3/s) at Kutru-II Dam

Catchment Area =21,189 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	246.41	29.75	18.82	29.75	11.40	13.48	1.94	1.09	2.84	17.61	38.42	26.28	2.02	0.37	7.49	2.67	15.03	1.23	3.87	27.87	6.14	21.96	1.40	7.28	22.30
	II	455.15	66.99	106.35	199.97	102.21	14.06	118.97	9.13	20.86	350.17	111.21	1615.72	2.88	1.91	1562.19	2.91	9.14	11.58	126.32	4.64	72.12	24.77	10.28	1258.45	260.75
	III	471.84	126.98	224.63	209.83	210.04	121.20	29.22	37.83	98.97	294.33	306.02	120.11	181.90	11.66	12.81	143.01	20.54	694.15	42.75	24.39	191.06	28.97	25.46	1004.40	193.00
JUL	I	499.65	180.80	134.00	249.55	777.27	138.50	80.97	65.82	235.97	75.83	300.93	2049.45	9.68	234.93	39.18	566.25	4027.42	1268.59	84.65	112.32	248.35	95.65	177.71	404.14	502.40
	II	1216.39	1207.17	301.93	1350.05	2539.68	517.99	302.05	18.50	665.27	215.72	840.62	1731.51	390.98	746.28	417.18	644.00	243.50	1080.67	79.75	647.62	439.25	146.62	132.97	829.87	696.06
	III	2041.87	1802.27	2546.94	775.99	1178.80	3714.40	1477.10	367.44	379.28	531.91	569.38	1209.27	140.77	2333.80	1251.74	962.65	720.58	425.14	1117.11	1553.52	1599.78	136.43	1083.65	1362.20	1220.08
AUG	I	790.23	2011.05	1435.70	1091.03	1181.60	1102.83	967.86	897.49	427.70	1829.50	204.15	1936.54	360.45	1479.29	1459.95	1341.88	3652.34	3168.29	1499.07	303.82	4584.10	310.27	2116.74	2115.02	1511.12
	II	2427.01	2046.05	2378.07	409.81	1609.39	894.44	1167.47	480.41	723.65	654.66	959.32	2250.12	634.86	1139.27	1807.66	701.43	2752.15	1690.82	1884.71	418.49	898.10	265.86	1585.60	1456.56	1301.50
	III	4005.46	1430.25	1797.21	615.61	2940.00	792.04	1223.53	1598.34	565.01	1366.61	1401.15	3112.58	1512.29	2018.64	2066.71	668.10	1768.47	1095.05	856.16	1468.29	1086.33	923.66	1643.21	822.82	1532.40
SEP	I	2414.87	676.94	2744.10	1120.73	5031.84	2284.61	761.49	747.29	493.86	1552.80	1173.28	481.22	647.10	1068.50	696.45	335.91	1788.59	1770.40	1211.50	821.64	2696.55	2023.28	1920.65	424.33	1453.66
	II	1589.45	649.31	1103.62	635.28	1391.02	741.96	610.04	1008.50	487.17	1159.95	383.07	503.17	478.54	309.74	572.13	2987.88	1393.20	813.50	1172.86	154.97	2024.06	1297.18	1479.85	639.34	982.74
	III	651.33	403.20	302.49	1272.42	746.33	424.85	428.50	648.88	389.93	785.94	444.69	277.55	78.39	426.17	465.61	1044.37	1556.44	1085.44	611.36	101.00	732.07	873.27	1227.78	769.15	656.13
OCT	I	3178.61	367.94	217.01	355.71	405.86	275.99	324.77	255.18	243.08	655.67	187.74	296.84	34.74	826.04	726.81	232.81	2285.94	1002.48	209.34	242.15	280.42	164.10	488.84	1189.92	602.00
	II	1456.36	473.12	160.76	431.98	243.76	392.93	100.99	114.30	244.95	444.35	114.05	259.25	37.52	224.18	308.09	205.79	273.53	319.33	127.26	79.30	819.89	130.57	162.49	815.25	330.83
	III	480.09	196.77	101.50	329.61	251.86	463.60	106.13	175.46	160.18	286.36	51.43	118.10	25.11	305.97	177.20	421.14	151.68	167.12	65.07	34.56	389.59	50.95	108.49	775.38	224.72
NOV	I	398.10	353.27	88.35	130.00	165.97	151.78	50.27	118.01	132.58	167.83	34.69	58.51	8.95	56.61	92.30	263.93	550.63	99.17	41.79	21.48	186.01	36.73	105.31	344.60	152.37
	II	245.92	149.58	74.94	83.10	118.65	131.18	30.54	101.69	225.58	76.25	26.99	48.82	5.80	7.28	115.02	95.17	216.65	63.38	35.04	39.80	199.14	29.20	86.36	174.20	99.18
	III	160.07	112.60	72.55	56.14	82.29	78.42	15.43	166.92	107.12	39.93	20.03	45.42	3.36	0.58	46.82	53.04	80.63	38.28	26.85	45.24	97.39	21.20	42.74	114.89	63.66
DEC	I	117.41	82.10	55.27	38.52	55.64	39.00	24.15	242.74	40.05	25.36	15.74	24.44	6.71	43.62	32.84	30.50	34.40	21.19	21.16	17.46	56.53	14.47	27.28	54.09	46.69
	II	97.38	65.04	43.95	31.09	40.52	32.05	19.87	264.47	27.98	18.04	18.74	18.77	3.64	84.57	20.01	17.61	24.33	16.71	11.81	12.64	77.58	13.64	19.21	33.87	42.23
	III	86.04	58.58	35.71	27.19	34.96	27.13	16.25	236.82	21.66	15.02	15.35	16.79	1.75	68.34	16.07	16.28	19.89	11.83	6.15	7.99	32.44	11.70	12.00	24.72	21.85
JAN	I	79.80	52.09	31.62	24.71	45.53	24.84	14.45	202.23	17.52	12.73	11.58	17.91	1.35	41.16	13.56	11.70	15.66	9.21	5.04	7.54	24.15	10.47	10.82	21.36	23.35
	II	67.86	44.16	28.25	21.24	150.99	24.51	16.18	126.48	15.35	10.61	10.35	18.96	0.76	27.03	11.03	8.25	13.22	7.50	4.55	11.41	21.10	12.10	11.03	18.48	19.49
	III	58.99	39.26	23.12	19.60	52.33	20.45	17.03	101.24	12.93	8.51	9.06	13.13	0.68	30.39	18.67	8.01	10.24	7.54	3.73	8.02	16.32	8.78	5.87	14.60	14.72
FEB	I	44.60	32.79	22.38	15.63	31.10	18.68	11.08	103.29	10.92	6.53	7.99	12.02	0.50	65.33	92.49	6.48	7.87	9.00	2.91	4.85	12.84	5.20	4.05	9.26	12.75
	II	37.34	30.61	22.07	16.75	24.07	18.20	8.66	37.19	9.88	7.67	7.13	10.18	0.90	22.11	19.80	5.35	12.02	12.24	2.68	3.50	9.58	3.74	3.35	8.58	11.03
	III	32.13	26.63	18.72	14.66	19.87	16.33	56.74	14.98	7.61	10.66	5.87	8.99	0.68	14.67	7.96	4.65	11.24	8.03	2.03	2.88	13.93	3.32	2.96	8.61	8.23
MAR	I	28.76	24.20	18.20	10.66	16.33	15.32	104.72	11.30	6.12	7.35	5.19	7.46	3.17	10.06	4.59	3.82	7.62	3.49	2.28	2.08	12.58	3.05	2.05	10.05	7.85
	II	36.05	19.01	17.17	8.66	13.37	15.40	103.65	9.68	5.25	2.95	4.64	3.92	3.09	5.71	3.91	7.61	2.99	3.35	1.23	1.92	7.00	2.40	3.57	25.38	7.10
	III	23.29	15.94	12.84	6.92	12.46	13.29	110.58	7.83	4.19	1.73	3.73	2.25	3.84	5.09	3.12	7.43	3.46	5.71	1.57	1.97	5.66	2.04	1.78	9.17	6.30
APR	I	20.78	14.63	12.54	6.33	13.58	12.67	104.67	6.70	3.47	1.01	2.94	2.30	4.08	9.54	1.77	3.48	1.81	13.77	1.32	1.28	5.63	1.61	1.16	5.29	9.10
	II	23.58	11.07	11.23	7.15	13.09	14.88	36.22	6.84	2.95	0.84	9.68	5.93	3.43	7.23	3.65	5.72	3.50	6.54	1.23	1.24	6.05	2.10	1.22	4.82	12.11
	III	16.38	10.69	12.93	5.37	7.08	19.90	15.75	3.44	3.01	1.09	21.12	5.69	3.50	6.65	4.46	9.85	6.25	2.50	0.64	1.72	11.73	2.00	7.27	5.95	16.05
MAY	I	16.23	15.99	16.49	9.01	32.58	16.58	17.12	10.42	2.50	0.91	5.29	4.37	2.47	10.24	8.83	5.63	3.37	0.60	0.22	8.77	12.22	1.99	9.60	3.60	19.49
	II	16.53	15.29	11.66	5.18	165.22	12.99	8.39	10.90	7.81	0.86	4.12	4.33	0.84	3.97	6.86	5.05	3.07	0.36	0.11	4.92	9.10	1.87	3.53	6.67	20.12
	III	30.23	13.22	20.87	13.72	40.12	11.95	4.55	4.29	36.93	2.95	4.81	6.28	0.91	11.15	2.71	6.10	1.52	0.07	2.20	19.36	8.10	1.91	3.53	5.58	10.60
Inflow (MCM) =		20933	11410	12678	8471	17456	11327	7579	7309	5147	9383	6510	14489	4118	10482	10757	9542	18968	13050	8183	5641	14864	5872	11072	13027	10727

Table 5.55: 10- Daily Inflow Series (MCM) at Kutru-II Project Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	212.90	25.70	16.26	25.70	9.85	11.65	1.68	0.95	2.45	15.22	33.19	22.71	1.74	0.32	6.47	2.31	12.98	1.06	3.35	24.08	5.30	18.98	1.21	6.29	19.26
	II	393.25	57.88	91.89	172.77	88.31	12.14	102.79	7.88	18.02	302.55	96.09	1395.98	2.49	1.65	1349.73	2.52	7.89	10.01	109.14	4.01	62.31	21.40	8.88	1087.30	225.29
	III	407.67	109.71	194.08	181.29	181.47	104.71	25.25	32.68	85.51	254.30	264.40	103.78	157.16	10.07	11.07	123.56	17.74	599.74	36.93	21.07	165.08	25.03	21.99	867.80	166.76
JUL	I	431.70	156.22	115.77	215.61	671.56	119.66	69.96	56.87	203.88	65.52	260.00	1770.72	8.36	202.98	33.85	489.24	3479.69	1096.06	73.13	97.04	214.57	82.64	153.54	349.17	434.07
	II	1050.96	1042.99	260.87	1166.44	2194.28	447.54	260.97	15.98	574.79	186.38	726.29	1496.02	337.80	644.78	360.45	556.41	210.38	933.70	68.91	559.55	379.51	126.68	114.88	717.01	601.40
	III	1940.59	1712.88	2420.61	737.50	1120.33	3530.16	1403.83	349.21	360.47	505.53	541.14	1149.29	133.79	2218.04	1189.65	914.90	684.83	404.05	1061.70	1476.46	1520.43	129.67	1029.90	1294.63	1159.57
AUG	I	682.76	1737.55	1240.45	942.65	1020.90	952.85	836.23	775.43	369.53	1580.68	176.38	1673.17	311.43	1278.10	1261.40	1159.39	3155.62	2737.40	1295.20	262.50	3960.66	268.07	1828.86	1827.38	1305.61
	II	2096.93	1767.79	2054.65	354.07	1390.51	772.80	1008.70	415.07	625.23	565.62	828.85	1944.11	548.52	984.33	1561.81	606.03	2377.86	1460.87	1628.39	361.57	775.96	229.70	1369.96	1258.47	1124.49
	III	3806.79	1359.31	1708.07	585.08	2794.18	752.75	1162.84	1519.07	536.98	1298.83	1331.65	2958.20	1437.28	1918.51	1964.20	634.96	1680.76	1040.73	813.70	1395.47	1032.45	877.85	1561.70	782.01	1456.39
SEP	I	2086.45	584.88	2370.90	968.31	4347.51	1973.90	657.93	645.66	426.70	1341.62	1013.71	415.77	559.09	923.18	601.73	290.22	1545.34	1529.63	1046.73	709.90	2329.82	1748.11	1659.44	366.62	1255.96
	II	1373.29	561.00	953.53	548.88	1201.85	641.05	527.08	871.34	420.92	1002.19	330.97	434.74	413.46	267.61	494.32	2581.53	1203.73	702.86	1013.35	133.89	1748.79	1120.76	1278.59	552.39	849.09
	III	562.75	348.37	261.35	1099.37	644.83	367.07	370.22	560.63	336.90	679.05	384.22	239.81	67.73	368.21	402.29	902.33	1344.77	937.82	528.21	87.27	632.51	754.50	1060.80	664.55	566.90
OCT	I	2746.32	317.90	187.50	307.33	350.66	238.46	280.60	220.48	210.02	566.50	162.21	266.47	30.02	713.70	627.96	201.15	1975.05	866.14	180.87	209.22	242.28	141.79	422.36	1028.09	520.13
	II	1258.30	408.77	138.90	373.23	210.61	339.49	87.26	98.75	211.64	383.92	98.54	224.00	32.42	193.69	266.19	177.81	236.33	275.90	109.95	68.51	708.39	112.81	140.39	704.37	285.84
	III	456.28	187.01	96.46	313.26	239.37	440.60	100.87	166.75	152.24	272.16	48.88	112.24	23.87	290.80	168.41	400.26	144.16	158.83	61.84	32.84	370.26	48.42	103.11	736.92	213.58
NOV	I	343.96	305.23	76.33	112.32	143.40	131.14	43.44	101.96	114.55	145.01	29.97	50.56	7.74	48.91	79.74	228.03	475.74	85.68	36.11	18.56	160.71	31.74	90.99	297.74	131.65
	II	212.48	129.24	64.75	71.80	102.51	113.34	26.38	87.86	194.90	65.88	23.32	42.18	5.02	6.29	99.38	82.23	187.19	54.76	30.27	34.38	172.06	25.22	74.61	150.51	85.69
	III	138.30	97.29	62.68	48.51	71.09	67.76	13.33	144.22	92.55	34.50	17.31	39.24	2.90	0.50	40.45	45.83	69.66	33.08	23.20	39.09	84.14	18.32	36.92	99.26	55.01
DEC	I	101.44	70.94	47.75	33.28	48.07	33.69	20.87	209.73	34.61	21.91	13.60	21.11	5.80	37.69	28.37	26.35	29.72	18.31	18.29	15.09	48.85	12.51	23.57	46.73	40.34
	II	84.13	56.20	37.98	26.86	35.01	27.69	17.17	228.50	24.17	15.59	16.19	16.21	3.15	73.07	17.29	15.22	21.02	14.44	10.20	10.92	67.03	11.78	16.60	29.26	36.49
	III	81.77	55.67	33.94	25.84	33.23	25.78	15.44	225.08	20.58	14.27	14.59	15.95	1.66	64.95	15.28	15.47	18.90	11.24	5.84	7.60	30.83	11.12	11.41	23.49	20.77
JAN	I	68.95	45.01	27.32	21.35	39.34	21.46	12.48	174.72	15.14	11.00	10.01	15.47	1.17	35.56	11.72	10.10	13.53	7.96	4.36	6.51	20.87	9.04	9.35	18.46	20.18
	II	58.63	38.16	24.41	18.35	130.46	21.18	13.98	109.28	13.26	9.17	8.95	16.38	0.66	23.35	9.53	7.13	11.42	6.48	3.93	9.86	18.23	10.46	9.53	15.97	16.84
	III	56.07	37.31	21.97	18.63	49.73	19.44	16.19	96.22	12.28	8.09	8.61	12.48	0.64	28.88	17.74	7.61	9.74	7.16	3.54	7.62	15.51	8.35	5.58	13.87	13.99
FEB	I	38.54	28.33	19.34	13.50	26.87	16.14	9.57	89.24	9.44	5.64	6.91	10.38	0.44	56.44	79.91	5.60	6.80	7.78	2.52	4.19	11.09	4.49	3.50	8.00	11.02
	II	32.26	26.45	19.07	14.47	20.79	15.73	7.48	32.13	8.53	6.63	6.16	8.80	0.78	19.10	17.11	4.62	10.38	10.57	2.32	3.03	8.28	3.23	2.89	7.42	9.53
	III	22.21	18.40	12.94	10.13	13.74	11.29	39.22	10.35	5.26	7.37	4.05	6.21	0.47	10.14	5.50	3.21	7.77	5.55	1.40	1.99	9.63	2.30	2.05	5.95	5.69
MAR	I	24.85	20.91	15.73	9.21	14.11	13.24	90.48	9.76	5.29	6.35	4.48	6.45	2.74	8.69	3.96	3.30	6.59	3.02	1.97	1.80	10.87	2.64	1.77	8.68	6.78
	II	31.14	16.43	14.83	7.48	11.55	13.30	89.55	8.36	4.54	2.55	4.01	3.39	2.67	4.93	3.38	6.58	2.58	2.89	1.06	1.66	6.05	2.07	3.08	21.93	6.13
	III	22.14	15.15	12.20	6.58	11.84	12.63	105.10	7.45	3.99	1.65	3.54	2.14	3.65	4.84	2.97	7.06	3.28	5.42	1.50	1.87	5.38	1.94	1.69	8.72	5.98
APR	I	17.96	12.64	10.84	5.47	11.73	10.94	90.43	5.79	3.00	0.87	2.54	1.99	3.53	8.25	1.53	3.01	1.56	11.90	1.14	1.11	4.87	1.39	1.00	4.57	7.86
	II	20.37	9.56	9.70	6.17	11.31	12.86	31.29	5.91	2.55	0.72	8.36	5.12	2.96	6.25	3.16	4.94	3.03	5.65	1.06	1.07	5.23	1.82	1.05	4.17	10.47
	III	14.15	9.23	11.17	4.64	6.12	17.19	13.61	2.98	2.60	0.95	18.24	4.92	3.03	5.75	3.86	8.51	5.40	2.16	0.55	1.49	10.14	1.73	6.28	5.14	13.87
MAY	I	14.03	13.81	14.25	7.79	28.15	14.32	14.79	9.00	2.16	0.79	4.57	3.77	2.14	8.85	7.63	4.87	2.91	0.52	0.19	7.58	10.56	1.72	8.30	3.11	16.84
	II	14.28	13.21	10.07	4.47	142.75	11.22	7.25	9.41	6.75	0.74	3.56	3.74	0.72	3.43	5.93	4.37	2.66	0.31	0.10	4.25	7.86	1.62	3.05	5.76	17.38
	III	28.73	12.56	19.83	13.04	38.13	11.36	4.32	4.08	35.10	2.81	4.57	5.97	0.86	10.60	2.57	5.80	1.45	0.07	2.09	18.40	7.70	1.81	3.35	5.31	10.08
Inflow (MCM) =		20933	11410	12678	8471	17456	11327	7579	7309	5147	9383	6510	14489	4118	10482	10757	9542	18968	13050	8183	5641	14864	5872	11072	13027	10727

5.5.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.56** and **Table 5.57**

Table 5.56: Computation of 90% and 50% Dependable Year for Kutru-II Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.04	20933	1990-1991	
2	0.08	18968	2006-2007	
3	0.12	17456	1994-1995	
4	0.15	14864	2010-2011	
5	0.19	14489	2001-2002	
6	0.23	13050	2007-2008	
7	0.27	13027	2013-2014	
8	0.31	12678	1992-1993	
9	0.35	11410	1991-1992	
10	0.38	11327	1995-1996	
11	0.42	11072	2012-2013	
12	0.46	10757	2004-2005	
13	**0.50**	**10727**	**2014-2015**	**50% Dependable**
14	0.54	10482	2003-2004	
15	0.58	9542	2005-2006	
16	0.62	9383	1999-2000	
17	0.65	8471	1993-1994	
18	0.69	8183	2008-2009	
19	0.73	7579	1996-1997	
20	0.77	7309	1997-1998	
21	0.81	6510	2000-2001	
22	0.85	5872	2011-2012	
23	**0.88**	**5641**	**2009-2010**	**90% Dependable**
24	0.92	5147	1998-1999	
25	0.96	4118	2002-2003	

Table 5.57: 90% and 50% dependable flows for the dam site (cumec)

		90% Dependable	50% Dependable
Period		**2009-2010**	**2014-2015**
Jun	**I**	27.87	22.30
	II	4.64	260.75
	III	24.39	193.00
Jul	**I**	112.32	502.40
	II	647.62	696.06
	III	1553.52	1220.08
Aug	**I**	303.82	1511.12
	II	418.49	1301.50
	III	1468.29	1532.40
Sep	**I**	821.64	1453.66
	II	154.97	982.74
	III	101.00	656.13
Oct	**I**	242.15	602.00
	II	79.30	330.83
	III	34.56	224.72
Nov	**I**	21.48	152.37
	II	39.80	99.18
	III	45.24	63.66
Dec	**I**	17.46	46.69
	II	12.64	42.23
	III	7.99	21.85
Jan	**I**	7.54	23.35
	II	11.41	19.49
	III	8.02	14.72
Feb	**I**	4.85	12.75
	II	3.50	11.03
	III	2.88	8.23
Mar	**I**	2.08	7.85
	II	1.92	7.10
	III	1.97	6.30
Apr	**I**	1.28	9.10
	II	1.24	12.11
	III	1.72	16.05
May	**I**	8.77	19.49
	II	4.92	20.12
	III	19.36	10.60
Inflow (MCM) =		**5641**	**10727**

5.5.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Kutru-II, is given in the following section.

5.5.5.1 EAC of Kutru-II Dam

The EAC curve and the table showing the different values are given in **Figure 5.35** and **Table 5.58** respectively.

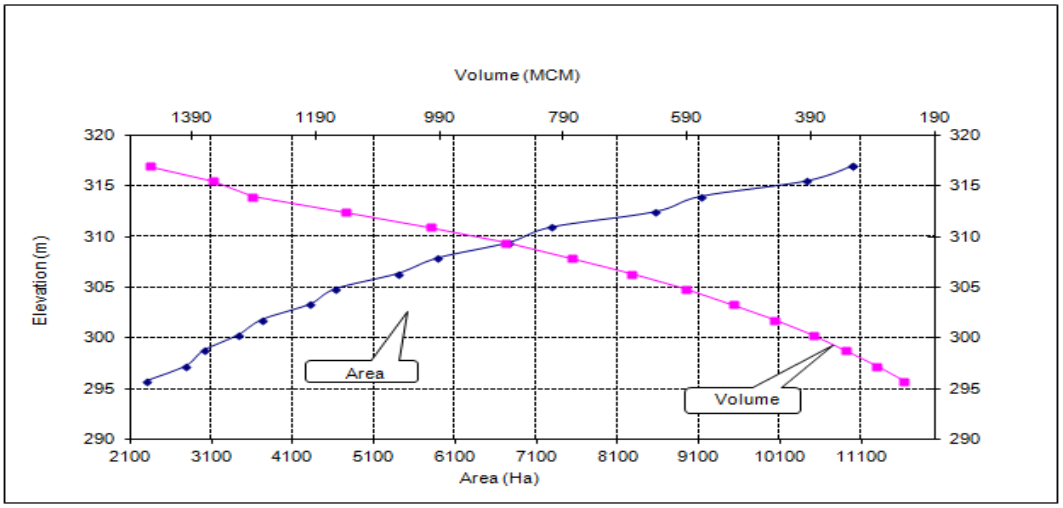


Figure 5.35: EAC curve of Kutru-II Dam

Table 5.58: EAC data of Kutru-II Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
295.70	22957982.03	2295.80	199647363.30	199.65
297.22	27877415.41	2787.74	238774263.10	238.77
298.74	30090549.85	3009.05	282785326.10	282.79
300.26	34305462.51	3430.55	332103138.50	332.10
301.78	37243783.61	3724.38	386538951.50	386.54
303.30	43113850.29	4311.39	447954510.60	447.95
304.82	46294526.53	4629.45	516096582.90	516.10
306.34	53969105.63	5396.91	592491418.00	592.49
307.86	58836874.16	5883.69	678710075.30	678.71
309.38	67552265.21	6755.23	775642835.50	775.64
310.90	72795778.12	7279.58	883040666.10	883.04
312.42	85592692.58	8559.27	1005236269.00	1005.24
313.94	91191283.94	9119.13	1140598911.00	1140.60
315.46	104203312.05	10420.33	1291856031.00	1291.86
316.98	109925899.06	10992.59	1355855298.00	1355.86
317.00	109925899.06	10992.59	1458052609.00	1458.05

5.5.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.5.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Chindnar G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Chindnar G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{\text{Kutru-II}}}{A_{\text{Chindnar}}}\right)^{\frac{3}{4}} = 1.17$$

Using the above multiplying factors to the peak flows at the Chindnar G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.59**.

Table 5.59: Final Peak Flows (cumec) at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1990	7464.38	9703.69	11312.29
1991	6147.00	7991.10	9315.80
1992	6291.00	8178.30	9534.03
1993	2614.00	3398.20	3961.53
1994	7418.00	9643.40	11242.00
1995	12223.00	15889.90	18524.00
1996	2352.00	3057.60	3564.46
1997	3069.62	3990.51	4652.02
1998	1507.85	1960.21	2285.15
1999	3003.38	3904.39	4551.63
2000	3247.50	4221.75	4921.60
2001	9820.18	12766.23	14882.52
2002	5273.50	6855.55	7992.01
2003	4310.71	5603.92	6532.90
2004	5008.05	6510.47	7589.72
2005	7127.40	9265.62	10801.60

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2006	13350.59	17355.77	20232.87
2007	10073.46	13095.50	15266.36
2008	4820.78	6267.01	7305.91
2009	4059.34	5277.14	6151.94
2010	11335.00	14735.50	17178.23
2011	2898.76	3768.39	4393.08
2012	4847.33	6301.53	7346.15
2013	3995.40	5194.02	6055.04

5.5.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.60**.

Table 5.60: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	8983.04
Variance	25203785.09
SD (Sx)	5020.34
Skewness	0.87
Kurtosis	-0.16
No. of Data	24

5.5.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.61**.

The detailed procedure for Gumbel distribution method for Kutru-II dam site has been shown in **Annexure-4**.

Table 5.61: Detail of different year Return Period Flood (cumec) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	8229
2	5	13467
3	10	16935
4	20	20261
5	25	21316
6	50	24567
7	100	27793
8	500	35249

Annexure-4 (Flood Frequency Analysis for Kutru-II Dam)

DESIGN FLOOD-Kutru II

			CA at G&D	17270		CA =	21189	
Sl.No.	**Period**	**Annual Flood Peak at G&D Site (cumec)**	**Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)**	**Annual Flood Peak at Dam Site (cumec)**	**Ln-stats**			
1	1990	7464.38	9703.69	11312.29	9.33	Conversion factor =		1.17
2	1991	6147.00	7991.10	9315.80	9.14	Instantaneous Peak =		30%
3	1992	6291.00	8178.30	9534.03	9.16		X-STAT	Ln-STAT
4	1993	2614.00	3398.20	3961.53	8.28	Mean(X_m)	8983.04	8.95
5	1994	7418.00	9643.40	11242.00	9.33	Variance	25203785.09	0.323
6	1995	12223.00	15889.90	18524.00	9.83	SD (Sx)	5020.34	0.569
7	1996	2352.00	3057.60	3564.46	8.18	Skewness	0.87	-0.08743
8	1997	3069.62	3990.51	4652.02	8.45	Kurtosis	-0.16	-0.53775
9	1998	1507.85	1960.21	2285.15	7.73	No. of Data	24	
10	1999	3003.38	3904.39	4551.63	8.42			
11	2000	3247.50	4221.75	4921.60	8.50			
12	2001	9820.18	12766.23	14882.52	9.61			
13	2002	5273.50	6855.55	7992.01	8.99			
14	2003	4310.71	5603.92	6532.90	8.78	**Parameters**	**Values**	
15	2004	5008.05	6510.47	7589.72	8.93	Mean(Xm)	8983.04	
16	2005	7127.40	9265.62	10801.60	9.29	Variance	25203785.09	
17	2006	13350.59	17355.77	20232.87	9.92	SD (Sx)	5020.34	
18	2007	10073.46	13095.50	15266.36	9.63	Skewness	0.87	
19	2008	4820.78	6267.01	7305.91	8.90	Kurtosis	-0.16	
20	2009	4059.34	5277.14	6151.94	8.72	No. of Data	24	
21	2010	11335.00	14735.50	17178.23	9.75			
22	2011	2898.76	3768.39	4393.08	8.39			
23	2012	4847.33	6301.53	7346.15	8.90			
24	2013	3995.40	5194.02	6055.04	8.71			
	X_T	=	$X_m+K.S_x$					

(GUMBEL PROB. DISTRIBUTION METHOD)

	N	=	24			
Reduced mean =	Y_n	=	0.530	From Table (Interpolated)	$f_{(C)}$ =	1.645 (90% confidence probability)
Reduced Std. Dev =	S_n	=	1.09			
Reduced Variate =	Y_T	=	$-(\ln.\ln(T/T-1))$			
Frequency factor =	K	=	$(Y_T-Y_n)/S_n$			
	X_T	=	$X_m+K.S_x$			
Confidence Band =	$f_{(C)}.S_e$					
	Se	=	$b.Sx/\sqrt{n}$			
	b	=	$\sqrt{(1+1.3K+1.1K^2)}$			
	X_{cl}	=	$X_T \pm f_{(C)}.Se$			

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	90% CONFIDENCE INTERVAL (X_{cl} Values in cumec) Lower Confidence Limit	Upper Confidence Limit
1	2	**8229**	0.367	-0.150	0.911	933.407	1535.455	6694	9765
2	5	**13467**	1.500	0.893	1.743	1786.354	2938.552	10528	16406
3	10	**16935**	2.250	1.584	2.412	2471.967	4066.385	12868	21001
4	20	**20261**	2.970	2.246	3.078	3153.881	5188.134	15073	25449
5	25	**21316**	3.199	2.457	3.291	3372.803	5548.261	15768	26865
6	50	**24567**	3.902	3.104	3.954	4052.017	6665.568	17901	31232
7	100	**27793**	4.600	3.747	4.617	4731.010	7782.512	20011	35576
8	500	**35249**	6.214	5.232	6.157	6309.831	10379.671	24870	45629

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	8229
2	5	13467
3	10	16935
4	20	20261
5	25	21316
6	50	24567
7	100	27793
8	500	35249

5.6 Hydrology of Nugur-I Hydroelectric Project

5.6.1 General

The present project, Nugur-I, envisages harnessing water from River Indravati and other small rivers. Indravati River is a stream of the river Godavari. Its starting point is in the Ghats of Dandakaranya range from a hilltop village Mardiguda of Thuamula Rampur Block in the Kalahandi district of the state of Odisha due to the amalgamation of three streams. The project is proposed to be of storage type performing the multifunctions of irrigation and power.

5.6.1.1 Description of Dam Site

The catchment area of the dam site which comes out to be 23,522 km^2. The dam site is located in Bastar district of Chattisgarh at 19°13' 00'' N, 80°45'00'' E. Locations of the dam site and of G&D site are shown in **Figure 5.36**.

5.6.1.2 Description of G&D Site

Tumnar G&D site is situated in the Malkangiri district of Odisha at 82° 07' 10" E, 18° 36' 04" N. Catchment area of the G&D site is around 1,700 km^2 .

5.6.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometers draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/ km^2 –

nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

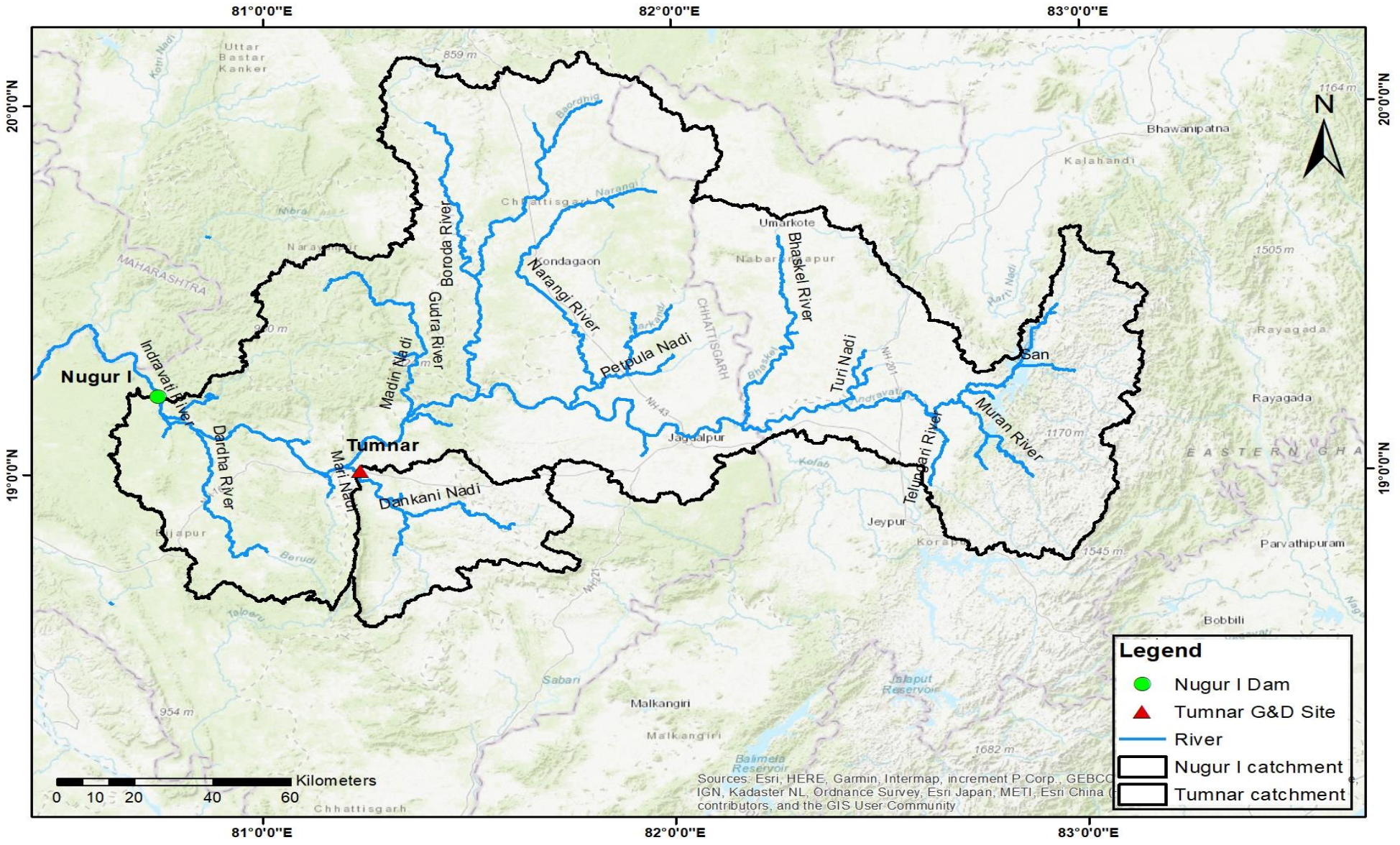


Figure 5.36: Catchment Area of Project and Locations of Dam and G&D site

5.6.2 Water Availability Studies

5.6.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Tumnar (Catchment Area=1,700 km^2), which is upstream of the project site along the Indravati River, is available and can be downloaded from India WRIS site. The G&D site lies in the Malkangiri district of Odisha.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.6.2.2 Rainfall data

Average of daily rainfall data generated at each grid point (as can be seen from **Figure 5.37**) within the boundary of the Tumnar G&D site and Nugur-I dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.37**, 5 grid point is considered to assess the catchment rainfall for Tumnar G&D site. Similarly, for Nugur-I proposed dam site, 33 grid points have been considered for the assessment of catchment rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

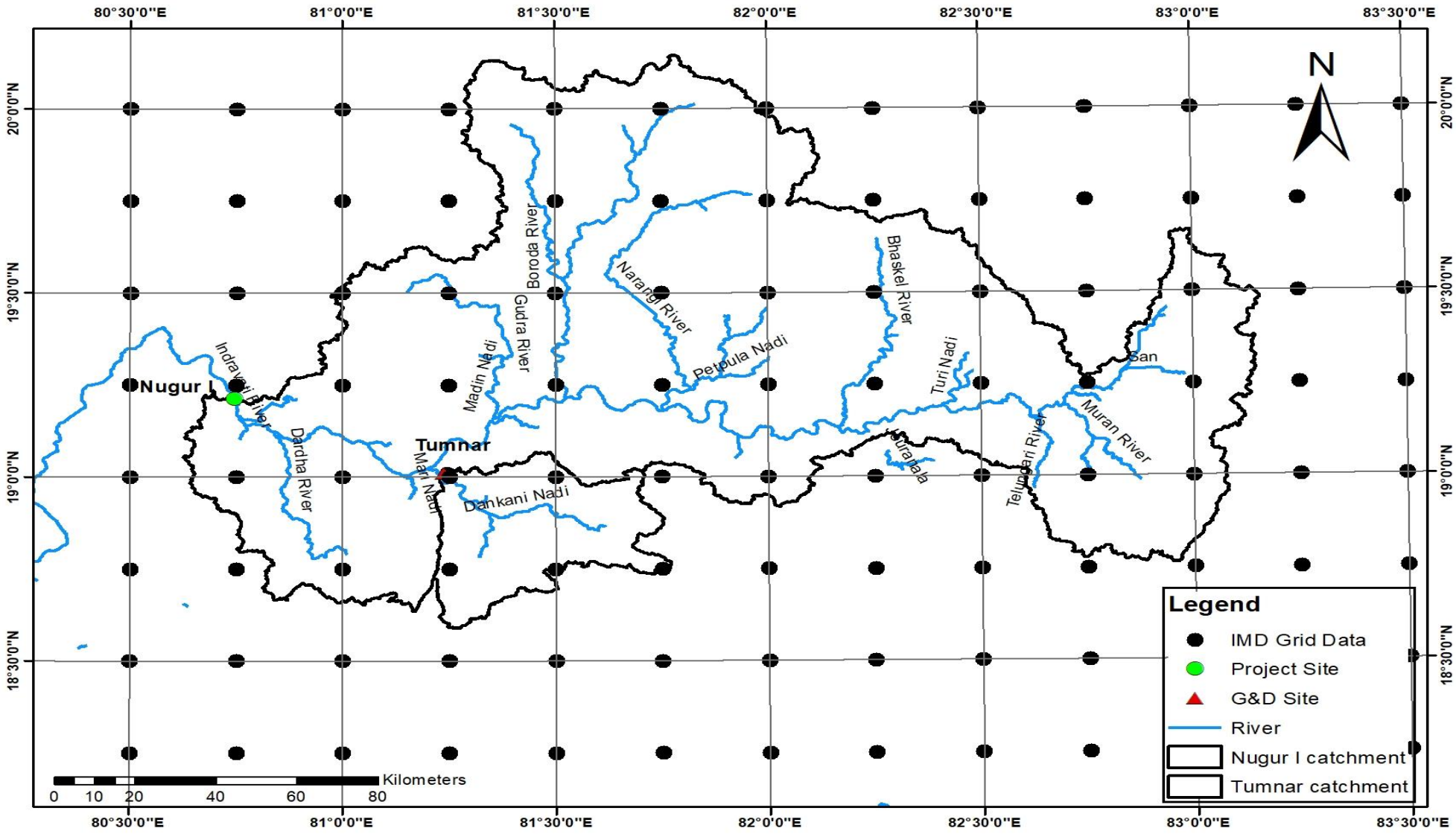


Figure 5.37: IMD Grid Rainfall Data for Nugur-I Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfalls for the last 25 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.62**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.63** and **Table 5.64** respectively.

Table 5.62: Average Annual Rainfall (in mm)

Year	Tumnar	Nugur-I
1990-1991	1669	1983
1991-1992	1287	1314
1992-1993	1397	1542
1993-1994	1460	1189
1994-1995	1947	2119
1995-1996	1426	1318
1996-1997	1453	1151
1997-1998	975	1373
1998-1999	1455	1081
1999-2000	1674	1345
2000-2001	1376	995
2001-2002	1583	1989
2002-2003	1075	988
2003-2004	2031	1686
2004-2005	1466	1350
2005-2006	1497	1435
2006-2007	1730	1993
2007-2008	1834	1466
2008-2009	1291	883
2009-2010	1037	1046
2010-2011	1840	1458
2011-2012	1386	1277
2012-2013	1689	1622
2013-2014	1545	1551
2014-2015	1319	1512
AVERAGE (mm)	1498	1427

Table 5.63: 10 Daily Rainfall (in mm) of Tumnar G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	3.91	1.75	2.91	1.35	0.09	0.15	3.49	0.41	0.62	1.04	15.91	6.16	5.24	0.06	1.77	1.80	2.36	1.19	9.63	1.96	1.68	1.97	2.19	7.34	1.33
	II	17.74	4.59	8.75	9.72	13.41	4.17	18.09	4.93	12.93	19.85	8.03	22.89	3.15	3.34	22.76	1.72	2.46	4.73	4.89	2.81	6.85	4.05	4.63	20.04	6.86
	III	12.19	6.16	5.58	3.24	10.84	7.92	1.06	5.16	6.08	5.06	8.33	3.13	12.17	2.70	5.67	14.81	5.90	19.64	8.74	2.69	4.56	6.92	9.92	12.67	4.99
JUL	I	11.63	14.29	3.19	11.47	27.84	4.55	4.27	6.04	19.66	2.68	13.14	25.37	1.01	11.83	10.54	8.95	17.84	8.02	11.92	18.19	11.18	10.51	12.20	12.49	4.25
	II	15.48	14.84	8.92	19.55	16.98	22.16	8.62	2.57	12.47	15.63	16.72	8.22	11.06	14.57	15.88	6.29	9.66	15.51	3.11	23.52	9.00	7.90	9.91	11.99	14.58
	III	13.47	12.36	27.09	13.72	16.02	23.90	25.01	18.04	9.75	21.99	7.13	8.53	4.21	24.38	20.55	14.23	13.84	3.00	14.68	6.70	25.41	8.44	19.36	14.15	18.05
AUG	I	6.27	15.51	9.52	16.55	11.49	15.22	18.20	3.67	11.31	27.86	12.39	19.65	16.83	18.15	18.37	9.74	36.40	22.38	21.39	2.35	23.51	10.63	26.37	11.26	6.95
	II	19.95	10.50	21.37	6.74	18.43	4.80	13.97	6.48	7.65	6.98	10.94	21.08	13.00	12.46	11.88	12.27	18.78	11.02	9.17	5.76	13.25	8.47	17.39	17.30	7.23
	III	12.51	10.57	12.12	9.11	22.87	17.05	13.65	12.95	4.30	18.13	14.05	4.98	14.25	35.22	3.29	2.11	6.94	11.59	6.21	11.08	13.93	20.50	10.76	1.94	14.98
SEP	I	5.45	2.88	23.10	16.56	18.42	8.41	7.19	4.50	11.59	13.03	6.49	2.99	7.52	7.64	4.51	7.76	3.92	19.48	15.76	4.48	16.56	12.67	15.41	4.44	12.28
	II	5.44	17.08	0.66	2.74	5.52	6.08	7.32	6.55	12.82	9.18	1.80	3.30	2.34	4.49	3.67	25.21	32.88	10.27	5.55	0.26	18.22	19.05	10.74	5.10	15.24
	III	6.18	2.12	3.31	13.58	0.63	2.40	3.66	3.89	5.10	6.71	5.00	7.03	0.07	9.25	5.28	5.18	6.17	15.39	0.87	3.84	3.37	2.38	6.35	5.27	1.79
OCT	I	20.18	5.05	0.62	4.68	5.19	2.29	1.95	0.46	11.35	4.15	0.51	6.34	0.17	18.62	4.09	1.86	0.25	26.25	0.91	1.88	1.69	3.70	2.84	4.33	0.27
	II	6.36	1.67	0.23	6.32	0.16	11.83	0.01	0.20	5.96	0.78	0.01	1.79	6.34	0.34	0.91	5.75	0.34	2.06	0.00	0.02	9.43	0.30	0.08	1.29	9.19
	III	1.83	0.03	0.57	1.35	2.09	2.40	0.47	0.75	0.63	2.54	0.00	0.01	0.00	4.90	1.12	13.32	0.65	0.45	0.12	0.00	2.00	0.00	0.00	11.98	0.24
NOV	I	0.80	2.99	0.04	0.00	0.84	0.07	0.19	1.13	2.72	0.09	0.27	0.09	0.00	0.37	0.08	3.08	5.19	0.07	0.00	0.29	1.32	0.00	4.47	0.00	0.02
	II	0.02	0.58	1.03	0.00	0.04	0.00	0.70	4.27	2.21	0.00	0.00	5.34	0.00	0.00	0.83	0.00	0.24	0.00	0.07	1.17	2.79	0.00	0.00	0.01	2.85
	III	0.02	0.00	0.07	0.00	0.23	0.00	0.19	0.45	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.04	0.00	1.03	0.00	0.00	0.25	0.00
DEC	I	0.03	0.00	0.00	0.00	0.00	0.00	0.22	1.35	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	1.92	0.00	0.00	0.00	0.00
	II	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.89	0.00	0.00	0.00	0.00	0.00	4.10	0.10	0.00	0.21	0.00	0.00	0.00	1.21	0.02	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.15	0.31	0.00	1.07	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00
JAN	I	1.57	0.05	0.00	0.00	4.93	0.07	0.07	0.37	0.00	0.67	0.02	2.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.42	0.00	0.00	0.13
	II	0.11	0.00	0.00	0.03	0.46	0.00	0.41	0.25	0.00	0.70	0.00	0.00	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.10	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	1.03	0.00	7.96	3.12	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEB	I	0.00	0.00	0.00	0.09	0.00	0.16	0.24	1.03	0.00	0.00	0.00	0.00	0.00	5.22	0.91	0.00	0.00	0.02	0.00	0.22	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.46	0.00	0.03	0.10	0.00	0.00	0.19	0.00	0.17	1.04	0.00	0.00	0.00	0.64	0.56	0.00	0.15	0.01	0.00	0.49	0.03	0.00
	III	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.18	0.00	0.32	0.56	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.60	0.00	0.00	0.00	0.18
MAR	I	0.00	0.00	0.63	0.01	0.00	0.55	0.00	0.04	0.00	0.00	0.13	0.00	0.05	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.40	0.29
	II	0.00	0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.04	0.00	0.18	0.00	0.89	0.00	0.09	1.40	0.00	0.60	0.00	0.00	0.00	0.00	0.26	0.01	0.01
	III	0.00	0.00	0.00	0.00	0.28	0.00	2.28	0.04	0.00	0.02	0.01	0.17	3.11	0.03	0.00	0.13	0.00	4.66	1.50	0.87	0.01	0.22	0.00	0.00	0.24
APR	I	0.05	0.11	0.04	0.17	0.58	0.08	2.58	0.76	0.00	0.07	0.47	1.33	1.35	0.94	0.26	0.69	0.00	0.67	0.45	0.00	0.50	1.23	0.39	0.02	0.00
	II	0.02	0.00	2.02	0.02	0.30	0.94	1.73	0.00	0.00	2.04	5.12	0.80	0.31	0.00	0.44	4.90	1.17	0.00	0.00	0.51	0.68	0.00	3.82	2.34	1.10
	III	0.24	0.31	0.45	0.66	0.79	1.90	2.36	1.02	0.00	0.01	0.24	0.00	0.73	5.95	2.69	0.39	0.00	0.08	0.00	4.68	4.21	6.65	4.67	0.79	3.08
MAY	I	0.12	0.28	0.00	2.01	2.75	0.77	2.01	2.96	1.33	1.31	1.99	0.02	0.00	0.49	2.06	0.77	1.70	0.67	2.73	1.58	1.91	2.49	0.02	2.65	1.87
	II	1.19	0.00	1.23	1.08	7.10	0.14	0.65	2.38	2.42	0.09	0.88	1.31	0.00	1.06	0.00	2.87	0.24	0.03	3.62	0.34	0.58	4.78	1.06	1.29	0.61
	III	1.10	2.13	2.07	2.16	1.07	0.17	0.29	0.37	2.83	0.92	5.06	2.53	0.08	0.20	2.62	1.28	1.62	2.19	4.99	5.00	2.33	0.20	2.33	0.25	0.01
Yearly Rainfall (mm)		1669	1287	1397	1460	1947	1426	1453	975	1455	1674	1376	1583	1075	2031	1466	1497	1730	1834	1291	1037	1840	1386	1689	1545	1319

Table 5.64: 10 Daily Rainfall (in mm) of Nugur-I Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	5.81	2.87	2.87	1.65	0.78	0.29	2.44	0.42	0.55	1.08	9.19	7.55	4.16	0.32	3.57	1.60	4.85	1.73	11.19	2.94	1.58	2.65	1.62	5.26	2.23
	II	12.89	7.90	12.56	11.36	12.01	3.38	11.39	4.73	9.32	17.78	9.85	26.67	3.92	3.72	27.62	2.02	2.24	7.10	5.43	2.41	4.11	6.04	5.18	25.32	6.46
	III	9.30	6.33	4.38	4.80	10.33	7.97	2.91	6.07	6.23	3.95	7.76	5.08	10.98	3.41	2.56	16.94	6.63	34.49	9.80	5.77	4.30	4.88	9.02	13.27	6.49
JUL	I	7.85	12.03	4.75	9.05	26.27	5.34	5.21	6.33	16.47	3.77	9.66	29.85	1.38	11.27	8.22	7.09	32.58	6.58	8.72	12.96	11.24	8.29	11.05	7.17	3.15
	II	13.42	18.16	10.95	19.25	16.03	21.17	15.32	4.72	10.95	10.96	20.64	10.73	11.60	15.77	11.56	5.78	7.48	12.81	4.27	25.51	9.95	5.64	9.33	10.17	16.01
	III	10.06	18.15	28.79	12.43	15.02	24.23	20.15	20.60	8.04	12.82	3.59	8.29	5.36	21.79	16.14	13.36	14.81	5.26	14.40	10.33	20.81	9.22	19.84	14.95	22.58
AUG	I	7.99	12.02	12.67	11.24	10.83	14.65	14.70	5.81	9.50	22.81	8.41	18.73	12.22	17.84	15.70	10.31	35.53	28.23	29.11	4.91	24.19	8.42	26.24	12.26	13.18
	II	18.08	12.76	21.92	6.49	14.72	4.10	18.17	12.24	8.45	5.04	12.18	21.18	10.62	11.17	12.47	12.50	17.23	14.19	11.63	8.38	8.53	10.19	17.31	12.35	7.99
	III	18.52	10.20	10.01	5.80	20.17	15.46	10.58	14.56	4.85	17.46	17.24	5.73	13.80	27.41	7.94	2.30	13.50	9.03	8.76	15.47	12.48	16.21	8.29	3.29	11.17
SEP	I	9.98	3.89	20.39	17.44	21.26	8.45	6.56	5.82	9.21	11.81	4.07	3.58	8.09	11.44	5.61	6.24	5.05	18.51	13.89	3.89	17.84	17.14	14.58	5.08	14.95
	II	8.30	11.04	0.61	3.89	8.06	6.43	6.19	10.65	7.59	7.91	2.77	5.42	3.21	5.43	4.34	30.51	18.85	6.56	13.74	0.57	17.26	15.46	6.42	5.19	10.55
	III	5.42	3.00	1.91	10.88	2.56	4.02	5.76	4.88	3.84	5.94	6.61	4.65	0.28	9.57	3.54	2.38	13.32	13.34	2.13	4.49	1.75	3.37	5.26	7.02	1.95
OCT	I	21.69	5.81	1.84	3.16	3.92	2.34	2.29	0.66	6.27	3.64	1.16	4.36	0.47	16.55	9.25	1.65	0.86	15.01	2.24	3.55	2.24	1.95	2.46	6.93	0.42
	II	5.54	1.64	0.87	5.81	1.08	8.50	0.49	0.65	5.01	1.22	0.19	2.29	6.30	0.25	2.10	5.24	0.26	1.29	0.13	0.05	11.38	0.73	2.35	1.78	7.98
	III	1.07	0.09	0.09	0.74	1.46	3.10	0.98	1.64	0.54	2.28	0.00	0.03	0.20	5.29	0.60	8.93	0.77	0.27	0.19	0.00	3.36	0.31	0.00	11.25	0.59
NOV	I	2.44	2.87	0.24	0.02	0.86	1.73	0.24	0.47	3.15	0.45	0.06	0.09	0.00	0.12	0.62	2.52	3.84	0.05	0.00	0.45	1.87	0.00	6.42	0.00	0.00
	II	0.06	0.33	0.35	0.00	0.04	0.07	0.49	2.42	2.55	0.00	0.00	3.74	0.00	0.00	0.26	0.00	0.09	0.00	0.04	1.15	1.56	0.00	0.00	0.00	1.12
	III	0.01	0.13	1.26	0.00	0.13	0.00	0.07	0.80	0.01	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.01	0.00	0.46	0.00	0.00	0.18	0.00
DEC	I	0.01	0.00	0.00	0.00	0.00	0.01	0.12	1.97	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	2.88	0.02	0.00	0.00	0.00
	II	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.00	0.00	0.00	4.12	0.04	0.00	0.10	0.00	0.00	0.00	0.47	0.04	0.00	0.00	0.00
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.05	0.56	0.00	0.40	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.17	0.00	0.00	0.03
JAN	I	0.59	0.22	0.00	0.00	5.17	0.10	0.05	0.14	0.00	0.26	0.07	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.77	0.05	0.00	0.32
	II	0.13	0.00	0.00	0.17	1.13	0.12	0.67	0.09	0.00	0.27	0.00	0.00	0.00	0.43	0.00	0.00	0.00	0.00	0.00	1.17	0.00	0.47	0.00	0.00	0.00
	III	0.00	0.03	0.00	0.00	0.00	0.06	0.09	0.01	0.00	0.00	0.00	0.90	0.00	4.18	3.87	0.00	0.00	1.20	0.00	0.00	0.09	0.43	0.01	0.00	0.00
FEB	I	0.00	0.13	0.00	0.21	0.02	0.17	0.08	1.12	0.11	0.04	0.00	0.00	0.01	2.31	0.57	0.00	0.00	0.19	0.00	0.12	0.00	0.00	0.01	0.00	0.00
	II	0.00	0.00	0.28	0.66	0.00	0.41	0.03	0.00	0.00	1.02	0.00	0.07	0.53	0.00	0.00	0.00	0.40	0.36	0.00	0.25	0.17	0.00	0.60	0.07	0.03
	III	0.00	0.28	0.02	0.00	0.14	0.00	0.11	0.04	0.00	0.72	0.00	0.13	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.36	2.05	0.00	0.00	0.00	0.06
MAR	I	0.69	0.00	0.39	0.11	0.08	1.45	0.00	1.08	0.00	0.00	0.18	0.00	0.08	0.09	0.00	1.48	0.01	0.00	0.00	0.00	0.00	0.12	0.00	2.95	0.17
	II	0.19	0.00	0.00	0.00	1.31	0.00	0.00	0.18	0.03	0.00	0.08	0.00	1.33	0.00	0.08	1.37	0.01	0.30	0.00	0.16	0.00	0.00	0.10	0.69	0.11
	III	0.03	0.11	0.05	0.06	0.44	0.00	2.61	0.61	0.00	0.00	0.12	0.13	1.37	0.04	0.02	0.04	0.00	2.58	1.05	0.58	0.03	0.53	0.00	0.00	0.35
APR	I	0.89	0.17	0.03	1.05	1.08	0.13	3.90	1.00	0.15	0.01	0.78	1.38	0.50	0.50	0.29	0.29	0.00	0.57	0.30	0.00	1.05	0.49	0.19	0.21	0.09
	II	0.40	0.02	1.64	0.12	0.44	1.28	1.24	0.00	0.07	1.18	4.32	1.20	1.00	0.20	0.39	4.08	1.08	0.03	0.00	0.53	2.24	0.09	3.16	1.89	1.96
	III	1.01	0.71	1.18	1.60	0.42	1.87	2.19	1.20	0.00	0.15	0.62	0.43	0.75	2.85	1.41	0.21	0.15	0.07	0.00	3.06	3.89	3.01	3.80	1.15	3.15
MAY	I	1.13	0.91	0.05	0.92	5.11	0.81	1.49	1.89	1.25	1.29	1.31	0.04	0.03	0.25	1.23	1.26	2.07	0.29	1.76	2.64	1.51	2.35	0.12	1.99	2.57
	II	0.82	0.31	1.85	1.00	11.00	0.06	0.77	1.23	2.19	0.30	1.24	0.64	0.00	0.99	0.01	2.27	1.17	0.01	2.32	0.30	1.28	2.08	0.92	0.73	0.78
	III	1.68	1.64	2.28	2.69	0.93	0.75	0.42	0.42	4.03	1.24	3.74	1.87	0.13	0.23	2.14	4.34	1.15	1.03	3.32	6.46	1.58	0.09	2.48	2.25	0.02
Yearly Rainfall		1694	1367	1483	1348	1966	1428	1412	1196	1221	1391	1284	1676	1007	1836	1452	1476	1876	1830	1472	1217	1756	1249	1599	1566	1399

5.6.2.3 Rainfall and Runoff Data at Tumnar G&D Site

Detailed calculations on water availability and flood magnitude will help select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the monthly runoff and monthly rainfall for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Tumnar G&D site is shown in **Figure 5.38**. The basic comparison between rainfall and runoff in **Figure 5.38** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.39** shows the plot of runoff coefficient at the G&D site.

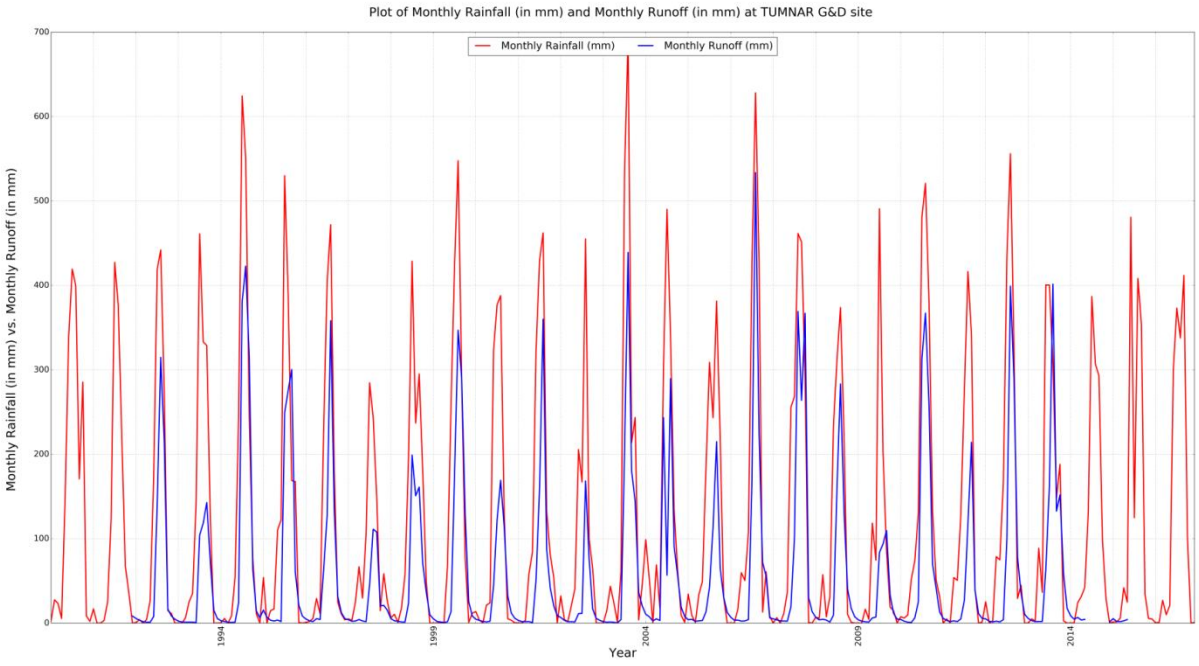


Figure 5.38: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tumnar G&D site

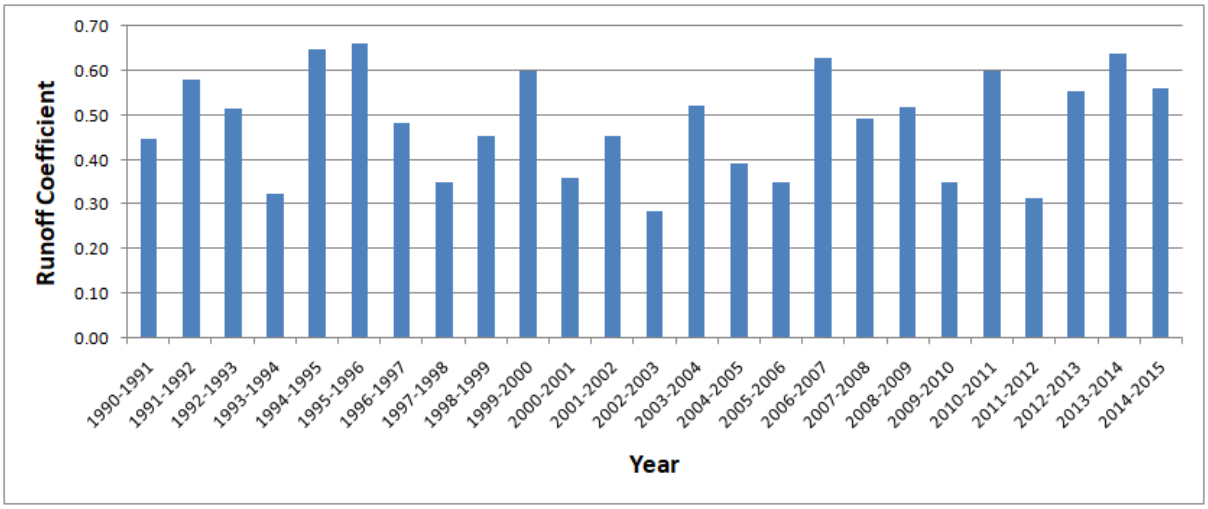


Figure 5.39: Plot of Runoff Coefficient at G&D site

5.6.3 Flow Series Computation

The dam site (CA = 23522 km^2) and Tumnar G&D site (CA = 1700 km^2) lie on the adjoint river basins. However, the G&D site is located at distance of about 11 km from Nugur-I dam. Thus, it is proposed to use 10 daily rainfall (in mm)-10 daily runoff (in mm) correlations for deriving the flow series at the project site for monsoon period i.e. Jun-Nov, whereas for non-monsoon period, the flow series has been developed based on the ratio of non-monsoon inflow (in MCM) to monsoon inflow (in MCM) at G&D site. The detailed approach for deriving the non-monsoon flow series has been explained in the subsequent paragraphs.

As there is no observed discharge data at the project site, the 10 daily rainfall (in mm)-10 daily runoff (in mm) correlation for monsoon period has been developed at the Central Water Commission (CWC) G&D Site of Tumnar. The correlation thus developed has been used to derive the 10 daily flow series at the dam site.

It is observed that the data for Tumnar G&D site is available for period from 1990 to 2015. The 10 daily rainfall-runoff correlation as developed at the Tumnar G&D site has been shown in **Figure 5.40.**

While developing the seasonal monsoon rainfall-runoff correlation, it has been noticed that the coefficient is weak, accordingly some points are deleted to improve the coefficient of determination which are shown by shaded cell in the **Table 5.29** and **Table 5.30**

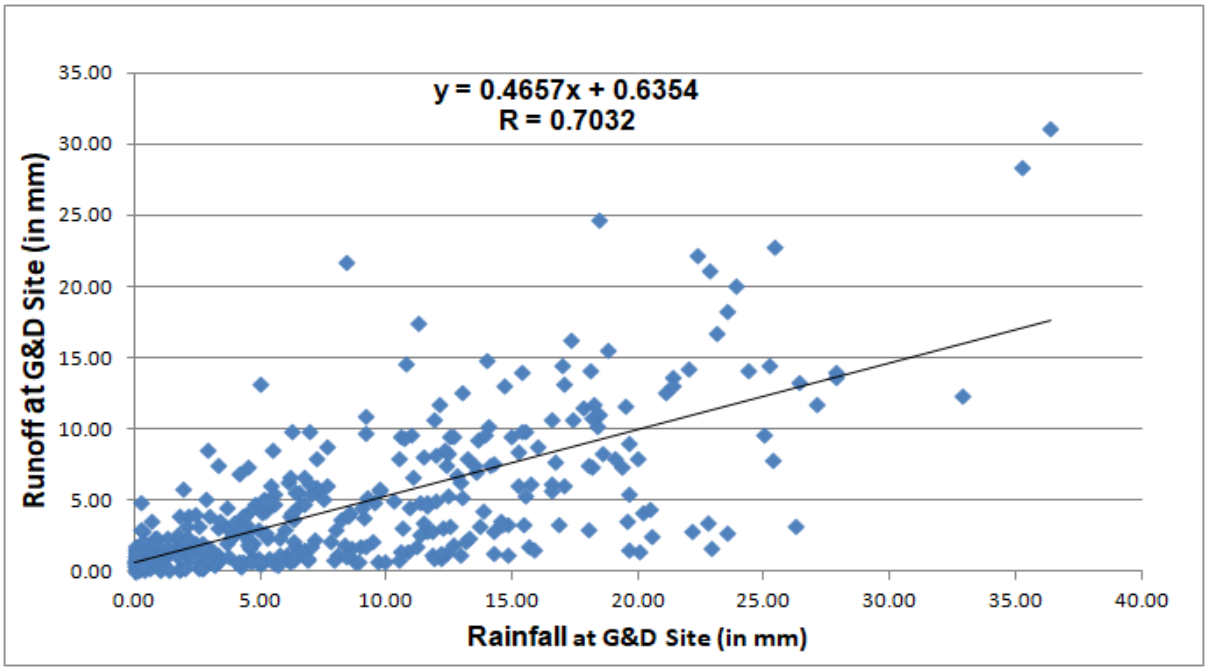


Figure 5.40: 10 Daily Rainfall-Runoff Correlation at Tumnar G&D Site

The final equation used for estimating 10-daily runoff depth (in mm) at the project site is as follows:

$$\text{Runoff\_Depth}_{\text{Nugur I Dam}} = (\text{Rainfall}_{\text{Nugur I Dam}} \text{ X } 0.4657) + 0.6354$$

Then, this runoff depth is converted to 10-daily discharge values accordingly.

For Non Monsoon period i.e. from Dec-May, flow series at the dam site has been derived as follows:

- Ratio of non-monsoon inflow (in MCM) to monsoon inflow (in MCM) at CWC G&D site of Tumnar has been worked out for each year.

$$\text{Ratio (m)} = \frac{\text{NM}_{\text{inflow}_{\text{Tumnar}}}}{\text{M}_{\text{inflow}_{\text{Tumnar}}}}$$

- It is assumed that the same ratio would prevail for the dam site also, considering that the catchments are hydro-meteorologically similar.

$$\text{NM}_{\text{inflow Nugur I}} = \text{m} * \text{M}_{\text{inflow Nugur I}}$$

- 10-daily flow (cumec) at each interval has been calculated as per the following formula:

$$\text{Q\_Nugur I}_{\text{NM}} = \frac{\text{NM}_{\text{inflow}_{\text{Nugur I}}}}{\text{NM}_{\text{inflow}_{\text{Tumnar}}}} \text{XQ\_Tumnar}_{\text{NM}}$$

Where

Q_Tumnar is 10 daily discharge data of Tumnar G&D site (in cumec).

NM_inflow_Tumnar is non-monsoon inflow for each year at Tumnar site (MCM)

NM_inflow_Nugur-I is non-monsoon inflow for each year at Nugur-I site

M_inflow_Tumnar is monsoon inflow for each year at Tumnar site (MCM)

M_inflow_Nugur-I is monsoon inflow data for each year for the dam site (MCM)

Q_Nugur-I_NM is 10 daily discharge data derived at the dam site for non-monsoon period (cumec)

Table 5.65 and **Table 5.66** shows 10-daily average rainfall and 10-daily average runoff, used to generate correlation at G&D site.

Table 5.67 shows 10-daily average flow series at G&D site. **Table 5.68** and **Table 5.69** give 10-daily average flow series (m^3/s) and 10-daily inflow series (MCM) developed for Nugur-I dam site.

Table 5.65: 10-Daily Average Rainfall (m^3/s) at Tumnar G&D

Period		1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Jun	I	3.91	1.75	2.91	1.35	0.09	0.15	3.49	0.41	0.62	1.04	15.91	6.16	5.24	0.06	1.77	1.80	2.36	1.19	9.63	1.96	1.68	1.97	2.19	7.34	1.33
	II	17.74	4.59	8.75	9.72	13.41	4.17	18.09	4.93	12.93	19.85	8.03	22.89	3.15	3.34	22.76	1.72	2.46	4.73	4.89	2.81	6.85	4.05	4.63	20.04	6.86
	III	12.19	6.16	5.58	3.24	10.84	7.92	1.06	5.16	6.08	5.06	8.33	3.13	12.17	2.70	5.67	14.81	5.90	19.64	8.74	2.69	4.56	6.92	9.92	12.67	4.99
Jul	I	11.63	14.29	3.19	11.47	27.84	4.55	4.27	6.04	19.66	2.68	13.14	25.37	1.01	11.83	10.54	8.95	17.84	8.02	11.92	18.19	11.18	10.51	12.20	12.49	4.25
	II	15.48	14.84	8.92	19.55	16.98	22.16	8.62	2.57	12.47	15.63	16.72	8.22	11.06	14.57	15.88	6.29	9.66	15.51	3.11	23.52	9.00	7.90	9.91	11.99	14.58
	III	13.47	12.36	27.09	13.72	16.02	23.90	25.01	18.04	9.75	21.99	7.13	8.53	4.21	24.38	20.55	14.23	13.84	3.00	14.68	6.70	25.41	8.44	19.36	14.15	18.05
Aug	I	6.27	15.51	9.52	16.55	11.49	15.22	18.20	3.67	11.31	27.86	12.39	19.65	16.83	18.15	18.37	9.74	36.40	22.38	21.39	2.35	23.51	10.63	26.37	11.26	6.95
	II	19.95	10.50	21.37	6.74	18.43	4.80	13.97	6.48	7.65	6.98	10.94	21.08	13.00	12.46	11.88	12.27	18.78	11.02	9.17	5.76	13.25	8.47	17.39	17.30	7.23
	III	12.51	10.57	12.12	9.11	22.87	17.05	13.65	12.95	4.30	18.13	14.05	4.98	14.25	35.22	3.29	2.11	6.94	11.59	6.21	11.08	13.93	20.50	10.76	1.94	14.98
Sep	I	5.45	2.88	23.10	16.56	18.42	8.41	7.19	4.50	11.59	13.03	6.49	2.99	7.52	7.64	4.51	7.76	3.92	19.48	15.76	4.48	16.56	12.67	15.41	4.44	12.28
	II	5.44	17.08	0.66	2.74	5.52	6.08	7.32	6.55	12.82	9.18	1.80	3.30	2.34	4.49	3.67	25.21	32.88	10.27	5.55	0.26	18.22	19.05	10.74	5.10	15.24
	III	6.18	2.12	3.31	13.58	0.63	2.40	3.66	3.89	5.10	6.71	5.00	7.03	0.07	9.25	5.28	5.18	6.17	15.39	0.87	3.84	3.37	2.38	6.35	5.27	1.79
Oct	I	20.18	5.05	0.62	4.68	5.19	2.29	1.95	0.46	11.35	4.15	0.51	6.34	0.17	18.62	4.09	1.86	0.25	26.25	0.91	1.88	1.69	3.70	2.84	4.33	0.27
	II	6.36	1.67	0.23	6.32	0.16	11.83	0.01	0.20	5.96	0.78	0.01	1.79	6.34	0.34	0.91	5.75	0.34	2.06	0.00	0.02	9.43	0.30	0.08	1.29	9.19
	III	1.83	0.03	0.57	1.35	2.09	2.40	0.47	0.75	0.63	2.54	0.00	0.01	0.00	4.90	1.12	13.32	0.65	0.45	0.12	0.00	2.00	0.00	0.00	11.98	0.24
Nov	I	0.80	2.99	0.04	0.00	0.84	0.07	0.19	1.13	2.72	0.09	0.27	0.09	0.00	0.37	0.08	3.08	5.19	0.07	0.00	0.29	1.32	0.00	4.47	0.00	0.02
	II	0.02	0.58	1.03	0.00	0.04	0.00	0.70	4.27	2.21	0.00	0.00	5.34	0.00	0.00	0.83	0.00	0.24	0.00	0.07	1.17	2.79	0.00	0.00	0.01	2.85
	III	0.02	0.00	0.07	0.00	0.23	0.00	0.19	0.45	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.66	0.00	0.04	0.00	1.03	0.00	0.00	0.25	0.00

Table 5.66: 10-Daily Average Runoff Series (m^3/s) at Tumnar G&D

Period		1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Jun	I	0.17	0.17	0.06	0.04	0.17	0.04	0.14	0.04	0.17	0.05	0.11	0.16	0.08	0.01	0.14	0.11	0.08	0.06	0.29	0.33	0.08	0.20	0.02	0.20	0.12
	II	0.80	0.80	0.70	0.59	0.80	0.64	0.90	0.53	1.16	0.78	1.13	1.64	1.12	0.67	3.42	1.08	0.99	0.87	0.89	0.72	0.79	0.62	0.63	1.34	0.98
	III	0.72	0.72	0.52	0.01	1.45	0.14	0.63	0.13	0.85	0.58	1.90	0.69	0.94	0.24	0.45	1.16	0.27	1.53	0.26	0.18	1.66	0.19	0.25	1.83	0.72
Jul	I	2.84	2.84	0.42	3.40	14.03	0.07	0.55	1.17	5.38	0.38	2.10	7.85	0.11	1.13	1.35	1.72	11.48	2.95	0.98	0.47	1.74	0.76	1.30	3.13	2.84
	II	3.26	3.26	0.72	3.52	14.46	2.83	1.64	0.22	8.25	1.76	7.64	3.62	0.66	3.53	1.56	1.07	0.71	5.33	0.57	2.74	4.44	0.80	0.67	4.95	3.26
	III	7.41	7.41	11.78	3.21	8.72	20.01	9.63	2.89	5.69	14.21	2.23	4.12	0.34	14.16	2.51	1.30	4.24	1.69	13.08	4.68	22.82	1.07	7.32	7.41	7.41
Aug	I	9.82	9.82	4.85	6.15	8.10	8.37	10.81	3.03	4.83	13.68	1.25	9.00	3.27	7.36	10.17	5.78	31.09	22.21	12.98	0.97	18.29	3.05	13.26	17.49	9.82
	II	7.98	7.98	13.66	1.55	10.97	4.76	14.79	1.26	6.00	5.48	4.53	12.55	5.17	5.38	10.61	3.02	15.55	9.65	10.86	1.12	7.89	3.86	10.61	16.23	7.98
	III	9.46	9.46	11.78	3.76	21.11	13.14	9.29	6.21	3.86	14.12	10.13	13.13	7.62	28.33	7.42	2.32	6.11	4.59	4.08	6.61	9.58	4.39	14.59	5.84	9.46
Sep	I	8.53	8.53	16.74	5.67	24.69	21.76	5.88	2.83	4.88	12.57	4.56	3.90	5.02	8.72	2.28	2.12	3.48	11.57	6.11	7.35	10.65	9.53	14.01	3.26	8.53
	II	6.00	6.00	3.48	1.63	5.41	6.30	5.63	5.51	6.71	9.75	2.19	3.06	1.86	4.10	4.49	14.42	12.35	4.97	4.73	1.17	11.73	7.87	9.41	5.11	6.00
	III	3.92	3.92	1.18	6.97	1.37	1.99	2.03	2.46	4.52	6.67	4.75	1.79	0.71	5.23	2.32	4.95	6.62	9.85	2.39	2.43	3.53	4.02	5.59	4.88	3.92
Oct	I	4.14	4.14	0.80	2.05	4.27	1.52	1.65	0.85	2.53	6.90	1.61	2.12	0.49	8.31	3.35	1.66	4.88	3.18	1.75	2.16	2.60	1.04	5.12	3.85	2.96
	II	1.75	1.75	0.54	3.71	0.71	2.87	0.68	0.45	2.97	2.39	1.05	1.30	0.78	2.88	1.27	2.36	1.37	3.19	1.22	0.76	2.09	2.13	1.43	2.36	1.75
	III	1.56	1.56	0.29	1.32	1.25	1.54	0.76	0.66	1.41	3.18	0.57	0.72	0.36	2.96	0.93	2.34	0.84	1.70	0.98	0.39	2.06	0.65	1.17	8.15	1.56
Nov	I	0.80	1.05	0.27	0.62	0.70	0.80	0.47	0.45	2.03	1.14	0.44	0.54	0.21	1.70	0.69	1.46	2.76	1.34	0.61	0.32	1.55	0.45	1.88	2.64	1.04
	II	0.60	0.79	0.28	0.51	0.43	0.71	0.45	0.67	0.99	0.78	0.42	0.88	0.19	1.16	0.72	0.92	1.69	0.93	0.55	0.44	1.51	0.36	0.96	1.81	0.78
	III	0.51	0.62	0.30	0.38	0.31	0.62	0.33	0.98	0.65	0.59	0.33	0.64	0.16	0.78	0.49	0.69	1.09	0.73	0.62	0.38	1.11	0.30	0.70	1.41	0.61

- **Shaded Cells are not used to generate correlation between 10-Daily Rainfall and 10-Daily Runoff for G&D Site.**
- **Correlation is developed only for Monsoon Period i.e. Jun-Nov.**

Table 5.67: 10-Daily Average Flow Series (m^3/s) at Tumnar

Catchment Area =1700 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	3.34	3.34	1.27	0.84	3.42	0.85	2.76	0.87	3.34	0.93	2.07	3.17	1.52	0.29	2.85	2.16	1.52	1.15	5.74	6.50	1.49	3.91	0.49	3.84	2.40
	II	15.68	15.68	13.83	11.56	15.67	12.62	17.78	10.43	22.79	15.43	22.23	32.31	22.01	13.10	67.20	21.18	19.43	17.08	17.48	14.15	15.60	12.23	12.49	26.39	19.35
	III	14.20	14.20	10.28	0.11	28.52	2.79	12.47	2.61	16.78	11.37	37.45	13.62	18.52	4.79	8.86	22.80	5.41	30.01	5.12	3.55	32.64	3.79	4.97	35.96	14.20
Jul	I	55.87	55.87	8.31	66.88	276.01	1.33	10.79	23.09	105.94	7.41	41.31	154.51	2.21	22.14	26.66	33.76	225.90	58.12	19.29	9.20	34.22	14.86	25.65	61.54	55.87
	II	64.11	64.11	14.15	69.20	284.44	55.77	32.20	4.33	162.36	34.54	150.30	71.20	13.04	69.52	30.75	20.98	14.06	104.88	11.16	53.97	87.35	15.74	13.18	97.31	64.11
	III	145.89	145.89	231.71	63.08	171.54	393.81	189.53	56.82	112.02	279.69	43.95	81.14	6.74	278.54	49.34	25.67	83.37	33.35	257.38	92.16	449.08	21.01	143.96	145.74	145.89
Aug	I	193.19	193.19	95.47	120.99	159.38	164.61	212.67	59.59	95.06	269.12	24.59	177.14	64.42	144.85	200.12	113.82	611.73	437.08	255.49	19.16	359.93	60.02	260.95	344.10	193.19
	II	156.96	156.96	268.72	30.57	215.81	93.56	291.03	24.75	118.11	107.79	89.06	246.91	101.72	105.81	208.81	59.34	306.04	189.87	213.70	22.07	155.27	75.92	208.84	319.38	156.96
	III	186.04	186.04	231.84	73.90	415.32	258.54	182.70	122.22	76.02	277.86	199.30	258.35	150.02	557.51	146.03	45.66	120.23	90.34	80.27	129.99	188.48	86.45	286.99	114.95	186.04
Sep	I	167.74	167.74	329.34	111.58	485.73	428.09	115.63	55.71	96.04	247.25	89.69	76.70	98.84	171.63	44.78	41.68	68.40	227.57	120.20	144.62	209.46	187.45	275.74	64.20	167.74
	II	117.96	117.96	68.46	32.16	106.53	123.91	110.80	108.34	132.04	191.84	43.07	60.27	36.64	80.68	88.44	283.72	242.96	97.72	93.14	23.01	230.75	154.90	185.17	100.62	117.96
	III	77.15	77.15	23.21	137.19	26.86	39.06	39.88	48.33	88.86	131.28	93.40	35.29	13.96	102.96	45.74	97.48	130.27	193.88	47.10	47.89	69.45	79.09	110.00	96.09	77.15
Oct	I	81.52	81.52	15.73	40.29	84.00	29.91	32.44	16.70	49.86	135.85	31.58	41.77	9.64	163.42	65.84	32.57	96.10	62.61	34.37	42.59	51.20	20.43	100.83	75.73	58.19
	II	34.46	34.46	10.57	73.06	14.04	56.54	13.36	8.93	58.47	47.04	20.61	25.58	15.33	56.73	25.04	46.45	26.91	62.70	23.93	14.92	41.14	41.99	28.20	46.53	34.46
	III	30.62	30.62	5.78	26.01	24.66	30.27	15.05	13.05	27.68	62.48	11.14	14.16	7.07	58.18	18.36	45.96	16.62	33.48	19.22	7.64	40.59	12.76	22.99	160.44	30.62
Nov	I	15.71	20.65	5.41	12.25	13.83	15.69	9.23	8.92	39.88	22.47	8.73	10.62	4.04	33.48	13.52	28.68	54.40	26.38	12.06	6.28	30.42	8.91	36.98	52.02	20.44
	II	11.89	15.53	5.52	10.13	8.52	14.02	8.85	13.24	19.42	15.28	8.35	17.28	3.71	22.75	14.11	18.09	33.30	18.29	10.76	8.68	29.75	7.16	18.91	35.58	15.38
	III	10.06	12.16	5.82	7.56	6.10	12.16	6.55	19.28	12.75	11.63	6.59	12.53	3.13	15.26	9.61	13.64	21.53	14.37	12.21	7.57	21.76	5.86	13.74	27.78	12.07
Dec	I	7.17	6.30	3.92	4.56	4.96	6.57	4.36	11.17	8.67	7.05	4.94	7.32	2.57	8.98	6.86	9.91	4.39	11.24	7.21	3.97	11.12	4.65	9.02	15.08	7.17
	II	5.89	5.09	2.88	3.33	4.00	5.24	3.39	11.15	5.58	5.06	3.44	5.67	2.21	18.40	4.58	7.41	3.92	8.60	4.20	2.94	8.29	3.43	5.90	10.84	5.89
	III	4.49	4.58	2.02	2.36	3.29	4.16	2.48	7.08	4.57	4.03	2.62	3.97	1.59	11.48	3.52	6.96	3.69	6.29	3.28	2.06	5.86	2.84	5.26	7.84	4.43
Jan	I	4.04	4.12	1.81	2.00	10.93	3.51	2.11	4.05	3.93	3.60	2.44	5.88	1.25	7.62	2.48	5.60	3.53	5.23	3.05	1.53	4.65	2.72	3.88	6.58	4.02
	II	3.73	3.43	1.56	1.83	12.10	3.33	3.36	3.08	3.46	3.00	2.09	4.15	1.06	5.58	2.06	4.83	3.19	4.48	2.49	4.58	3.41	4.40	3.45	5.29	3.75
	III	2.87	3.11	1.18	1.60	6.74	2.51	2.11	2.84	2.52	2.19	1.65	2.76	0.94	6.74	2.91	3.08	2.88	3.45	1.99	2.15	2.87	2.49	3.32	4.64	2.90
Feb	I	2.68	2.49	1.11	1.33	5.98	2.33	1.82	2.29	1.85	2.07	1.49	2.84	0.81	8.76	5.56	2.87	2.69	2.37	1.87	1.74	2.41	1.91	2.47	3.60	2.72
	II	2.10	2.23	0.97	1.54	5.60	1.76	1.50	1.92	1.32	2.23	1.29	2.20	0.79	3.73	2.22	2.39	2.70	2.67	1.62	1.62	2.04	1.49	2.00	3.24	2.13
	III	1.69	2.15	0.76	1.00	2.52	1.61	1.23	1.52	1.04	2.20	1.11	1.68	0.72	2.57	1.37	1.91	2.53	2.69	1.49	1.39	2.11	1.19	1.75	3.06	1.72
Mar	I	1.50	1.54	0.89	0.74	2.00	1.41	1.12	1.41	0.97	1.79	1.09	1.23	0.65	2.09	1.20	1.95	1.96	2.18	0.98	0.73	1.61	0.93	1.26	4.74	1.50
	II	1.47	0.96	0.74	0.55	2.89	1.22	1.09	1.62	0.89	1.14	1.05	1.01	0.65	1.69	1.51	3.37	1.51	1.66	0.96	0.71	1.17	0.91	1.05	5.33	1.46
	III	1.28	0.78	0.56	0.56	1.72	0.82	2.41	1.08	0.79	0.89	0.99	0.85	1.35	1.21	1.28	1.50	1.54	4.62	1.02	0.64	0.99	0.83	1.08	2.90	1.32
Apr	I	1.39	0.71	0.51	0.74	1.73	2.03	3.65	1.29	0.65	0.72	0.72	1.31	0.71	4.39	1.49	0.25	1.49	3.32	1.01	0.51	0.94	1.70	0.82	2.38	1.44
	II	1.53	0.47	1.18	0.49	1.48	4.41	2.52	0.77	0.54	0.99	1.45	1.24	0.53	1.41	1.91	3.63	1.68	2.17	0.92	0.42	2.02	1.66	0.76	2.32	1.52
	III	1.57	0.95	0.57	0.29	1.67	3.84	2.13	0.60	0.29	1.04	1.40	0.68	0.44	4.07	1.82	1.49	1.69	1.62	0.73	0.41	2.25	1.26	2.18	2.47	1.48
May	I	1.54	0.47	0.33	0.41	2.02	2.83	2.73	0.89	0.69	1.10	0.61	0.63	0.25	3.12	3.90	3.45	1.57	1.04	0.73	1.23	1.57	1.14	2.26	2.07	1.52
	II	1.38	0.25	0.25	0.51	3.03	2.36	1.37	1.16	1.18	0.82	0.30	0.46	0.14	1.64	1.29	0.59	1.39	0.74	4.30	0.51	1.11	1.05	0.73	2.86	1.23
	III	1.76	1.15	1.48	1.23	1.79	2.90	0.88	0.39	1.05	2.17	0.27	1.64	0.05	1.21	0.83	0.93	1.38	0.48	6.31	9.71	0.87	0.58	0.76	3.34	1.80
Inflow (MCM) =		**1268**	**1271**	**1223**	**803**	**2140**	**1603**	**1195**	**580**	**1123**	**1705**	**845**	**1222**	**523**	**1803**	**980**	**888**	**1853**	**1538**	**1140**	**618**	**1877**	**743**	**1593**	**1676**	**1259**

Table 5.68: 10-Daily Average Flow Series (m^3/s) at Nugur-I Dam

Catchment Area =23,522 km^2 All 10-daily flows in m^3/s.

Period		1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
JUN	I	959.05	544.46	533.05	399.93	283.29	209.75	459.52	231.31	247.79	320.05	1286.15	1130.21	710.55	217.36	661.11	385.98	842.41	406.27	1620.87	552.07	396.13	526.71	363.16	836.07	483.61
	II	1516.90	1128.94	1793.29	1653.83	1650.03	597.71	1327.99	777.75	1197.40	2365.09	1454.78	3480.80	683.93	644.62	3712.81	449.38	483.61	1132.74	884.25	484.87	695.34	994.55	748.59	3509.96	957.78
	III	1322.92	971.73	672.52	810.71	1449.71	1199.94	574.89	934.96	985.67	639.55	1175.85	842.41	1534.65	618.00	450.64	2423.41	1011.03	4847.54	1424.35	952.71	727.03	751.12	1355.89	1908.67	1059.21
JUL	I	1080.76	1606.92	820.85	1254.46	3416.14	837.34	852.55	900.73	2044.33	586.30	1362.22	3973.99	355.55	1603.12	1147.96	995.82	4611.72	965.39	1208.82	1712.15	1634.81	1147.96	1535.92	990.75	576.16
	II	1765.40	2495.68	1563.81	2612.32	2128.00	2740.37	2199.00	814.52	1572.69	1393.92	2685.86	1539.72	1675.38	2193.93	1566.35	918.48	1112.46	1665.24	733.37	3435.15	1450.97	875.37	1382.51	1341.94	2271.27
	III	1452.24	2609.79	3812.97	1670.31	2010.09	3195.53	2597.11	2792.36	1172.05	1518.17	623.07	1151.76	888.05	2838.00	2108.99	1800.90	2117.86	861.43	2035.45	1589.17	2745.45	1374.90	2704.87	2084.90	3118.19
AUG	I	1221.49	1576.49	1826.26	1401.53	1452.24	1991.08	1908.67	871.57	1319.12	2896.32	1198.67	2543.86	1566.35	2366.36	2128.00	1528.31	4703.00	3800.29	3957.51	848.75	3286.82	1174.58	3474.46	1718.49	1996.15
	II	2405.66	1817.38	2976.19	986.94	1852.88	669.98	2507.09	1861.76	1265.87	817.05	1579.03	2746.71	1450.97	1509.30	1743.85	1838.94	2339.73	1964.45	1691.87	1324.19	1232.90	1477.60	2305.50	1663.97	1216.42
	III	2555.27	1452.24	1396.46	874.10	2537.52	2067.15	1395.19	1991.08	768.87	2415.81	2319.45	848.75	1889.65	3452.90	1274.74	469.66	2030.38	1263.33	1344.48	2256.06	1766.67	2128.00	1229.10	618.00	1567.62
SEP	I	1530.85	700.41	2703.61	2387.91	2912.80	1199.94	959.05	953.98	1284.89	1619.60	702.94	634.48	1191.07	1636.08	960.32	936.23	881.71	2432.29	1913.74	663.64	2424.68	2447.50	2001.22	858.89	2141.95
	II	1283.62	1421.81	249.06	681.39	1205.01	995.82	923.55	1533.38	1004.69	1130.21	525.45	896.93	611.66	877.91	747.32	4231.36	2433.56	896.93	2036.72	251.59	2304.23	2040.52	975.53	861.43	1501.69
	III	903.26	590.11	399.93	1495.35	525.45	728.30	931.16	787.89	623.07	902.00	1049.07	724.50	212.29	1366.03	650.96	427.82	2032.92	1767.94	470.93	789.16	369.50	635.75	866.50	1116.26	435.43
OCT	I	2974.93	924.82	425.29	508.96	624.34	472.20	469.66	256.66	924.82	624.34	316.25	664.91	235.11	2220.56	1448.44	388.52	289.63	1731.17	482.34	654.77	467.13	363.16	477.27	1102.32	231.31
	II	880.44	385.98	287.09	941.30	350.48	1136.55	241.45	259.20	780.28	334.00	199.61	483.61	962.85	200.88	458.25	828.46	203.41	337.80	190.73	179.32	1708.35	263.00	501.36	415.14	1253.19
	III	294.70	184.40	185.66	276.95	354.29	592.64	313.72	365.70	247.79	459.52	172.98	176.79	200.88	829.73	257.93	1316.58	268.07	209.75	199.61	172.98	619.27	217.36	172.98	1575.22	255.39
NOV	I	514.04	545.73	205.95	176.79	283.29	415.14	199.61	233.84	586.30	231.31	180.59	184.40	172.98	189.47	259.20	476.00	691.53	179.32	172.98	235.11	396.13	172.98	1050.33	172.98	172.98
	II	179.32	212.29	222.43	172.98	178.06	181.86	240.18	465.86	516.57	172.98	172.98	639.55	172.98	172.98	203.41	172.98	181.86	172.98	178.06	318.79	378.38	172.98	172.98	172.98	269.34
	III	172.98	190.73	349.22	172.98	190.73	172.98	179.32	285.82	174.25	172.98	179.32	172.98	172.98	172.98	172.98	172.98	197.07	172.98	174.25	172.98	222.43	172.98	172.98	198.34	172.98
DEC	I	118.49	104.11	64.78	75.36	81.97	108.57	72.05	184.59	143.28	116.51	81.64	120.97	42.47	148.40	113.37	163.77	72.55	185.75	119.15	65.61	183.77	76.84	149.06	249.21	118.43
	II	97.34	84.12	47.59	55.03	66.10	86.60	56.02	184.26	92.21	83.62	56.85	93.70	36.52	304.07	75.69	122.46	64.78	142.12	69.41	48.59	137.00	56.68	97.50	179.14	97.39
	III	74.20	75.69	33.38	39.00	54.37	68.75	40.98	117.00	75.52	66.60	43.30	65.61	26.28	189.72	58.17	115.02	60.98	103.95	54.20	34.04	96.84	46.93	86.93	129.56	73.21
JAN	I	66.76	68.09	29.91	33.05	180.63	58.01	34.87	66.93	64.95	59.49	40.32	97.17	20.66	125.93	40.98	92.54	58.34	86.43	50.40	25.28	76.84	44.95	64.12	108.74	66.47
	II	61.64	56.68	25.78	30.24	199.96	55.03	55.53	50.90	57.18	49.58	34.54	68.58	17.52	92.21	34.04	79.82	52.72	74.04	41.15	75.69	56.35	72.71	57.01	87.42	61.93
	III	47.43	51.40	19.50	26.44	111.38	41.48	34.87	46.93	41.64	36.19	27.27	45.61	15.53	111.38	48.09	50.90	47.59	57.01	32.89	35.53	47.43	41.15	54.87	76.68	47.88
FEB	I	44.29	41.15	18.34	21.98	98.82	38.51	30.08	37.84	30.57	34.21	24.62	46.93	13.39	144.77	91.88	47.43	44.45	39.17	30.90	28.75	39.83	31.56	40.82	59.49	44.99
	II	34.70	36.85	16.03	25.45	92.54	29.09	24.79	31.73	21.81	36.85	21.32	36.36	13.06	61.64	36.69	39.50	44.62	44.12	26.77	26.77	33.71	24.62	33.05	53.54	35.23
	III	27.93	35.53	12.56	16.53	41.64	26.61	20.33	25.12	17.19	36.36	18.34	27.76	11.90	42.47	22.64	31.56	41.81	44.45	24.62	22.97	34.87	19.67	28.92	50.57	28.43
MAR	I	24.79	25.45	14.71	12.23	33.05	23.30	18.51	23.30	16.03	29.58	18.01	20.33	10.74	34.54	19.83	32.23	32.39	36.03	16.20	12.06	26.61	15.37	20.82	78.33	24.77
	II	24.29	15.86	12.23	9.09	47.76	20.16	18.01	26.77	14.71	18.84	17.35	16.69	10.74	27.93	24.95	55.69	24.95	27.43	15.86	11.73	19.34	15.04	17.35	88.08	24.20
	III	21.15	12.89	9.25	9.25	28.42	13.55	39.83	17.85	13.06	14.71	16.36	14.05	22.31	20.00	21.15	24.79	25.45	76.35	16.86	10.58	16.36	13.72	17.85	47.92	21.82
APR	I	22.97	11.73	8.43	12.23	28.59	33.55	60.32	21.32	10.74	11.90	11.90	21.65	11.73	72.55	24.62	4.13	24.62	54.87	16.69	8.43	15.53	28.09	13.55	39.33	23.73
	II	25.28	7.77	19.50	8.10	24.46	72.88	41.64	12.72	8.92	16.36	23.96	20.49	8.76	23.30	31.56	59.99	27.76	35.86	15.20	6.94	33.38	27.43	12.56	38.34	25.13
	III	25.95	15.70	9.42	4.79	27.60	63.46	35.20	9.92	4.79	17.19	23.14	11.24	7.27	67.26	30.08	24.62	27.93	26.77	12.06	6.78	37.18	20.82	36.03	40.82	24.42
MAY	I	25.45	7.77	5.45	6.78	33.38	46.77	45.12	14.71	11.40	18.18	10.08	10.41	4.13	51.56	64.45	57.01	25.95	17.19	12.06	20.33	25.95	18.84	37.35	34.21	25.19
	II	22.81	4.13	4.13	8.43	50.07	39.00	22.64	19.17	19.50	13.55	4.96	7.60	2.31	27.10	21.32	9.75	22.97	12.23	71.06	8.43	18.34	17.35	12.06	47.26	20.26
	III	29.09	19.00	24.46	20.33	29.58	47.92	14.54	6.45	17.35	35.86	4.46	27.10	0.83	20.00	13.72	15.37	22.81	7.93	104.28	160.47	14.38	9.58	12.56	55.20	29.72
Inflow (MCM)		20951	17685	18440	16571	21723	18037	16748	15326	15209	17058	15536	20576	13189	21954	18231	18280	23853	22573	18848	15216	20965	15464	19618	19919	18125

Table 5.69: 10-Daily Inflow Series (MCM) at Nugur-I Project Site

Period		1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
JUN	I	828.62	470.42	460.56	345.54	244.76	181.23	397.02	199.85	214.09	276.53	1111.24	976.50	613.92	187.80	571.20	333.49	727.84	351.02	1400.43	476.99	342.25	455.08	313.77	722.36	417.84
	II	1310.60	975.41	1549.40	1428.91	1425.62	516.42	1147.39	671.97	1034.56	2043.44	1256.93	3007.41	590.91	556.95	3207.87	388.26	417.84	978.69	763.99	418.93	600.77	859.29	646.78	3032.60	827.52
	III	1143.00	839.57	581.05	700.45	1252.55	1036.75	496.71	807.81	851.62	552.57	1015.94	727.84	1325.94	533.95	389.36	2093.83	873.53	4188.27	1230.64	823.14	628.16	648.97	1171.49	1649.09	915.16
JUL	I	933.78	1388.38	709.22	1083.85	2951.54	723.46	736.60	778.23	1766.30	506.57	1176.96	3433.53	307.20	1385.09	991.84	860.39	3984.52	834.10	1044.42	1479.30	1412.48	991.84	1327.03	856.00	497.80
	II	1525.31	2156.27	1351.13	2257.05	1838.60	2367.68	1899.94	703.74	1358.80	1204.35	2320.58	1330.32	1447.53	1895.56	1353.32	793.57	961.16	1438.77	633.63	2967.97	1253.64	756.32	1194.49	1159.44	1962.38
	III	1380.21	2480.34	3623.85	1587.46	1910.39	3037.03	2468.29	2653.86	1113.91	1442.87	592.17	1094.63	844.00	2697.23	2004.38	1711.58	2012.82	818.70	1934.49	1510.35	2609.27	1306.71	2570.71	1981.49	2963.53
AUG	I	1055.37	1362.09	1577.89	1210.92	1254.74	1720.29	1649.09	753.03	1139.72	2502.42	1035.65	2197.89	1353.32	2044.53	1838.60	1320.46	4063.39	3283.45	3419.29	733.32	2839.81	1014.84	3001.93	1484.78	1724.67
	II	2078.49	1570.22	2571.43	852.72	1600.89	578.86	2166.13	1608.56	1093.71	705.93	1364.28	2373.16	1253.64	1304.03	1506.68	1588.84	2021.53	1697.29	1461.77	1144.10	1065.23	1276.65	1991.95	1437.67	1050.99
	III	2428.53	1380.21	1327.19	830.75	2411.66	1964.62	1325.99	1892.32	730.74	2295.98	2204.40	806.65	1795.92	3281.64	1211.52	446.37	1929.67	1200.67	1277.79	2144.16	1679.04	2022.46	1168.14	587.35	1489.86
SEP	I	1322.65	605.15	2335.92	2063.16	2516.66	1036.75	828.62	824.24	1110.14	1399.33	607.34	548.19	1029.08	1413.57	829.71	808.90	761.80	2101.50	1653.47	573.39	2094.92	2114.64	1729.05	742.08	1850.65
	II	1109.05	1228.45	215.18	588.72	1041.13	860.39	797.95	1324.84	868.05	976.50	453.99	774.94	528.47	758.51	645.68	3655.90	2102.59	774.94	1759.73	217.37	1990.86	1763.01	842.86	744.27	1297.46
	III	780.42	509.85	345.54	1291.98	453.99	629.25	804.52	680.74	538.33	779.33	906.39	625.97	183.42	1180.25	562.43	369.64	1756.44	1527.50	406.88	681.83	319.25	549.29	748.65	964.45	376.21
OCT	I	2570.34	799.04	367.45	439.74	539.43	407.98	405.79	221.76	799.04	539.43	273.24	574.48	203.13	1918.56	1251.45	335.68	250.24	1495.73	416.74	565.72	403.60	313.77	412.36	952.40	199.85
	II	760.70	333.49	248.05	813.28	302.82	981.98	208.61	223.95	674.16	288.58	172.46	417.84	831.91	173.56	395.93	715.79	175.75	291.86	164.79	154.94	1476.01	227.23	433.17	358.68	1082.76
	III	280.08	175.25	176.45	263.21	336.71	563.25	298.16	347.56	235.50	436.73	164.40	168.02	190.91	788.57	245.14	1251.28	254.78	199.35	189.71	164.40	588.55	206.58	164.40	1497.09	242.73
NOV	I	444.13	471.51	177.94	152.75	244.76	358.68	172.46	202.04	506.57	199.85	156.03	159.32	149.46	163.70	223.95	411.26	597.49	154.94	149.46	203.13	342.25	149.46	907.49	149.46	149.46
	II	154.94	183.42	192.18	149.46	153.84	157.13	207.52	402.50	446.32	149.46	149.46	552.57	149.46	149.46	175.75	149.46	157.13	149.46	153.84	275.43	326.92	149.46	149.46	149.46	232.71
	III	149.46	164.79	301.72	149.46	164.79	149.46	154.94	246.95	150.55	149.46	154.94	149.46	149.46	149.46	149.46	149.46	170.27	149.46	150.55	149.46	192.18	149.46	149.46	171.37	149.46
DEC	I	102.38	89.95	55.97	65.11	70.82	93.81	62.25	159.49	123.79	100.66	70.53	104.52	36.70	128.22	97.95	141.50	62.68	160.49	102.95	56.68	158.77	66.39	128.79	215.32	102.32
	II	84.10	72.68	41.12	47.55	57.11	74.82	48.40	159.20	79.67	72.25	49.12	80.96	31.55	262.72	65.39	105.80	55.97	122.79	59.97	41.98	118.37	48.97	84.24	154.78	84.15
	III	64.11	65.39	28.84	33.70	46.98	59.40	35.41	101.09	65.25	57.54	37.41	56.68	22.70	163.91	50.26	99.38	52.69	89.81	46.83	29.41	83.67	40.55	75.10	111.94	63.25
JAN	I	57.68	58.83	25.84	28.56	156.06	50.12	30.13	57.83	56.11	51.40	34.84	83.96	17.85	108.80	35.41	79.96	50.40	74.68	43.55	21.85	66.39	38.84	55.40	93.95	57.43
	II	53.26	48.97	22.27	26.13	172.77	47.55	47.97	43.98	49.40	42.83	29.84	59.25	15.13	79.67	29.41	68.96	45.55	63.97	35.55	65.39	48.69	62.82	49.26	75.53	53.51
	III	45.08	48.85	18.53	25.13	105.86	39.42	33.14	44.61	39.58	34.40	25.92	43.35	14.76	105.86	45.70	48.37	45.23	54.19	31.26	33.77	45.08	39.11	52.14	72.88	45.51
FEB	I	38.27	35.55	15.85	18.99	85.38	33.27	25.99	32.70	26.41	29.56	21.27	40.55	11.57	125.08	79.39	40.98	38.41	33.84	26.70	24.84	34.41	27.27	35.27	51.40	38.87
	II	29.98	31.84	13.85	21.99	79.96	25.13	21.42	27.41	18.85	31.84	18.42	31.41	11.28	53.26	31.70	34.13	38.55	38.12	23.13	23.13	29.13	21.27	28.56	46.26	30.44
	III	26.54	33.77	11.94	15.71	39.58	25.29	19.32	23.87	16.33	34.55	17.43	26.39	11.31	40.36	21.52	30.00	39.74	42.25	23.40	21.83	33.14	18.69	27.49	48.06	27.02
MAR	I	21.42	21.99	12.71	10.57	28.56	20.13	15.99	20.13	13.85	25.56	15.56	17.56	9.28	29.84	17.13	27.84	27.99	31.13	13.99	10.42	22.99	13.28	17.99	67.68	21.40
	II	20.99	13.71	10.57	7.85	41.26	17.42	15.56	23.13	12.71	16.28	14.99	14.42	9.28	24.13	21.56	48.12	21.56	23.70	13.71	10.14	16.71	12.99	14.99	76.10	20.91
	III	18.28	11.14	8.00	8.00	24.56	11.71	34.41	15.42	11.28	12.71	14.14	12.14	19.28	17.28	18.28	21.42	21.99	65.97	14.56	9.14	14.14	11.85	15.42	41.41	18.85
APR	I	19.85	10.14	7.28	10.57	24.70	28.98	52.12	18.42	9.28	10.28	10.28	18.70	10.14	62.68	21.27	3.57	21.27	47.40	14.42	7.28	13.42	24.27	11.71	33.98	20.50
	II	21.85	6.71	16.85	7.00	21.13	62.97	35.98	10.99	7.71	14.14	20.70	17.71	7.57	20.13	27.27	51.83	23.99	30.98	13.14	6.00	28.84	23.70	10.85	33.13	21.71
	III	24.66	14.92	8.95	4.55	26.23	60.31	33.45	9.42	4.55	16.33	21.99	10.68	6.91	63.92	28.59	23.40	26.54	25.44	11.47	6.44	35.34	19.79	34.24	38.79	23.21
MAY	I	21.99	6.71	4.71	5.85	28.84	40.41	38.98	12.71	9.85	15.71	8.71	9.00	3.57	44.55	55.69	49.26	22.42	14.85	10.42	17.56	22.42	16.28	32.27	29.56	21.76
	II	19.70	3.57	3.57	7.28	43.26	33.70	19.56	16.56	16.85	11.71	4.28	6.57	2.00	23.42	18.42	8.42	19.85	10.57	61.40	7.28	15.85	14.99	10.42	40.84	17.50
	III	25.13	16.42	21.13	17.56	25.56	41.41	12.56	5.57	14.99	30.98	3.86	23.42	0.71	17.28	11.85	13.28	19.70	6.85	90.10	138.64	12.42	8.28	10.85	47.69	25.68
Inflow (MCM)		20951	17685	18440	16571	21723	18037	16748	15326	15209	17058	15536	20576	13189	21954	18231	18280	23853	22573	18848	15216	20965	15464	19618	19919	18125

5.6.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.70** and **Table 5.71**.

Table 5.70: Computation of 90% and 50% Dependable Year for Nugur-I Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.04	23853	2006-07	
2	0.08	22573	2007-08	
3	0.12	21954	2003-04	
4	0.15	21723	1994-95	
5	0.19	20965	2010-11	
6	0.23	20951	1990-91	
7	0.27	20576	2001-02	
8	0.31	19919	2013-14	
9	0.35	19618	2012-13	
10	0.38	18848	2008-09	
11	0.42	18440	1992-93	
12	0.46	18280	2005-06	
13	**0.50**	**18231**	**2004-05**	**50% Dependable**
14	0.54	18125	2014-15	
15	0.58	18037	1995-96	
16	0.62	17685	1991-92	
17	0.65	17058	1999-00	
18	0.69	16748	1996-97	
19	0.73	16571	1993-94	
20	0.77	15536	2000-01	
21	0.81	15464	2011-12	
22	0.85	15326	1997-98	
23	**0.88**	**15216**	**2009-10**	**90% Dependable**
24	0.92	15209	1998-99	
25	0.96	13189	2002-03	

Table 5.71: 90% and 50% Dependable Flows for the Nugur-I Dam Site (cumec)

		90% Dependable (cumec)	50% Dependable (cumec)
Period		**2009-2010**	**2004-2005**
Jun	**I**	552.07	661.11
	II	484.87	3712.81
	III	952.71	450.64
Jul	**I**	1712.15	1147.96
	II	3435.15	1566.35
	III	1589.17	2108.99
Aug	**I**	848.75	2128.00
	II	1324.19	1743.85
	III	2256.06	1274.74
Sep	**I**	663.64	960.32
	II	251.59	747.32
	III	789.16	650.96
Oct	**I**	654.77	1448.44
	II	179.32	458.25
	III	172.98	257.93
Nov	**I**	235.11	259.20
	II	318.79	203.41
	III	172.98	172.98
Dec	**I**	65.61	113.37
	II	48.59	75.69
	III	34.04	58.17
Jan	**I**	25.28	40.98
	II	75.69	34.04
	III	35.53	48.09
Feb	**I**	28.75	91.88
	II	26.77	36.69
	III	22.97	22.64
Mar	**I**	12.06	19.83
	II	11.73	24.95
	III	10.58	21.15
Apr	**I**	8.43	24.62
	II	6.94	31.56
	III	6.78	30.08
May	**I**	20.33	64.45
	II	8.43	21.32
	III	160.47	13.72
Inflow (MCM) =		15216	18231

5.6.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Nugur-I, is given in the following section.

5.6.5.1 EAC of Nugur-I Dam

The EAC curve and the table showing the different values are given in **Figure 5.41** and **Table 5.72** respectively.

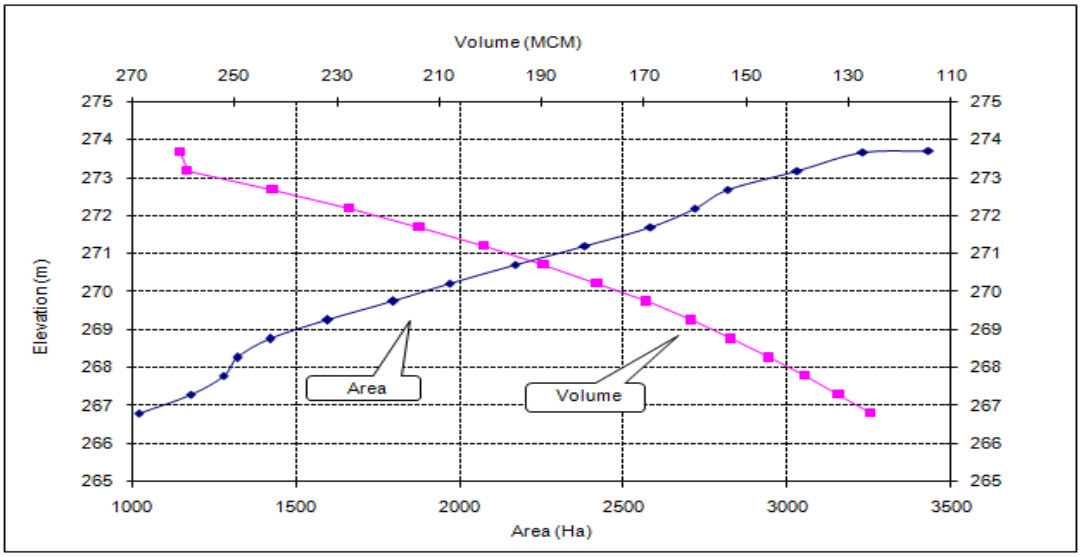


Figure 5.41: EAC curve of Nugur-I Dam

Table 5.72: EAC data of Nugur-I Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
266.8	10224944.12	1022.49	119895212.2	119.90
267.29	11805368.70	1180.54	125653992.2	125.65
267.78	12805368.70	1280.54	131928497.8	131.93
268.27	13229439.93	1322.94	138587487	138.59
268.76	14229439.93	1422.94	145560207.8	145.56
269.25	15973833.24	1597.38	152968592.8	152.97
269.74	17973833.24	1797.38	160795615.1	160.80
270.23	19689945.23	1968.99	169477871.4	169.48
270.72	21689945.23	2168.99	179125752.3	179.13
271.21	23822194.12	2382.22	189641370.1	189.64
271.7	25822194.12	2582.22	201314739.6	201.31
272.19	27178010.92	2717.80	213814997.9	213.81
272.68	28178010.92	2817.80	227621948.1	227.62
273.17	30315795.48	3031.58	242473264	242.47
273.66	32315795.48	3231.58	259287668.6	259.29
273.7	34315795.48	3431.58	260660593.7	260.66

5.6.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.6.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Tumnar G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Tumnar G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{\text{Nugur I}}}{A_{\text{Tumnar}}}\right)^{\frac{3}{4}} = 7.17$$

Using the above multiplying factors to the peak flows at the Tumnar G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.73**.

Table 5.73: Final Peak Flows (cumec) at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1992	1677.03	2180.14	15640.59
1993	514.92	669.40	4802.33
1994	1682.82	2187.67	15694.59
1995	1279.47	1663.31	11932.80
1996	1328.62	1727.21	12391.19
1997	466.60	606.58	4351.68
1998	827.70	1076.01	7719.43
1999	991.10	1288.43	9243.36
2000	534.32	694.62	4983.26
2001	1179.32	1533.12	10998.77
2002	658.42	855.95	6140.66
2003	1329.62	1728.51	12400.52
2004	3584.01	4659.21	33425.78
2005	714.03	928.24	6659.30
2006	2757.23	3584.40	25714.93

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2007	3193.27	4151.25	29781.60
2008	1564.25	2033.53	14588.76
2009	599.47	779.31	5590.88
2010	1923.69	2500.80	17941.03
2011	407.01	529.11	3795.92
2012	790.67	1027.87	7374.08
2013	1004.83	1306.28	9371.41

5.6.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.74**.

Table 5.74: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	12297.40
Variance	67458667.98
SD (Sx)	8213.32
Skewness	1.38
Kurtosis	1.36
No. of Data	22

5.6.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.75**.

The detailed procedure for Gumbel distribution method for Nugur-I dam site has been shown in **Annexure-5**.

Table 5.75: Detail of different year Return Period Flood (cumec) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	11064
2	5	19633
3	10	25307
4	20	30749
5	25	32475
6	50	37793
7	100	43071
8	500	55269

Annexure-5 (Flood Frequency Analysis for Nugur-I Dam)

DESIGN FLOOD-Nugur I

CA at G&D = 1700 | CA = 23522

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	1992	1677.03	2180.14	15640.59	9.66
2	1993	514.92	669.40	4802.33	8.48
3	1994	1682.82	2187.67	15694.59	9.66
4	1995	1279.47	1663.31	11932.80	9.39
5	1996	1328.62	1727.21	12391.19	9.42
6	1997	466.60	606.58	4351.68	8.38
7	1998	827.70	1076.01	7719.43	8.95
8	1999	991.10	1288.43	9243.36	9.13
9	2000	534.32	694.62	4983.26	8.51
10	2001	1179.32	1533.12	10998.77	9.31
11	2002	658.42	855.95	6140.66	8.72
12	2003	1329.62	1728.51	12400.52	9.43
13	2004	3584.01	4659.21	33425.78	10.42
14	2005	714.03	928.24	6659.30	8.80
15	2006	2757.23	3584.40	25714.93	10.15
16	2007	3193.27	4151.25	29781.60	10.30
17	2008	1564.25	2033.53	14588.76	9.59
18	2009	599.47	779.31	5590.88	8.63
19	2010	1923.69	2500.80	17941.03	9.79
20	2011	407.01	529.11	3795.92	8.24
21	2012	790.67	1027.87	7374.08	8.91
22	2013	1004.83	1306.28	9371.41	9.15
	X_T	=	$X_m+K.S_x$		

Conversion factor = 7.17

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	12297.40	9.23
Variance	67458667.98	0.387
SD (Sx)	8213.32	0.622
Skewness	1.38	0.27990
Kurtosis	1.36	-0.70295
No. of Data	22	

(GUMBEL PROB. DISTRIBUTION METHOD)

	N	=	22
Reduced mean =	Y_n	=	0.530
Reduced Std. Dev =	S_n	=	1.09
Reduced Variate =	Y_T	=	$-(\ln.\ln(T/T-1))$
Frequency factor =	K	=	$(Y_T-Y_n)/S_n$
	X_T	=	$X_m+K.S_x$
Confidence Band =	$f_{(C)}.S_e$		
	Se	=	$b.Sx/\sqrt{n}$
	b	=	$\sqrt{(1+1.3K+1.1K^2)}$
	X_{cl}	=	$X_T \pm f_{(C)}.Se$

From Table (Interpolate)

$f_{(C)}$ = 1.645 (90% confidence probability)

90% CONFIDENCE INTERVAL

(X_{cl} Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	**11064**	0.367	-0.150	0.911	1594.966	2623.719	8441	13688
2	5	**19633**	1.500	0.893	1.743	3052.445	5021.272	14612	24655
3	10	**25307**	2.250	1.584	2.412	4223.990	6948.464	18358	32255
4	20	**30749**	2.970	2.246	3.078	5389.215	8865.259	21883	39614
5	25	**32475**	3.199	2.457	3.291	5763.301	9480.630	22994	41956
6	50	**37793**	3.902	3.104	3.954	6923.912	11389.835	26403	49183
7	100	**43071**	4.600	3.747	4.617	8084.147	13298.421	29773	56370
8	500	**55269**	6.214	5.232	6.157	10781.966	17736.335	37533	73006

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	11064
2	5	19633
3	10	25307
4	20	30749
5	25	32475
6	50	37793
7	100	43071
8	500	55269

5.7 Hydrology of Kotri Hydroelectric Project

5.7.1 General

The present project, Kotri, envisages harnessing water from the River Kotri and other small rivers. Kotri River (also known as Paralkota river) is a tributary of Indravati River that flows through Chhattisgarh and Gadchiroli district of Maharashtra. The project is proposed to be of storage type with the multiple functions of irrigation and power.

5.7.1.1 Description of Dam Sites

The catchment area of the dam site which comes out to be 6,091 km^2. The dam site is located in Bastar district of Chattisgarh at 19° 39' 48.8" N, 80° 40' 06.6" E. Catchment area of project and Locations of the dam site and of G&D site are shown in **Figure 5.42**.

5.7.1.2 Description of G&D Site

Tumnar G&D site is situated in the Dantewada district of Chattisgarh at 82° 07' 10" E, 18° 36' 04" N. Catchment area of the G&D site is around 1,700 km^2.

5.7.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometres draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sealevels.

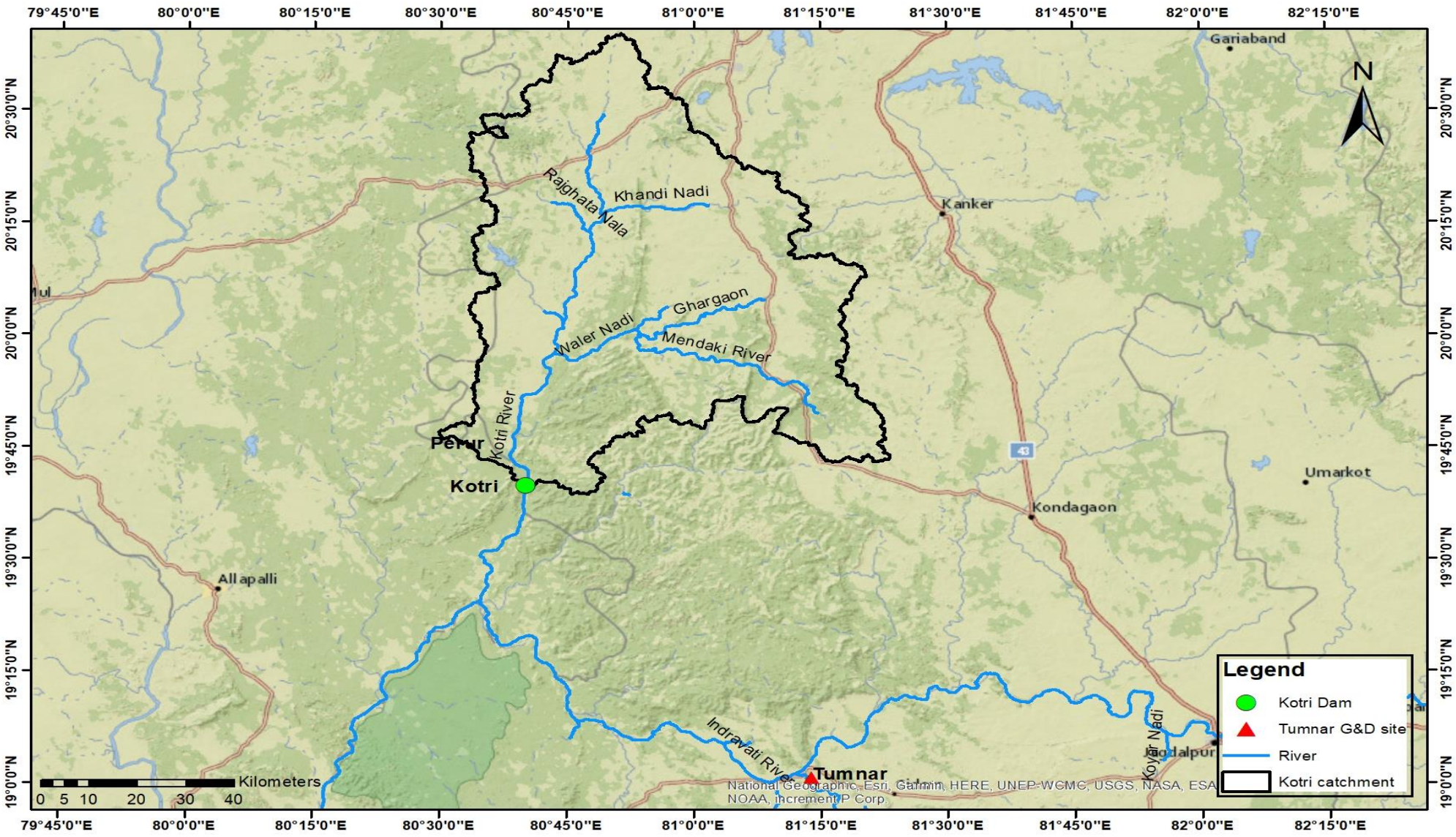


Figure 5.42: Catchment Area of Project and Locations of Dam and G&D site

5.7.2 Water Availability Studies

5.7.2.1 Data Availability

The discharge data at the Central Water Commission(CWC) G&D site, namely Tumnar (Catchment Area=1,700 km^2), which is adjoining basin of the project site along the Indravati River, is available and can be downloaded from India WRIS site. The G&D site lies in the Dantewada district of Chattisgarh.

Generally, 25-year flow series data is required for a Storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.7.2.2 Rainfall data

Indian Meteorological Department (IMD) daily rainfall grid data with a resolution of 0.25 degree x 0.25 degree from 1990 to 2015 is available. Average daily rainfall (in mm) have been calculated at each grid point (as can been seen from **Figure 5.43**) within the boundary of the Tumnar G&D site and Kotri dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.43**, 5 grid points is considered to assess the catchment rainfall for Tumnar G&D site and 7 grid points have been considered for the assessment of rainfall in Kotri proposed dam site. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations

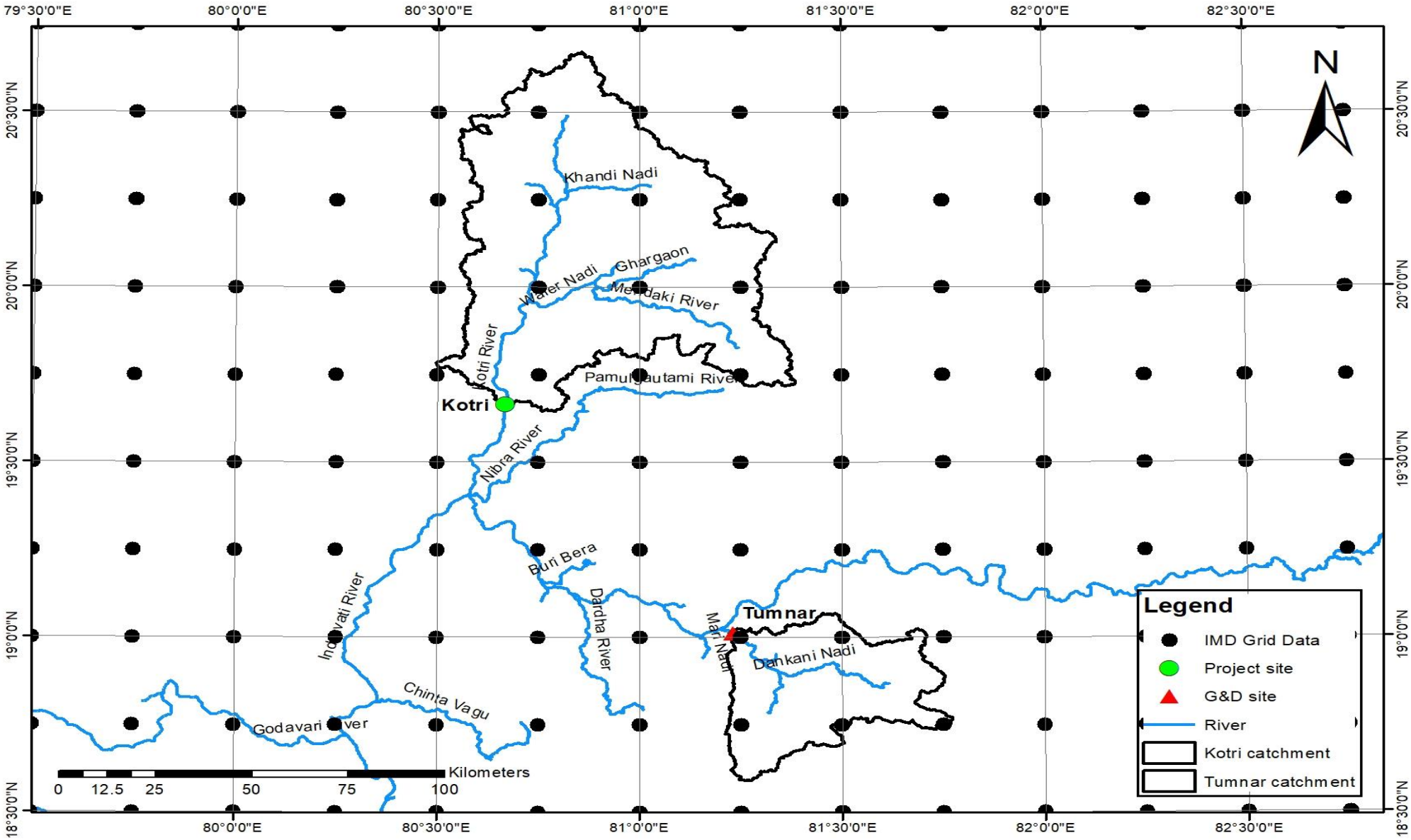


Figure 5.43: IMD Grid Rainfall Data for Kotri Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfalls for the last 25 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.76**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.77** and **Table 5.78** respectively.

Table 5.76: Average Annual Rainfall (in mm)

Year	Tumnar	Kotri
1990-1991	1669	1983
1991-1992	1287	1314
1992-1993	1397	1542
1993-1994	1460	1189
1994-1995	1947	2119
1995-1996	1426	1318
1996-1997	1453	1151
1997-1998	975	1373
1998-1999	1455	1081
1999-2000	1674	1345
2000-2001	1376	995
2001-2002	1583	1989
2002-2003	1075	988
2003-2004	2031	1686
2004-2005	1466	1350
2005-2006	1497	1435
2006-2007	1730	1993
2007-2008	1834	1466
2008-2009	1291	883
2009-2010	1037	1046
2010-2011	1840	1458
2011-2012	1386	1277
2012-2013	1689	1622
2013-2014	1545	1551
2014-2015	1319	1512
AVERAGE (mm)	1498	1427

Table 5.77: 10 Daily Rainfall (in mm) of Tumnar G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	3.91	1.75	2.91	1.35	0.09	0.15	3.49	0.41	0.62	1.04	15.91	6.16	5.24	0.06	1.77	1.8	2.36	1.19	9.63	1.96	1.68	1.97	2.19	7.34	1.33
	II	17.74	4.59	8.75	9.72	13.41	4.17	18.09	4.93	12.93	19.85	8.03	22.89	3.15	3.34	22.76	1.72	2.46	4.73	4.89	2.81	6.85	4.05	4.63	20.04	6.86
	III	12.19	6.16	5.58	3.24	10.84	7.92	1.06	5.16	6.08	5.06	8.33	3.13	12.17	2.7	5.67	14.81	5.9	19.64	8.74	2.69	4.56	6.92	9.92	12.67	4.99
JUL	I	11.63	14.29	3.19	11.47	27.84	4.55	4.27	6.04	19.66	2.68	13.14	25.37	1.01	11.83	10.54	8.95	17.84	8.02	11.92	18.19	11.18	10.51	12.2	12.49	4.25
	II	15.48	14.84	8.92	19.55	16.98	22.16	8.62	2.57	12.47	15.63	16.72	8.22	11.06	14.57	15.88	6.29	9.66	15.51	3.11	23.52	9	7.9	9.91	11.99	14.58
	III	13.47	12.36	27.09	13.72	16.02	23.9	25.01	18.04	9.75	21.99	7.13	8.53	4.21	24.38	20.55	14.23	13.84	3	14.68	6.7	25.41	8.44	19.36	14.15	18.05
AUG	I	6.27	15.51	9.52	16.55	11.49	15.22	18.2	3.67	11.31	27.86	12.39	19.65	16.83	18.15	18.37	9.74	36.4	22.38	21.39	2.35	23.51	10.63	26.37	11.26	6.95
	II	19.95	10.5	21.37	6.74	18.43	4.8	13.97	6.48	7.65	6.98	10.94	21.08	13	12.46	11.88	12.27	18.78	11.02	9.17	5.76	13.25	8.47	17.39	17.3	7.23
	III	12.51	10.57	12.12	9.11	22.87	17.05	13.65	12.95	4.3	18.13	14.05	4.98	14.25	35.22	3.29	2.11	6.94	11.59	6.21	11.08	13.93	20.5	10.76	1.94	14.98
SEP	I	5.45	2.88	23.1	16.56	18.42	8.41	7.19	4.5	11.59	13.03	6.49	2.99	7.52	7.64	4.51	7.76	3.92	19.48	15.76	4.48	16.56	12.67	15.41	4.44	12.28
	II	5.44	17.08	0.66	2.74	5.52	6.08	7.32	6.55	12.82	9.18	1.8	3.3	2.34	4.49	3.67	25.21	32.88	10.27	5.55	0.26	18.22	19.05	10.74	5.1	15.24
	III	6.18	2.12	3.31	13.58	0.63	2.4	3.66	3.89	5.1	6.71	5	7.03	0.07	9.25	5.28	5.18	6.17	15.39	0.87	3.84	3.37	2.38	6.35	5.27	1.79
OCT	I	20.18	5.05	0.62	4.68	5.19	2.29	1.95	0.46	11.35	4.15	0.51	6.34	0.17	18.62	4.09	1.86	0.25	26.25	0.91	1.88	1.69	3.7	2.84	4.33	0.27
	II	6.36	1.67	0.23	6.32	0.16	11.83	0.01	0.2	5.96	0.78	0.01	1.79	6.34	0.34	0.91	5.75	0.34	2.06	0	0.02	9.43	0.3	0.08	1.29	9.19
	III	1.83	0.03	0.57	1.35	2.09	2.4	0.47	0.75	0.63	2.54	0	0.01	0	4.9	1.12	13.32	0.65	0.45	0.12	0	2	0	0	11.98	0.24
NOV	I	0.8	2.99	0.04	0	0.84	0.07	0.19	1.13	2.72	0.09	0.27	0.09	0	0.37	0.08	3.08	5.19	0.07	0	0.29	1.32	0	4.47	0	0.02
	II	0.02	0.58	1.03	0	0.04	0	0.7	4.27	2.21	0	0	5.34	0	0	0.83	0	0.24	0	0.07	1.17	2.79	0	0	0.01	2.85
	III	0.02	0	0.07	0	0.23	0	0.19	0.45	0	0	0.07	0	0	0	0	0	0.66	0	0.04	0	1.03	0	0	0.25	0
DEC	I	0.03	0	0	0	0	0	0.22	1.35	0	0	0.04	0	0	0	0	0	0.61	0	0	0	1.92	0	0	0	0
	II	0.18	0	0	0	0	0	0	0.89	0	0	0	0	0	4.1	0.1	0	0.21	0	0	0	1.21	0.02	0	0	0
	III	0	0.01	0	0	0	0	0.15	0.31	0	1.07	0	0	0	0.4	0	0	0	0	0	0	0	0.08	0	0	0
JAN	I	1.57	0.05	0	0	4.93	0.07	0.07	0.37	0	0.67	0.02	2.09	0	0	0	0	0	0	0	0	0	2.42	0	0	0.13
	II	0.11	0	0	0.03	0.46	0	0.41	0.25	0	0.7	0	0	0	1.13	0	0	0	0	0	0.75	0	0.1	0	0	0
	III	0	0	0	0	0	0	0.01	0	0	0	0	1.03	0	7.96	3.12	0	0	0.64	0	0	0	0	0	0	0
FEB	I	0	0	0	0.09	0	0.16	0.24	1.03	0	0	0	0	0	5.22	0.91	0	0	0.02	0	0.22	0	0	0	0	0
	II	0	0	0	0.46	0	0.03	0.1	0	0	0.19	0	0.17	1.04	0	0	0	0.64	0.56	0	0.15	0.01	0	0.49	0.03	0
	III	0	0.46	0	0	0	0	0	0.01	0	0.18	0	0.32	0.56	0	0	0	0	0	0	0.3	0.6	0	0	0	0.18
MAR	I	0	0	0.63	0.01	0	0.55	0	0.04	0	0	0.13	0	0.05	0	0	0.08	0	0	0	0	0	0	0	2.4	0.29
	II	0	0	0	0	1.16	0	0	0	0.04	0	0.18	0	0.89	0	0.09	1.4	0	0.6	0	0	0	0	0.26	0.01	0.01
	III	0	0	0	0	0.28	0	2.28	0.04	0	0.02	0.01	0.17	3.11	0.03	0	0.13	0	4.66	1.5	0.87	0.01	0.22	0	0	0.24
APR	I	0.05	0.11	0.04	0.17	0.58	0.08	2.58	0.76	0	0.07	0.47	1.33	1.35	0.94	0.26	0.69	0	0.67	0.45	0	0.5	1.23	0.39	0.02	0
	II	0.02	0	2.02	0.02	0.3	0.94	1.73	0	0	2.04	5.12	0.8	0.31	0	0.44	4.9	1.17	0	0	0.51	0.68	0	3.82	2.34	1.1
	III	0.24	0.31	0.45	0.66	0.79	1.9	2.36	1.02	0	0.01	0.24	0	0.73	5.95	2.69	0.39	0	0.08	0	4.68	4.21	6.65	4.67	0.79	3.08
MAY	I	0.12	0.28	0	2.01	2.75	0.77	2.01	2.96	1.33	1.31	1.99	0.02	0	0.49	2.06	0.77	1.7	0.67	2.73	1.58	1.91	2.49	0.02	2.65	1.87
	II	1.19	0	1.23	1.08	7.1	0.14	0.65	2.38	2.42	0.09	0.88	1.31	0	1.06	0	2.87	0.24	0.03	3.62	0.34	0.58	4.78	1.06	1.29	0.61
	III	1.1	2.13	2.07	2.16	1.07	0.17	0.29	0.37	2.83	0.92	5.06	2.53	0.08	0.2	2.62	1.28	1.62	2.19	4.99	5	2.33	0.2	2.33	0.25	0.01
Yearly Rainfall (mm)		1669	1287	1397	1460	1947	1426	1453	975	1455	1674	1376	1583	1075	2031	1466	1497	1730	1834	1291	1037	1840	1386	1689	1545	1319

Table 5.78: 10 Daily Rainfall (in mm) of Kotri Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	3.17	2.68	1.53	1.14	1.06	0.00	0.30	0.01	0.24	0.16	5.38	7.95	2.15	0.18	0.53	0.47	3.64	0.43	5.77	2.98	0.59	2.08	0.19	2.94	0.70
	II	18.80	6.73	14.19	10.82	12.11	4.29	11.57	4.47	3.61	17.14	8.13	43.31	6.24	3.45	8.66	3.27	0.57	6.92	5.24	0.67	4.15	3.30	7.67	18.64	3.29
	III	15.05	3.77	1.93	6.04	16.83	8.79	2.26	4.43	7.76	6.43	6.54	6.28	14.29	6.98	0.93	17.96	3.82	32.94	7.92	2.22	2.98	7.13	5.85	13.45	1.70
JUL	I	15.21	9.49	3.14	12.12	34.31	5.33	6.34	6.17	19.21	4.89	4.09	29.76	0.87	10.41	3.58	16.14	42.59	10.21	8.13	8.78	11.16	8.31	12.71	6.19	6.65
	II	15.78	21.37	6.69	15.14	35.81	31.03	4.89	6.22	8.43	9.13	25.21	10.16	11.73	21.14	11.17	6.17	11.32	5.59	3.16	25.00	9.48	10.12	13.37	10.32	18.71
	III	13.70	28.26	37.48	9.38	13.08	23.92	18.63	42.30	5.26	11.10	3.16	8.48	3.22	19.24	13.92	13.23	25.06	5.71	8.89	10.31	16.23	12.98	21.38	26.28	32.50
AUG	I	7.47	10.18	12.82	9.78	11.59	19.71	18.46	8.85	10.41	22.05	3.56	16.83	11.21	17.82	27.92	18.40	26.98	28.46	21.87	3.31	21.36	11.65	19.35	14.55	19.45
	II	25.50	20.29	30.14	16.71	14.09	3.12	19.48	13.96	11.28	5.29	12.69	50.25	14.63	8.20	8.10	13.37	16.50	9.21	5.00	9.07	12.25	11.62	19.43	14.44	3.64
	III	31.53	11.26	16.97	7.23	27.58	11.04	10.11	24.91	6.62	16.24	10.48	7.04	13.30	24.24	19.60	7.59	21.59	8.06	4.91	15.71	11.54	13.15	14.67	6.03	8.35
SEP	I	11.03	2.41	15.80	17.15	19.12	13.24	4.12	5.49	9.97	11.97	1.98	0.52	12.53	13.35	5.73	4.51	9.07	15.92	5.35	6.46	24.33	28.23	18.91	1.26	22.66
	II	8.11	0.36	4.13	1.08	4.44	2.19	4.89	5.47	6.85	9.26	2.22	2.38	2.66	5.20	4.05	16.69	7.61	3.34	5.68	0.05	9.56	9.10	6.23	10.45	5.54
	III	3.16	2.78	0.07	3.77	0.56	0.04	1.68	1.95	5.59	4.00	3.72	0.71	0.00	8.01	7.22	1.07	18.63	9.24	3.08	0.94	0.46	3.08	8.89	5.40	3.21
OCT	I	17.53	6.11	0.32	1.37	2.62	0.54	0.55	0.01	3.80	5.96	0.64	5.27	0.15	10.11	1.77	0.20	0.06	3.53	0.57	3.69	0.91	0.29	2.76	9.92	0.45
	II	3.33	1.08	0.03	4.70	3.27	3.02	0.00	0.00	4.19	1.46	0.00	3.13	1.62	0.10	1.21	5.56	0.00	0.00	0.66	0.00	8.52	1.06	0.04	3.35	9.36
	III	1.42	0.00	0.00	0.19	0.02	0.92	2.68	0.67	1.66	3.59	0.00	0.00	0.00	8.95	0.22	2.55	0.31	0.00	0.00	0.00	0.88	0.00	0.00	4.24	0.96
NOV	I	1.68	0.52	0.00	0.00	0.11	0.03	0.02	0.03	0.32	0.00	0.00	0.00	0.00	0.00	0.00	0.28	4.62	0.00	0.00	0.28	0.33	0.00	2.41	0.00	0.00
	II	0.00	0.01	1.12	0.00	0.01	0.00	0.00	0.42	0.76	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.03	0.00	0.00	0.00	0.32
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00
DEC	I	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	3.41	0.00	0.00	0.00	0.00
	II	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.61	0.00	0.00	0.00	0.00	0.00	0.75	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.09	0.00	0.00	0.00	0.30	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.22	0.00	0.02	0.00
JAN	I	0.00	0.00	0.00	0.00	2.45	0.00	0.00	0.00	0.00	0.00	0.46	0.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.68	0.04	0.00	3.03
	II	0.00	0.00	0.00	0.05	1.12	0.04	0.81	0.02	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.73	0.00	4.23	9.31	0.00	0.00	1.16	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEB	I	0.00	0.00	0.00	0.07	0.07	0.00	0.00	0.74	0.20	0.00	0.00	0.21	0.14	0.04	1.15	0.00	0.00	0.51	0.00	0.12	0.00	0.00	0.01	0.00	0.00
	II	0.00	0.00	0.00	0.09	0.02	0.16	0.00	0.00	0.00	0.07	0.00	0.03	0.03	0.00	0.00	0.00	0.15	0.11	0.00	0.07	0.00	0.00	0.65	0.07	0.00
	III	0.02	0.00	0.13	0.00	0.17	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	1.64	0.00	0.00	0.09	0.00
MAR	I	0.67	0.00	2.00	0.00	0.20	0.10	0.00	0.06	0.00	0.07	0.70	0.00	0.00	0.00	0.05	0.17	0.00	0.00	0.00	0.00	0.00	0.52	0.00	1.37	1.98
	II	0.01	0.00	0.00	0.00	1.00	0.00	0.00	0.27	0.00	0.00	0.01	0.00	1.55	0.00	0.00	6.13	0.21	1.51	0.00	0.05	0.00	0.00	0.03	0.17	0.00
	III	0.02	0.00	0.00	0.00	0.20	0.00	0.03	0.04	0.00	0.81	0.00	0.00	0.35	0.00	0.00	0.00	0.00	1.24	0.05	0.21	0.28	0.49	0.00	0.00	0.02
APR	I	0.08	0.01	0.00	0.00	0.38	0.00	3.08	0.03	0.00	0.00	0.00	0.11	0.40	0.00	0.09	0.00	0.01	0.67	0.44	0.00	0.34	0.10	0.01	0.00	0.35
	II	0.09	0.00	0.00	0.02	0.10	0.20	1.38	0.00	0.00	0.11	6.06	0.23	0.01	0.00	0.28	4.85	0.92	0.00	0.00	0.10	1.74	0.00	2.11	2.06	3.31
	III	0.00	0.00	0.01	0.20	0.02	0.05	0.59	0.10	0.00	0.00	0.00	0.24	0.06	0.06	1.50	0.00	0.25	0.00	0.00	1.41	1.00	0.26	1.66	0.17	0.04
MAY	I	0.00	0.02	0.00	0.00	1.02	0.00	0.09	0.29	0.09	0.18	0.11	0.00	0.00	0.19	2.06	0.08	0.33	0.00	0.04	2.59	0.01	0.35	0.00	0.05	0.28
	II	0.01	0.02	0.00	0.05	3.73	0.00	0.00	0.00	0.14	0.00	0.84	1.44	0.00	0.26	0.00	1.70	0.00	0.00	0.06	0.04	0.01	0.28	0.00	0.01	0.46
	III	0.26	0.00	0.21	0.13	0.65	0.11	0.00	0.00	0.34	1.31	2.00	0.19	0.00	0.00	1.49	0.65	0.15	0.24	0.10	5.19	0.01	0.01	0.24	0.02	0.01
Yearly Rainfall (mm)		1983	1314	1542	1189	2119	1318	1151	1373	1081	1345	995	1989	988	1686	1350	1435	1993	1466	883	1046	1458	1277	1622	1551	1512

5.7.2.3 Rainfall and Runoff Data at Tumnar G&D Site

Detailed calculations on water availability and flood magnitude will help select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) for the entire period from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Tumnar G&D site is shown in **Figure 5.44** The basic comparison between rainfall and runoff in **Figure 5.44** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.45** shows the plot of runoff coefficient at G&D site.

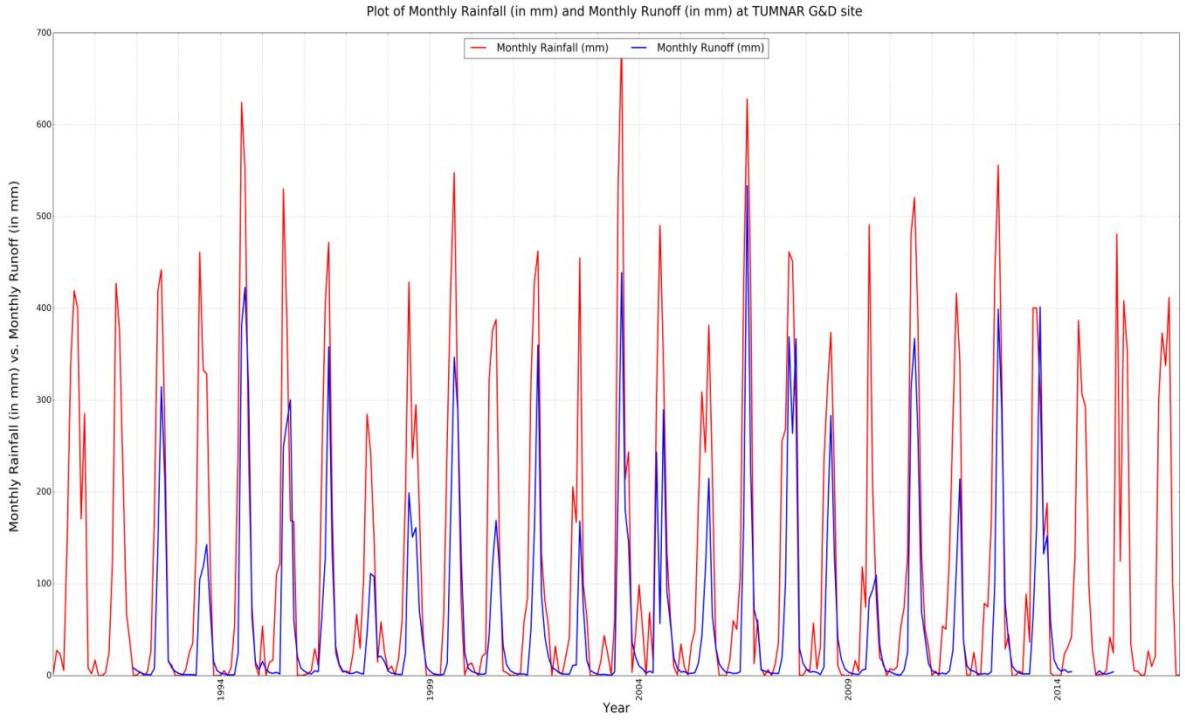


Figure 5.44: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tumnar G&D site

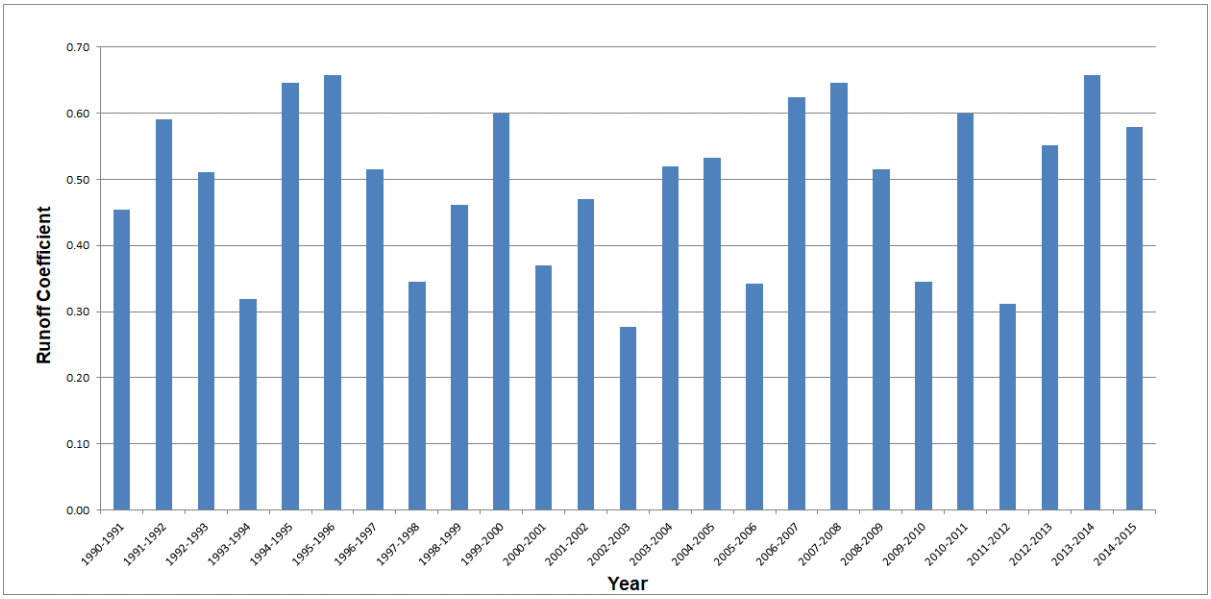


Figure 5.45: Plot of Runoff coefficient at G&D site

5.7.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission(CWC) gauge station i.e. Tumnar is around 1,700 km^2 as mentioned on India WRIS site. Daily discharge data for Tumnar site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Tumnar, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Tumnar G&D and the dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Tumnar G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Kotri}}{CA_{Tumnar}} = \frac{6091}{1700} = 3.58$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Kotri}}{\text{Average Annual Rainfall}_{Tumnar}} = \frac{1427}{1498} = 0.95$$

Discharge Series for the dam is computed according to the equation below

$$Q_{Kotri} = Q_{Tumnar\ G\&DSite} X\ 3.58\ X\ 0.95$$

Table 5.79 shows 10-daily average flow series at G&D site. **Table 5.80** and **Table 5.81** gives 10 daily average flow series (m^3/s) and 10-daily inflow series (MCM) developed for Kotri dam site.

Table 5.79: 10-Daily Average Flow Series (m^3/s) at Tumnar

Catchment Area =1,700 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	3.34	3.34	1.27	0.84	3.42	0.85	2.76	0.87	3.34	0.93	2.07	3.17	1.52	0.29	2.85	2.16	1.52	1.15	5.74	6.50	1.49	3.91	0.49	3.84	2.40
	II	15.68	15.68	13.83	11.56	15.67	12.62	17.78	10.43	22.79	15.43	22.23	32.31	22.01	13.10	67.20	21.18	19.43	17.08	17.48	14.15	15.60	12.23	12.49	26.39	19.35
	III	14.20	14.20	10.28	0.11	28.52	2.79	12.47	2.61	16.78	11.37	37.45	13.62	18.52	4.79	8.86	22.80	5.41	30.01	5.12	3.55	32.64	3.79	4.97	35.96	14.20
Jul	I	55.87	55.87	8.31	66.88	276.01	1.33	10.79	23.09	105.94	7.41	41.31	154.51	2.21	22.14	26.66	33.76	225.90	58.12	19.29	9.20	34.22	14.86	25.65	61.54	55.87
	II	64.11	64.11	14.15	69.20	284.44	55.77	32.20	4.33	162.36	34.54	150.30	71.20	13.04	69.52	30.75	20.98	14.06	104.88	11.16	53.97	87.35	15.74	13.18	97.31	64.11
	III	145.89	145.89	231.71	63.08	171.54	393.81	189.53	56.82	112.02	279.69	43.95	81.14	6.74	278.54	49.34	25.67	83.37	33.35	257.38	92.16	449.08	21.01	143.96	145.74	145.89
Aug	I	193.19	193.19	95.47	120.99	159.38	164.61	212.67	59.59	95.06	269.12	24.59	177.14	64.42	144.85	200.12	113.82	611.73	437.08	255.49	19.16	359.93	60.02	260.95	344.10	193.19
	II	156.96	156.96	268.72	30.57	215.81	93.56	291.03	24.75	118.11	107.79	89.06	246.91	101.72	105.81	208.81	59.34	306.04	189.87	213.70	22.07	155.27	75.92	208.84	319.38	156.96
	III	186.04	186.04	231.84	73.90	415.32	258.54	182.70	122.22	76.02	277.86	199.30	258.35	150.02	557.51	146.03	45.66	120.23	90.34	80.27	129.99	188.48	86.45	286.99	114.95	186.04
Sep	I	167.74	167.74	329.34	111.58	485.73	428.09	115.63	55.71	96.04	247.25	89.69	76.70	98.84	171.63	44.78	41.68	68.40	227.57	120.20	144.62	209.46	187.45	275.74	64.20	167.74
	II	117.96	117.96	68.46	32.16	106.53	123.91	110.80	108.34	132.04	191.84	43.07	60.27	36.64	80.68	88.44	283.72	242.96	97.72	93.14	23.01	230.75	154.90	185.17	100.62	117.96
	III	77.15	77.15	23.21	137.19	26.86	39.06	39.88	48.33	88.86	131.28	93.40	35.29	13.96	102.96	45.74	97.48	130.27	193.88	47.10	47.89	69.45	79.09	110.00	96.09	77.15
Oct	I	81.52	81.52	15.73	40.29	84.00	29.91	32.44	16.70	49.86	135.85	31.58	41.77	9.64	163.42	65.84	32.57	96.10	62.61	34.37	42.59	51.20	20.43	100.83	75.73	58.19
	II	34.46	34.46	10.57	73.06	14.04	56.54	13.36	8.93	58.47	47.04	20.61	25.58	15.33	56.73	25.04	46.45	26.91	62.70	23.93	14.92	41.14	41.99	28.20	46.53	34.46
	III	30.62	30.62	5.78	26.01	24.66	30.27	15.05	13.05	27.68	62.48	11.14	14.16	7.07	58.18	18.36	45.96	16.62	33.48	19.22	7.64	40.59	12.76	22.99	160.44	30.62
Nov	I	15.71	20.65	5.41	12.25	13.83	15.69	9.23	8.92	39.88	22.47	8.73	10.62	4.04	33.48	13.52	28.68	54.40	26.38	12.06	6.28	30.42	8.91	36.98	52.02	20.44
	II	11.89	15.53	5.52	10.13	8.52	14.02	8.85	13.24	19.42	15.28	8.35	17.28	3.71	22.75	14.11	18.09	33.30	18.29	10.76	8.68	29.75	7.16	18.91	35.58	15.38
	III	10.06	12.16	5.82	7.56	6.10	12.16	6.55	19.28	12.75	11.63	6.59	12.53	3.13	15.26	9.61	13.64	21.53	14.37	12.21	7.57	21.76	5.86	13.74	27.78	12.07
Dec	I	7.17	6.30	3.92	4.56	4.96	6.57	4.36	11.17	8.67	7.05	4.94	7.32	2.57	8.98	6.86	9.91	4.39	11.24	7.21	3.97	11.12	4.65	9.02	15.08	7.17
	II	5.89	5.09	2.88	3.33	4.00	5.24	3.39	11.15	5.58	5.06	3.44	5.67	2.21	18.40	4.58	7.41	3.92	8.60	4.20	2.94	8.29	3.43	5.90	10.84	5.89
	III	4.49	4.58	2.02	2.36	3.29	4.16	2.48	7.08	4.57	4.03	2.62	3.97	1.59	11.48	3.52	6.96	3.69	6.29	3.28	2.06	5.86	2.84	5.26	7.84	4.43
Jan	I	4.04	4.12	1.81	2.00	10.93	3.51	2.11	4.05	3.93	3.60	2.44	5.88	1.25	7.62	2.48	5.60	3.53	5.23	3.05	1.53	4.65	2.72	3.88	6.58	4.02
	II	3.73	3.43	1.56	1.83	12.10	3.33	3.36	3.08	3.46	3.00	2.09	4.15	1.06	5.58	2.06	4.83	3.19	4.48	2.49	4.58	3.41	4.40	3.45	5.29	3.75
	III	2.87	3.11	1.18	1.60	6.74	2.51	2.11	2.84	2.52	2.19	1.65	2.76	0.94	6.74	2.91	3.08	2.88	3.45	1.99	2.15	2.87	2.49	3.32	4.64	2.90
Feb	I	2.68	2.49	1.11	1.33	5.98	2.33	1.82	2.29	1.85	2.07	1.49	2.84	0.81	8.76	5.56	2.87	2.69	2.37	1.87	1.74	2.41	1.91	2.47	3.60	2.72
	II	2.10	2.23	0.97	1.54	5.60	1.76	1.50	1.92	1.32	2.23	1.29	2.20	0.79	3.73	2.22	2.39	2.70	2.67	1.62	1.62	2.04	1.49	2.00	3.24	2.13
	III	1.69	2.15	0.76	1.00	2.52	1.61	1.23	1.52	1.04	2.20	1.11	1.68	0.72	2.57	1.37	1.91	2.53	2.69	1.49	1.39	2.11	1.19	1.75	3.06	1.72
Mar	I	1.50	1.54	0.89	0.74	2.00	1.41	1.12	1.41	0.97	1.79	1.09	1.23	0.65	2.09	1.20	1.95	1.96	2.18	0.98	0.73	1.61	0.93	1.26	4.74	1.50
	II	1.47	0.96	0.74	0.55	2.89	1.22	1.09	1.62	0.89	1.14	1.05	1.01	0.65	1.69	1.51	3.37	1.51	1.66	0.96	0.71	1.17	0.91	1.05	5.33	1.46
	III	1.28	0.78	0.56	0.56	1.72	0.82	2.41	1.08	0.79	0.89	0.99	0.85	1.35	1.21	1.28	1.50	1.54	4.62	1.02	0.64	0.99	0.83	1.08	2.90	1.32
Apr	I	1.39	0.71	0.51	0.74	1.73	2.03	3.65	1.29	0.65	0.72	0.72	1.31	0.71	4.39	1.49	0.25	1.49	3.32	1.01	0.51	0.94	1.70	0.82	2.38	1.44
	II	1.53	0.47	1.18	0.49	1.48	4.41	2.52	0.77	0.54	0.99	1.45	1.24	0.53	1.41	1.91	3.63	1.68	2.17	0.92	0.42	2.02	1.66	0.76	2.32	1.52
	III	1.57	0.95	0.57	0.29	1.67	3.84	2.13	0.60	0.29	1.04	1.40	0.68	0.44	4.07	1.82	1.49	1.69	1.62	0.73	0.41	2.25	1.26	2.18	2.47	1.48
May	I	1.54	0.47	0.33	0.41	2.02	2.83	2.73	0.89	0.69	1.10	0.61	0.63	0.25	3.12	3.90	3.45	1.57	1.04	0.73	1.23	1.57	1.14	2.26	2.07	1.52
	II	1.38	0.25	0.25	0.51	3.03	2.36	1.37	1.16	1.18	0.82	0.30	0.46	0.14	1.64	1.29	0.59	1.39	0.74	4.30	0.51	1.11	1.05	0.73	2.86	1.23
	III	1.76	1.15	1.48	1.23	1.79	2.90	0.88	0.39	1.05	2.17	0.27	1.64	0.05	1.21	0.83	0.93	1.38	0.48	6.31	9.71	0.87	0.58	0.76	3.34	1.80
Inflow (MCM) =		1268	1271	1223	803	2140	1603	1195	580	1123	1705	845	1222	523	1803	980	888	1853	1538	1140	618	1877	743	1593	1676	1259

Table 5.80: 10-Daily Average Flow Series (m^3/s) at Kotri Dam

Catchment Area =6,091 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	11.40	11.40	4.33	2.87	11.67	2.90	9.42	2.97	11.40	3.17	7.06	10.82	5.19	0.99	9.73	7.37	5.19	3.92	19.59	22.18	5.09	13.34	1.67	13.11	8.20
	II	53.52	53.52	47.20	39.45	53.48	43.07	60.68	35.60	77.78	52.66	75.87	110.27	75.12	44.71	229.35	72.29	66.31	58.29	59.66	48.29	53.24	41.74	42.63	90.07	66.03
	III	48.46	48.46	35.09	0.38	97.34	9.52	42.56	8.91	57.27	38.81	127.82	46.48	63.21	16.35	30.24	77.82	18.46	102.42	17.47	12.12	111.40	12.94	16.96	122.73	48.47
Jul	I	190.68	190.68	28.36	228.26	942.02	4.54	36.83	78.81	361.57	25.29	140.99	527.34	7.54	75.56	90.99	115.22	770.99	198.36	65.84	31.40	116.79	50.72	87.54	210.04	190.68
	II	218.81	218.81	48.29	236.18	970.79	190.34	109.90	14.78	554.13	117.88	512.97	243.00	44.51	237.27	104.95	71.60	47.99	357.95	38.09	184.20	298.12	53.72	44.98	332.12	218.81
	III	497.92	497.92	790.82	215.29	585.46	1344.07	646.86	193.93	382.32	954.58	150.00	276.93	23.00	950.65	168.40	87.61	284.54	113.82	878.44	314.54	1532.71	71.71	491.33	497.41	497.93
Aug	I	659.36	659.36	325.84	412.94	543.96	561.81	725.84	203.38	324.44	918.50	83.93	604.58	219.86	494.37	683.01	388.47	2087.83	1491.75	871.98	65.39	1228.44	204.85	890.62	1174.41	659.37
	II	535.70	535.70	917.14	104.34	736.56	319.32	993.28	84.47	403.11	367.89	303.96	842.70	347.17	361.13	712.67	202.53	1044.51	648.02	729.36	75.32	529.93	259.11	712.77	1090.04	535.70
	III	634.95	634.95	791.27	252.22	1417.48	882.39	623.55	417.14	259.46	948.33	680.21	881.75	512.02	1902.78	498.40	155.84	410.34	308.33	273.96	443.65	643.28	295.05	979.49	392.32	634.97
Sep	I	572.49	572.49	1124.03	380.82	1657.79	1461.07	394.64	190.14	327.78	843.86	306.11	261.78	337.34	585.77	152.83	142.25	233.45	776.69	410.24	493.59	714.88	639.77	941.10	219.11	572.50
	II	402.60	402.60	233.65	109.76	363.59	422.90	378.16	369.76	450.65	654.75	147.00	205.70	125.05	275.36	301.84	968.33	829.22	333.52	317.89	78.53	787.55	528.67	631.98	343.42	402.60
	III	263.31	263.31	79.22	468.23	91.67	133.31	136.11	164.95	303.28	448.06	318.77	120.44	47.65	351.40	156.11	332.70	444.61	661.71	160.75	163.45	237.03	269.93	375.43	327.95	263.31
Oct	I	278.23	278.23	53.69	137.51	286.69	102.08	110.72	57.00	170.17	463.65	107.78	142.56	32.90	557.75	224.71	111.16	327.99	213.69	117.30	145.36	174.75	69.73	344.13	258.47	198.59
	II	117.61	117.61	36.08	249.35	47.92	192.97	45.60	30.48	199.56	160.55	70.34	87.30	52.32	193.62	85.46	158.53	91.84	213.99	81.67	50.92	140.41	143.31	96.25	158.81	117.60
	III	104.51	104.51	19.73	88.77	84.16	103.31	51.37	44.54	94.47	213.24	38.02	48.33	24.13	198.57	62.66	156.86	56.72	114.27	65.60	26.08	138.53	43.55	78.46	547.58	104.50
Nov	I	53.60	70.48	18.46	41.81	47.20	53.55	31.50	30.44	136.11	76.69	29.80	36.25	13.79	114.27	46.14	97.88	185.67	90.03	41.16	21.43	103.82	30.41	126.21	177.54	69.76
	II	40.57	53.00	18.84	34.57	29.08	47.85	30.20	45.19	66.28	52.15	28.50	58.98	12.66	77.65	48.16	61.74	113.65	62.42	36.72	29.62	101.54	24.44	64.54	121.43	52.49
	III	34.33	41.50	19.86	25.80	20.82	41.50	22.36	65.80	43.52	39.69	22.49	42.76	10.68	52.08	32.80	46.55	73.48	49.04	41.67	25.84	74.27	20.00	46.89	94.81	41.19
Dec	I	24.47	21.50	13.38	15.56	16.93	22.42	14.88	38.12	29.59	24.06	16.86	24.98	8.77	30.65	23.41	33.82	14.98	38.36	24.61	13.55	37.95	15.87	30.79	51.47	24.46
	II	20.10	17.37	9.83	11.37	13.65	17.88	11.57	38.05	19.04	17.27	11.74	19.35	7.54	62.80	15.63	25.29	13.38	29.35	14.33	10.03	28.29	11.71	20.14	37.00	20.11
	III	15.32	15.63	6.89	8.05	11.23	14.20	8.46	24.16	15.60	13.75	8.94	13.55	5.43	39.18	12.01	23.75	12.59	21.47	11.19	7.03	20.00	9.69	17.95	26.76	15.12
Jan	I	13.79	14.06	6.18	6.83	37.30	11.98	7.20	13.82	13.41	12.29	8.33	20.07	4.27	26.01	8.46	19.11	12.05	17.85	10.41	5.22	15.87	9.28	13.24	22.46	13.73
	II	12.73	11.71	5.32	6.25	41.30	11.37	11.47	10.51	11.81	10.24	7.13	14.16	3.62	19.04	7.03	16.48	10.89	15.29	8.50	15.63	11.64	15.02	11.77	18.05	12.79
	III	9.80	10.61	4.03	5.46	23.00	8.57	7.20	9.69	8.60	7.47	5.63	9.42	3.21	23.00	9.93	10.51	9.83	11.77	6.79	7.34	9.80	8.50	11.33	15.84	9.89
Feb	I	9.15	8.50	3.79	4.54	20.41	7.95	6.21	7.82	6.31	7.06	5.09	9.69	2.76	29.90	18.98	9.80	9.18	8.09	6.38	5.94	8.23	6.52	8.43	12.29	9.29
	II	7.17	7.61	3.31	5.26	19.11	6.01	5.12	6.55	4.51	7.61	4.40	7.51	2.70	12.73	7.58	8.16	9.22	9.11	5.53	5.53	6.96	5.09	6.83	11.06	7.28
	III	5.77	7.34	2.59	3.41	8.60	5.49	4.20	5.19	3.55	7.51	3.79	5.73	2.46	8.77	4.68	6.52	8.63	9.18	5.09	4.74	7.20	4.06	5.97	10.44	5.87
Mar	I	5.12	5.26	3.04	2.53	6.83	4.81	3.82	4.81	3.31	6.11	3.72	4.20	2.22	7.13	4.10	6.66	6.69	7.44	3.34	2.49	5.49	3.17	4.30	16.18	5.12
	II	5.02	3.28	2.53	1.88	9.86	4.16	3.72	5.53	3.04	3.89	3.58	3.45	2.22	5.77	5.15	11.50	5.15	5.67	3.28	2.42	3.99	3.11	3.58	18.19	5.00
	III	4.37	2.66	1.91	1.91	5.87	2.80	8.23	3.69	2.70	3.04	3.38	2.90	4.61	4.13	4.37	5.12	5.26	15.77	3.48	2.18	3.38	2.83	3.69	9.90	4.51
Apr	I	4.74	2.42	1.74	2.53	5.90	6.93	12.46	4.40	2.22	2.46	2.46	4.47	2.42	14.98	5.09	0.85	5.09	11.33	3.45	1.74	3.21	5.80	2.80	8.12	4.90
	II	5.22	1.60	4.03	1.67	5.05	15.05	8.60	2.63	1.84	3.38	4.95	4.23	1.81	4.81	6.52	12.39	5.73	7.41	3.14	1.43	6.89	5.67	2.59	7.92	5.19
	III	5.36	3.24	1.95	0.99	5.70	13.11	7.27	2.05	0.99	3.55	4.78	2.32	1.50	13.89	6.21	5.09	5.77	5.53	2.49	1.40	7.68	4.30	7.44	8.43	5.04
May	I	5.26	1.60	1.13	1.40	6.89	9.66	9.32	3.04	2.35	3.75	2.08	2.15	0.85	10.65	13.31	11.77	5.36	3.55	2.49	4.20	5.36	3.89	7.71	7.06	5.20
	II	4.71	0.85	0.85	1.74	10.34	8.05	4.68	3.96	4.03	2.80	1.02	1.57	0.48	5.60	4.40	2.01	4.74	2.53	14.68	1.74	3.79	3.58	2.49	9.76	4.18
	III	6.01	3.92	5.05	4.20	6.11	9.90	3.00	1.33	3.58	7.41	0.92	5.60	0.17	4.13	2.83	3.17	4.71	1.64	21.54	33.14	2.97	1.98	2.59	11.40	6.14
Inflow (MCM) =		4327	4337	4174	2740	7304	5471	4079	1980	3832	5821	2884	4170	1787	6155	3346	3032	6323	5250	3891	2108	6406	2536	5438	5721	4296

Table 5.81: 10-Daily Inflow Series (MCM) at Kotri project site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	9.85	9.85	3.75	2.48	10.08	2.51	8.14	2.57	9.85	2.74	6.10	9.35	4.48	0.86	8.40	6.37	4.48	3.39	16.93	19.17	4.39	11.53	1.44	11.32	7.08
	II	46.24	46.24	40.78	34.09	46.21	37.21	52.43	30.76	67.20	45.50	65.55	95.28	64.90	38.63	198.16	62.46	57.30	50.37	51.55	41.73	46.00	36.06	36.83	77.82	57.05
	III	41.87	41.87	30.31	0.32	84.10	8.23	36.77	7.70	49.48	33.53	110.43	40.16	54.61	14.12	26.13	67.23	15.95	88.49	15.10	10.47	96.25	11.18	14.66	106.04	41.88
Jul	I	164.75	164.75	24.50	197.22	813.90	3.92	31.82	68.09	312.40	21.85	121.82	455.62	6.52	65.29	78.62	99.55	666.14	171.39	56.88	27.13	100.91	43.82	75.64	181.47	164.75
	II	189.05	189.05	41.73	204.06	838.76	164.46	94.95	12.77	478.77	101.85	443.21	209.96	38.45	205.00	90.68	61.87	41.46	309.27	32.91	159.15	257.58	46.41	38.87	286.95	189.05
	III	473.22	473.22	751.60	204.61	556.43	1277.40	614.78	184.31	363.36	907.23	142.56	263.19	21.86	903.50	160.04	83.27	270.43	108.18	834.87	298.94	1456.68	68.15	466.96	472.74	473.23
Aug	I	569.68	569.68	281.52	356.78	469.98	485.41	627.13	175.72	280.32	793.59	72.51	522.35	189.96	427.14	590.12	335.64	1803.88	1288.87	753.39	56.50	1061.37	176.99	769.50	1014.69	569.70
	II	462.85	462.85	792.41	90.15	636.39	275.89	858.20	72.98	348.29	317.85	262.62	728.09	299.95	312.02	615.74	174.98	902.46	559.89	630.16	65.08	457.86	223.87	615.83	941.80	462.84
	III	603.46	603.46	752.02	239.71	1347.18	838.63	592.63	396.45	246.59	901.30	646.47	838.01	486.62	1808.40	473.68	148.11	389.99	293.04	260.37	421.65	611.37	280.42	930.91	372.86	603.47
Sep	I	494.64	494.64	971.17	329.03	1432.33	1262.36	340.97	164.28	283.21	729.10	264.48	226.17	291.46	506.11	132.05	122.91	201.70	671.06	354.45	426.46	617.66	552.76	813.11	189.31	494.64
	II	347.84	347.84	201.88	94.83	314.14	365.39	326.73	319.48	389.36	565.70	127.01	177.73	108.04	237.91	260.79	836.64	716.45	288.16	274.65	67.85	680.44	456.77	546.03	296.71	347.85
	III	227.50	227.50	68.44	404.55	79.21	115.18	117.60	142.52	262.03	387.12	275.42	104.06	41.17	303.61	134.88	287.45	384.14	571.72	138.89	141.22	204.80	233.22	324.37	283.35	227.50
Oct	I	240.39	240.39	46.38	118.81	247.70	88.20	95.66	49.25	147.03	400.60	93.12	123.17	28.43	481.90	194.15	96.04	283.38	184.63	101.35	125.59	150.98	60.24	297.33	223.31	171.58
	II	101.62	101.62	31.17	215.44	41.40	166.73	39.40	26.33	172.42	138.71	60.78	75.43	45.21	167.29	73.84	136.97	79.35	184.89	70.57	44.00	121.31	123.82	83.16	137.21	101.61
	III	99.32	99.32	18.75	84.37	79.99	98.19	48.82	42.33	89.79	202.67	36.13	45.93	22.93	188.72	59.55	149.08	53.91	108.60	62.34	24.78	131.66	41.39	74.57	520.42	99.32
Nov	I	46.31	60.89	15.95	36.12	40.78	46.27	27.22	26.30	117.60	66.26	25.74	31.32	11.91	98.73	39.87	84.57	160.42	77.79	35.56	18.52	89.70	26.27	109.05	153.40	60.27
	II	35.05	45.80	16.28	29.87	25.12	41.34	26.10	39.04	57.27	45.06	24.62	50.96	10.94	67.09	41.61	53.34	98.20	53.93	31.73	25.60	87.73	21.11	55.76	104.92	45.35
	III	29.67	35.86	17.16	22.29	17.99	35.86	19.31	56.85	37.60	34.29	19.43	36.95	9.23	45.00	28.34	40.22	63.49	42.37	36.01	22.32	64.17	17.28	40.52	81.92	35.59
Dec	I	21.14	18.58	11.56	13.45	14.63	19.37	12.86	32.94	25.57	20.79	14.57	21.59	7.58	26.48	20.23	29.22	12.95	33.14	21.26	11.71	32.79	13.71	26.60	44.47	21.13
	II	17.37	15.01	8.49	9.82	11.80	15.45	10.00	32.88	16.45	14.92	10.14	16.72	6.52	54.26	13.51	21.85	11.56	25.36	12.39	8.67	24.45	10.11	17.40	31.97	17.38
	III	14.56	14.86	6.55	7.66	10.67	13.49	8.04	22.97	14.82	13.07	8.50	12.88	5.16	37.24	11.42	22.58	11.97	20.40	10.64	6.68	19.01	9.21	17.06	25.43	14.37
Jan	I	11.91	12.15	5.34	5.90	32.23	10.35	6.22	11.94	11.59	10.62	7.20	17.34	3.69	22.47	7.31	16.51	10.41	15.42	8.99	4.51	13.71	8.02	11.44	19.40	11.86
	II	11.00	10.11	4.60	5.40	35.68	9.82	9.91	9.08	10.20	8.85	6.16	12.24	3.13	16.45	6.07	14.24	9.41	13.21	7.34	13.51	10.06	12.97	10.17	15.60	11.05
	III	9.31	10.09	3.83	5.19	21.86	8.14	6.84	9.21	8.17	7.10	5.35	8.95	3.05	21.86	9.44	9.99	9.34	11.19	6.45	6.97	9.31	8.08	10.77	15.05	9.40
Feb	I	7.90	7.34	3.27	3.92	17.63	6.87	5.37	6.75	5.46	6.10	4.39	8.37	2.39	25.83	16.40	8.46	7.93	6.99	5.51	5.13	7.11	5.63	7.28	10.62	8.03
	II	6.19	6.58	2.86	4.54	16.51	5.19	4.42	5.66	3.89	6.58	3.80	6.49	2.33	11.00	6.55	7.05	7.96	7.87	4.78	4.78	6.02	4.39	5.90	9.55	6.29
	III	3.99	5.07	1.79	2.36	5.94	3.80	2.90	3.59	2.45	5.19	2.62	3.96	1.70	6.06	3.23	4.51	5.97	6.35	3.51	3.28	4.98	2.81	4.13	7.22	4.06
Mar	I	4.42	4.54	2.62	2.18	5.90	4.16	3.30	4.16	2.86	5.28	3.21	3.63	1.92	6.16	3.54	5.75	5.78	6.43	2.89	2.15	4.75	2.74	3.72	13.98	4.42
	II	4.33	2.83	2.18	1.62	8.52	3.60	3.21	4.78	2.62	3.36	3.10	2.98	1.92	4.98	4.45	9.94	4.45	4.90	2.83	2.09	3.45	2.68	3.10	15.72	4.32
	III	4.15	2.53	1.82	1.82	5.58	2.66	7.82	3.50	2.56	2.89	3.21	2.76	4.38	3.92	4.15	4.87	5.00	14.99	3.31	2.08	3.21	2.69	3.50	9.41	4.28
Apr	I	4.10	2.09	1.50	2.18	5.10	5.99	10.76	3.80	1.92	2.12	2.12	3.86	2.09	12.95	4.39	0.74	4.39	9.79	2.98	1.50	2.77	5.01	2.42	7.02	4.23
	II	4.51	1.39	3.48	1.44	4.36	13.00	7.43	2.27	1.59	2.92	4.28	3.66	1.56	4.16	5.63	10.70	4.95	6.40	2.71	1.24	5.96	4.90	2.24	6.84	4.48
	III	4.63	2.80	1.68	0.86	4.92	11.32	6.28	1.77	0.86	3.07	4.13	2.01	1.30	12.00	5.37	4.39	4.98	4.78	2.15	1.21	6.63	3.72	6.43	7.28	4.36
May	I	4.54	1.39	0.97	1.21	5.96	8.35	8.05	2.62	2.03	3.24	1.80	1.86	0.74	9.20	11.50	10.17	4.63	3.07	2.15	3.63	4.63	3.36	6.66	6.10	4.49
	II	4.07	0.74	0.74	1.50	8.93	6.96	4.04	3.42	3.48	2.42	0.88	1.36	0.41	4.84	3.80	1.74	4.10	2.18	12.68	1.50	3.27	3.10	2.15	8.43	3.61
	III	5.71	3.73	4.80	3.99	5.81	9.41	2.85	1.27	3.41	7.04	0.88	5.32	0.16	3.92	2.69	3.02	4.48	1.56	20.47	31.50	2.82	1.88	2.47	10.83	5.83
Inflow (MCM) =		4327	4337	4174	2740	7304	5471	4079	1980	3832	5821	2884	4170	1787	6155	3346	3032	6323	5250	3891	2108	6406	2536	5438	5721	4296

5.7.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.82** and **Table 5.83** respectively.

Table 5.82: Computation of 90% and 50% Dependable Year for Kotri Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.04	7304	1994-1995	
2	0.08	6406	2010-2011	
3	0.12	6323	2006-2007	
4	0.15	6155	2003-2004	
5	0.19	5821	1999-2000	
6	0.23	5721	2013-2014	
7	0.27	5471	1995-1996	
8	0.31	5438	2012-2013	
9	0.35	5250	2007-2008	
10	0.38	4337	1991-1992	
11	0.42	4327	1990-1991	
12	0.46	4296	2014-2015	
13	**0.50**	**4174**	**1992-1993**	**50% Dependable**
14	0.54	4170	2001-2002	
15	0.58	4079	1996-1997	
16	0.62	3891	2008-2009	
17	0.65	3832	1998-1999	
18	0.69	3346	2004-2005	
19	0.73	3032	2005-2006	
20	0.77	2884	2000-2001	
21	0.81	2740	1993-1994	
22	0.85	2536	2011-2012	
23	**0.88**	**2108**	**2009-2010**	**90% Dependable**
24	0.92	1980	1997-1998	
25	0.96	1787	2002-2003	

Table 5.83: 90% and 50% Dependable year flows (cumec) for Kotri Project

Period		90% Dependable 2009-2010	50% Dependable 1992-1993
Jun	I	22.18	4.33
	II	48.29	47.20
	III	12.12	35.09
Jul	I	31.40	28.36
	II	184.20	48.29
	III	314.54	790.82
Aug	I	65.39	325.84
	II	75.32	917.14
	III	443.65	791.27
Sep	I	493.59	1124.03
	II	78.53	233.65
	III	163.45	79.22
Oct	I	145.36	53.69
	II	50.92	36.08
	III	26.08	19.73
Nov	I	21.43	18.46
	II	29.62	18.84
	III	25.84	19.86
Dec	I	13.55	13.38
	II	10.03	9.83
	III	7.03	6.89
Jan	I	5.22	6.18
	II	15.63	5.32
	III	7.34	4.03
Feb	I	5.94	3.79
	II	5.53	3.31
	III	4.74	2.59
Mar	I	2.49	3.04
	II	2.42	2.53
	III	2.18	1.91
Apr	I	1.74	1.74
	II	1.43	4.03
	III	1.40	1.95
May	I	4.20	1.13
	II	1.74	0.85
	III	33.14	5.05
Inflow (MCM) =		**2108**	**4174**

5.7.5 Elevation Area Capacity Curve

The EAC curve prepared for the dam site of Kotri, is given in the following section.

5.7.5.1 EAC of Kotri Dam

The EAC curve and the table showing the different values are given in **Figure 5.46** and **Table 5.84** respectively.

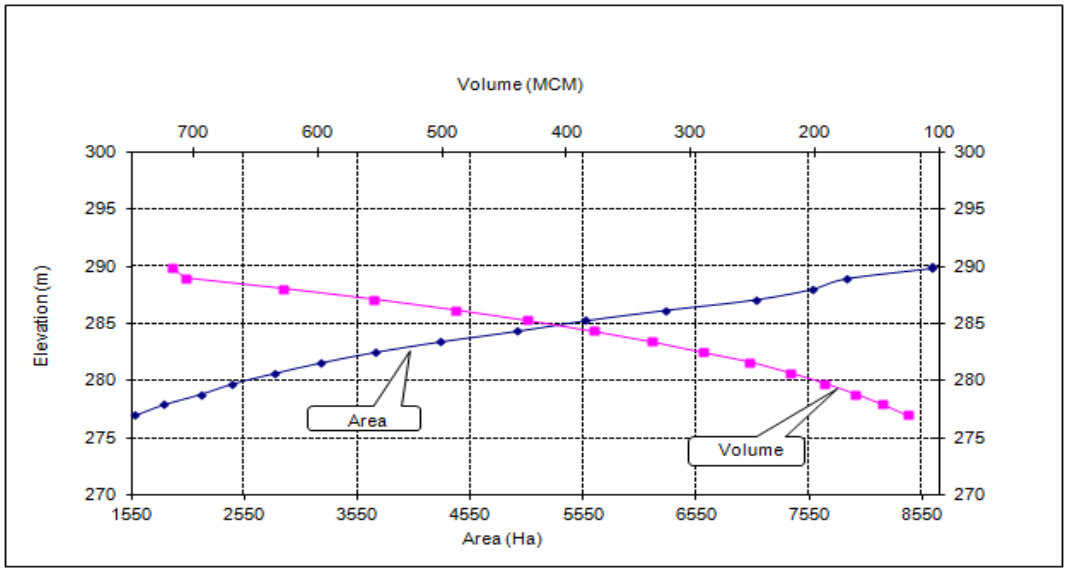


Figure 5.46: EAC curve of Kotri Dam

Table 5.84: EAC data of Kotri Dam

Elevation (m)	Area (Sq. m)	Area (ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
277.00	15800051.46	1580.01	108578855.40	108.58
277.92	18299690.99	1829.97	125414816.90	125.41
278.84	21590272.46	2159.03	145014296.20	145.01
279.76	24432778.75	2443.28	167037969.30	167.04
280.68	28169556.67	2816.96	192056689.90	192.06
281.60	32262352.41	3226.24	220428762.70	220.43
282.52	37058729.50	3705.87	252603638.90	252.60
283.44	42826405.84	4282.64	289235959.40	289.24
284.36	49595440.97	4959.54	331072274.30	331.07
285.28	55615805.40	5561.58	378386440.70	378.39
286.20	62782190.22	6278.22	430987092.90	430.99
287.12	70726365.91	7072.64	489698897.20	489.70
288.04	75736296.88	7573.63	555088569.20	555.09
288.96	78736296.88	7873.63	627524616.80	627.52
289.88	86376119.62	8637.61	706686148.50	706.69
290.00	86376119.62	8637.61	717050861.10	717.05

5.7.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk

5.7.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Tumnar G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Tumnar G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{\text{A\_Kotri}}{\text{A}_{\text{Tumnar}}}\right)^{\frac{3}{4}} = 2.60$$

Using the above multiplying factors to the peak flows at the Tumnar G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.85**.

Table 5.85: Final Peak Flows at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1992	1677	2180	5678
1993	515	669	1743
1994	1683	2188	5697
1995	1279	1663	4332
1996	1329	1727	4498
1997	467	607	1580
1998	828	1076	2802
1999	991	1288	3355
2000	534	695	1809
2001	1179	1533	3993
2002	658	856	2229
2003	1330	1729	4501
2004	3584	4659	12134
2005	714	928	2417
2006	2757	3584	9335

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2007	3193	4151	10811
2008	1564	2034	5296
2009	599	779	2030
2010	1924	2501	6513
2011	407	529	1378
2012	791	1028	2677
2013	1005	1306	3402

5.7.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.86**.

Table 5.86: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	4464.00
Variance	8889130.71
SD (Sx)	2981.46
Skewness	1.38
Kurtosis	1.36
No. of Data	22

5.7.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.87**.

The detailed procedure for Gumbel distribution method for Kotri dam site has been shown in **Annexure-6**.

Table 5.87: Details of different year Return Period Flood (m^3/s) at respective dam sits

S No.	Return Period (Years)	Flood (cumec)
1	2	4016
2	5	7127
3	10	9186
4	20	11162
5	25	11788
6	50	13719
7	100	15635
8	500	20063

Annexure-6 (Flood Frequency Analysis for Kotri Dam)

DESIGN FLOOD-Kotri

CA at G&D = 1700 | CA = 6091

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	1992	1677	2180	5678	7.21
2	1993	515	669	1743	6.86
3	1994	1683	2188	5697	6.59
4	1995	1279	1663	4332	6.93
5	1996	1329	1727	4498	6.75
6	1997	467	607	1580	7.01
7	1998	828	1076	2802	6.86
8	1999	991	1288	3355	6.59
9	2000	534	695	1809	7.40
10	2001	1179	1533	3993	4.89
11	2002	658	856	2229	6.92
12	2003	1330	1729	4501	6.85
13	2004	3584	4659	12134	6.48
14	2005	714	928	2417	6.53
15	2006	2757	3584	9335	6.39
16	2007	3193	4151	10811	6.35
17	2008	1564	2034	5296	6.31
18	2009	599	779	2030	6.27
19	2010	1924	2501	6513	6.22
20	2011	407	529	1378	6.18
21	2012	791	1028	2677	6.14
22	2013	1005	1306	3402	6.10

Conversion factor = 2.60

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	4464.00	6.54
Variance	8889130.71	0.264
SD (Sx)	2981.46	0.514
Skewness	1.38	-1.33185
Kurtosis	1.36	4.07286
No. of Data	22	

Parameters	Values
Mean(Xm)	4464.00
Variance	8889130.71
SD (Sx)	2981.46
Skewness	1.38
Kurtosis	1.36
No. of Data	22

X_T =

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 22

Reduced mean = Y_n = 0.530 (From Table) — $f_{(C)}$ = 1.65 (90% confidence probability)

Reduced Std. Dev = S_n = 1.09 (From Table)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

90% CONFIDENCE INTERVAL

(X_{cl} Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	4016	0.367	-0.150	0.911	578.978	952.419	3064	4969
2	5	7127	1.500	0.893	1.743	1108.048	1822.739	5304	8950
3	10	9186	2.250	1.584	2.412	1533.323	2522.316	6664	11709
4	20	11162	2.970	2.246	3.078	1956.304	3218.120	7944	14380
5	25	11788	3.199	2.457	3.291	2092.098	3441.502	8347	15230
6	50	13719	3.902	3.104	3.954	2513.404	4134.549	9584	17853
7	100	15635	4.600	3.747	4.617	2934.573	4827.373	10808	20462
8	500	20063	6.214	5.232	6.157	3913.891	6438.351	13625	26501

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	4016
2	5	7127
3	10	9186
4	20	11162
5	25	11788
6	50	13719
7	100	15635
8	500	20063

5.8 Hydrology of Wainganga Hydroelectric Project

5.8.1 General

The present project, Wainganga, envisages harnessing water from the River Wainganga and other small rivers. Wainganga is a river in India, originating in the Mahadeo Hills in Mundara near village Gopalganj in Seoni Madhya Pradesh. It is a tributary of the Godavari River. The river flows south in a winding course through the states of Madhya Pradesh and Maharashtra, the united stream, which is known as the Pranahita River, empties into the Godavari River at Kaleshwaram, Telangana. The project is proposed to be of Storage type with the multifunction of irrigation and power.

5.8.1.1 Description of Dam Site

The catchment area of the dam site is 43,264 km^2. The dam site is located in Gadchiroli district of Maharashtra at 79° 57' 35'' E, 20° 23' 0'' N. Catchment area of the project and locations of the dam site and of G&D site are shown in **Figure 5.47**.

5.8.1.2 Description of G&D Site

Ashti G&D site is situated in the Gadchiroli district of Maharashtra at 79° 40' 10" E, 19° 41' 04" N. Catchment area of the G&D site is around 50,990 km^2.

5.8.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometers draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past

few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/ km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

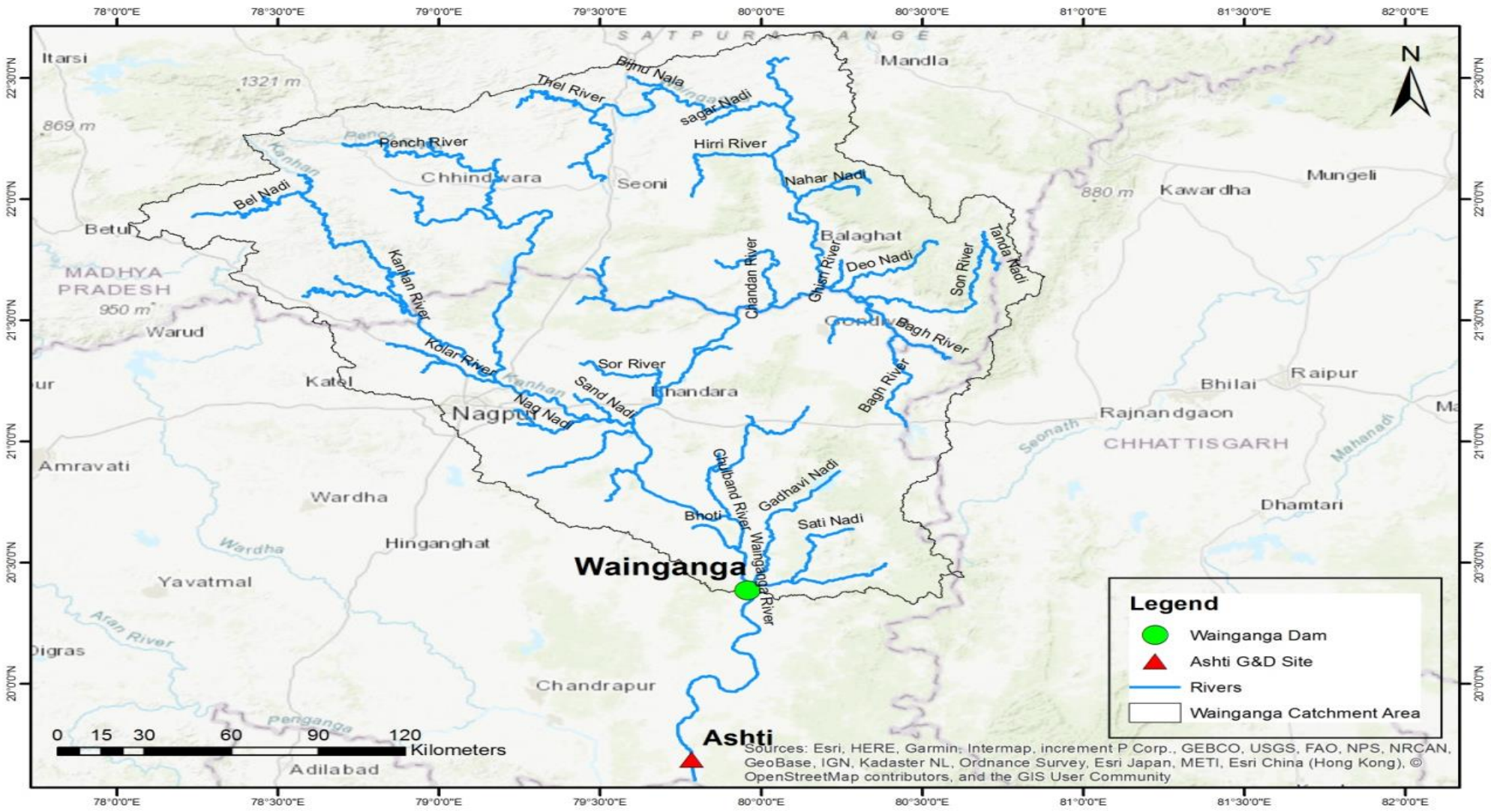


Figure 5.47: Catchment Area of Project and Locations of Dam and G&D site

5.8.2 Water Availability Studies

5.8.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Ashti (Catchment Area=50,990 km^2) which is downstream of the project site along the Wainganga River, is available and can be downloaded from India WRIS site. The G&D site lies in the Gadchiroli district of Maharashtra.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.8.2.2 Rainfall data

Indian Meteorological Department (IMD) daily rainfall grid data with a resolution of 0.25 degree x 0.25 degree from 1990 to 2015 is available. Average of daily rainfall data generated at each grid point (as can be seen from **Figure 5.48**) within the boundary of the Ashti G&D site and Wainganga dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.48**, 75 grid point is considered to assess the catchment rainfall for Ashti G&D site. Similarly, for Wainganga proposed dam site, 64 grid points have been considered for the assessment of catchment rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

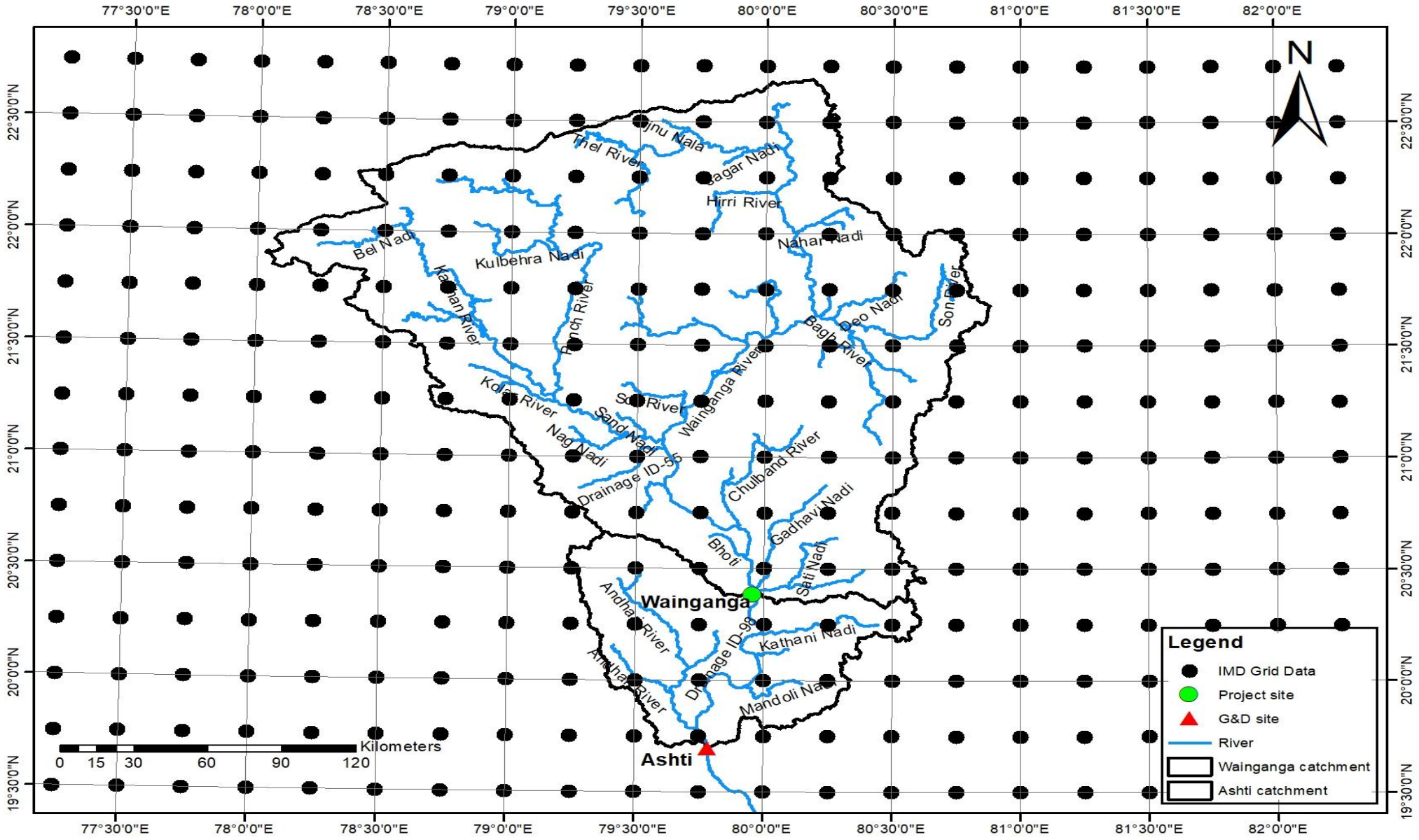


Figure 5.48: IMD Grid Rainfall Data for Wainganga Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfalls for the last 25 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.88**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.89** and **Table 5.90** respectively.

Table 5.88: Average Annual Rainfall (in mm)

Year	Ashti	Wainganga
1990-1991	1490	1365
1991-1992	990	930
1992-1993	1207	1109
1993-1994	1235	1240
1994-1995	2001	1979
1995-1996	1195	1160
1996-1997	932	917
1997-1998	1480	1501
1998-1999	1248	1235
1999-2000	1408	1393
2000-2001	1097	1042
2001-2002	1336	1319
2002-2003	1127	1155
2003-2004	1439	1439
2004-2005	1057	1015
2005-2006	1436	1437
2006-2007	1100	1040
2007-2008	1072	959
2008-2009	993	970
2009-2010	1102	1112
2010-2011	1399	1330
2011-2012	1158	1150
2012-2013	1220	1161
2013-2014	1777	1704
2014-2015	1135	1102
AVERAGE (mm)	1265	1231

Table 5.89: 10 Daily Rainfall (in mm) of Ashti G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	3.98	2.37	0.21	0.45	3.21	0.00	0.99	0.57	0.53	1.32	10.70	7.24	0.70	0.17	1.71	0.11	1.29	0.61	3.88	1.10	0.12	1.62	0.33	2.34	0.03
	II	13.13	6.25	4.76	6.91	10.51	6.75	6.84	6.74	5.97	15.01	8.21	24.11	4.66	4.80	14.08	0.92	0.08	4.98	5.52	0.26	8.05	5.82	6.55	15.03	5.55
	III	15.39	3.68	6.45	9.38	15.66	6.70	0.48	3.92	6.19	8.29	6.02	4.70	21.51	8.71	1.98	18.85	6.41	16.35	11.26	5.09	6.07	9.92	2.84	15.51	4.62
JUL	I	8.08	4.06	2.19	11.05	17.94	5.23	7.60	9.99	19.04	4.01	8.09	11.51	1.03	14.35	4.78	14.75	12.59	16.97	9.61	15.49	14.96	5.74	11.94	12.51	2.55
	II	15.20	18.85	9.91	19.61	39.04	23.78	9.14	5.92	5.70	10.24	33.34	12.55	6.81	13.88	7.99	8.42	9.54	6.06	2.32	22.42	12.60	14.30	10.17	26.14	14.84
	III	12.47	17.37	21.83	8.40	11.82	16.82	13.97	29.39	7.87	13.17	6.09	8.58	1.61	27.24	15.45	17.29	16.36	5.53	17.26	11.82	19.70	10.35	15.11	22.80	23.78
AUG	I	5.61	10.11	14.21	14.28	12.14	11.15	9.18	3.98	10.65	21.95	4.57	14.06	14.56	10.28	16.09	11.68	11.48	19.68	19.46	2.81	18.24	14.37	14.59	17.86	11.79
	II	13.97	18.11	23.91	13.35	11.07	6.80	9.95	4.77	8.77	2.34	12.53	18.95	24.81	11.02	6.91	12.54	19.52	3.62	6.57	9.74	8.80	10.35	13.34	17.35	3.61
	III	18.39	9.02	16.60	4.73	22.60	9.41	8.49	22.00	7.11	7.33	8.45	6.82	12.68	15.54	6.63	3.21	11.00	3.56	4.89	10.08	7.96	10.57	11.40	10.95	5.51
SEP	I	9.09	1.20	10.26	11.01	26.52	11.39	6.40	6.16	11.16	5.92	0.98	2.53	11.83	11.51	3.23	6.55	7.14	12.98	6.43	10.39	20.86	19.44	17.02	1.48	14.87
	II	7.28	0.37	1.97	1.82	2.89	7.00	5.39	8.87	16.43	26.69	0.79	2.06	1.09	6.44	3.72	26.27	3.97	3.40	6.08	0.35	10.04	6.12	4.16	5.45	3.28
	III	5.99	1.20	0.17	11.07	0.46	0.18	1.55	1.81	5.60	10.31	2.26	0.87	0.23	7.61	2.98	1.91	3.45	5.36	1.51	1.43	0.41	0.99	3.95	4.82	0.76
OCT	I	6.99	1.54	0.43	1.24	7.95	0.04	1.41	1.01	1.25	6.98	0.29	13.65	0.09	2.65	0.65	0.00	1.24	2.50	0.77	3.41	1.08	0.39	1.86	10.72	0.37
	II	2.77	0.03	0.18	5.52	0.02	3.94	0.01	0.70	2.55	1.16	0.02	1.58	4.05	0.03	1.01	8.14	0.19	0.00	0.03	0.04	1.13	0.10	0.00	1.77	2.83
	III	1.74	0.00	0.09	0.03	1.37	1.21	4.08	4.60	1.94	1.14	0.00	0.00	0.00	2.02	0.00	0.16	0.20	0.00	0.00	0.00	0.95	0.00	0.21	1.26	0.09
NOV	I	0.09	0.26	0.00	0.00	0.03	0.14	0.01	0.27	6.87	0.01	0.00	0.00	0.00	0.04	0.10	0.00	0.62	0.62	0.00	0.30	0.15	0.00	1.06	0.01	0.00
	II	0.00	0.52	0.79	0.03	0.05	0.01	0.10	2.30	0.56	0.00	0.00	0.29	0.07	0.00	0.60	0.00	0.00	0.00	0.30	7.23	2.73	0.00	0.00	0.00	0.40
	III	0.00	0.00	0.02	0.00	0.00	0.00	0.00	5.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
DEC	I	0.67	0.00	0.00	0.03	0.00	0.02	0.00	6.53	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
	II	0.05	0.00	0.00	0.00	0.00	0.00	0.00	2.52	0.00	0.00	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.00	0.10	0.00	0.57
	III	0.00	0.22	0.00	0.00	0.00	0.39	0.00	3.09	0.00	0.00	0.00	0.00	0.03	0.14	0.00	0.54	0.00	0.00	0.00	0.09	0.00	0.01	0.00	0.00	0.00
JAN	I	0.89	0.00	0.00	0.17	3.41	1.55	0.00	0.37	0.01	0.00	0.46	0.03	0.00	0.02	0.03	0.00	0.00	0.00	0.09	0.00	0.08	2.17	0.49	0.13	1.70
	II	0.43	0.00	0.00	1.12	0.99	0.53	1.68	0.07	0.00	0.01	0.07	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.96	0.06	0.00	0.00	0.46	0.00
	III	0.00	0.00	0.00	0.14	0.01	0.00	0.00	2.70	0.00	0.00	0.00	0.19	0.01	1.27	9.06	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.10	0.06	0.01
FEB	I	0.01	0.05	0.00	0.38	0.34	1.45	0.00	2.12	2.37	0.01	0.00	0.40	2.46	0.63	1.94	0.00	0.01	0.14	0.05	1.03	0.00	0.01	0.12	0.00	0.32
	II	0.01	0.00	0.00	0.73	0.13	0.12	0.00	0.03	0.03	0.21	0.01	0.49	2.01	0.00	0.04	0.00	0.35	0.00	0.00	0.31	0.02	0.11	1.55	0.06	0.64
	III	0.69	0.00	0.71	0.00	0.80	0.38	0.00	0.04	0.00	1.02	0.00	0.26	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.26	0.31	0.00	0.41	3.90	0.07
MAR	I	1.90	0.00	1.44	0.00	2.24	0.70	0.00	0.33	0.00	0.00	1.05	0.01	0.02	0.00	0.94	2.41	0.03	0.00	0.00	0.00	0.07	0.00	0.00	2.56	5.64
	II	0.24	0.00	0.14	0.00	2.59	0.07	0.00	1.99	0.00	0.02	0.34	0.09	0.43	0.00	0.29	3.09	0.26	0.22	0.08	1.27	0.00	0.00	0.55	0.37	1.41
	III	0.04	0.06	0.01	0.00	1.37	0.00	0.13	0.32	0.00	0.02	0.06	0.10	0.06	0.03	0.00	0.00	0.00	2.50	0.06	0.14	0.01	0.00	0.40	0.02	0.22
APR	I	0.43	0.06	0.09	0.25	0.54	0.08	1.84	0.47	0.00	0.00	0.07	0.07	0.06	0.08	0.00	0.00	0.08	0.52	0.48	0.00	0.38	0.09	0.29	0.02	0.75
	II	0.00	0.02	0.09	0.31	0.24	0.43	0.35	0.41	0.00	0.00	2.84	0.00	0.14	0.00	0.66	1.94	0.38	0.00	0.00	0.01	1.06	0.01	0.17	0.66	1.93
	III	0.01	0.21	0.00	0.03	0.01	0.38	0.09	0.90	0.00	0.00	0.02	0.00	0.09	0.38	0.44	0.02	0.04	0.00	0.00	0.20	0.29	0.04	0.57	0.05	0.16
MAY	I	0.00	0.19	0.00	0.05	0.25	0.02	0.85	0.79	0.30	0.60	0.01	0.14	0.02	0.09	0.68	0.38	0.03	0.32	0.00	0.10	0.17	0.00	0.00	0.53	1.06
	II	0.07	0.17	0.00	0.00	0.34	0.00	0.02	0.43	0.52	0.15	0.32	0.27	0.18	0.25	0.00	0.84	0.34	0.00	0.02	0.07	0.05	0.03	0.01	0.04	1.14
	III	0.21	0.36	0.52	0.05	0.03	0.09	0.01	0.02	1.54	0.81	0.63	0.49	0.02	0.01	0.36	1.30	0.06	0.10	0.34	0.53	0.06	0.01	0.04	0.13	0.03
Yearly Rainfall (mm)		1490	990	1207	1235	2001	1195	932	1480	1248	1408	1097	1336	1127	1439	1057	1436	1100	1072	993	1102	1399	1158	1220	1777	1135

Table 5.90: 10 Daily Rainfall (in mm) of Wainganga Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	2.84	2.01	0.24	0.45	2.90	0.00	0.54	0.58	0.44	1.30	10.60	6.81	0.50	0.06	1.65	0.07	1.06	0.49	3.95	1.15	0.13	1.54	0.29	2.00	0.03
	II	12.72	5.41	2.73	6.79	9.88	6.29	6.47	6.49	5.96	14.05	7.67	22.92	4.94	4.92	14.38	0.95	0.07	4.81	5.80	0.20	8.05	5.90	6.43	13.78	5.37
	III	15.64	4.12	6.74	10.13	14.92	6.52	0.38	3.50	6.32	8.51	5.52	5.13	21.15	9.11	1.63	18.84	5.84	13.34	10.98	4.87	6.12	9.52	2.69	15.03	5.08
JUL	I	7.53	3.52	1.72	11.85	17.04	5.54	7.17	10.53	18.71	3.35	7.77	11.24	1.09	14.35	5.01	14.57	9.57	16.92	8.99	16.36	14.93	5.97	11.49	12.30	2.44
	II	14.56	17.91	9.14	18.42	38.53	23.42	9.67	6.04	5.35	10.06	30.61	13.24	5.73	13.04	7.62	8.63	9.42	4.81	2.12	23.04	12.34	14.68	9.89	25.11	13.65
	III	10.74	16.90	21.10	7.67	12.02	17.15	13.41	30.71	7.54	12.96	6.43	8.75	1.76	29.09	15.34	17.03	15.86	5.65	15.96	11.42	18.42	11.10	14.79	20.36	24.78
AUG	I	5.18	9.14	14.44	14.27	12.46	11.04	7.93	3.92	10.86	21.58	4.66	13.45	15.19	9.47	14.83	11.58	9.52	16.61	18.28	2.20	15.70	14.67	13.92	16.88	11.70
	II	12.08	15.26	21.59	13.66	11.52	7.02	10.09	4.73	8.74	2.21	12.31	17.94	26.47	11.99	6.60	12.49	21.24	3.28	7.05	9.45	8.45	9.74	11.22	17.07	3.74
	III	14.07	10.01	14.04	4.41	22.98	8.94	8.66	21.26	7.33	6.66	7.48	6.59	12.07	14.11	5.75	3.37	10.92	3.66	4.65	10.16	7.88	10.33	10.40	12.08	5.22
SEP	I	8.99	1.30	9.49	11.38	25.79	10.61	6.65	5.82	11.34	5.59	0.97	2.64	12.88	12.27	2.98	5.56	7.23	11.13	6.30	11.34	18.58	17.89	16.40	1.15	11.22
	II	7.00	0.35	2.01	1.91	2.71	6.60	5.44	7.97	16.83	28.88	0.73	1.97	1.15	6.92	3.87	28.29	3.73	3.35	6.79	0.25	10.14	6.22	4.08	5.39	3.38
	III	6.23	1.09	0.14	11.68	0.51	0.22	1.70	1.59	5.26	11.00	1.88	0.81	0.20	8.04	2.84	1.94	2.22	5.18	1.63	1.43	0.31	0.71	3.75	4.32	0.77
OCT	I	6.35	1.38	0.29	1.11	8.01	0.02	1.35	1.20	1.25	7.24	0.33	14.68	0.09	1.96	0.56	0.00	1.25	1.37	0.86	3.23	1.07	0.42	1.57	10.05	0.43
	II	2.44	0.02	0.17	5.37	0.01	2.50	0.01	0.83	2.63	1.24	0.02	1.12	4.45	0.02	1.09	7.75	0.22	0.00	0.02	0.05	0.70	0.03	0.00	1.72	3.25
	III	1.47	0.00	0.10	0.02	1.24	0.49	4.67	4.65	2.14	0.83	0.00	0.00	0.00	1.24	0.00	0.19	0.23	0.00	0.00	0.00	1.07	0.00	0.25	1.08	0.07
NOV	I	0.03	0.05	0.00	0.00	0.03	0.16	0.01	0.33	6.65	0.01	0.00	0.00	0.00	0.05	0.01	0.00	0.57	0.66	0.00	0.34	0.08	0.00	1.07	0.02	0.00
	II	0.00	0.56	0.53	0.03	0.06	0.01	0.08	2.63	0.59	0.00	0.00	0.23	0.09	0.00	0.71	0.00	0.00	0.00	0.36	7.80	3.02	0.00	0.00	0.00	0.47
	III	0.00	0.00	0.03	0.00	0.00	0.00	0.00	6.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.49	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
DEC	I	0.76	0.00	0.00	0.00	0.00	0.02	0.00	7.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00
	II	0.06	0.00	0.00	0.00	0.00	0.00	0.00	2.56	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00	0.11	0.00	0.68
	III	0.00	0.06	0.00	0.00	0.00	0.46	0.00	3.38	0.00	0.00	0.00	0.00	0.04	0.14	0.00	0.50	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00
JAN	I	1.05	0.00	0.00	0.19	3.43	1.77	0.00	0.38	0.01	0.00	0.36	0.03	0.00	0.02	0.04	0.00	0.00	0.00	0.10	0.00	0.10	2.43	0.54	0.15	1.35
	II	0.52	0.00	0.00	1.31	0.72	0.62	1.66	0.07	0.00	0.00	0.08	0.01	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.52	0.08	0.00	0.00	0.55	0.00
	III	0.00	0.00	0.00	0.17	0.01	0.00	0.00	2.97	0.00	0.00	0.00	0.21	0.01	1.33	8.38	0.00	0.00	0.00	0.00	0.00	0.00	1.23	0.11	0.08	0.01
FEB	I	0.02	0.06	0.00	0.41	0.40	1.66	0.00	1.96	2.33	0.00	0.00	0.44	2.86	0.56	1.99	0.00	0.01	0.16	0.05	1.19	0.00	0.02	0.14	0.00	0.38
	II	0.01	0.00	0.00	0.74	0.14	0.14	0.00	0.04	0.01	0.15	0.01	0.59	2.31	0.00	0.05	0.00	0.42	0.00	0.00	0.33	0.01	0.13	1.63	0.08	0.76
	III	0.56	0.00	0.84	0.00	0.83	0.43	0.00	0.05	0.00	0.68	0.00	0.31	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.12	0.36	0.00	0.48	4.55	0.09
MAR	I	2.12	0.00	1.42	0.00	2.65	0.58	0.00	0.37	0.00	0.00	1.14	0.01	0.02	0.00	0.93	2.62	0.04	0.00	0.00	0.00	0.08	0.00	0.00	2.12	5.86
	II	0.29	0.00	0.17	0.00	2.63	0.09	0.00	1.98	0.00	0.00	0.31	0.11	0.50	0.00	0.34	3.15	0.31	0.22	0.10	1.25	0.00	0.00	0.64	0.41	1.65
	III	0.05	0.07	0.00	0.00	1.41	0.00	0.11	0.34	0.00	0.01	0.07	0.09	0.07	0.03	0.00	0.00	0.00	2.29	0.07	0.01	0.01	0.00	0.47	0.02	0.26
APR	I	0.39	0.06	0.08	0.26	0.63	0.10	1.63	0.41	0.00	0.00	0.06	0.04	0.07	0.02	0.00	0.00	0.03	0.32	0.50	0.00	0.15	0.11	0.34	0.02	0.78
	II	0.00	0.02	0.05	0.37	0.28	0.48	0.27	0.41	0.00	0.00	2.75	0.00	0.16	0.00	0.33	1.50	0.33	0.00	0.00	0.00	1.25	0.01	0.17	0.78	2.08
	III	0.00	0.23	0.00	0.01	0.02	0.39	0.10	1.00	0.00	0.00	0.03	0.00	0.11	0.24	0.43	0.02	0.05	0.00	0.00	0.21	0.35	0.03	0.66	0.06	0.10
MAY	I	0.00	0.20	0.00	0.06	0.22	0.02	0.95	0.84	0.05	0.27	0.01	0.12	0.03	0.04	0.66	0.31	0.01	0.39	0.00	0.04	0.21	0.00	0.00	0.58	0.65
	II	0.02	0.17	0.00	0.00	0.27	0.00	0.03	0.51	0.44	0.13	0.25	0.28	0.18	0.23	0.00	0.66	0.40	0.00	0.02	0.05	0.06	0.04	0.01	0.05	0.86
	III	0.22	0.35	0.45	0.05	0.03	0.10	0.01	0.02	0.96	0.63	0.67	0.56	0.02	0.01	0.33	1.42	0.07	0.08	0.31	0.63	0.07	0.01	0.03	0.15	0.03
Yearly Rainfall (mm)		1365	930	1109	1240	1979	1160	917	1501	1235	1393	1042	1319	1155	1439	1015	1437	1040	959	970	1112	1330	1150	1161	1704	1102

5.8.2.3 Rainfall and Runoff Data at Ashti G&D Site

Detailed calculations on water availability and flood magnitude will help select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the monthly runoff and monthly rainfall for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Ashti G&D site is shown in **Figure 5.49**. The basic comparison between rainfall and runoff in **Figure 5.49** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.50** shows plot of runoff coefficient at G&D site.

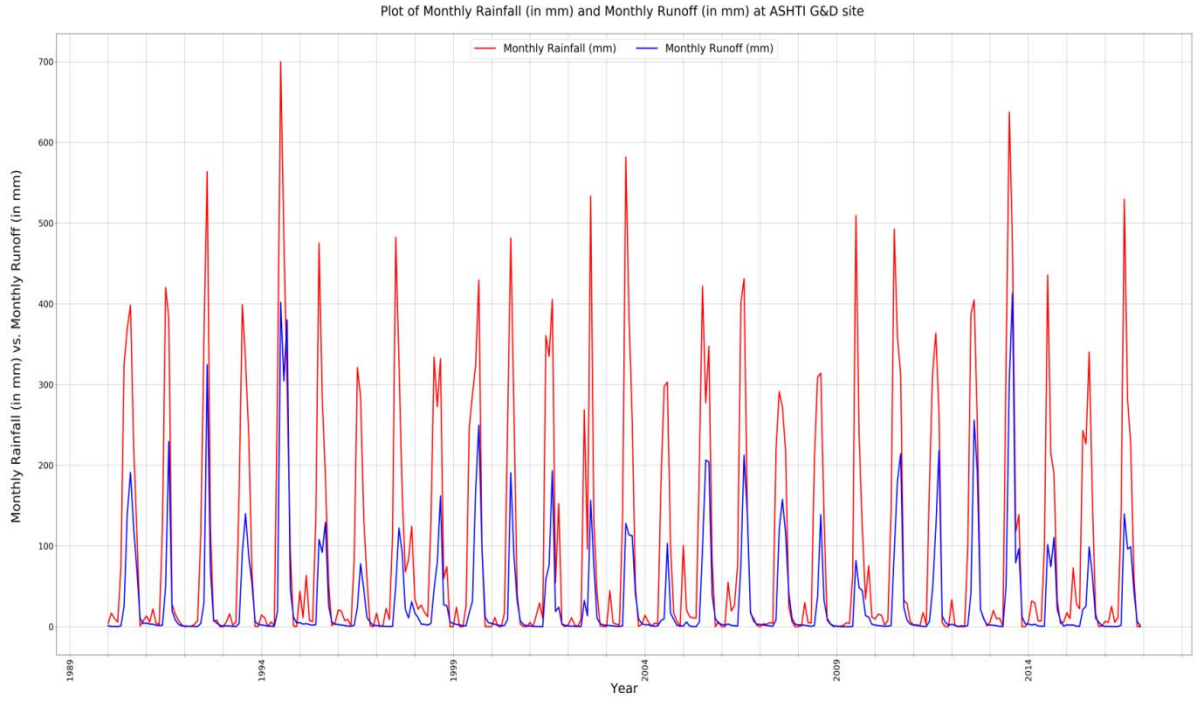


Figure 5.49: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site

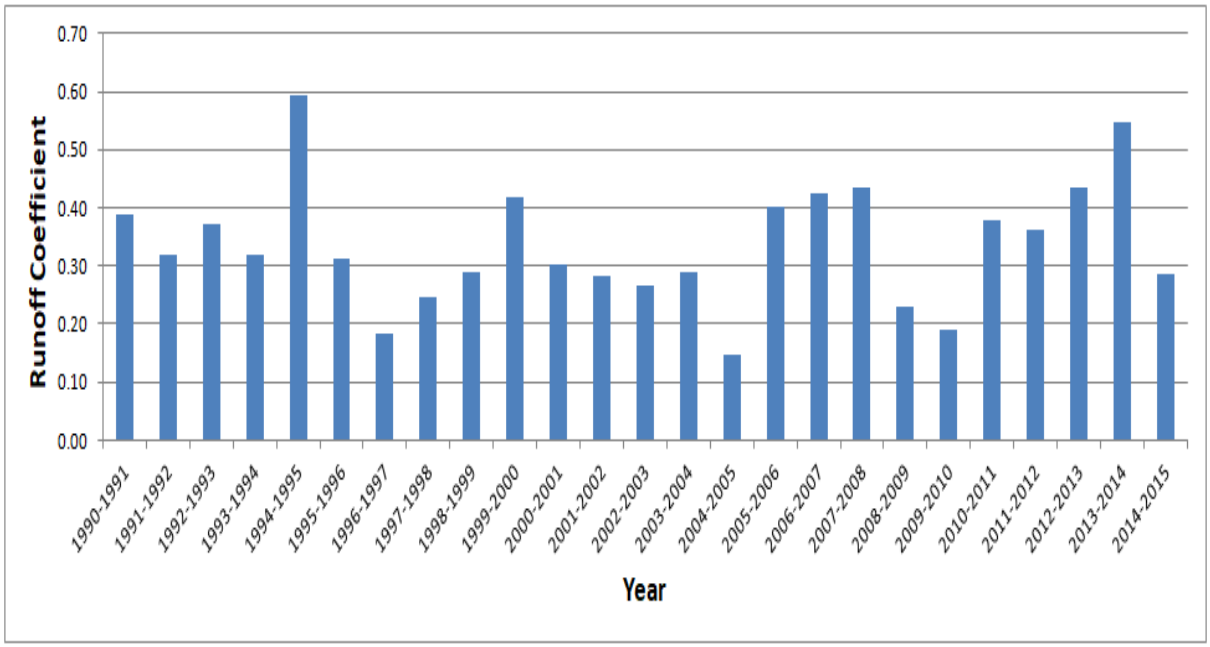


Figure 5.50: Plot of Runoff Coefficient at G&D site

5.8.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Ashti is around 50,990 km^2 as mentioned on India WRIS site. Daily discharge data for Ashti site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Ashti, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Ashti G&D and the dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Ashti G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Wainganga}}{CA_{Ashti}} = \frac{43264}{50990} = 0.85$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Wainganga}}{\text{Average Annual Rainfall}_{Ashti}} = \frac{1231}{1265} = 0.97$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Wainganga}} = Q_{\text{Ashti G\&D } Site} \text{X } 0.97 \text{ X } 0.85$$

Table 5.91 shows 10-daily average flow series at G&D site. **Table 5.92** and **Table 5.93** show 10-daily average flow series (m^3/s) and 10-daily inflow series (MCM) respectively at Wainganga Dam site.

Table 5.91: 10-Daily Average Flow Series (m^3/s) at Ashti G&D

Catchment Area =50,990 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	41.27	5.15	3.34	31.78	5.23	13.58	3.85	1.86	27.09	15.97	74.46	5.62	1.12	7.27	16.50	0.27	14.28	3.10	3.74	7.56	10.54	2.74	2.33	1.77	3.46
	II	273.59	83.91	63.52	48.65	73.35	26.46	16.97	0.78	63.11	340.94	206.35	3199.33	0.25	9.10	229.33	0.41	11.44	27.71	23.69	5.34	15.07	95.12	1.44	534.33	16.11
	III	1184.86	13.17	175.87	160.69	1020.38	109.69	83.61	21.58	137.64	666.97	251.59	299.72	1911.02	48.66	200.64	347.61	20.23	481.82	49.67	6.48	51.40	283.26	92.41	2475.56	21.12
JUL	I	1185.60	16.26	79.64	419.30	1757.15	159.78	77.18	44.63	1024.91	134.07	195.16	553.98	296.27	508.69	62.90	905.16	1327.04	4241.15	464.16	102.12	359.96	290.91	149.63	1491.06	39.04
	II	1772.18	1091.52	112.76	3382.00	14039.19	980.15	204.00	148.65	1084.40	320.11	7123.90	1389.90	172.73	975.20	123.14	1897.42	291.69	1905.86	440.04	2081.24	2018.01	543.94	422.42	6706.13	494.47
	III	4865.23	1665.07	1425.73	1462.34	7206.56	4762.73	1024.38	2562.62	600.58	1271.87	3576.15	2322.01	303.06	5508.44	353.29	2622.16	2656.47	884.87	1173.33	2411.72	2841.54	1751.83	1688.63	8933.97	4974.45
AUG	I	865.35	4255.20	1760.57	4759.60	4383.23	1969.40	1303.09	3003.64	1456.70	4874.60	698.91	1997.13	417.68	1421.72	2407.48	6451.29	3827.50	6032.85	5120.11	283.52	6324.87	1808.03	5193.31	10198.43	2492.86
	II	3136.88	6318.70	6690.45	1815.73	3167.48	1552.41	1032.56	323.47	1978.20	3510.68	1787.50	5867.60	2968.11	1837.05	2019.65	1935.40	6525.82	2057.02	2356.21	607.72	2423.15	2580.22	3495.10	5990.84	1088.29
	III	6611.05	2699.64	9725.66	1538.84	9465.02	1735.00	2059.18	3528.89	1145.84	1406.72	2393.64	3212.06	5318.68	3137.01	1508.52	3446.99	1991.15	1102.12	651.08	1792.53	1751.67	2537.76	5826.79	7449.61	729.24
SEP	I	3545.98	687.23	2269.25	1625.51	19084.62	5488.40	1351.30	1578.59	1914.83	1292.51	1179.51	580.41	3053.01	2783.14	308.58	595.36	5466.45	3118.43	782.97	1432.35	7082.43	8363.88	7043.53	1737.11	4073.71
	II	2282.21	276.86	1651.22	1224.97	2436.13	1315.50	1023.57	2658.80	5721.40	6404.40	431.20	334.70	1124.87	2115.82	298.21	9295.49	1730.10	2126.92	513.90	815.98	3717.62	3343.52	2860.17	947.44	1834.09
	III	1342.39	202.14	322.86	2325.93	915.24	820.06	346.07	1218.21	1916.40	7036.80	291.79	195.60	252.71	1741.84	362.59	2149.39	1145.43	1546.75	668.78	379.27	1833.90	1156.07	1372.66	1987.36	611.81
OCT	I	2083.17	171.97	175.21	1358.66	1206.81	314.17	217.33	403.04	728.73	2921.60	157.56	781.41	149.38	1436.56	245.19	474.37	686.31	1447.10	250.43	379.43	501.69	272.49	622.54	2990.02	370.18
	II	1408.75	209.52	147.62	965.44	980.28	340.04	150.24	220.68	358.67	1967.73	124.39	489.21	156.60	438.47	150.42	1070.75	195.47	667.44	203.16	309.45	412.81	281.43	300.64	1904.97	481.52
	III	592.76	107.16	134.75	786.54	535.02	810.71	274.92	601.53	463.77	668.18	119.10	146.00	283.12	492.53	121.38	743.07	191.71	316.20	142.19	120.07	451.95	208.70	291.91	726.32	376.85
NOV	I	364.12	96.63	112.03	184.61	321.73	163.63	161.00	329.77	447.52	405.11	78.85	97.60	127.25	241.29	40.10	267.55	184.46	293.68	105.88	123.71	163.11	150.50	301.86	413.75	265.63
	II	145.90	53.38	89.31	107.69	211.65	108.80	102.78	171.33	811.24	182.32	49.40	62.46	62.78	167.82	28.86	195.47	137.48	203.51	63.72	104.26	124.45	114.21	173.13	210.25	132.25
	III	95.04	30.96	60.24	84.77	163.99	66.93	62.25	137.85	279.18	117.84	32.79	41.04	35.94	148.58	28.56	156.83	86.75	123.64	41.24	468.87	195.92	54.72	83.63	85.08	53.97
DEC	I	94.01	23.56	40.46	66.63	117.42	62.91	33.35	828.50	127.26	101.74	26.47	37.14	35.52	114.12	25.54	88.63	68.01	56.70	33.95	82.77	74.98	36.00	65.94	51.05	18.17
	II	77.45	16.45	26.88	58.13	74.93	68.07	26.09	603.46	102.41	102.71	19.14	28.64	40.67	52.98	20.74	88.82	58.70	53.49	27.26	59.69	64.03	28.73	44.41	74.07	10.94
	III	57.49	19.03	23.86	40.83	70.52	46.50	29.65	362.88	97.51	82.06	17.76	24.21	41.83	52.88	17.67	63.87	55.61	57.88	8.80	28.82	48.77	38.69	39.09	69.74	7.34
JAN	I	73.35	15.09	28.78	37.45	68.80	47.05	29.75	583.65	80.79	76.94	18.16	18.59	36.19	45.25	15.55	62.14	62.20	54.01	9.09	40.18	58.56	68.82	44.58	77.24	15.50
	II	81.88	14.08	23.33	26.79	149.39	58.14	25.67	237.81	80.87	76.70	24.71	17.72	29.28	35.64	12.20	52.48	44.54	37.15	15.46	35.60	46.63	80.22	49.12	56.20	68.63
	III	104.26	15.31	13.93	56.37	74.68	47.24	33.13	153.53	65.30	73.32	12.80	14.38	29.46	54.51	17.69	49.59	52.04	39.37	8.25	38.78	28.53	26.51	28.49	53.81	50.09
FEB	I	69.79	15.61	21.64	28.60	85.18	46.66	23.44	394.60	64.53	60.96	8.77	14.94	31.89	87.43	274.25	40.06	46.89	53.82	5.12	28.44	23.85	64.45	30.64	50.92	50.82
	II	63.26	9.58	23.10	31.91	58.15	45.80	24.59	177.31	63.33	60.26	7.56	13.00	30.46	32.08	52.02	41.49	33.46	46.30	3.21	19.42	39.36	30.53	44.25	46.10	39.78
	III	73.04	10.72	12.76	40.48	53.89	40.45	14.88	100.93	47.80	58.23	5.36	16.72	30.56	27.83	25.92	40.43	49.03	25.85	2.51	38.19	30.53	8.42	37.45	34.21	30.13
MAR	I	63.98	6.86	26.53	21.18	52.90	37.96	10.63	59.55	41.53	42.57	3.69	10.73	21.18	28.99	16.54	34.33	35.79	36.67	1.80	22.47	23.88	4.67	37.76	88.08	37.88
	II	62.77	10.75	21.00	13.36	79.93	33.59	10.98	46.82	36.54	35.23	4.19	11.01	13.46	19.27	12.99	102.19	29.06	34.22	1.29	20.11	23.32	4.13	14.89	61.97	54.75
	III	52.43	8.65	10.33	16.04	87.25	17.44	11.32	79.13	42.94	33.89	4.49	7.70	20.63	22.90	10.38	53.15	29.71	30.09	0.93	17.23	15.37	11.47	17.16	23.53	32.59
APR	I	26.87	5.30	5.88	11.33	59.46	14.67	9.14	45.96	30.81	19.82	3.13	8.24	12.57	16.74	5.28	23.01	21.29	31.03	0.73	11.08	5.47	11.24	13.34	20.89	9.94
	II	30.10	4.77	7.12	12.40	53.84	13.63	6.26	42.25	24.12	33.61	2.38	6.27	7.25	12.43	3.11	31.95	21.73	22.25	0.35	8.94	4.72	4.63	7.75	17.90	10.22
	III	50.41	4.23	6.04	10.66	44.85	15.02	6.47	79.08	20.02	26.11	3.50	4.02	5.51	7.76	1.78	42.40	18.76	13.96	0.21	5.76	5.81	2.48	4.54	13.00	12.07
MAY	I	28.88	3.53	5.15	5.77	55.27	15.63	5.91	61.23	17.88	22.68	3.94	3.46	7.96	28.29	1.27	25.31	11.48	11.51	0.18	8.60	3.74	3.01	6.15	15.24	11.52
	II	22.31	3.49	5.06	7.10	30.75	6.67	6.23	26.27	20.40	26.51	2.89	6.03	5.28	15.14	0.84	23.81	16.08	9.73	0.12	15.31	2.40	2.22	4.69	11.46	13.35
	III	30.94	3.69	5.04	4.37	24.48	5.28	3.67	32.55	25.83	29.27	1.03	1.43	4.35	12.15	0.14	21.00	5.11	5.85	0.13	12.99	6.97	2.20	5.51	7.46	6.42

Table 5.92: 10-Daily Average Flow Series (m^3/s) at Wainganga Dam

Catchment Area =43,264 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	34.05	4.25	2.76	26.22	4.32	11.21	3.18	1.53	22.35	13.18	61.44	4.64	0.92	6.00	13.61	0.22	11.78	2.56	3.09	6.24	8.70	2.26	1.92	1.46	2.86
	II	225.75	69.24	52.41	40.14	60.52	21.83	14.00	0.64	52.07	281.32	170.27	2639.91	0.21	7.51	189.23	0.34	9.44	22.86	19.55	4.41	12.43	78.49	1.19	440.90	13.29
	III	977.68	10.87	145.12	132.59	841.96	90.51	68.99	17.81	113.57	550.35	207.60	247.31	1576.87	40.15	165.56	286.83	16.69	397.57	40.98	5.35	42.41	233.73	76.25	2042.70	17.43
JUL	I	978.29	13.42	65.71	345.98	1449.90	131.84	63.68	36.83	845.70	110.63	161.04	457.11	244.47	419.74	51.90	746.89	1095.00	3499.56	383.00	84.26	297.02	240.04	123.47	1230.34	32.21
	II	1462.31	900.66	93.04	2790.64	11584.37	808.77	168.33	122.66	894.79	264.14	5878.25	1146.87	142.53	804.68	101.61	1565.65	240.69	1572.61	363.10	1717.33	1665.15	448.83	348.56	5533.53	408.01
	III	4014.52	1373.92	1176.43	1206.64	5946.46	3929.94	845.26	2114.53	495.57	1049.48	2950.84	1916.00	250.07	4545.26	291.52	2163.66	2191.97	730.15	968.17	1990.02	2344.68	1445.51	1393.36	7371.82	4104.64
AUG	I	714.04	3511.16	1452.73	3927.36	3616.80	1625.04	1075.24	2478.44	1201.99	4022.25	576.70	1647.92	344.65	1173.13	1986.52	5323.25	3158.24	4977.98	4224.83	233.95	5218.94	1491.89	4285.23	8415.19	2056.97
	II	2588.38	5213.84	5520.59	1498.24	2613.63	1280.96	852.01	266.91	1632.30	2896.82	1474.95	4841.62	2449.12	1515.83	1666.50	1596.99	5384.75	1697.34	1944.22	501.46	1999.45	2129.06	2883.96	4943.31	898.00
	III	5455.08	2227.59	8025.08	1269.77	7810.02	1431.63	1699.12	2911.85	945.48	1160.75	1975.10	2650.42	4388.68	2588.49	1244.75	2844.27	1642.99	909.41	537.24	1479.10	1445.38	2094.02	4807.95	6147.01	601.73
SEP	I	2925.95	567.06	1872.46	1341.28	15747.58	4528.73	1115.02	1302.57	1580.01	1066.51	973.27	478.92	2519.18	2296.49	254.62	491.26	4510.61	2573.16	646.06	1181.90	5844.03	6901.42	5811.93	1433.37	3361.40
	II	1883.15	228.45	1362.50	1010.78	2010.16	1085.48	844.59	2193.90	4720.99	5284.56	355.80	276.18	928.18	1745.86	246.07	7670.13	1427.58	1755.02	424.04	673.30	3067.58	2758.89	2360.06	781.78	1513.39
	III	1107.67	166.79	266.41	1919.23	755.21	676.67	285.56	1005.20	1581.31	5806.38	240.77	161.40	208.52	1437.27	299.19	1773.56	945.15	1276.29	551.84	312.95	1513.23	953.93	1132.64	1639.86	504.83
OCT	I	1718.92	141.90	144.57	1121.09	995.79	259.24	179.33	332.57	601.31	2410.74	130.01	644.78	123.26	1185.37	202.32	391.42	566.31	1194.07	206.64	313.08	413.97	224.84	513.69	2467.20	305.45
	II	1162.42	172.88	121.81	796.63	808.87	280.58	123.97	182.09	295.95	1623.66	102.64	403.67	129.22	361.80	124.12	883.52	161.29	550.73	167.64	255.34	340.63	232.22	248.07	1571.88	397.32
	III	489.11	88.42	111.19	649.01	441.47	668.95	226.85	496.35	382.68	551.35	98.27	120.47	233.62	406.41	100.16	613.14	158.19	260.91	117.33	99.08	372.92	172.21	240.87	599.32	310.96
NOV	I	300.45	79.73	92.44	152.33	265.47	135.02	132.85	272.11	369.27	334.27	65.06	80.53	105.00	199.10	33.09	220.77	152.21	242.33	87.37	102.08	134.59	124.18	249.08	341.40	219.18
	II	120.39	44.05	73.69	88.86	174.64	89.78	84.81	141.37	669.39	150.44	40.76	51.54	51.80	138.48	23.81	161.29	113.44	167.93	52.58	86.03	102.69	94.24	142.86	173.49	109.13
	III	78.42	25.55	49.71	69.95	135.32	55.23	51.37	113.75	230.36	97.24	27.06	33.86	29.66	122.60	23.57	129.41	71.58	102.02	34.03	386.89	161.66	45.15	69.01	70.20	44.53
DEC	I	77.57	19.44	33.39	54.98	96.89	51.91	27.52	683.63	105.01	83.95	21.84	30.65	29.31	94.17	21.07	73.13	56.12	46.79	28.01	68.30	61.87	29.71	54.41	42.12	14.99
	II	63.91	13.57	22.18	47.97	61.83	56.17	21.53	497.94	84.50	84.75	15.79	23.63	33.56	43.72	17.11	73.29	48.44	44.14	22.49	49.25	52.83	23.71	36.64	61.12	9.03
	III	47.44	15.70	19.69	33.69	58.19	38.37	24.47	299.43	80.46	67.71	14.65	19.98	34.52	43.63	14.58	52.70	45.89	47.76	7.26	23.78	40.24	31.92	32.25	57.55	6.06
JAN	I	60.52	12.45	23.75	30.90	56.77	38.82	24.55	481.60	66.66	63.49	14.98	15.34	29.86	37.34	12.83	51.27	51.32	44.57	7.50	33.15	48.32	56.79	36.78	63.73	12.79
	II	67.56	11.62	19.25	22.11	123.27	47.97	21.18	196.23	66.73	63.29	20.39	14.62	24.16	29.41	10.07	43.30	36.75	30.65	12.76	29.38	38.48	66.19	40.53	46.37	56.63
	III	86.03	12.63	11.49	46.51	61.62	38.98	27.34	126.68	53.88	60.50	10.56	11.87	24.31	44.98	14.60	40.92	42.94	32.49	6.81	32.00	23.54	21.87	23.51	44.40	41.33
FEB	I	57.59	12.88	17.86	23.60	70.29	38.50	19.34	325.60	53.25	50.30	7.24	12.33	26.31	72.14	226.30	33.06	38.69	44.41	4.22	23.47	19.68	53.18	25.28	42.02	41.93
	II	52.20	7.90	19.06	26.33	47.98	37.79	20.29	146.31	52.26	49.72	6.24	10.73	25.13	26.47	42.92	34.24	27.61	38.20	2.65	16.02	32.48	25.19	36.51	38.04	32.82
	III	60.27	8.85	10.53	33.40	44.47	33.38	12.28	83.28	39.44	48.05	4.42	13.80	25.22	22.96	21.39	33.36	40.46	21.33	2.07	31.51	25.19	6.95	30.90	28.23	24.86
MAR	I	52.79	5.66	21.89	17.48	43.65	31.32	8.77	49.14	34.27	35.13	3.04	8.85	17.48	23.92	13.65	28.33	29.53	30.26	1.49	18.54	19.70	3.85	31.16	72.68	31.26
	II	51.79	8.87	17.33	11.02	65.95	27.72	9.06	38.63	30.15	29.07	3.46	9.08	11.11	15.90	10.72	84.32	23.98	28.24	1.06	16.59	19.24	3.41	12.29	51.13	45.18
	III	43.26	7.14	8.52	13.24	71.99	14.39	9.34	65.29	35.43	27.96	3.70	6.35	17.02	18.90	8.57	43.86	24.52	24.83	0.77	14.22	12.68	9.46	14.16	19.42	26.89
APR	I	22.17	4.37	4.85	9.35	49.06	12.10	7.54	37.92	25.42	16.35	2.58	6.80	10.37	13.81	4.36	18.99	17.57	25.60	0.60	9.14	4.51	9.27	11.01	17.24	8.20
	II	24.84	3.94	5.88	10.23	44.43	11.25	5.17	34.86	19.90	27.73	1.96	5.17	5.98	10.26	2.57	26.36	17.93	18.36	0.29	7.38	3.89	3.82	6.39	14.77	8.43
	III	41.60	3.49	4.98	8.80	37.01	12.39	5.34	65.25	16.52	21.54	2.89	3.32	4.55	6.40	1.47	34.99	15.48	11.52	0.17	4.75	4.79	2.05	3.75	10.73	9.96
MAY	I	23.83	2.91	4.25	4.76	45.61	12.90	4.88	50.52	14.75	18.71	3.25	2.86	6.57	23.34	1.05	20.88	9.47	9.50	0.15	7.10	3.09	2.48	5.07	12.58	9.51
	II	18.41	2.88	4.18	5.86	25.37	5.50	5.14	21.68	16.83	21.87	2.38	4.98	4.36	12.49	0.69	19.65	13.27	8.03	0.10	12.63	1.98	1.83	3.87	9.46	11.02
	III	25.53	3.04	4.16	3.61	20.20	4.36	3.03	26.86	21.31	24.15	0.85	1.18	3.59	10.03	0.12	17.33	4.22	4.83	0.11	10.72	5.75	1.82	4.55	6.16	5.30
Inflow (MCM) =		24294	13278	18849	16508	49869	15752	7233	15387	15246	24843	13940	15962	12571	17544	6571	24333	19704	19562	9533	8812	22311	17626	22243	40834	13653

Table 5.93: 10-Daily Inflow Series (MCM) at Wainganga Project Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	29.42	3.67	2.38	22.66	3.73	9.68	2.74	1.33	19.31	11.39	53.08	4.01	0.80	5.18	11.76	0.19	10.18	2.21	2.67	5.39	7.51	1.95	1.66	1.26	2.47
	II	195.05	59.82	45.29	34.68	52.29	18.86	12.10	0.56	44.99	243.06	147.11	2280.88	0.18	6.49	163.50	0.29	8.16	19.76	16.89	3.81	10.74	67.81	1.03	380.94	11.49
	III	844.72	9.39	125.38	114.56	727.45	78.20	59.61	15.38	98.13	475.50	179.36	213.68	1362.41	34.69	143.04	247.82	14.42	343.50	35.41	4.62	36.64	201.94	65.88	1764.89	15.06
JUL	I	845.24	11.59	56.78	298.93	1252.72	113.91	55.02	31.82	730.68	95.58	139.13	394.95	211.22	362.66	44.84	645.31	946.08	3023.62	330.91	72.80	256.62	207.40	106.68	1063.01	27.83
	II	1263.43	778.17	80.39	2411.11	10008.90	698.77	145.44	105.98	773.10	228.21	5078.81	990.90	123.14	695.24	87.79	1352.72	207.95	1358.74	313.72	1483.77	1438.69	387.79	301.15	4780.97	352.52
	III	3815.40	1305.78	1118.08	1146.79	5651.51	3735.02	803.34	2009.65	470.99	997.42	2804.48	1820.96	237.67	4319.82	277.06	2056.34	2083.25	693.93	920.15	1891.31	2228.39	1373.82	1324.25	7006.18	3901.05
AUG	I	616.93	3033.64	1255.16	3393.24	3124.92	1404.04	929.01	2141.37	1038.52	3475.23	498.27	1423.80	297.77	1013.58	1716.35	4599.29	2728.72	4300.97	3650.26	202.13	4509.16	1288.99	3702.44	7270.72	1777.22
	II	2236.36	4504.76	4769.79	1294.48	2258.18	1106.75	736.14	230.61	1410.31	2502.85	1274.35	4183.16	2116.04	1309.68	1439.86	1379.80	4652.42	1466.50	1679.80	433.26	1727.53	1839.50	2491.75	4271.02	775.87
	III	5184.50	2117.11	7627.04	1206.79	7422.64	1360.62	1614.85	2767.42	898.59	1103.18	1877.14	2518.96	4171.00	2460.10	1183.01	2703.19	1561.50	864.30	510.59	1405.73	1373.69	1990.16	4569.47	5842.12	571.88
SEP	I	2528.02	489.94	1617.81	1158.87	13605.91	3912.82	963.38	1125.42	1365.13	921.46	840.90	413.79	2176.57	1984.17	219.99	424.45	3897.17	2223.21	558.20	1021.16	5049.24	5962.82	5021.51	1238.43	2904.25
	II	1627.05	197.38	1177.20	873.31	1736.78	937.85	729.73	1895.53	4078.93	4565.86	307.41	238.62	801.95	1508.42	212.60	6626.99	1233.43	1516.34	366.37	581.73	2650.39	2383.68	2039.09	675.45	1307.57
	III	957.02	144.11	230.18	1658.21	652.50	584.64	246.72	868.49	1366.25	5016.71	208.02	139.45	180.16	1241.80	258.50	1532.35	816.61	1102.72	476.79	270.39	1307.43	824.19	978.60	1416.84	436.17
OCT	I	1485.14	122.60	124.91	968.62	860.37	223.98	154.94	287.34	519.53	2082.88	112.33	557.09	106.50	1024.16	174.80	338.19	489.29	1031.67	178.54	270.51	357.67	194.27	443.82	2131.66	263.91
	II	1004.33	149.37	105.24	688.29	698.87	242.42	107.11	157.33	255.70	1402.84	88.68	348.77	111.64	312.60	107.24	763.36	139.36	475.83	144.84	220.61	294.30	200.64	214.33	1358.10	343.29
	III	464.85	84.04	105.67	616.82	419.57	635.77	215.60	471.73	363.70	524.00	93.40	114.50	222.03	386.25	95.19	582.73	150.34	247.97	111.51	94.16	354.43	163.67	228.92	569.59	295.53
NOV	I	259.59	68.89	79.87	131.61	229.37	116.66	114.78	235.10	319.05	288.81	56.21	69.58	90.72	172.02	28.59	190.74	131.51	209.37	75.48	88.20	116.29	107.30	215.20	294.97	189.37
	II	104.02	38.06	63.67	76.77	150.89	77.57	73.27	122.15	578.35	129.98	35.22	44.53	44.76	119.64	20.58	139.36	98.01	145.09	45.43	74.33	88.72	81.42	123.43	149.89	94.28
	III	67.76	22.07	42.95	60.43	116.91	47.72	44.38	98.28	199.03	84.01	23.38	29.26	25.62	105.93	20.36	111.81	61.85	88.15	29.40	334.27	139.68	39.01	59.62	60.66	38.48
DEC	I	67.02	16.80	28.84	47.50	83.71	44.85	23.78	590.66	90.73	72.53	18.87	26.48	25.32	81.36	18.21	63.19	48.49	40.42	24.20	59.01	53.46	25.67	47.01	36.39	12.95
	II	55.22	11.73	19.16	41.44	53.42	48.53	18.60	430.22	73.01	73.22	13.65	20.42	28.99	37.77	14.79	63.32	41.85	38.13	19.43	42.55	45.65	20.48	31.66	52.81	7.80
	III	45.08	14.92	18.71	32.02	55.30	36.47	23.25	284.58	76.47	64.35	13.93	18.99	32.80	41.47	13.86	50.09	43.61	45.39	6.90	22.60	38.25	30.34	30.66	54.69	5.76
JAN	I	52.29	10.76	20.52	26.70	49.05	33.54	21.21	416.10	57.60	54.85	12.95	13.25	25.80	32.26	11.09	44.30	44.34	38.51	6.48	28.65	41.75	49.06	31.78	55.07	11.05
	II	58.37	10.04	16.63	19.10	106.50	41.45	18.30	169.54	57.65	54.68	17.62	12.63	20.87	25.41	8.70	37.41	31.75	26.49	11.02	25.38	33.24	57.19	35.02	40.07	48.93
	III	81.76	12.01	10.92	44.21	58.57	37.05	25.98	120.40	51.21	57.50	10.04	11.28	23.10	42.75	13.87	38.89	40.81	30.87	6.47	30.41	22.37	20.79	22.34	42.20	39.28
FEB	I	49.76	11.13	15.43	20.39	60.73	33.27	16.71	281.32	46.01	43.46	6.25	10.65	22.74	62.33	195.52	28.56	33.43	38.37	3.65	20.28	17.00	45.95	21.84	36.30	36.23
	II	45.10	6.83	16.47	22.75	41.46	32.65	17.53	126.41	45.15	42.96	5.39	9.27	21.72	22.87	37.09	29.58	23.85	33.01	2.29	13.85	28.06	21.77	31.55	32.87	28.36
	III	41.66	6.11	7.28	23.09	30.74	23.07	8.49	57.56	27.26	33.21	3.06	9.54	17.43	15.87	14.78	23.06	27.96	14.74	1.43	21.78	17.41	4.80	21.36	19.51	17.18
MAR	I	45.61	4.89	18.91	15.10	37.71	27.06	7.58	42.45	29.61	30.35	2.63	7.65	15.10	20.67	11.79	24.47	25.52	26.14	1.28	16.02	17.02	3.33	26.92	62.79	27.01
	II	44.75	7.66	14.97	9.52	56.98	23.95	7.83	33.38	26.05	25.12	2.99	7.85	9.60	13.74	9.26	72.85	20.72	24.40	0.92	14.34	16.63	2.94	10.62	44.18	39.03
	III	41.12	6.78	8.10	12.58	68.42	13.68	8.88	62.06	33.67	26.58	3.52	6.04	16.18	17.96	8.14	41.68	23.30	23.60	0.73	13.51	12.05	8.99	13.46	18.45	25.56
APR	I	19.16	3.78	4.19	8.08	42.39	10.46	6.52	32.77	21.97	14.13	2.23	5.87	8.96	11.93	3.76	16.40	15.18	22.12	0.52	7.90	3.90	8.01	9.51	14.89	7.09
	II	21.46	3.40	5.08	8.84	38.38	9.72	4.46	30.12	17.20	23.96	1.70	4.47	5.17	8.86	2.22	22.78	15.49	15.86	0.25	6.37	3.37	3.30	5.53	12.76	7.29
	III	35.94	3.02	4.31	7.60	31.97	10.71	4.61	56.38	14.27	18.61	2.50	2.87	3.93	5.53	1.27	30.23	13.37	9.95	0.15	4.11	4.14	1.77	3.24	9.27	8.61
MAY	I	20.59	2.52	3.67	4.11	39.40	11.14	4.21	43.65	12.75	16.17	2.81	2.47	5.67	20.17	0.91	18.04	8.18	8.21	0.13	6.13	2.67	2.15	4.38	10.86	8.21
	II	15.91	2.49	3.61	5.06	21.92	4.76	4.44	18.73	14.54	18.90	2.06	4.30	3.76	10.79	0.60	16.97	11.46	6.94	0.09	10.91	1.71	1.58	3.34	8.17	9.52
	III	24.26	2.89	3.95	3.43	19.20	4.14	2.88	25.53	20.26	22.95	0.81	1.12	3.41	9.53	0.11	16.47	4.01	4.59	0.10	10.19	5.47	1.73	4.32	5.85	5.03
Total Inflow (MCM) =		24294	13278	18849	16508	49869	15752	7233	15387	15246	24843	13940	15962	12571	17544	6571	24333	19704	19562	9533	8812	22311	17626	22243	40834	13653

5.8.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.9** and **Table 5.95**

Table 5.94: Computation of 90% and 50% Dependable Year for Wainganga Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.04	49869	1994-1995	
2	0.08	40834	2013-2014	
3	0.12	24843	1999-2000	
4	0.15	24333	2005-2006	
5	0.19	24294	1990-1991	
6	0.23	22311	2010-2011	
7	0.27	22243	2012-2013	
8	0.31	19704	2006-2007	
9	0.35	19562	2007-2008	
10	0.38	18849	1992-1993	
11	0.42	17626	2011-2012	
12	0.46	17544	2003-2004	
13	**0.50**	**16508**	**1993-1994**	**50% Dependable**
14	0.54	15962	2001-2002	
15	0.58	15752	1995-1996	
16	0.62	15387	1997-1998	
17	0.65	15246	1998-1999	
18	0.69	13940	2000-2001	
19	0.73	13653	2014-2015	
20	0.77	13278	1991-1992	
21	0.81	12571	2002-2003	
22	0.85	9533	2008-2009	
23	**0.88**	**8812**	**2009-2010**	**90% Dependable**
24	0.92	7233	1996-1997	
25	0.96	6571	2004-2005	

Table 5.95: 90% and 50% dependable flows for the dam site (cumec)

Period		90% Dependable 2009-2010	50% Dependable 1993-1994
Jun	I	6.24	26.22
	II	4.41	40.14
	III	5.35	132.59
Jul	I	84.26	345.98
	II	1717.33	2790.64
	III	1990.02	1206.64
Aug	I	233.95	3927.36
	II	501.46	1498.24
	III	1479.10	1269.77
Sep	I	1181.90	1341.28
	II	673.30	1010.78
	III	312.95	1919.23
Oct	I	313.08	1121.09
	II	255.34	796.63
	III	99.08	649.01
Nov	I	102.08	152.33
	II	86.03	88.86
	III	386.89	69.95
Dec	I	68.30	54.98
	II	49.25	47.97
	III	23.78	33.69
Jan	I	33.15	30.90
	II	29.38	22.11
	III	32.00	46.51
Feb	I	23.47	23.60
	II	16.02	26.33
	III	31.51	33.40
Mar	I	18.54	17.48
	II	16.59	11.02
	III	14.22	13.24
Apr	I	9.14	9.35
	II	7.38	10.23
	III	4.75	8.80
May	I	7.10	4.76
	II	12.63	5.86
	III	10.72	3.61
Inflow (MCM) =		8812	16508

5.8.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Wainganga, is given in the following section.

5.8.5.1 EAC of Wainganga Dam

The EAC curve and the table showing the different values are given in **Figure 5.51** and **Table 5.96** respectively.

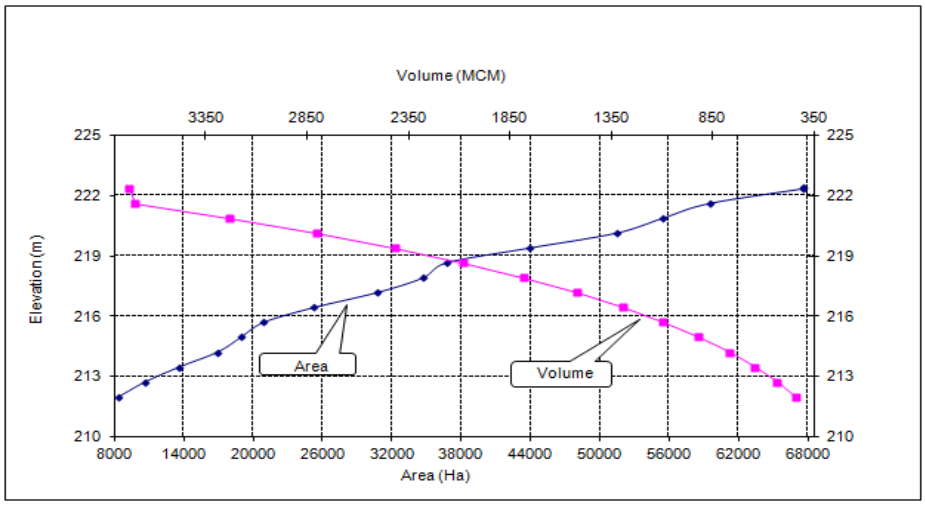


Figure 5.51: EAC curve of Wainganga Dam

Table 5.96: EAC data of Wainganga Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
212.00	83950689.61	8395.07	359764917.3	359.76
212.74	106785615.35	10678.56	438786859.3	438.79
213.48	136237399.74	13623.74	531943902.5	531.94
214.22	169363964.24	16936.40	640048211.3	640.05
214.96	189363964.24	18936.40	765378475.2	765.38
215.70	209228564.95	20922.86	918611253.6	918.61
216.44	252701251.13	25270.13	1092569629	1092.57
217.18	307191702.10	30719.17	1289373969	1289.37
217.92	347191702.10	34719.17	1516697516	1516.70
218.66	366897485.15	36689.75	1783427099	1783.43
219.40	438912654.31	43891.27	2083733283	2083.73
220.14	514069985.90	51407.00	2419053039	2419.05
220.88	554069985.90	55407.00	2799467652	2799.47
221.62	594823090.78	59482.31	3229940952	3229.94
222.36	676196173.89	67619.62	3699407666	3699.41
222.40	676196173.89	67619.62	3726450973	3726.45

5.8.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.8.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks from daily data are available at the downstream location, namely, Ashti G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Ashti G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{\text{A\_Wainganga}}{\text{A}_{\text{Ashti}}}\right)^{\frac{3}{4}} = 0.88$$

Using the above multiplying factors to the peak flows at the Ashti G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.97**.

Table 5.97: Final Peak Flows (cumec) at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1990	22320.00	29016.00	25651.86
1991	17807.00	23149.10	20465.17
1992	20000.00	26000.00	22985.53
1993	8252.00	10727.60	9483.83
1994	27874.00	36236.20	32034.94
1995	13649.00	17743.70	15686.48
1996	2660.00	3458.00	3057.08
1997	10264.00	13343.20	11796.18
1998	15084.00	19609.20	17335.69
1999	20718.00	26933.40	23810.71
2000	24276.00	31558.80	27899.84
2001	15890.01	20657.01	18262.02
2002	14177.55	18430.82	16293.93

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2003	15190.70	19747.91	17458.32
2004	4609.03	5991.74	5297.05
2005	24481.00	31825.30	28135.44
2006	15551.00	20216.30	17872.40
2007	20613.88	26798.04	23691.05
2008	10718.40	13933.92	12318.41
2009	8058.19	10475.65	9261.09
2010	17500.36	22750.47	20112.76
2011	16347.06	21251.18	18787.29
2012	15829.89	20578.86	18192.92
2013	18596.33	24175.23	21372.33
2014	16908.37	21980.88	19432.40

5.8.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.98**.

Table 5.98: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	18267.79
Variance	49312588.77
SD (Sx)	7022.29
Skewness	-0.30
Kurtosis	0.04
No. of Data	25

5.8.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.99**.

The detailed procedure for Gumbel's distribution method for Wainganga dam site has been shown in **Annexure-7.**

Table 5.99: Detail of different year Return Period Flood (cumec) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	17214
2	5	24540
3	10	29391
4	20	34043
5	25	35519
6	50	40066
7	100	44579
8	500	55008

Annexure-7 (Flood Frequency Analysis for Wainganga Dam)

DESIGN FLOOD-Wainganga

CA at G&D = 50990 sq.km; CA = 43264 sq.km

Sl.No.	Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	1990	22320.00	29016.00	25651.86	10.15
2	1991	17807.00	23149.10	20465.17	9.93
3	1992	20000.00	26000.00	22985.53	10.04
4	1993	8252.00	10727.60	9483.83	9.16
5	1994	27874.00	36236.20	32034.94	10.37
6	1995	13649.00	17743.70	15686.48	9.66
7	1996	2660.00	3458.00	3057.08	8.03
8	1997	10264.00	13343.20	11796.18	9.38
9	1998	15084.00	19609.20	17335.69	9.76
10	1999	20718.00	26933.40	23810.71	10.08
11	2000	24276.00	31558.80	27899.84	10.24
12	2001	15890.01	20657.01	18262.02	9.81
13	2002	14177.55	18430.82	16293.93	9.70
14	2003	15190.70	19747.91	17458.32	9.77
15	2004	4609.03	5991.74	5297.05	8.57
16	2005	24481.00	31825.30	28135.44	10.24
17	2006	15551.00	20216.30	17872.40	9.79
18	2007	20613.88	26798.04	23691.05	10.07
19	2008	10718.40	13933.92	12318.41	9.42
20	2009	8058.19	10475.65	9261.09	9.13
21	2010	17500.36	22750.47	20112.76	9.91
22	2011	16347.06	21251.18	18787.29	9.84
23	2012	15829.89	20578.86	18192.92	9.81
24	2013	18596.33	24175.23	21372.33	9.97
25	2014	16908.37	21980.88	19432.40	9.87

Conversion factor = 0.88

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	18267.79	9.71
Variance	49312588.77	0.282
SD (Sx)	7022.29	0.531
Skewness	-0.30	-1.74447
Kurtosis	0.04	3.54161
No. of Data	25	

Parameters	Values
Mean(Xm)	18267.79
Variance	49312588.77
SD (Sx)	7022.29
Skewness	-0.30
Kurtosis	0.04
No. of Data	25

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 25

Reduced mean = Y_n = 0.530 (From Table (Interpolated)

Reduced Std. Dev = S_n = 1.09 (From Table (Interpolated)

$f_{(C.)}$ = 1.645 (90% confidence probability)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C.)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C.)}.Se$

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	90% CONFIDENCE INTERVAL (X_{cl} Values in cumec) Lower Confidence Limit	Upper Confidence Limit
1	2	**17214**	0.367	-0.150	0.911	1279.242	2104.354	15109	19318
2	5	**24540**	1.500	0.893	1.743	2448.213	4027.310	20513	28567
3	10	**29391**	2.250	1.584	2.412	3387.851	5573.014	23818	34964
4	20	**34043**	2.970	2.246	3.078	4322.419	7110.379	26933	41154
5	25	**35519**	3.199	2.457	3.291	4622.455	7603.938	27915	43123
6	50	**40066**	3.902	3.104	3.954	5553.322	9135.215	30931	49201
7	100	**44579**	4.600	3.747	4.617	6483.889	10665.997	33913	55245
8	500	**55008**	6.214	5.232	6.157	8647.674	14225.424	40783	69234

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	17214
2	5	24540
3	10	29391
4	20	34043
5	25	35519
6	50	40066
7	100	44579
8	500	55008

5.9 Hydrology of Samda Hydroelectric Project

5.9.1 General

The present project, Samda, envisages harnessing water from the River Wainganga and other small rivers. Wainganga is a river in India, originating in the Mahadeo Hills in Mundara near village Gopalganj in Seoni Madhya Pradesh. It is a tributary of the Godavari River. The river flows south in a winding course through the states of Madhya Pradesh and Maharashtra, the united stream, which is known as the Pranahita River, empties into the Godavari River at Kaleshwaram, Telangana. The project is proposed to be of RoR type with the multifunction of irrigation and power.

5.9.1.1 Description of Dam Site

The catchment area of the dam site is 45,452 km^2. A plan of the catchment area map of the present project comprising the dam site, along with the G&D site of Ashti is delineated from DEM as shown in **Figure 5.52**. The dam site is located in Gadchiroli district of Maharashtra at 79°56'47"E, 20°11'54" N. Locations of the dam site and G&D site and catchment area shown in **Figure 5.52**.

5.9.1.2 Description of G&D Site

Ashti G&D site is situated in the Gadchiroli district of Maharashtra at 79°40'10" E, 19°41'04"N. Catchment area of the G&D site is around 50,990 km^2.

5.9.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometers draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges.

The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/ km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

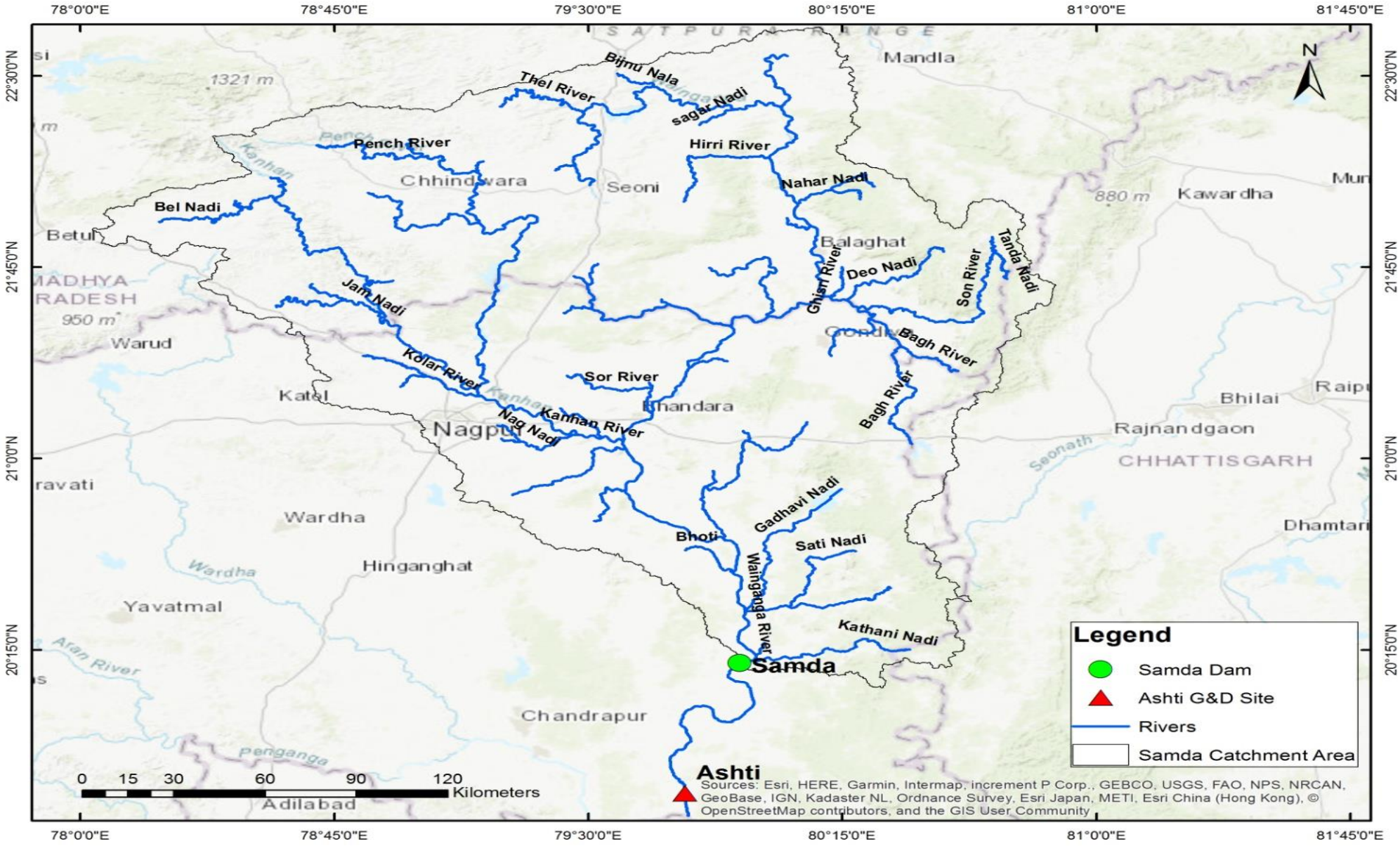


Figure 5.52: Catchment Area of Project and Locations of Dam and G&D site

5.9.2 Water Availability Studies

5.9.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Ashti (Catchment Area=50,990 km^2) which is downstream of the project site along the Wainganga River, is available and can be downloaded from India WRIS site. The G&D site lies in the Gadchiroli district of Maharashtra.

Generally, 15-year flow series data is required for a RoR project. Thus, flow series for the period 2000-2015 has been considered for generating the flow at the present project site.

5.9.2.2 Rainfall data

Indian Meteorological Department (IMD) daily rainfall grid data with a resolution of 0.25 degree x 0.25 degree from 1990 to 2015 is available. Average of daily rainfall data generated at each grid point (as can be seen from **Figure 5.53**) within the boundary of the Ashti G&D site and Samda dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.53**, 75 grid point is considered to assess the catchment rainfall for Ashti G&D site. Similarly, for Samda proposed dam site, 67 grid points have been considered for the assessment of catchment rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

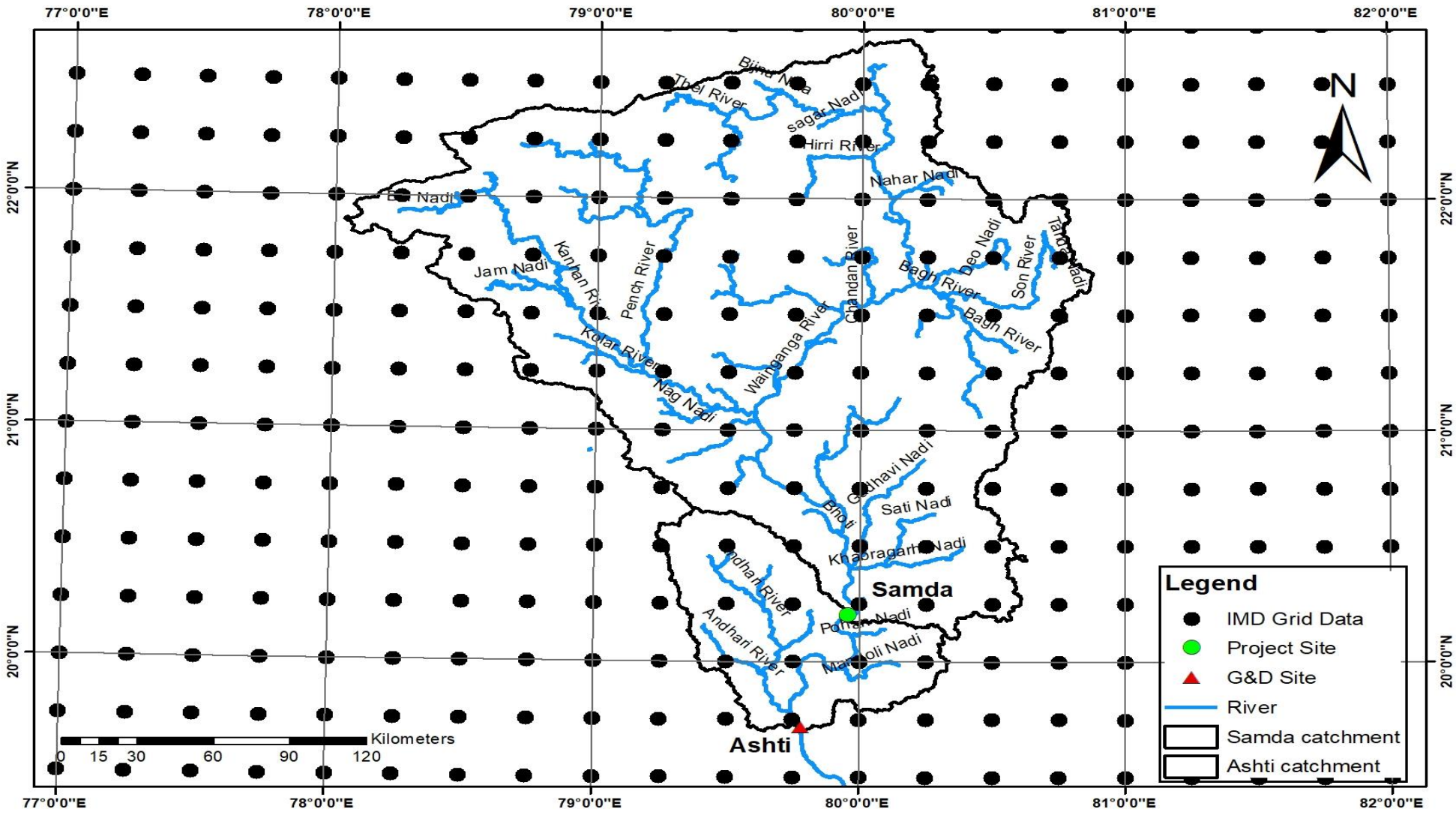


Figure 5.53: IMD Grid Rainfall Data for Samda Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfalls for the last 15 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.100**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.101** and **Table 5.102** respectively.

Table 5.100: Average Annual Rainfall (in mm)

Year	Ashti	Samda
2000-2001	1097	1062
2001-2002	1336	1342
2002-2003	1127	1152
2003-2004	1439	1450
2004-2005	1057	1035
2005-2006	1436	1437
2006-2007	1100	1077
2007-2008	1072	997
2008-2009	993	979
2009-2010	1102	1105
2010-2011	1399	1350
2011-2012	1158	1156
2012-2013	1220	1180
2013-2014	1777	1724
2014-2015	1135	1120
AVERAGE (mm)	1230	1211

Table 5.101: 10 Daily Rainfall (in mm) of Ashti G&D Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	10.70	7.24	0.70	0.17	1.71	0.11	1.29	0.61	3.88	1.10	0.12	1.62	0.33	2.34	0.03
	II	8.21	24.11	4.66	4.80	14.08	0.92	0.08	4.98	5.52	0.26	8.05	5.82	6.55	15.03	5.55
	III	6.02	4.70	21.51	8.71	1.98	18.85	6.41	16.35	11.26	5.09	6.07	9.92	2.84	15.51	4.62
JUL	I	8.09	11.51	1.03	14.35	4.78	14.75	12.59	16.97	9.61	15.49	14.96	5.74	11.94	12.51	2.55
	II	33.34	12.55	6.81	13.88	7.99	8.42	9.54	6.06	2.32	22.42	12.60	14.30	10.17	26.14	14.84
	III	6.09	8.58	1.61	27.24	15.45	17.29	16.36	5.53	17.26	11.82	19.70	10.35	15.11	22.80	23.78
AUG	I	4.57	14.06	14.56	10.28	16.09	11.68	11.48	19.68	19.46	2.81	18.24	14.37	14.59	17.86	11.79
	II	12.53	18.95	24.81	11.02	6.91	12.54	19.52	3.62	6.57	9.74	8.80	10.35	13.34	17.35	3.61
	III	8.45	6.82	12.68	15.54	6.63	3.21	11.00	3.56	4.89	10.08	7.96	10.57	11.40	10.95	5.51
SEP	I	0.98	2.53	11.83	11.51	3.23	6.55	7.14	12.98	6.43	10.39	20.86	19.44	17.02	1.48	14.87
	II	0.79	2.06	1.09	6.44	3.72	26.27	3.97	3.40	6.08	0.35	10.04	6.12	4.16	5.45	3.28
	III	2.26	0.87	0.23	7.61	2.98	1.91	3.45	5.36	1.51	1.43	0.41	0.99	3.95	4.82	0.76
OCT	I	0.29	13.65	0.09	2.65	0.65	0.00	1.24	2.50	0.77	3.41	1.08	0.39	1.86	10.72	0.37
	II	0.02	1.58	4.05	0.03	1.01	8.14	0.19	0.00	0.03	0.04	1.13	0.10	0.00	1.77	2.83
	III	0.00	0.00	0.00	2.02	0.00	0.16	0.20	0.00	0.00	0.00	0.95	0.00	0.21	1.26	0.09
NOV	I	0.00	0.00	0.00	0.04	0.10	0.00	0.62	0.62	0.00	0.30	0.15	0.00	1.06	0.01	0.00
	II	0.00	0.29	0.07	0.00	0.60	0.00	0.00	0.00	0.30	7.23	2.73	0.00	0.00	0.00	0.40
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.00	0.10	0.00	0.57
	III	0.00	0.00	0.03	0.14	0.00	0.54	0.00	0.00	0.00	0.09	0.00	0.01	0.00	0.00	0.00
JAN	I	0.46	0.03	0.00	0.02	0.03	0.00	0.00	0.00	0.09	0.00	0.08	2.17	0.49	0.13	1.70
	II	0.07	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.96	0.06	0.00	0.00	0.46	0.00
	III	0.00	0.19	0.01	1.27	9.06	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.10	0.06	0.01
FEB	I	0.00	0.40	2.46	0.63	1.94	0.00	0.01	0.14	0.05	1.03	0.00	0.01	0.12	0.00	0.32
	II	0.01	0.49	2.01	0.00	0.04	0.00	0.35	0.00	0.00	0.31	0.02	0.11	1.55	0.06	0.64
	III	0.00	0.26	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.26	0.31	0.00	0.41	3.90	0.07
MAR	I	1.05	0.01	0.02	0.00	0.94	2.41	0.03	0.00	0.00	0.00	0.07	0.00	0.00	2.56	5.64
	II	0.34	0.09	0.43	0.00	0.29	3.09	0.26	0.22	0.08	1.27	0.00	0.00	0.55	0.37	1.41
	III	0.06	0.10	0.06	0.03	0.00	0.00	0.00	2.50	0.06	0.14	0.01	0.00	0.40	0.02	0.22
APR	I	0.07	0.07	0.06	0.08	0.00	0.00	0.08	0.52	0.48	0.00	0.38	0.09	0.29	0.02	0.75
	II	2.84	0.00	0.14	0.00	0.66	1.94	0.38	0.00	0.00	0.01	1.06	0.01	0.17	0.66	1.93
	III	0.02	0.00	0.09	0.38	0.44	0.02	0.04	0.00	0.00	0.20	0.29	0.04	0.57	0.05	0.16
MAY	I	0.01	0.14	0.02	0.09	0.68	0.38	0.03	0.32	0.00	0.10	0.17	0.00	0.00	0.53	1.06
	II	0.32	0.27	0.18	0.25	0.00	0.84	0.34	0.00	0.02	0.07	0.05	0.03	0.01	0.04	1.14
	III	0.63	0.49	0.02	0.01	0.36	1.30	0.06	0.10	0.34	0.53	0.06	0.01	0.04	0.13	0.03
Yearly Rainfall (mm)		1097	1336	1127	1439	1057	1436	1100	1072	993	1102	1399	1158	1220	1777	1135

Table 5.102: 10 Daily Rainfall (in mm) of Samda Dam Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	10.64	6.94	0.60	0.12	1.65	0.07	1.21	0.52	3.98	1.14	0.12	1.64	0.28	2.06	0.03
	II	7.73	23.72	4.98	4.90	14.24	0.96	0.07	4.83	5.76	0.21	8.02	5.78	6.49	14.01	5.47
	III	5.75	5.08	21.36	8.96	1.75	18.87	6.10	14.27	11.19	4.87	5.98	9.69	2.77	15.05	4.92
JUL	I	7.88	11.75	1.06	14.43	5.00	14.60	10.94	16.84	9.23	16.00	14.83	5.88	11.79	12.30	2.63
	II	31.58	13.04	6.05	13.40	7.76	8.58	9.65	5.22	2.20	22.90	12.41	14.70	9.96	25.53	14.09
	III	6.34	8.90	1.75	28.74	15.58	16.92	16.25	5.62	16.23	11.47	18.94	10.94	15.04	21.13	24.73
AUG	I	4.58	13.63	15.07	9.93	15.39	11.66	10.14	17.71	18.50	2.28	16.74	14.51	14.33	17.25	11.93
	II	12.41	18.86	26.13	11.81	6.77	12.53	20.82	3.45	6.95	9.56	8.54	9.98	11.73	17.21	3.73
	III	7.82	6.74	12.31	14.78	6.25	3.43	11.36	3.60	4.88	10.13	7.78	10.31	10.57	11.86	5.26
SEP	I	1.02	2.58	12.60	12.11	3.05	5.82	7.39	11.74	6.28	11.04	19.15	18.48	16.45	1.26	12.40
	II	0.76	2.02	1.18	6.80	3.83	27.71	3.72	3.35	6.58	0.25	10.13	6.29	4.18	5.55	3.38
	III	2.00	0.85	0.20	7.80	2.93	1.91	2.69	5.37	1.58	1.44	0.37	0.79	3.84	4.33	0.82
OCT	I	0.33	14.32	0.09	2.10	0.57	0.00	1.20	1.76	0.84	3.26	1.10	0.43	1.59	10.14	0.41
	II	0.02	1.19	4.26	0.02	1.04	7.81	0.21	0.00	0.03	0.05	0.83	0.07	0.00	1.74	3.18
	III	0.00	0.00	0.00	1.66	0.00	0.18	0.22	0.00	0.00	0.00	1.03	0.00	0.24	1.14	0.07
NOV	I	0.00	0.00	0.00	0.04	0.02	0.00	0.61	0.63	0.00	0.33	0.09	0.00	1.05	0.02	0.00
	II	0.00	0.22	0.08	0.00	0.68	0.00	0.00	0.00	0.34	7.54	2.92	0.00	0.00	0.00	0.45
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.00	0.19	0.00	0.00	0.00	0.68	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1.24	0.00	0.00	0.11	0.00	0.65
	III	0.00	0.00	0.03	0.13	0.00	0.50	0.00	0.00	0.00	0.10	0.00	0.01	0.00	0.00	0.00
JAN	I	0.40	0.03	0.00	0.02	0.04	0.00	0.00	0.00	0.10	0.00	0.09	2.32	0.53	0.15	1.51
	II	0.08	0.01	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.63	0.07	0.00	0.00	0.52	0.00
	III	0.00	0.21	0.01	1.32	8.57	0.00	0.00	0.00	0.00	0.00	0.00	1.17	0.11	0.07	0.01
FEB	I	0.00	0.42	2.73	0.58	1.97	0.00	0.01	0.15	0.05	1.16	0.00	0.02	0.14	0.00	0.36
	II	0.01	0.56	2.20	0.00	0.05	0.00	0.40	0.00	0.00	0.32	0.01	0.13	1.57	0.07	0.72
	III	0.00	0.30	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.16	0.35	0.00	0.46	4.36	0.08
MAR	I	1.10	0.01	0.02	0.00	0.93	2.54	0.03	0.00	0.00	0.00	0.08	0.00	0.00	2.14	5.75
	II	0.31	0.10	0.48	0.00	0.33	3.17	0.30	0.24	0.09	1.28	0.00	0.00	0.61	0.40	1.58
	III	0.06	0.09	0.07	0.03	0.00	0.00	0.00	2.31	0.07	0.03	0.01	0.00	0.45	0.02	0.25
APR	I	0.06	0.05	0.07	0.03	0.00	0.00	0.07	0.45	0.50	0.00	0.17	0.10	0.33	0.02	0.78
	II	2.86	0.00	0.16	0.00	0.45	1.74	0.33	0.00	0.00	0.00	1.20	0.01	0.19	0.74	2.04
	III	0.03	0.00	0.10	0.32	0.43	0.02	0.04	0.00	0.00	0.22	0.34	0.03	0.64	0.06	0.12
MAY	I	0.01	0.12	0.02	0.07	0.66	0.35	0.01	0.37	0.00	0.05	0.20	0.00	0.00	0.56	0.72
	II	0.29	0.29	0.17	0.23	0.00	0.70	0.39	0.00	0.02	0.05	0.06	0.04	0.01	0.05	0.93
	III	0.67	0.54	0.02	0.01	0.35	1.37	0.07	0.08	0.32	0.61	0.06	0.01	0.03	0.14	0.03
Yearly Rainfall (mm)		1062	1342	1152	1450	1035	1437	1077	997	979	1105	1350	1156	1180	1724	1120

5.9.2.3 Rainfall and Runoff Data at Ashti G&D Site

Detailed calculations on water availability and flood magnitude will help select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the monthly runoff and monthly rainfall for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Ashti G&D site is shown in **Figure 5.54**. The basic comparison between rainfall and runoff in **Figure 5.54** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. For the above stated reason, we have used the monsoon period discharge data to derive the flow series at the dam site from June to November of each year. **Figure 5.55** shows plot of runoff coefficient at G&D site.

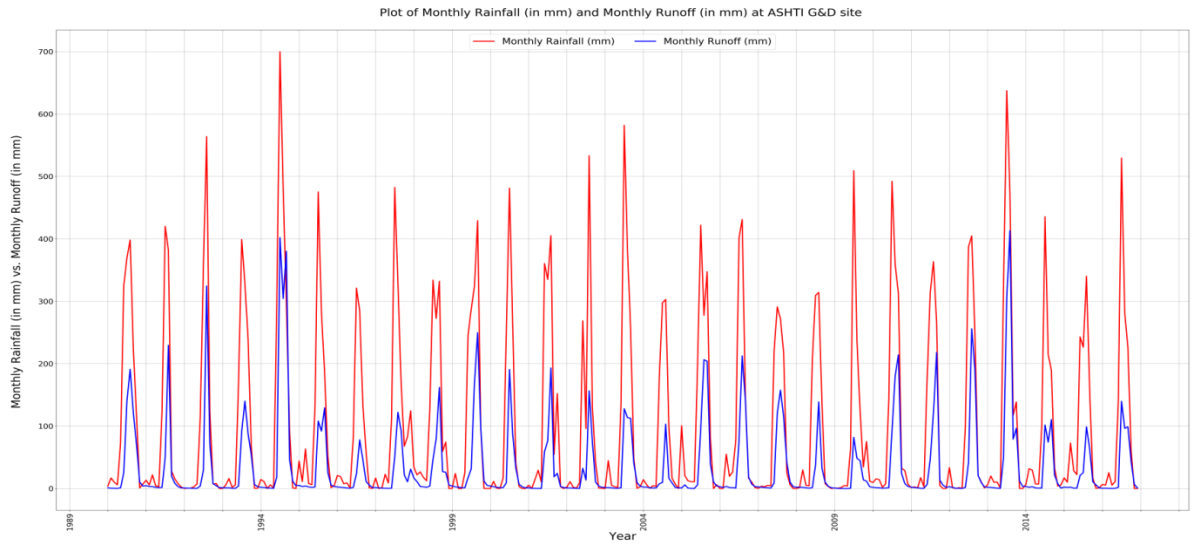


Figure 5.54: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site

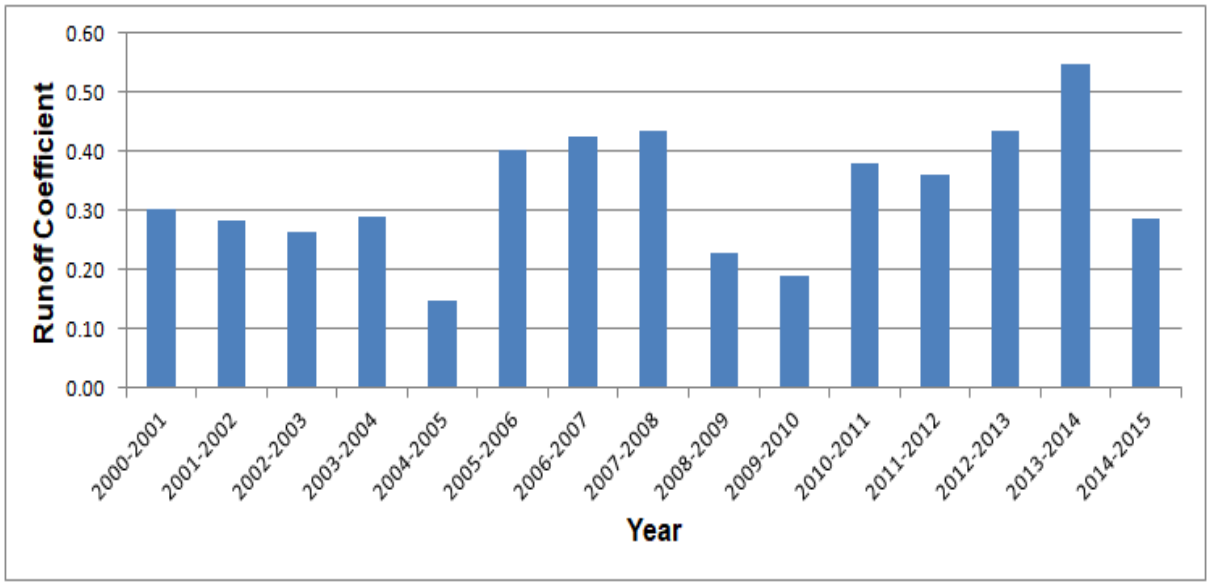


Figure 5.55: Plot of Runoff Coefficient at G&D site

5.9.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Ashti is around 50,990 km^2 as mentioned on India WRIS site. Daily discharge data for Ashti site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Ashti, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Ashti G&D and the dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Ashti G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Samda}}{CA_{Ashti}} = \frac{45452}{50990} = 0.89$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Samda}}{\text{Average Annual Rainfall}_{Ashti}} = \frac{1211}{1230} = 0.98$$

Discharge Series for the dam is computed according to the equation below

$$Q_{Samda} = Q_{Ashti\ G\&D\ Site} \text{X } 0.89 \text{ X } 0.98$$

Table 5.103 shows 10-daily average flow series for G&D site. **Table 5.104** and **Table 5.105** show 10-daily average flow series (m^3/s) and 10-daily inflow series (MCM) respectively for Samda Dam.

Table 5.103: 10-Daily Average Flow Series (m^3/s) at Ashti G&D

Catchment Area =50,990 km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	74.46	5.62	1.12	7.27	16.50	0.27	14.28	3.10	3.74	7.56	10.54	2.74	2.33	1.77	3.46
	II	206.35	3199.33	0.25	9.10	229.33	0.41	11.44	27.71	23.69	5.34	15.07	95.12	1.44	534.33	16.11
	III	251.59	299.72	1911.02	48.66	200.64	347.61	20.23	481.82	49.67	6.48	51.40	283.26	92.41	2475.56	21.12
Jul	I	195.16	553.98	296.27	508.69	62.90	905.16	1327.04	4241.15	464.16	102.12	359.96	290.91	149.63	1491.06	39.04
	II	7123.90	1389.90	172.73	975.20	123.14	1897.42	291.69	1905.86	440.04	2081.24	2018.01	543.94	422.42	6706.13	494.47
	III	3576.15	2322.01	303.06	5508.44	353.29	2622.16	2656.47	884.87	1173.33	2411.72	2841.54	1751.83	1688.63	8933.97	4974.45
Aug	I	698.91	1997.13	417.68	1421.72	2407.48	6451.29	3827.50	6032.85	5120.11	283.52	6324.87	1808.03	5193.31	10198.43	2492.86
	II	1787.50	5867.60	2968.11	1837.05	2019.65	1935.40	6525.82	2057.02	2356.21	607.72	2423.15	2580.22	3495.10	5990.84	1088.29
	III	2393.64	3212.06	5318.68	3137.01	1508.52	3446.99	1991.15	1102.12	651.08	1792.53	1751.67	2537.76	5826.79	7449.61	729.24
Sep	I	1179.51	580.41	3053.01	2783.14	308.58	595.36	5466.45	3118.43	782.97	1432.35	7082.43	8363.88	7043.53	1737.11	4073.71
	II	431.20	334.70	1124.87	2115.82	298.21	9295.49	1730.10	2126.92	513.90	815.98	3717.62	3343.52	2860.17	947.44	1834.09
	III	291.79	195.60	252.71	1741.84	362.59	2149.39	1145.43	1546.75	668.78	379.27	1833.90	1156.07	1372.66	1987.36	611.81
Oct	I	157.56	781.41	149.38	1436.56	245.19	474.37	686.31	1447.10	250.43	379.43	501.69	272.49	622.54	2990.02	370.18
	II	124.39	489.21	156.60	438.47	150.42	1070.75	195.47	667.44	203.16	309.45	412.81	281.43	300.64	1904.97	481.52
	III	119.10	146.00	283.12	492.53	121.38	743.07	191.71	316.20	142.19	120.07	451.95	208.70	291.91	726.32	376.85
Nov	I	78.85	97.60	127.25	241.29	40.10	267.55	184.46	293.68	105.88	123.71	163.11	150.50	301.86	413.75	265.63
	II	49.40	62.46	62.78	167.82	28.86	195.47	137.48	203.51	63.72	104.26	124.45	114.21	173.13	210.25	132.25
	III	32.79	41.04	35.94	148.58	28.56	156.83	86.75	123.64	41.24	468.87	195.92	54.72	83.63	85.08	53.97
Dec	I	26.47	37.14	35.52	114.12	25.54	88.63	68.01	56.70	33.95	82.77	74.98	36.00	65.94	51.05	18.17
	II	19.14	28.64	40.67	52.98	20.74	88.82	58.70	53.49	27.26	59.69	64.03	28.73	44.41	74.07	10.94
	III	17.76	24.21	41.83	52.88	17.67	63.87	55.61	57.88	8.80	28.82	48.77	38.69	39.09	69.74	7.34
Jan	I	18.16	18.59	36.19	45.25	15.55	62.14	62.20	54.01	9.09	40.18	58.56	68.82	44.58	77.24	15.50
	II	24.71	17.72	29.28	35.64	12.20	52.48	44.54	37.15	15.46	35.60	46.63	80.22	49.12	56.20	68.63
	III	12.80	14.38	29.46	54.51	17.69	49.59	52.04	39.37	8.25	38.78	28.53	26.51	28.49	53.81	50.09
Feb	I	8.77	14.94	31.89	87.43	274.25	40.06	46.89	53.82	5.12	28.44	23.85	64.45	30.64	50.92	50.82
	II	7.56	13.00	30.46	32.08	52.02	41.49	33.46	46.30	3.21	19.42	39.36	30.53	44.25	46.10	39.78
	III	5.36	16.72	30.56	27.83	25.92	40.43	49.03	25.85	2.51	38.19	30.53	8.42	37.45	34.21	30.13
Mar	I	3.69	10.73	21.18	28.99	16.54	34.33	35.79	36.67	1.80	22.47	23.88	4.67	37.76	88.08	37.88
	II	4.19	11.01	13.46	19.27	12.99	102.19	29.06	34.22	1.29	20.11	23.32	4.13	14.89	61.97	54.75
	III	4.49	7.70	20.63	22.90	10.38	53.15	29.71	30.09	0.93	17.23	15.37	11.47	17.16	23.53	32.59
Apr	I	3.13	8.24	12.57	16.74	5.28	23.01	21.29	31.03	0.73	11.08	5.47	11.24	13.34	20.89	9.94
	II	2.38	6.27	7.25	12.43	3.11	31.95	21.73	22.25	0.35	8.94	4.72	4.63	7.75	17.90	10.22
	III	3.50	4.02	5.51	7.76	1.78	42.40	18.76	13.96	0.21	5.76	5.81	2.48	4.54	13.00	12.07
May	I	3.94	3.46	7.96	28.29	1.27	25.31	11.48	11.51	0.18	8.60	3.74	3.01	6.15	15.24	11.52
	II	2.89	6.03	5.28	15.14	0.84	23.81	16.08	9.73	0.12	15.31	2.40	2.22	4.69	11.46	13.35
	III	1.03	1.43	4.35	12.15	0.14	21.00	5.11	5.85	0.13	12.99	6.97	2.20	5.51	7.46	6.42
Inflow (MCM)		*16894.35*	*19344.48*	*15234.59*	*21261.36*	*7963.46*	*29489.66*	*23878.92*	*23706.88*	*11553.11*	*10679.54*	*27039.21*	*21361.35*	*26956.94*	*49486.87*	*16546.34*

Table 5.104: 10-Daily Average Flow Series (m^3/s) at Samda Dam

Catchment Area =45,452 km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	65.35	4.93	0.98	6.38	14.48	0.24	12.53	2.72	3.28	6.64	9.25	2.40	2.04	1.55	3.04
	II	181.11	2807.95	0.22	7.99	201.28	0.36	10.04	24.32	20.79	4.69	13.23	83.48	1.26	468.97	14.14
	III	220.81	263.06	1677.24	42.71	176.10	305.09	17.76	422.88	43.59	5.69	45.11	248.61	81.11	2172.72	18.54
JUL	I	171.29	486.21	260.03	446.46	55.21	794.43	1164.70	3722.33	407.38	89.63	315.93	255.32	131.33	1308.66	34.26
	II	6252.43	1219.87	151.60	855.90	108.08	1665.31	256.01	1672.71	386.21	1826.64	1771.15	477.40	370.75	5885.76	433.98
	III	3138.68	2037.96	265.99	4834.59	310.07	2301.39	2331.50	776.62	1029.80	2116.69	2493.93	1537.53	1482.06	7841.07	4365.92
AUG	I	613.41	1752.82	366.58	1247.80	2112.97	5662.10	3359.28	5294.85	4493.76	248.84	5551.14	1586.85	4558.01	8950.85	2187.91
	II	1568.83	5149.81	2605.02	1612.32	1772.58	1698.64	5727.51	1805.38	2067.97	533.38	2126.72	2264.58	3067.54	5257.98	955.16
	III	2100.82	2819.13	4668.04	2753.26	1323.98	3025.32	1747.57	967.30	571.43	1573.25	1537.39	2227.31	5113.99	6538.29	640.03
SEP	I	1035.22	509.41	2679.53	2442.68	270.83	522.53	4797.74	2736.95	687.19	1257.13	6216.03	7340.72	6181.89	1524.61	3575.37
	II	378.45	293.76	987.26	1856.99	261.73	8158.37	1518.46	1866.73	451.03	716.16	3262.84	2934.50	2510.28	831.54	1609.72
	III	256.10	171.67	221.80	1528.76	318.23	1886.45	1005.31	1357.54	586.97	332.87	1609.56	1014.65	1204.74	1744.24	536.97
OCT	I	138.29	685.82	131.11	1260.82	215.20	416.34	602.35	1270.08	219.79	333.01	440.32	239.16	546.38	2624.25	324.90
	II	109.17	429.36	137.44	384.83	132.02	939.76	171.56	585.79	178.31	271.59	362.31	247.00	263.86	1671.93	422.62
	III	104.53	128.14	248.49	432.28	106.53	652.17	168.26	277.52	124.80	105.38	396.66	183.17	256.20	637.47	330.75
NOV	I	69.20	85.66	111.68	211.77	35.19	234.82	161.89	257.75	92.93	108.58	143.16	132.09	264.93	363.14	233.14
	II	43.36	54.82	55.10	147.29	25.33	171.56	120.66	178.61	55.93	91.51	109.23	100.24	151.95	184.53	116.07
	III	28.78	36.02	31.54	130.40	25.07	137.64	76.14	108.52	36.20	411.51	171.95	48.03	73.40	74.67	47.37
DEC	I	23.23	32.60	31.17	100.16	22.42	77.79	59.69	49.76	29.80	72.64	65.81	31.60	57.87	44.81	15.95
	II	16.80	25.14	35.69	46.50	18.20	77.95	51.52	46.95	23.93	52.39	56.20	25.22	38.98	65.01	9.60
	III	15.59	21.25	36.71	46.41	15.51	56.06	48.81	50.80	7.72	25.29	42.80	33.96	34.31	61.21	6.44
JAN	I	15.94	16.32	31.76	39.71	13.65	54.54	54.59	47.40	7.98	35.26	51.40	60.40	39.13	67.79	13.60
	II	21.69	15.55	25.70	31.28	10.71	46.06	39.09	32.61	13.57	31.25	40.93	70.41	43.11	49.33	60.23
	III	11.23	12.62	25.86	47.84	15.53	43.52	45.67	34.55	7.24	34.04	25.04	23.27	25.00	47.23	43.96
FEB	I	7.70	13.11	27.99	76.73	240.70	35.16	41.15	47.24	4.49	24.96	20.93	56.57	26.89	44.69	44.60
	II	6.64	11.41	26.73	28.16	45.66	36.41	29.37	40.64	2.82	17.04	34.55	26.80	38.84	40.46	34.91
	III	4.70	14.67	26.82	24.43	22.75	35.48	43.03	22.69	2.20	33.52	26.80	7.39	32.87	30.03	26.44
MAR	I	3.24	9.42	18.59	25.44	14.52	30.13	31.41	32.18	1.58	19.72	20.96	4.10	33.14	77.31	33.25
	II	3.68	9.66	11.81	16.91	11.40	89.69	25.51	30.03	1.13	17.65	20.47	3.62	13.07	54.39	48.05
	III	3.94	6.76	18.11	20.10	9.11	46.65	26.08	26.41	0.82	15.12	13.49	10.07	15.06	20.65	28.60
APR	I	2.75	7.23	11.03	14.69	4.63	20.20	18.69	27.23	0.64	9.72	4.80	9.87	11.71	18.33	8.72
	II	2.09	5.50	6.36	10.91	2.73	28.04	19.07	19.53	0.31	7.85	4.14	4.06	6.80	15.71	8.97
	III	3.07	3.53	4.84	6.81	1.56	37.21	16.47	12.25	0.18	5.06	5.10	2.18	3.98	11.41	10.59
MAY	I	3.46	3.04	6.99	24.83	1.11	22.21	10.08	10.10	0.16	7.55	3.28	2.64	5.40	13.38	10.11
	II	2.54	5.29	4.63	13.29	0.74	20.90	14.11	8.54	0.11	13.44	2.11	1.95	4.12	10.06	11.72
	III	0.90	1.26	3.82	10.66	0.12	18.43	4.48	5.13	0.11	11.40	6.12	1.93	4.84	6.55	5.63
Inflow (MCM) =		14827.65	16978.06	13370.94	18660.44	6989.29	25882.17	20957.80	20806.80	10139.81	9373.10	23731.49	18748.20	23659.28	43433.11	14522.22

Table 5.105: 10-Daily Inflow Series (MCM) at Samda Project Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	56.46	4.26	0.85	5.51	12.51	0.20	10.83	2.35	2.84	5.73	7.99	2.08	1.77	1.34	2.62
	II	156.48	2426.07	0.19	6.90	173.90	0.31	8.68	21.01	17.96	4.05	11.43	72.13	1.09	405.19	12.22
	III	190.78	227.28	1449.14	36.90	152.15	263.59	15.34	365.37	37.67	4.91	38.98	214.80	70.08	1877.23	16.02
JUL	I	147.99	420.09	224.66	385.74	47.70	686.39	1006.30	3216.09	351.98	77.44	272.96	220.60	113.47	1130.68	29.60
	II	5402.10	1053.97	130.98	739.50	93.38	1438.83	221.19	1445.23	333.69	1578.22	1530.27	412.47	320.32	5085.30	374.96
	III	2983.00	1936.87	252.79	4594.79	294.69	2187.24	2215.86	738.10	978.72	2011.70	2370.23	1461.27	1408.55	7452.15	4149.37
AUG	I	529.99	1514.44	316.73	1078.10	1825.61	4892.05	2902.42	4574.75	3882.61	215.00	4796.19	1371.04	3938.12	7733.53	1890.35
	II	1355.47	4449.44	2250.74	1393.05	1531.51	1467.63	4948.57	1559.85	1786.73	460.84	1837.49	1956.60	2650.36	4542.89	825.26
	III	1996.62	2679.30	4436.51	2616.70	1258.31	2875.26	1660.89	919.32	543.09	1495.22	1461.13	2116.84	4860.34	6213.99	608.29
SEP	I	894.43	440.13	2315.12	2110.47	234.00	451.47	4145.24	2364.73	593.73	1086.16	5370.65	6342.38	5341.15	1317.26	3089.12
	II	326.98	253.81	853.00	1604.44	226.13	7048.83	1311.95	1612.86	389.69	618.76	2819.09	2535.41	2168.88	718.45	1390.80
	III	221.27	148.32	191.63	1320.85	274.95	1629.90	868.59	1172.91	507.14	287.60	1390.66	876.66	1040.90	1507.03	463.94
OCT	I	119.48	592.55	113.28	1089.35	185.93	359.72	520.43	1097.35	189.90	287.72	380.43	206.63	472.08	2267.35	280.71
	II	94.33	370.97	118.75	332.49	114.06	811.96	148.23	506.12	154.06	234.66	313.04	213.41	227.98	1444.55	365.14
	III	99.35	121.78	236.16	410.84	101.25	619.82	159.91	263.75	118.61	100.15	376.99	174.08	243.49	605.85	314.34
NOV	I	59.79	74.01	96.49	182.97	30.41	202.88	139.88	222.70	80.29	93.81	123.69	114.13	228.90	313.75	201.43
	II	37.46	47.36	47.61	127.26	21.88	148.23	104.25	154.32	48.32	79.06	94.37	86.61	131.29	159.43	100.29
	III	24.86	31.12	27.25	112.67	21.66	118.93	65.78	93.76	31.27	355.55	148.57	41.49	63.42	64.52	40.93
DEC	I	20.07	28.16	26.94	86.54	19.37	67.21	51.57	43.00	25.74	62.77	56.86	27.30	50.00	38.71	13.78
	II	14.51	21.72	30.84	40.18	15.73	67.35	44.51	40.56	20.67	45.26	48.55	21.79	33.68	56.17	8.30
	III	14.81	20.19	34.89	44.11	14.74	53.28	46.39	48.28	7.34	24.04	40.68	32.27	32.61	58.17	6.12
JAN	I	13.77	14.10	27.44	34.31	11.79	47.12	47.17	40.96	6.89	30.47	44.41	52.19	33.81	58.57	11.75
	II	18.74	13.44	22.20	27.03	9.25	39.80	33.77	28.17	11.72	27.00	35.36	60.83	37.25	42.62	52.04
	III	10.68	11.99	24.57	45.47	14.76	41.36	43.41	32.84	6.88	32.35	23.80	22.11	23.76	44.88	41.78
FEB	I	6.65	11.33	24.18	66.30	207.97	30.38	35.56	40.81	3.88	21.57	18.09	48.87	23.23	38.61	38.54
	II	5.73	9.86	23.10	24.33	39.45	31.46	25.37	35.11	2.43	14.73	29.85	23.15	33.56	34.96	30.17
	III	3.25	10.14	18.54	16.88	15.72	24.53	29.74	15.68	1.52	23.17	18.52	5.11	22.72	20.75	18.28
MAR	I	2.80	8.14	16.06	21.98	12.54	26.03	27.14	27.81	1.36	17.04	18.11	3.54	28.63	66.79	28.72
	II	3.18	8.35	10.21	14.61	9.85	77.49	22.04	25.95	0.98	15.25	17.68	3.13	11.29	46.99	41.52
	III	3.75	6.42	17.21	19.10	8.66	44.33	24.78	25.10	0.78	14.37	12.82	9.57	14.31	19.63	27.18
APR	I	2.37	6.25	9.53	12.69	4.00	17.45	16.14	23.53	0.55	8.40	4.15	8.52	10.12	15.84	7.54
	II	1.80	4.75	5.50	9.43	2.36	24.23	16.48	16.87	0.27	6.78	3.58	3.51	5.88	13.57	7.75
	III	2.65	3.05	4.18	5.88	1.35	32.15	14.23	10.59	0.16	4.37	4.41	1.88	3.44	9.86	9.15
MAY	I	2.99	2.62	6.04	21.45	0.96	19.19	8.71	8.73	0.14	6.52	2.84	2.28	4.66	11.56	8.74
	II	2.19	4.57	4.00	11.48	0.64	18.06	12.19	7.38	0.09	11.61	1.82	1.68	3.56	8.69	10.12
	III	0.86	1.19	3.63	10.13	0.12	17.52	4.26	4.88	0.11	10.84	5.81	1.84	4.60	6.22	5.36
Total Inflow (MCM) =		*14827.65*	*16978.06*	*13370.94*	*18660.44*	*6989.29*	*25882.17*	*20957.80*	*20806.80*	*10139.81*	*9373.10*	*23731.49*	*18748.20*	*23659.28*	*43433.11*	*14522.22*

5.9.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.106** and **Table 5.107**

Table 5.106: Computation of 90% and 50% Dependable Year for Samda Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.06	25882	2005-2006	
2	0.13	25006	2013-2014	
3	0.19	23731	2010-2011	
4	0.25	23659	2012-2013	
5	0.31	20958	2006-2007	
6	0.38	20807	2007-2008	
7	0.44	18748	2011-2012	
8	**0.50**	**18660**	**2003-2004**	**50% Dependable**
9	0.56	16978	2001-2002	
10	0.63	14828	2000-2001	
11	0.69	14522	2014-2015	
12	0.75	13371	2002-2003	
13	0.81	10140	2008-2009	
14	**0.88**	**9373**	**2009-2010**	**90% Dependable**
15	0.94	6989	2004-2005	

Table 5.107: 90% and 50% dependable flows for the dam site (cumec)

		90% Dependable Year	50% Dependable Year
Period		**2009-2010**	**2003-2004**
Jun	**I**	6.64	6.38
	II	4.69	7.99
	III	5.69	42.71
Jul	**I**	89.63	446.46
	II	1826.64	855.90
	III	2116.69	4834.59
Aug	**I**	248.84	1247.80
	II	533.38	1612.32
	III	1573.25	2753.26
Sep	**I**	1257.13	2442.68
	II	716.16	1856.99
	III	332.87	1528.76
Oct	**I**	333.01	1260.82
	II	271.59	384.83
	III	105.38	432.28
Nov	**I**	108.58	211.77
	II	91.51	147.29
	III	411.51	130.40
Dec	**I**	72.64	100.16
	II	52.39	46.50
	III	25.29	46.41
Jan	**I**	35.26	39.71
	II	31.25	31.28
	III	34.04	47.84
Feb	**I**	24.96	76.73
	II	17.04	28.16
	III	33.52	24.43
Mar	**I**	19.72	25.44
	II	17.65	16.91
	III	15.12	20.10
Apr	**I**	9.72	14.69
	II	7.85	10.91
	III	5.06	6.81
May	**I**	7.55	24.83
	II	13.44	13.29
	III	11.40	10.66
Inflow (MCM) =		9373	18660

5.9.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Samda, is given in the following section.

5.9.5.1 EAC of Samda Dam

The EAC curve and the table showing the different values are given in **Figure 5.56** and **Table 5.108** respectively.

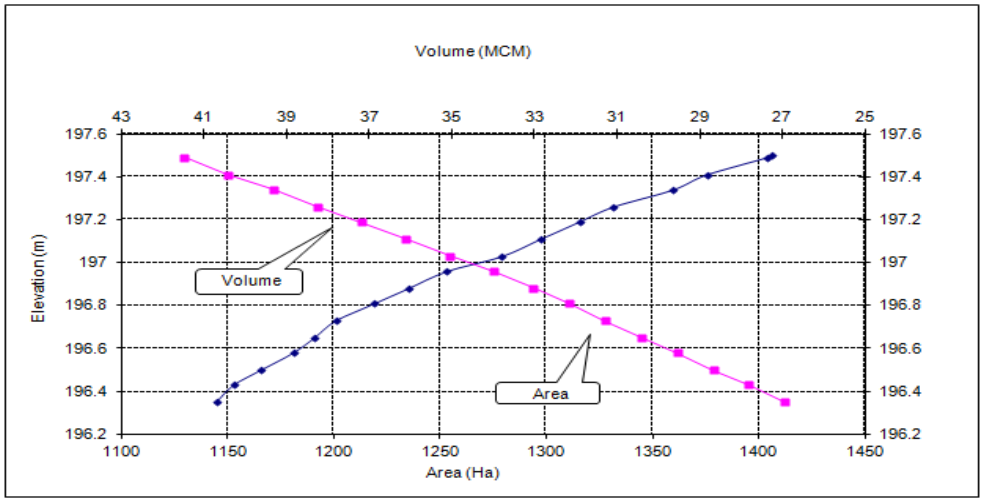


Figure 5.56: EAC curve of Samda Dam

Table 5.108: EAC data of Samda Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
196.35	11447059.69	1144.71	26066575.54	26.07
196.43	11528905.16	1152.89	26936423.52	26.94
196.50	11658019.95	1165.80	27806446.17	27.81
196.58	11809865.42	1180.99	28676468.82	28.68
196.65	11908980.21	1190.90	29546491.47	29.55
196.73	12010825.68	1201.08	30416339.45	30.42
196.81	12192671.15	1219.27	31286362.1	31.29
196.88	12351785.94	1235.18	32156384.75	32.16
196.96	12533631.41	1253.36	33026232.73	33.03
197.03	12792746.20	1279.27	33985123.41	33.99
197.11	12974591.67	1297.46	35053822.77	35.05
197.19	13156437.14	1315.64	36122522.13	36.12
197.26	13315551.93	1331.56	37191006.93	37.19
197.34	13597397.40	1359.74	38259706.28	38.26
197.41	13756512.18	1375.65	39328405.64	39.33
197.49	14038357.66	1403.84	40397105.00	40.44
197.50	14061088.34	1406.11	41437638.64	41.48

5.9.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.9.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Ashti G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Ashti G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{Samda}}{A_{Ashti}}\right)^{\frac{3}{4}} = 0.92$$

Using the above multiplying factors to the peak flows at the Ashti G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.109**.

Table 5.109: Final Peak Flows(cumec) at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2000	24276.00	31558.80	28951.53
2001	15890.01	20657.01	18950.41
2002	14177.55	18430.82	16908.13
2003	15190.70	19747.91	18116.41
2004	4609.03	5991.74	5496.72
2005	24481.00	31825.30	29196.01
2006	15551.00	20216.30	18546.10
2007	20613.88	26798.04	24584.09
2008	10718.40	13933.92	12782.75
2009	8058.19	10475.65	9610.19
2010	17500.36	22750.47	20870.91
2011	16347.06	21251.18	19495.48
2012	15829.89	20578.86	18878.71

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2013	18596.33	24175.23	22177.96
2014	16908.37	21980.88	20164.90

5.9.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.110**.

Table 5.110: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	18982.02
Variance	40279428.90
SD (Sx)	6346.61
Skewness	-0.40
Kurtosis	0.58
No. of Data	15.00

5.9.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel's distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.111**.

The detailed procedure for Gumbel's distribution method for Samda dam site has been shown in **Annexure-8**.

Table 5.111: Detail of different year Return Period Flood (cumec) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	18072
2	5	25121
3	10	29787
4	20	34264
5	25	35684
6	50	40058
7	100	44400
8	500	54433

Annexure-8 (Flood Frequency Analysis for Samda Dam)

DESIGN Flood_Samda

CA at G&D = 50990.00 | CA = 45452

Sl.No.	Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	2000	24276.00	31558.80	28951.53	10.27
2	2001	15890.01	20657.01	18950.41	9.85
3	2002	14177.55	18430.82	16908.13	9.74
4	2003	15190.70	19747.91	18116.41	9.80
5	2004	4609.03	5991.74	5496.72	8.61
6	2005	24481.00	31825.30	29196.01	10.28
7	2006	15551.00	20216.30	18546.10	9.83
8	2007	20613.88	26798.04	24584.09	10.11
9	2008	10718.40	13933.92	12782.75	9.46
10	2009	8058.19	10475.65	9610.19	9.17
11	2010	17500.36	22750.47	20870.91	9.95
12	2011	16347.06	21251.18	19495.48	9.88
13	2012	15829.89	20578.86	18878.71	9.85
14	2013	18596.33	24175.23	22177.96	10.01
15	2014	16908.37	21980.88	20164.90	9.91

Conversion factor = 0.92

Instantaneous Peak = 30%

Mean(X_m)	18982.02	9.78
Variance	40279428.90	0.183
SD (Sx)	6346.61	0.428
Skewness	-0.40	-1.63591
Kurtosis	0.58	3.27907
No. of Data	15.00	

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 15

Reduced mean = Y_n = 0.530 } From Table

Reduced Std. Dev = S_n = 1.09 } From Table

$f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

90% CONFIDENCE INTERVAL (X_{cl} Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	**18072**	0.367	-0.150	0.911	1492.588	2455.307	15617	20527
2	5	**25121**	1.500	0.893	1.743	2856.514	4698.965	20422	29820
3	10	**29787**	2.250	1.584	2.412	3952.860	6502.454	23285	36289
4	20	**34264**	2.970	2.246	3.078	5043.291	8296.213	25968	42560
5	25	**35684**	3.199	2.457	3.291	5393.365	8872.085	26812	44556
6	50	**40058**	3.902	3.104	3.954	6479.478	10658.741	29399	50717
7	100	**44400**	4.600	3.747	4.617	7565.239	12444.819	31955	56845
8	500	**54433**	6.214	5.232	6.157	10089.891	16597.870	37835	71031

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	18072
2	5	25121
3	10	29787
4	20	34264
5	25	35684
6	50	40058
7	100	44400
8	500	54433

5.10 Hydrology of Kunghara Hydroelectric Project

5.10.1 General

The present project, Kunghara, envisages harnessing water from the River Wainganga and other small rivers. Wainganga is a river in India, originating in the Mahadeo Hills in Mundara near village Gopalganj in Seoni Madhya Pradesh. It is a tributary of the Godavari River. The river flows south in a winding course through the states of Madhya Pradesh and Maharashtra, the united stream, which is known as the Pranahita River, empties into the Godavari River at Kaleshwaram, Telangana. The project is proposed to be of RoR type with the multifunction of irrigation and power.

5.10.1.1 Description of Dam Site

The catchment area of the dam site is 52,243 km^2. The dam site is located in Chandrapur district of Maharashtra at 79° 47' 30"E, 19° 37' 13" N. Catchment area of the project and locations of the dam site and of G&D site are shown in **Figure 5.57**.

5.10.1.2 Description of G&D Site

Ashti G&D site is situated in the Gadchiroli district of Maharashtra at 79° 40' 10" E, 19° 41' 04" N. Catchment area of the G&D site is around 50,990 km^2.

5.10.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometers draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past

few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/ km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

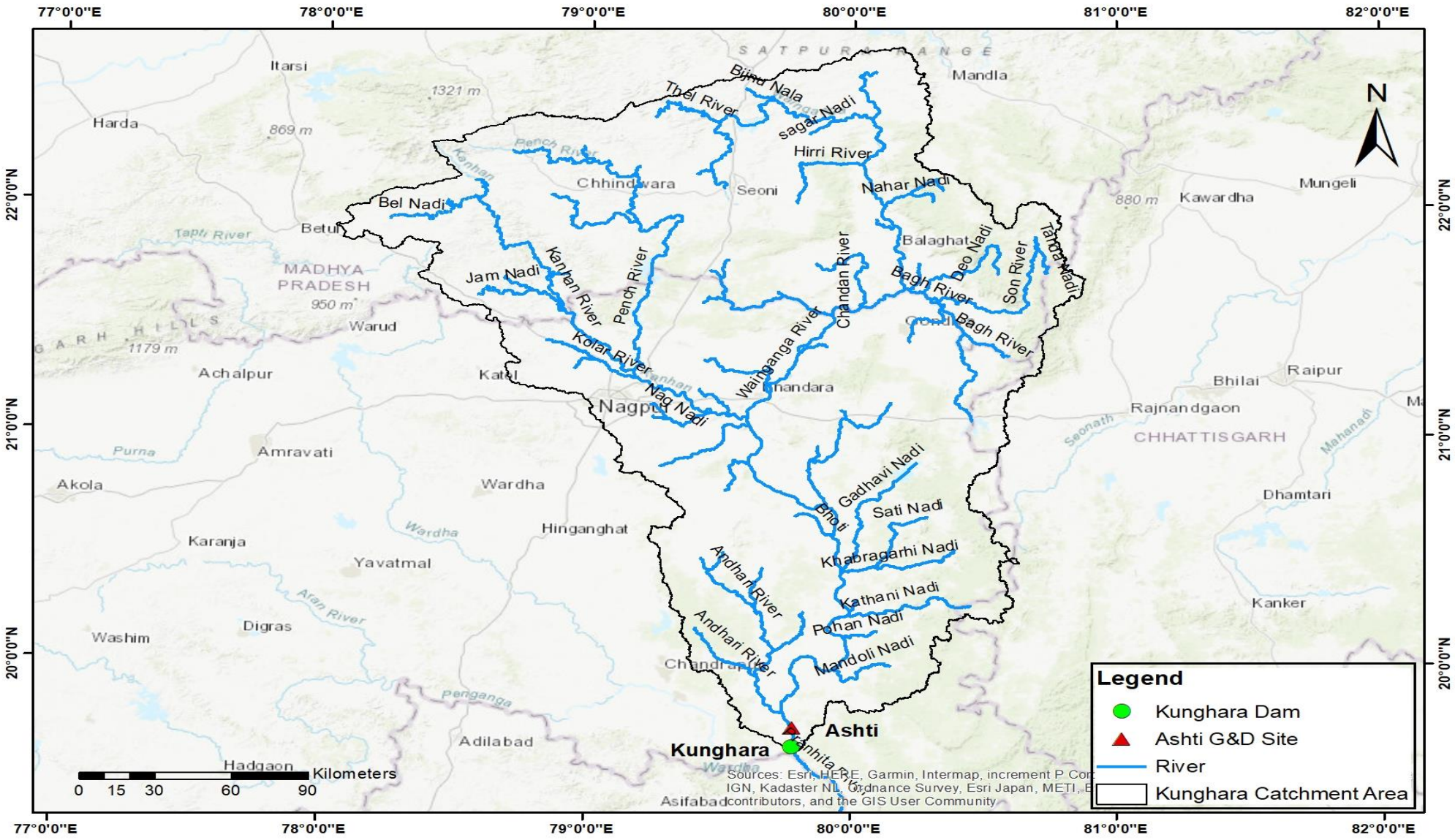


Figure 5.57: Catchment Area of Project and Locations of Dam and G&D site

5.10.2 Water Availability Studies

5.10.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Ashti (Catchment Area=50,990 km^2) which is upstream of the project site along the Wainganga River, is available and can be downloaded from India WRIS site. The G&D site lies in the Gadchiroli district of Maharashtra.

Generally, 15-year flow series data is required for a RoR project. Thus, flow series for the period 2000-2015 has been considered for generating the flow at the present project site.

5.10.2.2 Rainfall data

Indian Meteorological Department (IMD) daily rainfall grid data with a resolution of 0.25 degree x 0.25 degree from 1990 to 2015 is available. Average of daily rainfall data generated at each grid point (as can be seen from **Figure 5.58**) within the boundary of the Ashti G&D site and Kunghara dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus in **Figure 5.58**, 75 grid point is considered to assess the catchment rainfall for Ashti G&D site. Similarly, for Kunghara proposed dam site, 75 grid points have been considered for the assessment of catchment rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

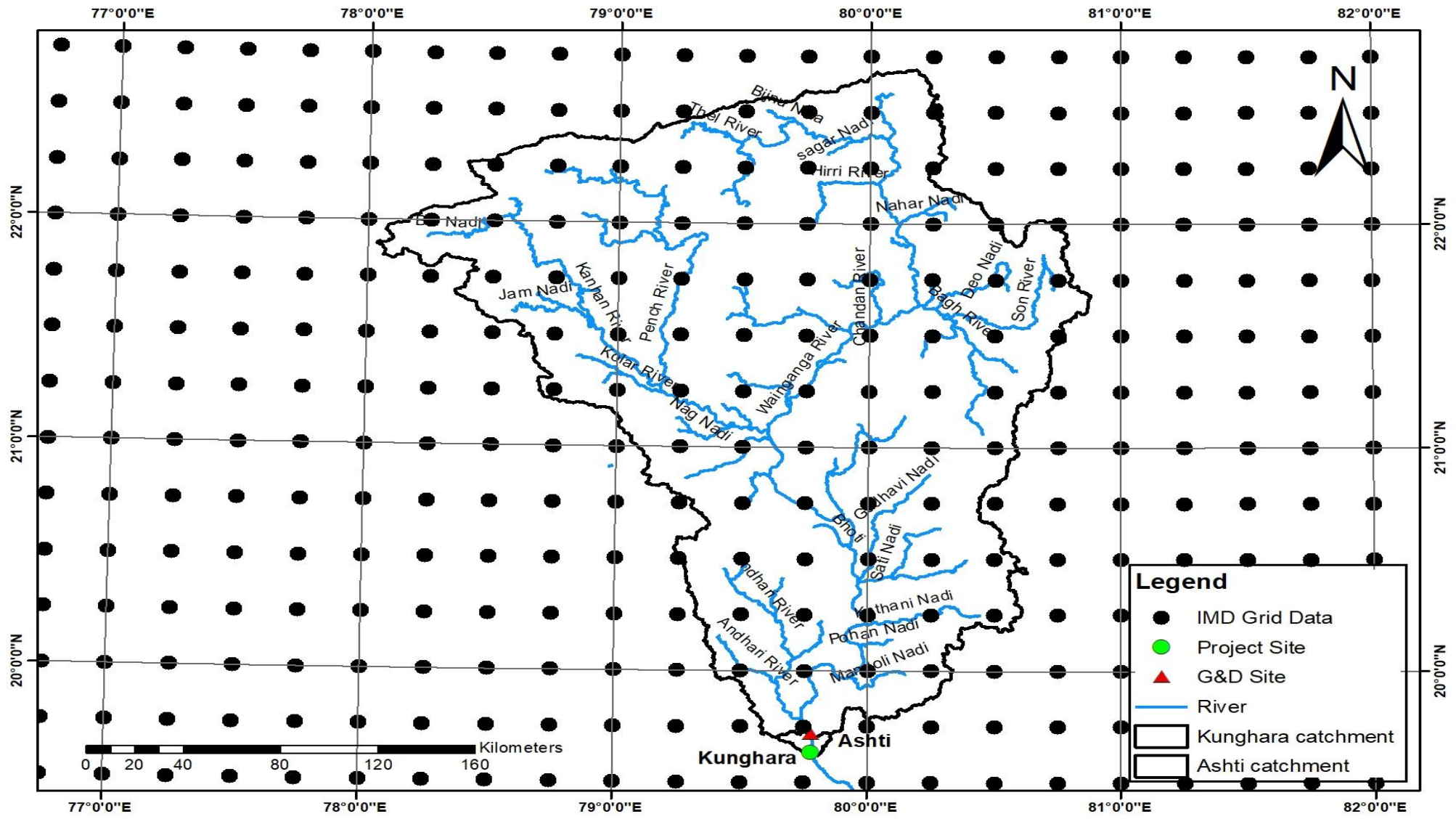


Figure 5.58: IMD Grid Rainfall Data for Kunghara Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfalls for the last 15 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.112**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.113** and **Table 5.114** respectively.

Table 5.112: Average Annual Rainfall (in mm)

Year	Ashti	Kunghara
2000-2001	1097	1097
2001-2002	1336	1336
2002-2003	1127	1127
2003-2004	1439	1439
2004-2005	1057	1057
2005-2006	1436	1436
2006-2007	1100	1100
2007-2008	1072	1072
2008-2009	993	993
2009-2010	1102	1102
2010-2011	1399	1399
2011-2012	1158	1158
2012-2013	1220	1220
2013-2014	1777	1777
2014-2015	1135	1135
AVERAGE (mm)	1230	1230

Table 5.113: 10 Daily Rainfall (in mm) of Ashti G&D Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	10.70	7.24	0.70	0.17	1.71	0.11	1.29	0.61	3.88	1.10	0.12	1.62	0.33	2.34	0.03
	II	8.21	24.11	4.66	4.80	14.08	0.92	0.08	4.98	5.52	0.26	8.05	5.82	6.55	15.03	5.55
	III	6.02	4.70	21.51	8.71	1.98	18.85	6.41	16.35	11.26	5.09	6.07	9.92	2.84	15.51	4.62
JUL	I	8.09	11.51	1.03	14.35	4.78	14.75	12.59	16.97	9.61	15.49	14.96	5.74	11.94	12.51	2.55
	II	33.34	12.55	6.81	13.88	7.99	8.42	9.54	6.06	2.32	22.42	12.60	14.30	10.17	26.14	14.84
	III	6.09	8.58	1.61	27.24	15.45	17.29	16.36	5.53	17.26	11.82	19.70	10.35	15.11	22.80	23.78
AUG	I	4.57	14.06	14.56	10.28	16.09	11.68	11.48	19.68	19.46	2.81	18.24	14.37	14.59	17.86	11.79
	II	12.53	18.95	24.81	11.02	6.91	12.54	19.52	3.62	6.57	9.74	8.80	10.35	13.34	17.35	3.61
	III	8.45	6.82	12.68	15.54	6.63	3.21	11.00	3.56	4.89	10.08	7.96	10.57	11.40	10.95	5.51
SEP	I	0.98	2.53	11.83	11.51	3.23	6.55	7.14	12.98	6.43	10.39	20.86	19.44	17.02	1.48	14.87
	II	0.79	2.06	1.09	6.44	3.72	26.27	3.97	3.40	6.08	0.35	10.04	6.12	4.16	5.45	3.28
	III	2.26	0.87	0.23	7.61	2.98	1.91	3.45	5.36	1.51	1.43	0.41	0.99	3.95	4.82	0.76
OCT	I	0.29	13.65	0.09	2.65	0.65	0.00	1.24	2.50	0.77	3.41	1.08	0.39	1.86	10.72	0.37
	II	0.02	1.58	4.05	0.03	1.01	8.14	0.19	0.00	0.03	0.04	1.13	0.10	0.00	1.77	2.83
	III	0.00	0.00	0.00	2.02	0.00	0.16	0.20	0.00	0.00	0.00	0.95	0.00	0.21	1.26	0.09
NOV	I	0.00	0.00	0.00	0.04	0.10	0.00	0.62	0.62	0.00	0.30	0.15	0.00	1.06	0.01	0.00
	II	0.00	0.29	0.07	0.00	0.60	0.00	0.00	0.00	0.30	7.23	2.73	0.00	0.00	0.00	0.40
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.00	0.10	0.00	0.57
	III	0.00	0.00	0.03	0.14	0.00	0.54	0.00	0.00	0.00	0.09	0.00	0.01	0.00	0.00	0.00
JAN	I	0.46	0.03	0.00	0.02	0.03	0.00	0.00	0.00	0.09	0.00	0.08	2.17	0.49	0.13	1.70
	II	0.07	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.96	0.06	0.00	0.00	0.46	0.00
	III	0.00	0.19	0.01	1.27	9.06	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.10	0.06	0.01
FEB	I	0.00	0.40	2.46	0.63	1.94	0.00	0.01	0.14	0.05	1.03	0.00	0.01	0.12	0.00	0.32
	II	0.01	0.49	2.01	0.00	0.04	0.00	0.35	0.00	0.00	0.31	0.02	0.11	1.55	0.06	0.64
	III	0.00	0.26	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.26	0.31	0.00	0.41	3.90	0.07
MAR	I	1.05	0.01	0.02	0.00	0.94	2.41	0.03	0.00	0.00	0.00	0.07	0.00	0.00	2.56	5.64
	II	0.34	0.09	0.43	0.00	0.29	3.09	0.26	0.22	0.08	1.27	0.00	0.00	0.55	0.37	1.41
	III	0.06	0.10	0.06	0.03	0.00	0.00	0.00	2.50	0.06	0.14	0.01	0.00	0.40	0.02	0.22
APR	I	0.07	0.07	0.06	0.08	0.00	0.00	0.08	0.52	0.48	0.00	0.38	0.09	0.29	0.02	0.75
	II	2.84	0.00	0.14	0.00	0.66	1.94	0.38	0.00	0.00	0.01	1.06	0.01	0.17	0.66	1.93
	III	0.02	0.00	0.09	0.38	0.44	0.02	0.04	0.00	0.00	0.20	0.29	0.04	0.57	0.05	0.16
MAY	I	0.01	0.14	0.02	0.09	0.68	0.38	0.03	0.32	0.00	0.10	0.17	0.00	0.00	0.53	1.06
	II	0.32	0.27	0.18	0.25	0.00	0.84	0.34	0.00	0.02	0.07	0.05	0.03	0.01	0.04	1.14
	III	0.63	0.49	0.02	0.01	0.36	1.30	0.06	0.10	0.34	0.53	0.06	0.01	0.04	0.13	0.03
Yearly Rainfall (mm)		1097	1336	1127	1439	1057	1436	1100	1072	993	1102	1399	1158	1220	1777	1135

Table 5.114: 10 Daily Rainfall (in mm) of Kunghara Dam Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	10.70	7.24	0.70	0.17	1.71	0.11	1.29	0.61	3.88	1.10	0.12	1.62	0.33	2.34	0.03
	II	8.21	24.11	4.66	4.80	14.08	0.92	0.08	4.98	5.52	0.26	8.05	5.82	6.55	15.03	5.55
	III	6.02	4.70	21.51	8.71	1.98	18.85	6.41	16.35	11.26	5.09	6.07	9.92	2.84	15.51	4.62
JUL	I	8.09	11.51	1.03	14.35	4.78	14.75	12.59	16.97	9.61	15.49	14.96	5.74	11.94	12.51	2.55
	II	33.34	12.55	6.81	13.88	7.99	8.42	9.54	6.06	2.32	22.42	12.60	14.30	10.17	26.14	14.84
	III	6.09	8.58	1.61	27.24	15.45	17.29	16.36	5.53	17.26	11.82	19.70	10.35	15.11	22.80	23.78
AUG	I	4.57	14.06	14.56	10.28	16.09	11.68	11.48	19.68	19.46	2.81	18.24	14.37	14.59	17.86	11.79
	II	12.53	18.95	24.81	11.02	6.91	12.54	19.52	3.62	6.57	9.74	8.80	10.35	13.34	17.35	3.61
	III	8.45	6.82	12.68	15.54	6.63	3.21	11.00	3.56	4.89	10.08	7.96	10.57	11.40	10.95	5.51
SEP	I	0.98	2.53	11.83	11.51	3.23	6.55	7.14	12.98	6.43	10.39	20.86	19.44	17.02	1.48	14.87
	II	0.79	2.06	1.09	6.44	3.72	26.27	3.97	3.40	6.08	0.35	10.04	6.12	4.16	5.45	3.28
	III	2.26	0.87	0.23	7.61	2.98	1.91	3.45	5.36	1.51	1.43	0.41	0.99	3.95	4.82	0.76
OCT	I	0.29	13.65	0.09	2.65	0.65	0.00	1.24	2.50	0.77	3.41	1.08	0.39	1.86	10.72	0.37
	II	0.02	1.58	4.05	0.03	1.01	8.14	0.19	0.00	0.03	0.04	1.13	0.10	0.00	1.77	2.83
	III	0.00	0.00	0.00	2.02	0.00	0.16	0.20	0.00	0.00	0.00	0.95	0.00	0.21	1.26	0.09
NOV	I	0.00	0.00	0.00	0.04	0.10	0.00	0.62	0.62	0.00	0.30	0.15	0.00	1.06	0.01	0.00
	II	0.00	0.29	0.07	0.00	0.60	0.00	0.00	0.00	0.30	7.23	2.73	0.00	0.00	0.00	0.40
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00
DEC	I	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.00	1.09	0.00	0.00	0.10	0.00	0.57
	III	0.00	0.00	0.03	0.14	0.00	0.54	0.00	0.00	0.00	0.09	0.00	0.01	0.00	0.00	0.00
JAN	I	0.46	0.03	0.00	0.02	0.03	0.00	0.00	0.00	0.09	0.00	0.08	2.17	0.49	0.13	1.70
	II	0.07	0.01	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.96	0.06	0.00	0.00	0.46	0.00
	III	0.00	0.19	0.01	1.27	9.06	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.10	0.06	0.01
FEB	I	0.00	0.40	2.46	0.63	1.94	0.00	0.01	0.14	0.05	1.03	0.00	0.01	0.12	0.00	0.32
	II	0.01	0.49	2.01	0.00	0.04	0.00	0.35	0.00	0.00	0.31	0.02	0.11	1.55	0.06	0.64
	III	0.00	0.26	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.26	0.31	0.00	0.41	3.90	0.07
MAR	I	1.05	0.01	0.02	0.00	0.94	2.41	0.03	0.00	0.00	0.00	0.07	0.00	0.00	2.56	5.64
	II	0.34	0.09	0.43	0.00	0.29	3.09	0.26	0.22	0.08	1.27	0.00	0.00	0.55	0.37	1.41
	III	0.06	0.10	0.06	0.03	0.00	0.00	0.00	2.50	0.06	0.14	0.01	0.00	0.40	0.02	0.22
APR	I	0.07	0.07	0.06	0.08	0.00	0.00	0.08	0.52	0.48	0.00	0.38	0.09	0.29	0.02	0.75
	II	2.84	0.00	0.14	0.00	0.66	1.94	0.38	0.00	0.00	0.01	1.06	0.01	0.17	0.66	1.93
	III	0.02	0.00	0.09	0.38	0.44	0.02	0.04	0.00	0.00	0.20	0.29	0.04	0.57	0.05	0.16
MAY	I	0.01	0.14	0.02	0.09	0.68	0.38	0.03	0.32	0.00	0.10	0.17	0.00	0.00	0.53	1.06
	II	0.32	0.27	0.18	0.25	0.00	0.84	0.34	0.00	0.02	0.07	0.05	0.03	0.01	0.04	1.14
	III	0.63	0.49	0.02	0.01	0.36	1.30	0.06	0.10	0.34	0.53	0.06	0.01	0.04	0.13	0.03
Yearly Rainfall (mm)		1097	1336	1127	1439	1057	1436	1100	1072	993	1102	1399	1158	1220	1777	1135

5.10.2.3 Rainfall and Runoff Data at Ashti G&D Site

Detailed calculations on water availability and flood magnitude will help to select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) against the monthly runoff and monthly rainfall for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Ashti G&D site is shown in **Figure 5.59**. The basic comparison between rainfall and runoff in **Figure 5.59** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.60** shows plot of runoff coefficient at G&D site.

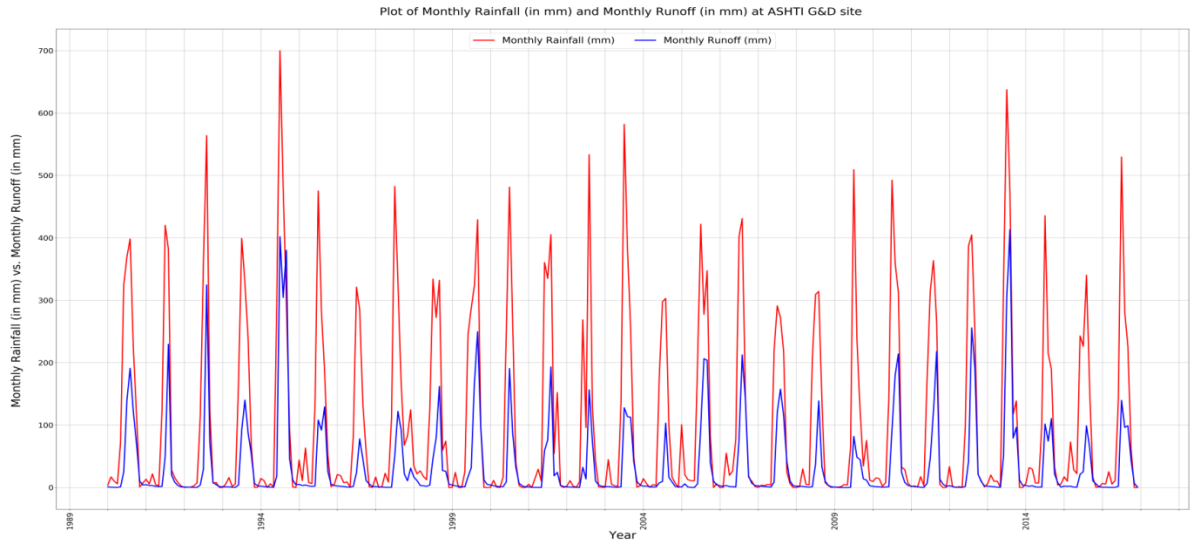


Figure 5.59: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Ashti G&D site

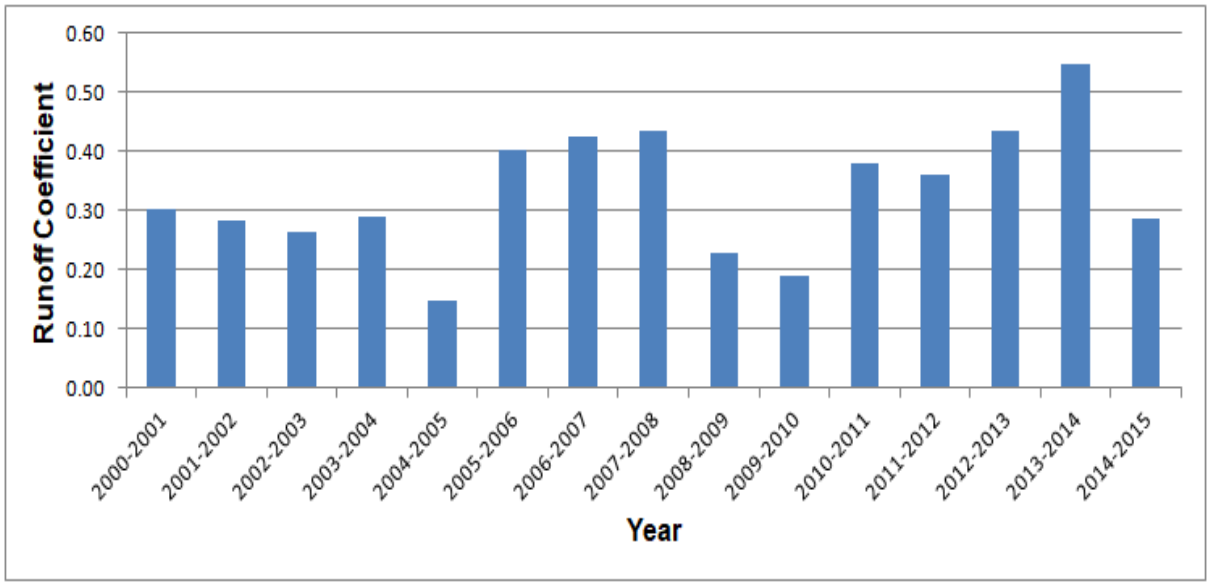


Figure 5.60: Plot of Runoff Coefficient at G&D site

5.10.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Ashti is around 50,990 km^2 as mentioned on India WRIS site. Daily discharge data for Ashti site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Ashti, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Ashti G&D and the dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Ashti G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Kunghara}}{CA_{Ashti}} = \frac{52243}{50990} = 1.02$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Kunghara}}{\text{Average Annual Rainfall}_{Ashti}} = \frac{1230}{1230} = 1$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Kunghara}} = Q_{\text{Ashti G\&D } Site} \text{X } 1.02 \text{ X } 1$$

Table 5.115 shows 10-daily average flow series for G&D site. **Table 5.116** and **Table 5.117** show 10-daily average flow series (m^3/s) and 10-daily inflow series (MCM) respectively developed for Kunghara Dam.

Table 5.115: 10-Daily Average Flow Series (m^3/s) at Ashti G&D

Catchment Area =50,990 km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	74.46	5.62	1.12	7.27	16.50	0.27	14.28	3.10	3.74	7.56	10.54	2.74	2.33	1.77	3.46
	II	206.35	3199.33	0.25	9.10	229.33	0.41	11.44	27.71	23.69	5.34	15.07	95.12	1.44	534.33	16.11
	III	251.59	299.72	1911.02	48.66	200.64	347.61	20.23	481.82	49.67	6.48	51.40	283.26	92.41	2475.56	21.12
Jul	I	195.16	553.98	296.27	508.69	62.90	905.16	1327.04	4241.15	464.16	102.12	359.96	290.91	149.63	1491.06	39.04
	II	7123.90	1389.90	172.73	975.20	123.14	1897.42	291.69	1905.86	440.04	2081.24	2018.01	543.94	422.42	6706.13	494.47
	III	3576.15	2322.01	303.06	5508.44	353.29	2622.16	2656.47	884.87	1173.33	2411.72	2841.54	1751.83	1688.63	8933.97	4974.45
Aug	I	698.91	1997.13	417.68	1421.72	2407.48	6451.29	3827.50	6032.85	5120.11	283.52	6324.87	1808.03	5193.31	10198.43	2492.86
	II	1787.50	5867.60	2968.11	1837.05	2019.65	1935.40	6525.82	2057.02	2356.21	607.72	2423.15	2580.22	3495.10	5990.84	1088.29
	III	2393.64	3212.06	5318.68	3137.01	1508.52	3446.99	1991.15	1102.12	651.08	1792.53	1751.67	2537.76	5826.79	7449.61	729.24
Sep	I	1179.51	580.41	3053.01	2783.14	308.58	595.36	5466.45	3118.43	782.97	1432.35	7082.43	8363.88	7043.53	1737.11	4073.71
	II	431.20	334.70	1124.87	2115.82	298.21	9295.49	1730.10	2126.92	513.90	815.98	3717.62	3343.52	2860.17	947.44	1834.09
	III	291.79	195.60	252.71	1741.84	362.59	2149.39	1145.43	1546.75	668.78	379.27	1833.90	1156.07	1372.66	1987.36	611.81
Oct	I	157.56	781.41	149.38	1436.56	245.19	474.37	686.31	1447.10	250.43	379.43	501.69	272.49	622.54	2990.02	370.18
	II	124.39	489.21	156.60	438.47	150.42	1070.75	195.47	667.44	203.16	309.45	412.81	281.43	300.64	1904.97	481.52
	III	119.10	146.00	283.12	492.53	121.38	743.07	191.71	316.20	142.19	120.07	451.95	208.70	291.91	726.32	376.85
Nov	I	78.85	97.60	127.25	241.29	40.10	267.55	184.46	293.68	105.88	123.71	163.11	150.50	301.86	413.75	265.63
	II	49.40	62.46	62.78	167.82	28.86	195.47	137.48	203.51	63.72	104.26	124.45	114.21	173.13	210.25	132.25
	III	32.79	41.04	35.94	148.58	28.56	156.83	86.75	123.64	41.24	468.87	195.92	54.72	83.63	85.08	53.97
Dec	I	26.47	37.14	35.52	114.12	25.54	88.63	68.01	56.70	33.95	82.77	74.98	36.00	65.94	51.05	18.17
	II	19.14	28.64	40.67	52.98	20.74	88.82	58.70	53.49	27.26	59.69	64.03	28.73	44.41	74.07	10.94
	III	17.76	24.21	41.83	52.88	17.67	63.87	55.61	57.88	8.80	28.82	48.77	38.69	39.09	69.74	7.34
Jan	I	18.16	18.59	36.19	45.25	15.55	62.14	62.20	54.01	9.09	40.18	58.56	68.82	44.58	77.24	15.50
	II	24.71	17.72	29.28	35.64	12.20	52.48	44.54	37.15	15.46	35.60	46.63	80.22	49.12	56.20	68.63
	III	12.80	14.38	29.46	54.51	17.69	49.59	52.04	39.37	8.25	38.78	28.53	26.51	28.49	53.81	50.09
Feb	I	8.77	14.94	31.89	87.43	274.25	40.06	46.89	53.82	5.12	28.44	23.85	64.45	30.64	50.92	50.82
	II	7.56	13.00	30.46	32.08	52.02	41.49	33.46	46.30	3.21	19.42	39.36	30.53	44.25	46.10	39.78
	III	5.36	16.72	30.56	27.83	25.92	40.43	49.03	25.85	2.51	38.19	30.53	8.42	37.45	34.21	30.13
Mar	I	3.69	10.73	21.18	28.99	16.54	34.33	35.79	36.67	1.80	22.47	23.88	4.67	37.76	88.08	37.88
	II	4.19	11.01	13.46	19.27	12.99	102.19	29.06	34.22	1.29	20.11	23.32	4.13	14.89	61.97	54.75
	III	4.49	7.70	20.63	22.90	10.38	53.15	29.71	30.09	0.93	17.23	15.37	11.47	17.16	23.53	32.59
Apr	I	3.13	8.24	12.57	16.74	5.28	23.01	21.29	31.03	0.73	11.08	5.47	11.24	13.34	20.89	9.94
	II	2.38	6.27	7.25	12.43	3.11	31.95	21.73	22.25	0.35	8.94	4.72	4.63	7.75	17.90	10.22
	III	3.50	4.02	5.51	7.76	1.78	42.40	18.76	13.96	0.21	5.76	5.81	2.48	4.54	13.00	12.07
May	I	3.94	3.46	7.96	28.29	1.27	25.31	11.48	11.51	0.18	8.60	3.74	3.01	6.15	15.24	11.52
	II	2.89	6.03	5.28	15.14	0.84	23.81	16.08	9.73	0.12	15.31	2.40	2.22	4.69	11.46	13.35
	III	1.03	1.43	4.35	12.15	0.14	21.00	5.11	5.85	0.13	12.99	6.97	2.20	5.51	7.46	6.42
Inflow (MCM)		*16894.35*	*19344.48*	*15234.59*	*21261.36*	*7963.46*	*29489.66*	*23878.92*	*23706.88*	*11553.11*	*10679.54*	*27039.21*	*21361.35*	*26956.94*	*49486.87*	*16546.34*

Table 5.116: 10-Daily Average Flow Series (m^3/s) at Kunghara Dam

Catchment Area =52,243 km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	76.29	5.76	1.15	7.45	16.91	0.28	14.63	3.18	3.83	7.75	10.80	2.81	2.39	1.81	3.55
	II	211.42	3277.95	0.26	9.32	234.97	0.42	11.72	28.39	24.27	5.47	15.44	97.46	1.48	547.46	16.51
	III	257.77	307.09	1957.98	49.86	205.57	356.15	20.73	493.66	50.89	6.64	52.66	290.22	94.68	2536.39	21.64
JUL	I	199.96	567.59	303.55	521.19	64.45	927.40	1359.65	4345.37	475.57	104.63	368.81	298.06	153.31	1527.70	40.00
	II	7298.96	1424.05	176.97	999.16	126.17	1944.05	298.86	1952.69	450.85	2132.38	2067.60	557.31	432.80	6870.92	506.62
	III	3664.03	2379.07	310.51	5643.80	361.97	2686.60	2721.75	906.61	1202.16	2470.98	2911.37	1794.88	1730.13	9153.51	5096.69
AUG	I	716.08	2046.21	427.94	1456.66	2466.64	6609.82	3921.55	6181.10	5245.93	290.49	6480.29	1852.46	5320.93	10449.04	2554.12
	II	1831.43	6011.79	3041.05	1882.19	2069.28	1982.96	6686.18	2107.57	2414.11	622.65	2482.70	2643.62	3580.99	6138.06	1115.03
	III	2452.46	3290.99	5449.38	3214.10	1545.59	3531.69	2040.08	1129.20	667.08	1836.58	1794.71	2600.12	5969.97	7632.67	747.16
SEP	I	1208.49	594.67	3128.03	2851.53	316.16	609.99	5600.78	3195.06	802.21	1467.55	7256.47	8569.41	7216.61	1779.80	4173.82
	II	441.80	342.92	1152.51	2167.81	305.54	9523.91	1772.61	2179.19	526.53	836.03	3808.97	3425.68	2930.45	970.72	1879.16
	III	298.96	200.41	258.92	1784.64	371.50	2202.21	1173.58	1584.76	685.21	388.59	1878.97	1184.48	1406.39	2036.20	626.84
OCT	I	161.43	800.61	153.05	1471.86	251.22	486.03	703.18	1482.66	256.58	388.75	514.02	279.19	637.84	3063.50	379.28
	II	127.45	501.23	160.45	449.24	154.12	1097.06	200.27	683.84	208.15	317.05	422.95	288.35	308.03	1951.78	493.35
	III	122.03	149.59	290.08	504.63	124.36	761.33	196.42	323.97	145.68	123.02	463.06	213.83	299.08	744.17	386.11
NOV	I	80.79	100.00	130.38	247.22	41.09	274.12	188.99	300.90	108.48	126.75	167.12	154.20	309.28	423.92	272.16
	II	50.61	63.99	64.32	171.94	29.57	200.27	140.86	208.51	65.29	106.82	127.51	117.02	177.38	215.42	135.50
	III	33.60	42.05	36.82	152.23	29.26	160.68	88.88	126.68	42.25	480.39	200.73	56.06	85.69	87.17	55.30
DEC	I	27.12	38.05	36.39	116.92	26.17	90.81	69.68	58.09	34.78	84.80	76.82	36.88	67.56	52.30	18.62
	II	19.61	29.34	41.67	54.28	21.25	91.00	60.14	54.80	27.93	61.16	65.60	29.44	45.50	75.89	11.21
	III	18.20	24.80	42.86	54.18	18.10	65.44	56.98	59.30	9.02	29.53	49.97	39.64	40.05	71.45	7.52
JAN	I	18.61	19.05	37.08	46.36	15.93	63.67	63.73	55.34	9.31	41.17	60.00	70.51	45.68	79.14	15.88
	II	25.32	18.16	30.00	36.52	12.50	53.77	45.63	38.06	15.84	36.47	47.78	82.19	50.33	57.58	70.32
	III	13.11	14.73	30.18	55.85	18.12	50.81	53.32	40.34	8.45	39.73	29.23	27.16	29.19	55.13	51.32
FEB	I	8.99	15.31	32.67	89.58	280.99	41.04	48.04	55.14	5.25	29.14	24.44	66.03	31.39	52.17	52.07
	II	7.75	13.32	31.21	32.87	53.30	42.51	34.28	47.44	3.29	19.90	40.33	31.28	45.34	47.23	40.76
	III	5.49	17.13	31.31	28.51	26.56	41.42	50.23	26.49	2.57	39.13	31.28	8.63	38.37	35.05	30.87
MAR	I	3.78	10.99	21.70	29.70	16.95	35.17	36.67	37.57	1.84	23.02	24.47	4.78	38.69	90.24	38.81
	II	4.29	11.28	13.79	19.74	13.31	104.70	29.77	35.06	1.32	20.60	23.89	4.23	15.26	63.49	56.10
	III	4.60	7.89	21.14	23.46	10.64	54.46	30.44	30.83	0.95	17.65	15.75	11.75	17.58	24.11	33.39
APR	I	3.21	8.44	12.88	17.15	5.41	23.58	21.81	31.79	0.75	11.35	5.60	11.52	13.67	21.40	10.18
	II	2.44	6.42	7.43	12.74	3.19	32.74	22.26	22.80	0.36	9.16	4.84	4.74	7.94	18.34	10.47
	III	3.59	4.12	5.65	7.95	1.82	43.44	19.22	14.30	0.22	5.90	5.95	2.54	4.65	13.32	12.37
MAY	I	4.04	3.55	8.16	28.99	1.30	25.93	11.76	11.79	0.18	8.81	3.83	3.08	6.30	15.61	11.80
	II	2.96	6.18	5.41	15.51	0.86	24.40	16.48	9.97	0.12	15.69	2.46	2.27	4.81	11.74	13.68
	III	1.06	1.47	4.46	12.45	0.14	21.52	5.24	5.99	0.13	13.31	7.14	2.25	5.65	7.64	6.58
Inflow (MCM) =		17310	19820	15609	21784	8159	30214	24466	24289	11837	10942	27704	21886	27619	50703	16953

Table 5.117: 10-Daily Inflow Series (MCM) at Kunghara Project Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	65.91	4.98	0.99	6.44	14.61	0.24	12.64	2.74	3.31	6.69	9.33	2.43	2.06	1.57	3.06
	II	182.67	2832.15	0.22	8.06	203.01	0.36	10.13	24.53	20.97	4.73	13.34	84.20	1.27	473.01	14.26
	III	222.72	265.32	1691.70	43.08	177.61	307.72	17.91	426.52	43.97	5.74	45.50	250.75	81.80	2191.44	18.70
JUL	I	172.76	490.40	262.27	450.31	55.68	801.28	1174.74	3754.40	410.89	90.40	318.65	257.52	132.46	1319.93	34.56
	II	6306.30	1230.38	152.91	863.28	109.01	1679.66	258.21	1687.13	389.54	1842.38	1786.41	481.51	373.94	5936.48	437.72
	III	3482.29	2261.07	295.11	5363.87	344.02	2553.34	2586.75	861.65	1142.54	2348.42	2766.96	1705.85	1644.31	8699.49	4843.89
AUG	I	618.70	1767.92	369.74	1258.55	2131.18	5710.88	3388.22	5340.47	4532.48	250.98	5598.97	1600.53	4597.28	9027.97	2206.76
	II	1582.35	5194.18	2627.46	1626.21	1787.86	1713.28	5776.86	1820.94	2085.79	537.97	2145.05	2284.09	3093.97	5303.28	963.39
	III	2330.82	3127.76	5179.09	3054.68	1468.93	3356.52	1938.89	1073.19	633.99	1745.48	1705.70	2471.16	5673.86	7254.09	710.10
SEP	I	1044.14	513.80	2702.62	2463.72	273.16	527.03	4839.07	2760.53	693.11	1267.96	6269.59	7403.97	6235.15	1537.74	3606.18
	II	381.71	296.29	995.77	1872.99	263.98	8228.66	1531.54	1882.82	454.92	722.33	3290.95	2959.79	2531.91	838.70	1623.59
	III	258.30	173.15	223.71	1541.93	320.98	1902.71	1013.97	1369.23	592.03	335.74	1623.43	1023.39	1215.12	1759.27	541.59
OCT	I	139.48	691.73	132.24	1271.69	217.05	419.93	607.54	1281.02	221.69	335.88	444.11	241.22	551.09	2646.86	327.69
	II	110.11	433.06	138.63	388.15	133.16	947.86	173.04	590.84	179.84	273.93	365.43	249.13	266.14	1686.34	426.26
	III	115.97	142.17	275.69	479.60	118.19	723.57	186.68	307.90	138.46	116.92	440.09	203.22	284.25	707.26	366.96
NOV	I	69.80	86.40	112.65	213.60	35.50	236.84	163.29	259.97	93.73	109.51	144.39	133.23	267.22	366.26	235.14
	II	43.73	55.29	55.57	148.56	25.55	173.04	121.70	180.15	56.41	92.29	110.17	101.10	153.26	186.12	117.07
	III	29.03	36.33	31.82	131.53	25.28	138.83	76.79	109.45	36.51	415.06	173.43	48.44	74.03	75.32	47.78
DEC	I	23.43	32.88	31.44	101.02	22.61	78.46	60.20	50.19	30.05	73.27	66.37	31.87	58.37	45.19	16.08
	II	16.94	25.35	36.00	46.90	18.36	78.63	51.96	47.35	24.13	52.84	56.68	25.43	39.31	65.57	9.68
	III	17.29	23.57	40.73	51.49	17.21	62.19	54.15	56.36	8.57	28.06	47.49	37.67	38.06	67.91	7.15
JAN	I	16.08	16.46	32.04	40.06	13.77	55.01	55.06	47.81	8.05	35.57	51.84	60.92	39.46	68.38	13.72
	II	21.87	15.69	25.92	31.55	10.80	46.46	39.43	32.89	13.69	31.51	41.28	71.01	43.48	49.75	60.75
	III	12.46	14.00	28.69	53.08	17.23	48.29	50.67	38.34	8.03	37.76	27.78	25.81	27.74	52.40	48.78
FEB	I	7.76	13.23	28.23	77.40	242.77	35.46	41.51	47.64	4.53	25.18	21.11	57.05	27.12	45.08	44.99
	II	6.69	11.51	26.96	28.40	46.05	36.73	29.62	40.99	2.84	17.19	34.84	27.03	39.17	40.81	35.21
	III	3.80	11.84	21.64	19.71	18.36	28.63	34.72	18.31	1.78	27.05	21.62	5.96	26.52	24.23	21.34
MAR	I	3.27	9.50	18.75	25.66	14.64	30.39	31.68	32.46	1.59	19.89	21.14	4.13	33.43	77.97	33.53
	II	3.71	9.75	11.92	17.06	11.50	90.46	25.72	30.29	1.14	17.80	20.64	3.66	13.18	54.86	48.47
	III	4.37	7.50	20.09	22.30	10.11	51.76	28.93	29.30	0.91	16.78	14.97	11.17	16.71	22.91	31.73
APR	I	2.77	7.29	11.13	14.82	4.67	20.37	18.85	27.47	0.65	9.81	4.84	9.95	11.81	18.49	8.80
	II	2.11	5.55	6.42	11.00	2.75	28.28	19.24	19.70	0.31	7.91	4.18	4.10	6.86	15.85	9.05
	III	3.10	3.56	4.88	6.87	1.58	37.53	16.61	12.36	0.19	5.10	5.14	2.20	4.02	11.51	10.68
MAY	I	3.49	3.06	7.05	25.04	1.12	22.41	10.16	10.19	0.16	7.61	3.31	2.66	5.44	13.49	10.20
	II	2.56	5.34	4.67	13.40	0.74	21.08	14.23	8.61	0.11	13.55	2.12	1.97	4.15	10.14	11.82
	III	1.00	1.39	4.24	11.83	0.14	20.45	4.98	5.70	0.13	12.65	6.79	2.14	5.37	7.26	6.25
Total Inflow (MCM) =		*17310*	*19820*	*15609*	*21784*	*8159*	*30214*	*24466*	*24289*	*11837*	*10942*	*27704*	*21886*	*27619*	*50703*	*16953*

5.10.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.118** and **Table 5.119**

Table 5.118: Computation of 90% and 50% Dependable Year for Kunghara Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.06	50703	2013-2014	
2	0.13	30214	2005-2006	
3	0.19	27704	2010-2011	
4	0.25	27619	2012-2013	
5	0.31	24466	2006-2007	
6	0.38	24289	2007-2008	
7	0.44	21886	2011-2012	
8	**0.50**	**21784**	**2003-2004**	**50% Dependable**
9	0.56	19820	2001-2002	
10	0.63	17310	2000-2001	
11	0.69	16953	2014-2015	
12	0.75	15609	2002-2003	
13	0.81	11837	2008-2009	
14	**0.88**	**10942**	**2009-2010**	**90% Dependable**
15	0.94	8159	2004-2005	

Table 5.119: 90% and 50% dependable flows for the dam site (cumec)

		90% Dependable Year	50% Dependable Year
Period		**2009-2010**	**2003-2004**
Jun	**I**	7.75	7.45
	II	5.47	9.32
	III	6.64	49.86
Jul	**I**	104.63	521.19
	II	2132.38	999.16
	III	2470.98	5643.80
Aug	**I**	290.49	1456.66
	II	622.65	1882.19
	III	1836.58	3214.10
Sep	**I**	1467.55	2851.53
	II	836.03	2167.81
	III	388.59	1784.64
Oct	**I**	388.75	1471.86
	II	317.05	449.24
	III	123.02	504.63
Nov	**I**	126.75	247.22
	II	106.82	171.94
	III	480.39	152.23
Dec	**I**	84.80	116.92
	II	61.16	54.28
	III	29.53	54.18
Jan	**I**	41.17	46.36
	II	36.47	36.52
	III	39.73	55.85
Feb	**I**	29.14	89.58
	II	19.90	32.87
	III	39.13	28.51
Mar	**I**	23.02	29.70
	II	20.60	19.74
	III	17.65	23.46
Apr	**I**	11.35	17.15
	II	9.16	12.74
	III	5.90	7.95
May	**I**	8.81	28.99
	II	15.69	15.51
	III	13.31	12.45
Inflow (MCM) =		10942	21784

5.10.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Kunghara, is given in the following section.

5.10.5.1 EAC of Kunghara Dam

The EAC curve and the table showing the different values are given in **Figure 5.61** and **Table 5.120** respectively.

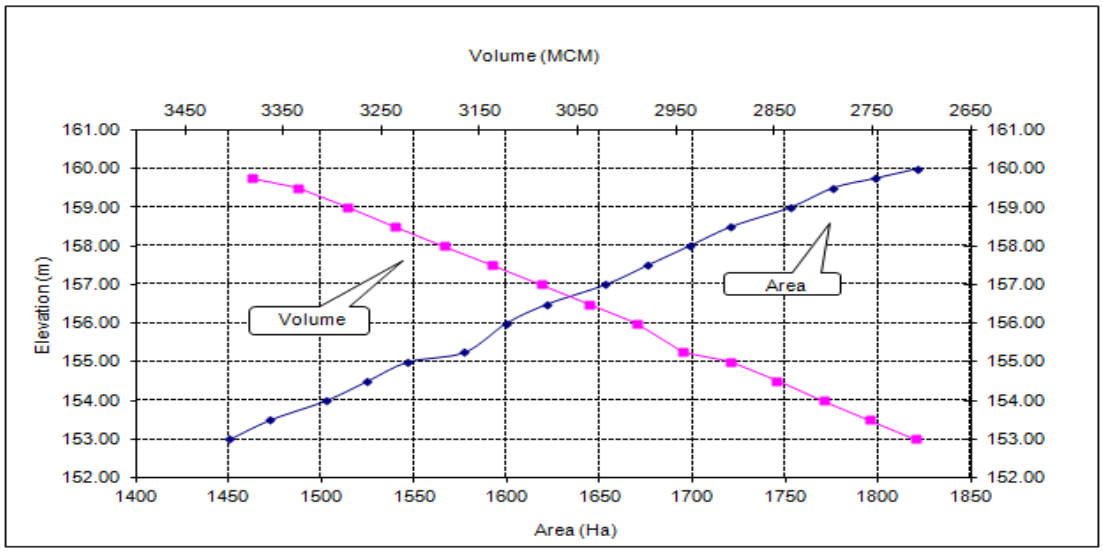


Figure 5.61: EAC curve of Kunghara Dam

Table 5.120: EAC data of Kunghara Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
153.00	14504883.39	1450.49	2659719679.89	2659.72
153.50	14723741.07	1472.37	2706209845.45	2706.21
154.00	15023718.39	1502.37	2752981134.02	2752.98
154.50	15244571.68	1524.46	2800023470.89	2800.02
155.00	15465831.71	1546.58	2847317977.12	2847.32
155.25	15771463.07	1577.15	2894884505.62	2894.88
156.00	15994725.16	1599.47	2942735574.98	2942.74
156.50	16218396.16	1621.84	2990840163.40	2990.84
157.00	16530058.35	1653.01	3039206872.14	3039.21
157.50	16755742.92	1675.57	3087872623.22	3087.87
158.00	16981838.57	1698.18	3136794259.91	3136.79
158.50	17208345.30	1720.83	3185969762.44	3185.97
159.00	17527364.22	1752.74	3235452404.68	3235.45
159.50	17755893.97	1775.59	3285194822.06	3285.19
159.75	17984836.98	1798.48	3335193455.24	3335.19
160.00	18214193.24	1821.42	3377629485.18	3381.01

5.10.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.10.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Ashti G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Ashti G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{Kunghara}}{A_{Ashti}}\right)^{\frac{3}{4}} = 1.02$$

Using the above multiplying factors to the peak flows at the Ashti G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.121**.

Table 5.121: Final Peak Flows (cumec) at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2000	24276.00	31558.80	32138.66
2001	15890.01	20657.01	21036.57
2002	14177.55	18430.82	18769.46
2003	15190.70	19747.91	20110.76
2004	4609.03	5991.74	6101.83
2005	24481.00	31825.30	32410.06
2006	15551.00	20216.30	20587.76
2007	20613.88	26798.04	27290.43
2008	10718.40	13933.92	14189.94
2009	8058.19	10475.65	10668.13
2010	17500.36	22750.47	23168.49
2011	16347.06	21251.18	21641.65

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2012	15829.89	20578.86	20956.97
2013	18596.33	24175.23	24619.43
2014	16908.37	21980.88	22384.76

5.10.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.122**.

Table 5.122: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	21071.66
Variance	49635907.79
SD (Sx)	7045.28
Skewness	-0.40
Kurtosis	0.58
No. of Data	15.00

5.10.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel's distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.123**.

The detailed procedure for Gumbel's distribution method for Kunghara dam site has been shown in **Annexure-9**.

Table 5.123: Detail of different year Return Period Flood (cumec) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	20062
2	5	27886
3	10	33067
4	20	38036
5	25	39612
6	50	44468
7	100	49288
8	500	60426

Annexure-9 (Flood Frequency Analysis for Kunghara Dam)

DESIGN Flood_Kunghara

CA at G&D = 50990.00 | CA = 52243

Sl.No.	Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	2000	24276.00	31558.80	32138.66	10.38
2	2001	15890.01	20657.01	21036.57	9.95
3	2002	14177.55	18430.82	18769.46	9.84
4	2003	15190.70	19747.91	20110.76	9.91
5	2004	4609.03	5991.74	6101.83	8.72
6	2005	24481.00	31825.30	32410.06	10.39
7	2006	15551.00	20216.30	20587.76	9.93
8	2007	20613.88	26798.04	27290.43	10.21
9	2008	10718.40	13933.92	14189.94	9.56
10	2009	8058.19	10475.65	10668.13	9.28
11	2010	17500.36	22750.47	23168.49	10.05
12	2011	16347.06	21251.18	21641.65	9.98
13	2012	15829.89	20578.86	20956.97	9.95
14	2013	18596.33	24175.23	24619.43	10.11
15	2014	16908.37	21980.88	22384.76	10.02
	X_T	=	$X_m+K.S_x$		

Conversion factor = 1.02

Instantaneous Peak = 30%

Mean(X_m)	21071.66	9.89
Variance	49635907.79	0.183
SD (Sx)	7045.28	0.428
Skewness	-0.40	-1.63591
Kurtosis	0.58	3.27907
No. of Data	15.00	

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 15

Reduced mean = Y_n = 0.530 } From Table

Reduced Std. Dev = S_n = 1.09 } From Table

$f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	90% CONFIDENCE INTERVAL (X_{cl} Values in cumec) Lower Confidence Limit	Upper Confidence Limit
1	2	**20062**	0.367	-0.150	0.911	1656.900	2725.600	17336	22788
2	5	**27886**	1.500	0.893	1.743	3170.974	5216.252	22670	33102
3	10	**33067**	2.250	1.584	2.412	4388.011	7218.278	25849	40285
4	20	**38036**	2.970	2.246	3.078	5598.483	9209.504	28826	47246
5	25	**39612**	3.199	2.457	3.291	5987.094	9848.770	29763	49461
6	50	**44468**	3.902	3.104	3.954	7192.773	11832.111	32636	56300
7	100	**49288**	4.600	3.747	4.617	8398.060	13814.810	35473	63103
8	500	**60426**	6.214	5.232	6.157	11200.639	18425.051	42001	78851

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	20062
2	5	27886
3	10	33067
4	20	38036
5	25	39612
6	50	44468
7	100	49288
8	500	60426

5.11 Hydrology of Pranhita Hydroelectric Project

5.11.1 General

The present project, Pranhita, envisages harnessing water from the River Pranhita and other small rivers. Pranhita is the largest tributary of Godavari River covering about 34% of its drainage basin conveying the combined waters of the Penganga River, Wardha River and River. By virtue of its extensive network of tributaries, the river drains all of Vidarbha region in Maharashtra as well as the southern slopes of the Satpura Ranges. It flows along the border of Gadchiroli district in Maharashtra and Adilabad district in Telangana. The Pranhita sub-basin is the 7th largest in India, measuring about 1,09,078 km^2 making it larger than the individual basins of significant rivers like the Narmada and Cauvery. The project is proposed to be of storage type with the multifunction of irrigation and power.

5.11.1.1 Description of Dam Sites

The catchment area of the dam site is 1,02,174 km^2. The dam site is located in Gadchiroli district of Maharashtra at a longitude of 79° 56' 51'' E and latitude of 19° 16' 52'' N. Locations of the dam site and of G&D site are shown in **Figure 5.62**.

5.11.1.2 Description of G&D Site

Tekra G&D site is situated in the Gadchiroli district of Maharashtra at 79° 40' 10" E, 18° 58' 04" N. Catchment area of the G&D site is around 1,08,780 km^2.

5.11.1.3 The River System

The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Maharashtra. It flows east for about 1,465 kilometres draining the states of Maharashtra (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2, it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length,

catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow. The river delta supports 729 persons/km^2 – nearly twice the density average for the nation, and has been categorized as having substantial to greater risk of flooding with rising sea levels.

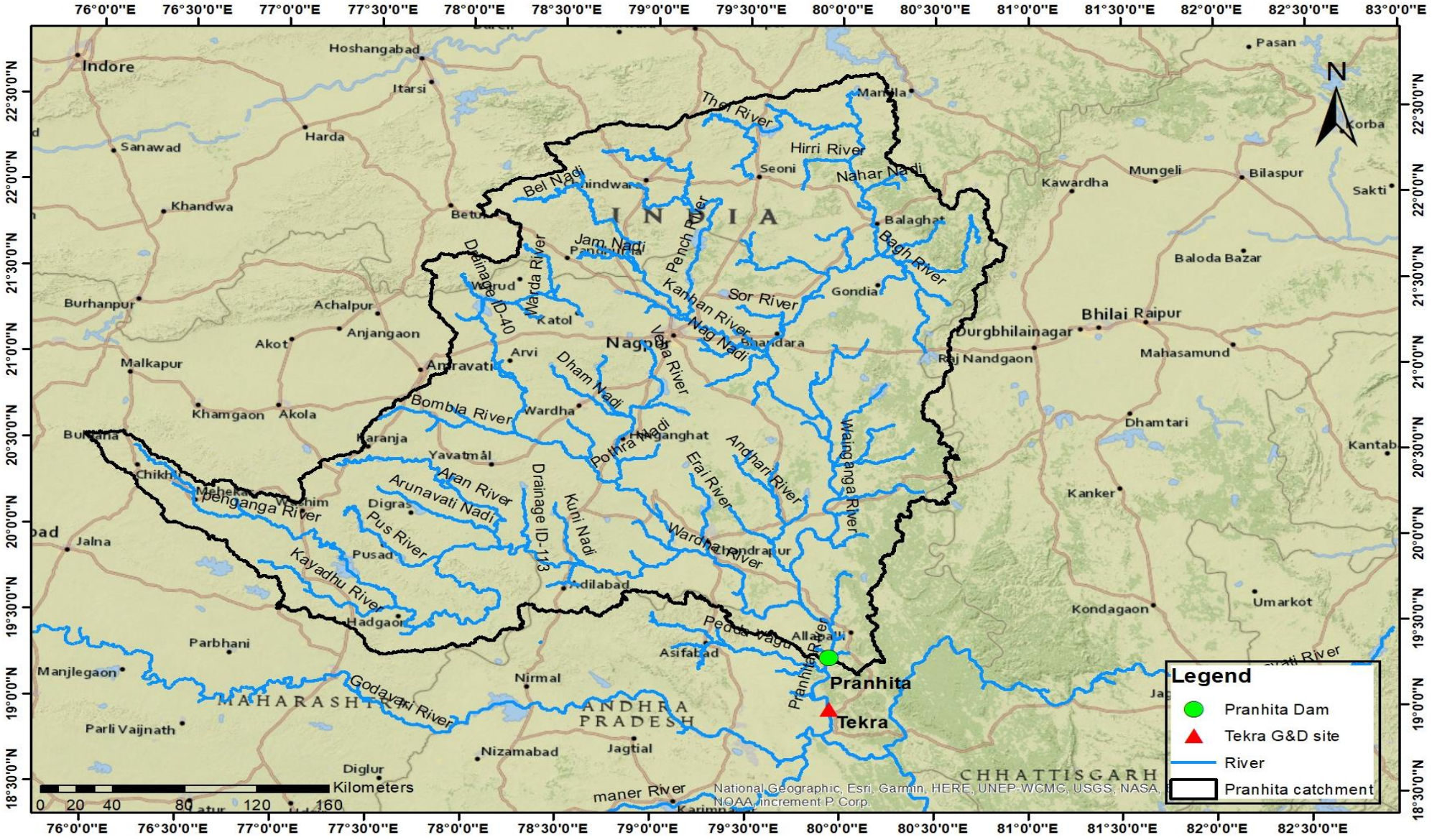


Figure 5.62: Catchment Area of Project and Locations of Dam and G&D site

5.11.2 Water Availability Studies

5.11.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Tekra (Catchment Area=1,08,780 km^2) which is downstream of the project site along the Pranhita River, is available and can be downloaded from India WRIS site.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.11.2.2 Rainfall data

Average daily rainfall (in mm) have been calculated at each grid point (as can been seen from **Figure 5.63**) within the boundary of the Tekra G&D site and Pranhita dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus, in **Figure 5.63**, 147 grid points is considered to assess the catchment rainfall for Tekra G&D site and 141 grid points have been considered for the assessment of rainfall in Pranhita proposed dam site. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

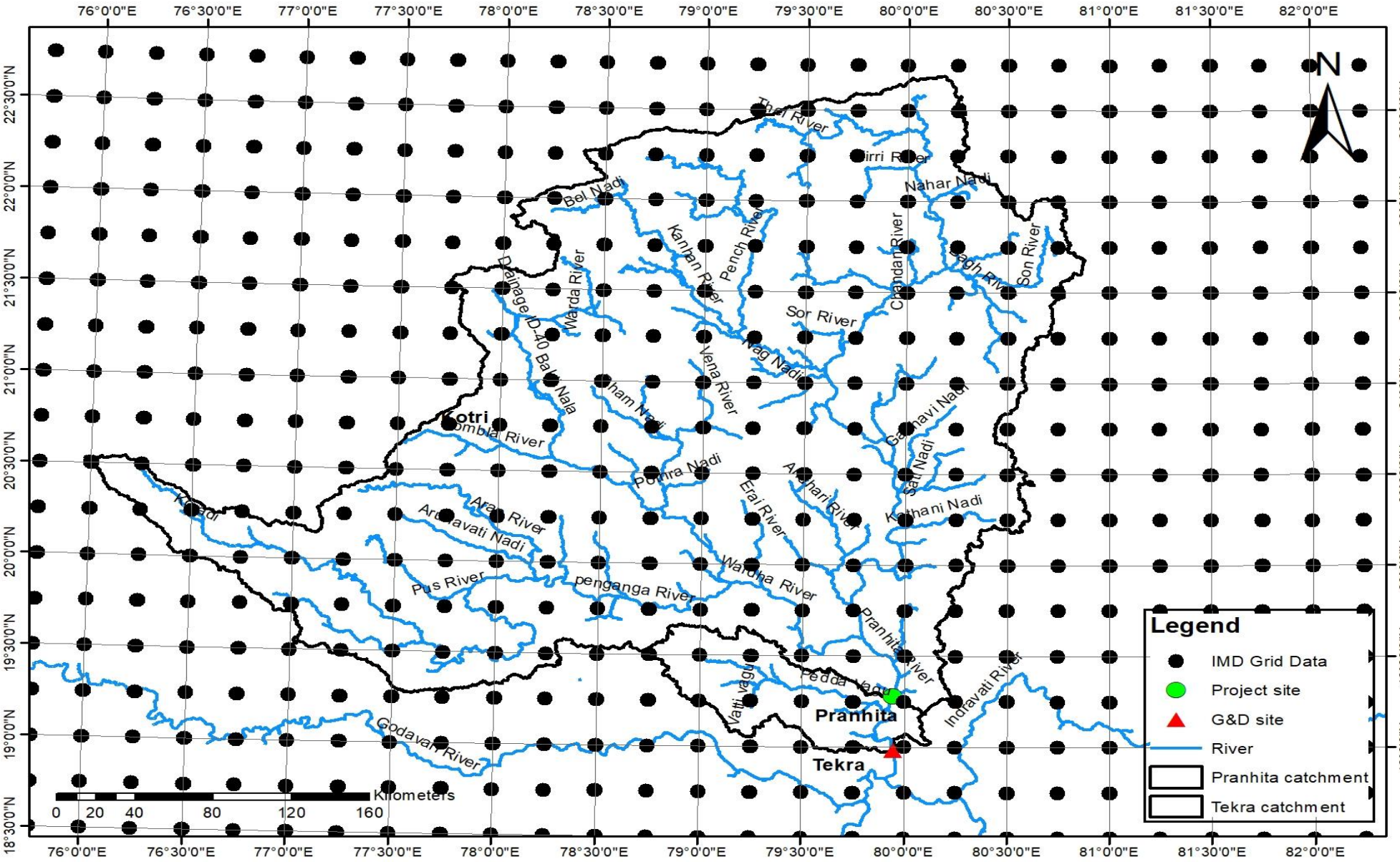


Figure 5.63: IMD Grid Rainfall Data for Pranhita Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfall for the last 25 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the G&D site and dam site are given in **Table 5.124**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.125** and **Table 5.126** respectively.

Table 5.124: Average Annual Rainfall (in mm)

Year	Tekra	Pranhita
1990-1991	1463	1452
1991-1992	864	862
1992-1993	1160	1155
1993-1994	1085	1089
1994-1995	1672	1685
1995-1996	1126	1112
1996-1997	915	907
1997-1998	1234	1245
1998-1999	1156	1135
1999-2000	1235	1258
2000-2001	1019	1002
2001-2002	1173	1171
2002-2003	1023	1032
2003-2004	1247	1247
2004-2005	918	915
2005-2006	1342	1329
2006-2007	1108	1094
2007-2008	1099	1089
2008-2009	936	917
2009-2010	945	954
2010-2011	1375	1362
2011-2012	1005	1012
2012-2013	1162	1154
2013-2014	1695	1677
2014-2015	1022	1021
AVERAGE (mm)	1159	1155

Table 5.125: 10 Daily Rainfall (in mm) of Tekra G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	4.64	2.81	0.26	0.54	2.47	0.01	0.69	0.78	0.38	1.52	9.74	7.15	1.24	0.20	1.74	0.35	1.27	1.57	3.58	1.17	0.11	2.19	0.66	3.73	0.21
	II	17.72	7.56	8.75	7.75	9.95	5.74	6.19	5.83	9.01	15.90	7.93	23.23	4.31	5.68	10.98	1.42	0.37	6.57	4.76	0.42	7.39	4.88	8.56	17.44	5.42
	III	10.14	4.45	6.06	7.65	12.54	10.32	0.45	4.21	5.15	6.46	5.69	2.75	24.17	8.95	2.78	16.30	9.31	15.42	8.71	7.18	6.50	8.60	2.18	14.60	2.63
JUL	I	6.74	5.52	2.09	9.92	16.60	3.97	6.76	9.23	16.00	3.63	8.34	9.48	0.76	14.47	3.76	14.76	15.09	15.55	7.96	12.93	14.84	6.67	10.78	10.62	2.39
	II	12.00	14.78	8.01	15.93	30.51	20.20	9.08	4.15	4.25	9.95	28.55	9.77	7.40	15.17	7.47	8.24	6.91	8.19	2.38	15.65	9.28	11.80	8.74	26.87	12.40
	III	13.37	13.89	16.03	9.85	9.54	13.45	11.72	19.23	9.47	9.56	3.77	6.39	1.55	19.01	11.70	21.02	13.36	6.09	16.14	8.98	19.88	8.67	16.00	20.89	18.25
AUG	I	6.82	7.42	15.68	11.77	8.45	7.78	8.73	3.45	10.43	20.83	4.36	14.02	12.14	9.84	14.14	13.80	20.15	17.70	20.20	1.71	17.78	11.49	10.82	16.41	7.76
	II	17.44	16.30	23.76	8.07	9.89	5.00	8.62	3.67	7.76	2.08	11.58	16.09	15.29	6.65	5.14	8.95	12.75	2.90	5.46	7.91	9.23	8.92	11.77	13.07	2.61
	III	20.73	5.42	13.76	5.19	18.60	8.97	9.49	19.65	6.85	5.94	10.33	6.86	14.02	14.90	4.56	2.00	6.80	4.98	4.17	9.26	11.08	11.22	9.95	8.10	9.41
SEP	I	6.59	0.91	10.64	8.70	20.54	12.49	6.94	5.03	9.62	5.56	0.95	2.00	10.98	6.85	4.32	5.50	5.14	13.87	6.80	9.01	17.85	14.97	17.01	1.27	17.20
	II	4.25	0.55	1.02	1.57	2.09	6.86	6.19	8.74	11.77	18.26	0.86	1.89	0.94	3.72	2.92	18.04	7.45	4.89	5.98	0.41	7.59	5.83	3.90	5.94	2.83
	III	5.14	1.35	0.33	8.88	0.35	0.15	1.33	2.97	6.14	9.01	2.25	0.59	0.17	7.35	2.73	3.10	4.35	4.78	1.89	1.52	0.93	0.76	4.64	4.70	0.49
OCT	I	8.40	1.20	1.51	1.27	7.75	0.13	2.94	0.62	1.44	6.93	0.35	11.26	0.09	2.39	1.19	0.02	3.05	2.33	1.51	3.78	0.92	0.31	2.88	11.13	0.31
	II	2.19	0.02	0.62	5.68	0.17	9.39	0.02	0.50	2.97	1.59	0.47	1.86	3.93	0.07	1.05	8.27	0.15	0.00	0.03	0.02	2.25	0.23	0.00	1.39	1.77
	III	2.43	0.00	0.08	0.08	1.40	1.79	4.43	6.06	1.29	1.42	0.00	0.00	0.00	2.15	0.00	0.29	0.16	0.00	0.05	0.00	1.41	0.00	0.15	1.38	0.23
NOV	I	0.11	0.29	0.04	0.01	0.25	0.07	0.04	0.16	5.73	0.01	0.00	0.02	0.01	0.06	0.22	0.00	1.00	0.45	0.00	0.67	0.63	0.00	0.95	0.01	0.00
	II	0.00	0.63	1.19	0.01	0.21	0.00	0.11	2.06	0.79	0.00	0.00	0.41	0.04	0.00	0.48	0.00	0.00	0.00	0.26	6.35	3.72	0.00	0.00	0.00	0.29
	III	0.02	0.09	0.11	0.01	0.02	0.00	0.00	4.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.02	0.00	0.05	0.00	0.00	0.03	0.00
DEC	I	0.64	0.00	0.00	0.67	0.00	0.01	0.00	5.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.54	0.00	0.00	0.01	0.00
	II	0.03	0.00	0.00	0.02	0.00	0.00	0.00	2.23	0.01	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.68	0.05	0.00	0.05	0.00	0.29
	III	0.00	0.13	0.00	0.00	0.00	0.20	0.00	1.88	0.00	0.00	0.00	0.00	0.01	0.12	0.00	0.55	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
JAN	I	0.62	0.00	0.00	0.12	3.39	0.82	0.00	0.19	0.01	0.00	0.69	0.15	0.03	0.01	0.02	0.00	0.00	0.00	0.04	0.00	0.04	1.15	0.38	0.06	2.19
	II	0.26	0.00	0.00	0.97	1.81	0.28	1.49	0.10	0.00	0.01	0.07	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	1.32	0.03	0.00	0.00	0.24	0.00
	III	0.00	0.00	0.00	0.11	0.00	0.00	0.00	2.00	0.00	0.00	0.00	0.11	0.00	1.29	8.77	0.00	0.00	0.00	0.00	0.00	0.00	0.55	0.22	0.05	0.01
FEB	I	0.01	0.05	0.00	0.49	0.25	0.74	0.00	1.96	1.90	0.10	0.00	0.32	1.27	0.50	1.44	0.00	0.01	0.09	0.02	0.52	0.00	0.01	0.11	0.00	0.16
	II	0.00	0.00	0.00	0.57	0.07	0.07	0.00	0.02	0.02	0.15	0.00	0.29	1.13	0.00	0.02	0.00	0.18	0.06	0.00	0.60	0.06	0.06	1.62	0.03	0.55
	III	0.43	0.01	0.52	0.00	0.61	0.24	0.00	0.02	0.00	1.04	0.00	0.13	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.40	0.27	0.00	0.59	2.79	0.08
MAR	I	1.04	0.00	1.61	0.00	1.27	0.41	0.01	0.23	0.00	0.00	1.03	0.00	0.01	0.00	1.36	2.40	0.02	0.00	0.00	0.00	0.03	0.00	0.00	4.33	5.75
	II	0.12	0.00	0.13	0.00	2.72	0.04	0.00	1.58	0.00	0.01	0.34	0.06	0.47	0.00	0.17	2.43	0.16	0.16	0.11	1.13	0.00	0.00	0.39	0.59	1.11
	III	0.02	0.03	0.03	0.00	1.08	0.01	0.34	0.16	0.01	0.01	0.03	0.07	0.10	0.10	0.00	0.00	0.00	2.23	0.10	0.18	0.02	0.00	0.20	0.01	0.24
APR	I	0.45	0.03	0.18	0.41	0.59	0.05	1.70	0.31	0.00	0.00	0.30	0.18	0.17	0.20	0.00	0.00	0.05	0.38	0.31	0.00	0.41	0.11	0.29	0.01	0.51
	II	0.02	0.02	0.09	0.37	0.30	0.58	0.49	0.25	0.00	0.03	2.08	0.01	0.21	0.05	0.42	2.07	0.31	0.00	0.00	0.03	0.96	0.01	0.14	0.44	2.09
	III	0.02	0.24	0.03	0.08	0.02	0.37	0.22	0.60	0.00	0.00	0.01	0.00	0.07	0.30	0.72	0.01	0.06	0.00	0.00	0.12	0.27	0.04	0.53	0.10	0.19
MAY	I	0.01	0.28	0.01	0.11	0.33	0.02	0.92	0.75	0.23	0.54	0.01	0.07	0.01	0.40	0.75	0.25	0.08	0.23	0.05	0.14	0.09	0.00	0.03	0.60	0.87
	II	0.06	0.14	0.00	0.03	0.38	0.00	0.01	0.35	1.01	0.16	0.28	0.34	0.22	0.39	0.00	0.73	0.19	0.00	0.45	0.12	0.04	0.02	0.00	0.04	1.11
	III	0.26	0.30	0.53	0.16	0.09	0.06	0.01	0.06	1.49	1.17	0.43	0.42	0.01	0.05	0.30	1.15	0.09	0.09	0.49	0.28	0.10	0.00	0.09	0.16	0.04
Yearly Rainfall (mm)		1463	864	1160	1085	1672	1126	915	1234	1156	1235	1019	1173	1023	1247	918	1342	1108	1099	936	945	1375	1005	1162	1695	1022

Table 5.126: 10 Daily Rainfall (in mm) of Pranhita Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	4.44	2.87	0.24	0.53	2.52	0.01	0.69	0.80	0.39	1.44	9.72	6.97	0.91	0.19	1.73	0.20	1.18	1.56	3.54	1.10	0.10	2.19	0.59	3.55	0.19
	II	17.35	7.34	8.42	7.72	9.96	5.79	6.07	5.92	8.29	15.99	7.46	23.08	4.46	5.53	11.15	1.40	0.36	6.42	4.76	0.41	7.57	5.03	8.70	17.16	5.29
	III	10.43	4.53	5.78	7.78	12.78	10.42	0.39	4.10	5.31	6.68	5.76	2.85	24.77	9.01	2.79	16.47	9.37	15.23	8.56	7.19	6.53	8.46	2.19	14.76	2.76
JUL	I	6.77	5.11	1.97	9.98	16.14	4.01	6.73	9.47	15.28	3.66	8.15	9.48	0.76	14.53	3.76	13.95	15.02	15.92	7.89	13.17	15.10	6.52	10.90	10.63	2.22
	II	11.93	14.83	8.21	15.79	31.20	20.21	8.80	4.28	4.17	10.18	29.19	9.82	7.26	15.00	7.33	8.43	7.08	7.78	2.33	16.05	9.38	12.14	8.51	26.68	12.67
	III	13.59	14.18	16.24	9.63	9.56	13.46	11.82	19.61	9.11	9.74	3.81	6.39	1.46	19.37	11.96	20.05	13.15	6.09	16.15	9.19	19.51	8.71	15.77	20.33	18.82
AUG	I	6.90	7.42	16.05	11.92	8.58	7.70	8.79	3.43	10.32	21.46	4.33	14.17	12.12	9.83	14.18	14.05	19.30	17.80	19.16	1.77	17.70	11.68	11.02	16.34	7.92
	II	17.03	16.49	23.55	8.35	9.76	5.04	8.55	3.50	7.20	2.06	11.34	16.31	15.82	6.87	5.25	9.06	13.16	2.85	5.35	7.68	8.86	9.03	11.61	12.87	2.61
	III	20.24	5.58	14.05	5.27	18.73	8.51	9.41	19.73	6.91	5.97	9.37	6.78	13.90	14.85	4.60	2.07	7.01	4.86	4.13	9.30	10.63	11.16	9.74	8.31	8.97
SEP	I	6.65	0.82	10.36	8.63	21.28	12.70	6.79	5.05	9.62	5.65	0.91	1.92	11.35	7.04	3.65	5.40	5.23	13.79	6.69	9.15	17.66	15.22	17.08	1.28	16.79
	II	4.26	0.49	1.06	1.55	2.12	6.70	6.27	8.85	12.05	18.92	0.75	1.91	0.93	3.79	2.90	18.61	6.86	4.72	5.93	0.43	7.64	5.77	3.84	5.71	2.82
	III	5.22	1.23	0.29	9.03	0.36	0.16	1.24	2.77	5.96	9.26	2.20	0.57	0.18	7.39	2.81	3.05	4.19	4.83	1.93	1.52	0.89	0.78	4.53	4.74	0.50
OCT	I	8.37	1.13	1.42	1.23	7.82	0.09	2.87	0.63	1.40	7.09	0.36	11.49	0.10	2.34	1.08	0.02	3.07	2.19	1.48	3.75	0.96	0.29	2.80	11.17	0.32
	II	2.06	0.02	0.54	5.84	0.17	8.69	0.01	0.52	3.00	1.57	0.48	1.69	3.94	0.07	1.08	8.10	0.16	0.00	0.02	0.02	2.11	0.24	0.00	1.35	1.81
	III	2.38	0.00	0.06	0.06	1.40	1.42	4.56	6.04	1.34	1.45	0.00	0.00	0.00	1.93	0.00	0.28	0.13	0.00	0.01	0.00	1.38	0.00	0.16	1.24	0.20
NOV	I	0.10	0.24	0.04	0.01	0.18	0.08	0.04	0.17	5.88	0.01	0.00	0.02	0.01	0.07	0.21	0.00	0.75	0.46	0.00	0.67	0.57	0.00	0.94	0.01	0.00
	II	0.00	0.65	1.12	0.02	0.19	0.00	0.11	2.02	0.81	0.00	0.00	0.27	0.05	0.00	0.50	0.00	0.00	0.00	0.28	6.38	3.87	0.00	0.00	0.00	0.31
	III	0.02	0.09	0.10	0.01	0.00	0.00	0.00	4.57	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.01	0.00	0.04	0.00	0.00	0.02	0.00
DEC	I	0.67	0.00	0.00	0.66	0.00	0.01	0.00	5.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.53	0.00	0.00	0.00	0.00
	II	0.03	0.00	0.00	0.02	0.00	0.00	0.00	2.28	0.01	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.72	0.05	0.00	0.05	0.00	0.30
	III	0.00	0.13	0.00	0.00	0.00	0.21	0.00	1.96	0.00	0.00	0.00	0.00	0.02	0.13	0.00	0.50	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00
JAN	I	0.59	0.00	0.00	0.12	3.37	0.86	0.00	0.20	0.01	0.00	0.63	0.05	0.03	0.01	0.02	0.00	0.00	0.00	0.05	0.00	0.04	1.18	0.40	0.07	2.06
	II	0.27	0.00	0.00	1.01	1.61	0.29	1.51	0.09	0.00	0.01	0.07	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	1.35	0.03	0.00	0.00	0.25	0.00
	III	0.00	0.00	0.00	0.12	0.00	0.00	0.00	2.08	0.00	0.00	0.00	0.12	0.00	1.22	8.81	0.00	0.00	0.00	0.00	0.00	0.00	0.57	0.23	0.05	0.01
FEB	I	0.01	0.06	0.00	0.42	0.27	0.78	0.00	1.81	1.92	0.05	0.00	0.34	1.33	0.46	1.41	0.00	0.01	0.08	0.02	0.55	0.00	0.01	0.12	0.00	0.16
	II	0.00	0.00	0.00	0.58	0.07	0.06	0.00	0.02	0.02	0.13	0.00	0.30	1.17	0.00	0.02	0.00	0.19	0.02	0.00	0.63	0.03	0.06	1.44	0.03	0.58
	III	0.44	0.01	0.54	0.00	0.63	0.24	0.00	0.02	0.00	1.08	0.00	0.14	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.39	0.22	0.00	0.60	2.89	0.09
MAR	I	1.07	0.00	1.60	0.00	1.33	0.43	0.01	0.24	0.00	0.00	1.02	0.00	0.01	0.00	1.33	2.47	0.02	0.00	0.00	0.00	0.04	0.00	0.00	4.05	5.74
	II	0.13	0.00	0.12	0.00	2.84	0.04	0.00	1.65	0.00	0.01	0.36	0.06	0.37	0.00	0.17	2.41	0.17	0.17	0.12	1.19	0.00	0.00	0.41	0.62	1.16
	III	0.02	0.03	0.02	0.00	1.07	0.00	0.30	0.17	0.01	0.01	0.03	0.07	0.10	0.09	0.00	0.00	0.00	2.09	0.09	0.18	0.02	0.00	0.21	0.01	0.19
APR	I	0.42	0.03	0.16	0.41	0.59	0.05	1.56	0.32	0.00	0.00	0.19	0.18	0.16	0.06	0.00	0.00	0.05	0.37	0.32	0.00	0.39	0.05	0.30	0.01	0.53
	II	0.00	0.02	0.08	0.38	0.22	0.49	0.42	0.26	0.00	0.02	1.99	0.00	0.17	0.05	0.43	1.83	0.29	0.00	0.00	0.01	0.80	0.01	0.13	0.38	2.05
	III	0.02	0.21	0.00	0.05	0.02	0.34	0.23	0.61	0.00	0.00	0.01	0.00	0.06	0.23	0.74	0.01	0.03	0.00	0.00	0.12	0.28	0.04	0.54	0.10	0.16
MAY	I	0.00	0.19	0.01	0.09	0.31	0.02	0.86	0.75	0.22	0.53	0.01	0.08	0.01	0.38	0.67	0.22	0.08	0.24	0.05	0.10	0.09	0.00	0.01	0.50	0.90
	II	0.05	0.13	0.00	0.01	0.35	0.00	0.01	0.32	0.94	0.14	0.29	0.31	0.23	0.39	0.00	0.70	0.19	0.00	0.29	0.09	0.04	0.02	0.00	0.04	1.11
	III	0.16	0.30	0.52	0.15	0.09	0.06	0.01	0.07	1.44	1.09	0.45	0.37	0.01	0.05	0.30	1.18	0.05	0.08	0.50	0.29	0.07	0.00	0.07	0.13	0.04
Yearly Rainfall (mm)		1452	862	1155	1089	1685	1112	907	1245	1135	1258	1002	1171	1032	1247	915	1329	1094	1089	917	954	1362	1012	1154	1677	1021

5.11.2.3 Rainfall and Runoff Data at Tekra G&D Site

Detailed calculations on water availability and flood magnitude will help select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) for the entire period from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Tekra G&D site is shown in **Figure 5.64**. The basic comparison between rainfall and runoff in **Figure 5.64** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.65** shows the plot of runoff coefficient at G&D site.

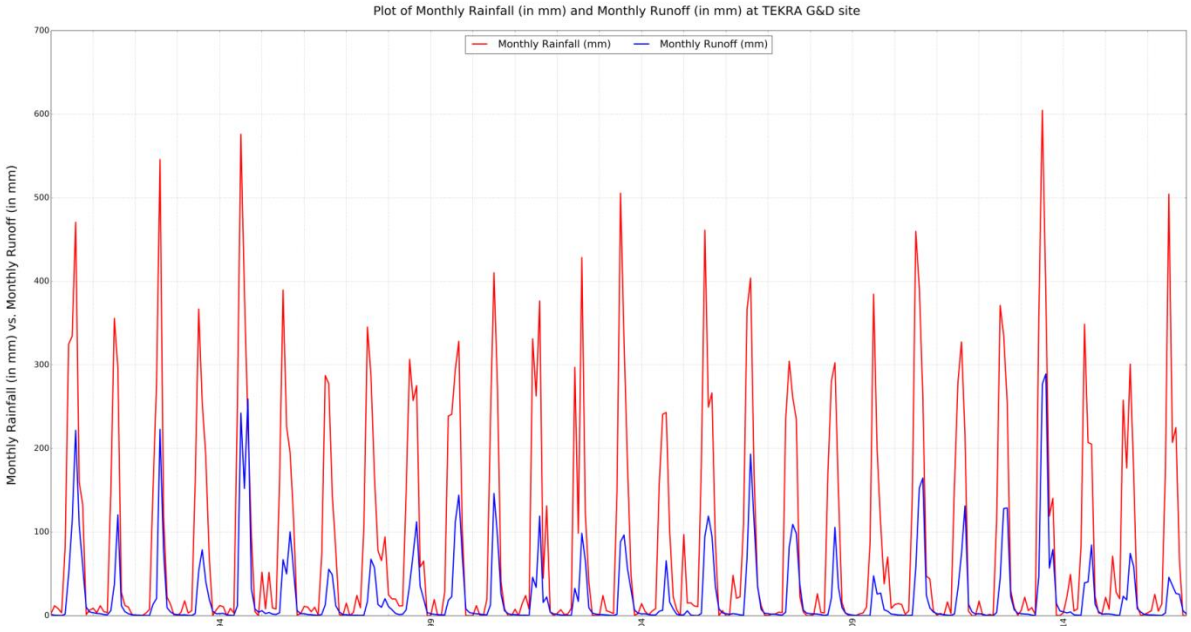


Figure 5.64: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tekra G&D site

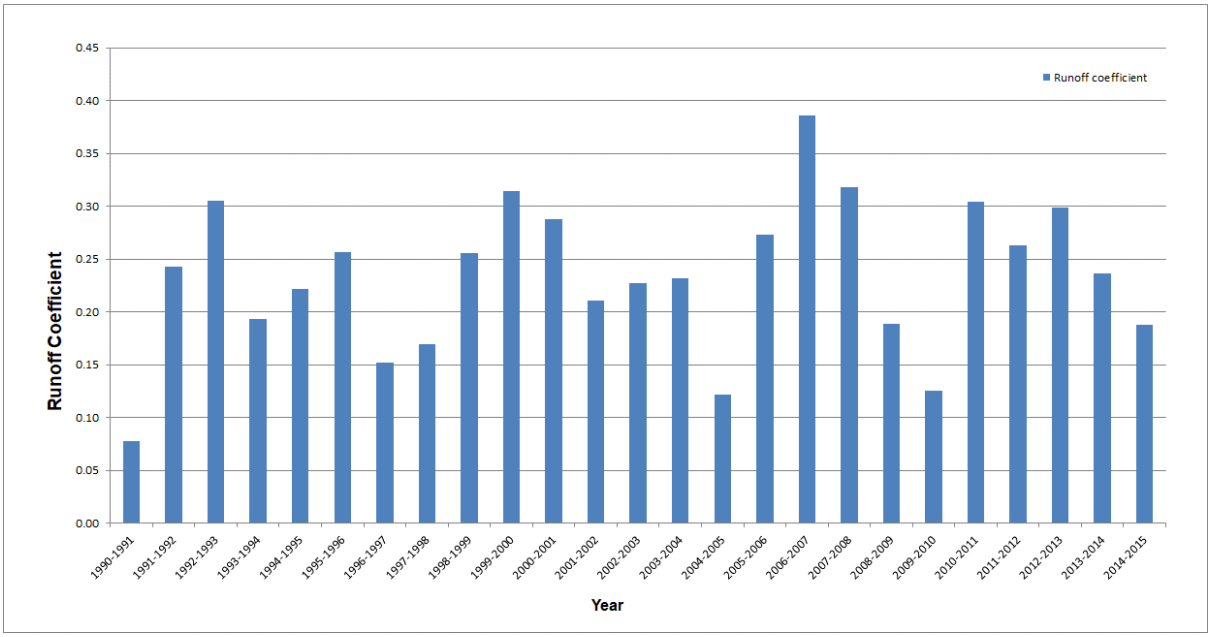


Figure 5.65: Plot of Runoff coefficient at the G&D

5.11.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission(CWC) gauge station i.e. Tekra is around 1,08,780 km^2 as mentioned on India WRIS site. Daily discharge data for Tekra site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Tekra, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Tekra G&D and the dam site.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Tekra G&D site to the project site are as follows:

$$\text{Catchment area factor} = \frac{CA_{Pranhita}}{CA_{Tekra}} = \frac{102174}{108780} = 0.94$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Pranhita}}{\text{Average Annual Rainfall}_{Tekra}} = \frac{1155}{1159} = 0.99$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Pranhita}} = Q_{\text{Tekra G\&}D\ Site}\text{X } 0.94 \text{ X } 0.99$$

Table 5.127 shows 10-daily average flow series in m^3/s are available at G&D site. **Table 5.128** and **Table 5.129** give 10-daily average flow series and 10-daily inflow series developed for Pranhita dam site considering the above factor.

Table 5.127: 10-Daily Average Flow Series (m^3/s) at Tekra

Catchment Area =1,08,780 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	7.09	35.36	9.17	7.87	5.00	30.54	16.81	7.83	78.44	47.20	225.39	20.76	11.79	5.82	16.51	1.45	24.16	9.57	18.60	19.93	9.59	32.68	27.87	5.87	13.00
	II	359.96	425.30	211.96	74.87	129.42	40.01	62.85	8.35	433.08	877.65	724.99	5100.31	25.83	50.42	203.07	1.29	20.49	89.79	26.11	23.59	10.83	35.27	365.95	961.24	23.01
	III	254.40	280.83	1474.81	209.90	1334.87	353.52	103.97	53.99	348.93	1355.79	671.60	663.12	4071.90	146.43	428.08	315.26	24.48	427.84	100.40	87.10	52.92	173.23	378.21	335.75	35.70
Jul	I	170.51	296.14	380.40	575.96	3895.81	896.65	118.12	178.54	1846.58	372.64	735.67	455.50	674.25	1097.32	175.04	1597.93	4901.89	4589.04	455.14	260.84	1160.49	405.94	189.71	419.64	52.14
	II	216.85	2384.70	212.76	4052.20	4705.20	1646.38	355.52	204.94	1549.26	470.94	8086.56	1654.63	323.83	3246.74	218.02	4046.29	894.17	3971.91	555.14	2396.16	2279.38	1168.13	937.35	2233.43	538.27
	III	935.58	1835.70	1798.04	1928.29	2101.64	5351.09	1047.99	1615.83	1140.60	1853.40	8710.44	1947.19	1042.32	6160.02	384.47	5734.37	2626.22	1642.08	1500.26	3032.59	3367.24	2252.31	4060.60	3394.22	3956.42
Aug	I	167.56	5398.64	3331.80	6524.60	4268.80	2344.70	1625.00	3164.89	2782.90	6154.30	1257.29	2581.11	1001.43	3434.47	3779.70	8125.42	11987.29	8301.98	8357.45	430.77	10373.23	2158.65	5045.18	6919.21	2400.36
	II	5036.16	6119.36	10836.00	1599.05	4329.26	1607.38	1413.53	450.49	3846.70	5879.21	3427.46	6655.08	2695.49	3160.32	2416.19	2903.11	9085.73	3806.32	3791.07	645.53	4516.76	2979.46	3345.39	4562.21	1366.94
	III	2443.07	3331.70	12636.27	1632.88	9607.82	2120.64	3594.64	4438.91	2363.27	1865.52	6653.54	5240.64	7905.40	5043.64	1879.99	3610.44	2959.13	1481.93	1043.94	1976.86	3940.04	3802.87	7031.57	9020.94	1189.37
Sep	I	2876.08	3867.61	6131.10	2265.44	2608.00	9399.40	2454.30	2052.50	2965.30	1854.12	2020.86	872.56	5933.66	2928.13	590.07	1251.48	5685.35	5634.51	1578.68	2053.76	11213.96	9840.25	8766.63	1873.10	6326.20
	II	330.16	352.90	2903.90	907.78	3615.90	1987.50	2709.40	3181.60	7252.40	6926.25	732.70	649.54	1793.46	2169.67	771.99	7654.34	4390.12	3767.08	1553.81	898.86	6625.73	4686.93	4516.41	1577.31	3058.94
	III	159.40	282.30	743.97	2002.90	1415.97	1236.10	987.92	1982.40	3915.80	9367.97	516.07	469.35	536.46	1933.47	662.37	3152.24	3959.63	2997.65	1094.69	447.47	2879.44	1997.81	2938.89	3720.81	1263.36
Oct	I	335.68	203.83	445.21	1225.83	1837.93	442.23	697.46	605.17	1861.60	4416.45	306.39	1261.03	299.25	1903.05	489.09	991.58	2911.60	2729.57	580.92	379.71	1129.74	714.19	1669.27	5012.27	736.85
	II	295.82	239.00	466.73	632.14	1423.06	1229.03	382.79	300.01	1563.19	3590.19	226.68	1145.71	253.84	839.07	276.15	1684.21	907.78	1256.17	374.19	351.19	866.85	556.76	717.85	3172.64	573.39
	III	105.61	146.51	253.20	559.46	662.27	4631.00	361.49	700.04	912.12	838.98	193.74	365.07	555.99	1011.87	209.75	1448.72	564.53	690.99	239.04	132.85	973.54	389.82	453.90	1618.14	393.94
Nov	I	63.70	138.60	227.35	314.43	444.13	396.17	307.49	772.10	719.80	495.60	131.21	210.30	191.93	400.84	98.72	583.25	564.36	360.04	178.75	114.67	503.88	260.38	424.30	1049.61	300.36
	II	39.02	84.00	158.56	212.46	315.82	228.82	159.44	257.64	1297.12	298.91	98.49	200.13	118.63	239.60	54.34	254.36	227.86	298.37	117.86	107.19	362.29	170.25	295.81	484.85	187.57
	III	24.66	63.95	154.34	132.60	245.34	138.81	100.24	225.41	483.60	210.72	73.97	120.67	80.45	184.22	47.27	188.76	151.71	170.60	76.28	444.88	304.55	125.16	170.32	274.59	127.72
Dec	I	19.43	52.72	96.00	98.84	203.46	108.04	59.95	1013.28	222.62	168.77	59.93	96.81	74.16	165.24	36.70	132.92	125.43	135.12	73.82	100.33	255.31	93.40	144.47	225.20	73.03
	II	18.59	40.16	69.59	95.01	154.69	103.77	46.78	854.90	130.04	157.11	51.63	86.26	69.44	102.21	31.36	132.59	114.09	104.14	61.80	83.07	153.83	76.94	116.20	225.69	75.58
	III	15.60	37.26	57.61	85.77	140.24	77.98	46.12	618.07	112.80	136.80	43.83	72.04	73.20	92.45	28.10	131.73	101.71	108.94	36.94	49.82	123.81	61.27	101.23	228.62	39.93
Jan	I	13.67	36.84	56.80	77.23	124.17	67.81	41.42	698.85	102.10	122.42	47.90	72.19	72.78	89.15	29.28	110.31	94.19	111.29	22.17	59.69	108.95	92.08	94.94	191.24	63.56
	II	14.19	29.42	51.60	70.47	408.74	143.94	39.42	365.23	92.53	110.45	53.89	54.79	55.29	74.59	22.52	92.72	95.23	89.73	29.02	55.22	102.05	130.53	112.04	183.08	96.88
	III	14.22	24.50	30.53	140.65	192.45	71.44	48.98	266.76	78.68	99.80	45.94	52.37	48.47	95.13	53.63	87.28	93.91	78.20	26.13	52.76	74.03	69.93	80.87	187.87	98.09
Feb	I	12.70	30.88	31.40	122.25	135.14	57.80	36.70	450.88	70.70	87.20	35.25	45.09	48.61	147.42	531.64	66.96	87.88	97.12	19.11	40.98	60.70	86.98	69.53	164.47	100.19
	II	11.51	21.12	33.39	119.83	104.49	56.20	33.92	306.66	75.47	109.24	28.99	32.13	54.72	81.10	167.08	69.44	73.50	103.49	13.74	38.61	84.15	80.68	87.27	156.71	90.84
	III	11.00	19.19	33.81	108.19	75.44	59.75	25.59	160.03	58.66	90.86	25.73	36.01	49.49	54.55	45.40	66.58	62.46	73.64	10.74	32.14	90.66	50.76	95.37	113.36	64.29
Mar	I	10.36	15.14	36.04	61.63	172.66	54.06	21.46	103.63	55.33	94.03	20.25	31.42	42.08	65.44	32.50	73.53	62.04	73.13	8.94	37.21	71.86	27.36	87.80	182.73	54.39
	II	9.27	12.21	56.77	39.74	112.21	52.90	19.64	66.46	57.45	68.28	20.87	24.96	31.15	50.97	25.72	117.63	69.06	76.76	7.51	27.03	43.57	24.21	72.30	237.72	64.88
	III	8.31	14.11	32.30	28.28	171.46	31.66	18.77	139.10	45.48	67.35	17.21	19.87	33.08	43.96	22.21	97.89	70.07	68.42	5.62	21.39	34.28	18.01	46.80	120.78	57.79
Apr	I	6.05	10.40	20.73	24.85	91.59	30.83	25.56	61.68	42.27	48.03	15.31	18.11	27.82	41.16	13.62	49.08	55.66	79.16	4.70	13.20	23.62	16.87	35.97	54.86	31.54
	II	4.68	8.51	16.32	17.59	78.00	27.41	21.52	43.80	36.96	46.47	33.04	13.94	17.84	29.97	8.58	82.05	42.44	49.10	3.32	8.87	17.35	12.20	29.93	43.51	22.38
	III	6.45	7.17	13.00	16.92	60.10	27.95	17.32	62.82	31.93	47.85	22.16	12.73	14.53	21.24	4.66	102.29	36.65	28.64	2.49	8.29	33.49	5.95	17.43	34.26	21.66
May	I	3.68	8.68	9.28	16.54	72.21	24.92	15.85	62.07	30.37	25.18	12.34	9.81	10.11	32.83	5.28	52.35	33.32	17.21	2.10	6.04	27.82	4.11	10.43	26.60	19.25
	II	3.86	8.56	8.03	6.87	53.93	19.17	12.32	71.57	32.80	33.69	10.01	9.36	9.23	34.14	2.76	32.91	30.32	13.17	1.68	11.60	11.93	20.96	7.85	24.58	18.03
	III	4.67	8.08	7.10	5.50	45.70	13.47	9.99	60.20	43.00	60.52	6.88	10.80	6.53	28.22	1.78	29.01	18.37	10.07	2.13	12.96	9.40	19.83	5.52	20.17	13.84
Inflow (MCM) =		12407	22816	38457	22819	40280	31386	15161	22774	32087	42270	31887	26849	25238	31485	12107	39893	46469	37961	19231	12947	45560	28766	37766	43627	20833

Table 5.128: 10-Daily Average Flow Series (m^3/s) at Pranhita Dam

Catchment Area =1,02,174 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	6.59	32.88	8.53	7.32	4.65	28.40	15.63	7.28	72.94	43.89	209.59	19.30	10.96	5.41	15.35	1.35	22.47	8.90	17.30	18.53	8.92	30.39	25.92	5.46	12.09
	II	334.72	395.48	197.10	69.62	120.34	37.20	58.44	7.76	402.71	816.11	674.15	4742.67	24.02	46.88	188.83	1.20	19.05	83.49	24.28	21.94	10.07	32.80	340.29	893.84	21.40
	III	236.56	261.14	1371.40	195.18	1241.27	328.73	96.68	50.20	324.46	1260.72	624.51	616.62	3786.38	136.16	398.06	293.15	22.76	397.84	93.36	80.99	49.21	161.08	351.69	312.21	33.20
Jul	I	158.55	275.37	353.73	535.57	3622.63	833.78	109.84	166.02	1717.10	346.51	684.08	423.56	626.97	1020.38	162.77	1485.88	4558.17	4267.25	423.23	242.55	1079.12	377.48	176.41	390.21	48.48
	II	201.64	2217.48	197.84	3768.06	4375.27	1530.93	330.59	190.57	1440.62	437.92	7519.52	1538.61	301.12	3019.08	202.73	3762.56	831.47	3693.40	516.21	2228.14	2119.55	1086.22	871.62	2076.82	500.53
	III	869.98	1706.98	1671.96	1793.08	1954.27	4975.87	974.50	1502.53	1060.62	1723.44	8099.66	1810.65	969.23	5728.07	357.51	5332.27	2442.07	1526.94	1395.06	2819.94	3131.13	2094.38	3775.87	3156.21	3678.99
Aug	I	155.81	5020.08	3098.17	6067.09	3969.47	2180.29	1511.05	2942.97	2587.76	5722.76	1169.13	2400.12	931.21	3193.64	3514.66	7555.66	11146.73	7719.84	7771.42	400.56	9645.85	2007.28	4691.41	6434.03	2232.04
	II	4683.02	5690.27	10076.17	1486.92	4025.69	1494.67	1314.41	418.90	3576.97	5466.96	3187.12	6188.42	2506.48	2938.72	2246.76	2699.54	8448.63	3539.42	3525.24	600.26	4200.04	2770.54	3110.81	4242.30	1271.09
	III	2271.76	3098.08	11750.20	1518.38	8934.11	1971.94	3342.58	4127.65	2197.56	1734.71	6186.99	4873.16	7351.07	4689.98	1748.16	3357.27	2751.63	1378.02	970.74	1838.24	3663.76	3536.21	6538.51	8388.38	1105.97
Sep	I	2674.41	3596.41	5701.18	2106.59	2425.12	8740.31	2282.20	1908.58	2757.37	1724.11	1879.16	811.38	5517.59	2722.81	548.69	1163.73	5286.69	5239.41	1467.98	1909.75	10427.63	9150.24	8151.91	1741.76	5882.60
	II	307.01	328.15	2700.28	844.13	3362.35	1848.13	2519.41	2958.50	6743.86	6440.58	681.32	603.99	1667.70	2017.53	717.86	7117.61	4082.28	3502.93	1444.86	835.83	6161.13	4358.28	4199.72	1466.71	2844.44
	III	148.22	262.50	691.80	1862.46	1316.68	1149.42	918.65	1843.39	3641.22	8711.08	479.88	436.44	498.84	1797.89	615.92	2931.20	3681.98	2787.45	1017.93	416.09	2677.53	1857.72	2732.81	3459.90	1174.77
Oct	I	312.14	189.54	413.99	1139.87	1709.05	411.22	648.55	562.73	1731.06	4106.77	284.91	1172.61	278.27	1769.61	454.79	922.05	2707.44	2538.17	540.19	353.08	1050.52	664.11	1552.22	4660.81	685.18
	II	275.08	222.24	434.00	587.81	1323.27	1142.85	355.95	278.97	1453.58	3338.44	210.79	1065.37	236.04	780.23	256.79	1566.11	844.13	1168.09	347.95	326.56	806.07	517.72	667.51	2950.17	533.18
	III	98.20	136.24	235.45	520.23	615.83	4306.27	336.14	650.95	848.16	780.15	180.15	339.47	517.00	940.92	195.04	1347.13	524.94	642.54	222.28	123.53	905.27	362.49	422.07	1504.67	366.32
Nov	I	59.23	128.88	211.41	292.38	412.99	368.39	285.93	717.96	669.33	460.85	122.01	195.55	178.47	372.73	91.80	542.35	524.79	334.79	166.22	106.63	468.55	242.12	394.55	976.01	279.30
	II	36.28	78.11	147.44	197.56	293.67	212.77	148.26	239.57	1206.16	277.95	91.58	186.10	110.31	222.80	50.53	236.52	211.88	277.45	109.60	99.67	336.89	158.31	275.07	450.85	174.42
	III	22.93	59.47	143.52	123.30	228.14	129.08	93.21	209.60	449.69	195.94	68.78	112.21	74.81	171.30	43.96	175.52	141.07	158.64	70.93	413.68	283.19	116.38	158.38	255.34	118.76
Dec	I	18.07	49.02	89.27	91.91	189.19	100.46	55.75	942.23	207.01	156.94	55.73	90.02	68.96	153.65	34.13	123.60	116.63	125.65	68.64	93.29	237.41	86.85	134.34	209.41	67.91
	II	17.29	37.34	64.71	88.35	143.84	96.49	43.50	794.95	120.92	146.09	48.01	80.21	64.57	95.04	29.16	123.29	106.09	96.84	57.47	77.25	143.04	71.54	108.05	209.86	70.28
	III	14.51	34.65	53.57	79.76	130.41	72.51	42.89	574.73	104.89	127.21	40.76	66.99	68.07	85.97	26.13	122.49	94.58	101.30	34.35	46.33	115.13	56.97	94.13	212.59	37.13
Jan	I	12.71	34.26	52.82	71.81	115.46	63.06	38.52	649.85	94.94	113.84	44.54	67.13	67.68	82.90	27.23	102.57	87.59	103.49	20.62	55.50	101.31	85.62	88.28	177.83	59.10
	II	13.19	27.36	47.98	65.53	380.08	133.85	36.66	339.62	86.04	102.71	50.11	50.95	51.41	69.36	20.94	86.22	88.55	83.44	26.99	51.35	94.89	121.38	104.18	170.24	90.09
	III	13.22	22.78	28.39	130.79	178.96	66.43	45.55	248.05	73.16	92.80	42.72	48.70	45.07	88.46	49.87	81.16	87.32	72.72	24.30	49.06	68.84	65.03	75.20	174.70	91.21
Feb	I	11.81	28.71	29.20	113.68	125.66	53.75	34.13	419.26	65.74	81.09	32.78	41.93	45.20	137.08	494.36	62.26	81.72	90.31	17.77	38.11	56.44	80.88	64.65	152.94	93.16
	II	10.71	19.64	31.05	111.43	97.16	52.26	31.54	285.16	70.18	101.58	26.96	29.88	50.88	75.41	155.36	64.57	68.35	96.23	12.78	35.90	78.25	75.02	81.15	145.72	84.47
	III	10.23	17.84	31.44	100.60	70.15	55.56	23.80	148.81	54.55	84.49	23.93	33.48	46.02	50.72	42.22	61.91	58.08	68.48	9.99	29.89	84.30	47.20	88.68	105.41	59.78
Mar	I	9.64	14.08	33.51	57.31	160.55	50.27	19.96	96.36	51.45	87.44	18.83	29.22	39.13	60.85	30.22	68.37	57.69	68.00	8.31	34.60	66.82	25.44	81.64	169.92	50.58
	II	8.62	11.35	52.79	36.95	104.34	49.19	18.26	61.80	53.42	63.49	19.41	23.21	28.97	47.40	23.92	109.38	64.22	71.38	6.98	25.13	40.51	22.51	67.23	221.05	60.33
	III	7.73	13.12	30.04	26.30	159.44	29.44	17.45	129.35	42.29	62.63	16.00	18.48	30.76	40.88	20.65	91.03	65.16	63.62	5.23	19.89	31.88	16.75	43.52	112.31	53.74
Apr	I	5.63	9.67	19.28	23.11	85.17	28.67	23.77	57.35	39.31	44.66	14.24	16.84	25.87	38.27	12.66	45.64	51.76	73.61	4.37	12.27	21.96	15.69	33.45	51.01	29.33
	II	4.35	7.91	15.18	16.36	72.53	25.49	20.01	40.73	34.37	43.21	30.72	12.96	16.59	27.87	7.98	76.30	39.46	45.66	3.09	8.25	16.13	11.34	27.83	40.46	20.81
	III	6.00	6.67	12.09	15.73	55.89	25.99	16.11	58.42	29.69	44.49	20.61	11.84	13.51	19.75	4.33	95.12	34.08	26.63	2.32	7.71	31.14	5.53	16.21	31.86	20.14
May	I	3.42	8.07	8.63	15.38	67.15	23.17	14.74	57.72	28.24	23.41	11.47	9.12	9.40	30.53	4.91	48.68	30.98	16.00	1.95	5.62	25.87	3.82	9.70	24.73	17.90
	II	3.59	7.96	7.47	6.39	50.15	17.83	11.46	66.55	30.50	31.33	9.31	8.70	8.58	31.75	2.57	30.60	28.19	12.25	1.56	10.79	11.09	19.49	7.30	22.86	16.77
	III	4.35	7.51	6.60	5.11	42.50	12.53	9.29	55.98	39.98	56.28	6.40	10.04	6.07	26.24	1.66	26.98	17.08	9.36	1.98	12.05	8.74	18.44	5.13	18.76	12.87
Inflow (MCM) =		11537	21216	35761	21219	37455	29186	14098	21177	29837	39306	29651	24966	23469	29278	11258	37096	43211	35299	17882	12039	42365	26748	35117	40567	19372

Table 5.129:10-Daily Inflow Series (MCM) at Pranhita Project Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	5.70	28.41	7.37	6.32	4.02	24.54	13.51	6.29	63.02	37.92	181.08	16.68	9.47	4.68	13.26	1.16	19.41	7.69	14.94	16.01	7.70	26.26	22.39	4.72	10.44
	II	289.19	341.69	170.29	60.15	103.98	32.14	50.49	6.71	347.94	705.12	582.47	4097.67	20.75	40.51	163.15	1.04	16.46	72.14	20.98	18.95	8.70	28.34	294.01	772.28	18.49
	III	204.39	225.62	1184.89	168.64	1072.46	284.02	83.53	43.38	280.34	1089.26	539.57	532.76	3271.43	117.64	343.93	253.28	19.67	343.73	80.66	69.98	42.52	139.18	303.86	269.75	28.68
Jul	I	136.99	237.92	305.62	462.74	3129.95	720.38	94.90	143.44	1483.57	299.38	591.05	365.96	541.70	881.60	140.63	1283.80	3938.26	3686.91	365.67	209.56	932.36	326.14	152.42	337.15	41.89
	II	174.22	1915.91	170.93	3255.60	3780.23	1322.73	285.63	164.65	1244.70	378.36	6496.87	1329.36	260.17	2608.48	175.16	3250.85	718.39	3191.09	446.01	1925.11	1831.29	938.49	753.08	1794.37	432.45
	III	826.83	1622.31	1589.03	1704.14	1857.34	4729.06	926.17	1428.00	1008.01	1637.96	7697.91	1720.84	921.16	5443.96	339.78	5067.79	2320.94	1451.20	1325.87	2680.07	2975.82	1990.50	3588.58	2999.67	3496.51
Aug	I	134.62	4337.35	2676.82	5241.97	3429.62	1883.77	1305.55	2542.72	2235.83	4944.46	1010.13	2073.70	804.56	2759.31	3036.67	6528.09	9630.78	6669.94	6714.51	346.09	8334.02	1734.29	4053.38	5559.00	1928.49
	II	4046.13	4916.39	8705.81	1284.70	3478.20	1291.39	1135.65	361.93	3090.50	4723.45	2753.67	5346.80	2165.60	2539.05	1941.20	2332.40	7299.62	3058.06	3045.80	518.63	3628.84	2393.74	2687.74	3665.35	1098.22
	III	2159.08	2944.41	11167.39	1443.07	8490.98	1874.13	3176.79	3922.92	2088.56	1648.67	5880.11	4631.45	6986.45	4457.35	1661.45	3190.75	2615.15	1309.67	922.59	1747.06	3482.04	3360.81	6214.20	7972.32	1051.11
Sep	I	2310.69	3107.30	4925.82	1820.09	2095.31	7551.62	1971.82	1649.01	2382.37	1489.63	1623.59	701.03	4767.20	2352.51	474.07	1005.46	4567.70	4526.85	1268.34	1650.02	9009.47	7905.81	7043.25	1504.88	5082.57
	II	265.26	283.53	2333.04	729.32	2905.07	1596.79	2176.77	2556.15	5826.69	5564.66	588.66	521.85	1440.89	1743.15	620.23	6149.62	3527.09	3026.53	1248.36	722.16	5323.22	3765.55	3628.55	1267.24	2457.60
	III	128.06	226.80	597.72	1609.16	1137.61	993.10	793.71	1592.69	3146.01	7526.37	414.62	377.08	431.00	1553.38	532.16	2532.56	3181.23	2408.36	879.49	359.50	2313.39	1605.07	2361.15	2989.36	1015.00
Oct	I	269.69	163.76	357.69	984.85	1476.62	355.29	560.35	486.20	1495.64	3548.24	246.16	1013.13	240.42	1528.94	392.94	796.65	2339.22	2192.98	466.72	305.06	907.65	573.79	1341.12	4026.94	592.00
	II	237.67	192.02	374.98	507.87	1143.31	987.42	307.54	241.03	1255.89	2884.41	182.12	920.48	203.94	674.12	221.86	1353.12	729.32	1009.23	300.63	282.15	696.44	447.31	576.73	2548.95	460.67
	III	93.33	129.48	223.77	494.43	585.29	4092.68	319.47	618.67	806.09	741.45	171.22	322.63	491.36	894.25	185.37	1280.32	498.91	610.67	211.25	117.41	860.37	344.51	401.14	1430.04	348.15
Nov	I	51.17	111.35	182.66	252.62	356.82	318.29	247.04	620.32	578.30	398.17	105.42	168.96	154.20	322.04	79.31	468.59	453.42	289.26	143.61	92.13	404.83	209.19	340.89	843.27	241.31
	II	31.35	67.49	127.39	170.69	253.73	183.84	128.10	206.99	1042.13	240.15	79.13	160.79	95.31	192.50	43.66	204.36	183.07	239.72	94.69	86.12	291.07	136.78	237.66	389.54	150.70
	III	19.81	51.38	124.00	106.53	197.11	111.52	80.53	181.10	388.53	169.30	59.43	96.95	64.63	148.01	37.98	151.65	121.89	137.06	61.28	357.42	244.68	100.56	136.84	220.61	102.61
Dec	I	15.61	42.36	77.13	79.41	163.46	86.80	48.16	814.08	178.86	135.59	48.15	77.78	59.58	132.76	29.49	106.79	100.77	108.56	59.31	80.61	205.12	75.04	116.07	180.93	58.67
	II	14.94	32.27	55.91	76.33	124.28	83.37	37.58	686.84	104.48	126.22	41.48	69.30	55.79	82.12	25.20	106.52	91.66	83.67	49.65	66.74	123.59	61.81	93.36	181.32	60.72
	III	13.79	32.93	50.91	75.80	123.94	68.92	40.76	546.22	99.69	120.90	38.74	63.67	64.69	81.70	24.83	116.42	89.89	96.28	32.65	44.03	109.42	54.15	89.46	202.04	35.29
Jan	I	10.98	29.60	45.63	62.05	99.76	54.48	33.28	561.47	82.03	98.35	38.48	58.00	58.47	71.62	23.52	88.62	75.67	89.41	17.81	47.96	87.53	73.98	76.28	153.65	51.07
	II	11.40	23.64	41.46	56.62	328.39	115.64	31.67	293.43	74.34	88.74	43.30	44.02	44.42	59.93	18.09	74.49	76.51	72.09	23.32	44.36	81.99	104.87	90.01	147.09	77.83
	III	12.56	21.65	26.98	124.30	170.08	63.14	43.29	235.75	69.53	88.20	40.60	46.28	42.84	84.07	47.40	77.13	82.99	69.11	23.09	46.63	65.42	61.80	71.47	166.03	86.69
Feb	I	10.20	24.81	25.23	98.22	108.57	46.44	29.49	362.24	56.80	70.06	28.32	36.23	39.05	118.44	427.13	53.80	70.60	78.03	15.35	32.92	48.77	69.88	55.86	132.14	80.49
	II	9.25	16.97	26.83	96.27	83.95	45.15	27.25	246.38	60.63	87.77	23.29	25.81	43.96	65.16	134.23	55.79	59.05	83.15	11.04	31.02	67.61	64.82	70.11	125.90	72.98
	III	7.07	12.33	21.73	69.54	48.49	38.40	16.45	102.86	37.70	58.40	16.54	23.14	31.81	35.06	29.18	42.79	40.15	47.33	6.90	20.66	58.27	32.63	61.30	72.86	41.32
Mar	I	8.32	12.16	28.96	49.51	138.72	43.43	17.24	83.26	44.45	75.55	16.27	25.24	33.81	52.58	26.11	59.08	49.84	58.75	7.18	29.90	57.73	21.98	70.54	146.81	43.70
	II	7.45	9.81	45.61	31.93	90.15	42.50	15.78	53.40	46.16	54.86	16.77	20.05	25.03	40.95	20.66	94.51	55.48	61.67	6.03	21.72	35.00	19.45	58.09	190.99	52.13
	III	7.34	12.47	28.55	24.99	151.53	27.98	16.59	122.93	40.19	59.52	15.21	17.56	29.23	38.85	19.63	86.51	61.92	60.47	4.97	18.90	30.30	15.92	41.36	106.74	51.07
Apr	I	4.86	8.36	16.65	19.96	73.58	24.77	20.54	49.55	33.96	38.59	12.30	14.55	22.35	33.07	10.94	39.43	44.72	63.60	3.78	10.61	18.98	13.55	28.90	44.08	25.34
	II	3.76	6.84	13.11	14.13	62.67	22.02	17.29	35.19	29.69	37.33	26.54	11.20	14.33	24.08	6.89	65.92	34.10	39.45	2.67	7.13	13.94	9.80	24.05	34.96	17.98
	III	5.18	5.76	10.44	13.59	48.29	22.46	13.92	50.47	25.65	38.44	17.80	10.23	11.67	17.06	3.74	82.18	29.45	23.01	2.00	6.66	26.91	4.78	14.00	27.53	17.40
May	I	2.96	6.97	7.46	13.29	58.01	20.02	12.73	49.87	24.40	20.23	9.91	7.88	8.12	26.38	4.24	42.06	26.77	13.83	1.69	4.85	22.35	3.30	8.38	21.37	15.47
	II	3.10	6.88	6.45	5.52	43.33	15.40	9.90	57.50	26.35	27.07	8.04	7.52	7.42	27.43	2.22	26.44	24.36	10.58	1.35	9.32	9.58	16.84	6.31	19.75	14.49
	III	4.13	7.14	6.27	4.86	40.39	11.90	8.83	53.20	38.00	53.48	6.08	9.54	5.77	24.94	1.57	25.64	16.23	8.90	1.88	11.45	8.31	17.52	4.88	17.83	12.23
Inflow (MCM) =		11537	21216	35761	21219	37455	29186	14098	21177	29837	39306	29651	24966	23469	29278	11258	37096	43211	35299	17882	12039	42365	26748	35117	40567	19372

5.11.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.130** and **Table 5.131** respectively.

Table 5.130: Computation of 90% and 50% Dependable Year for Pranhita Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.04	43211	2006-2007	
2	0.08	42365	2010-2011	
3	0.12	40567	2013-2014	
4	0.15	39306	1999-2000	
5	0.19	37455	1994-1995	
6	0.23	37096	2005-2006	
7	0.27	35761	1992-1993	
8	0.31	35299	2007-2008	
9	0.35	35117	2012-2013	
10	0.38	29837	1998-1999	
11	0.42	29651	2000-2001	
12	0.46	29278	2003-2004	
13	**0.50**	**29186**	**1995-1996**	**50% Dependable**
14	0.54	26748	2011-2012	
15	0.58	24966	2001-2002	
16	0.62	23469	2002-2003	
17	0.65	21219	1993-1994	
18	0.69	21216	1991-1992	
19	0.73	21177	1997-1998	
20	0.77	19372	2014-2015	
21	0.81	17882	2008-2009	
22	0.85	14098	1996-1997	
23	**0.88**	**12039**	**2009-2010**	**90% Dependable**
24	0.92	11537	1990-1991	
25	0.96	11258	2004-2005	

Table 5.131: 90% and 50% Dependable year flows (cumec) for Pranhita Project

		90% Dependable (cumec)	50% Dependable (cumec)
Period		**2009-2010**	**1995-1996**
Jun	**I**	18.53	28.40
	II	21.94	37.20
	III	80.99	328.73
Jul	**I**	242.55	833.78
	II	2228.14	1530.93
	III	2819.94	4975.87
Aug	**I**	400.56	2180.29
	II	600.26	1494.67
	III	1838.24	1971.94
Sep	**I**	1909.75	8740.31
	II	835.83	1848.13
	III	416.09	1149.42
Oct	**I**	353.08	411.22
	II	326.56	1142.85
	III	123.53	4306.27
Nov	**I**	106.63	368.39
	II	99.67	212.77
	III	413.68	129.08
Dec	**I**	93.29	100.46
	II	77.25	96.49
	III	46.33	72.51
Jan	**I**	55.50	63.06
	II	51.35	133.85
	III	49.06	66.43
Feb	**I**	38.11	53.75
	II	35.90	52.26
	III	29.89	55.56
Mar	**I**	34.60	50.27
	II	25.13	49.19
	III	19.89	29.44
Apr	**I**	12.27	28.67
	II	8.25	25.49
	III	7.71	25.99
May	**I**	5.62	23.17
	II	10.79	17.83
	III	12.05	12.53
Inflow (MCM) =		**12039**	**29186**

5.11.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam sites of Pranhita, is given in the following section.

5.11.5.1 EAC of Pranhita Dam

The EAC curve and the table showing the different values are given in **Figure 5.66** and **Table 5.132** respectively.

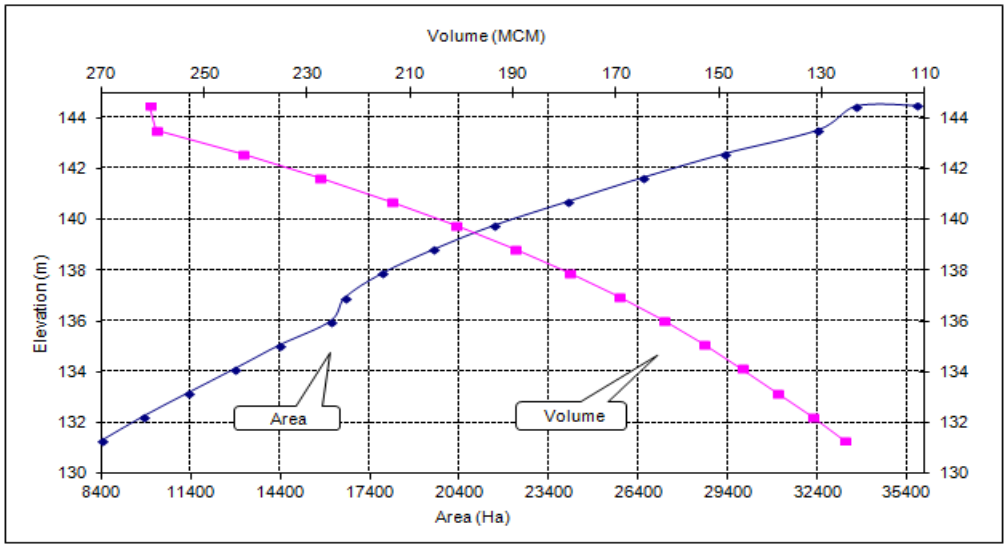


Figure 5.66: EAC curve of Pranhita Dam

Table 5.132: EAC data of Pranhita Dam

Elevation (m)	Area (Sq. m)	Area (ha.)	Cumulative Volume (m3)	Cumulative Volume (MCM)
131.32	84178954.32	8417.90	119895212.20	119.90
132.26	97910532.93	9791.05	125653992.20	125.65
133.20	113115968.90	11311.60	131928497.80	131.93
134.14	128662392.90	12866.24	138587487.00	138.59
135.08	143837769.32	14383.78	145560207.80	145.56
136.02	160856171.96	16085.62	152968592.80	152.97
136.96	165856171.96	16585.62	160795615.10	160.80
137.90	178214623.27	17821.46	169477871.40	169.48
138.84	195438745.95	19543.87	179125752.30	179.13
139.78	215601189.75	21560.12	189641370.10	189.64
140.72	240275384.26	24027.54	201314739.60	201.31
141.66	265336595.50	26533.66	213814997.90	213.81
142.60	292714270.87	29271.43	227621948.10	227.62
143.54	324252375.97	32425.24	242473264.00	242.47
144.48	337155372.56	33715.54	259287668.60	259.29
144.50	357155372.56	35715.54	260660593.70	260.66

5.11.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk

5.11.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location, namely, Tekra G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Tekra G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{\text{A\_Pranhita}}{\text{A}_{\text{Tekra}}}\right)^{\frac{3}{4}} = 0.954$$

Using the above multiplying factors to the peak flows at the Tekra G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.133**.

Table 5.133: Final Peak Flows at G&D and Project Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1990	26200	34060	32497
1991	19826	25774	24591
1992	24823	32270	30789
1993	9800	12740	12155
1994	35750	46475	44342
1995	19972	25964	24772
1996	4887	6353	6061
1997	7877	10240	9770
1998	14796	19235	18352
1999	17623	22909	21858
2000	38915	50589	48267
2001	15497	20145	19221
2002	16446	21379	20398
2003	14828	19277	18392

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2004	6180	8034	7665
2005	16243	21116	20147
2006	20397	26516	25299
2007	25540	33201	31677
2008	14223	18490	17641
2009	8737	11358	10836
2010	20695	26903	25668
2011	14976	19469	18576
2012	16927	22005	20995
2013	32665	42465	40516
2014	12273	15955	15223

5.11.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam site are given below in the following **Table 5.134**.

Table 5.134: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	22628.27
Variance	116260873.79
SD (Sx)	10782.43
Skewness	0.78
Kurtosis	0.99
No. of Data	25

5.11.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in **Table 5.135**.

The detailed procedure for Gumbel distribution method for Pranhita dam site has been shown in **Annexure-10**.

Table 5.135: Detail of different year Return Period Flood (m^3/s) at respective dam sites

S No.	Return Period (Years)	Flood (cumec)
1	2	21010
2	5	32259
3	10	39707
4	20	46851
5	25	49117

S No.	Return Period (Years)	Flood (cumec)
6	50	56098
7	100	63028
8	500	79042

Annexure-10 (Flood Frequency Analysis for Pranhita Dam)

DESIGN FLOOD-Pranhita

CA at G&D = 108780 | CA = 102174

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	1990	26200	34060	32497	7.21
2	1991	19826	25774	24591	6.86
3	1992	24823	32270	30789	6.59
4	1993	9800	12740	12155	6.93
5	1994	35750	46475	44342	6.75
6	1995	19972	25964	24772	7.01
7	1996	4887	6353	6061	6.86
8	1997	7877	10240	9770	6.59
9	1998	14796	19235	18352	7.40
10	1999	17623	22909	21858	4.89
11	2000	38915	50589	48267	6.92
12	2001	15497	20145	19221	6.85
13	2002	16446	21379	20398	6.48
14	2003	14828	19277	18392	6.53
15	2004	6180	8034	7665	6.39
16	2005	16243	21116	20147	6.35
17	2006	20397	26516	25299	6.31
18	2007	25540	33201	31677	6.27
19	2008	14223	18490	17641	6.22
20	2009	8737	11358	10836	6.18
21	2010	20695	26903	25668	6.14
22	2011	14976	19469	18576	6.10
23	2012	16927	22005	20995	
24	2013	32665	42465	40516	
25	2014	12273	15955	15223	

Conversion factor = 0.95

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	22628.27	6.54
Variance	116260873.79	0.264
SD (Sx)	10782.43	0.514
Skewness	0.78	-1.33185
Kurtosis	0.99	4.07286
No. of Data	25	

Parameters	Values
Mean(Xm)	22628.27
Variance	116260873.79
SD (Sx)	10782.43
Skewness	0.78
Kurtosis	0.99
No. of Data	25

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 25

Reduced mean = Y_n = 0.530 (From Table)

Reduced Std. Dev = S_n = 1.09 (From Table)

$f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

90% CONFIDENCE INTERVAL

(X_{cl} Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	**21010**	0.367	-0.150	0.911	1964.223	3231.146	17778	24241
2	5	**32259**	1.500	0.893	1.743	3759.128	6183.765	26075	38443
3	10	**39707**	2.250	1.584	2.412	5201.902	8557.129	31150	48264
4	20	**46851**	2.970	2.246	3.078	6636.892	10917.688	35933	57769
5	25	**49117**	3.199	2.457	3.291	7097.584	11675.526	37442	60793
6	50	**56098**	3.902	3.104	3.954	8526.892	14026.738	42072	70125
7	100	**63028**	4.600	3.747	4.617	9955.737	16377.188	46651	79405
8	500	**79042**	6.214	5.232	6.157	13278.139	21842.539	57199	100884

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	21010
2	5	32259
3	10	39707
4	20	46851
5	25	49117
6	50	56098
7	100	63028
8	500	79042

5.12 Hydrology of Balimela Hydroelectric Project

5.12.1 General

The present project, Balimela, envisages harnessing water from the River Machkund and several other small rivers. The Balimela project is proposed to be of Storage type with the multifunction of irrigation and power.

5.12.1.1 Description of Dam Sites

The catchment area of the dam site which is be 4,961 km^2. A plan of the catchment area of the present scheme comprising the dam site and location of dam, as shown in **Figure 5.67**. The dam site is located in Malkangiri district of Odisha at 18°08'26.8"N, 82°07'20.5"E.

5.12.1.2 The River System

Machkund river is the tributary of Godavari River. The Godavari is India's second longest river after the Ganga. Its source is in Triambakeshwar, Telangana. It flows east for about 1,465 kilometres draining the states of Telangana (48.6%), Telangana (18.8%), Andhra Pradesh (4.5%), Chhattisgarh (10.9%), Madhya Pradesh (10.0%), Odisha (5.7%), Karnataka (1.4%) and Puducherry (Yanam) and emptying into Bay of Bengal through its extensive network of tributaries. Measuring up to some 312,812 km^2 , it forms one of the largest river basins in the Indian subcontinent, with only the Ganges and Indus rivers having a larger drainage basin. In terms of length, catchment area and discharge, the Godavari river is the largest in peninsular India, and had been dubbed as the Vridha Ganga – Ganges. The river has been revered in Hindu scriptures for many millennia and continues to harbour and nourish a rich cultural heritage. In the past few decades, the river has been barricaded by a number of barrages and dams, restricting its flow.

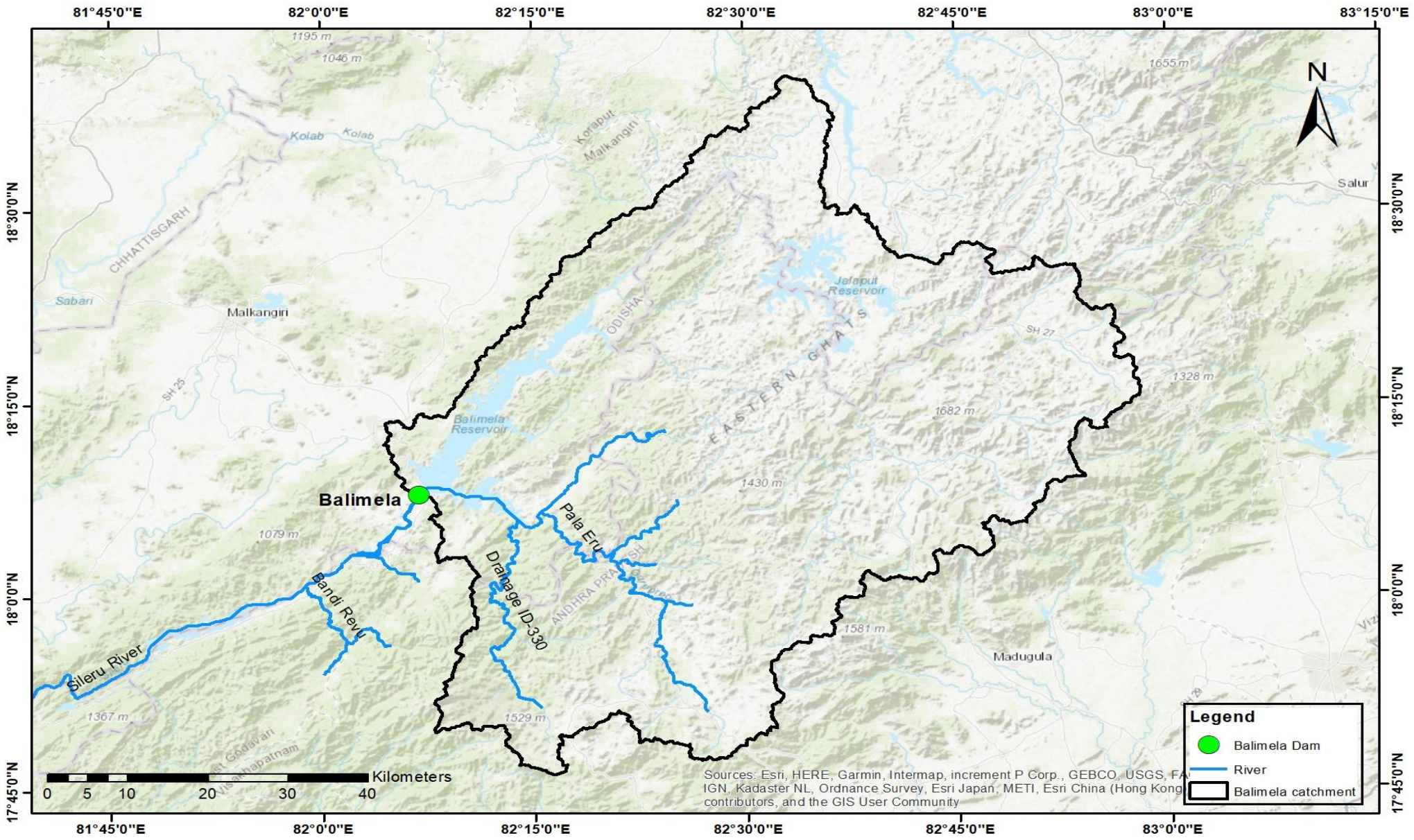


Figure 5.67: Catchment Area of the Project and Locations of Dam Site

5.12.2 Water Availability Studies

5.12.2.1 Data Availability

Data relevant to a hydrological assessment of the project is available at Balimela Dam from the year 1942 to 2015, which is provided by CWC (Central Water Commission). The flow data can be used for the development of complete flow series at the project site.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.12.2.2 Rainfall data

Average daily rainfall (in mm) have been calculated as per the basin boundary. Average of daily rainfall for the entire Indian Meteorological Department (IMD) grid data falling in basin boundary is calculated to find the average daily rainfall of the catchment area, as can be seen from **Figure 5.68**. Total 6 rainfall grids lying inside or on the boundary of Balimela project site catchment, are used to calculate average rainfall for the catchment. Finally, 10-daily rainfall and monthly average rainfall are estimated for the dam catchments.

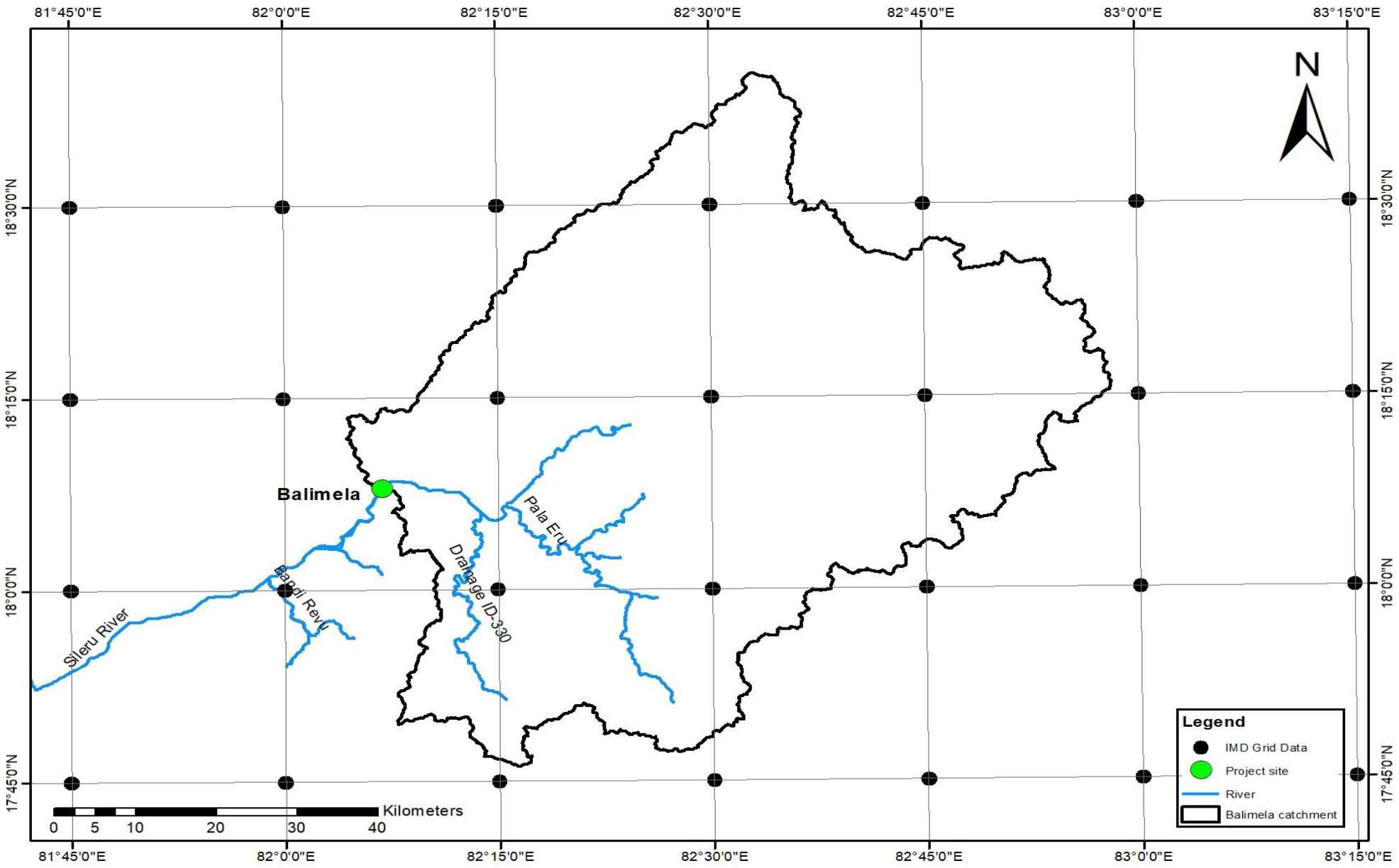


Figure 5.68: IMD Grid Rainfall Data for Balimela Project site

a) Average Annual Rainfall

Catchment area rainfall for the last 25 years have been considered to derive the rainfall factor at different dam sites. The computed average annual rainfall for the dam site is given in **Table 5.136**. 10-daily rainfall variation for the dam site is shown in **Table 5.137** respectively.

Table 5.136: Average Annual Rainfall

Year	Balimela
1990-1991	1191
1991-1992	1404
1992-1993	1475
1993-1994	947
1994-1995	1420
1995-1996	1242
1996-1997	1192
1997-1998	1004
1998-1999	1165
1999-2000	979
2000-2001	1177
2001-2002	1418
2002-2003	940
2003-2004	1682
2004-2005	1383
2005-2006	1726
2006-2007	2262
2007-2008	2291
2008-2009	1340
2009-2010	975
2010-2011	1540
2011-2012	974
2012-2013	1253
2013-2014	1344
2014-2015	1451
AVERAGE (mm)	**1351**

Table 5.137: 10 Daily Rainfall (in mm) of Balimela Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	6.08	10.75	4.42	2.91	2.42	0.77	2.34	0.87	2.46	2.46	10.35	7.82	3.83	1.31	4.56	6.40	5.59	4.71	6.20	2.46	4.13	6.60	4.02	5.71	6.92
	II	3.56	4.07	8.53	3.88	5.29	4.45	14.07	13.13	19.51	14.02	5.48	13.01	6.08	5.88	27.82	2.80	4.87	10.30	3.49	5.37	10.21	4.89	0.84	7.74	0.94
	III	2.99	5.67	3.74	1.13	1.98	3.83	3.28	4.69	2.43	3.86	9.49	2.07	4.14	2.06	0.32	15.00	10.32	57.68	10.91	7.07	1.17	1.55	5.93	2.38	5.63
Jul	I	5.06	11.57	10.89	6.75	12.99	4.85	3.72	3.58	7.80	2.18	10.24	26.80	0.34	10.72	4.69	5.30	14.10	3.58	5.31	2.09	10.73	7.57	4.47	5.34	2.30
	II	7.75	10.64	8.18	7.24	6.52	12.92	17.93	1.64	5.62	3.62	10.20	5.12	5.00	13.81	7.17	2.51	24.49	8.04	3.35	13.50	12.21	3.75	2.71	4.29	11.23
	III	6.35	9.69	16.43	7.09	6.33	13.15	10.73	9.57	9.41	6.97	1.86	4.08	4.53	14.62	10.65	11.95	13.36	8.52	14.00	2.78	16.61	8.01	11.28	6.98	9.21
Aug	I	8.78	10.19	9.38	4.35	4.06	6.39	5.38	2.71	2.69	7.39	4.67	13.32	7.09	13.66	7.98	7.96	52.22	18.59	23.32	1.01	6.96	2.35	7.89	6.26	7.69
	II	11.57	6.66	16.82	2.97	6.28	3.71	9.05	3.36	4.54	2.66	9.93	12.95	6.67	4.34	8.78	4.53	11.68	10.29	6.45	4.48	5.68	9.66	8.19	13.83	4.86
	III	8.74	7.33	5.22	4.60	7.90	13.52	6.65	5.51	5.90	3.75	13.86	2.27	7.76	10.83	3.01	3.20	9.00	11.23	8.53	8.73	5.47	8.63	6.78	0.90	15.85
Sep	I	5.77	3.84	14.94	10.58	14.49	4.38	2.59	6.27	3.73	7.42	1.92	1.43	4.86	6.46	11.88	11.09	4.09	23.40	17.83	4.30	7.00	11.13	7.66	1.73	10.42
	II	4.11	15.05	0.40	5.22	1.79	6.68	5.00	10.38	8.68	1.73	2.99	9.13	8.37	3.65	2.99	34.35	39.10	7.70	18.67	3.30	9.57	7.51	8.17	8.09	7.13
	III	4.86	7.88	1.99	8.09	2.17	7.02	5.05	10.39	5.87	6.89	7.19	8.35	0.24	8.51	0.91	8.21	17.39	11.58	2.96	5.52	1.75	1.20	11.86	2.90	0.84
Oct	I	18.11	6.21	11.71	5.36	12.94	11.88	8.33	1.17	6.62	5.19	3.82	6.71	2.51	18.35	18.89	4.47	1.16	19.95	1.38	9.20	2.50	0.45	4.86	5.31	3.58
	II	9.15	6.04	2.20	4.08	4.08	8.43	1.77	1.86	4.00	3.81	1.24	5.78	14.94	1.08	1.81	12.63	0.88	1.51	0.38	0.20	3.66	1.25	3.03	1.89	31.25
	III	2.20	1.14	0.16	3.78	3.45	1.99	0.65	1.47	1.91	4.80	0.00	1.18	0.86	11.80	0.14	9.33	4.81	2.87	1.26	0.00	6.22	1.30	0.90	23.60	3.10
Nov	I	3.80	3.83	0.57	0.82	2.71	3.31	1.12	0.01	3.49	3.04	0.06	1.01	0.10	0.49	3.18	3.11	2.13	0.39	0.02	1.01	10.27	0.75	24.25	0.00	0.08
	II	0.76	1.05	4.48	0.00	0.07	1.81	0.86	2.35	14.54	0.00	0.00	3.93	0.06	0.00	1.22	0.00	0.00	0.08	0.67	6.08	2.33	0.00	0.00	0.00	0.29
	III	0.27	0.44	1.05	0.00	0.18	0.05	0.00	1.95	0.26	0.00	0.21	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.48	0.03	1.52	0.00	0.23	4.18	0.00
Dec	I	0.00	0.00	0.00	0.15	0.00	0.08	0.47	0.92	0.00	0.00	1.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.11	0.00	0.00	0.93	0.00
	II	0.25	0.00	0.00	0.00	0.00	0.00	0.01	0.61	0.00	0.00	0.00	0.00	0.00	12.48	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00
	III	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.05	0.14	0.00	0.00	0.54	0.00	0.00	0.02	0.21	0.00	0.47	0.00	0.00	1.16
Jan	I	0.58	0.48	0.00	0.00	0.99	0.28	0.75	0.01	0.00	0.00	0.49	2.18	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.91	0.03	0.00	0.25
	II	0.00	0.00	0.00	0.06	1.07	0.15	1.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	1.04	0.00	0.83	0.00	0.00	0.00
	III	0.00	0.03	0.00	0.00	0.01	0.00	0.15	1.05	0.00	0.00	0.00	0.04	0.00	2.06	0.89	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00
Feb	I	0.00	0.00	0.00	1.09	0.04	0.00	0.00	1.28	0.01	0.11	0.00	0.00	0.00	0.95	0.74	0.00	0.00	3.84	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.15	0.51	0.00	1.00	0.00	0.00	0.00	1.77	0.00	0.00	0.61	0.00	0.00	0.00	0.43	0.62	0.00	0.24	0.01	0.00	0.40	0.01	0.02
	III	0.00	1.10	0.00	0.00	0.04	0.00	0.89	0.18	0.00	1.83	0.00	0.00	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.13	0.00	0.00	0.00	0.06
Mar	I	1.18	0.00	0.01	0.19	0.03	0.65	0.00	0.88	0.00	0.00	0.56	0.00	0.39	1.11	0.00	0.52	0.16	0.00	0.00	0.00	0.00	0.00	0.00	3.71	0.47
	II	0.06	0.00	0.14	0.00	2.37	0.00	0.01	0.15	0.00	0.00	1.59	0.00	4.14	0.00	0.58	3.15	0.00	0.05	0.00	0.11	0.17	0.22	0.00	1.25	0.01
	III	0.13	0.00	2.68	0.02	1.34	0.03	2.88	0.50	0.00	0.23	0.77	0.26	0.51	0.52	0.35	0.00	0.00	10.47	1.29	0.01	0.05	0.12	0.00	0.11	1.64
Apr	I	1.03	1.31	0.25	2.05	5.01	0.59	1.98	2.03	0.39	0.11	1.52	5.24	2.92	4.78	1.57	0.36	0.00	3.39	0.10	0.00	4.64	6.00	0.01	0.12	0.33
	II	0.56	2.22	5.25	1.79	0.71	1.02	1.72	0.00	0.95	2.98	3.62	2.29	2.39	2.48	5.82	5.88	0.83	0.53	0.00	0.63	2.98	1.80	1.54	3.04	2.93
	III	0.25	2.31	2.43	4.16	0.64	3.92	2.66	3.13	0.26	1.21	0.03	0.45	0.77	5.88	2.35	0.42	0.33	0.38	0.14	5.71	5.24	4.42	4.73	5.71	6.94
May	I	0.90	5.59	0.66	1.49	19.33	0.31	4.03	2.09	0.53	4.47	6.25	2.42	1.49	1.98	4.39	1.53	3.56	1.43	1.65	0.78	2.49	1.37	0.32	9.85	4.31
	II	1.03	0.31	6.62	1.12	11.07	0.62	1.35	4.75	1.45	0.70	4.40	1.15	0.49	1.14	2.55	2.73	0.95	0.18	0.77	1.29	1.21	1.84	3.20	3.54	1.69
	III	1.33	2.98	5.22	1.58	1.62	3.23	0.12	0.09	1.55	2.97	2.06	1.77	0.36	2.94	1.43	11.02	1.79	4.06	2.09	8.13	1.96	0.76	0.12	1.67	0.80
Yearly Rainfall (mm)		1191	1403	1475	948	1420	1242	1192	1004	1165	977	1177	1418	940	1682	1383	1726	2261	2291	1340	975	1540	974	1253	1344	1451

5.12.2.3 Rainfall and Runoff Data at Balimela Dam Site

Detailed calculations on water availability and flood magnitude will help to select the design features of the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Monsoon & non-monsoon period discharge data of Balimela dam have been used to derive the flow series at the dam site from June to May of each year. **Figure 5.69** shows comparison of annual rainfall and annual computed runoff in mm at the Balimela Dam site from which it can be seen that annual runoff depth is less than annual rainfall. The difference between rainfall and runoff might arise due to presence of dams, barrages, etc.

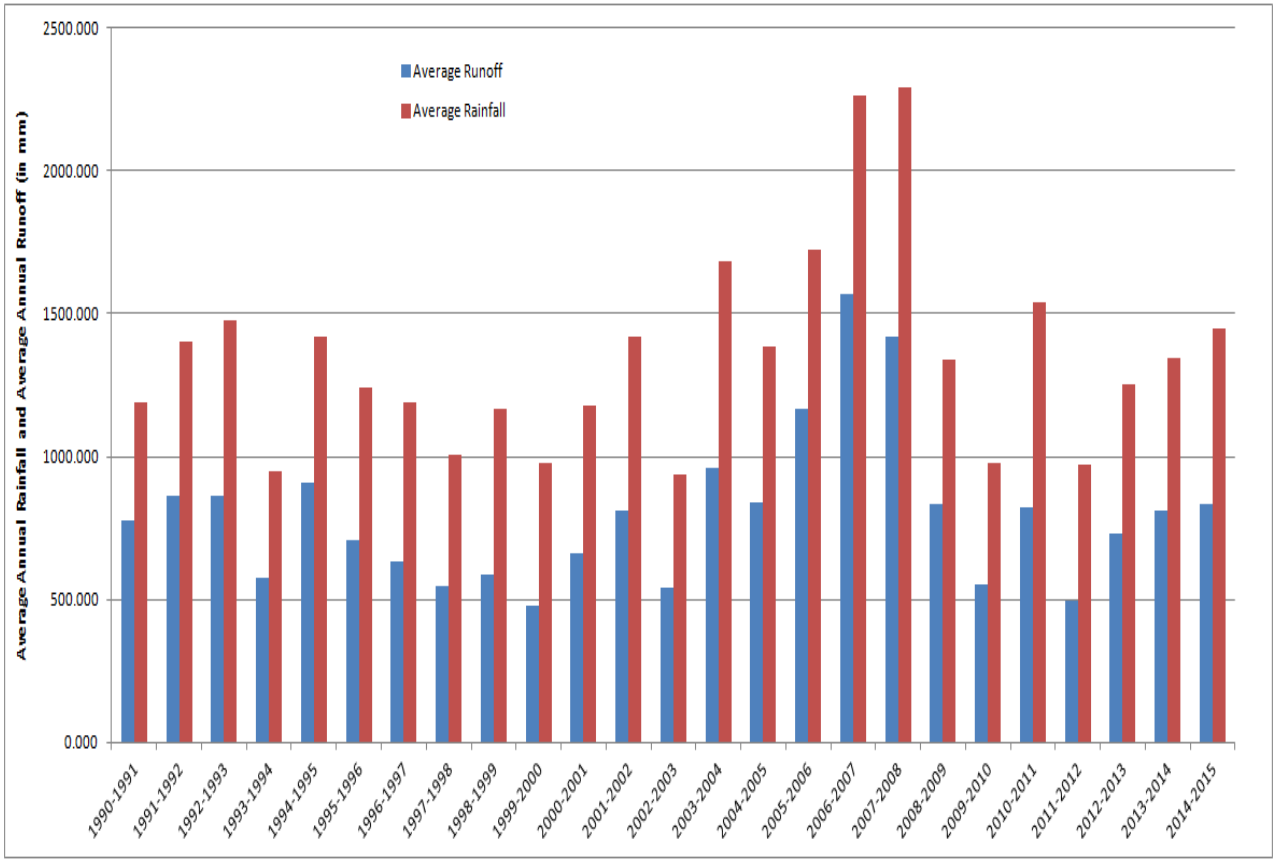


Figure 5.69: Comparison of Annual Rainfall and Annual Runoff in mm at Balimela Dam site

5.12.3 Flow Series Computation

Flow series at the proposed Balimela project site is estimated by converting monthly flow series into 10-daily flow series by using the ratio of 10-daily rainfall. Monthly discharge data for Balimela Dam site is available for the period from 1942 to 2015. For non-monsoon when there is no rainfall, then the long-term average ratio is used to fill the place of no rainfall. Further the monthly flow is distributed using the rainfall ratio.

Discharge Series for the dam is computed according to the equation below:

$$10 \text{ Daily Average Flow} = \text{Rainfall Ratio(10daily)} \times \text{Monthly Flow}$$

Table 5.138 shows the rainfall ratio to convert the monthly flow into 10-daily average flow. For the period from 1990 to 2015 the 10-daily average flow and 10-daily inflow flow series for the Balimela dam site is given in **Table 5.139** and **Table 5.140**.

Table 5.138: Rainfall Ratio for converting 10-Daily flow Series

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	0.48	0.52	0.26	0.37	0.25	0.09	0.12	0.05	0.10	0.12	0.41	0.34	0.27	0.14	0.14	0.26	0.27	0.06	0.30	0.17	0.27	0.51	0.37	0.36	0.51
	II	0.28	0.20	0.51	0.49	0.55	0.49	0.71	0.70	0.80	0.69	0.22	0.57	0.43	0.64	0.85	0.12	0.23	0.14	0.17	0.36	0.66	0.38	0.08	0.49	0.07
	III	0.24	0.28	0.22	0.14	0.20	0.42	0.17	0.25	0.10	0.19	0.37	0.09	0.29	0.22	0.01	0.62	0.50	0.79	0.53	0.47	0.08	0.12	0.55	0.15	0.42
Jul	I	0.26	0.36	0.31	0.32	0.50	0.16	0.11	0.24	0.34	0.17	0.46	0.74	0.03	0.27	0.21	0.27	0.27	0.18	0.23	0.11	0.27	0.39	0.24	0.32	0.10
	II	0.40	0.33	0.23	0.34	0.25	0.42	0.55	0.11	0.25	0.28	0.46	0.14	0.51	0.35	0.32	0.13	0.47	0.40	0.15	0.73	0.31	0.19	0.15	0.26	0.49
	III	0.33	0.30	0.46	0.33	0.24	0.43	0.33	0.65	0.41	0.55	0.08	0.11	0.46	0.37	0.47	0.60	0.26	0.42	0.62	0.15	0.42	0.41	0.61	0.42	0.41
Aug	I	0.30	0.42	0.30	0.36	0.22	0.27	0.26	0.23	0.20	0.54	0.16	0.47	0.33	0.47	0.40	0.51	0.72	0.46	0.61	0.07	0.38	0.11	0.35	0.30	0.27
	II	0.40	0.28	0.54	0.25	0.34	0.16	0.43	0.29	0.35	0.19	0.35	0.45	0.31	0.15	0.44	0.29	0.16	0.26	0.17	0.32	0.31	0.47	0.36	0.66	0.17
	III	0.30	0.30	0.17	0.39	0.43	0.57	0.32	0.48	0.45	0.27	0.49	0.08	0.36	0.38	0.15	0.20	0.12	0.28	0.22	0.61	0.30	0.42	0.30	0.04	0.56
Sep	I	0.39	0.14	0.86	0.44	0.79	0.24	0.20	0.23	0.20	0.46	0.16	0.08	0.36	0.35	0.75	0.21	0.07	0.55	0.45	0.33	0.38	0.56	0.28	0.14	0.57
	II	0.28	0.56	0.02	0.22	0.10	0.37	0.40	0.38	0.47	0.11	0.25	0.48	0.62	0.20	0.19	0.64	0.65	0.18	0.47	0.25	0.52	0.38	0.30	0.64	0.39
	III	0.33	0.29	0.11	0.33	0.12	0.39	0.40	0.38	0.32	0.43	0.59	0.44	0.02	0.46	0.06	0.15	0.29	0.27	0.08	0.42	0.10	0.06	0.43	0.23	0.05
Oct	I	0.61	0.46	0.83	0.41	0.63	0.53	0.77	0.26	0.53	0.38	0.47	0.49	0.14	0.59	0.91	0.17	0.17	0.82	0.46	0.47	0.20	0.15	0.55	0.17	0.09
	II	0.31	0.45	0.16	0.31	0.20	0.38	0.16	0.41	0.32	0.28	0.31	0.42	0.82	0.03	0.09	0.48	0.13	0.06	0.13	0.31	0.30	0.42	0.34	0.06	0.82
	III	0.07	0.09	0.01	0.29	0.17	0.09	0.06	0.33	0.15	0.35	0.22	0.09	0.05	0.38	0.01	0.35	0.70	0.12	0.42	0.22	0.50	0.43	0.10	0.77	0.08
Nov	I	0.79	0.72	0.09	0.58	0.92	0.64	0.58	0.00	0.19	0.58	0.58	0.20	0.58	0.58	0.58	0.58	0.58	0.58	0.02	0.14	0.73	0.58	0.58	0.58	0.58
	II	0.16	0.20	0.73	0.34	0.02	0.35	0.34	0.55	0.79	0.34	0.34	0.79	0.34	0.34	0.34	0.34	0.34	0.34	0.57	0.85	0.17	0.34	0.34	0.34	0.34
	III	0.06	0.08	0.17	0.09	0.06	0.01	0.09	0.45	0.01	0.09	0.09	0.01	0.09	0.09	0.09	0.09	0.09	0.09	0.41	0.00	0.11	0.09	0.09	0.09	0.09
Dec	I	0.52	0.52	0.33	0.52	0.33	0.52	0.52	0.58	0.33	0.33	0.52	0.52	0.52	0.52	0.33	0.52	0.33	0.33	0.52	0.52	0.52	0.52	0.52	0.52	0.52
	II	0.40	0.40	0.33	0.40	0.33	0.40	0.40	0.38	0.33	0.33	0.40	0.40	0.40	0.40	0.33	0.40	0.33	0.33	0.40	0.40	0.40	0.40	0.40	0.40	0.40
	III	0.08	0.08	0.33	0.08	0.33	0.08	0.08	0.04	0.33	0.33	0.08	0.08	0.08	0.08	0.33	0.08	0.33	0.33	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Jan	I	0.44	0.44	0.33	0.44	0.48	0.44	0.28	0.44	0.33	0.33	0.44	0.44	0.44	0.44	0.44	0.33	0.44	0.33	0.33	0.44	0.33	0.50	0.44	0.33	0.44
	II	0.30	0.30	0.33	0.30	0.52	0.30	0.66	0.30	0.33	0.33	0.30	0.30	0.30	0.30	0.30	0.33	0.30	0.33	0.33	0.30	0.33	0.46	0.30	0.33	0.30
	III	0.26	0.26	0.33	0.26	0.00	0.26	0.06	0.26	0.33	0.33	0.26	0.26	0.26	0.26	0.26	0.33	0.26	0.33	0.33	0.26	0.33	0.04	0.26	0.33	0.26
Feb	I	0.33	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.42	0.03	0.33	0.33	0.42	0.42	0.42	0.42	0.42	0.42	0.33	0.42	0.42	0.33	0.42	0.42	0.42
	II	0.33	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.48	0.33	0.33	0.30	0.30	0.30	0.30	0.30	0.30	0.33	0.30	0.30	0.33	0.30	0.30	0.30
	III	0.33	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.28	0.49	0.33	0.33	0.28	0.28	0.28	0.28	0.28	0.28	0.33	0.28	0.28	0.33	0.28	0.28	0.28
Mar	I	0.86	0.33	0.00	0.21	0.01	0.21	0.21	0.58	0.21	0.21	0.19	0.21	0.08	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.33	0.73	0.22
	II	0.04	0.33	0.05	0.29	0.63	0.29	0.29	0.10	0.29	0.29	0.54	0.29	0.82	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.29	0.33	0.25	0.00
	III	0.09	0.33	0.95	0.50	0.36	0.50	0.50	0.33	0.50	0.50	0.26	0.50	0.10	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.33	0.02	0.77
Apr	I	0.56	0.22	0.03	0.26	0.79	0.11	0.31	0.28	0.24	0.03	0.29	0.66	0.48	0.36	0.16	0.05	0.28	0.79	0.28	0.28	0.36	0.49	0.00	0.01	0.03
	II	0.30	0.38	0.66	0.22	0.11	0.18	0.27	0.33	0.59	0.69	0.70	0.29	0.39	0.19	0.60	0.88	0.33	0.12	0.33	0.33	0.23	0.15	0.25	0.34	0.29
	III	0.14	0.40	0.31	0.52	0.10	0.71	0.42	0.39	0.16	0.28	0.01	0.06	0.13	0.45	0.24	0.06	0.39	0.09	0.39	0.39	0.41	0.36	0.75	0.64	0.68
May	I	0.28	0.63	0.05	0.36	0.60	0.07	0.73	0.30	0.15	0.55	0.49	0.45	0.64	0.33	0.52	0.10	0.57	0.25	0.37	0.08	0.44	0.35	0.09	0.65	0.63
	II	0.32	0.03	0.53	0.27	0.35	0.15	0.25	0.69	0.41	0.09	0.35	0.22	0.21	0.19	0.30	0.18	0.15	0.03	0.17	0.13	0.21	0.46	0.88	0.24	0.25
	III	0.41	0.33	0.42	0.38	0.05	0.78	0.02	0.01	0.44	0.36	0.16	0.33	0.15	0.49	0.17	0.72	0.28	0.72	0.46	0.80	0.35	0.19	0.03	0.11	0.12

Table 5.139: 10-Daily Average Flow Series (m^3/s) at Balimela Project Site

Catchment Area =4,961 km^2

All 10-daily flows in m^3/s

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	277.94	340.17	185.37	145.50	177.97	46.97	58.64	19.20	46.86	41.87	194.78	223.75	96.98	106.98	84.25	222.09	323.16	74.45	204.71	62.32	179.34	178.40	204.13	220.98	332.76
	II	162.74	128.79	357.73	194.00	389.04	271.46	352.57	289.77	371.61	238.64	103.13	372.25	153.96	480.19	513.98	97.17	281.54	162.81	115.23	136.04	443.37	132.18	42.65	299.55	45.20
	III	136.69	179.42	156.85	56.50	145.61	233.64	82.19	103.51	46.28	65.70	178.59	59.23	104.83	168.23	5.91	520.53	596.61	911.74	360.22	179.11	50.81	41.90	301.12	92.11	270.73
Jul	I	233.44	360.02	328.72	194.12	548.45	132.57	86.78	152.85	243.09	90.48	334.98	746.77	18.76	316.66	192.71	344.84	499.17	312.68	244.01	65.75	279.75	211.32	203.11	301.53	100.45
	II	357.54	330.88	246.91	208.21	275.28	353.16	418.27	70.02	175.15	150.25	333.67	142.67	275.92	407.94	294.61	163.31	866.99	702.23	153.94	424.70	318.33	104.69	123.14	242.24	490.44
	III	267.84	274.11	450.86	183.73	242.96	326.77	228.88	371.45	266.60	263.00	55.31	103.35	227.26	392.60	397.81	706.84	429.97	676.50	584.85	79.51	393.68	203.28	465.96	358.31	365.65
Aug	I	270.95	424.84	324.90	224.69	246.63	232.22	195.79	150.09	148.04	288.27	121.57	475.48	182.25	556.50	379.16	662.44	1337.98	828.01	643.91	41.69	402.46	62.40	294.03	284.09	273.10
	II	357.05	277.67	582.60	153.41	381.49	134.83	329.35	186.09	249.86	103.76	258.50	462.27	171.46	176.81	417.17	376.99	299.26	458.32	178.10	184.91	328.45	256.50	305.21	627.63	172.60
	III	245.20	277.82	164.37	216.00	436.27	446.67	220.01	277.42	295.19	132.98	328.00	73.67	181.34	401.10	130.01	242.10	209.63	454.72	214.12	327.57	287.55	208.32	229.70	37.13	511.73
Sep	I	292.52	120.37	780.97	226.97	724.35	173.10	130.85	123.79	122.73	207.28	97.86	64.13	166.14	339.19	588.66	224.67	104.97	815.32	397.76	160.12	333.07	255.92	196.17	107.84	475.71
	II	208.36	471.77	20.91	111.98	89.48	263.99	252.60	204.93	285.61	48.33	152.39	409.44	286.12	191.65	148.16	695.90	1003.50	268.29	416.50	122.88	455.36	172.68	209.23	504.30	325.51
	III	246.39	247.01	104.02	170.86	108.48	277.43	255.12	205.13	193.15	192.48	366.45	374.46	8.20	446.83	45.09	166.33	446.31	403.48	66.03	205.55	83.27	27.59	303.73	180.78	38.35
Oct	I	299.31	253.58	491.25	135.39	379.89	248.02	322.41	90.44	207.06	109.80	188.46	271.23	41.13	374.29	461.80	119.77	171.55	794.51	262.10	149.30	114.70	44.59	255.47	89.07	51.63
	II	151.23	246.64	92.29	103.06	119.78	175.99	68.51	143.77	125.11	80.61	125.48	233.63	244.80	22.03	44.25	338.42	130.14	60.14	72.17	99.41	167.91	123.85	159.27	31.70	450.70
	III	33.05	42.32	6.10	86.80	92.08	37.77	22.87	103.30	54.31	92.32	79.90	43.36	12.81	218.81	3.11	227.27	646.69	103.91	217.55	63.30	259.42	117.10	43.01	359.88	40.64
Nov	I	101.02	103.81	14.55	50.61	145.09	78.61	63.06	0.21	19.72	44.25	60.90	29.55	45.47	96.54	77.21	107.33	153.53	146.85	2.59	11.91	108.94	45.04	70.03	78.30	82.91
	II	20.20	28.46	114.32	29.53	3.75	42.98	36.79	50.01	82.17	25.82	35.53	114.99	26.53	56.33	45.05	62.62	89.58	85.68	86.62	71.68	24.72	26.28	40.86	45.68	48.37
	III	7.18	11.93	26.79	7.92	9.64	1.19	9.87	41.50	1.47	6.93	9.53	1.17	7.12	15.12	12.09	16.81	24.04	22.99	62.06	0.35	16.12	7.05	10.96	12.26	12.98
Dec	I	12.36	13.88	9.54	8.48	9.71	11.82	10.56	9.76	6.33	4.72	10.20	14.02	7.62	16.17	8.23	17.98	16.37	15.65	14.56	8.08	14.42	7.55	11.73	13.12	13.88
	II	9.35	10.50	9.54	6.42	9.71	8.94	7.99	6.47	6.33	4.72	7.72	10.61	5.77	12.24	8.23	13.60	16.37	15.65	11.02	6.11	10.91	5.71	8.87	9.93	10.51
	III	1.72	1.93	8.67	1.18	8.83	1.64	1.47	0.58	5.75	4.29	1.42	1.95	1.06	2.25	7.48	2.50	14.88	14.23	2.02	1.12	2.00	1.05	1.63	1.82	1.93
Jan	I	9.28	10.01	4.32	10.20	8.64	7.06	3.81	6.65	3.78	5.20	9.38	5.09	10.81	8.64	12.02	13.10	16.44	7.42	4.12	9.64	3.85	8.96	8.76	7.07	8.21
	II	6.36	6.87	4.32	7.00	9.34	4.84	8.93	4.56	3.78	5.20	6.43	3.49	7.42	5.93	8.25	13.10	11.28	7.42	4.12	6.61	3.85	8.18	6.01	7.07	5.63
	III	5.07	5.47	3.93	5.57	0.08	3.86	0.69	3.63	3.43	4.72	5.12	2.78	5.91	4.72	6.57	11.91	8.98	6.74	3.74	5.27	3.50	0.72	4.79	6.43	4.49
Feb	I	9.34	12.63	7.14	12.86	9.96	8.90	7.44	8.39	6.24	0.61	9.44	5.12	13.63	10.90	15.15	21.67	20.73	12.27	5.44	12.15	6.36	7.89	11.05	11.71	10.35
	II	9.34	9.04	5.11	9.20	7.13	6.37	5.33	6.00	4.47	9.82	9.44	5.12	9.76	7.80	10.85	15.52	14.84	8.79	5.44	8.70	4.55	7.89	7.91	8.38	7.41
	III	11.67	10.71	6.06	10.91	8.45	7.55	6.31	7.11	5.30	12.70	11.79	6.40	11.56	9.25	12.85	18.39	17.59	10.41	6.79	10.31	5.40	9.86	9.38	9.93	8.78
Mar	I	57.95	24.21	0.15	15.26	0.46	10.57	8.83	27.74	7.42	10.21	13.04	7.62	6.07	12.94	17.99	25.73	24.61	14.57	8.09	14.43	7.55	11.74	21.19	49.26	13.20
	II	2.95	24.21	2.03	21.67	36.31	15.01	12.54	4.73	10.53	14.49	37.03	10.82	64.39	18.37	25.54	36.54	34.94	20.68	11.48	20.48	10.72	16.67	21.19	16.60	0.28
	III	5.80	22.01	35.38	33.65	18.66	23.30	19.48	14.33	16.35	22.50	16.30	16.80	7.21	28.53	39.66	56.72	54.25	32.11	17.83	31.80	16.64	25.87	19.26	1.33	41.87
Apr	I	128.62	55.64	4.42	64.71	154.12	18.65	45.51	45.88	29.91	4.32	68.27	82.79	128.56	77.88	47.97	23.01	113.43	190.02	37.27	66.49	45.07	95.34	0.35	3.11	6.58
	II	69.93	94.29	92.91	56.50	21.84	32.25	39.53	54.14	72.85	117.03	162.58	36.18	105.23	40.41	177.83	375.86	133.84	29.71	43.97	78.46	28.94	28.60	53.24	78.79	58.40
	III	31.22	98.11	43.00	131.32	19.69	123.94	61.13	64.68	19.94	47.52	1.35	7.11	33.90	95.81	71.80	26.85	159.91	21.30	52.54	93.74	50.90	70.23	163.52	147.99	138.32
May	I	94.40	232.36	11.03	133.64	175.75	19.39	159.39	73.91	27.41	137.99	169.92	85.03	253.65	104.10	232.28	63.43	342.40	90.46	72.83	27.16	81.77	99.71	28.40	223.74	191.75
	II	108.03	12.89	110.60	100.46	100.65	38.78	53.39	167.98	75.00	21.61	119.62	40.41	83.42	59.93	134.92	113.19	91.37	11.39	33.99	44.92	39.74	133.92	284.03	80.41	75.19
	III	139.50	123.05	87.21	141.71	14.73	202.03	4.75	3.18	80.17	91.68	56.00	62.54	61.29	154.57	75.66	456.90	172.16	256.83	92.25	283.10	64.37	55.31	10.65	37.93	35.59
Inflow (MCM) =		3832	4275	4286	2869	4500	3547	3145	2738	2922	2377	3271	3999	2687	4788	4156	5808	7786	7063	4158	2733	4098	2478	3633	4028	4162

Table 5.140: 10-Daily Inflow Series (MCM) at Balimela Project Site

Catchment Area =4,961 km^2 All 10-daily flows in MCM.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	240.14	293.91	160.16	125.71	153.77	40.58	50.66	16.59	40.48	36.18	168.29	193.32	83.79	92.43	72.79	191.89	279.21	64.33	176.87	53.85	154.95	154.14	176.37	190.93	287.51
	II	140.61	111.27	309.08	167.61	336.13	234.54	304.62	250.36	321.07	206.18	89.10	321.63	133.02	414.88	444.08	83.95	243.25	140.67	99.56	117.54	383.07	114.20	36.85	258.81	39.05
	III	118.10	155.02	135.52	48.82	125.81	201.86	71.01	89.43	39.99	56.77	154.30	51.17	90.58	145.35	5.11	449.74	515.47	787.75	311.23	154.75	43.90	36.20	260.17	79.58	233.91
Jul	I	201.69	311.06	284.01	167.72	473.86	114.54	74.98	132.06	210.03	78.18	289.42	645.21	16.21	273.59	166.50	297.94	431.28	270.16	210.82	56.81	241.70	182.58	175.49	260.53	86.79
	II	308.91	285.88	213.33	179.90	237.84	305.13	361.39	60.50	151.33	129.82	288.29	123.26	238.40	352.46	254.54	141.10	749.08	606.72	133.01	366.94	275.04	90.45	106.39	209.30	423.74
	III	254.56	260.52	428.49	174.61	230.91	310.56	217.53	353.03	253.38	249.95	52.57	98.23	215.99	373.13	378.08	671.78	408.65	642.95	555.84	75.56	374.15	193.20	442.85	340.54	347.52
Aug	I	234.10	367.06	280.71	194.13	213.09	200.64	169.16	129.68	127.91	249.06	105.04	410.82	157.47	480.81	327.59	572.35	1156.01	715.40	556.34	36.02	347.73	53.91	254.04	245.45	235.96
	II	308.49	239.91	503.36	132.55	329.60	116.49	284.56	160.78	215.88	89.65	223.34	399.40	148.14	152.76	360.43	325.72	258.56	395.99	153.88	159.76	283.78	221.61	263.70	542.27	149.12
	III	233.04	264.04	156.22	205.29	414.63	424.51	209.09	263.66	280.54	126.39	311.73	70.01	172.35	381.20	123.57	230.09	199.24	432.16	203.50	311.32	273.29	197.98	218.30	35.29	486.34
Sep	I	252.74	104.00	674.76	196.10	625.84	149.55	113.05	106.95	106.04	179.09	84.55	55.41	143.54	293.06	508.60	194.12	90.69	704.44	343.67	138.34	287.78	221.11	169.49	93.18	411.01
	II	180.03	407.61	18.07	96.75	77.31	228.09	218.24	177.06	246.77	41.76	131.67	353.76	247.21	165.58	128.01	601.26	867.02	231.80	359.86	106.17	393.43	149.20	180.77	435.72	281.24
	III	212.88	213.42	89.88	147.63	93.73	239.70	220.43	177.23	166.88	166.30	316.62	323.53	7.09	386.06	38.96	143.71	385.61	348.61	57.05	177.60	71.94	23.84	262.42	156.19	33.13
Oct	I	258.61	219.09	424.44	116.98	328.22	214.29	278.56	78.14	178.90	94.87	162.83	234.34	35.53	323.39	398.99	103.48	148.22	686.46	226.45	128.99	99.10	38.52	220.72	76.96	44.61
	II	130.66	213.10	79.74	89.04	103.49	152.06	59.19	124.22	108.10	69.64	108.42	201.86	211.51	19.03	38.23	292.40	112.44	51.96	62.36	85.89	145.08	107.01	137.61	27.39	389.40
	III	31.42	40.22	5.80	82.50	87.51	35.89	21.74	98.17	51.62	87.74	75.94	41.21	12.18	207.96	2.96	216.00	614.61	98.75	206.76	60.16	246.55	111.29	40.87	342.03	38.63
Nov	I	87.28	89.69	12.57	43.73	125.36	67.92	54.48	0.18	17.04	38.23	52.61	25.53	39.29	83.41	66.71	92.73	132.65	126.88	2.23	10.29	94.12	38.92	60.50	67.65	71.63
	II	17.46	24.59	98.77	25.51	3.24	37.14	31.79	43.21	70.99	22.31	30.70	99.35	22.92	48.67	38.92	54.11	77.40	74.03	74.84	61.94	21.35	22.71	35.30	39.47	41.79
	III	6.20	10.30	23.15	6.85	8.33	1.03	8.53	35.86	1.27	5.99	8.24	1.01	6.15	13.06	10.45	14.52	20.77	19.87	53.62	0.31	13.93	6.09	9.47	10.59	11.22
Dec	I	10.68	11.99	8.24	7.33	8.39	10.21	9.13	8.43	5.47	4.08	8.81	12.12	6.58	13.97	7.11	15.53	14.14	13.53	12.58	6.98	12.46	6.52	10.13	11.33	12.00
	II	8.08	9.07	8.24	5.54	8.39	7.73	6.91	5.59	5.47	4.08	6.67	9.17	4.98	10.57	7.11	11.75	14.14	13.53	9.52	5.28	9.43	4.93	7.67	8.58	9.08
	III	1.63	1.83	8.24	1.12	8.39	1.56	1.40	0.55	5.47	4.08	1.35	1.85	1.01	2.14	7.11	2.38	14.14	13.53	1.92	1.07	1.91	1.00	1.55	1.73	1.83
Jan	I	8.01	8.65	3.73	8.81	7.47	6.10	3.29	5.74	3.26	4.49	8.10	4.40	9.34	7.47	10.38	11.32	14.20	6.41	3.56	8.33	3.32	7.75	7.57	6.11	7.09
	II	5.50	5.94	3.73	6.05	8.07	4.19	7.71	3.94	3.26	4.49	5.56	3.02	6.41	5.12	7.13	11.32	9.75	6.41	3.56	5.72	3.32	7.06	5.20	6.11	4.87
	III	4.82	5.20	3.73	5.30	0.08	3.67	0.66	3.45	3.26	4.49	4.87	2.64	5.61	4.49	6.24	11.32	8.54	6.41	3.56	5.01	3.32	0.68	4.55	6.11	4.26
Feb	I	8.07	10.91	6.17	11.11	8.61	7.69	6.43	7.25	5.40	0.53	8.15	4.43	11.78	9.42	13.09	18.73	17.91	10.60	4.70	10.50	5.50	6.82	9.55	10.11	8.94
	II	8.07	7.81	4.42	7.95	6.16	5.51	4.60	5.19	3.86	8.49	8.15	4.43	8.43	6.74	9.37	13.41	12.82	7.59	4.70	7.52	3.93	6.82	6.84	7.24	6.40
	III	8.07	7.41	4.19	7.54	5.84	5.22	4.36	4.92	3.66	8.78	8.15	4.43	7.99	6.39	8.89	12.71	12.16	7.20	4.70	7.13	3.73	6.82	6.48	6.86	6.07
Mar	I	50.07	20.92	0.13	13.19	0.40	9.13	7.63	23.97	6.41	8.82	11.27	6.58	5.24	11.18	15.54	22.23	21.26	12.59	6.99	12.46	6.52	10.14	18.31	42.56	11.40
	II	2.55	20.92	1.76	18.72	31.37	12.97	10.84	4.09	9.10	12.52	31.99	9.35	55.64	15.88	22.07	31.57	30.19	17.87	9.92	17.70	9.26	14.40	18.31	14.34	0.24
	III	5.52	20.92	33.63	31.98	17.74	22.14	18.51	13.62	15.54	21.38	15.49	15.97	6.85	27.11	37.69	53.91	51.56	30.52	16.94	30.23	15.82	24.59	18.31	1.26	39.79
Apr	I	111.13	48.07	3.82	55.91	133.16	16.12	39.32	39.64	25.84	3.73	58.98	71.53	111.08	67.29	41.45	19.88	98.00	164.18	32.20	57.45	38.94	82.37	0.30	2.69	5.68
	II	60.42	81.47	80.27	48.82	18.87	27.86	34.15	46.77	62.94	101.11	140.47	31.26	90.92	34.91	153.64	324.74	115.64	25.67	37.99	67.79	25.01	24.71	46.00	68.07	50.46
	III	26.97	84.77	37.15	113.46	17.01	107.09	52.82	55.88	17.23	41.06	1.16	6.14	29.29	82.78	62.04	23.20	138.17	18.40	45.39	80.99	43.97	60.68	141.28	127.86	119.51
May	I	81.56	200.76	9.53	115.47	151.85	16.75	137.71	63.86	23.68	119.22	146.81	73.47	219.16	89.94	200.69	54.81	295.84	78.16	62.92	23.47	70.65	86.15	24.54	193.31	165.67
	II	93.34	11.13	95.56	86.79	86.96	33.51	46.13	145.14	64.80	18.67	103.35	34.91	72.07	51.78	116.57	97.79	78.95	9.84	29.36	38.81	34.33	115.71	245.40	69.47	64.96
	III	120.52	106.31	75.35	122.44	12.73	174.55	4.10	2.75	69.27	79.22	48.39	54.03	52.95	133.55	65.37	394.76	148.75	221.90	79.70	244.60	55.61	47.79	9.20	32.77	30.75
Inflow (MCM) =		3832	4275	4286	2869	4500	3547	3145	2738	2922	2377	3271	3999	2687	4788	4156	5808	7786	7063	4158	2733	4098	2478	3633	4028	4162

5.12.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.141** and **Table 5.142** respectively.

Table 5.141: Computation of 90% and 50% Dependable Year for Balimela Project

m	m/(n+1)	Runoff in descending order	Dependable Year	
1	0.04	7786	2006-2007	
2	0.08	7063	2007-2008	
3	0.12	5808	2005-2006	
4	0.15	4788	2003-2004	
5	0.19	4500	1994-1995	
6	0.23	4286	1992-1993	
7	0.27	4275	1991-1992	
8	0.31	4162	2014-2015	
9	0.35	4158	2008-2009	
10	0.38	4156	2004-2005	
11	0.42	4098	2010-2011	
12	0.46	4028	2013-2014	
13	**0.50**	**3999**	**2001-2002**	**50% Dependable**
14	0.54	3832	1990-1991	
15	0.58	3633	2012-2013	
16	0.62	3547	1995-1996	
17	0.65	3271	2000-2001	
18	0.69	3145	1996-1997	
19	0.73	2922	1998-1999	
20	0.77	2869	1993-1994	
21	0.81	2738	1997-1998	
22	0.85	2733	2009-2010	
23	**0.88**	**2687**	**2002-2003**	**90% Dependable**
24	0.92	7786	2011-2012	
25	0.96	7063	1999-2000	

Table 5.142: 90% and 50% Dependable year flows for Balimela Project

		90% Dependable	50% Dependable
Period		**2002-2003**	**2001-2002**
Jun	I	96.98	223.75
	II	153.96	372.25
	III	104.83	59.23
Jul	I	18.76	746.77
	II	275.92	142.67
	III	227.26	103.35
Aug	I	182.25	475.48
	II	171.46	462.27
	III	181.34	73.67
Sep	I	166.14	64.13
	II	286.12	409.44
	III	8.20	374.46
Oct	I	41.13	271.23
	II	244.80	233.63
	III	12.81	43.36
Nov	I	45.47	29.55
	II	26.53	114.99
	III	7.12	1.17
Dec	I	7.62	14.02
	II	5.77	10.61
	III	1.06	1.95
Jan	I	10.81	5.09
	II	7.42	3.49
	III	5.91	2.78
Feb	I	13.63	5.12
	II	9.76	5.12
	III	11.56	6.40
Mar	I	6.07	7.62
	II	64.39	10.82
	III	7.21	16.80
Apr	I	128.56	82.79
	II	105.23	36.18
	III	33.90	7.11
May	I	253.65	85.03
	II	83.42	40.41
	III	61.29	62.54
Inflow (MCM) =		**2687**	**3999**

5.12.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam sites of Balimela, is given in the following section.

5.12.5.1 EAC of Balimela Dam

The EAC curve and the table showing the different values are given in **Figure 5.70** and **Table 5.143** respectively.

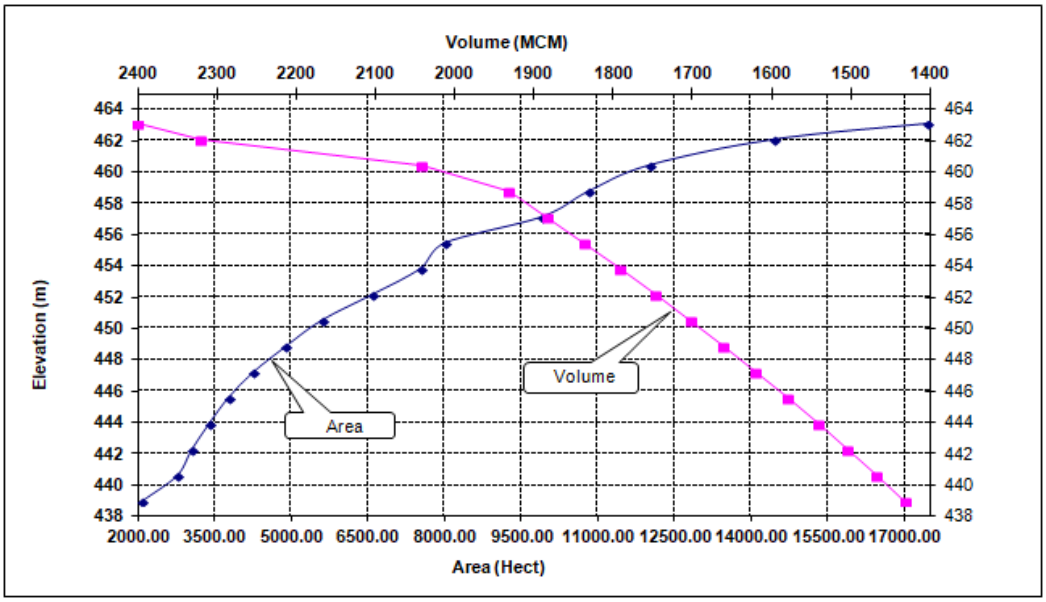


Figure 5.70: EAC curve of Balimela Dam

Table 5.143: EAC data of Balimela Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
438.9	20740136.80	2074.01	1431802714	1431.80
440.65	27672457.12	2767.25	1467046684	1467.05
442.30	30513704.86	3051.37	1503506322	1503.51
443.95	33900528.59	3390.05	1541021972	1541.02
445.60	37649764.86	3764.98	1579631869	1579.63
447.25	42585840.75	4258.58	1619421146	1619.42
448.90	48969847.81	4896.98	1660333238	1660.33
450.55	55932212.69	5593.22	1702585586	1702.59
452.20	65815710.60	6581.57	1745983910	1745.98
453.85	75241028.93	7524.10	1790591192	1790.59
455.50	80125465.73	8012.55	1836432549	1836.43
457.15	98925402.20	9892.54	1883391272	1883.39
458.80	108266220.20	10826.62	1931390659	1931.39
460.45	120026743.60	12002.67	2041413457	2041.41
462.10	144417133.20	14441.71	2319826113	2319.83
463.10	174417133.20	17441.71	2399826113	2399.83

5.12.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood values is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk. Since Balimela dam is existing for the last five decades and as such design flood has not be assessed now.

5.12.1.1 Computation of Design flood

At present, observed flood peak data are available at the Balimela sites, the catchment area for the project site and the dam site same. So, the flood peaks for Balimela Dam are used, which will then be subjected to frequency analysis. Assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived. The final peak flows derived are given in **Table 5.144**.

Table 5.144: Final Peak Flows at Project Site

Sl.No.	Period	Annual Flood Peak at Dam Site	Daily values increased for inst. peak
1	1990	775.63	1008.32
2	1991	871.01	1132.31
3	1992	940.29	1222.38
4	1993	531.97	691.56
5	1994	957.32	1244.52
6	1995	741.64	964.13
7	1996	662.81	861.65
8	1997	554.11	720.34
9	1998	624.33	811.63
10	1999	465.1	604.63
11	2000	640.11	832.14
12	2001	880.23	1144.30
13	2002	477.95	621.34
14	2003	1014.78	1319.21
15	2004	811.59	1055.07
16	2005	1128.16	1466.61
17	2006	1613.81	2097.95
18	2007	1543.55	2006.62
19	2008	913.71	1187.82
20	2009	507.1	659.23
21	2010	904.79	1176.23
22	2011	473.51	615.56
23	2012	736.05	956.87
24	2013	823.01	1069.91
25	2014	871.43	1132.86

5.12.1.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.145**.

Table 5.145: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(Xm)	1064.13
Variance	145751.65
SD (Sx)	381.77
Skewness	1.27
Kurtosis	2.02
No. of Data	25

5.12.1.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.146**.

The detailed procedure for Gumbel distribution method for Balimela dam site has been shown in **Annexure-11**.

Table 5.146: Details of different year Return Period Flood (m^3/s) at respective dam sits

S No.	Return Period (Years)	Flood (cumec)
1	2	1006
2	5	1400
3	10	1660
4	20	1910
5	25	1989
6	50	2233
7	100	2475
8	500	3035

Annexure-11 (Flood Frequency Analysis for Balimela Dam)

DESIGN FLOOD- Balimela

CA = 4961sqkm

Sl.No.	Period	Annual Flood Peak at Dam Site	Daily values increased for inst. peak	Ln-stats
1	1990	775.63	1008.32	6.92
2	1991	871.01	1132.31	7.03
3	1992	940.29	1222.38	7.11
4	1993	531.97	691.56	6.54
5	1994	957.32	1244.52	7.13
6	1995	741.64	964.13	6.87
7	1996	662.81	861.65	6.76
8	1997	554.11	720.34	6.58
9	1998	624.33	811.63	6.70
10	1999	465.1	604.63	6.40
11	2000	640.11	832.14	6.72
12	2001	880.23	1144.30	7.04
13	2002	477.95	621.34	6.43
14	2003	1014.78	1319.21	7.18
15	2004	811.59	1055.07	6.96
16	2005	1128.16	1466.61	7.29
17	2006	1613.81	2097.95	7.65
18	2007	1543.55	2006.62	7.60
19	2008	913.71	1187.82	7.08
20	2009	507.1	659.23	6.49
21	2010	904.79	1176.23	7.07
22	2011	473.51	615.56	6.42
23	2012	736.05	956.87	6.86
24	2013	823.01	1069.91	6.98
25	2014	871.43	1132.86	7.03

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	1064.13	6.91
Variance	145751.65	0.112
SD (Sx)	381.77	0.335
Skewness	1.27	0.33456
Kurtosis	2.02	-0.02526
No. of Data	25	

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 25

Reduced mean = Y_n = 0.533 (From Table)

Reduced Std. Dev S_n = 1.100 (From Table)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

$f_{(C)}$ = 1.645 (90% confidence pr

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	90% CONFIDENCE INTERVAL (X_{cl} Values) Lower Confidence Limit	Upper Confidence Limit
1	2	**1006**	0.367	-0.151	0.910	69.492	114.314	892	1121
2	5	**1400**	1.500	0.879	1.729	132.054	217.229	1182	1617
3	10	**1660**	2.250	1.560	2.389	182.411	300.067	1360	1960
4	20	**1910**	2.970	2.215	3.045	232.527	382.507	1527	2292
5	25	**1989**	3.199	2.422	3.256	248.620	408.980	1580	2398
6	50	**2233**	3.902	3.061	3.910	298.556	491.125	1742	2724
7	100	**2475**	4.600	3.696	4.564	348.484	573.256	1902	3048
8	500	**3035**	6.214	5.162	6.085	464.594	764.256	2271	3799

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	1006
2	5	1400
3	10	1660
4	20	1910
5	25	1989
6	50	2233
7	100	2475
8	500	3035

5.13 Hydrology of Konta HydroelectricProject

5.13.1 General

The present project Konta envisages harnessing water of River Sabari which finally meets the River Godavari, feeding the two dams i.e. Sabari and Sileru. Both sites are located in Raichur district of Karnataka. The proposed project is of RoR type in nature.

5.13.1.1 Description of Dam Sites

A plan of the catchment area map of the present project comprising the two dam sites, along with the G&D site Konta, are delineated from DEM is shown in **Figure 5.71**. The details of the location as well as the respective catchment areas of the dam sites are given in **Table 5.147**. Both the dam sites are located in Raichur district of Karnataka. Locations of both the dam sites and of G&D site is shown in **Figure 5.71**.

Table 5.147: Details of Catchment Area

Name of the Dam Sites	Location (Latitude , Longitude)	Catchment Area (km^2)
Sabari	76° 59' 49.5" E, 10° 13' 01.5" N	16,000
Sileru	76° 57' 28.06" E, 10° 12' 47.9" N	3,400

.

5.13.1.2 Description of G&D Site

Konta G&D site is situated in Dantewada district of Chhattisgarh. It lies about 80 km downstream of the dam sites, on the river Sabari at longitude 81° 23' 20" E, and latitude of 17° 49' 14" N. Catchment area of the G&D site is around 19,550 km^2 is shown in **Figure 5.59**.

5.13.1.3 The River System

The project envisages water of river Sabari. Sabari River is one of the main tributaries of Godavari. It originates from the western slopes of Eastern Ghats in Odisha state from Sinkaram hill ranges. It is also known as Kolab river in Odisha. The Sabari river basin receives nearly around 1250 mm annual average rainfall. It forms common boundary between Chhattisgarh and Odisha states and later enters into Andhra Pradesh to merge with River Godavari. Upper Kolab project, located in Odisha across the Sabari is a major dam project supplying water for irrigation and Hydro power generation.

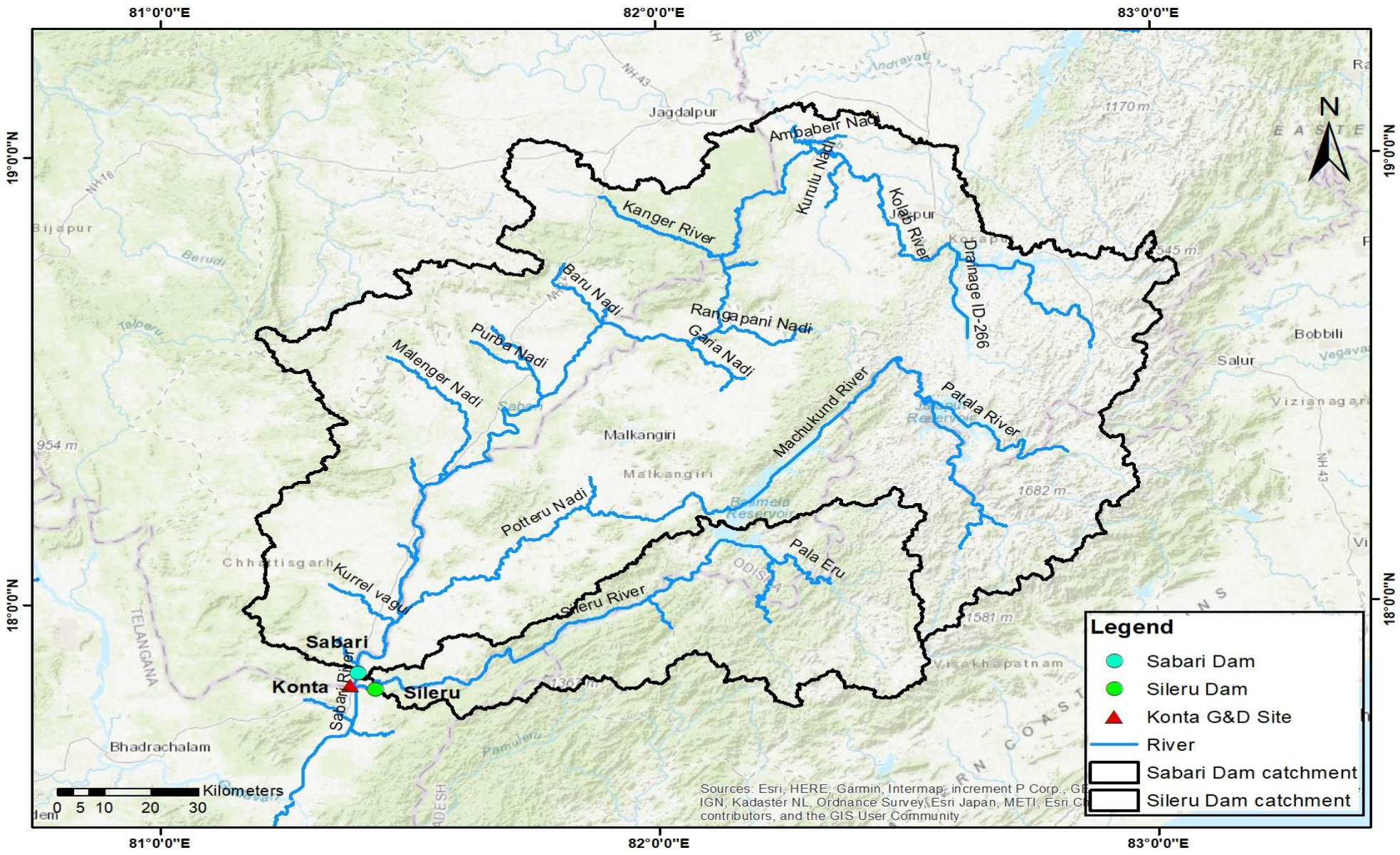


Figure 5.71: Catchment Area of Project and Locations of Dam and G&D site

5.13.2 Water Availability Studies

5.13.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site namely Konta (Catchment Area=19,550 km^2), which is downstream of the project site along Sabari River, is available and can be downloaded from India WRIS site. The G&D site lies in Dantewada district of Chhattisgarh.

Generally, 15 years flow series is required for a storage project. Thus, flow series of the period from 2000 to 2015 is considered to generate the flow at the present project site.

5.13.2.2 Rainfall data

Average daily rainfall (in mm) have been calculated at each grid point (as can been seen from **Figure 5.72**) within the boundary of the Konta G&D site and Sabari and Sileru dam is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus, in **Figure 5.72**, 28 grid points is considered to assess the catchment rainfall for Konta G&D site. Similarly for Sabari and Sileru dam, 25 and 3 grid points have been considered for the assessment of rainfall. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations.

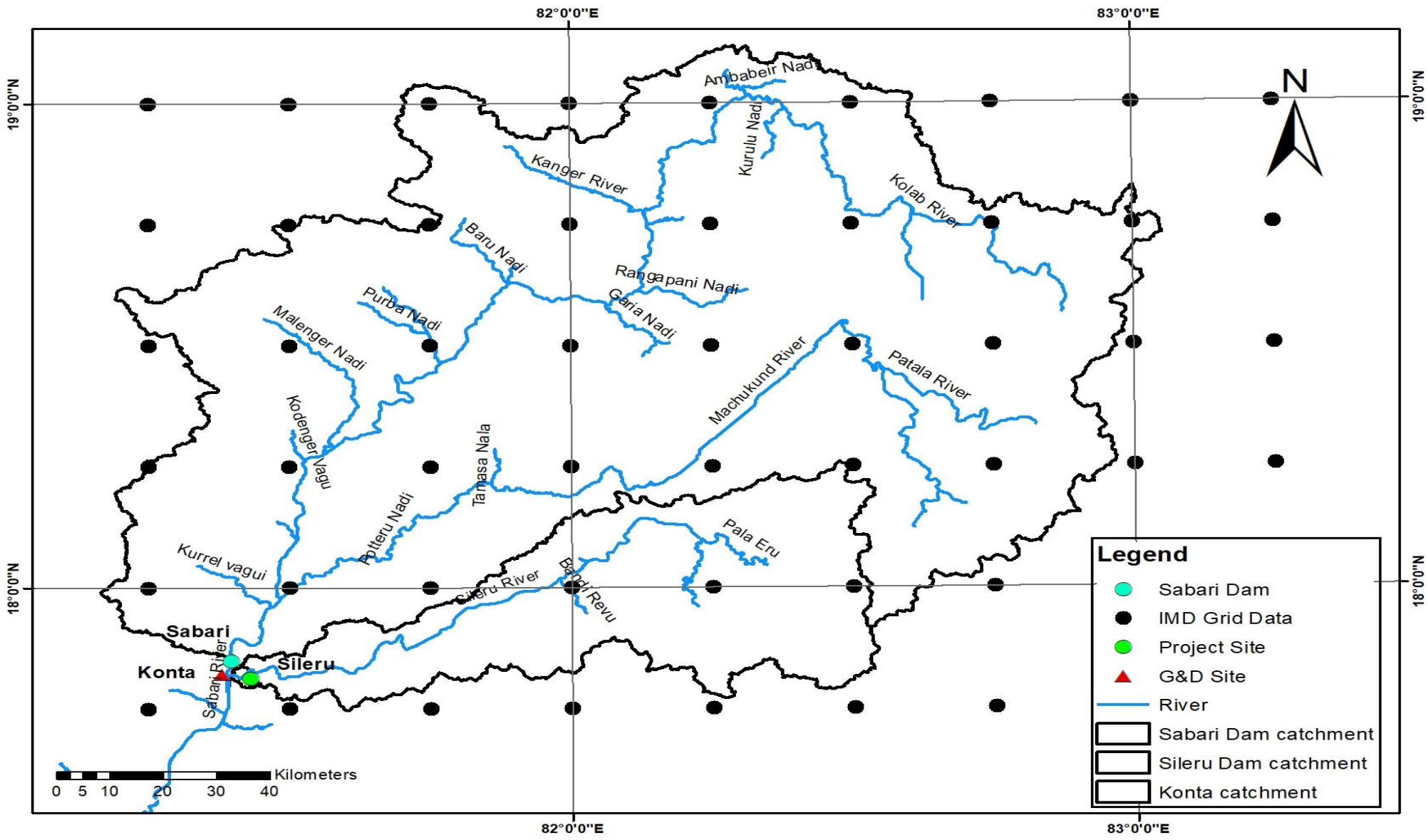


Figure 5.72: IMD Grid Rainfall Data for Konta Project site and G&D site

a) Average Annual Rainfall

Catchment area rainfalls for the last 15 years have been considered to derive the rainfall factor at different dam sites. Average Annual rainfall for the G&D site and dam sites as computed are given in **Table 5.148**. 10 daily rainfall variations for the G&D site and the dam sites are shown in **Table 5.149** and **Table 5.150** and **Table 5.151** respectively.

Table 5.148: Average Annual Rainfall (in mm)

Year	Konta	Sabari	Sileru
2000-2001	1331	1359	1419
2001-2002	1437	1482	1358
2002-2003	919	1017	850
2003-2004	1791	1769	1582
2004-2005	1255	1350	1359
2005-2006	1668	1743	1722
2006-2007	2002	2589	2210
2007-2008	1834	2019	1823
2008-2009	1079	1514	1327
2009-2010	971	1136	1140
2010-2011	1603	1780	1629
2011-2012	1188	1173	1129
2012-2013	1407	1638	1519
2013-2014	1371	1683	1333
2014-2015	1501	1651	1534
AVERAGE (mm)	1509	1528	1462

Table 5.149: 10 Daily Rainfall (in mm) of Konta G&D Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	14.83	8.78	5.31	1.08	2.73	8.16	2.59	2.91	8.04	1.75	4.12	5.65	3.80	5.44	9.62
	II	4.13	12.03	3.11	6.65	28.79	3.21	3.87	7.60	5.29	5.78	13.22	5.07	1.44	6.45	0.83
	III	6.68	0.60	5.12	3.37	0.06	17.06	8.60	32.42	6.59	6.39	0.96	0.90	5.53	3.28	6.34
JUL	I	8.45	21.72	0.04	9.56	4.91	4.76	9.17	4.50	5.04	3.36	15.73	10.27	5.03	4.77	2.62
	II	12.92	4.04	3.60	17.49	6.12	1.35	16.61	6.69	2.51	12.66	10.09	5.09	4.20	5.34	12.52
	III	4.36	2.07	2.85	18.45	4.98	11.48	12.35	5.15	12.10	2.68	18.51	9.75	11.55	6.02	7.51
AUG	I	4.71	11.86	7.48	13.50	8.98	8.64	46.28	11.83	19.28	0.57	6.41	3.43	6.59	5.02	6.90
	II	12.16	11.57	4.78	3.08	7.31	2.32	10.80	6.18	3.99	3.02	6.54	13.12	8.13	15.13	3.25
	III	13.71	0.19	5.91	12.85	1.48	1.24	6.94	9.37	5.15	8.43	6.82	10.41	7.27	1.07	17.17
SEP	I	2.02	0.26	5.78	5.38	12.90	10.73	3.79	20.36	8.87	5.24	7.89	16.62	7.24	2.66	13.47
	II	2.91	10.34	6.71	2.27	1.96	37.50	38.72	8.19	13.17	2.19	6.81	5.78	9.79	8.19	6.32
	III	6.92	13.04	0.00	7.26	0.73	8.51	12.76	11.21	3.03	7.31	0.87	1.04	13.32	3.84	0.72
OCT	I	7.90	10.07	3.55	16.82	12.66	4.78	0.48	20.59	1.42	7.34	1.60	1.19	6.00	5.28	5.44
	II	1.10	8.54	17.97	0.74	1.43	12.76	0.21	2.09	0.38	0.57	3.07	1.52	2.19	2.07	31.15
	III	0.11	1.57	1.91	15.83	0.80	6.93	9.32	2.85	2.57	0.00	7.20	0.99	2.33	26.42	2.19
NOV	I	0.10	1.09	0.33	1.25	1.14	4.49	5.06	0.48	0.03	0.50	11.06	0.71	30.89	0.00	0.20
	II	0.00	5.49	0.03	0.00	1.02	0.00	0.00	0.12	1.70	7.27	3.70	0.00	0.00	0.00	0.50
	III	0.12	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.11	0.78	0.00	0.79	3.76	0.00
DEC	I	0.85	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.00	13.79	0.00	0.00	1.98	0.00
	II	0.00	0.00	0.00	14.52	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
	III	0.00	0.10	0.29	0.00	0.00	0.65	0.00	0.00	0.07	0.04	0.00	0.65	0.00	0.00	0.99
JAN	I	0.95	2.08	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	1.11	0.08	0.00	0.06
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.41	0.00	0.78	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.93	1.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
FEB	I	0.00	0.00	0.00	1.10	1.56	0.00	0.00	7.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.71	0.00	0.00	0.00	1.26	1.39	0.00	0.01	0.00	0.00	0.52	0.02	0.00
	III	0.00	0.00	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.17	0.00	0.00	0.00	0.13
MAR	I	1.05	0.00	0.00	0.64	0.00	0.18	0.25	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.66
	II	1.82	0.00	3.65	0.00	1.32	2.67	0.00	0.01	0.00	0.05	0.52	0.56	0.00	1.04	0.01
	III	1.83	0.79	0.48	0.37	0.80	0.08	0.00	10.04	0.98	0.00	0.07	0.14	0.00	0.02	1.35
APR	I	1.88	7.65	2.81	4.48	2.70	0.16	0.00	2.07	0.01	0.00	3.88	8.54	0.00	0.03	0.12
	II	4.74	3.00	1.91	1.88	6.84	4.62	0.61	0.26	0.00	0.74	2.68	3.38	0.74	1.34	1.87
	III	0.05	0.49	1.17	7.11	1.62	0.46	0.92	0.08	0.37	6.94	4.84	4.77	6.56	6.68	10.29
MAY	I	9.76	2.63	2.27	2.96	5.62	0.75	4.04	0.86	0.84	0.38	1.85	1.07	0.48	10.84	2.69
	II	3.96	1.40	0.44	1.65	3.43	4.13	0.92	0.35	0.13	1.43	1.46	2.66	3.80	2.98	1.75
	III	0.97	1.69	0.48	2.79	1.45	6.48	1.57	5.04	2.93	9.69	2.22	1.30	0.27	0.96	0.50
Yearly Rainfall (mm)		1331	1437	919	1791	1255	1668	2002	1834	1079	971	1603	1188	1407	1371	1501

Table 5.150: 10 Daily Rainfall (in mm) of Sabari Dam Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	11.60	7.08	3.58	0.46	3.63	4.43	5.41	3.06	8.35	2.60	2.83	3.78	2.54	8.81	2.24
	II	9.35	13.68	5.93	4.63	26.00	2.07	3.82	9.21	4.90	2.89	10.65	6.77	4.05	20.25	3.94
	III	9.43	3.60	10.62	3.80	1.19	14.73	8.74	44.83	11.28	4.26	3.77	5.33	6.09	11.05	5.65
JUL	I	11.31	31.26	1.78	10.88	5.82	6.24	20.34	4.64	8.84	7.20	11.65	7.23	8.44	10.12	2.99
	II	15.17	7.18	7.69	14.72	9.74	3.88	18.43	10.10	4.10	23.93	11.10	7.90	7.28	12.68	22.00
	III	4.61	5.99	5.38	18.82	10.81	15.15	20.90	7.05	18.09	7.02	27.49	7.87	16.71	12.18	20.40
AUG	I	8.22	14.50	10.78	18.08	13.56	9.83	57.70	19.76	29.34	2.60	13.59	6.68	19.94	10.84	11.90
	II	11.02	14.73	8.65	7.34	11.10	8.51	21.25	11.13	10.38	9.29	8.60	10.78	11.06	16.99	7.68
	III	16.20	4.11	10.44	22.21	4.33	3.24	12.09	11.14	8.65	13.09	10.38	12.22	11.16	2.63	18.14
SEP	I	5.22	3.22	6.31	6.42	7.93	9.48	6.52	21.53	14.85	5.15	18.25	14.27	15.58	4.74	12.20
	II	2.02	6.66	4.74	6.07	3.78	33.44	47.38	6.26	11.88	2.00	9.63	11.65	12.48	7.48	13.65
	III	7.16	8.28	0.67	9.27	4.06	7.12	14.32	13.48	1.95	5.79	2.52	1.53	9.64	7.03	2.58
OCT	I	2.41	5.20	0.88	15.45	13.96	3.02	1.44	14.31	2.22	7.73	2.52	0.79	3.89	5.92	0.90
	II	0.78	4.13	11.18	0.44	0.88	9.39	0.82	3.07	0.37	0.08	6.44	0.99	2.40	2.05	19.20
	III	0.08	0.56	0.30	5.64	1.20	11.31	0.93	1.94	0.71	0.00	3.94	1.39	0.70	13.96	1.43
NOV	I	0.17	0.57	0.01	0.67	1.95	4.27	5.27	0.34	0.00	0.77	5.44	0.25	16.49	0.00	0.04
	II	0.00	4.22	0.01	0.00	1.44	0.00	0.00	0.01	0.11	2.97	2.92	0.00	0.00	0.00	0.72
	III	0.17	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.97	0.00	0.11	1.48	0.00
DEC	I	0.64	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	5.85	0.00	0.00	0.11	0.00
	II	0.00	0.00	0.00	9.33	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.10	0.00	0.00	0.00
	III	0.00	0.01	0.02	0.20	0.00	0.14	0.00	0.00	0.00	0.24	0.00	0.64	0.00	0.00	0.40
JAN	I	0.18	1.69	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.02	0.00	0.29
	II	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	1.72	0.00	0.76	0.00	0.00	0.00
	III	0.00	0.94	0.00	3.48	0.84	0.00	0.00	0.01	0.00	0.00	0.00	0.27	0.00	0.00	0.00
FEB	I	0.00	0.00	0.00	0.42	0.75	0.00	0.00	0.25	0.00	0.03	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.28	0.00	0.00	0.00	0.42	0.24	0.00	0.34	0.03	0.00	0.81	0.13	0.04
	III	0.00	0.00	0.94	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.49	0.00	0.00	0.00	0.12
MAR	I	0.39	0.00	0.42	0.76	0.00	0.38	0.01	0.00	0.00	0.00	0.00	0.00	0.00	2.53	0.40
	II	0.45	0.00	2.99	0.00	0.32	2.61	0.00	0.21	0.00	0.28	0.07	0.12	0.03	0.39	0.09
	III	0.33	0.29	0.74	0.19	0.17	0.15	0.00	8.97	1.58	0.14	0.23	0.17	0.03	0.03	0.87
APR	I	1.56	1.95	2.57	3.36	0.80	0.16	0.00	1.97	0.36	0.00	1.62	3.75	0.24	0.09	0.09
	II	3.69	1.36	1.85	0.88	1.75	8.15	1.32	0.24	0.00	0.54	1.67	1.40	2.07	1.40	2.94
	III	0.28	0.17	0.63	3.67	2.47	0.34	0.01	0.46	0.06	3.03	5.91	3.80	5.21	1.86	5.16
MAY	I	3.09	0.58	0.43	0.78	2.66	1.71	4.47	0.93	2.42	1.30	1.63	1.79	0.06	6.32	2.51
	II	3.63	1.39	0.12	1.73	0.59	3.73	1.24	0.12	2.79	0.50	1.61	1.60	2.42	1.51	2.10
	III	4.21	3.27	0.24	1.98	1.36	7.12	2.45	3.40	4.71	5.21	1.90	0.50	1.33	2.55	0.34
Yearly Rainfall (mm)		1359	1482	1017	1769	1350	1743	2589	2019	1514	1136	1780	1173	1638	1683	1651

Table 5.151: 10 Daily Rainfall (in mm) of Sileru Dam Sites

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	11.60	7.08	5.31	0.46	2.73	4.43	2.59	3.06	8.04	1.75	2.83	3.78	3.80	8.81	9.62
	II	9.35	13.68	3.11	6.65	28.79	3.21	3.82	7.60	4.90	2.89	10.65	5.07	1.44	6.45	3.94
	III	9.43	0.60	5.12	3.37	0.06	17.06	8.60	32.42	11.28	6.39	0.96	0.90	6.09	3.28	6.34
JUL	I	11.31	21.72	1.78	9.56	5.82	4.76	9.17	4.64	8.84	3.36	15.73	10.27	8.44	10.12	2.62
	II	12.92	7.18	3.60	14.72	9.74	1.35	16.61	10.10	2.51	23.93	10.09	7.90	4.20	12.68	22.00
	III	4.36	5.99	5.38	18.45	10.81	15.15	12.35	5.15	18.09	2.68	18.51	7.87	16.71	6.02	7.51
AUG	I	8.22	14.50	7.48	13.50	13.56	8.64	57.70	11.83	29.34	2.60	6.41	3.43	19.94	5.02	6.90
	II	11.02	14.73	4.78	7.34	7.31	8.51	10.80	11.13	3.99	3.02	6.54	10.78	11.06	16.99	7.68
	III	16.20	0.19	5.91	12.85	4.33	3.24	12.09	11.14	5.15	13.09	10.38	12.22	7.27	2.63	18.14
SEP	I	5.22	0.26	5.78	6.42	7.93	10.73	6.52	20.36	8.87	5.24	18.25	14.27	7.24	4.74	13.47
	II	2.02	6.66	4.74	2.27	3.78	33.44	38.72	8.19	13.17	2.19	6.81	11.65	9.79	8.19	13.65
	III	7.16	8.28	0.67	9.27	4.06	7.12	12.76	11.21	1.95	7.31	0.87	1.04	13.32	3.84	0.72
OCT	I	2.41	5.20	3.55	16.82	12.66	3.02	1.44	14.31	1.42	7.34	2.52	0.79	3.89	5.28	0.90
	II	1.10	8.54	11.18	0.74	0.88	12.76	0.82	2.09	0.37	0.08	6.44	1.52	2.40	2.07	19.20
	III	0.11	1.57	0.30	5.64	0.80	6.93	9.32	1.94	0.71	0.00	3.94	1.39	2.33	13.96	1.43
NOV	I	0.17	1.09	0.01	1.25	1.95	4.27	5.27	0.48	0.03	0.50	5.44	0.25	16.49	0.00	0.20
	II	0.00	5.49	0.01	0.00	1.44	0.00	0.00	0.01	0.11	7.27	3.70	0.00	0.00	0.00	0.72
	III	0.12	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.00	0.97	0.00	0.79	1.48	0.00
DEC	I	0.85	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.01	0.00	13.79	0.00	0.00	1.98	0.00
	II	0.00	0.00	0.00	9.33	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.10	0.00	0.00	0.00
	III	0.00	0.10	0.29	0.20	0.00	0.65	0.00	0.00	0.00	0.24	0.00	0.64	0.00	0.00	0.40
JAN	I	0.95	2.08	0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.11	0.02	0.00	0.29
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.72	0.00	0.78	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.93	0.84	0.00	0.00	0.01	0.00	0.00	0.00	0.27	0.00	0.00	0.00
FEB	I	0.00	0.00	0.00	1.10	1.56	0.00	0.00	7.47	0.00	0.03	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.71	0.00	0.00	0.00	0.42	0.24	0.00	0.01	0.00	0.00	0.81	0.13	0.04
	III	0.00	0.00	2.03	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.49	0.00	0.00	0.00	0.13
MAR	I	0.39	0.00	0.00	0.64	0.00	0.18	0.25	0.00	0.00	0.00	0.00	0.00	0.00	3.00	0.66
	II	1.82	0.00	2.99	0.00	1.32	2.67	0.00	0.21	0.00	0.28	0.52	0.56	0.03	0.39	0.09
	III	1.83	0.29	0.48	0.37	0.17	0.08	0.00	8.97	1.58	0.00	0.07	0.17	0.03	0.03	0.87
APR	I	1.56	1.95	2.81	3.36	2.70	0.16	0.00	1.97	0.01	0.00	1.62	3.75	0.00	0.09	0.12
	II	4.74	1.36	1.91	0.88	1.75	8.15	1.32	0.24	0.00	0.74	1.67	1.40	2.07	1.34	2.94
	III	0.05	0.49	0.63	3.67	1.62	0.46	0.01	0.08	0.37	6.94	4.84	4.77	6.56	1.86	5.16
MAY	I	9.76	2.63	2.27	0.78	2.66	1.71	4.04	0.86	2.42	0.38	1.63	1.79	0.48	6.32	2.51
	II	3.96	1.39	0.44	1.65	3.43	3.73	1.24	0.12	2.79	1.43	1.61	1.60	3.80	1.51	1.75
	III	0.97	1.69	0.48	1.98	1.36	6.48	1.57	3.40	2.93	9.69	2.22	0.50	0.27	2.55	0.50
Yearly Rainfall (mm)		1419	1358	850	1582	1359	1722	2210	1823	1327	1140	1629	1129	1519	1333	1534

5.13.2.3 Rainfall and Runoff Data at Tekra G&D Site

Detailed calculations on water availability and flood magnitude will help to select the design features for the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check of observed data has been performed by plotting the monthly runoff (in mm) and monthly rainfall (in mm) for the entire period from 2000 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Konta G&D site is shown in **Figure 5.73**. For years 2014 and above, discharge data for monsoon period is not available. The basic comparison between rainfall and runoff in **Figure 5.73** shows a genuine difference, which might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. **Figure 5.74** shows the plot of runoff coefficient at G&D site.

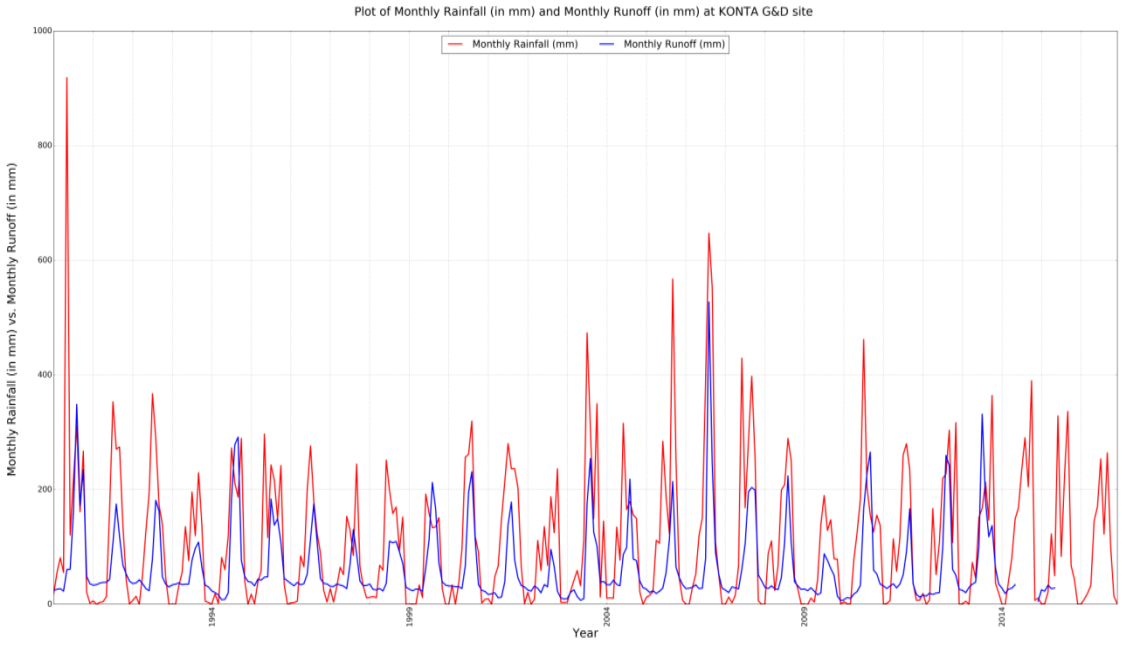


Figure 5.73: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Tekra G&D site

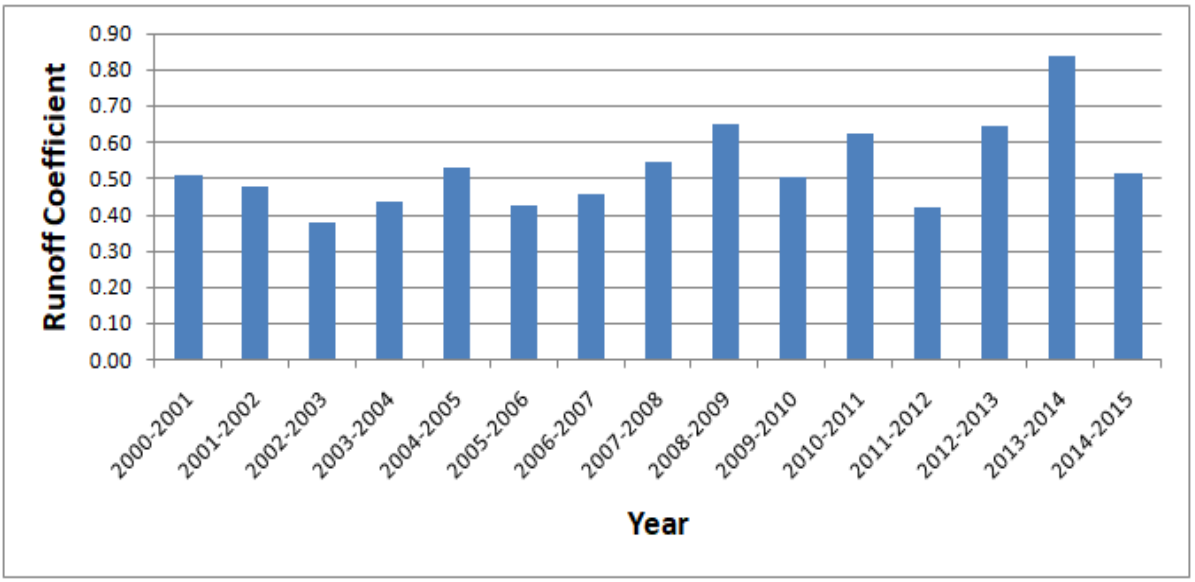


Figure 5.74: Plot of Runoff coefficient at the G&D

5.13.3 Flow Series Computation

Flow series at the proposed dam site is estimated using catchment area ratio and rainfall variability factor. Catchment area (CA) of the Central Water Commission (CWC) gauge station i.e. Konta is around 19,950 km^2 as mentioned on India WRIS site. Daily discharge data for Konta site is available for period from 1990 to 2015. After finalizing the flow series at the G&D site of Konta, the flow series at the project site has been developed using the catchment area ratio and variation of annual rainfall factor. Catchment area ratio is used as it can be assumed that both the catchments are having similar drainage characteristics. In addition to it, annual rainfall yield factor represents the extent in hydro-metrological similarity between Konta G&D and the two dam sites.

The catchment area proportion factor and annual rainfall yield factor used for transposing the flow series from the Konta G&D site to the project sites are as follows:

$$\text{Catchment area factor} = \frac{CA_{Sabari}}{CA_{Konta}} = \frac{16000}{19950} = 0.82$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Sabari}}{\text{Average Annual Rainfall}_{Konta}} = \frac{1528}{1509} = 1.01$$

$$\text{Catchment area factor} = \frac{CA_{Sileru}}{CA_{Konta}} = \frac{3400}{19950} = 0.17$$

$$\text{Annual Rainfall yield factor} = \frac{\text{Average Annual Rainfall}_{Sileru}}{\text{Average Annual Rainfall}_{Konta}} = \frac{1528}{1509} = 0.97$$

Discharge Series for the dams are computed according to the equation below

$$Q_{\text{Sabari}} = Q_{\text{Konta G\&}D\ Site}\text{X } 0.82 \text{ X } 1.01$$

$$Q_{\text{Sileru}} = Q_{\text{Konta G\&}D\ Site}\text{X } 0.17 \text{ X } 0.97$$

Table 5.152 shows 10-daily average flow series at G&D site. **Table 5.153** and **Table 5.154** gives 10-daily average flow series of Sabari and Sileru Dam respectively. **Table 5.155** and **Table 5.156** shows 10-daily average flow series and 10 daily inflow series developed for Konta project.

Table 5.152: 10-Daily Average Flow Series (m^3/s) at Konta G&D

Catchment Area =19,550 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	431.99	100.95	156.55	35.47	275.01	210.66	203.74	229.81	214.69	143.40	159.79	222.47	129.45	285.65	199.97
	II	438.29	542.26	199.83	69.19	387.54	189.42	207.62	193.71	427.91	149.90	241.80	303.11	149.07	1112.67	329.45
	III	631.18	239.18	418.75	113.38	305.43	240.66	220.68	958.44	411.58	154.95	341.72	271.38	182.52	875.39	383.23
JUL	I	724.79	1119.19	185.87	233.61	437.41	260.27	635.62	864.15	538.17	161.50	458.35	317.21	309.33	697.16	495.90
	II	984.58	905.08	305.75	964.41	661.95	294.52	260.45	895.34	493.39	430.30	687.22	373.61	255.57	2218.15	695.02
	III	1549.75	1010.98	179.81	1540.96	1032.90	637.92	832.61	558.30	1311.90	406.39	2379.13	426.93	1491.07	4170.18	1252.06
AUG	I	901.32	994.89	559.68	1032.85	1324.33	1069.97	1213.90	1680.18	2009.66	918.50	3096.86	762.83	2457.31	1687.78	1407.86
	II	1286.16	1258.22	771.51	1116.07	1518.28	787.45	3117.65	1714.53	1947.00	1638.66	975.88	620.76	1518.59	2069.44	1452.87
	III	1763.84	1618.73	762.05	1362.71	1094.85	644.16	1453.88	944.56	1007.59	1615.91	990.15	623.27	1725.30	1216.85	1201.70
SEP	I	1327.83	973.93	703.22	1341.35	795.72	423.70	898.95	2069.17	754.37	761.50	2989.00	1979.01	2050.20	857.27	1280.37
	II	700.27	729.29	504.03	751.46	632.14	2548.88	2186.40	1036.14	1096.50	345.00	2177.30	883.18	2142.32	871.41	1186.02
	III	544.00	441.61	290.31	752.96	559.47	1871.81	2455.86	1503.81	569.50	308.52	837.88	912.77	1277.84	936.31	947.33
OCT	I	340.22	436.44	206.06	1200.16	864.04	437.83	1042.32	2809.28	334.50	614.98	439.06	319.37	688.66	1019.35	768.02
	II	248.04	326.73	183.76	658.93	479.13	410.18	588.96	925.63	289.50	291.71	461.65	319.58	388.73	733.59	450.44
	III	175.18	251.06	112.71	401.83	343.61	565.15	379.42	702.97	239.00	220.41	408.65	156.87	273.47	1229.19	389.97
NOV	I	185.42	249.57	85.59	372.77	318.66	499.37	492.18	447.83	232.60	232.30	428.47	139.20	562.09	658.47	350.32
	II	196.55	243.70	78.71	253.10	336.47	306.42	419.50	386.07	256.10	202.19	448.68	157.25	357.18	406.59	289.18
	III	168.20	247.41	81.58	235.65	260.38	243.86	265.43	321.58	238.30	194.08	315.99	99.23	228.68	399.97	235.74
DEC	I	177.92	216.07	69.99	251.74	230.79	249.19	201.48	331.53	208.97	164.21	266.81	85.02	207.28	328.51	213.54
	II	164.25	233.03	72.25	312.46	203.74	249.79	214.24	297.03	174.10	157.29	260.12	90.10	182.18	245.71	204.02
	III	148.62	212.30	62.89	309.78	198.87	249.44	198.65	273.78	183.64	119.61	243.52	99.14	181.80	200.90	247.05
JAN	I	133.56	187.27	57.43	257.22	219.56	224.75	188.50	230.77	195.24	73.76	234.86	126.96	204.43	218.64	224.45
	II	131.25	183.91	54.14	245.00	165.55	191.01	178.39	207.88	202.80	58.46	245.31	111.55	174.49	217.32	170.16
	III	107.56	176.12	100.06	244.26	192.31	183.55	176.85	213.15	185.67	70.94	225.86	112.03	157.21	179.59	159.60
FEB	I	119.38	176.59	132.87	256.60	163.58	211.87	169.41	216.78	196.33	81.65	234.43	108.10	134.63	139.86	163.93
	II	156.68	189.92	185.17	246.22	144.03	210.38	167.05	217.13	178.59	102.83	220.69	107.77	170.93	173.72	202.35
	III	175.23	187.69	199.52	295.80	194.14	262.70	155.88	202.10	203.38	101.03	206.13	119.81	188.16	159.61	188.65
MAR	I	176.22	187.89	182.41	277.11	187.52	218.52	234.88	222.42	209.80	94.02	207.02	141.35	176.74	177.30	237.27
	II	125.56	252.44	191.93	342.41	175.81	215.29	214.56	224.21	210.50	67.51	191.59	134.27	219.79	223.34	243.92
	III	131.46	251.80	179.48	301.49	158.22	211.90	214.39	255.54	208.87	60.39	290.44	146.09	242.70	181.74	249.13
APR	I	93.68	237.10	106.78	269.85	164.20	234.49	215.11	232.20	180.78	110.67	292.48	152.31	228.82	204.44	191.60
	II	65.52	223.61	109.09	286.56	138.59	248.25	232.28	196.61	175.10	145.17	261.59	130.66	258.94	210.93	201.22
	III	94.51	169.73	89.61	224.65	120.55	286.90	200.54	182.57	160.62	145.89	255.53	107.34	308.05	217.41	222.89
MAY	I	79.21	129.91	63.51	217.89	122.87	216.58	181.67	199.08	158.20	127.02	229.37	143.20	289.16	196.88	213.02
	II	103.30	138.00	49.74	222.07	173.04	196.14	191.32	203.41	106.38	226.16	212.91	139.71	256.74	284.62	195.62
	III	95.68	168.19	42.78	266.95	199.77	185.90	213.52	160.97	99.82	130.97	185.47	142.93	294.93	262.54	207.05
Inflow (MCM) =		13167	13428	6773	15248	13015	13741	17919	19508	13732	9565	19468	9705	17680	22447	15020

Table 5.153: 10-Daily Average Flow Series (m^3/s) at Sabari Dam

Catchment Area =16,000 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	358.05	83.67	129.76	29.40	227.94	174.61	168.87	190.48	177.95	118.86	132.44	184.39	107.29	236.76	165.75
	II	363.28	449.45	165.63	57.35	321.21	157.00	172.09	160.56	354.67	124.24	200.42	251.23	123.56	922.23	273.07
	III	523.15	198.24	347.08	93.97	253.16	199.47	182.91	794.40	341.14	128.43	283.23	224.93	151.28	725.57	317.64
JUL	I	600.74	927.64	154.06	193.63	362.55	215.72	526.83	716.25	446.06	133.86	379.90	262.92	256.39	577.84	411.03
	II	816.07	750.17	253.42	799.35	548.66	244.11	215.87	742.10	408.95	356.65	569.60	309.67	211.83	1838.51	576.07
	III	1284.51	837.95	149.04	1277.22	856.12	528.74	690.11	462.75	1087.37	336.84	1971.94	353.86	1235.87	3456.45	1037.77
AUG	I	747.06	824.61	463.89	856.08	1097.67	886.84	1006.14	1392.61	1665.70	761.30	2566.83	632.27	2036.74	1398.91	1166.90
	II	1066.03	1042.87	639.46	925.05	1258.42	652.68	2584.06	1421.08	1613.77	1358.20	808.86	514.52	1258.68	1715.25	1204.21
	III	1461.96	1341.68	631.62	1129.48	907.46	533.91	1205.05	782.90	835.14	1339.34	820.68	516.60	1430.01	1008.58	996.03
SEP	I	1100.57	807.24	582.86	1111.78	659.53	351.18	745.09	1715.03	625.26	631.17	2477.43	1640.30	1699.30	710.55	1061.23
	II	580.42	604.47	417.76	622.85	523.95	2112.63	1812.19	858.80	908.83	285.95	1804.65	732.02	1775.66	722.27	983.03
	III	450.89	366.03	240.62	624.09	463.72	1551.45	2035.53	1246.43	472.03	255.72	694.48	756.55	1059.14	776.06	785.19
OCT	I	281.99	361.74	170.79	994.75	716.16	362.89	863.92	2328.47	277.25	509.72	363.91	264.71	570.79	844.89	636.57
	II	205.59	270.81	152.31	546.15	397.13	339.98	488.16	767.21	239.95	241.78	382.64	264.88	322.20	608.03	373.34
	III	145.20	208.09	93.42	333.06	284.80	468.42	314.48	582.66	198.09	182.69	338.71	130.02	226.67	1018.81	323.22
NOV	I	153.68	206.86	70.94	308.97	264.12	413.90	407.94	371.18	192.79	192.54	355.14	115.38	465.89	545.77	290.36
	II	162.91	201.99	65.24	209.78	278.88	253.98	347.70	319.99	212.27	167.58	371.89	130.34	296.05	337.00	239.69
	III	139.41	205.07	67.62	195.32	215.82	202.12	220.00	266.54	197.51	160.86	261.91	82.25	189.54	331.51	195.39
DEC	I	147.47	179.09	58.01	208.65	191.29	206.54	167.00	274.79	173.20	136.11	221.14	70.47	171.80	272.28	176.99
	II	136.14	193.15	59.88	258.98	168.87	207.04	177.57	246.19	144.30	130.37	215.60	74.68	151.00	203.66	169.10
	III	123.18	175.96	52.13	256.76	164.83	206.75	164.65	226.92	152.21	99.14	201.84	82.17	150.68	166.52	204.77
JAN	I	110.70	155.22	47.60	213.20	181.98	186.28	156.24	191.27	161.82	61.14	194.66	105.23	169.44	181.22	186.03
	II	108.79	152.43	44.87	203.07	137.22	158.32	147.86	172.30	168.09	48.45	203.32	92.46	144.63	180.13	141.04
	III	89.15	145.98	82.93	202.45	159.40	152.14	146.58	176.67	153.89	58.80	187.20	92.86	130.30	148.85	132.28
FEB	I	98.95	146.37	110.13	212.68	135.58	175.61	140.42	179.68	162.73	67.68	194.31	89.60	111.59	115.92	135.87
	II	129.86	157.41	153.48	204.08	119.38	174.37	138.46	179.97	148.02	85.23	182.92	89.32	141.67	143.99	167.72
	III	145.24	155.57	165.37	245.17	160.91	217.74	129.20	167.51	168.57	83.74	170.85	99.30	155.96	132.29	156.36
MAR	I	146.06	155.73	151.19	229.68	155.43	181.12	194.68	184.35	173.89	77.93	171.59	117.16	146.49	146.95	196.66
	II	104.07	209.23	159.08	283.81	145.72	178.44	177.84	185.84	174.47	55.96	158.80	111.29	182.17	185.11	202.17
	III	108.96	208.70	148.76	249.89	131.14	175.63	177.70	211.80	173.12	50.05	240.73	121.09	201.16	150.63	206.49
APR	I	77.65	196.52	88.50	223.66	136.10	194.36	178.29	192.46	149.84	91.73	242.42	126.24	189.66	169.45	158.81
	II	54.31	185.34	90.42	237.51	114.87	205.76	192.52	162.96	145.13	120.32	216.82	108.30	214.62	174.83	166.78
	III	78.33	140.68	74.27	186.20	99.92	237.80	166.22	151.32	133.13	120.92	211.80	88.97	255.33	180.20	184.74
MAY	I	65.65	107.68	52.64	180.60	101.84	179.51	150.58	165.01	131.12	105.28	190.11	118.69	239.67	163.18	176.56
	II	85.62	114.38	41.23	184.06	143.42	162.57	158.58	168.60	88.17	187.45	176.47	115.80	212.80	235.91	162.14
	III	79.30	139.40	35.46	221.26	165.58	154.08	176.98	133.42	82.74	108.55	153.73	118.47	244.45	217.61	171.61
Inflow (MCM) =		10913	11130	5614	12639	10787	11389	14852	16169	11382	7928	16136	8044	14654	18605	12449

Table 5.154: 10-Daily Average Flow Series (m^3/s) at Sileru Dam

Catchment Area =3,400 km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	72.82	17.02	26.39	5.98	46.36	35.51	34.34	38.74	36.19	24.17	26.93	37.50	21.82	48.15	33.71
	II	73.88	91.41	33.68	11.66	65.33	31.93	35.00	32.65	72.13	25.27	40.76	51.09	25.13	187.56	55.53
	III	106.39	40.32	70.59	19.11	51.48	40.57	37.20	161.56	69.38	26.12	57.60	45.74	30.77	147.56	64.60
JUL	I	122.17	188.66	31.33	39.38	73.73	43.87	107.14	145.66	90.72	27.22	77.26	53.47	52.14	117.52	83.59
	II	165.96	152.56	51.54	162.57	111.58	49.65	43.90	150.92	83.17	72.53	115.84	62.98	43.08	373.90	117.16
	III	261.23	170.42	30.31	259.75	174.11	107.53	140.35	94.11	221.14	68.50	401.04	71.97	251.34	702.94	211.05
AUG	I	151.93	167.70	94.34	174.10	223.23	180.36	204.62	283.22	338.76	154.83	522.02	128.59	414.21	284.50	237.32
	II	216.80	212.09	130.05	188.13	255.93	132.74	525.52	289.01	328.19	276.22	164.50	104.64	255.98	348.83	244.90
	III	297.32	272.86	128.45	229.70	184.55	108.58	245.07	159.22	169.84	272.38	166.90	105.06	290.82	205.12	202.56
SEP	I	223.82	164.17	118.54	226.10	134.13	71.42	151.53	348.79	127.16	128.36	503.84	333.59	345.59	144.51	215.83
	II	118.04	122.93	84.96	126.67	106.56	429.65	368.55	174.66	184.83	58.15	367.01	148.87	361.12	146.89	199.92
	III	91.70	74.44	48.94	126.92	94.31	315.52	413.97	253.49	96.00	52.01	141.24	153.86	215.40	157.83	159.69
OCT	I	57.35	73.57	34.73	202.30	145.65	73.80	175.70	473.54	56.38	103.66	74.01	53.83	116.08	171.83	129.46
	II	41.81	55.07	30.98	111.07	80.76	69.14	99.28	156.03	48.80	49.17	77.82	53.87	65.53	123.66	75.93
	III	29.53	42.32	19.00	67.73	57.92	95.26	63.96	118.50	40.29	37.15	68.88	26.44	46.10	207.20	65.73
NOV	I	31.26	42.07	14.43	62.84	53.71	84.18	82.96	75.49	39.21	39.16	72.22	23.46	94.75	110.99	59.05
	II	33.13	41.08	13.27	42.66	56.72	51.65	70.71	65.08	43.17	34.08	75.63	26.51	60.21	68.54	48.75
	III	28.35	41.70	13.75	39.72	43.89	41.11	44.74	54.21	40.17	32.71	53.26	16.73	38.55	67.42	39.74
DEC	I	29.99	36.42	11.80	42.43	38.90	42.00	33.96	55.88	35.22	27.68	44.97	14.33	34.94	55.38	35.99
	II	27.69	39.28	12.18	52.67	34.34	42.11	36.11	50.07	29.35	26.51	43.85	15.19	30.71	41.42	34.39
	III	25.05	35.79	10.60	52.22	33.52	42.05	33.49	46.15	30.96	20.16	41.05	16.71	30.64	33.86	41.64
JAN	I	22.51	31.57	9.68	43.36	37.01	37.88	31.77	38.90	32.91	12.43	39.59	21.40	34.46	36.85	37.83
	II	22.12	31.00	9.13	41.30	27.91	32.20	30.07	35.04	34.18	9.85	41.35	18.80	29.41	36.63	28.68
	III	18.13	29.69	16.87	41.17	32.42	30.94	29.81	35.93	31.30	11.96	38.07	18.88	26.50	30.27	26.90
FEB	I	20.12	29.77	22.40	43.25	27.57	35.71	28.56	36.54	33.09	13.76	39.52	18.22	22.69	23.58	27.63
	II	26.41	32.01	31.21	41.50	24.28	35.46	28.16	36.60	30.10	17.33	37.20	18.17	28.81	29.28	34.11
	III	29.54	31.64	33.63	49.86	32.73	44.28	26.28	34.07	34.28	17.03	34.75	20.20	31.72	26.90	31.80
MAR	I	29.70	31.67	30.75	46.71	31.61	36.83	39.59	37.49	35.36	15.85	34.90	23.83	29.79	29.89	40.00
	II	21.16	42.55	32.35	57.72	29.64	36.29	36.17	37.79	35.48	11.38	32.30	22.63	37.05	37.65	41.12
	III	22.16	42.44	30.25	50.82	26.67	35.72	36.14	43.07	35.21	10.18	48.96	24.63	40.91	30.63	41.99
APR	I	15.79	39.97	18.00	45.49	27.68	39.53	36.26	39.14	30.47	18.66	49.30	25.67	38.57	34.46	32.30
	II	11.04	37.69	18.39	48.30	23.36	41.85	39.15	33.14	29.52	24.47	44.09	22.02	43.65	35.56	33.92
	III	15.93	28.61	15.11	37.87	20.32	48.36	33.80	30.77	27.07	24.59	43.07	18.09	51.93	36.65	37.57
MAY	I	13.35	21.90	10.71	36.73	20.71	36.51	30.62	33.56	26.67	21.41	38.66	24.14	48.74	33.19	35.91
	II	17.41	23.26	8.38	37.43	29.17	33.06	32.25	34.29	17.93	38.12	35.89	23.55	43.28	47.98	32.97
	III	16.13	28.35	7.21	45.00	33.67	31.34	35.99	27.13	16.83	22.08	31.26	24.09	49.71	44.25	34.90
Inflow (MCM) =		2219	2264	1142	2570	2194	2316	3021	3288	2315	1612	3282	1636	2980	3784	2532

Table 5.155: 10-Daily Average Flow Series (m^3/s) at Konta Project site (Combined 10-daily flow series of Sabari Dam and Sileru Dam)

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	430.87	100.69	156.14	35.38	274.30	210.11	203.21	229.22	214.13	143.03	159.38	221.89	129.12	284.91	199.46
	II	437.16	540.86	199.31	69.01	386.54	188.93	207.08	193.21	426.80	149.51	241.17	302.33	148.68	1109.79	328.60
	III	629.55	238.56	417.67	113.09	304.64	240.04	220.11	955.96	410.51	154.55	340.84	270.68	182.05	873.12	382.24
JUL	I	722.91	1116.29	185.39	233.01	436.28	259.60	633.98	861.91	536.78	161.08	457.16	316.39	308.53	695.36	494.62
	II	982.03	902.74	304.96	961.91	660.24	293.76	259.78	893.02	492.11	429.19	685.44	372.64	254.91	2212.41	693.22
	III	1545.74	1008.36	179.34	1536.97	1030.23	636.27	830.46	556.86	1308.51	405.34	2372.97	425.83	1487.21	4159.39	1248.82
AUG	I	898.99	992.32	558.23	1030.18	1320.90	1067.20	1210.76	1675.83	2004.46	916.12	3088.85	760.86	2450.95	1683.41	1404.22
	II	1282.83	1254.96	769.51	1113.18	1514.35	785.41	3109.58	1710.09	1941.96	1634.42	973.35	619.15	1514.66	2064.08	1449.11
	III	1759.28	1614.54	760.08	1359.18	1092.02	642.49	1450.12	942.12	1004.98	1611.73	987.59	621.66	1720.84	1213.70	1198.59
SEP	I	1324.39	971.41	701.40	1337.88	793.66	422.60	896.62	2063.82	752.42	759.53	2981.26	1973.89	2044.89	855.05	1277.06
	II	698.46	727.40	502.73	749.52	630.50	2542.28	2180.74	1033.46	1093.66	344.11	2171.67	880.89	2136.78	869.15	1182.95
	III	542.59	440.47	289.56	751.01	558.02	1866.97	2449.50	1499.92	568.03	307.72	835.71	910.41	1274.53	933.89	944.88
OCT	I	339.34	435.31	205.53	1197.05	861.80	436.70	1039.62	2802.01	333.63	613.39	437.92	318.54	686.88	1016.71	766.03
	II	247.40	325.88	183.28	657.22	477.89	409.12	587.44	923.23	288.75	290.96	460.46	318.75	387.72	731.69	449.27
	III	174.73	250.41	112.42	400.79	342.72	563.69	378.44	701.15	238.38	219.84	407.59	156.46	272.76	1226.01	388.96
NOV	I	184.94	248.92	85.37	371.81	317.84	498.08	490.91	446.67	232.00	231.70	427.36	138.84	560.64	656.77	349.42
	II	196.04	243.07	78.51	252.45	335.60	305.63	418.41	385.07	255.44	201.67	447.52	156.84	356.26	405.54	288.43
	III	167.76	246.77	81.37	235.04	259.71	243.23	264.74	320.75	237.68	193.58	315.17	98.97	228.09	398.93	235.13
DEC	I	177.46	215.51	69.81	251.09	230.19	248.55	200.96	330.67	208.43	163.79	266.12	84.80	206.74	327.66	212.98
	II	163.82	232.43	72.06	311.65	203.21	249.14	213.69	296.26	173.65	156.88	259.45	89.87	181.71	245.07	203.49
	III	148.24	211.75	62.73	308.98	198.36	248.79	198.14	273.07	183.16	119.30	242.89	98.88	181.33	200.38	246.41
JAN	I	133.21	186.79	57.28	256.55	218.99	224.17	188.01	230.17	194.73	73.57	234.25	126.63	203.90	218.07	223.87
	II	130.91	183.43	54.00	244.37	165.12	190.52	177.93	207.34	202.28	58.31	244.68	111.26	174.04	216.76	169.72
	III	107.28	175.66	99.80	243.63	191.81	183.08	176.39	212.60	185.19	70.76	225.28	111.74	156.80	179.13	159.19
FEB	I	119.07	176.13	132.53	255.94	163.16	211.32	168.97	216.22	195.82	81.44	233.82	107.82	134.28	139.50	163.51
	II	156.27	189.43	184.69	245.58	143.66	209.84	166.62	216.57	178.13	102.56	220.12	107.49	170.49	173.27	201.83
	III	174.78	187.20	199.00	295.03	193.64	262.02	155.48	201.58	202.85	100.77	205.60	119.50	187.67	159.20	188.16
MAR	I	175.76	187.40	181.94	276.39	187.03	217.95	234.27	221.84	209.26	93.78	206.48	140.98	176.28	176.84	236.66
	II	125.24	251.79	191.43	341.52	175.36	214.73	214.00	223.63	209.96	67.34	191.09	133.92	219.22	222.76	243.29
	III	131.12	251.15	179.02	300.71	157.81	211.35	213.84	254.88	208.33	60.23	289.69	145.71	242.07	181.27	248.49
APR	I	93.44	236.49	106.50	269.15	163.78	233.88	214.55	231.60	180.31	110.38	291.72	151.92	228.23	203.91	191.10
	II	65.35	223.03	108.81	285.82	138.23	247.61	231.68	196.10	174.65	144.79	260.91	130.32	258.27	210.38	200.70
	III	94.27	169.29	89.38	224.07	120.24	286.16	200.02	182.10	160.20	145.51	254.87	107.06	307.25	216.85	222.31
MAY	I	79.01	129.57	63.35	217.33	122.55	216.02	181.20	198.56	157.79	126.69	228.78	142.83	288.41	196.37	212.47
	II	103.03	137.64	49.61	221.50	172.59	195.63	190.82	202.88	106.10	225.57	212.36	139.35	256.08	283.88	195.11
	III	95.43	167.75	42.67	266.26	199.25	185.42	212.97	160.55	99.56	130.63	184.99	142.56	294.17	261.86	206.51
Inflow (MCM) =		13133	13394	6756	15209	12981	13706	17873	19458	13697	9540	19418	9680	17635	22389	14981

Table 5.156: Inflow Series (MCM) at Konta Project Site (Combined 10-Daily Inflow series of Sabari Dam and Sileru Dam)

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	372.27	87.00	134.91	30.57	236.99	181.54	175.58	198.04	185.01	123.58	137.70	191.72	111.56	246.16	172.33
	II	377.70	467.30	172.21	59.63	333.97	163.24	178.92	166.93	368.76	129.18	208.37	261.21	128.46	958.86	283.91
	III	543.93	206.12	360.86	97.71	263.21	207.39	190.17	825.95	354.68	133.53	294.48	233.87	157.29	754.38	330.26
JUL	I	624.60	964.48	160.18	201.32	376.94	224.29	547.75	744.69	463.78	139.17	394.99	273.36	266.57	600.79	427.35
	II	848.48	779.97	263.48	831.09	570.44	253.81	224.45	771.57	425.19	370.82	592.22	321.96	220.24	1911.52	598.95
	III	1469.07	958.35	170.45	1460.74	979.13	604.71	789.26	529.24	1243.60	385.23	2255.27	404.70	1413.45	3953.08	1186.88
AUG	I	776.73	857.36	482.31	890.07	1141.26	922.06	1046.10	1447.92	1731.85	791.53	2668.76	657.38	2117.62	1454.47	1213.24
	II	1108.37	1084.29	664.86	961.79	1308.40	678.60	2686.68	1477.52	1677.85	1412.14	840.98	534.95	1308.67	1783.37	1252.03
	III	1672.02	1534.46	722.38	1291.77	1037.85	610.63	1378.19	895.39	955.14	1531.79	938.60	590.82	1635.48	1153.50	1139.14
SEP	I	1144.28	839.30	606.01	1155.93	685.72	365.13	774.68	1783.14	650.09	656.23	2575.81	1705.44	1766.79	738.76	1103.38
	II	603.47	628.48	434.35	647.58	544.76	2196.53	1884.16	892.91	944.92	297.31	1876.32	761.09	1846.17	750.95	1022.07
	III	468.80	380.56	250.18	648.87	482.13	1613.06	2116.37	1295.93	490.77	265.87	722.05	786.59	1101.20	806.88	816.38
OCT	I	293.19	376.11	177.58	1034.25	744.60	377.31	898.23	2420.94	288.26	529.97	378.37	275.22	593.46	878.44	661.85
	II	213.75	281.56	158.36	567.84	412.90	353.48	507.54	797.67	249.48	251.39	397.83	275.40	334.99	632.18	388.17
	III	166.06	237.99	106.84	380.91	325.72	535.73	359.67	666.37	226.56	208.94	387.38	148.70	259.23	1165.20	369.66
NOV	I	159.79	215.07	73.76	321.24	274.61	430.34	424.14	385.92	200.45	200.19	369.24	119.96	484.39	567.45	301.90
	II	169.38	210.01	67.83	218.11	289.96	264.06	361.51	332.70	220.70	174.24	386.66	135.51	307.80	350.38	249.20
	III	144.95	213.21	70.30	203.07	224.39	210.15	228.74	277.13	205.36	167.25	272.31	85.51	197.07	344.68	203.15
DEC	I	153.33	186.20	60.31	216.94	198.89	214.74	173.63	285.70	180.08	141.51	229.93	73.27	178.63	283.10	184.02
	II	141.54	200.82	62.26	269.27	175.58	215.26	184.62	255.97	150.03	135.55	224.16	77.64	157.00	211.74	175.82
	III	140.88	201.25	59.62	293.65	188.52	236.45	188.31	259.53	174.08	113.38	230.84	93.98	172.34	190.44	234.19
JAN	I	115.10	161.38	49.49	221.66	189.21	193.68	162.44	198.87	168.25	63.56	202.39	109.41	176.17	188.42	193.42
	II	113.11	158.49	46.66	211.13	142.67	164.61	153.73	179.14	174.77	50.38	211.40	96.13	150.37	187.28	146.64
	III	101.96	166.95	94.85	231.54	182.30	173.99	167.64	202.05	176.00	67.25	214.10	106.20	149.03	170.24	151.29
FEB	I	102.88	152.18	114.50	221.13	140.97	182.58	145.99	186.81	169.19	70.36	202.02	93.16	116.02	120.53	141.27
	II	135.02	163.67	159.57	212.18	124.12	181.30	143.96	187.11	153.90	88.62	190.18	92.87	147.30	149.71	174.38
	III	120.81	129.40	137.55	203.93	133.84	181.11	107.47	139.33	140.21	69.65	142.11	82.60	129.72	110.04	130.06
MAR	I	151.86	161.92	157.19	238.80	161.60	188.31	202.41	191.67	180.80	81.02	178.40	121.81	152.31	152.79	204.47
	II	108.20	217.54	165.40	295.08	151.51	185.53	184.90	193.22	181.40	58.18	165.11	115.71	189.41	192.47	210.20
	III	124.62	238.69	170.14	285.79	149.98	200.87	203.23	242.24	198.00	57.25	275.32	138.48	230.07	172.28	236.16
APR	I	80.73	204.32	92.02	232.55	141.50	202.08	185.37	200.10	155.79	95.37	252.05	131.26	197.19	176.18	165.11
	II	56.46	192.70	94.01	246.95	119.43	213.93	200.17	169.43	150.89	125.10	225.43	112.60	223.15	181.77	173.40
	III	81.45	146.27	77.22	193.60	103.89	247.24	172.82	157.33	138.42	125.72	220.21	92.50	265.47	187.36	192.08
MAY	I	68.26	111.95	54.73	187.77	105.88	186.64	156.56	171.56	136.33	109.46	197.66	123.40	249.19	169.66	183.57
	II	89.02	118.92	42.86	191.37	149.12	169.03	164.87	175.29	91.67	194.90	183.48	120.40	221.25	245.28	168.58
	III	90.70	159.43	40.55	253.05	189.37	176.22	202.40	152.59	94.62	124.15	175.81	135.49	279.58	248.87	196.27
Inflow (MCM) =		13133	13394	6756	15209	12981	13706	17873	19458	13697	9540	19418	9680	17635	22389	14981

5.13.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable year and the corresponding year flows are given in **Table 5.157** and **Table 5.158** respectively.

Table 5.157: Computation of 90% and 50% Dependable Year for Konta Project

m	m/(n+1)	Runoff in descending order (MCM)	Dependable Year	
1	0.06	22389	2013-2014	
2	0.13	19458	2007-2008	
3	0.19	19418	2010-2011	
4	0.25	17873	2006-2007	
5	0.31	17635	2012-2013	
6	0.38	15209	2003-2004	
7	0.44	14981	2014-2015	
8	**0.50**	**13706**	**2005-2006**	**50% Dependable**
9	0.56	13697	2008-2009	
10	0.63	13394	2001-2002	
11	0.69	13133	2000-2001	
12	0.75	12981	2004-2005	
13	0.81	9680	2011-2012	
14	**0.88**	**9540**	**2009-2010**	**90% Dependable**
15	0.94	6756	2002-2003	

Table 5.158: 90% and 50% Dependable year flows for Konta Project

		90% Dependable (cumec)	50% Dependable (cumec)
Period		**2009-2010**	**2005-2006**
Jun	**I**	143.03	210.11
	II	149.51	188.93
	III	154.55	240.04
Jul	**I**	161.08	259.60
	II	429.19	293.76
	III	405.34	636.27
Aug	**I**	916.12	1067.20
	II	1634.42	785.41
	III	1611.73	642.49
Sep	**I**	759.53	422.60
	II	344.11	2542.28
	III	307.72	1866.97
Oct	**I**	613.39	436.70
	II	290.96	409.12
	III	219.84	563.69
Nov	**I**	231.70	498.08
	II	201.67	305.63
	III	193.58	243.23
Dec	**I**	163.79	248.55
	II	156.88	249.14
	III	119.30	248.79
Jan	**I**	73.57	224.17
	II	58.31	190.52
	III	70.76	183.08
Feb	**I**	81.44	211.32
	II	102.56	209.84
	III	100.77	262.02
Mar	**I**	93.78	217.95
	II	67.34	214.73
	III	60.23	211.35
Apr	**I**	110.38	233.88
	II	144.79	247.61
	III	145.51	286.16
May	**I**	126.69	216.02
	II	225.57	195.63
	III	130.63	185.42
Inflow (MCM) =		**9540**	**13706**

5.13.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam sites of Konta, is given in the following section.

5.13.5.1 EAC of Sabari Dam

The EAC curve and the table showing the different values are given in **Figure 5.75** and **Table 5.159** respectively.

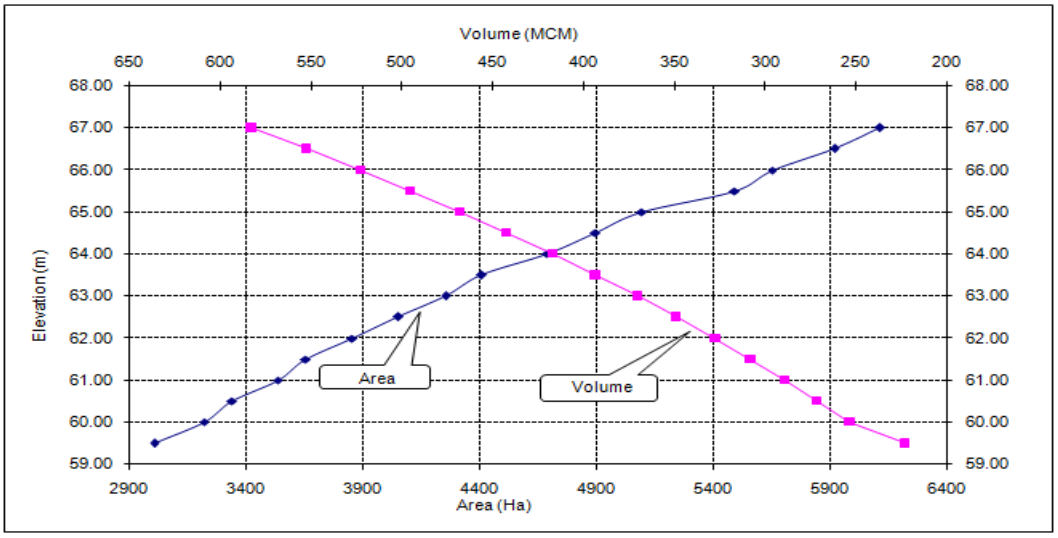


Figure 5.75: EAC curve of Sabari Dam

Table 5.159: EAC data of Sabari Dam

Elevation (m)	Area (Sq. m)	Area (ha.)	Cumulative Volume (m3)	Cumulative Volume (MCM)
59.50	30069082.25	3006.91	223080519.50	223.08
60.00	32189082.25	3218.91	253688519.50	253.69
60.50	33378546.79	3337.85	271367292.90	271.37
61.00	35357546.79	3535.75	289046066.30	289.05
61.50	36531647.50	3653.16	308311890.10	308.31
62.00	38531647.50	3853.16	327577713.80	327.58
62.50	40515203.44	4051.52	348845315.80	348.85
63.00	42535203.94	4253.52	370112917.70	370.11
63.50	44082366.49	4408.24	393554201.00	393.55
64.00	46882566.49	4688.26	416995484.20	417.00
64.50	48930848.43	4893.08	442463908.40	442.46
65.00	50936848.43	5093.68	467932332.70	467.93
65.50	54891558.10	5489.16	495378111.70	495.38
66.00	56491558.10	5649.16	522823890.80	522.82
66.50	59173584.81	5917.36	552910683.20	552.91
67.00	61133584.81	6113.36	582997475.60	583.00

5.13.5.2 EAC of Sileru Dam

The EAC curve and the table showing the different values are given in **Figure 5.76** and **Table 5.160** respectively.

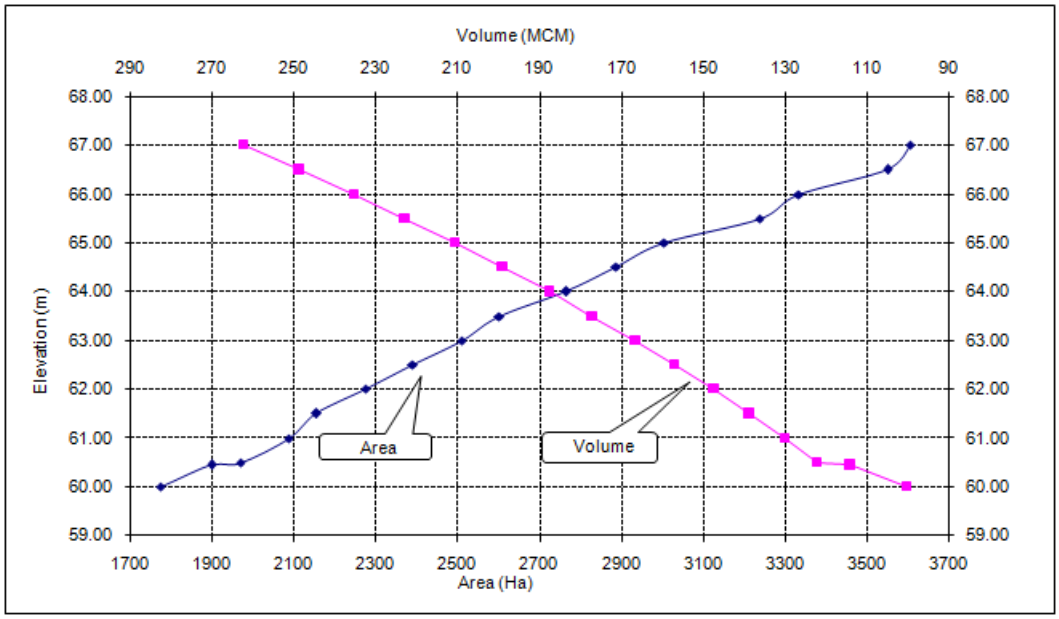


Figure 5.76: EAC curve of Sileru Dam

Table 5.160: EAC data of Sileru Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
60.00	17740758.53	1774.08	100086233.80	100.09
60.45	18991558.53	1899.16	114159833.80	114.16
60.50	19693342.61	1969.33	122115281.80	122.12
61.00	20860952.61	2086.10	130070729.80	130.07
61.50	21553672.03	2155.37	138740350.50	138.74
62.00	22733672.03	2273.37	147409971.20	147.41
62.50	23903970.03	2390.40	156980392.10	156.98
63.00	25095770.32	2509.58	166550813.00	166.55
63.50	26008596.23	2600.86	177099390.40	177.10
64.00	27660714.23	2766.07	187647967.90	187.65
64.50	28869200.57	2886.92	199108758.80	199.11
65.00	30052740.57	3005.27	210569549.70	210.57
65.50	32386019.28	3238.60	222920150.30	222.92
66.00	33330019.28	3333.00	235270750.80	235.27
66.50	35502415.04	3550.24	248809807.40	248.81
67.00	36068815.04	3606.88	262348864.00	262.35

5.13.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk

5.13.6.1 Computation of Design flood

At present, no observed flood peak data are available at the project sites. However, flood peaks are available at the downstream location namely, Konta G&d site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula which will then be subjected to frequency analysis. The multiplying factors as used for transferring the peak flows from Konta G&D site to the project site is as given below:

$$\text{Factor} = \left(\frac{A_{Sabari}}{A_{Konta}}\right)^{\frac{3}{4}} = 0.86$$

$$\text{Factor} = \left(\frac{A_{Sileru}}{A_{Konta}}\right)^{\frac{3}{4}} = 0.27$$

Using the above multiplying factors to the peak flows at the Konta G&D site and assuming an instantaneous peak factor of 30%, the final peak flows at the project site are derived. The final peak flows as derived are given in **Table 5.161** and **Table 5.162**. Peak discharge for year 2014 is not available at G&D site and hence not shown in tables below.

Table 5.161: Final Peak Flows at G&D and Sabari Dam Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2000	5563	7233	6223
2001	3291	4279	3682
2002	1745	2268	1952
2003	7512	9765	8403
2004	5804	7545	6492
2005	8854	11510	9904
2006	12181	15836	13626
2007	6924	9001	7745

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2008	4193	5451	4690
2009	2000	2600	2237
2010	7021	9127	7854
2011	3494	4542	3908
2012	5730	7448	6409
2013	6201	8061	6936

Table 5.162: Final Peak Flows at G&D and Sileru Dam Site

Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
2000	5563	7233	1948
2001	3291	4279	1152
2002	1745	2268	611
2003	7512	9765	2630
2004	5804	7545	2032
2005	8854	11510	3100
2006	12181	15836	4265
2007	6924	9001	2424
2008	4193	5451	1468
2009	2000	2600	700
2010	7021	9127	2458
2011	3494	4542	1223
2012	5730	7448	2006
2013	6201	8061	2171

5.13.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam site are given below in the following **Table 5.163**.

Table 5.163: Statistical Parameters of Peak Flows at project sites

Parameters	Values	
	Sabari	Sileru
Mean(Xm)	6433	2013
Variance	9721400	952286
SD (Sx)	3117.92	976
Skewness	0.65	0.65
Kurtosis	0.90	0.90
No. of Data	14	14

5.13.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in **Table 5.164**.

The detailed procedure for Gumbel distribution method for Konta dam site has been shown in **Annexure-12 & 13**.

Table 5.164: Detail of different year Return Period Flood (m^3/s) at respective dam sites

S No.	Return Period (Years)	Flood (cumec) at Sabari dam	Flood (cumec) at Sileru Dam
1	2	5990	1875
2	5	9262	2899
3	10	11428	3577
4	20	13507	4227
5	25	14166	4434
6	50	16196	5069
7	100	18212	5700
8	500	22870	7158

Annexure-12 (Flood Frequency Analysis for Sabari Dam)

DESIGN FLOOD-Sabari

CA at G&D = 19550 | CA = 16000

Conversion factor = 0.86

Instantaneous Peak = 30%

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	2000	5563	7233	6223	8.74
2	2001	3291	4279	3682	8.21
3	2002	1745	2268	1952	7.58
4	2003	7512	9765	8403	9.04
5	2004	5804	7545	6492	8.78
6	2005	8854	11510	9904	9.20
7	2006	12181	15836	13626	9.52
8	2007	6924	9001	7745	8.95
9	2008	4193	5451	4690	8.45
10	2009	2000	2600	2237	7.71
11	2010	7021	9127	7854	8.97
12	2011	3494	4542	3908	8.27
13	2012	5730	7448	6409	8.77
14	2013	6201	8061	6936	8.84

	X-STAT	Ln-STAT
Mean(X_m)	6433	8.64
Variance	9721400	0.299
SD (Sx)	3117.92	0.547
Skewness	0.65	-0.65562
Kurtosis	0.90	0.05464
No. of Data	14	

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 14

Reduced mean = Y_n = 0.520 } From Table (Interpolated)

Reduced Std. Dev = S_n = 1.08 } From Table (Interpolated)

$f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

Se = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	90% CONFIDENCE INTERVAL (X_{cl} Values in cumec) Lower Confidence Limit	Upper Confidence Limit
1	2	**5990**	0.367	-0.142	0.915	762.577	1254.439	4735	7244
2	5	**9262**	1.500	0.907	1.756	1463.660	2407.721	6854	11670
3	10	**11428**	2.250	1.602	2.430	2025.201	3331.455	8097	14760
4	20	**13507**	2.970	2.269	3.100	2583.359	4249.626	9257	17756
5	25	**14166**	3.199	2.480	3.315	2762.516	4544.338	9621	18710
6	50	**16196**	3.902	3.131	3.982	3318.290	5458.588	10738	21655
7	100	**18212**	4.600	3.778	4.649	3873.824	6372.440	11840	24585
8	500	**22870**	6.214	5.272	6.199	5165.451	8497.167	14373	31367

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	5990
2	5	9262
3	10	11428
4	20	13507
5	25	14166
6	50	16196
7	100	18212
8	500	22870

Annexure-13 (Flood Frequency Analysis for Sileru Dam)

DESIGN FLOOD-Sileru

CA at G&D = 19550 | CA = 3400

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats
1	2000	5563	7233	1948	7.57
2	2001	3291	4279	1152	7.05
3	2002	1745	2268	611	6.41
4	2003	7512	9765	2630	7.87
5	2004	5804	7545	2032	7.62
6	2005	8854	11510	3100	8.04
7	2006	12181	15836	4265	8.36
8	2007	6924	9001	2424	7.79
9	2008	4193	5451	1468	7.29
10	2009	2000	2600	700	6.55
11	2010	7021	9127	2458	7.81
12	2011	3494	4542	1223	7.11
13	2012	5730	7448	2006	7.60
14	2013	6201	8061	2171	7.68

Conversion factor = 0.27

Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	2013	7.48
Variance	952286	0.299
SD (Sx)	976	0.547
Skewness	0.65	-0.65562
Kurtosis	0.90	0.05464
No. of Data	14	

Parameters	Values

$X_T = X_m + K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 14

Reduced mean = Y_n = 0.520 } From Table (Interpolated) $f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Std. Dev S_n = 1.08 }

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

$X_T = X_m+K.S_x$

Confidence Band = $f_{(C)}.S_e$

$S_e = b.Sx/\sqrt{n}$

$b = \sqrt{(1+1.3K+1.1K^2)}$

$X_{cl} = X_T \pm f_{(C)}.Se$

90% CONFIDENCE INTERVAL

(X_{cl} Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	**1875**	0.367	-0.142	0.915	238.673	392.617	1482	2267
2	5	**2899**	1.500	0.907	1.756	458.099	753.573	2145	3652
3	10	**3577**	2.250	1.602	2.430	633.851	1042.685	2534	4620
4	20	**4227**	2.970	2.269	3.100	808.545	1330.056	2897	5557
5	25	**4434**	3.199	2.480	3.315	864.617	1422.296	3011	5856
6	50	**5069**	3.902	3.131	3.982	1038.565	1708.439	3361	6778
7	100	**5700**	4.600	3.778	4.649	1212.437	1994.458	3706	7695
8	500	**7158**	6.214	5.272	6.199	1616.693	2659.459	4498	9817

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	1875
2	5	2899
3	10	3577
4	20	4227
5	25	4434
6	50	5069
7	100	5700
8	500	7158

5.14 Hydrology of Tamankal HydroelectricProject

5.14.1 Introduction

5.14.1.1 General

The present project, Tamankal, envisages harnessing water from the River Krishna. It is situated in Raichur district of the Indian state of Karnataka. It is located in Tamankal mandal of Lingsugur revenue division. The project is proposed to be of Storage type with the multifunction of irrigation and power.

5.14.1.2 Description of Dam Sites

The catchment area of the dam site is to be 48,104 km^2. A plan of the catchment area map of the present scheme comprising the dam site, along with the G&D site of Huvinhedgi is delineated from DEM as shown in **Figure 5.77**.

Table 5.165: Details of Catchment Area

Name of the Dam Sites	Location (Latitude , Longitude)	Catchment Area (km^2)
Tamankal	76°20'39.7"E 16°13'28.5"N	48,104
Forebay	76°25'00.5"E 16°14'37.4"N	100

5.14.1.3 Description of G&D Site

Huvinhedgi G&D site is situated in the Raichur district of Karnataka at 16° 29’ 27” N, 76° 55’ 28” E,. Catchment area of the G&D site is around 55,750 km^2.

5.14.1.4 The River System

The Krishna river originates in the Western Ghats near Mahabaleshwar at an elevation of about 1,300 metres, in the state of Maharashtra in central India. It is one of the longest rivers in India, The Krishna river is around 1,400 km in length (282 KM in Maharashtra). The Krishna river's source is at Mahabaleswar near the Jor village in the extreme north of Wai Taluka, Satara District, Maharashtra in the west and empties into the Bay of Bengal at Hamasaladeevi in Andhra Pradesh, onthe east coast It flows through the state of Karnataka before entering

Telangana State. The delta of this river is most fertile regions in India and was the home to ancient Satavahana and IkshvakuSun Dynasty kings. Vijayawada is the largest city on the River Krishna It causes heavy soil erosion during the monsoon floods.

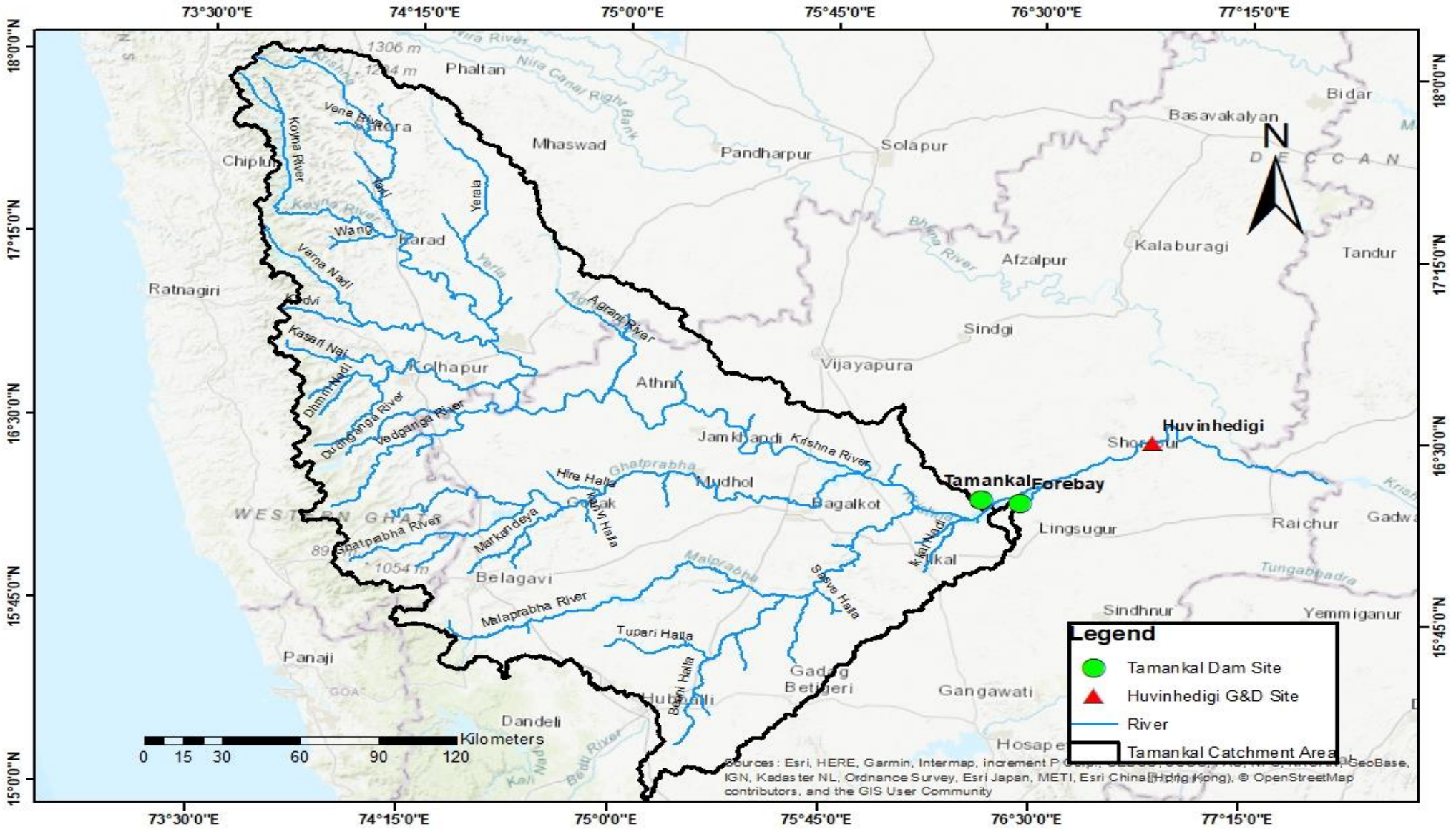


Figure 5.77: Catchment Area of Project Locations of Dams and G&D site

5.14.2 Water Availability Studies

5.14.2.1 Data Availability

The discharge data at the Central Water Commission (CWC) G&D site, namely Huvinhedgi (Catchment Area=55,150 km^2) which is upstream of the project site along the Krishna River, is available from 1990 to 2015 and that can be downloaded from India WRIS site. The G&D site lies in the Raichur district of Karnataka.

Generally, 25-year flow series data is required for a storage project. Thus, flow series for the period 1990-2015 has been considered for generating the flow at the present project site.

5.14.2.2 Rainfall data

Average daily rainfall (in mm) have been calculated at each grid point (as can been seen from **Figure 5.78**) within the boundary of the Huvinhedgi G&D site and Narayanpur dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus, in **Figure 5.78**, 74 grid points is considered to assess the catchment rainfall for Huvinhedgi G&D site and 66 grid points have been considered for the assessment of rainfall in Narayanpur dam site and Tamankal proposed dam site. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations

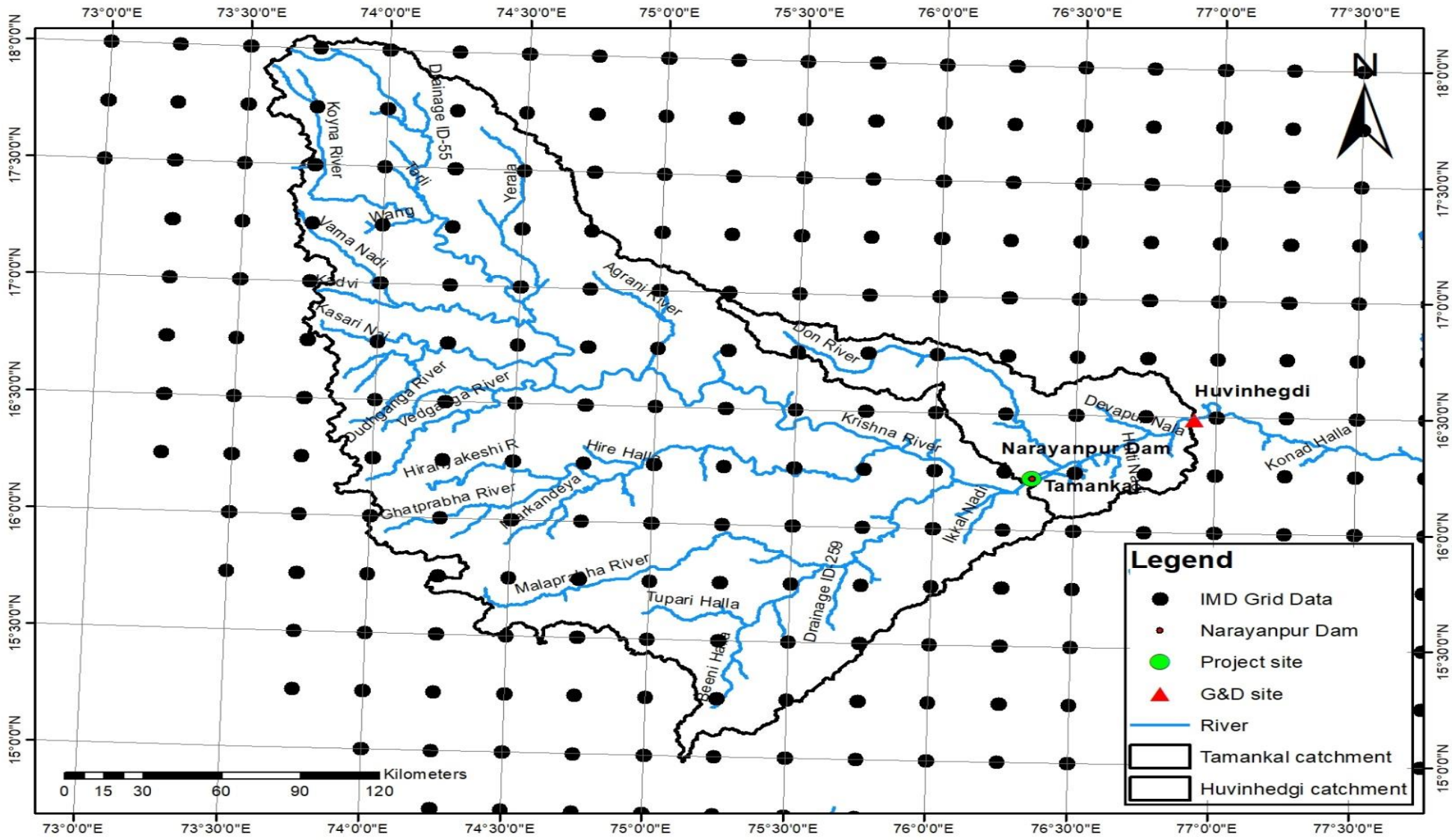


Figure 5.78: IMD GRID Rainfall Data for Project site and Dam site

a) Average Annual Rainfall

The computed average annual rainfall for the G&D site and dam siteare given in **Table 5.166**. 10-daily rainfall variation for the G&D site and the dam sites are shown in **Table 5.167**, **Table 5.168** and **Table 5.169** respectively.

Table 5.166: Average Annual Rainfall

Year	Rainfall in mm		
	Huvinhedgi	Tamankal	Narayanpur Dam
1990-91	648	661	661
1991-92	759	784	784
1992-93	661	679	679
1993-94	846	881	881
1994-95	762	794	794
1995-96	623	623	623
1996-97	835	837	837
1997-98	809	849	849
1998-99	899	882	882
1999-20	689	710	710
2000-01	633	642	642
2001-02	637	638	638
2002-03	511	518	518
2003-04	500	501	501
2004-05	714	749	749
2005-06	1800	1915	1915
2006-07	764	806	806
2007-08	927	946	946
2008-09	651	671	671
2009-10	994	1004	1004
2010-11	871	885	885
2011-12	718	750	750
2012-13	676	695	695
2013-14	811	815	815
2014-15	804	828	828
AVERAGE (mm)	782	803	803

Table 5.167: 10 Daily Rainfall (in mm) of Huvinhedgi G&D Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	2.06	17.53	2.02	2.6	6.9	0.21	4.76	3.57	2.61	1.77	5.4	1.21	4.9	0.83	7.64	2.45	4.76	4.81	3.42	3.38	2.46	5.73	1.58	5.59	3.73
	II	5.92	2.28	4.59	9	4.44	1.02	9.99	5.53	2.85	4.64	2.08	4.32	4.98	2.49	8.24	4.91	4.13	1.48	2.4	5.77	11.77	5.54	4.28	4.47	1.55
	III	3.53	8.2	3.83	0.67	5.64	4.59	0.45	7.19	6.54	6.3	1.38	0.75	3.27	5.82	1.61	15.39	6.98	19.46	2.27	1.09	1.57	2.78	3.62	2.46	0.37
JUL	I	4.21	4.34	1.8	2.07	3.25	1.29	2.55	7.18	7.09	2.13	4.01	5.65	0.51	2.35	1.88	14.33	6.57	9.77	1.64	8.06	2.35	5.08	2.94	3.21	3.17
	II	4.34	6.56	5.42	6.77	11.36	7.08	2.68	1.86	2.3	7.1	7.35	1.61	2.19	2.74	2.15	11.1	2.66	1.98	0.74	9.81	2.86	7.44	4.02	7.02	5.49
	III	3.27	7.1	5.47	5.51	3.93	5.98	7.89	6.7	6.24	6.1	0.23	1.94	1.68	3.32	4.02	30.56	8.2	2.56	3.59	4.56	12.28	5.04	5.3	7.58	10.14
AUG	I	3.55	3.34	2.52	3.8	0.84	2.28	2.61	9.34	2.99	2.85	5.35	4.95	7.22	2.12	10.37	19.56	9.04	8.87	6.22	0.6	2.33	4.44	6.59	3.82	4.29
	II	8.36	4.71	8.72	3.97	2.95	1.08	2.54	3.39	3.2	1.27	2.93	2.62	4.39	1.38	4.01	12.14	5.28	2.06	6.44	4.57	4.58	4.68	2.12	2.79	3.54
	III	2.06	1.98	2.64	4.51	4.85	2.82	5.32	6	8.12	2.07	3.97	1.21	0.76	3.48	0.74	6.33	0.71	5.1	2.23	6.16	8.53	7.08	2.57	1.09	12.84
SEP	I	1.99	0.12	3.16	2.44	3.55	3.35	5.57	0.83	6.31	2.07	1.16	0.53	1.92	1.06	6.01	12.24	2.9	2.98	10.33	4.32	3.44	7.89	6.34	6.4	3.46
	II	0.18	3.52	1.16	1.23	0.17	6.1	4.82	0.52	2.84	0.62	4.05	6.21	2.16	1.22	2.42	8.84	7.29	12.36	3.78	3.75	2.33	1.43	0.79	11.23	3.3
	III	1.79	4.96	4.32	3.7	0.89	4.19	5.98	6.24	9.81	7.43	9.19	12.7	0.83	2.75	6.66	12.08	3.6	3.11	2.59	12.52	6.91	1.24	2.84	1.11	1.91
OCT	I	4.02	4.86	4.39	9.58	8.87	5.2	12.98	1.7	9.14	10.17	4.59	8.58	0.99	7.05	3.96	3.07	4.42	0.72	3.52	17	3.34	1.97	10.79	1.42	4.04
	II	0.86	0.58	0.68	13.65	4.21	9	4.22	0.84	7.85	5.36	6.1	3.91	10.7	0.59	0.87	10.91	0.34	0.62	1.81	1.06	3.33	7.61	0.01	1.49	0.71
	III	4.1	0.06	1.12	1.46	4.28	0.82	3.58	4.17	0.44	2.57	1.3	0.05	0.11	0.9	0.09	1.52	0.41	1.79	0.73	0.02	1.91	0.49	1.71	5.2	3.56
NOV	I	0.68	0.21	0.07	0.07	0.2	0	0.42	0.22	1.68	0.01	0.64	0.01	0	0.54	0.27	0.08	2.76	0.51	0.03	0.76	4.52	0.01	3.55	0	0
	II	1.71	0.07	6.77	1.11	0.06	0.06	0.05	4.94	0.07	0	0	0.57	0.39	0.01	0.06	0	0.02	0.03	0.83	5.93	1.89	0	0.01	0	2.91
	III	0.17	0.13	0.54	0.06	0	1.6	0.18	1.44	0	0	0	0.01	0	0	0	0	0.73	0.07	1.95	0.12	1.22	0.17	0	0.48	0
DEC	I	0	0	0	3.45	0	0	0	2.74	0	0	0	0	0	0	0	0.04	0	0.1	0.07	0	0.14	0	0	0.06	0
	II	0	0	0	0.11	0	0	0.12	0.5	0	0	0	0	0	0	0	0	0	0.03	0	0.24	0.01	0	0	0	1.6
	III	0	0	0	0	0	0	0	0	0	0	0.05	0.07	0	0.1	0	0.08	0	0.18	0	0.96	0	0	0.12	0	0
JAN	I	0	0	0	0	0.63	0	0	0	0	0	0.06	0.17	0	0	0	0	0	0	0	0.29	0	0	0.01	0	0.11
	II	0	0	0	0.4	1.81	0	0.41	0	0	0.05	0	0	0.01	0	0	0	0.01	0	0	2.43	0	0	0	0	0
	III	0	0	0	0.08	0	0	0.01	0	0	0	0	0	0.01	0.1	0.13	0	0.05	0	0	0	0	0	0	0	0
FEB	I	0	0	0	0	0	0	0	0	0.37	0	0	0.4	0.18	0.01	0.09	0	0.06	0	0	0	0	0	0.04	0	0
	II	0	0	0	0.02	0	0	0	0	0	0	0	0.26	0	0	0	0	0	0.63	0	0.03	0	0	0.22	0.02	0
	III	0	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0	0	0.1	0	0	0.01	0.28	0	0.01	0.64	0
MAR	I	0.01	0	0.53	0	0.01	0	0	0	0	0	0	0	0.07	0	0.12	0.78	0.02	0.01	0	0	0	0	0	1.53	2.22
	II	0.03	0	0.1	0	0.2	0.01	0.2	0	0	0	0.02	0.04	0.36	0	0	0.05	0	1.03	0.29	0.11	0	0	0.26	0.47	0.16
	III	0	0.01	0	0.09	0.11	0.02	0.67	0.02	0.07	0.03	0	0.02	0.52	0.02	0	0.02	0.08	6.75	0.71	0	0.01	0	0	0	0.08
APR	I	2.2	0	0	1.3	0.18	0.06	0.07	0.04	0.01	0.13	0.46	1.22	0.22	0.81	0.16	0.04	0.05	0.89	0.77	0	0.2	0.34	0.03	0.5	0.45
	II	0.82	0.25	0.63	2.42	0.18	1.46	0.13	0.07	0.03	0.26	0.7	0.4	1.03	0	3.6	0.44	1.14	0.32	0.27	1.02	1.75	0.43	0.01	1.26	2.13
	III	1.2	0.54	1.01	0.31	0.69	0.09	2.12	0.21	0.13	0.13	0.13	0.46	0.92	0.75	1.14	0.04	0.27	0.36	0.44	0.83	0.58	0.94	2.39	0.99	0.62
MAY	I	0.18	0.74	0.7	0.3	1.4	0	0.99	1.65	1.36	1.63	0.48	1.19	0.41	1.51	1.12	1.12	1	0.17	0.54	0.57	1.02	0.1	1.1	4.94	1.55
	II	2.65	1.39	0.86	0.05	1.26	0.08	0.46	1.84	2.26	0.57	0.1	1.46	0.06	3.68	0	0.2	0.03	0.16	3.63	0.25	0.82	0.14	0.15	1.66	1.77
	III	3.6	1.41	1.89	2.49	1.84	2.69	0	0.44	3.73	2.14	0.94	0.81	0	3.3	3.17	7.13	1.71	1.97	2.82	1.79	2.2	0	2.97	2.22	1.85
Yearly Rainfall (mm)		648	759	661	846	762	623	835	809	899	689	633	637	511	501	713	1800	764	927	651	994	871	718	676	811	804

Table 5.168: 10 Daily Rainfall (in mm) of Tamankal Dam Site

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	1.99	18.86	2.11	2.88	7.3	0.17	4.43	3.47	2.71	1.38	5.76	1.19	4.94	0.92	8.1	2.61	5.03	4.64	3.66	3.62	2.4	5.76	1.71	5.57	3.97
	II	5.54	1.95	4.88	9.91	4.93	1.08	10.27	5.76	2.81	4.93	2.01	4.69	5.46	2.76	9.15	5.18	3.99	1.6	2.65	5.52	12.29	6.11	4.61	4.86	1.62
	III	3.9	7.59	4.05	0.74	6.27	4.34	0.51	8.02	6.81	7.02	1.13	0.8	3.57	6.1	1.68	16.94	7.53	19.86	2.53	0.94	1.49	3.04	3.92	2.5	0.38
JUL	I	4.55	3.82	1.44	2.28	3.45	1.3	2.64	7.65	7.84	2.11	3.91	6.31	0.57	2.19	1.88	15.83	7.35	10.95	1.78	8.79	2.33	5.21	3.09	3.19	2.96
	II	4.71	7.19	5.72	7.56	12.56	7.78	2.73	2.08	2.3	7.87	8.03	1.79	1.84	2.66	2.06	11.24	2.94	2.14	0.82	10.84	2.92	7.95	3.89	7.24	6.01
	III	3.6	7.91	6.07	5.5	4.33	6.08	8.73	7.29	6.2	6.75	0.26	1.86	1.8	3.58	4.01	33.44	9.07	2.41	3.58	5.07	13.11	4.88	5.55	8.12	11.02
AUG	I	3.28	3.44	2.47	4.14	0.94	2.45	2.88	10.32	2.94	3.03	5.06	4.95	7.36	1.83	11.38	21.58	10.06	9.71	6.66	0.64	2.59	4.67	7.23	4.13	4.73
	II	8.64	5.19	9.37	4.36	2.92	0.95	1.77	3.56	3.04	1.22	3.11	2.76	4.83	1.52	4.43	12.89	5.89	2.13	7.16	4.46	4.23	4.93	2.27	2.57	3.51
	III	2.28	2.18	2.76	4.31	5.12	2.53	4.69	6.61	8.14	1.72	3.9	1.16	0.81	3.27	0.83	6.24	0.73	4.82	1.9	6.14	8.15	7.25	2.3	1.05	12.49
SEP	I	2.06	0.13	3.32	2.38	3.95	3.73	5.29	0.71	5.8	1.89	1.2	0.53	1.78	1.15	5.94	12.69	3.05	2.72	9.96	3.79	3.56	8.63	6.27	5.84	3.65
	II	0.18	3.53	0.96	1.13	0.18	6.03	4.48	0.34	2.48	0.65	3.71	5.79	2.24	1.19	2.32	9.65	6.96	12.52	4.06	3.79	2.26	1.47	0.77	11.24	2.94
	III	1.27	5.1	4.61	3.37	0.93	4.24	6.22	6.23	9	7.6	9.66	12.57	0.83	2.15	6.95	13.28	3.6	3.26	2.67	11.98	7.06	1.15	2.9	1.15	1.98
OCT	I	3.99	5.13	4.49	9.16	8.39	5.34	13.49	1.62	9.07	10.93	4.42	7.95	0.9	7.42	4.08	3.24	4.55	0.75	3.55	16.08	3.44	2.06	11.08	1.49	4.23
	II	0.65	0.61	0.72	14.49	4.14	8.67	4.39	0.91	7.16	5.02	6.42	3.64	10.05	0.66	0.7	10.65	0.34	0.64	1.85	1.14	3.4	8.03	0.01	1.42	0.78
	III	4.36	0.06	1.21	1.61	4.1	0.78	3.68	4.1	0.47	2.53	1.24	0.01	0.12	0.89	0.09	1.39	0.32	1.71	0.65	0.02	1.88	0.52	1.67	4.84	3.47
NOV	I	0.72	0.07	0.07	0.06	0.12	0	0.39	0.24	1.8	0.02	0.66	0.01	0.01	0.6	0.29	0.08	2.59	0.48	0.04	0.81	4.65	0.02	3.64	0	0
	II	1.88	0.08	5.92	1.24	0.06	0.07	0.05	5.01	0.06	0	0	0.58	0.41	0.01	0.06	0	0.02	0.03	0.81	6.25	1.84	0	0.01	0	3.12
	III	0.19	0.14	0.55	0.07	0	1.68	0.12	1.46	0	0	0	0.01	0	0	0	0	0.82	0.08	2.09	0.14	1.34	0.19	0	0.5	0
DEC	I	0	0	0	3.46	0	0	0	2.79	0	0	0	0	0	0	0	0.03	0	0.11	0.07	0	0.13	0	0	0.07	0
	II	0	0	0	0.12	0	0	0.13	0.45	0	0	0	0	0	0	0	0	0	0.03	0	0.27	0.01	0	0	0	1.72
	III	0	0	0	0	0	0	0	0	0	0	0.05	0.08	0	0.09	0	0	0	0.2	0	1.02	0	0	0.13	0	0.01
JAN	I	0	0	0	0	0.68	0	0	0	0	0	0.07	0.15	0	0	0	0	0	0	0	0.32	0	0	0.01	0	0.09
	II	0	0	0	0.34	1.56	0	0.36	0	0	0.05	0	0	0.01	0	0	0	0.02	0	0	2.43	0	0	0	0	0
	III	0	0	0	0.09	0	0	0.01	0	0	0	0	0	0.01	0.08	0.09	0	0.05	0	0	0	0	0	0	0	0
FEB	I	0	0	0	0	0	0	0	0	0.38	0	0	0.42	0.2	0.01	0.07	0	0.07	0	0	0	0	0	0.02	0	0
	II	0	0	0	0	0	0	0	0	0	0	0	0.29	0	0	0	0	0	0.58	0	0.04	0	0	0.19	0.02	0
	III	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0.01	0	0.11	0	0	0.01	0.3	0	0.01	0.67	0
MAR	I	0	0	0.55	0	0.01	0	0	0	0	0	0	0	0.08	0	0.1	0.69	0.02	0	0	0	0	0	0	1.38	2.24
	II	0.02	0	0.12	0	0.18	0.01	0.17	0	0	0	0.02	0.05	0.24	0	0	0.03	0	1.11	0.33	0.11	0	0	0.27	0.5	0.16
	III	0	0.01	0	0.1	0.09	0.02	0.7	0.02	0.05	0.03	0	0.02	0.57	0.02	0	0.03	0.09	6.47	0.77	0	0.01	0	0	0	0.09
APR	I	2.3	0	0	1.36	0.18	0.06	0.03	0.04	0.01	0.14	0.44	1.34	0.25	0.86	0.16	0.05	0.05	0.86	0.84	0	0.2	0.38	0	0.48	0.44
	II	0.75	0.25	0.69	2.59	0.1	1.12	0.13	0.07	0.02	0.25	0.68	0.44	1.13	0	3.82	0.43	1.17	0.35	0.23	1.12	1.83	0.42	0.01	1.34	2.09
	III	1.2	0.54	1.1	0.35	0.74	0.06	2.16	0.16	0.13	0.15	0.12	0.5	0.94	0.78	1.2	0.05	0.3	0.4	0.45	0.89	0.61	0.84	2.47	0.94	0.62
MAY	I	0.15	0.73	0.76	0.33	1.51	0	0.98	1.69	1.44	1.69	0.51	1.26	0.46	1.35	1.21	1.15	1.1	0.19	0.54	0.61	0.98	0.11	1.17	4.8	1.68
	II	2.71	1.46	0.91	0.05	1.24	0.02	0.46	1.96	2.33	0.62	0.11	1.45	0.07	3.33	0	0.18	0.03	0.16	3.63	0.22	0.91	0.12	0.13	1.81	1.87
	III	3.77	1.32	1.92	2.72	1.92	2.62	0	0.48	3.36	2.02	1.04	0.77	0	3.53	3.36	7.14	1.57	1.96	2.84	1.91	2.07	0	2.95	2.23	1.99
Yearly Rainfall (mm)		661	784	680	881	795	623	837	849	882	710	642	638	518	501	748	1915	806	946	671	1004	885	750	695	814	828

Table 5.169: 10 Daily Rainfall (in mm) of Narayanpur Dam

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	1.99	18.86	2.11	2.88	7.3	0.17	4.43	3.47	2.71	1.38	5.76	1.19	4.94	0.92	8.1	2.61	5.03	4.64	3.66	3.62	2.4	5.76	1.71	5.57	3.97
	II	5.54	1.95	4.88	9.91	4.93	1.08	10.27	5.76	2.81	4.93	2.01	4.69	5.46	2.76	9.15	5.18	3.99	1.6	2.65	5.52	12.29	6.11	4.61	4.86	1.62
	III	3.9	7.59	4.05	0.74	6.27	4.34	0.51	8.02	6.81	7.02	1.13	0.8	3.57	6.1	1.68	16.94	7.53	19.86	2.53	0.94	1.49	3.04	3.92	2.5	0.38
JUL	I	4.55	3.82	1.44	2.28	3.45	1.3	2.64	7.65	7.84	2.11	3.91	6.31	0.57	2.19	1.88	15.83	7.35	10.95	1.78	8.79	2.33	5.21	3.09	3.19	2.96
	II	4.71	7.19	5.72	7.56	12.56	7.78	2.73	2.08	2.3	7.87	8.03	1.79	1.84	2.66	2.06	11.24	2.94	2.14	0.82	10.84	2.92	7.95	3.89	7.24	6.01
	III	3.6	7.91	6.07	5.5	4.33	6.08	8.73	7.29	6.2	6.75	0.26	1.86	1.8	3.58	4.01	33.44	9.07	2.41	3.58	5.07	13.11	4.88	5.55	8.12	11.02
AUG	I	3.28	3.44	2.47	4.14	0.94	2.45	2.88	10.32	2.94	3.03	5.06	4.95	7.36	1.83	11.38	21.58	10.06	9.71	6.66	0.64	2.59	4.67	7.23	4.13	4.73
	II	8.64	5.19	9.37	4.36	2.92	0.95	1.77	3.56	3.04	1.22	3.11	2.76	4.83	1.52	4.43	12.89	5.89	2.13	7.16	4.46	4.23	4.93	2.27	2.57	3.51
	III	2.28	2.18	2.76	4.31	5.12	2.53	4.69	6.61	8.14	1.72	3.9	1.16	0.81	3.27	0.83	6.24	0.73	4.82	1.9	6.14	8.15	7.25	2.3	1.05	12.49
SEP	I	2.06	0.13	3.32	2.38	3.95	3.73	5.29	0.71	5.8	1.89	1.2	0.53	1.78	1.15	5.94	12.69	3.05	2.72	9.96	3.79	3.56	8.63	6.27	5.84	3.65
	II	0.18	3.53	0.96	1.13	0.18	6.03	4.48	0.34	2.48	0.65	3.71	5.79	2.24	1.19	2.32	9.65	6.96	12.52	4.06	3.79	2.26	1.47	0.77	11.24	2.94
	III	1.27	5.1	4.61	3.37	0.93	4.24	6.22	6.23	9	7.6	9.66	12.57	0.83	2.15	6.95	13.28	3.6	3.26	2.67	11.98	7.06	1.15	2.9	1.15	1.98
OCT	I	3.99	5.13	4.49	9.16	8.39	5.34	13.49	1.62	9.07	10.93	4.42	7.95	0.9	7.42	4.08	3.24	4.55	0.75	3.55	16.08	3.44	2.06	11.08	1.49	4.23
	II	0.65	0.61	0.72	14.49	4.14	8.67	4.39	0.91	7.16	5.02	6.42	3.64	10.05	0.66	0.7	10.65	0.34	0.64	1.85	1.14	3.4	8.03	0.01	1.42	0.78
	III	4.36	0.06	1.21	1.61	4.1	0.78	3.68	4.1	0.47	2.53	1.24	0.01	0.12	0.89	0.09	1.39	0.32	1.71	0.65	0.02	1.88	0.52	1.67	4.84	3.47
NOV	I	0.72	0.07	0.07	0.06	0.12	0	0.39	0.24	1.8	0.02	0.66	0.01	0.01	0.6	0.29	0.08	2.59	0.48	0.04	0.81	4.65	0.02	3.64	0	0
	II	1.88	0.08	5.92	1.24	0.06	0.07	0.05	5.01	0.06	0	0	0.58	0.41	0.01	0.06	0	0.02	0.03	0.81	6.25	1.84	0	0.01	0	3.12
	III	0.19	0.14	0.55	0.07	0	1.68	0.12	1.46	0	0	0	0.01	0	0	0	0	0.82	0.08	2.09	0.14	1.34	0.19	0	0.5	0
DEC	I	0	0	0	3.46	0	0	0	2.79	0	0	0	0	0	0	0	0.03	0	0.11	0.07	0	0.13	0	0	0.07	0
	II	0	0	0	0.12	0	0	0.13	0.45	0	0	0	0	0	0	0	0	0	0.03	0	0.27	0.01	0	0	0	1.72
	III	0	0	0	0	0	0	0	0	0	0	0.05	0.08	0	0.09	0	0	0	0.2	0	1.02	0	0	0.13	0	0.01
JAN	I	0	0	0	0	0.68	0	0	0	0	0	0.07	0.15	0	0	0	0	0	0	0	0.32	0	0	0.01	0	0.09
	II	0	0	0	0.34	1.56	0	0.36	0	0	0.05	0	0	0.01	0	0	0	0.02	0	0	2.43	0	0	0	0	0
	III	0	0	0	0.09	0	0	0.01	0	0	0	0	0	0.01	0.08	0.09	0	0.05	0	0	0	0	0	0	0	0
FEB	I	0	0	0	0	0	0	0	0	0.38	0	0	0.42	0.2	0.01	0.07	0	0.07	0	0	0	0	0	0.02	0	0
	II	0	0	0	0	0	0	0	0	0	0	0	0.29	0	0	0	0	0	0.58	0	0.04	0	0	0.19	0.02	0
	III	0	0	0	0	0	0	0	0	0	0.08	0	0	0	0	0.01	0	0.11	0	0	0.01	0.3	0	0.01	0.67	0
MAR	I	0	0	0.55	0	0.01	0	0	0	0	0	0	0	0.08	0	0.1	0.69	0.02	0	0	0	0	0	0	1.38	2.24
	II	0.02	0	0.12	0	0.18	0.01	0.17	0	0	0	0.02	0.05	0.24	0	0	0.03	0	1.11	0.33	0.11	0	0	0.27	0.5	0.16
	III	0	0.01	0	0.1	0.09	0.02	0.7	0.02	0.05	0.03	0	0.02	0.57	0.02	0	0.03	0.09	6.47	0.77	0	0.01	0	0	0	0.09
APR	I	2.3	0	0	1.36	0.18	0.06	0.03	0.04	0.01	0.14	0.44	1.34	0.25	0.86	0.16	0.05	0.05	0.86	0.84	0	0.2	0.38	0	0.48	0.44
	II	0.75	0.25	0.69	2.59	0.1	1.12	0.13	0.07	0.02	0.25	0.68	0.44	1.13	0	3.82	0.43	1.17	0.35	0.23	1.12	1.83	0.42	0.01	1.34	2.09
	III	1.2	0.54	1.1	0.35	0.74	0.06	2.16	0.16	0.13	0.15	0.12	0.5	0.94	0.78	1.2	0.05	0.3	0.4	0.45	0.89	0.61	0.84	2.47	0.94	0.62
MAY	I	0.15	0.73	0.76	0.33	1.51	0	0.98	1.69	1.44	1.69	0.51	1.26	0.46	1.35	1.21	1.15	1.1	0.19	0.54	0.61	0.98	0.11	1.17	4.8	1.68
	II	2.71	1.46	0.91	0.05	1.24	0.02	0.46	1.96	2.33	0.62	0.11	1.45	0.07	3.33	0	0.18	0.03	0.16	3.63	0.22	0.91	0.12	0.13	1.81	1.87
	III	3.77	1.32	1.92	2.72	1.92	2.62	0	0.48	3.36	2.02	1.04	0.77	0	3.53	3.36	7.14	1.57	1.96	2.84	1.91	2.07	0	2.95	2.23	1.99
Yearly Rainfall (mm)		661	784	680	881	795	623	837	849	882	710	642	638	518	501	748	1915	806	946	671	1004	885	750	695	814	828

5.14.2.3 Rainfall and Runoff Data at Huvinhedgi G&D Site and Narayanpur Dam

Detailed calculations on water availability and flood magnitude will help to select the design features of the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check has been performed by plotting the monthly runoff (in mm) against the monthly rainfall (in mm) for the entire period ranging from 1990 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Huvinhedgi G&D site is shown in **Figure 5.79**, The difference between the rainfall and runoff values might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. For the above stated reason, monsoon & non-monsoon period discharge data of Narayapur dam and Huvinhedgi G&D have been used to derive the flow series at the dam site from June to May of each year. **Figure 5.80** shows the plot of runoff coefficient at the G&D Site **Figure 5.81** shows the plot of runoff coefficient at Narayanpur Dam.

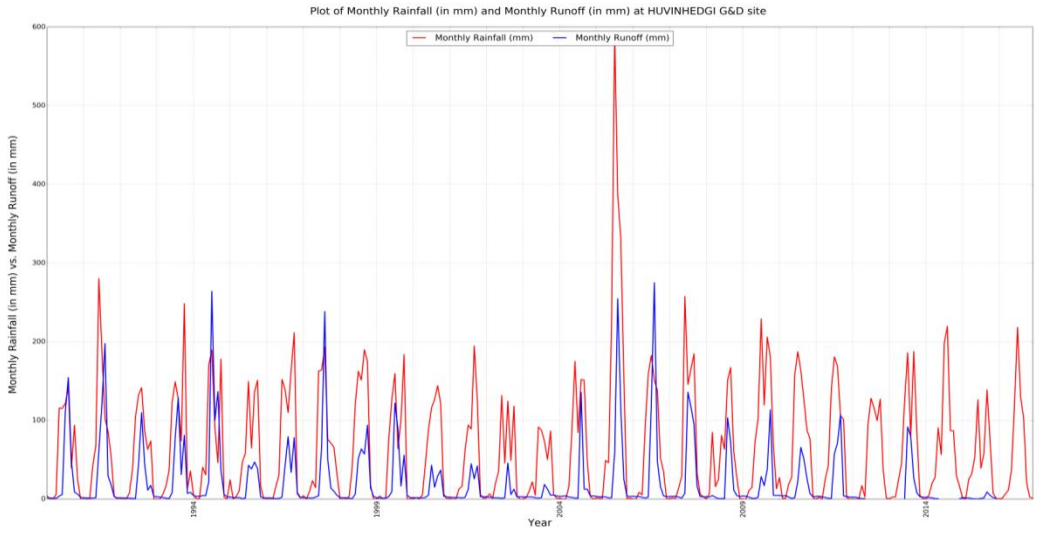


Figure 5.79: Plot of Monthly Rainfall (in mm) and Monthly Runoff (in mm) at Huvinhedgi G&D site

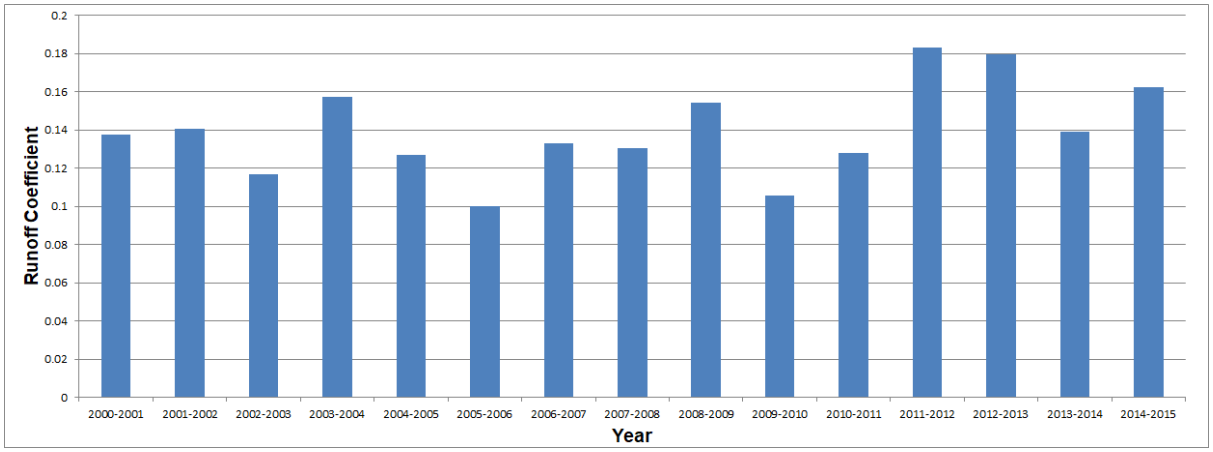


Figure 5.80: Plot of Runoff Coefficient at G&D Site

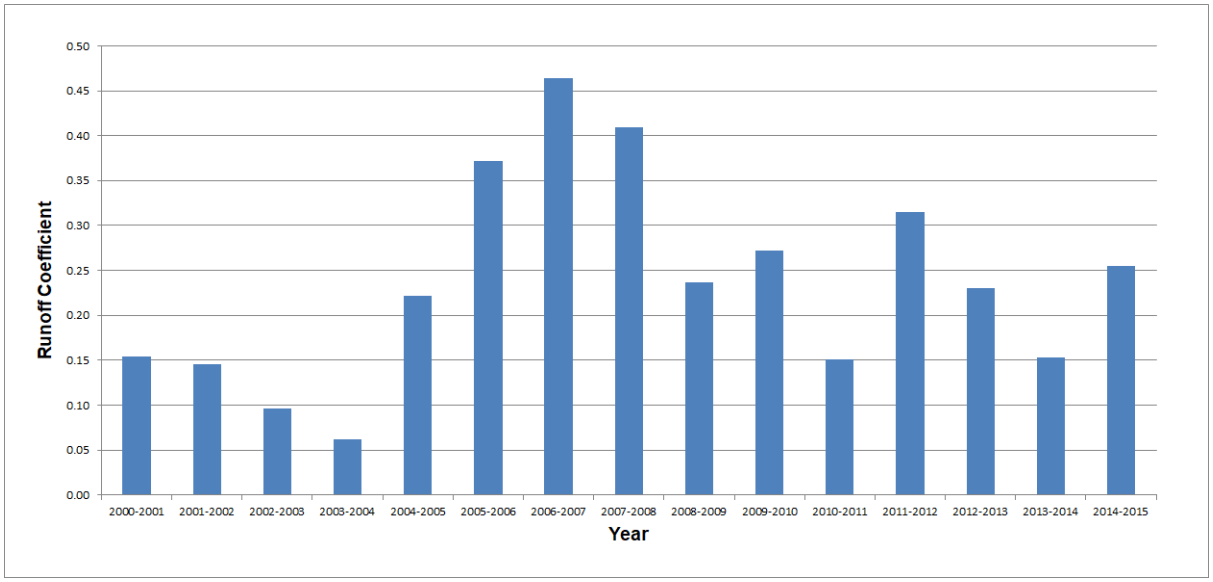


Figure 5.81: Plot of Runoff Coefficient at Narayanpur Dam site

5.14.3 Flow Series Computation

Flow series at the proposed project site (Tamankal Project Site) is estimated using discharge ratio. Daily discharge data for Huvinhedgi site is available for the period from 1990 to 2015 and Daily Sluice release data at Narayanpur Dam is available for the period from 2006 to 2018. After finalizing the flow series at the G&D site of Huvinhedgi for the period from 1990 to 2015 and Narayanpur Dam site for the period from 2006 to 2015, the flow series at the Tamankal project site has been developed using discharge ratio factor. Discharge ratio factor has been used for transposing the missing flow series data for the period from 1990 to 2005 from G&D site to Narayanpur Dam for getting long term complete flow series at project site as it can be assumed that the

catchments i.e. Huvinhedgi G&D site and both the Dam Sites are having similar drainage and hydro-meteorological characteristics.

$$\text{Discharge Ratio Factor} = \frac{\text{Average 10 daily Flow}_{\text{Narayanpur}}}{\text{Average 10 daily Flow}_{\text{Huvinhedgi}}}$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Tamankal}} = Q_{\text{Narayanpur}} = \left(Q_{\text{Huvinhedgi G\&D Site}}\ X\ Discharge\ Ratio\ Fator\right) + Q_{\text{forebay}}$$

Table 5.170 shows the discharge ratio factor for the period from 2006 to 2015 and **Table 5.171** shows 10-daily average flow series at G&D site. **Table 5.172** & **Table 5.173** show the 10-daily average flow at the Tamankal dam site and Forebay respectively. **Table 5.174** & **Table 5.175** shows the 10-daily average flow series & **Table 5.176** illustrate the 10-daily inflow series for the project site.

Table 5.170: Discharge Ratio Factor for the period from 2006 to 2015

Period		Average 10 Daily Flow at	Average 10 Daily Flow at	Discharge Ratio Factor
JUN	I	25.29	0.07	0.00266
	II	38.03	0.02	0.00058
	III	83.81	0.00	0
JUL	I	1015.28	72.91	0.07181
	II	694.91	47.34	0.06812
	III	2035.34	140.77	0.06916
AUG	I	2519.57	220.00	0.08731
	II	2940.12	222.45	0.07565
	III	909.85	56.84	0.06247
SEP	I	1704.45	141.20	0.08283
	II	1306.90	72.87	0.05575
	III	1036.35	51.75	0.04993
OCT	I	1451.21	26.38	0.01817
	II	292.86	19.75	0.06742
	III	166.28	51.75	0.31123
NOV	I	100.57	0.22	0.00220
	II	96.14	0.17	0.00176
	III	81.62	0.00	0
DEC	I	67.08	0.14	0.00209
	II	59.65	0.14	0.00242
	III	59.57	0.04	0.00064
JAN	I	64.90	0.00	0
	II	65.17	0.00	0
	III	66.93	0.00	0

Period		Average 10 Daily Flow at	Average 10 Daily Flow at	Discharge Ratio Factor
FEB	I	67.44	0.08	0.00118
	II	64.00	0.00	0
	III	67.58	0.00	0
MAR	I	56.97	0.00	0
	II	52.79	0.00	0
	III	63.34	0.08	0.00121
APR	I	41.72	0.10	0.00237
	II	33.28	0.00	0
	III	20.90	0.01	0.00051
MAY	I	14.44	0.03	0.00195
	II	13.71	0.25	0.01841
	III	14.59	0.10	0.00681

Table 5.171: 10-Daily Average Flow Series (m^3/s) at Huvinhedgi

Catchment Area =55750 km^2 All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	36.72	866.56	8.12	40.34	106.43	10.33	29.51	12.37	211.62	27.78	108.10	37.07	27.18	26.85	58.76	50.02	37.11	27.92	13.65	10.89	27.05	36.77	23.26	29.39	25.47
	II	176.14	2171.02	16.16	24.67	286.53	26.42	110.75	147.45	103.24	33.93	198.21	34.60	21.58	20.88	12.28	33.61	43.91	37.12	12.52	96.71	43.02	16.16	41.11	5.39	40.48
	III	159.69	926.00	16.73	456.17	1020.42	35.69	14.69	105.71	83.41	549.86	13.69	74.33	5.95	26.27	7.70	13.62	77.46	414.10	10.61	37.86	33.11	8.68	100.87	3.72	36.85
Jul	I	1446.23	884.77	215.18	462.61	3226.61	40.94	14.67	1006.55	944.83	909.33	32.01	24.11	3.86	35.63	19.98	276.81	2560.59	4740.85	11.70	7.94	25.41	29.63	963.11	2.20	205.66
	II	1730.86	1952.88	112.09	2906.55	5223.16	14.22	147.23	2871.25	1855.86	884.74	1568.82	219.48	64.35	50.91	24.07	671.41	1287.03	3531.47	8.38	6.27	20.57	10.28	715.39	160.32	182.57
	III	3663.34	4514.64	2308.40	1462.91	7799.27	2462.26	2325.03	495.71	468.39	5520.82	1065.51	489.95	29.24	21.74	24.66	2592.97	3491.84	440.74	26.29	1658.10	1271.87	3356.43	1350.69	5222.96	2572.01
Aug	I	874.40	5300.20	1189.38	3319.56	2795.70	1865.35	2934.32	5843.80	1032.79	2758.10	386.95	662.84	40.50	476.60	3079.12	9575.44	7380.26	2589.07	48.43	539.16	2899.69	1847.82	1584.83	3508.26	2075.95
	II	2634.77	3289.46	2678.47	2609.95	885.64	490.24	1279.90	5354.29	1731.37	2538.84	266.65	1061.09	1677.51	330.50	4107.30	4511.12	8067.37	3806.79	6374.00	149.08	347.78	1293.56	2394.24	864.05	1009.74
	III	5862.21	3785.51	2914.45	2162.28	2511.09	100.77	812.37	3795.91	1218.48	388.15	285.61	1058.47	1118.84	351.03	1421.68	2130.71	2080.40	1045.54	221.60	373.47	895.38	1318.87	770.97	704.17	812.57
Sep	I	2064.44	905.12	1807.00	751.85	6531.00	1721.15	876.11	2244.09	1525.60	520.73	1217.04	342.02	149.15	472.31	155.25	1172.03	133.39	2365.19	661.44	1106.47	1756.14	5702.02	2318.25	209.40	2218.46
	II	962.58	506.02	965.69	830.96	2065.54	927.17	815.48	337.71	912.15	186.24	240.79	165.16	150.57	200.83	244.01	2858.97	936.06	2275.75	2421.79	415.84	861.61	1071.58	1409.31	1091.88	970.04
	III	84.46	469.06	69.45	416.63	206.03	386.21	489.79	636.59	1253.85	358.01	428.53	1151.16	69.23	136.11	409.23	3460.01	2006.94	1463.47	1579.00	915.26	657.04	153.06	953.57	409.36	617.66
Oct	I	111.27	881.09	334.83	1132.05	1130.69	551.52	3382.98	379.24	1912.75	1359.78	925.52	1674.00	51.30	136.01	565.24	1169.77	535.10	780.64	237.61	6386.37	1087.75	79.06	1714.29	232.50	1899.99
	II	317.57	162.56	286.79	2867.04	432.04	1307.82	713.82	291.57	3379.10	1785.87	967.91	768.71	603.79	72.32	163.23	342.00	342.77	134.16	336.76	730.18	214.37	81.79	299.45	122.52	289.66
	III	123.55	118.59	100.69	1121.61	697.00	565.39	850.62	202.90	690.15	404.57	427.26	247.41	136.33	94.24	81.14	107.46	112.20	114.06	159.23	175.20	348.62	72.16	173.85	144.08	182.78
Nov	I	206.84	53.82	171.70	307.61	218.74	108.80	314.48	173.82	363.26	228.37	104.16	62.28	44.97	91.69	89.05	92.40	127.62	82.76	88.80	106.68	157.87	63.03	99.83	65.15	98.51
	II	101.13	89.25	750.36	76.33	96.11	28.49	157.69	294.50	372.04	49.31	52.38	65.22	53.83	113.46	88.97	78.00	72.85	60.11	102.82	115.10	162.67	72.29	102.60	66.54	103.84
	III	92.99	51.54	193.64	80.08	72.03	31.44	68.56	171.05	180.15	41.38	60.25	65.28	59.97	118.62	83.84	72.82	64.06	59.43	96.70	82.91	115.87	78.70	86.72	61.83	85.21
Dec	I	54.81	34.18	71.20	140.76	66.34	28.59	45.39	139.98	93.49	39.61	59.80	63.22	64.79	107.88	87.20	68.52	67.59	59.94	68.10	107.03	62.70	54.85	70.52	39.12	66.84
	II	44.96	28.73	66.56	249.97	56.83	36.05	42.79	93.86	60.11	23.50	60.49	62.70	69.69	88.54	85.44	65.41	62.14	54.46	60.79	83.77	59.18	47.98	61.24	42.68	58.97
	III	38.52	30.08	69.16	143.07	50.33	33.12	30.14	60.06	47.24	38.25	52.80	61.59	54.18	59.28	74.88	70.20	58.73	53.56	63.25	90.62	64.71	45.67	63.56	56.48	64.21
Jan	I	40.11	34.87	64.83	110.51	41.15	22.58	37.44	31.97	21.59	38.30	54.59	64.27	56.04	61.57	69.04	71.96	65.21	59.12	72.78	98.78	66.96	44.22	68.37	33.60	62.39
	II	31.41	34.98	66.00	90.77	83.54	20.59	47.83	40.68	34.93	35.82	44.82	55.88	56.04	68.66	65.25	72.77	67.92	61.84	81.74	102.97	68.94	51.47	73.39	52.14	69.78
	III	28.71	28.05	56.71	80.23	38.42	33.97	31.57	42.06	43.59	32.72	46.10	51.71	59.75	73.23	76.06	72.20	68.22	58.67	91.06	90.25	69.69	54.62	72.86	53.31	68.15
Feb	I	32.91	30.33	56.91	72.72	37.95	32.95	34.15	41.46	21.04	36.75	49.01	55.72	61.30	78.32	82.85	75.85	69.17	62.44	88.05	88.33	77.01	67.43	76.65	39.48	69.78
	II	24.41	32.58	58.62	80.16	43.85	31.45	34.96	35.62	33.52	36.28	48.10	50.90	60.69	79.73	54.87	70.25	82.34	59.56	76.56	84.93	82.25	48.91	70.44	43.61	66.03
	III	27.80	26.55	53.94	77.03	40.12	30.24	27.46	35.20	33.68	38.68	47.67	47.23	57.88	81.06	56.81	64.36	80.52	48.43	72.89	93.47	84.05	44.38	68.64	53.37	68.78
Mar	I	30.41	25.65	50.64	74.71	33.17	26.46	24.11	33.37	20.32	33.10	44.33	46.86	57.26	84.56	58.76	75.49	75.35	45.34	65.44	76.06	66.97	45.40	59.84	43.91	58.44
	II	23.67	21.44	46.56	73.11	38.59	21.63	30.34	33.26	19.87	32.22	40.26	42.34	58.80	88.26	66.26	67.06	70.45	48.75	56.95	99.27	60.50	14.59	56.01	33.02	52.68
	III	25.52	27.30	34.04	71.17	39.45	14.83	32.83	35.41	30.03	34.80	36.09	37.85	57.59	81.96	58.27	59.91	77.07	175.99	30.18	100.11	53.39	3.58	72.65	19.97	49.94
Apr	I	30.09	27.57	45.78	68.13	33.96	12.82	31.92	33.77	19.63	33.53	40.46	29.67	53.96	84.51	59.59	58.69	69.39	56.36	25.25	88.33	45.18	10.56	45.14	8.82	39.61
	II	21.42	27.30	12.35	145.94	68.39	16.48	27.45	23.98	24.04	36.05	44.50	34.98	57.94	52.21	75.73	62.98	60.06	48.70	16.75	62.11	43.82	5.46	35.37	9.25	31.20
	III	18.05	19.99	3.14	70.69	20.01	7.52	16.56	9.51	25.02	20.97	38.67	30.74	57.18	31.30	43.24	22.88	28.09	29.56	8.31	14.44	45.39	19.58	23.46	12.59	23.09
May	I	12.92	12.59	2.00	97.67	5.95	3.21	13.38	6.82	22.98	13.07	33.94	25.86	38.08	25.07	32.01	11.88	18.37	11.60	16.42	25.20	14.95	10.56	15.75	10.77	15.45
	II	17.40	14.88	2.82	83.72	15.14	20.05	136.78	8.00	110.14	6.58	44.08	28.56	38.72	77.79	20.21	18.76	25.01	7.70	10.04	15.61	15.95	8.24	11.51	11.70	12.60
	III	69.00	12.32	23.91	91.17	6.45	19.96	9.45	11.37	63.60	102.99	6.69	34.07	26.46	25.35	29.87	47.55	33.44	12.03	21.75	8.30	19.80	7.53	13.88	7.74	11.45
Inflow (MCM) =		19178	24403	13361	20173	32080	9853	14166	22065	16600	17128	8056	7963	4693	3525	10279	26578	26794	21690	11564	12506	10526	14130	14083	12170	12683

Table 5.172: 10-Daily Average Flow Series (m^3/s) at Narayanpur Dam

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	0.10	2.31	0.02	0.11	0.28	0.03	0.08	0.03	0.56	0.07	0.29	0.10	0.07	0.07	0.16	0.13	0.00	0.00	0.00	0.45	0.23	0.00	0.00	0.00	0.00
	II	0.10	1.26	0.01	0.01	0.17	0.02	0.06	0.09	0.06	0.02	0.12	0.02	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	I	103.86	63.54	15.45	33.22	231.73	2.94	1.05	72.29	67.85	65.31	2.30	1.73	0.28	2.56	1.43	19.88	244.10	484.98	0.00	0.00	0.00	0.00	0.00	0.06	0.00
	II	117.91	133.04	7.64	198.00	355.82	0.97	10.03	195.60	126.43	60.27	106.87	14.95	4.38	3.47	1.64	45.74	117.41	343.62	0.00	0.00	0.00	0.00	0.00	12.37	0.00
	III	253.36	312.24	159.65	101.18	539.41	170.29	160.80	34.28	32.39	381.83	73.69	33.89	2.02	1.50	1.71	179.33	312.88	29.28	0.00	149.44	101.75	288.79	0.00	476.86	48.67
Aug	I	76.35	462.79	103.85	289.85	244.11	162.87	256.21	510.25	90.18	240.82	33.79	57.88	3.54	41.61	268.85	836.08	802.09	205.35	2.97	36.92	302.54	148.89	77.20	344.99	279.02
	II	199.35	248.88	202.65	197.47	67.01	37.09	96.84	405.10	130.99	192.09	20.17	80.28	126.92	25.01	310.76	341.31	898.04	357.62	601.92	0.00	11.66	104.63	129.78	51.81	69.03
	III	366.24	236.50	182.08	135.09	156.88	6.30	50.75	237.15	76.13	24.25	17.84	66.13	69.90	21.93	88.82	133.12	210.14	71.06	15.13	16.36	36.76	102.83	0.00	41.63	74.52
Sep	I	171.02	74.98	149.69	62.28	541.02	142.58	72.58	185.90	126.38	43.14	100.82	28.33	12.36	39.13	12.86	97.09	0.00	199.02	13.11	73.28	156.18	551.04	205.71	0.00	213.62
	II	53.67	28.21	53.84	46.33	115.17	51.69	45.47	18.83	50.86	10.38	13.43	9.21	8.40	11.20	13.60	159.40	49.73	144.18	200.18	12.74	67.77	80.58	48.84	60.54	61.83
	III	4.22	23.42	3.47	20.81	10.29	19.29	24.46	31.79	62.61	17.88	21.40	57.49	3.46	6.80	20.44	172.78	166.96	107.06	121.32	53.44	50.58	1.96	0.00	11.87	4.34
Oct	I	2.02	16.02	6.09	20.58	20.55	10.03	61.49	6.89	34.77	24.72	16.82	30.43	0.93	2.47	10.27	21.26	24.84	51.22	0.00	2.89	99.64	0.00	80.72	4.48	0.00
	II	21.41	10.96	19.34	193.30	29.13	88.18	48.13	19.66	227.83	120.41	65.26	51.83	40.71	4.88	11.01	23.06	8.71	0.00	8.30	152.01	7.94	0.00	20.49	0.00	0.00
	III	38.45	36.91	31.34	349.09	216.93	175.97	264.74	63.15	214.80	125.92	132.98	77.00	42.43	29.33	25.25	33.45	166.96	107.06	121.32	53.44	50.58	1.96	0.00	11.87	4.34
Nov	I	0.46	0.12	0.38	0.68	0.48	0.24	0.69	0.38	0.80	0.50	0.23	0.14	0.10	0.20	0.20	0.20	0.00	0.00	0.00	0.00	2.22	0.00	0.00	0.00	0.00
	II	0.18	0.16	1.32	0.13	0.17	0.05	0.28	0.52	0.66	0.09	0.09	0.12	0.09	0.20	0.16	0.14	0.00	0.00	0.00	0.00	1.70	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	I	0.11	0.07	0.15	0.30	0.14	0.06	0.10	0.29	0.20	0.08	0.13	0.13	0.14	0.23	0.18	0.14	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.00	0.00
	II	0.11	0.07	0.16	0.61	0.14	0.09	0.10	0.23	0.15	0.06	0.15	0.15	0.17	0.21	0.21	0.16	0.00	0.00	0.00	1.42	0.00	0.03	0.00	0.00	0.00
	III	0.02	0.02	0.04	0.09	0.03	0.02	0.02	0.04	0.03	0.02	0.03	0.04	0.04	0.04	0.05	0.05	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Jan	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	I	0.04	0.04	0.07	0.09	0.05	0.04	0.04	0.05	0.03	0.04	0.06	0.07	0.07	0.09	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.03	0.03	0.04	0.09	0.05	0.02	0.04	0.04	0.04	0.04	0.04	0.05	0.07	0.10	0.07	0.07	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00
Apr	I	0.07	0.07	0.11	0.16	0.08	0.03	0.08	0.08	0.05	0.08	0.10	0.07	0.13	0.20	0.14	0.14	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.01	0.01	0.00	0.04	0.01	0.00	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.01	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
May	I	0.03	0.02	0.00	0.19	0.01	0.01	0.03	0.01	0.04	0.03	0.07	0.05	0.07	0.05	0.06	0.02	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00
	II	0.32	0.27	0.05	1.54	0.28	0.37	2.52	0.15	2.03	0.12	0.81	0.53	0.71	1.43	0.37	0.35	0.00	0.00	0.14	0.14	0.49	0.00	0.00	0.00	0.00
	III	0.47	0.08	0.16	0.62	0.04	0.14	0.06	0.08	0.43	0.70	0.05	0.23	0.18	0.17	0.20	0.32	0.00	0.00	0.13	0.13	0.74	0.00	0.00	0.00	0.00

Table 5.173: 10-Daily Average Flow Series (m^3/s) at Tamankal Dam

Catchment Area = 48104 km^2

All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	0.10	2.31	0.02	0.11	0.28	0.03	0.08	0.03	0.56	0.07	0.29	0.10	0.07	0.07	0.16	0.13	0.00	0.00	0.00	0.45	0.23	0.00	0.00	0.00	0.00
	II	0.10	1.26	0.01	0.01	0.17	0.02	0.06	0.09	0.06	0.02	0.12	0.02	0.01	0.01	0.01	0.02	0.00	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jul	I	103.86	63.54	15.45	33.22	231.73	2.94	1.05	72.29	67.85	65.31	2.30	1.73	0.28	2.56	1.43	19.88	244.10	484.98	0.00	0.00	0.00	0.00	0.00	0.06	0.00
	II	117.91	133.04	7.64	198.00	355.82	0.97	10.03	195.60	126.43	60.27	106.87	14.95	4.38	3.47	1.64	45.74	117.41	343.62	0.00	0.00	0.00	0.00	0.00	12.37	0.00
	III	253.36	312.24	159.65	101.18	539.41	170.29	160.80	34.28	32.39	381.83	73.69	33.89	2.02	1.50	1.71	179.33	312.88	29.28	0.00	149.44	101.75	288.79	0.00	476.86	48.67
Aug	I	76.35	462.79	103.85	289.85	244.11	162.87	256.21	510.25	90.18	240.82	33.79	57.88	3.54	41.61	268.85	836.08	802.09	205.35	2.97	36.92	302.54	148.89	77.20	344.99	279.02
	II	199.35	248.88	202.65	197.47	67.01	37.09	96.84	405.10	130.99	192.09	20.17	80.28	126.92	25.01	310.76	341.31	898.04	357.62	601.92	0.00	11.66	104.63	129.78	51.81	69.03
	III	366.24	236.50	182.08	135.09	156.88	6.30	50.75	237.15	76.13	24.25	17.84	66.13	69.90	21.93	88.82	133.12	210.14	71.06	15.13	16.36	36.76	102.83	0.00	41.63	74.52
Sep	I	171.02	74.98	149.69	62.28	541.02	142.58	72.58	185.90	126.38	43.14	100.82	28.33	12.36	39.13	12.86	97.09	0.00	199.02	13.11	73.28	156.18	551.04	205.71	0.00	213.62
	II	53.67	28.21	53.84	46.33	115.17	51.69	45.47	18.83	50.86	10.38	13.43	9.21	8.40	11.20	13.60	159.40	49.73	144.18	200.18	12.74	67.77	80.58	48.84	60.54	61.83
	III	4.22	23.42	3.47	20.81	10.29	19.29	24.46	31.79	62.61	17.88	21.40	57.49	3.46	6.80	20.44	172.78	166.96	107.06	121.32	53.44	50.58	1.96	0.00	11.87	4.34
Oct	I	2.02	16.02	6.09	20.58	20.55	10.03	61.49	6.89	34.77	24.72	16.82	30.43	0.93	2.47	10.27	21.26	24.84	51.22	0.00	2.89	99.64	0.00	80.72	4.48	0.00
	II	21.41	10.96	19.34	193.30	29.13	88.18	48.13	19.66	227.83	120.41	65.26	51.83	40.71	4.88	11.01	23.06	8.71	0.00	8.30	152.01	7.94	0.00	20.49	0.00	0.00
	III	38.45	36.91	31.34	349.09	216.93	175.97	264.74	63.15	214.80	125.92	132.98	77.00	42.43	29.33	25.25	33.45	166.96	107.06	121.32	53.44	50.58	1.96	0.00	11.87	4.34
Nov	I	0.46	0.12	0.38	0.68	0.48	0.24	0.69	0.38	0.80	0.50	0.23	0.14	0.10	0.20	0.20	0.20	0.00	0.00	0.00	0.00	2.22	0.00	0.00	0.00	0.00
	II	0.18	0.16	1.32	0.13	0.17	0.05	0.28	0.52	0.66	0.09	0.09	0.12	0.09	0.20	0.16	0.14	0.00	0.00	0.00	0.00	1.70	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec	I	0.11	0.07	0.15	0.30	0.14	0.06	0.10	0.29	0.20	0.08	0.13	0.13	0.14	0.23	0.18	0.14	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.00	0.00
	II	0.11	0.07	0.16	0.61	0.14	0.09	0.10	0.23	0.15	0.06	0.15	0.15	0.17	0.21	0.21	0.16	0.00	0.00	0.00	1.42	0.00	0.03	0.00	0.00	0.00
	III	0.02	0.02	0.04	0.09	0.03	0.02	0.02	0.04	0.03	0.02	0.03	0.04	0.04	0.04	0.05	0.05	0.00	0.00	0.00	0.39	0.00	0.00	0.00	0.00	0.00
Jan	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	I	0.04	0.04	0.07	0.09	0.05	0.04	0.04	0.05	0.03	0.04	0.06	0.07	0.07	0.09	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.03	0.03	0.04	0.09	0.05	0.02	0.04	0.04	0.04	0.04	0.04	0.05	0.07	0.10	0.07	0.07	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00
Apr	I	0.07	0.07	0.11	0.16	0.08	0.03	0.08	0.08	0.05	0.08	0.10	0.07	0.13	0.20	0.14	0.14	0.00	0.00	0.00	0.00	0.99	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.01	0.01	0.00	0.04	0.01	0.00	0.01	0.00	0.01	0.01	0.02	0.02	0.03	0.02	0.02	0.01	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00
May	I	0.03	0.02	0.00	0.19	0.01	0.01	0.03	0.01	0.04	0.03	0.07	0.05	0.07	0.05	0.06	0.02	0.00	0.00	0.14	0.14	0.00	0.00	0.00	0.00	0.00
	II	0.32	0.27	0.05	1.54	0.28	0.37	2.52	0.15	2.03	0.12	0.81	0.53	0.71	1.43	0.37	0.35	0.00	0.00	0.14	0.14	0.49	0.00	0.00	0.00	0.00
	III	0.47	0.08	0.16	0.62	0.04	0.14	0.06	0.08	0.43	0.70	0.05	0.23	0.18	0.17	0.20	0.32	0.00	0.00	0.13	0.13	0.74	0.00	0.00	0.00	0.00

Table 5.174: 10-Daily Average Flow Series (m^3/s) at Forebay

Catchment Area = 100 km^2

All 10-daily flows in m^3/s.

Period		1990-1991	1991-1992	1992-1993	1993-1994	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	3.95	1.62	2.52	0.00	0.00	0.37	0.02	0.54	0.58	0.00	0.89	0.99	0.00	4.10	0.61	1.34	4.03	10.08	0.00	0.39	4.21	0.77	0.04	9.94	0.10
	II	9.67	8.35	0.68	0.00	0.00	1.57	0.00	0.05	1.72	0.07	1.23	0.68	3.64	0.00	2.35	2.88	5.67	2.27	0.12	0.91	1.59	0.35	0.11	0.62	1.32
	III	0.63	0.49	1.44	0.54	0.35	3.51	4.53	0.11	0.23	1.43	3.55	0.41	0.56	1.39	0.02	1.73	0.69	13.84	0.10	5.42	6.24	5.72	2.42	1.47	0.76
Jul	I	1.64	19.10	3.77	0.00	0.00	0.00	1.90	0.00	0.04	1.45	2.66	0.24	2.74	3.34	1.64	12.38	0.07	0.00	2.36	0.18	4.20	1.50	1.40	2.94	1.17
	II	0.58	5.58	8.51	0.00	0.08	1.16	9.69	3.42	0.42	2.09	0.05	0.03	1.65	5.78	3.01	7.84	0.98	0.26	0.09	0.35	0.89	7.72	8.56	7.15	4.38
	III	0.05	0.70	4.65	0.00	0.65	6.12	0.25	1.42	0.00	2.53	11.80	5.76	1.15	1.59	1.27	1.40	0.00	2.50	2.58	0.17	4.27	2.50	3.23	6.39	0.96
Aug	I	0.85	4.79	0.20	0.05	1.12	0.10	0.00	0.14	3.78	0.12	8.23	2.02	0.40	1.22	0.29	9.11	0.05	1.25	12.41	8.60	14.91	1.18	2.19	9.44	12.06
	II	11.34	2.26	2.44	0.33	0.64	1.79	0.50	0.10	0.35	0.09	1.51	0.91	4.74	2.01	2.43	3.15	0.64	0.26	0.65	10.60	11.89	5.63	4.44	9.02	2.64
	III	0.07	2.38	7.07	1.56	0.09	4.25	1.55	0.08	0.18	0.53	1.15	1.38	0.27	1.61	0.20	1.34	0.00	1.24	0.00	3.22	4.88	2.72	7.89	0.59	11.60
Sep	I	0.28	0.84	0.19	0.60	2.42	0.31	0.14	1.65	8.25	2.07	0.20	0.94	0.05	4.87	4.34	4.01	4.21	6.40	1.82	5.66	4.29	0.68	5.77	1.68	0.43
	II	0.47	0.00	2.97	2.23	2.62	1.89	2.42	1.82	0.68	0.13	4.94	8.38	1.48	0.18	2.29	2.15	6.18	10.47	15.14	31.11	4.18	0.30	0.91	10.44	4.55
	III	8.01	7.22	0.00	0.02	0.10	4.02	4.10	1.15	1.21	0.71	5.22	16.00	0.76	0.28	5.36	10.40	1.21	1.13	0.85	3.56	0.42	1.06	7.22	2.58	5.94
Oct	I	4.60	5.49	2.93	1.46	0.00	3.11	6.52	1.58	15.42	0.17	9.48	8.68	0.00	1.40	0.00	19.26	1.68	1.07	0.00	0.00	3.20	1.64	1.97	0.00	5.96
	II	5.23	1.18	0.88	0.00	0.00	5.01	14.99	1.30	8.44	4.71	3.68	4.19	17.28	2.75	0.00	4.49	0.55	0.16	0.41	0.00	3.57	0.77	0.05	1.00	0.70
	III	1.88	0.00	1.71	0.08	10.18	1.62	1.91	3.60	3.70	4.33	0.00	0.00	0.21	0.42	2.66	2.67	4.71	1.47	2.52	0.31	2.52	0.00	3.05	9.66	0.25
Nov	I	0.06	0.19	0.13	0.99	1.12	5.32	10.73	6.38	6.05	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.59	0.00	0.31	0.00	0.35	0.00	1.07	0.00	0.00
	II	0.63	1.49	0.11	6.26	7.66	13.22	0.00	0.54	15.27	7.46	0.00	0.00	0.16	0.07	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00
	III	0.24	0.00	0.02	0.57	2.45	1.40	5.60	1.91	11.18	11.95	0.00	0.00	0.00	0.00	0.39	0.40	0.00	0.00	2.13	3.59	4.51	0.00	0.00	0.00	0.57
Dec	I	0.00	0.00	20.50	0.87	0.03	0.00	0.00	0.24	0.71	5.70	0.00	0.29	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	7.32	0.00	0.00	0.00	0.00	0.48	1.18	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.71
	III	0.00	0.00	0.00	2.99	0.00	0.00	0.03	2.44	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.58
Jan	I	0.00	0.00	0.00	1.53	0.00	0.00	0.00	2.59	0.32	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
	II	0.00	0.00	0.33	4.77	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	14.41	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	0.00	0.00	0.00	0.00	0.00
Feb	I	0.00	0.00	1.64	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.57	3.91	0.20
	II	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.10	0.00	0.77	0.00	0.00
	III	0.00	0.00	0.17	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	1.57	0.00	2.65	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	1.74	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.55	0.90
	III	0.00	0.00	4.70	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.10	0.00	0.06	0.00	0.87	0.00	0.00	10.20	0.12	0.06	0.00	0.06	0.00	0.00	0.00
Apr	I	1.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.09	0.04	0.37	1.11	0.14	0.49	0.00	0.38	0.00	0.43	0.05	0.00	1.57	3.17
	II	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.67	0.02	0.00	3.60	1.23	0.00	0.45	0.00	0.28	0.26	0.50	1.24	0.00	1.06	0.17
	III	2.89	0.18	0.00	0.02	0.47	0.00	0.34	0.00	0.00	0.00	0.07	0.12	0.38	0.00	0.15	1.28	0.09	0.00	0.22	0.00	0.00	0.82	3.11	0.96	2.58
May	I	0.11	0.46	0.00	0.09	0.00	0.00	0.10	0.00	0.00	0.00	0.00	4.81	0.00	0.11	0.99	1.07	0.00	0.51	0.00	2.96	0.02	1.42	0.34	4.08	2.42
	II	0.73	1.55	0.00	0.01	0.06	2.77	0.88	0.38	0.00	0.00	0.00	0.88	0.00	7.78	1.03	2.51	0.00	0.00	0.39	1.73	2.36	0.00	0.21	6.97	0.64
	III	4.35	1.78	0.00	0.00	0.00	0.33	0.00	0.17	0.00	0.00	0.00	0.00	0.00	4.71	0.05	0.84	1.79	1.31	6.71	0.00	0.00	0.00	2.17	1.27	3.25

Table 5.175: 10-daily Average Flow Series (m^3/s) at Tamankal Project Site

Period		1990-91	1991-92	1992-1993	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Jun	I	4.04	3.92	2.54	0.11	0.28	0.39	0.10	0.58	1.14	0.07	1.17	1.09	0.07	4.17	0.77	1.48	4.03	10.08	0.00	0.83	4.44	0.77	0.04	9.94	0.10
	II	9.77	9.61	0.69	0.01	0.17	1.58	0.06	0.14	1.78	0.09	1.34	0.70	3.65	0.01	2.36	2.90	5.67	2.27	0.12	0.91	1.81	0.35	0.11	0.62	1.32
	III	0.63	0.49	1.44	0.54	0.35	3.51	4.53	0.11	0.23	1.43	3.55	0.41	0.56	1.39	0.02	1.73	0.69	13.84	0.10	5.42	6.24	5.72	2.42	1.47	0.76
Jul	I	105.50	82.65	19.23	33.22	231.73	2.94	2.95	72.29	67.89	66.75	4.96	1.97	3.02	5.90	3.08	32.26	244.17	484.98	2.36	0.18	4.20	1.50	1.40	2.99	1.17
	II	118.49	138.62	16.15	198.00	355.90	2.13	19.72	199.02	126.84	62.36	106.92	14.98	6.03	9.25	4.65	53.58	118.39	343.88	0.09	0.35	0.89	7.72	8.56	19.52	4.38
	III	253.41	312.94	164.30	101.18	540.06	176.42	161.05	35.71	32.39	384.36	85.49	39.64	3.17	3.09	2.98	180.74	312.88	31.78	2.58	149.61	106.01	291.29	3.23	483.24	49.63
Aug	I	77.20	467.58	104.05	289.90	245.22	162.98	256.21	510.39	93.96	240.94	42.01	59.89	3.94	42.83	269.14	845.19	802.14	206.59	15.38	45.53	317.45	150.07	79.40	354.43	291.07
	II	210.68	251.14	205.09	197.80	67.65	38.88	97.34	405.21	131.34	192.17	21.68	81.19	131.66	27.01	313.18	344.46	898.68	357.88	602.57	10.60	23.55	110.26	134.22	60.83	71.67
	III	366.31	238.88	189.16	136.65	156.97	10.55	52.30	237.23	76.31	24.78	18.99	67.51	70.17	23.54	89.02	134.46	210.14	72.29	15.13	19.58	41.64	105.56	7.89	42.21	86.11
Sep	I	171.30	75.82	149.88	62.88	543.44	142.89	72.72	187.55	134.62	45.21	101.02	29.28	12.40	44.00	17.20	101.10	4.21	205.42	14.92	78.94	160.47	551.73	211.47	1.68	214.05
	II	54.14	28.21	56.81	48.56	117.78	53.58	47.88	20.65	51.54	10.51	18.36	17.59	9.87	11.37	15.90	161.55	55.90	154.65	215.32	43.85	71.95	80.87	49.75	70.98	66.38
	III	12.23	30.64	3.47	20.82	10.39	23.31	28.56	32.94	63.82	18.59	26.62	73.48	4.22	7.08	25.80	183.18	168.17	108.19	122.17	57.00	51.00	3.01	7.22	14.45	10.28
Oct	I	6.62	21.50	9.02	22.04	20.55	13.13	68.02	8.47	50.19	24.89	26.30	39.11	0.93	3.87	10.27	40.53	26.53	52.28	0.00	2.89	102.84	1.64	82.69	4.48	5.96
	II	26.64	12.14	20.21	193.30	29.13	93.18	63.12	20.96	236.27	125.12	68.94	56.01	57.99	7.63	11.01	27.54	9.26	0.16	8.71	152.01	11.51	0.77	20.54	1.00	0.70
	III	40.34	36.91	33.05	349.17	227.11	177.59	266.65	66.74	218.50	130.25	132.98	77.00	42.64	29.75	27.92	36.12	171.67	108.53	123.84	53.76	53.10	1.96	3.05	21.52	4.59
Nov	I	0.52	0.31	0.51	1.67	1.60	5.56	11.43	6.76	6.85	0.54	0.23	0.14	0.10	0.20	0.20	0.20	0.59	0.00	0.31	0.00	2.57	0.00	1.07	0.00	0.00
	II	0.80	1.65	1.44	6.40	7.83	13.27	0.28	1.06	15.92	7.55	0.09	0.12	0.26	0.27	0.16	0.16	0.00	0.00	0.00	0.00	1.70	0.09	0.00	0.00	0.00
	III	0.24	0.00	0.02	0.57	2.45	1.40	5.60	1.91	11.18	11.95	0.00	0.00	0.00	0.00	0.39	0.40	0.00	0.00	2.13	3.59	4.51	0.00	0.00	0.00	0.57
Dec	I	0.11	0.07	20.65	1.17	0.17	0.06	0.10	0.54	0.90	5.78	0.13	0.42	0.14	0.90	0.18	0.14	0.00	0.00	0.00	1.41	0.00	0.00	0.00	0.00	0.00
	II	0.11	0.07	0.16	7.93	0.14	0.09	0.10	0.23	0.63	1.23	0.15	0.15	0.17	0.21	0.28	0.16	0.00	0.00	0.00	1.78	0.00	0.03	0.00	0.00	0.71
	III	0.02	0.02	0.04	3.08	0.03	0.02	0.05	2.48	0.30	0.02	0.03	0.04	0.04	0.04	0.05	0.05	0.00	0.00	0.00	0.39	0.06	0.00	0.00	0.00	0.58
Jan	I	0.00	0.00	0.00	1.53	0.00	0.00	0.00	2.59	0.32	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
	II	0.00	0.00	0.33	4.77	0.00	0.00	0.00	0.54	0.00	0.00	0.00	0.00	0.00	0.00	1.52	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	14.41	1.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.44	0.00	0.00	0.00	0.00	0.00
Feb	I	0.04	0.04	1.71	0.09	0.14	0.04	0.04	0.05	0.03	0.04	0.06	0.07	0.07	0.09	0.10	0.09	0.00	0.00	0.00	0.00	0.00	0.80	0.57	3.91	0.20
	II	0.00	0.00	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.01	0.00	0.00	0.10	0.00	0.77	0.00	0.00
	III	0.00	0.00	0.17	0.00	0.00	0.00	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	1.57	0.00	2.65	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.29	1.74	0.00	0.00	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.55	0.90
	III	0.03	0.03	4.74	0.09	0.05	0.02	0.04	0.04	0.09	0.04	0.15	0.05	0.13	0.10	0.94	0.07	0.00	10.20	0.12	0.06	0.77	0.06	0.00	0.00	0.00
Apr	I	1.71	0.07	0.11	0.16	0.08	0.03	0.08	0.08	0.05	0.08	0.10	1.16	0.17	0.57	1.25	0.28	0.49	0.00	0.38	0.00	1.42	0.05	0.00	1.57	3.17
	II	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.45	0.67	0.02	0.00	3.60	1.23	0.00	0.45	0.00	0.28	0.26	0.50	1.24	0.00	1.06	0.17
	III	2.90	0.19	0.00	0.05	0.48	0.00	0.35	0.00	0.01	0.01	0.09	0.13	0.41	0.02	0.17	1.29	0.13	0.00	0.30	0.00	0.00	0.82	3.11	0.96	2.58
May	I	0.14	0.49	0.00	0.28	0.01	0.01	0.13	0.01	0.04	0.03	0.07	4.86	0.07	0.16	1.05	1.09	0.00	0.51	0.14	3.10	0.02	1.42	0.34	4.08	2.42
	II	1.05	1.82	0.05	1.56	0.34	3.14	3.40	0.53	2.03	0.12	0.81	1.41	0.71	9.21	1.40	2.86	0.00	0.00	0.53	1.87	2.85	0.00	0.21	6.97	0.64
	III	4.82	1.86	0.16	0.62	0.04	0.47	0.06	0.25	0.43	0.70	0.05	0.23	0.18	4.89	0.25	1.16	1.79	1.31	6.84	0.13	0.74	0.00	2.17	1.27	3.25
Total Inflow (MCM) =		1327	1535	916	1507	2292	833	1046	1598	1174	1219	593	507	316	216	704	1894	2683	1894	993	569	858	1173	537	1006	724

Table 5.176: 10-daily Inflow Series (MCM) at Tamankal Project Site

Period		1990-91	1991-92	1992-1993	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-00	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15
Jun	I	3.49	3.39	2.20	0.09	0.24	0.34	0.09	0.50	0.99	0.06	1.01	0.94	0.06	3.60	0.66	1.28	3.48	8.71	0.00	0.72	3.84	0.66	0.04	8.59	0.08
	II	8.44	8.31	0.60	0.01	0.14	1.37	0.06	0.12	1.53	0.08	1.16	0.61	3.16	0.01	2.04	2.51	4.90	1.97	0.11	0.78	1.56	0.30	0.10	0.54	1.14
	III	0.55	0.42	1.25	0.46	0.30	3.03	3.91	0.10	0.20	1.23	3.06	0.35	0.48	1.20	0.02	1.49	0.60	11.95	0.09	4.68	5.39	4.94	2.09	1.27	0.66
Jul	I	91.16	71.41	16.61	28.70	200.21	2.54	2.55	62.46	58.66	57.68	4.29	1.71	2.61	5.10	2.66	27.87	210.96	419.03	2.04	0.16	3.63	1.30	1.21	2.59	1.01
	II	102.38	119.76	13.95	171.08	307.50	1.84	17.04	171.95	109.59	53.88	92.38	12.95	5.21	7.99	4.02	46.29	102.29	297.11	0.07	0.31	0.77	6.67	7.40	16.87	3.78
	III	240.84	297.42	156.15	96.16	513.27	167.67	153.06	33.93	30.79	365.30	81.25	37.68	3.02	2.94	2.83	171.77	297.36	30.21	2.45	142.19	100.75	276.84	3.07	459.28	47.17
Aug	I	66.70	403.98	89.90	250.47	211.87	140.81	221.37	440.98	81.18	208.18	36.30	51.75	3.40	37.01	232.54	730.24	693.05	178.50	13.29	39.33	274.28	129.66	68.60	306.23	251.49
	II	182.03	216.98	177.20	170.90	58.45	33.59	84.10	350.10	113.48	166.04	18.73	70.15	113.75	23.34	270.59	297.61	776.46	309.21	520.62	9.15	20.35	95.26	115.97	52.56	61.92
	III	348.14	227.03	179.77	129.87	149.18	10.02	49.71	225.47	72.52	23.55	18.05	64.16	66.69	22.37	84.61	127.79	199.72	68.71	14.38	18.61	39.58	100.32	7.50	40.12	81.84
Sep	I	148.00	65.51	129.50	54.33	469.53	123.46	62.83	162.04	116.32	39.06	87.28	25.29	10.72	38.01	14.86	87.35	3.64	177.49	12.89	68.20	138.65	476.69	182.71	1.45	184.94
	II	46.78	24.38	49.09	41.95	101.76	46.29	41.37	17.84	44.53	9.08	15.86	15.20	8.53	9.83	13.74	139.58	48.30	133.62	186.04	37.89	62.16	69.87	42.98	61.33	57.35
	III	10.56	26.47	3.00	17.99	8.97	20.14	24.68	28.46	55.14	16.06	23.00	63.49	3.65	6.12	22.29	158.27	145.30	93.47	105.56	49.25	44.06	2.60	6.24	12.48	8.88
Oct	I	5.72	18.58	7.79	19.04	17.76	11.35	58.77	7.32	43.36	21.51	22.73	33.79	0.81	3.35	8.88	35.02	22.92	45.17	0.00	2.50	88.85	1.42	71.44	3.87	5.15
	II	23.02	10.49	17.47	167.01	25.17	80.51	54.53	18.11	204.14	108.10	59.56	48.40	50.10	6.59	9.51	23.80	8.00	0.14	7.52	131.34	9.94	0.67	17.75	0.87	0.60
	III	38.34	35.08	31.41	331.85	215.84	168.78	253.43	63.43	207.67	123.79	126.38	73.18	40.52	28.27	26.53	34.33	163.15	103.14	117.70	51.09	50.46	1.86	2.90	20.46	4.36
Nov	I	0.45	0.27	0.44	1.44	1.38	4.80	9.87	5.84	5.92	0.47	0.20	0.12	0.09	0.17	0.17	0.18	0.51	0.00	0.27	0.00	2.22	0.00	0.92	0.00	0.00
	II	0.69	1.42	1.24	5.53	6.77	11.47	0.24	0.92	13.76	6.52	0.08	0.10	0.22	0.23	0.14	0.14	0.00	0.00	0.00	0.00	1.47	0.08	0.00	0.00	0.00
	III	0.20	0.00	0.02	0.49	2.12	1.21	4.84	1.65	9.66	10.32	0.00	0.00	0.00	0.00	0.33	0.34	0.00	0.00	1.84	3.10	3.90	0.00	0.00	0.00	0.49
Dec	I	0.10	0.06	17.84	1.01	0.15	0.05	0.08	0.46	0.78	4.99	0.11	0.37	0.12	0.78	0.16	0.12	0.00	0.00	0.00	1.22	0.00	0.00	0.00	0.00	0.00
	II	0.09	0.06	0.14	6.85	0.12	0.08	0.09	0.20	0.54	1.07	0.13	0.13	0.15	0.19	0.24	0.14	0.00	0.00	0.00	1.54	0.00	0.03	0.00	0.00	0.61
	III	0.02	0.02	0.04	2.93	0.03	0.02	0.05	2.36	0.29	0.02	0.03	0.04	0.03	0.04	0.05	0.04	0.00	0.00	0.00	0.37	0.05	0.00	0.00	0.00	0.55
Jan	I	0.00	0.00	0.00	1.32	0.00	0.00	0.00	2.23	0.28	0.00	0.00	0.00	0.00	0.48	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00
	II	0.00	0.00	0.28	4.12	0.00	0.00	0.00	0.47	0.00	0.00	0.00	0.00	0.00	0.00	1.32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	13.69	1.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.37	0.00	0.00	0.00	0.00	0.00
Feb	I	0.03	0.03	1.48	0.07	0.12	0.03	0.04	0.04	0.02	0.04	0.05	0.06	0.06	0.08	0.09	0.08	0.00	0.00	0.00	0.00	0.00	0.69	0.49	3.38	0.17
	II	0.00	0.00	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.87	0.00	0.00	0.09	0.00	0.66	0.00	0.00
	III	0.00	0.00	0.12	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.00	0.00	0.00	0.00	0.00	1.35	0.00	2.29	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.12	1.51	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.47	0.78
	III	0.03	0.03	4.51	0.08	0.05	0.02	0.04	0.04	0.08	0.04	0.14	0.04	0.13	0.09	0.90	0.07	0.00	9.69	0.11	0.06	0.73	0.06	0.00	0.00	0.00
Apr	I	1.48	0.06	0.09	0.14	0.07	0.03	0.07	0.07	0.04	0.07	0.08	1.01	0.15	0.49	1.08	0.24	0.42	0.00	0.33	0.00	1.23	0.05	0.00	1.35	2.74
	II	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.39	0.58	0.02	0.00	3.11	1.06	0.00	0.39	0.00	0.24	0.23	0.44	1.07	0.00	0.92	0.15
	III	2.50	0.16	0.00	0.05	0.42	0.00	0.30	0.00	0.01	0.01	0.07	0.12	0.35	0.01	0.15	1.11	0.11	0.00	0.26	0.00	0.00	0.71	2.69	0.83	2.23
May	I	0.12	0.42	0.00	0.24	0.01	0.01	0.11	0.01	0.04	0.02	0.06	4.20	0.06	0.13	0.91	0.94	0.00	0.44	0.12	2.68	0.02	1.23	0.29	3.52	2.09
	II	0.91	1.58	0.04	1.34	0.29	2.71	2.93	0.46	1.75	0.10	0.70	1.22	0.62	7.96	1.21	2.47	0.00	0.00	0.46	1.62	2.46	0.00	0.18	6.03	0.56
	III	4.58	1.77	0.15	0.59	0.04	0.44	0.06	0.24	0.41	0.67	0.04	0.22	0.17	4.64	0.24	1.10	1.70	1.25	6.50	0.12	0.70	0.00	2.06	1.21	3.09
Total Inflow (MCM) =		1327	1535	916	1507	2292	833	1046	1598	1174	1219	593	507	316	216	704	1894	2683	1894	993	569	858	1173	537	1006	724

5.14.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.177** and **Table 5.178** respectively.

Table 5.177: Computation of 90% and 50% Dependable Year for Tamankal Project

m	m/(n+1)	Runoff in descending order (in MCM)	Dependable Year	
1	0.04	2683	2006-2007	
2	0.08	2292	1994-1995	
3	0.12	1894	2007-2008	
4	0.15	1894	2005-2006	
5	0.19	1598	1997-1998	
6	0.23	1535	1991-1992	
7	0.27	1507	1993-1994	
8	0.31	1327	1990-1991	
9	0.35	1219	1999-2000	
10	0.38	1174	1998-1999	
11	0.42	1173	2011-2012	
12	0.46	1046	1996-1997	
13	**0.50**	**1006**	**2013-2014**	**50% Dependable**
14	0.54	993	2008-2009	
15	0.58	916	1992-1993	
16	0.62	858	2010-2011	
17	0.65	833	1995-1996	
18	0.69	724	2014-2015	
19	0.73	704	2004-2005	
20	0.77	593	2000-2001	
21	0.81	569	2009-2010	
22	0.85	537	2012-2013	
23	**0.88**	**507**	**2001-2002**	**90% Dependable**
24	0.92	316	**2002-2003**	
25	0.96	216	2003-2004	

Table 5.178: 90% and 50% Dependable year flows for Tamankal Project

		90% Dependable	50% Dependable
Period		**2001-2002**	**2013-14**
Jun	**I**	1.09	9.94
	II	0.70	0.62
	III	0.41	1.47
Jul	**I**	1.97	2.99
	II	14.98	19.52
	III	39.64	483.24
Aug	**I**	59.89	354.43
	II	81.19	60.83
	III	67.51	42.21
Sep	**I**	29.28	1.68
	II	17.59	70.98
	III	73.48	14.45
Oct	**I**	39.11	4.48
	II	56.01	1.00
	III	77.00	21.52
Nov	**I**	0.14	0.00
	II	0.12	0.00
	III	0.00	0.00
Dec	**I**	0.42	0.00
	II	0.15	0.00
	III	0.04	0.00
Jan	**I**	0.00	0.00
	II	0.00	0.00
	III	0.00	0.00
Feb	**I**	0.07	3.91
	II	0.00	0.00
	III	0.00	0.00
Mar	**I**	0.00	0.00
	II	0.00	0.55
	III	0.05	0.00
Apr	**I**	1.16	1.57
	II	0.02	1.06
	III	0.13	0.96
May	**I**	4.86	4.08
	II	1.41	6.97
	III	0.23	1.27
Inflow (MCM) =		507	1006

5.14.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam site of Tamankal, is given in the following section.

5.14.5.1 EAC of Tamankal Dam

The EAC curve and the table showing the different values are given in **Figure 5.82** and **Table 5.179** respectively.

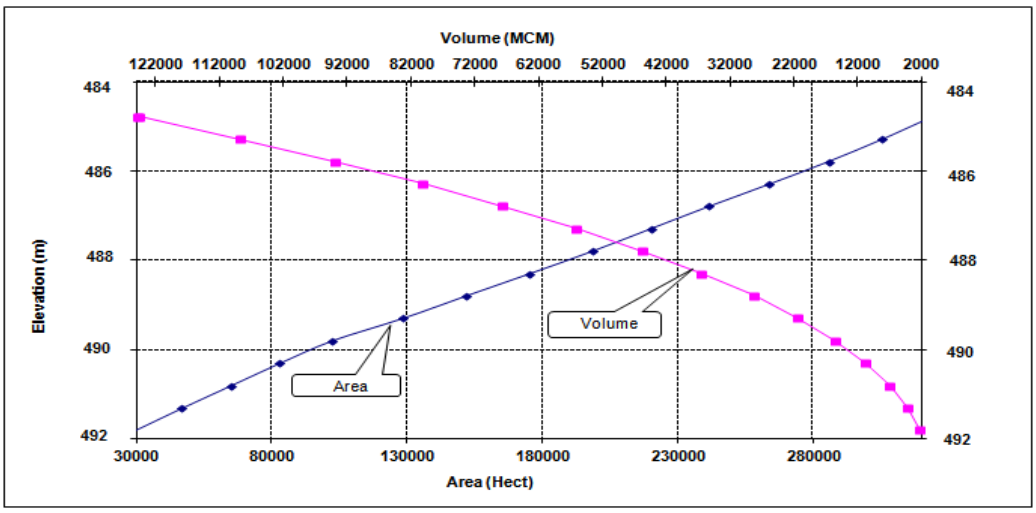


Figure 5.82: EAC curve of Tamankal Dam

Table 5.179: EAC data of Tamankal Dam

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
485.55	14604887.52	1460.49	141616606.12	141.62
486.49	15354043.52	1535.40	158711024.52	158.71
487.63	15887130.78	1588.71	176550706.62	176.55
488.77	16359939.63	1635.99	195025841.22	195.03
489.91	16811085.92	1681.11	214086956.83	214.09
491.05	17173042.81	1717.30	233675575.17	233.68
492.19	17911167.07	1791.12	253773345.83	253.77
492.25	17911167.07	1791.12	254847972.12	254.85

5.14.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value p0laces the structure and population at risk

5.14.6.1 Computation of Design flood

At present, observed flood peak data are available partially at the Narayanpur Dam and flood peaks are available at the downstream location, namely, Huvinhedgi G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Huvinhedgi G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{Tamankal}}{A_{\text{Huvinhedgi}}}\right)^{\frac{3}{4}} = 0.895$$

Using the above multiplying factors to the peak flows at the Huvinhedgi G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived for the period from 1990 to 2005. Final peak flows for the period from 2006 to 2015 have been derived by multiplying the instantaneous peak factor of 30% with peak flows at Narayanpur Dam. The final peak flows derived are given in **Table 5.180**.

Table 5.180: Final Peak Flows (cumec) at G&D and Project Site

Sl.No.	Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1	1990	7752.00	10077.60	9022.14
2	1991	8748.00	11372.40	10181.33
3	1992	4415.00	5739.50	5138.38
4	1993	5411.00	7034.30	6297.57

Sl.No.	Period	Annual Flood Peak at G&D Site (cumec)	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
5	1994	10125.69	13163.40	11784.75
6	1995	3911.00	5084.30	4551.80
7	1996	5342.00	6944.60	6217.27
8	1997	8910.00	11583.00	10369.87
9	1998	5464.00	7103.20	6359.26
10	1999	7267.00	9447.10	8457.67
11	2000	4831.00	6280.30	5622.54
12	2001	4253.50	5529.55	4950.42
13	2002	3915.84	5090.59	4557.44
14	2003	1369.32	1780.12	1593.68
15	2004	5306.91	6898.98	6176.43
16	2005	10458.68	13596.28	12172.29
17	2006	9193.01	11950.91	10699.25
18	2007	7771.81	10103.35	9045.19
19	2008	8299.94	10789.92	9659.85
20	2009	13908.77	18081.40	16187.67
21	2010	8097.15	10526.30	9423.84
22	2011	8469.64	11010.53	9857.36
23	2012	1741.46	2263.90	2026.79
24	2013	6962.03	9050.64	8102.73
25	2014	3137.35	4078.56	3651.39

5.14.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.181**.

Table 5.181: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean(X_m)	7684.28
Variance	11630621.31
SD (Sx)	2804.58
Skewness	0.31
Kurtosis	0.20
No. of Data	25

5.14.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in **Table 5.182**.

The detailed procedure for Gumbel distribution method for Tamankal dam site has been shown in **Annexure-14**

Table 5.182: Detail of different year Return Period Flood (m^3/s) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	7286
2	5	10229
3	10	12178
4	20	14047
5	25	14640
6	50	16467
7	100	18280
8	500	22470

Annexure-14 (Flood Frequency Analysis for Tamankal Dam)

DESIGN FLOOD-Tamankal

CA at G&D 55750 CA = 48104

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site	Ln-stats
1	1990	7752.00	10077.60	9022.14	9.11
2	1991	8748.00	11372.40	10181.33	9.23
3	1992	4415.00	5739.50	5138.38	8.54
4	1993	5411.00	7034.30	6297.57	8.75
5	1994	10125.69	13163.40	11784.75	9.37
6	1995	3911.00	5084.30	4551.80	8.42
7	1996	5342.00	6944.60	6217.27	8.74
8	1997	8910.00	11583.00	10369.87	9.25
9	1998	5464.00	7103.20	6359.26	8.76
10	1999	7267.00	9447.10	8457.67	9.04
11	2000	4831.00	6280.30	5622.54	8.63
12	2001	4253.50	5529.55	4950.42	8.51
13	2002	3915.84	5090.59	4557.44	8.42
14	2003	1369.32	1780.12	1593.68	7.37
15	2004	5306.91	6898.98	6176.43	8.73
16	2005	10458.68	13596.28	12172.29	9.41
17	2006	9193.01	11950.91	10699.25	9.28
18	2007	7771.81	10103.35	9045.19	9.11
19	2008	8299.94	10789.92	9659.85	9.18
20	2009	13908.77	18081.40	16187.67	9.69
21	2010	8097.15	10526.30	9423.84	9.15
22	2011	8469.64	11010.53	9857.36	9.20
23	2012	1741.46	2263.90	2026.79	7.61
24	2013	6962.03	9050.64	8102.73	9.00
25	2014	3137.35	4078.56	3651.39	8.20

Conversion factor = 0.895
Instantaneous Peak = 30%

	X-STAT	Ln-STAT
Mean(X_m)	7684.28	8.83
Variance	11630621.31	0.295
SD (Sx)	2804.58	0.543
Skewness	0.31	-1.10303
Kurtosis	0.20	1.38891
No. of Data	25	

Parameters	Values
Mean(X_m)	7684.28
Variance	11630621.31
SD (Sx)	2804.58
Skewness	0.31
Kurtosis	0.20
No. of Data	25

$X_T = X_m + K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

N = 25

Reduced mean = Y_n = 0.520 } From Table (Interpolated)

Reduced Std. Dev = S_n = 1.08 } From Table (Interpolated)

$f_{(C)}$ = 1.645 (90% confidence probability)

Reduced Variate = Y_T = $-(\ln.\ln(T/T-1))$

Frequency factor = K = $(Y_T-Y_n)/S_n$

X_T = $X_m+K.S_x$

Confidence Band = $f_{(C)}S_e$

S_e = $b.Sx/\sqrt{n}$

b = $\sqrt{(1+1.3K+1.1K^2)}$

X_{cl} = $X_T \pm f_{(C)}.Se$

90% CONFIDENCE INTERVAL

(X_{cl} Values in cumec)

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	Lower Confidence Limit	Upper Confidence Limit
1	2	**7286**	0.367	-0.142	0.915	513.312	844.399	6441	8130
2	5	**10229**	1.500	0.907	1.756	985.232	1620.706	8608	11850
3	10	**12178**	2.250	1.602	2.430	1363.221	2242.498	9935	14420
4	20	**14047**	2.970	2.269	3.100	1738.933	2860.545	11186	16908
5	25	**14640**	3.199	2.480	3.315	1859.529	3058.925	11581	17699
6	50	**16467**	3.902	3.131	3.982	2233.636	3674.332	12792	20141
7	100	**18280**	4.600	3.778	4.649	2607.582	4289.472	13990	22569
8	500	**22470**	6.214	5.272	6.199	3477.013	5719.687	16750	28189

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	7286
2	5	10229
3	10	12178
4	20	14047
5	25	14640
6	50	16467
7	100	18280
8	500	22470

5.15 Hydrology of Jaldurg Hydroelectric Project

5.15.1 Introduction

5.15.1.1 General

The present project, Jaldurg Diversion, envisages harnessing water from the River Krishna. It is situated in Raichur district of the Indian state of Karnataka. It is located in Jaldurg Diversion Mandal of Lingsugur revenue division. The project is proposed to be of RoR type with the multifunction of irrigation and power.

5.15.1.2 Description of Dam Sites

The catchment area of the present scheme comprising the dam site, along with the G&D site of Huvinhedgi is delineated from DEM. Details of catchment area and location of dam and all corresponding diversions is shown in **Fig 5.83**. The dam site is located in Raichur district of Karnataka at 16°14'46.7" N, 76°22'53.6" E. Catchment of the dam site and locations of the dam site and of G&D site are shown in **Table 5.183**.

Table 5.183: Details of Catchment Area

Name of the Dam Sites	Location (Latitude, Longitude)	Catchment Area (km^2)
Jaldurg Diversion	16°14'46.7" N, 76°22'53.6" E	48,168
Diversion 1	16°12'35.23"N, 76°29'1.46"E	113
Diversion 2	16°14'25.98"N, 76°31'43.34"E	21
Diversion 3	16°15'30.29"N, 76°32'55.60"E	10
Diversion 4	16°17'1.37"N, 76°34'53.05"E	10
Diversion 5	16°17'36.97"N, 76°36'28.82"E	11

5.15.1.3 Description of G&D Site

Huvinhedgi G&D site is situated in the Raichur district of Karnatakaat, 16° 29' 27" N, 76° 55' 28" E. Catchment area of the G&D site is around 55,750 km^2 .

5.15.1.4 The River System

The Krishna river originates in the Western Ghats near Mahabaleshwar at an elevation of about 1,300 metres, in the state of Maharashtra in central India. It is one of the longest rivers in India, The Krishna river is around 1,400 km in length (282 km in Maharashtra). The Krishna river's source is at Mahabaleswar near the Jor village in the extreme north of Wai Taluka, Satara District, Maharashtra in the west and empties into the Bay of Bengal at Hamasaladeevi (near Koduru) in Andhra Pradesh, on the east coast It flows through the state of Karnataka before entering Telangana State. The delta of this river is one of the most fertile regions in India and was the home to ancient Satavahana and Ikshvaku Sun Dynasty kings.

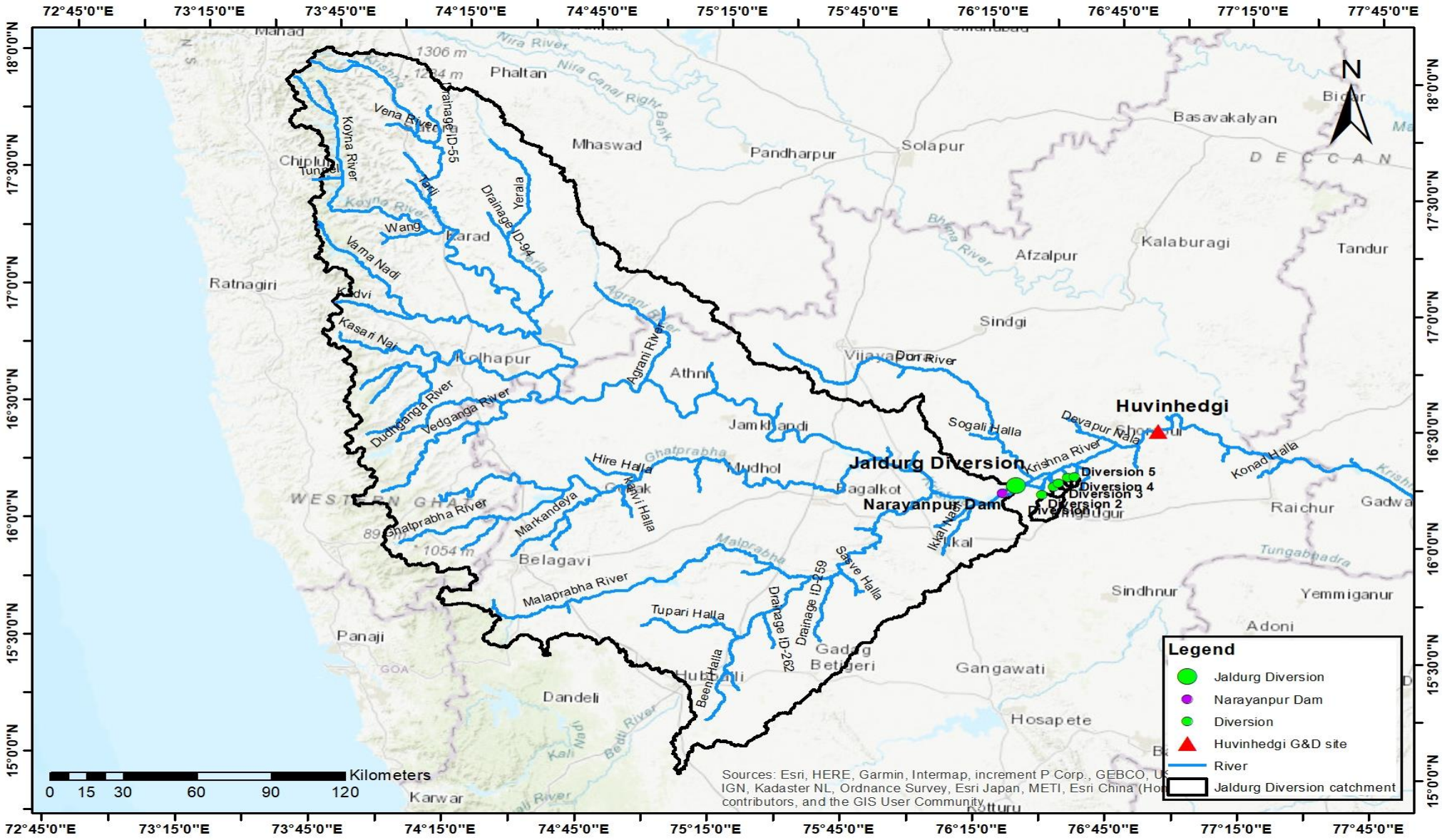


Figure 5.83: Catchment Area of Project and Locations of Dam site

5.15.2 Water Availability Studies

5.15.2.1 Data Availability

Data relevant to a hydrological assessment of the project is partially available at Narayanpur Dam from the year 2006 to 2018. However, the discharge data at the Central Water Commission (CWC) G&D site, namely Huvinhedgi (Catchment Area=55,750 km^2) which is upstream of the project site along the Krishna River, is available and can be downloaded from India WRIS site.

Generally, 15-year flow series data is required for a ROR project. Thus, flow series for the period 2000-2015 has been considered for generating the flow at the present project site.

5.15.2.2 Rainfall data

Average daily rainfall (in mm) have been calculated at each grid point (as can been seen from **Figure 5.84**) within the boundary of the Huvinhedgi G&D site, Narayanpur dam site and Jaldurg dam site is considered to compute the average daily rainfall (in mm) for the catchment. It is reiterated that all the grid points lying inside the catchment is used to estimate average rainfall irrespective of the number of the grid points. Thus, in **Figure 5.84**, 75 grid points is considered to assess the catchment rainfall for Huvinhedgi G&D site and 67 grid points have been considered for the assessment of rainfall in Jaldurg diversion proposed dam site. From the estimated daily average rainfall, 10-daily/monthly rainfall (in mm) is calculated for further calculations

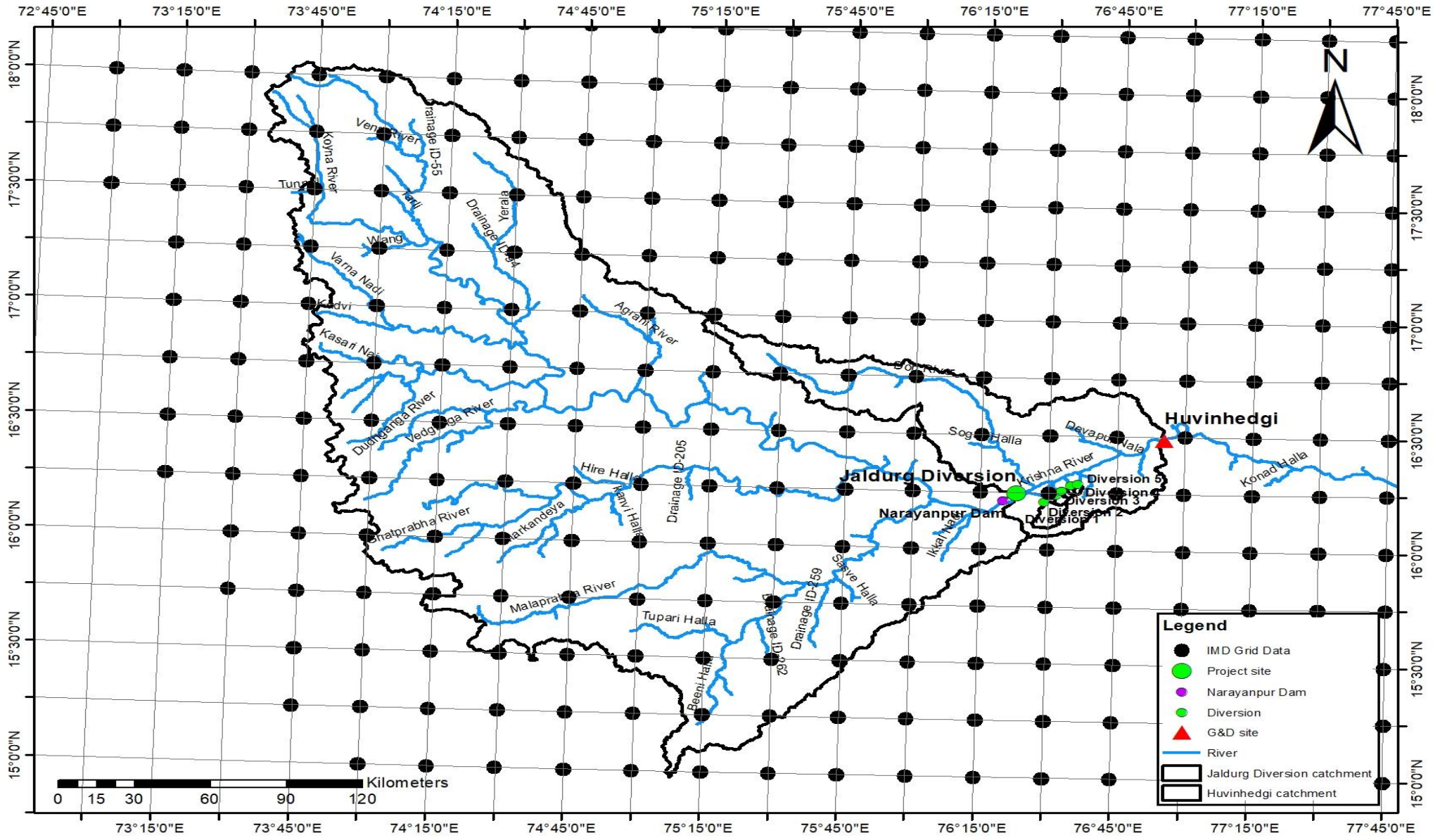


Figure 5.84: IMD GRID Rainfall Data for Jaldurg Diversion Site & Dam site

a) Average Annual Rainfall

The computed average annual rainfall for the G&D site and dam site is given in **Table 5.184**. 10-daily rainfall variation for the G&D site and the dam site are shown in **Table 5.185**, **Table 5.186**, **Table 5.187** and **Table 5.188** respectively.

Table 5.184: Average Annual Rainfall

Year	Huvinhedgi	Jaldurg Diversion	Narayanpur Dam
2000-2001	633	642	642
2001-2002	637	638	638
2002-2003	511	518	518
2003-2004	500	501	501
2004-2005	714	749	749
2005-2006	1800	1915	1915
2006-2007	764	806	806
2007-2008	927	946	946
2008-2009	651	671	671
2009-2010	994	1004	1004
2010-2011	871	885	885
2011-2012	718	750	750
2012-2013	676	695	695
2013-2014	811	815	815
2014-2015	804	828	828
AVERAGE (mm)	**801**	**824**	**824**

Table 5.185:10 Daily Rainfall (in mm) of Huvinhedgi G&D Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	5.40	1.21	4.90	0.83	7.64	2.45	4.76	4.81	3.42	3.38	2.46	5.73	1.58	5.59	3.73
	II	2.08	4.32	4.98	2.49	8.24	4.91	4.13	1.48	2.40	5.77	11.77	5.54	4.28	4.47	1.55
	III	1.38	0.75	3.27	5.82	1.61	15.39	6.98	19.46	2.27	1.09	1.57	2.78	3.62	2.46	0.37
Jul	I	4.01	5.65	0.51	2.35	1.88	14.33	6.57	9.77	1.64	8.06	2.35	5.08	2.94	3.21	3.17
	II	7.35	1.61	2.19	2.74	2.15	11.10	2.66	1.98	0.74	9.81	2.86	7.44	4.02	7.02	5.49
	III	0.23	1.94	1.68	3.32	4.02	30.56	8.20	2.56	3.59	4.56	12.28	5.04	5.30	7.58	10.14
Aug	I	5.35	4.95	7.22	2.12	10.37	19.56	9.04	8.87	6.22	0.60	2.33	4.44	6.59	3.82	4.29
	II	2.93	2.62	4.39	1.38	4.01	12.14	5.28	2.06	6.44	4.57	4.58	4.68	2.12	2.79	3.54
	III	3.97	1.21	0.76	3.48	0.74	6.33	0.71	5.10	2.23	6.16	8.53	7.08	2.57	1.09	12.84
Sep	I	1.16	0.53	1.92	1.06	6.01	12.24	2.90	2.98	10.33	4.32	3.44	7.89	6.34	6.40	3.46
	II	4.05	6.21	2.16	1.22	2.42	8.84	7.29	12.36	3.78	3.75	2.33	1.43	0.79	11.23	3.30
	III	9.19	12.70	0.83	2.75	6.66	12.08	3.60	3.11	2.59	12.52	6.91	1.24	2.84	1.11	1.91
Oct	I	4.59	8.58	0.99	7.05	3.96	3.07	4.42	0.72	3.52	17.00	3.34	1.97	10.79	1.42	4.04
	II	6.10	3.91	10.70	0.59	0.87	10.91	0.34	0.62	1.81	1.06	3.33	7.61	0.01	1.49	0.71
	III	1.30	0.05	0.11	0.90	0.09	1.52	0.41	1.79	0.73	0.02	1.91	0.49	1.71	5.20	3.56
Nov	I	0.64	0.01	0.00	0.54	0.27	0.08	2.76	0.51	0.03	0.76	4.52	0.01	3.55	0.00	0.00
	II	0.00	0.57	0.39	0.01	0.06	0.00	0.02	0.03	0.83	5.93	1.89	0.00	0.01	0.00	2.91
	III	0.00	0.01	0.00	0.00	0.00	0.00	0.73	0.07	1.95	0.12	1.22	0.17	0.00	0.48	0.00
Dec	I	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.10	0.07	0.00	0.14	0.00	0.00	0.06	0.00
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.24	0.01	0.00	0.00	0.00	1.60
	III	0.05	0.07	0.00	0.10	0.00	0.08	0.00	0.18	0.00	0.96	0.00	0.00	0.12	0.00	0.00
Jan	I	0.06	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.00	0.00	0.01	0.00	0.11
	II	0.00	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.00	2.43	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.01	0.10	0.13	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	I	0.00	0.40	0.18	0.01	0.09	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
	II	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.63	0.00	0.03	0.00	0.00	0.22	0.02	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.01	0.28	0.00	0.01	0.64	0.00
Mar	I	0.00	0.00	0.07	0.00	0.12	0.78	0.02	0.01	0.00	0.00	0.00	0.00	0.00	1.53	2.22
	II	0.02	0.04	0.36	0.00	0.00	0.05	0.00	1.03	0.29	0.11	0.00	0.00	0.26	0.47	0.16
	III	0.00	0.02	0.52	0.02	0.00	0.02	0.08	6.75	0.71	0.00	0.01	0.00	0.00	0.00	0.08
Apr	I	0.46	1.22	0.22	0.81	0.16	0.04	0.05	0.89	0.77	0.00	0.20	0.34	0.03	0.50	0.45
	II	0.70	0.40	1.03	0.00	3.60	0.44	1.14	0.32	0.27	1.02	1.75	0.43	0.01	1.26	2.13
	III	0.13	0.46	0.92	0.75	1.14	0.04	0.27	0.36	0.44	0.83	0.58	0.94	2.39	0.99	0.62
May	I	0.48	1.19	0.41	1.51	1.12	1.12	1.00	0.17	0.54	0.57	1.02	0.10	1.10	4.94	1.55
	II	0.10	1.46	0.06	3.68	0.00	0.20	0.03	0.16	3.63	0.25	0.82	0.14	0.15	1.66	1.77
	III	0.94	0.81	0.00	3.30	3.17	7.13	1.71	1.97	2.82	1.79	2.20	0.00	2.97	2.22	1.85
Yearly Rainfall (mm)		633	637	511	501	713	1800	764	927	651	994	871	718	676	811	804

Table 5.186:10 Daily Rainfall (in mm) of Jaldurg Diversion Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	5.76	1.19	4.94	0.92	8.1	2.61	5.03	4.64	3.66	3.62	2.4	5.76	1.71	5.57	3.97
	II	2.01	4.69	5.46	2.76	9.15	5.18	3.99	1.6	2.65	5.52	12.29	6.11	4.61	4.86	1.62
	III	1.13	0.8	3.57	6.1	1.68	16.94	7.53	19.86	2.53	0.94	1.49	3.04	3.92	2.5	0.38
Jul	I	3.91	6.31	0.57	2.19	1.88	15.83	7.35	10.95	1.78	8.79	2.33	5.21	3.09	3.19	2.96
	II	8.03	1.79	1.84	2.66	2.06	11.24	2.94	2.14	0.82	10.84	2.92	7.95	3.89	7.24	6.01
	III	0.26	1.86	1.8	3.58	4.01	33.44	9.07	2.41	3.58	5.07	13.11	4.88	5.55	8.12	11.02
Aug	I	5.06	4.95	7.36	1.83	11.38	21.58	10.06	9.71	6.66	0.64	2.59	4.67	7.23	4.13	4.73
	II	3.11	2.76	4.83	1.52	4.43	12.89	5.89	2.13	7.16	4.46	4.23	4.93	2.27	2.57	3.51
	III	3.9	1.16	0.81	3.27	0.83	6.24	0.73	4.82	1.9	6.14	8.15	7.25	2.3	1.05	12.49
Sep	I	1.2	0.53	1.78	1.15	5.94	12.69	3.05	2.72	9.96	3.79	3.56	8.63	6.27	5.84	3.65
	II	3.71	5.79	2.24	1.19	2.32	9.65	6.96	12.52	4.06	3.79	2.26	1.47	0.77	11.24	2.94
	III	9.66	12.57	0.83	2.15	6.95	13.28	3.6	3.26	2.67	11.98	7.06	1.15	2.9	1.15	1.98
Oct	I	4.42	7.95	0.9	7.42	4.08	3.24	4.55	0.75	3.55	16.08	3.44	2.06	11.08	1.49	4.23
	II	6.42	3.64	10.05	0.66	0.7	10.65	0.34	0.64	1.85	1.14	3.4	8.03	0.01	1.42	0.78
	III	1.24	0.01	0.12	0.89	0.09	1.39	0.32	1.71	0.65	0.02	1.88	0.52	1.67	4.84	3.47
Nov	I	0.66	0.01	0.01	0.6	0.29	0.08	2.59	0.48	0.04	0.81	4.65	0.02	3.64	0	0
	II	0	0.58	0.41	0.01	0.06	0	0.02	0.03	0.81	6.25	1.84	0	0.01	0	3.12
	III	0	0.01	0	0	0	0	0.82	0.08	2.09	0.14	1.34	0.19	0	0.5	0
Dec	I	0	0	0	0	0	0.03	0	0.11	0.07	0	0.13	0	0	0.07	0
	II	0	0	0	0	0	0	0	0.03	0	0.27	0.01	0	0	0	1.72
	III	0.05	0.08	0	0.09	0	0	0	0.2	0	1.02	0	0	0.13	0	0.01
Jan	I	0.07	0.15	0	0	0	0	0	0	0	0.32	0	0	0.01	0	0.09
	II	0	0	0.01	0	0	0	0.02	0	0	2.43	0	0	0	0	0
	III	0	0	0.01	0.08	0.09	0	0.05	0	0	0	0	0	0	0	0
Feb	I	0	0.42	0.2	0.01	0.07	0	0.07	0	0	0	0	0	0.02	0	0
	II	0	0.29	0	0	0	0	0	0.58	0	0.04	0	0	0.19	0.02	0
	III	0	0	0	0	0.01	0	0.11	0	0	0.01	0.3	0	0.01	0.67	0
Mar	I	0	0	0.08	0	0.1	0.69	0.02	0	0	0	0	0	0	1.38	2.24
	II	0.02	0.05	0.24	0	0	0.03	0	1.11	0.33	0.11	0	0	0.27	0.5	0.16
	III	0	0.02	0.57	0.02	0	0.03	0.09	6.47	0.77	0	0.01	0	0	0	0.09
Apr	I	0.44	1.34	0.25	0.86	0.16	0.05	0.05	0.86	0.84	0	0.2	0.38	0	0.48	0.44
	II	0.68	0.44	1.13	0	3.82	0.43	1.17	0.35	0.23	1.12	1.83	0.42	0.01	1.34	2.09
	III	0.12	0.5	0.94	0.78	1.2	0.05	0.3	0.4	0.45	0.89	0.61	0.84	2.47	0.94	0.62
May	I	0.51	1.26	0.46	1.35	1.21	1.15	1.1	0.19	0.54	0.61	0.98	0.11	1.17	4.8	1.68
	II	0.11	1.45	0.07	3.33	0	0.18	0.03	0.16	3.63	0.22	0.91	0.12	0.13	1.81	1.87
	III	1.04	0.77	0	3.53	3.36	7.14	1.57	1.96	2.84	1.91	2.07	0	2.95	2.23	1.99
Yearly Rainfall (mm)		642	638	518	501	748	1915	806	946	671	1004	885	750	695	814	828

Table 5.187: 10 Daily Rainfall (in mm) for Remaining Diversion Sites

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	7.59	8.51	0	35.12	5.24	11.51	34.56	86.44	0	3.32	36.11	6.56	0.37	85.22	0.83
	II	10.53	5.85	31.2	0	20.13	24.71	48.64	19.5	1.07	7.76	13.6	2.98	0.97	5.31	11.3
	III	30.39	3.49	4.78	11.93	0.21	14.81	5.94	118.61	0.89	46.44	53.5	49.02	20.73	12.56	6.51
Jul	I	22.82	2.08	23.47	28.64	14.08	106.1	0.6	0	20.23	1.55	36.04	12.86	11.99	25.16	10.01
	II	0.43	0.27	14.15	49.56	25.8	67.21	8.41	2.26	0.73	3.04	7.61	66.22	73.42	61.3	37.54
	III	111.25	54.28	10.85	14.99	12.01	13.23	0	23.57	24.34	1.61	40.22	23.53	30.47	60.24	9.05
Aug	I	70.53	17.28	3.43	10.43	2.47	78.11	0.43	10.7	106.38	73.74	127.8	10.11	18.81	80.96	103.34
	II	12.92	7.82	40.63	17.21	20.8	26.97	5.46	2.19	5.57	90.83	101.96	48.26	38.1	77.33	22.62
	III	10.8	12.99	2.54	15.17	1.92	12.62	0	11.65	0	30.34	46.03	25.66	74.42	5.52	109.37
Sep	I	1.75	8.09	0.4	41.74	37.17	34.38	36.08	54.88	15.58	48.51	36.77	5.87	49.46	14.38	3.69
	II	42.32	71.86	12.65	1.51	19.67	18.39	52.96	89.75	129.78	266.69	35.83	2.55	7.82	89.51	39.01
	III	44.79	137.12	6.54	2.42	45.95	89.13	10.41	9.66	7.32	30.49	3.58	9.05	61.91	22.12	50.9
Oct	I	81.27	74.39	0	12.02	0	165.14	14.44	9.14	0	0	27.42	14.05	16.85	0	51.09
	II	31.55	35.88	148.1	23.58	0	38.45	4.68	1.4	3.48	0	30.59	6.63	0.46	8.61	5.98
	III	0	0	1.94	3.94	25.12	25.22	44.44	13.83	23.8	2.95	23.74	0	28.73	91.07	2.33
Nov	I	0	0	0	0	0	0	5.07	0	2.64	0	3.04	0	9.14	0	0
	II	0	0	1.38	0.6	0	0.16	0	0	0	0	0	0.78	0	0	0
	III	0	0	0	0	3.32	3.39	0	0	18.3	30.79	38.69	0	0	0	4.91
Dec	I	0	2.49	0	5.77	0	0	0	0	0	0	0	0	0	0	0
	II	0	0	0	0	0.62	0	0	0	0	3.16	0	0	0	0	6.06
	III	0	0	0	0	0	0	0	0	0	0	0.54	0	0	0	5.49
Jan	I	0	0	0	4.75	0	0	0	0	0	0	0	0.83	0	0	0
	II	0	0	0	0	13.05	0	0	0	0	0	0	0	0	0	0
	III	0	0	0	0	0	0	0	0	0	13.62	0	0	0	0	0
Feb	I	0		0	0	0	0	0	0	0	0	0	0	4.91	33.5	1.68
	II	0	0	0	0	0	0	0	8.63	0	0	0.89	0	6.57	0	0
	III	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0
Mar	I	0	0	0	0	0	13.42	0	22.7	0.17	0	0	0	0	0	0
	II	0	0	11.09	14.94	0	0	0	6.15	0	0	0	0	0	4.7	7.71
	III	0.99	0	0.6	0	8.23	0	0	96.15	1.09	0.55	0	0.56	0	0	0
Apr	I	0	9.38	0.34	3.17	9.5	1.17	4.18	0	3.24	0	3.68	0.45	0	13.43	27.2
	II	5.75	0.16	0	30.86	10.56	0	3.9	0	2.37	2.26	4.32	10.59	0	9.09	1.5
	III	0.56	1.01	3.25	0	1.25	10.94	0.81	0	1.92	0	0	7.03	26.64	8.26	22.11
May	I	0	41.26	0	0.91	8.48	9.13	0	4.35	0	25.35	0.15	12.17	2.91	34.95	20.71
	II	0	7.55	0	66.71	8.8	21.54	0	0	3.31	14.83	20.21	0	1.81	59.79	5.51
	III	0	0	0	44.44	0.45	7.89	16.91	12.37	63.29	0	0	0	20.43	11.98	30.66

Table 5.188:10 Daily Rainfall (in mm) of Narayanpur Dam

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	5.76	1.19	4.94	0.92	8.1	2.61	5.03	4.64	3.66	3.62	2.4	5.76	1.71	5.57	3.97
	II	2.01	4.69	5.46	2.76	9.15	5.18	3.99	1.6	2.65	5.52	12.29	6.11	4.61	4.86	1.62
	III	1.13	0.8	3.57	6.1	1.68	16.94	7.53	19.86	2.53	0.94	1.49	3.04	3.92	2.5	0.38
Jul	I	3.91	6.31	0.57	2.19	1.88	15.83	7.35	10.95	1.78	8.79	2.33	5.21	3.09	3.19	2.96
	II	8.03	1.79	1.84	2.66	2.06	11.24	2.94	2.14	0.82	10.84	2.92	7.95	3.89	7.24	6.01
	III	0.26	1.86	1.8	3.58	4.01	33.44	9.07	2.41	3.58	5.07	13.11	4.88	5.55	8.12	11.02
Aug	I	5.06	4.95	7.36	1.83	11.38	21.58	10.06	9.71	6.66	0.64	2.59	4.67	7.23	4.13	4.73
	II	3.11	2.76	4.83	1.52	4.43	12.89	5.89	2.13	7.16	4.46	4.23	4.93	2.27	2.57	3.51
	III	3.9	1.16	0.81	3.27	0.83	6.24	0.73	4.82	1.9	6.14	8.15	7.25	2.3	1.05	12.49
Sep	I	1.2	0.53	1.78	1.15	5.94	12.69	3.05	2.72	9.96	3.79	3.56	8.63	6.27	5.84	3.65
	II	3.71	5.79	2.24	1.19	2.32	9.65	6.96	12.52	4.06	3.79	2.26	1.47	0.77	11.24	2.94
	III	9.66	12.57	0.83	2.15	6.95	13.28	3.6	3.26	2.67	11.98	7.06	1.15	2.9	1.15	1.98
Oct	I	4.42	7.95	0.9	7.42	4.08	3.24	4.55	0.75	3.55	16.08	3.44	2.06	11.08	1.49	4.23
	II	6.42	3.64	10.05	0.66	0.7	10.65	0.34	0.64	1.85	1.14	3.4	8.03	0.01	1.42	0.78
	III	1.24	0.01	0.12	0.89	0.09	1.39	0.32	1.71	0.65	0.02	1.88	0.52	1.67	4.84	3.47
Nov	I	0.66	0.01	0.01	0.6	0.29	0.08	2.59	0.48	0.04	0.81	4.65	0.02	3.64	0	0
	II	0	0.58	0.41	0.01	0.06	0	0.02	0.03	0.81	6.25	1.84	0	0.01	0	3.12
	III	0	0.01	0	0	0	0	0.82	0.08	2.09	0.14	1.34	0.19	0	0.5	0
Dec	I	0	0	0	0	0	0.03	0	0.11	0.07	0	0.13	0	0	0.07	0
	II	0	0	0	0	0	0	0	0.03	0	0.27	0.01	0	0	0	1.72
	III	0.05	0.08	0	0.09	0	0	0	0.2	0	1.02	0	0	0.13	0	0.01
Jan	I	0.07	0.15	0	0	0	0	0	0	0	0.32	0	0	0.01	0	0.09
	II	0	0	0.01	0	0	0	0.02	0	0	2.43	0	0	0	0	0
	III	0	0	0.01	0.08	0.09	0	0.05	0	0	0	0	0	0	0	0
Feb	I	0	0.42	0.2	0.01	0.07	0	0.07	0	0	0	0	0	0.02	0	0
	II	0	0.29	0	0	0	0	0	0.58	0	0.04	0	0	0.19	0.02	0
	III	0	0	0	0	0.01	0	0.11	0	0	0.01	0.3	0	0.01	0.67	0
Mar	I	0	0	0.08	0	0.1	0.69	0.02	0	0	0	0	0	0	1.38	2.24
	II	0.02	0.05	0.24	0	0	0.03	0	1.11	0.33	0.11	0	0	0.27	0.5	0.16
	III	0	0.02	0.57	0.02	0	0.03	0.09	6.47	0.77	0	0.01	0	0	0	0.09
Apr	I	0.44	1.34	0.25	0.86	0.16	0.05	0.05	0.86	0.84	0	0.2	0.38	0	0.48	0.44
	II	0.68	0.44	1.13	0	3.82	0.43	1.17	0.35	0.23	1.12	1.83	0.42	0.01	1.34	2.09
	III	0.12	0.5	0.94	0.78	1.2	0.05	0.3	0.4	0.45	0.89	0.61	0.84	2.47	0.94	0.62
May	I	0.51	1.26	0.46	1.35	1.21	1.15	1.1	0.19	0.54	0.61	0.98	0.11	1.17	4.8	1.68
	II	0.11	1.45	0.07	3.33	0	0.18	0.03	0.16	3.63	0.22	0.91	0.12	0.13	1.81	1.87
	III	1.04	0.77	0	3.53	3.36	7.14	1.57	1.96	2.84	1.91	2.07	0	2.95	2.23	1.99
Yearly Rainfall (mm)		642	638	518	501	748	1915	806	946	671	1004	885	750	695	814	828

5.15.2.3 Rainfall and Runoff Data at Huvinhedgi G&D Site and Narayanpur Dam

Detailed calculations on water availability and flood magnitude will help to select the design features of the project (installed capacity, turbine flow, spillway capacity, etc.). These features directly reflect on the project cost and on the quantity and value of energy produced. Thus, a gross consistency check has been performed by plotting the monthly runoff (in mm) against the monthly rainfall (in mm) for the entire period ranging from 2000 to 2015. The plot between monthly runoff depth and rainfall data in "mm" at Huvinhedgi G&D site is shown in **Figure 5.85**, The difference between the rainfall and runoff values might be due to initial abstractions, other losses, presence of depressions or diversions that depend upon land use and land cover of the catchment. For the above stated reason, monsoon & non-monsoon period discharge data of Narayapur dam and Huvinhedgi G&D have been used to derive the flow series at the dam site from June to May of each year. **Figure 5.86** shows the plot of runoff coefficient at the G&D Site. It can be seen that annual runoff depth is less than annual rainfall and G&D site has achieved maximum average rainfall during the year 2005-06. **Figure 5.87** shows the plot of runoff coefficient at Narayanpur Dam. which shows the similar trend as that of G&D site, where the annual runoff depth is less than annual rainfall and a lesser amount of rainfall-runoff values have been spotted in both G&D site and Dam sites during the year 2002-04 as compared to rest of the years.

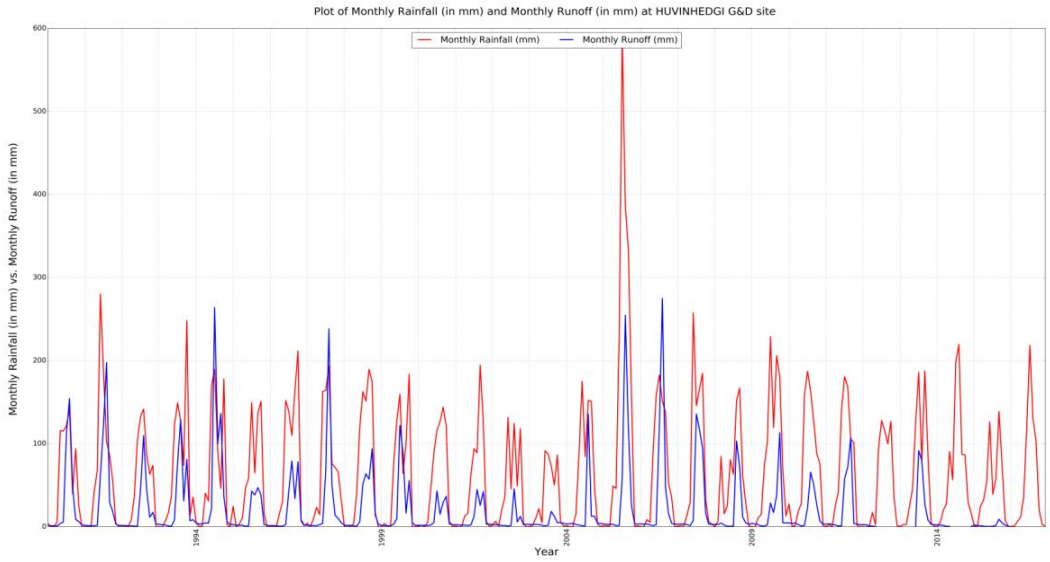


Figure 5.85: Plot of Monthly Rainfall (mm) and Monthly Runoff (mm) at Huvinhedgi G&D site

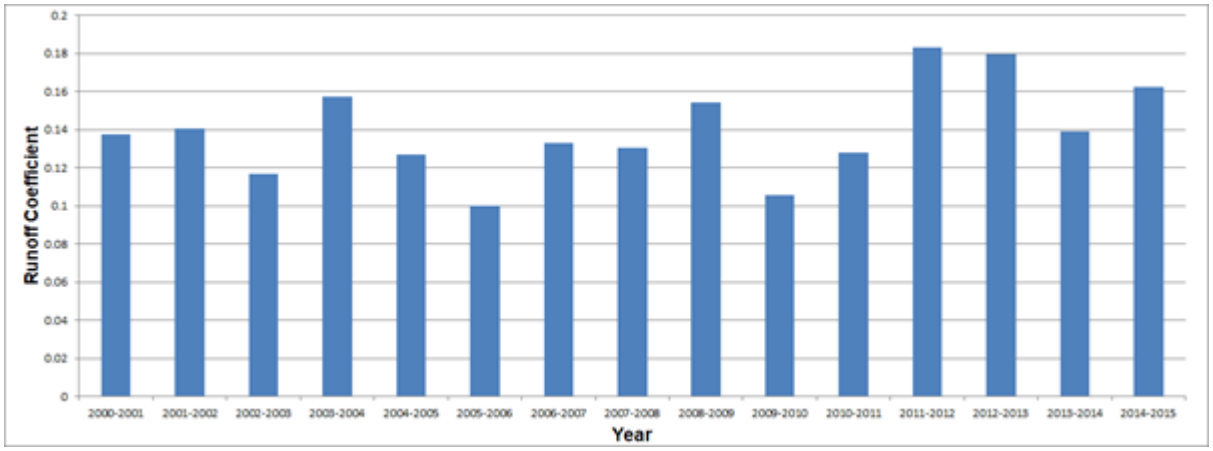


Figure 5.86: Plot of Runoff Coefficient at G&D Site

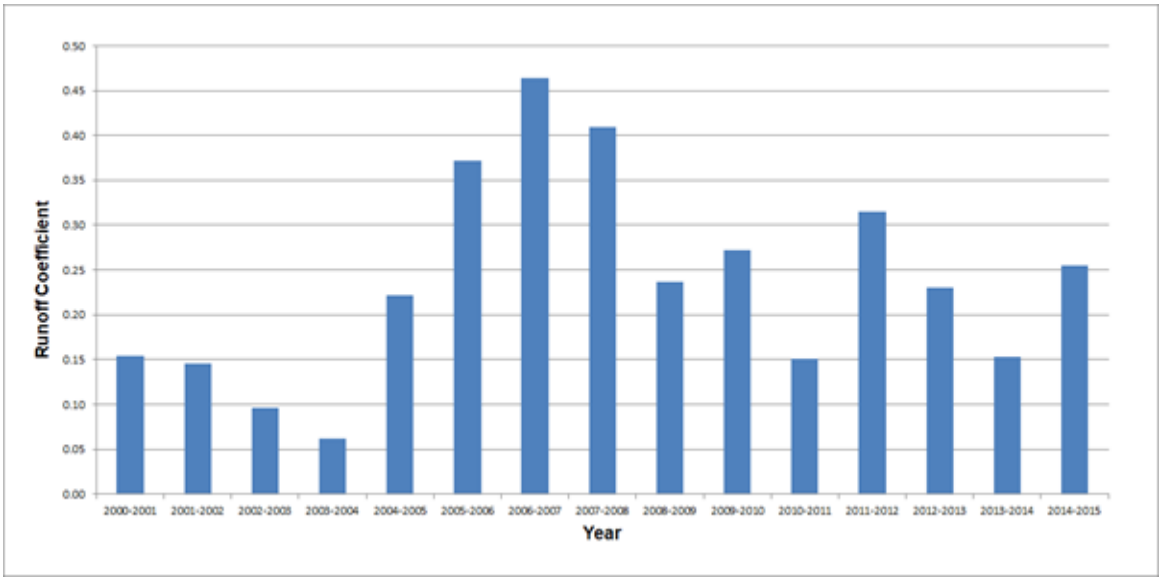


Figure 5.87: Plot of Runoff Coefficient at Narayanpur Dam site

5.15.3 Flow Series Computation

Flow series at the proposed project site (Jaldurg Project Site) is estimated using discharge ratio. Daily discharge data for Huvinhedgi site is available for the period from 2000 to 2015 and daily outflow data at Narayanpur Dam is available for the period from 2006 to 2018. After finalizing the flow series at the G&D site of Huvinhedgi for the period from 2000 to 2015 and Narayanpur Dam site for the period from 2006 to 2015, the flow series at the Jaldurg project site has been developed using discharge ratio factor. Discharge ratio factor has been used for transposing the missing flow series data for the period from 2000 to 2005 from G&D site to Narayanpur Dam for getting long term complete flow series at project site as it can be assumed that the catchments i.e Huvinhedgi G&D site and both the dam Sites are having similar drainage and hydro-meteorological characteristics. The flow series for the other five diversions have been computed from rainfall in those catchment. The runoff for the other diversion site has been computed based on their catchment area.

$$\text{Discharge Ratio Factor} = \frac{\text{Average 10 daily Flow}_{\text{Narayanpur}}}{\text{Average 10 daily Flow}_{\text{Huvinhedgi}}}$$

Discharge Series for the dam is computed according to the equation below

$$Q_{\text{Jaldurg diversion}} = Q_{\text{Narayanpur}} = Q_{\text{Huvinhedgi G\&}D\ Site}\ X\ Discharge\ Ratio\ Fator$$

$$Q_{\text{Final}} = Q_{\text{Jaldurg Diversion}} + Q_{\text{Diversion 1}} + Q_{\text{Diversion 2}} + Q_{\text{Diversion 3}} + Q_{\text{Diversion 4}} + Q_{\text{Diversion 5}}$$

Table 5.189 shows the discharge ratio factor for the period from 2006 to 2015 and **Table 5.190** shows the 10-daily average flow series at Narayanpur Dam whereas **Table 5.191** shows the 10-daily average flow series at G&D site and **Table 5.192** to **Table 5.199** illustrates the 10-daily average flow series and 10-daily inflow flow series for Jaldurg diversion and Jaldurg dam site.

Table 5.189: Discharge Ratio Factor for the period from 2006-2015

Period		Average 10 Daily Flow at Narayanpur	Average 10 Daily Flow at Huvinehdgi	Discharge Ratio Factor
JUN	I	24.11	25.29	0.95
	II	37.44	38.03	0.98
	III	84.45	83.81	1.01
JUL	I	860.75	1015.28	0.85
	II	635.70	694.91	0.91
	III	1889.69	2035.34	0.93
AUG	I	2033.50	2519.57	0.81
	II	2427.40	2940.12	0.83
	III	792.80	909.85	0.87
SEP	I	1861.56	1704.45	1.09
	II	1343.98	1306.90	1.03
	III	939.29	1036.35	0.91
OCT	I	1542.83	1451.21	1.06
	II	287.86	292.86	0.98
	III	171.69	166.28	1.03
NOV	I	97.86	100.57	0.97
	II	98.47	96.14	1.02
	III	83.37	81.62	1.02
DEC	I	67.03	67.08	1.00
	II	59.40	59.65	1.00
	III	59.65	59.57	1.00

Period		Average 10 Daily Flow at Narayanpur	Average 10 Daily Flow at Huvinehdgi	Discharge Ratio Factor
JAN	I	64.87	64.90	1.00
	II	64.89	65.17	1.00
	III	66.80	66.93	1.00
FEB	I	67.26	67.44	1.00
	II	62.17	64.00	0.97
	III	66.29	67.58	0.98
MAR	I	55.13	56.97	0.97
	II	51.02	52.79	0.97
	III	61.97	63.34	0.98
APR	I	38.95	41.72	0.93
	II	30.61	33.28	0.92
	III	20.18	20.90	0.97
MAY	I	14.05	14.44	0.97
	II	12.58	13.71	0.92
	III	12.70	14.59	0.87

Table 5.190: 10-Daily Average Flow Series (m^3/s) at Narayanpur Dam

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	103.05	35.34	25.91	25.59	56.01	47.68	0.07	0.00	0.00	0.45	0.23	0.00	0.59	0.44	0.70
	II	195.14	34.06	21.25	20.56	12.09	33.09	0.07	1.41	0.00	0.00	0.80	0.40	0.59	0.13	0.44
	III	13.79	74.89	6.00	26.47	7.76	13.72	0.28	0.05	0.00	0.00	0.00	0.86	0.59	0.23	0.14
Jul	I	27.14	20.44	3.27	30.21	16.94	234.68	257.46	501.56	0.93	0.00	0.00	0.67	0.59	0.18	0.43
	II	1435.14	200.78	58.87	46.57	22.02	614.20	285.88	521.86	1.17	0.00	0.00	0.11	0.59	0.18	0.43
	III	989.26	454.89	27.15	20.18	22.90	2407.42	300.09	528.22	1.22	0.00	0.00	0.00	0.59	0.15	0.43
Aug	I	312.30	534.97	32.69	384.66	2485.10	7728.17	840.69	239.85	24.04	77.59	327.50	180.71	26.85	384.94	304.93
	II	220.15	876.05	1384.97	272.86	3391.03	3724.43	939.76	396.01	639.86	33.98	33.02	133.85	116.23	93.16	97.58
	III	248.87	922.30	974.90	305.87	1238.78	1856.59	249.24	109.10	41.28	36.04	60.60	127.08	25.71	77.15	109.14
Sep	I	1329.22	373.55	162.90	515.84	169.56	1280.06	24.97	230.18	42.37	93.65	172.52	574.35	177.84	24.40	241.82
	II	247.62	169.85	154.84	206.53	250.93	2940.09	77.99	175.17	231.33	41.24	85.01	102.84	80.50	86.50	92.04
	III	388.40	1043.35	62.75	123.36	370.90	3135.96	196.76	137.65	159.76	80.21	65.22	25.12	25.99	41.18	26.29
Oct	I	983.95	1779.68	54.54	144.60	600.92	1243.61	57.77	85.88	34.31	607.31	118.41	19.97	53.14	43.50	23.19
	II	951.41	755.61	593.50	71.09	160.45	336.17	43.57	26.18	45.67	75.69	30.02	19.93	42.25	28.64	19.87
	III	441.16	255.46	140.76	97.30	83.78	110.95	25.49	26.73	30.69	25.59	40.32	20.08	24.30	19.70	26.65
Nov	I	101.36	60.60	43.76	89.22	86.65	89.91	24.82	28.16	28.73	29.66	27.23	21.52	24.02	24.43	28.88
	II	53.65	66.80	55.13	116.21	91.13	79.89	20.63	28.60	29.06	25.08	23.03	24.72	24.97	24.47	24.11
	III	61.55	66.68	61.26	121.17	85.64	74.39	22.49	26.96	25.62	16.28	21.07	23.80	24.98	21.18	10.50
Dec	I	59.75	63.17	64.74	107.80	87.13	68.47	23.20	22.20	22.11	18.66	17.20	18.78	22.67	17.49	26.72
	II	60.24	62.44	69.40	88.17	85.08	65.14	23.74	21.83	24.55	20.84	17.32	22.42	22.81	24.99	11.65
	III	52.87	61.68	54.26	59.36	74.99	70.30	21.75	26.43	22.80	21.88	19.44	21.07	22.69	26.21	20.37
Jan	I	54.56	64.24	56.01	61.54	69.01	71.93	25.72	27.54	28.10	22.71	21.53	21.31	24.00	11.05	23.90
	II	44.63	55.64	55.80	68.37	64.97	72.46	25.63	24.88	29.32	21.16	23.72	19.25	23.43	26.01	4.60
	III	46.01	51.61	59.63	73.09	75.91	72.06	25.72	26.89	30.01	21.75	23.87	21.33	21.22	26.47	30.03
Feb	I	48.88	55.58	61.14	78.12	82.64	75.66	24.38	27.95	29.72	25.94	24.49	24.83	22.46	14.89	8.60
	II	46.72	49.44	58.95	77.45	53.30	68.24	25.21	23.34	28.41	21.34	25.17	23.73	21.76	26.27	22.65
	III	46.76	46.33	56.77	79.51	55.72	63.13	24.58	25.31	28.15	24.92	24.35	23.77	1.63	25.34	27.12
Mar	I	42.90	45.35	55.41	81.83	56.86	73.05	22.38	23.83	23.38	17.63	23.11	18.96	3.63	3.10	3.52
	II	38.91	40.92	56.83	85.31	64.04	64.82	23.91	23.74	22.35	27.36	22.95	0.00	0.26	20.47	23.55
	III	35.31	37.03	56.34	80.18	57.01	58.61	24.80	9.74	9.95	26.44	22.90	0.00	0.57	2.35	15.67
Apr	I	37.78	27.70	50.38	78.90	55.64	54.80	22.18	11.91	14.06	27.87	20.19	0.00	0.57	0.34	48.48
	II	40.92	32.17	53.28	48.01	69.64	57.91	10.47	15.84	3.24	11.29	11.29	0.00	0.57	0.56	0.00
	III	37.34	29.68	55.21	30.22	41.75	22.09	1.18	2.37	0.26	0.00	1.08	0.00	0.85	0.67	0.00
May	I	33.02	25.16	37.04	24.39	31.14	11.56	0.43	0.00	0.66	0.66	0.00	0.06	0.92	0.36	0.00
	II	40.44	26.20	35.53	71.37	18.54	17.21	1.41	0.00	0.71	0.71	0.94	0.59	0.71	0.19	1.47
	III	5.83	29.67	23.04	22.07	26.01	41.41	1.22	0.00	0.13	0.13	0.94	0.59	0.71	0.13	0.00

Table 5.191:10-Daily Average Flow Series (m^3/s) at Huvinhedgi

Catchment Area =55750 km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	108.10	37.07	27.18	26.85	58.76	50.02	37.11	27.92	13.65	10.89	27.05	36.77	23.26	29.39	25.47
	II	198.21	34.60	21.58	20.88	12.28	33.61	43.91	37.12	12.52	96.71	43.02	16.16	41.11	5.39	40.48
	III	13.69	74.33	5.95	26.27	7.70	13.62	77.46	414.10	10.61	37.86	33.11	8.68	100.87	3.72	36.85
Jul	I	32.01	24.11	3.86	35.63	19.98	276.81	2560.59	4740.85	11.70	7.94	25.41	29.63	963.11	2.20	205.66
	II	1568.82	219.48	64.35	50.91	24.07	671.41	1287.03	3531.47	8.38	6.27	20.57	10.28	715.39	160.32	182.57
	III	1065.51	489.95	29.24	21.74	24.66	2592.97	3491.84	440.74	26.29	1658.10	1271.87	3356.43	1350.69	5222.96	2572.01
Aug	I	386.95	662.84	40.50	476.60	3079.12	9575.44	7380.26	2589.07	48.43	539.16	2899.69	1847.82	1584.83	3508.26	2075.95
	II	266.65	1061.09	1677.51	330.50	4107.30	4511.12	8067.37	3806.79	6374.00	149.08	347.78	1293.56	2394.24	864.05	1009.74
	III	285.61	1058.47	1118.84	351.03	1421.68	2130.71	2080.40	1045.54	221.60	373.47	895.38	1318.87	770.97	704.17	812.57
Sep	I	1217.04	342.02	149.15	472.31	155.25	1172.03	133.39	2365.19	661.44	1106.47	1756.14	5702.02	2318.25	209.40	2218.46
	II	240.79	165.16	150.57	200.83	244.01	2858.97	936.06	2275.75	2421.79	415.84	861.61	1071.58	1409.31	1091.88	970.04
	III	428.53	1151.16	69.23	136.11	409.23	3460.01	2006.94	1463.47	1579.00	915.26	657.04	153.06	953.57	409.36	617.66
Oct	I	925.52	1674.00	51.30	136.01	565.24	1169.77	535.10	780.64	237.61	6386.37	1087.75	79.06	1714.29	232.50	1899.99
	II	967.91	768.71	603.79	72.32	163.23	342.00	342.77	134.16	336.76	730.18	214.37	81.79	299.45	122.52	289.66
	III	427.26	247.41	136.33	94.24	81.14	107.46	112.20	114.06	159.23	175.20	348.62	72.16	173.85	144.08	182.78
Nov	I	104.16	62.28	44.97	91.69	89.05	92.40	127.62	82.76	88.80	106.68	157.87	63.03	99.83	65.15	98.51
	II	52.38	65.22	53.83	113.46	88.97	78.00	72.85	60.11	102.82	115.10	162.67	72.29	102.60	66.54	103.84
	III	60.25	65.28	59.97	118.62	83.84	72.82	64.06	59.43	96.70	82.91	115.87	78.70	86.72	61.83	85.21
Dec	I	59.80	63.22	64.79	107.88	87.20	68.52	67.59	59.94	68.10	107.03	62.70	54.85	70.52	39.12	66.84
	II	60.49	62.70	69.69	88.54	85.44	65.41	62.14	54.46	60.79	83.77	59.18	47.98	61.24	42.68	58.97
	III	52.80	61.59	54.18	59.28	74.88	70.20	58.73	53.56	63.25	90.62	64.71	45.67	63.56	56.48	64.21
Jan	I	54.59	64.27	56.04	61.57	69.04	71.96	65.21	59.12	72.78	98.78	66.96	44.22	68.37	33.60	62.39
	II	44.82	55.88	56.04	68.66	65.25	72.77	67.92	61.84	81.74	102.97	68.94	51.47	73.39	52.14	69.78
	III	46.10	51.71	59.75	73.23	76.06	72.20	68.22	58.67	91.06	90.25	69.69	54.62	72.86	53.31	68.15
Feb	I	49.01	55.72	61.30	78.32	82.85	75.85	69.17	62.44	88.05	88.33	77.01	67.43	76.65	39.48	69.78
	II	48.10	50.90	60.69	79.73	54.87	70.25	82.34	59.56	76.56	84.93	82.25	48.91	70.44	43.61	66.03
	III	47.67	47.23	57.88	81.06	56.81	64.36	80.52	48.43	72.89	93.47	84.05	44.38	68.64	53.37	68.78
Mar	I	44.33	46.86	57.26	84.56	58.76	75.49	75.35	45.34	65.44	76.06	66.97	45.40	59.84	43.91	58.44
	II	40.26	42.34	58.80	88.26	66.26	67.06	70.45	48.75	56.95	99.27	60.50	14.59	56.01	33.02	52.68
	III	36.09	37.85	57.59	81.96	58.27	59.91	77.07	175.99	30.18	100.11	53.39	3.58	72.65	19.97	49.94
Apr	I	40.46	29.67	53.96	84.51	59.59	58.69	69.39	56.36	25.25	88.33	45.18	10.56	45.14	8.82	39.61
	II	44.50	34.98	57.94	52.21	75.73	62.98	60.06	48.70	16.75	62.11	43.82	5.46	35.37	9.25	31.20
	III	38.67	30.74	57.18	31.30	43.24	22.88	28.09	29.56	8.31	14.44	45.39	19.58	23.46	12.59	23.09
May	I	33.94	25.86	38.08	25.07	32.01	11.88	18.37	11.60	16.42	25.20	14.95	10.56	15.75	10.77	15.45
	II	44.08	28.56	38.72	77.79	20.21	18.76	25.01	7.70	10.04	15.61	15.95	8.24	11.51	11.70	12.60
	III	6.69	34.07	26.46	25.35	29.87	47.55	33.44	12.03	21.75	8.30	19.80	7.53	13.88	7.74	11.45
Inflow(MCM)		8056	7963	4693	3525	10279	26578	26794	21690	11564	12506	10526	14130	14083	12170	12683

Table 5.192:10-Daily Average Flow Series (m^3/s) at Jaldurg Diversion

Catchment Area= 64 km^2 All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	103.05	35.34	25.91	25.59	56.01	47.68	0.07	0.00	0.00	0.45	0.23	0.00	0.59	0.44	0.70
	II	195.14	34.06	21.25	20.56	12.09	33.09	0.07	1.41	0.00	0.00	0.80	0.40	0.59	0.13	0.44
	III	13.79	74.89	6.00	26.47	7.76	13.72	0.28	0.05	0.00	0.00	0.00	0.86	0.59	0.23	0.14
Jul	I	27.14	20.44	3.27	30.21	16.94	234.68	257.46	501.56	0.93	0.00	0.00	0.67	0.59	0.18	0.43
	II	1435.14	200.78	58.87	46.57	22.02	614.20	285.88	521.86	1.17	0.00	0.00	0.11	0.59	0.18	0.43
	III	989.26	454.89	27.15	20.18	22.90	2407.42	300.09	528.22	1.22	0.00	0.00	0.00	0.59	0.15	0.43
Aug	I	312.30	534.97	32.69	384.66	2485.10	7728.17	840.69	239.85	24.04	77.59	327.50	180.71	26.85	384.94	304.93
	II	220.15	876.05	1384.97	272.86	3391.03	3724.43	939.76	396.01	639.86	33.98	33.02	133.85	116.23	93.16	97.58
	III	248.87	922.30	974.90	305.87	1238.78	1856.59	249.24	109.10	41.28	36.04	60.60	127.08	25.71	77.15	109.14
Sep	I	1329.22	373.55	162.90	515.84	169.56	1280.06	24.97	230.18	42.37	93.65	172.52	574.35	177.84	24.40	241.82
	II	247.62	169.85	154.84	206.53	250.93	2940.09	77.99	175.17	231.33	41.24	85.01	102.84	80.50	86.50	92.04
	III	388.40	1043.35	62.75	123.36	370.90	3135.96	196.76	137.65	159.76	80.21	65.22	25.12	25.99	41.18	26.29
Oct	I	983.95	1779.68	54.54	144.60	600.92	1243.61	57.77	85.88	34.31	607.31	118.41	19.97	53.14	43.50	23.19
	II	951.41	755.61	593.50	71.09	160.45	336.17	43.57	26.18	45.67	75.69	30.02	19.93	42.25	28.64	19.87
	III	441.16	255.46	140.76	97.30	83.78	110.95	25.49	26.73	30.69	25.59	40.32	20.08	24.30	19.70	26.65
Nov	I	101.36	60.60	43.76	89.22	86.65	89.91	24.82	28.16	28.73	29.66	27.23	21.52	24.02	24.43	28.88
	II	53.65	66.80	55.13	116.21	91.13	79.89	20.63	28.60	29.06	25.08	23.03	24.72	24.97	24.47	24.11
	III	61.55	66.68	61.26	121.17	85.64	74.39	22.49	26.96	25.62	16.28	21.07	23.80	24.98	21.18	10.50
Dec	I	59.75	63.17	64.74	107.80	87.13	68.47	23.20	22.20	22.11	18.66	17.20	18.78	22.67	17.49	26.72
	II	60.24	62.44	69.40	88.17	85.08	65.14	23.74	21.83	24.55	20.84	17.32	22.42	22.81	24.99	11.65
	III	52.87	61.68	54.26	59.36	74.99	70.30	21.75	26.43	22.80	21.88	19.44	21.07	22.69	26.21	20.37
Jan	I	54.56	64.24	56.01	61.54	69.01	71.93	25.72	27.54	28.10	22.71	21.53	21.31	24.00	11.05	23.90
	II	44.63	55.64	55.80	68.37	64.97	72.46	25.63	24.88	29.32	21.16	23.72	19.25	23.43	26.01	4.60
	III	46.01	51.61	59.63	73.09	75.91	72.06	25.72	26.89	30.01	21.75	23.87	21.33	21.22	26.47	30.03
Feb	I	48.88	55.58	61.14	78.12	82.64	75.66	24.38	27.95	29.72	25.94	24.49	24.83	22.46	14.89	8.60
	II	46.72	49.44	58.95	77.45	53.30	68.24	25.21	23.34	28.41	21.34	25.17	23.73	21.76	26.27	22.65
	III	46.76	46.33	56.77	79.51	55.72	63.13	24.58	25.31	28.15	24.92	24.35	23.77	1.63	25.34	27.12
Mar	I	42.90	45.35	55.41	81.83	56.86	73.05	22.38	23.83	23.38	17.63	23.11	18.96	3.63	3.10	3.52
	II	38.91	40.92	56.83	85.31	64.04	64.82	23.91	23.74	22.35	27.36	22.95	0.00	0.26	20.47	23.55
	III	35.31	37.03	56.34	80.18	57.01	58.61	24.80	9.74	9.95	26.44	22.90	0.00	0.57	2.35	15.67
Apr	I	37.78	27.70	50.38	78.90	55.64	54.80	22.18	11.91	14.06	27.87	20.19	0.00	0.57	0.34	48.48
	II	40.92	32.17	53.28	48.01	69.64	57.91	10.47	15.84	3.24	11.29	11.29	0.00	0.57	0.56	0.00
	III	37.34	29.68	55.21	30.22	41.75	22.09	1.18	2.37	0.26	0.00	1.08	0.00	0.85	0.67	0.00
May	I	33.02	25.16	37.04	24.39	31.14	11.56	0.43	0.00	0.66	0.66	0.00	0.06	0.92	0.36	0.00
	II	40.44	26.20	35.53	71.37	18.54	17.21	1.41	0.00	0.71	0.71	0.94	0.59	0.71	0.19	1.47
	III	5.83	29.67	23.04	22.07	26.01	41.41	1.22	0.00	0.13	0.13	0.94	0.59	0.71	0.13	0.00

Table 5.193: 10-Daily Flow Series (m^3/s) at Diversion 1

Catchment Area = 113 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	1.00	1.12	0.00	4.61	0.69	1.51	4.54	11.35	0.00	0.44	4.74	0.86	0.05	11.19	0.11
	II	1.38	0.77	4.10	0.00	2.64	3.25	6.39	2.56	0.14	1.02	1.79	0.39	0.13	0.70	1.48
	III	3.99	0.46	0.63	1.57	0.03	1.95	0.78	15.58	0.12	6.10	7.03	6.44	2.72	1.65	0.86
Jul	I	3.00	0.27	3.08	3.76	1.85	13.94	0.08	0.00	2.66	0.20	4.73	1.69	1.57	3.30	1.31
	II	0.06	0.04	1.86	6.51	3.39	8.83	1.10	0.30	0.10	0.40	1.00	8.70	9.64	8.05	4.93
	III	13.29	6.48	1.30	1.79	1.43	1.58	0.00	2.81	2.91	0.19	4.80	2.81	3.64	7.19	1.08
Aug	I	9.26	2.27	0.45	1.37	0.32	10.26	0.06	1.41	13.97	9.69	16.79	1.33	2.47	10.63	13.57
	II	1.70	1.03	5.34	2.26	2.73	3.54	0.72	0.29	0.73	11.93	13.39	6.34	5.00	10.16	2.97
	III	1.29	1.55	0.30	1.81	0.23	1.51	0.00	1.39	0.00	3.62	5.50	3.06	8.89	0.66	13.06
Sep	I	0.23	1.06	0.05	5.48	4.88	4.52	4.74	7.21	2.05	6.37	4.83	0.77	6.50	1.89	0.48
	II	5.56	9.44	1.66	0.20	2.58	2.42	6.96	11.79	17.05	35.03	4.71	0.33	1.03	11.76	5.12
	III	5.88	18.01	0.86	0.32	6.04	11.71	1.37	1.27	0.96	4.01	0.47	1.19	8.13	2.91	6.69
Oct	I	10.68	9.77	0.00	1.58	0.00	21.69	1.90	1.20	0.00	0.00	3.60	1.85	2.21	0.00	6.71
	II	4.14	4.71	19.45	3.10	0.00	5.05	0.61	0.18	0.46	0.00	4.02	0.87	0.06	1.13	0.79
	III	0.00	0.00	0.23	0.47	3.00	3.01	5.31	1.65	2.84	0.35	2.83	0.00	3.43	10.88	0.28
Nov	I	0.00	0.00	0.00	0.00	0.00	0.00	0.67	0.00	0.35	0.00	0.40	0.00	1.20	0.00	0.00
	II	0.00	0.00	0.18	0.08	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.44	0.45	0.00	0.00	2.40	4.04	5.08	0.00	0.00	0.00	0.64
Dec	I	0.00	0.33	0.00	0.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.80
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.66
Jan	I	0.00	0.00	0.00	0.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	1.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.63	0.00	0.00	0.00	0.00	0.00
Feb	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	4.40	0.22
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13	0.00	0.00	0.12	0.00	0.86	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.00	0.00	0.00	1.76	0.00	2.98	0.02	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	1.46	1.96	0.00	0.00	0.00	0.81	0.00	0.00	0.00	0.00	0.00	0.62	1.01
	III	0.12	0.00	0.07	0.00	0.98	0.00	0.00	11.48	0.13	0.07	0.00	0.07	0.00	0.00	0.00
Apr	I	0.00	1.23	0.04	0.42	1.25	0.15	0.55	0.00	0.43	0.00	0.48	0.06	0.00	1.76	3.57
	II	0.76	0.02	0.00	4.05	1.39	0.00	0.51	0.00	0.31	0.30	0.57	1.39	0.00	1.19	0.20
	III	0.07	0.13	0.43	0.00	0.16	1.44	0.11	0.00	0.25	0.00	0.00	0.92	3.50	1.09	2.90
May	I	0.00	5.42	0.00	0.12	1.11	1.20	0.00	0.57	0.00	3.33	0.02	1.60	0.38	4.59	2.72
	II	0.00	0.99	0.00	8.76	1.16	2.83	0.00	0.00	0.43	1.95	2.65	0.00	0.24	7.85	0.72
	III	0.00	0.00	0.00	5.31	0.05	0.94	2.02	1.48	7.56	0.00	0.00	0.00	2.44	1.43	3.66

Table 5.194:10-Daily Flow Series (m^3/s) at Diversion 2

Area = 21 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	0.18	0.20	0.00	0.84	0.13	0.28	0.83	2.08	0.00	0.08	0.87	0.16	0.01	2.05	0.02
	II	0.25	0.14	0.75	0.00	0.48	0.59	1.17	0.47	0.03	0.19	0.33	0.07	0.02	0.13	0.27
	III	0.73	0.08	0.11	0.29	0.01	0.36	0.14	2.85	0.02	1.12	1.28	1.18	0.50	0.30	0.16
Jul	I	0.55	0.05	0.56	0.69	0.34	2.55	0.01	0.00	0.49	0.04	0.87	0.31	0.29	0.60	0.24
	II	0.01	0.01	0.34	1.19	0.62	1.61	0.20	0.05	0.02	0.07	0.18	1.59	1.76	1.47	0.90
	III	2.43	1.18	0.24	0.33	0.26	0.29	0.00	0.51	0.53	0.04	0.88	0.51	0.67	1.31	0.20
Aug	I	1.69	0.41	0.08	0.25	0.06	1.88	0.01	0.26	2.55	1.77	3.07	0.24	0.45	1.94	2.48
	II	0.31	0.19	0.98	0.41	0.50	0.65	0.13	0.05	0.13	2.18	2.45	1.16	0.91	1.86	0.54
	III	0.24	0.28	0.06	0.33	0.04	0.28	0.00	0.25	0.00	0.66	1.00	0.56	1.62	0.12	2.39
Sep	I	0.04	0.19	0.01	1.00	0.89	0.83	0.87	1.32	0.37	1.16	0.88	0.14	1.19	0.35	0.09
	II	1.02	1.73	0.30	0.04	0.47	0.44	1.27	2.16	3.12	6.40	0.86	0.06	0.19	2.15	0.94
	III	1.08	3.29	0.16	0.06	1.10	2.14	0.25	0.23	0.18	0.73	0.09	0.22	1.49	0.53	1.22
Oct	I	1.95	1.79	0.00	0.29	0.00	3.97	0.35	0.22	0.00	0.00	0.66	0.34	0.40	0.00	1.23
	II	0.76	0.86	3.56	0.57	0.00	0.92	0.11	0.03	0.08	0.00	0.73	0.16	0.01	0.21	0.14
	III	0.00	0.00	0.04	0.09	0.55	0.55	0.97	0.30	0.52	0.06	0.52	0.00	0.63	1.99	0.05
Nov	I	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.06	0.00	0.07	0.00	0.22	0.00	0.00
	II	0.00	0.00	0.03	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.00	0.44	0.74	0.93	0.00	0.00	0.00	0.12
Dec	I	0.00	0.06	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.15
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.12
Jan	I	0.00	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00
Feb	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.80	0.04
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.21	0.00	0.00	0.02	0.00	0.16	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.27	0.36	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.11	0.19
	III	0.02	0.00	0.01	0.00	0.18	0.00	0.00	2.10	0.02	0.01	0.00	0.01	0.00	0.00	0.00
Apr	I	0.00	0.23	0.01	0.08	0.23	0.03	0.10	0.00	0.08	0.00	0.09	0.01	0.00	0.32	0.65
	II	0.14	0.00	0.00	0.74	0.25	0.00	0.09	0.00	0.06	0.05	0.10	0.25	0.00	0.22	0.04
	III	0.01	0.02	0.08	0.00	0.03	0.26	0.02	0.00	0.05	0.00	0.00	0.17	0.64	0.20	0.53
May	I	0.00	0.99	0.00	0.02	0.20	0.22	0.00	0.10	0.00	0.61	0.00	0.29	0.07	0.84	0.50
	II	0.00	0.18	0.00	1.60	0.21	0.52	0.00	0.00	0.08	0.36	0.49	0.00	0.04	1.44	0.13
	III	0.00	0.00	0.00	0.97	0.01	0.17	0.37	0.27	1.38	0.00	0.00	0.00	0.45	0.26	0.67

Table 5.195:10-Daily Flow Series (m^3/s) at Diversion 3

Area = 10 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	0.09	0.10	0.00	0.40	0.06	0.13	0.39	0.98	0.00	0.04	0.41	0.07	0.00	0.96	0.01
	II	0.12	0.07	0.35	0.00	0.23	0.28	0.55	0.22	0.01	0.09	0.15	0.03	0.01	0.06	0.13
	III	0.34	0.04	0.05	0.13	0.00	0.17	0.07	1.34	0.01	0.52	0.60	0.55	0.23	0.14	0.07
Jul	I	0.26	0.02	0.26	0.32	0.16	1.20	0.01	0.00	0.23	0.02	0.41	0.15	0.14	0.28	0.11
	II	0.00	0.00	0.16	0.56	0.29	0.76	0.09	0.03	0.01	0.03	0.09	0.75	0.83	0.69	0.42
	III	1.14	0.56	0.11	0.15	0.12	0.14	0.00	0.24	0.25	0.02	0.41	0.24	0.31	0.62	0.09
Aug	I	0.80	0.19	0.04	0.12	0.03	0.88	0.00	0.12	1.20	0.83	1.44	0.11	0.21	0.91	1.17
	II	0.15	0.09	0.46	0.19	0.23	0.30	0.06	0.02	0.06	1.02	1.15	0.54	0.43	0.87	0.26
	III	0.11	0.13	0.03	0.16	0.02	0.13	0.00	0.12	0.00	0.31	0.47	0.26	0.76	0.06	1.12
Sep	I	0.02	0.09	0.00	0.47	0.42	0.39	0.41	0.62	0.18	0.55	0.41	0.07	0.56	0.16	0.04
	II	0.48	0.81	0.14	0.02	0.22	0.21	0.60	1.01	1.46	3.01	0.40	0.03	0.09	1.01	0.44
	III	0.51	1.55	0.07	0.03	0.52	1.01	0.12	0.11	0.08	0.34	0.04	0.10	0.70	0.25	0.57
Oct	I	0.92	0.84	0.00	0.14	0.00	1.86	0.16	0.10	0.00	0.00	0.31	0.16	0.19	0.00	0.58
	II	0.36	0.40	1.67	0.27	0.00	0.43	0.05	0.02	0.04	0.00	0.35	0.07	0.01	0.10	0.07
	III	0.00	0.00	0.02	0.04	0.26	0.26	0.46	0.14	0.24	0.03	0.24	0.00	0.29	0.93	0.02
Nov	I	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.00	0.03	0.00	0.10	0.00	0.00
	II	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.21	0.35	0.44	0.00	0.00	0.00	0.06
Dec	I	0.00	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.07
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.06
Jan	I	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Feb	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.38	0.02
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.01	0.00	0.07	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.13	0.17	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.05	0.09
	III	0.01	0.00	0.01	0.00	0.08	0.00	0.00	0.99	0.01	0.01	0.00	0.01	0.00	0.00	0.00
Apr	I	0.00	0.11	0.00	0.04	0.11	0.01	0.05	0.00	0.04	0.00	0.04	0.01	0.00	0.15	0.31
	II	0.06	0.00	0.00	0.35	0.12	0.00	0.04	0.00	0.03	0.03	0.05	0.12	0.00	0.10	0.02
	III	0.01	0.01	0.04	0.00	0.01	0.12	0.01	0.00	0.02	0.00	0.00	0.08	0.30	0.09	0.25
May	I	0.00	0.47	0.00	0.01	0.10	0.10	0.00	0.05	0.00	0.29	0.00	0.14	0.03	0.39	0.23
	II	0.00	0.09	0.00	0.75	0.10	0.24	0.00	0.00	0.04	0.17	0.23	0.00	0.02	0.67	0.06
	III	0.00	0.00	0.00	0.46	0.00	0.08	0.17	0.13	0.65	0.00	0.00	0.00	0.21	0.12	0.31

Table 5.196:10-Daily Flow Series (m^3/s) at Diversion 4

Area = 10 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	0.08	0.10	0.00	0.39	0.06	0.13	0.39	0.97	0.00	0.04	0.40	0.07	0.00	0.95	0.01
	II	0.12	0.07	0.35	0.00	0.23	0.28	0.54	0.22	0.01	0.09	0.15	0.03	0.01	0.06	0.13
	III	0.34	0.04	0.05	0.13	0.00	0.17	0.07	1.33	0.01	0.52	0.60	0.55	0.23	0.14	0.07
Jul	I	0.26	0.02	0.26	0.32	0.16	1.19	0.01	0.00	0.23	0.02	0.40	0.14	0.13	0.28	0.11
	II	0.00	0.00	0.16	0.55	0.29	0.75	0.09	0.03	0.01	0.03	0.09	0.74	0.82	0.69	0.42
	III	1.13	0.55	0.11	0.15	0.12	0.13	0.00	0.24	0.25	0.02	0.41	0.24	0.31	0.61	0.09
Aug	I	0.79	0.19	0.04	0.12	0.03	0.87	0.00	0.12	1.19	0.82	1.43	0.11	0.21	0.91	1.16
	II	0.14	0.09	0.45	0.19	0.23	0.30	0.06	0.02	0.06	1.02	1.14	0.54	0.43	0.86	0.25
	III	0.11	0.13	0.03	0.15	0.02	0.13	0.00	0.12	0.00	0.31	0.47	0.26	0.76	0.06	1.11
Sep	I	0.02	0.09	0.00	0.47	0.42	0.38	0.40	0.61	0.17	0.54	0.41	0.07	0.55	0.16	0.04
	II	0.47	0.80	0.14	0.02	0.22	0.21	0.59	1.00	1.45	2.98	0.40	0.03	0.09	1.00	0.44
	III	0.50	1.53	0.07	0.03	0.51	1.00	0.12	0.11	0.08	0.34	0.04	0.10	0.69	0.25	0.57
Oct	I	0.91	0.83	0.00	0.13	0.00	1.85	0.16	0.10	0.00	0.00	0.31	0.16	0.19	0.00	0.57
	II	0.35	0.40	1.66	0.26	0.00	0.43	0.05	0.02	0.04	0.00	0.34	0.07	0.01	0.10	0.07
	III	0.00	0.00	0.02	0.04	0.26	0.26	0.45	0.14	0.24	0.03	0.24	0.00	0.29	0.93	0.02
Nov	I	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.00	0.03	0.00	0.10	0.00	0.00
	II	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.20	0.34	0.43	0.00	0.00	0.00	0.05
Dec	I	0.00	0.03	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.07
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.06
Jan	I	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00
Feb	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.37	0.02
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.01	0.00	0.07	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.12	0.17	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.05	0.09
	III	0.01	0.00	0.01	0.00	0.08	0.00	0.00	0.98	0.01	0.01	0.00	0.01	0.00	0.00	0.00
Apr	I	0.00	0.10	0.00	0.04	0.11	0.01	0.05	0.00	0.04	0.00	0.04	0.01	0.00	0.15	0.30
	II	0.06	0.00	0.00	0.35	0.12	0.00	0.04	0.00	0.03	0.03	0.05	0.12	0.00	0.10	0.02
	III	0.01	0.01	0.04	0.00	0.01	0.12	0.01	0.00	0.02	0.00	0.00	0.08	0.30	0.09	0.25
May	I	0.00	0.46	0.00	0.01	0.09	0.10	0.00	0.05	0.00	0.28	0.00	0.14	0.03	0.39	0.23
	II	0.00	0.08	0.00	0.75	0.10	0.24	0.00	0.00	0.04	0.17	0.23	0.00	0.02	0.67	0.06
	III	0.00	0.00	0.00	0.45	0.00	0.08	0.17	0.13	0.64	0.00	0.00	0.00	0.21	0.12	0.31

Table 5.197:10-Daily Flow Series (m^3/s) at Diversion 5

Area = 11 km^2

All 10-daily flows in m^3/s.

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
Jun	I	0.10	0.11	0.00	0.45	0.07	0.15	0.44	1.11	0.00	0.04	0.46	0.08	0.00	1.09	0.01
	II	0.13	0.07	0.40	0.00	0.26	0.32	0.62	0.25	0.01	0.10	0.17	0.04	0.01	0.07	0.14
	III	0.39	0.04	0.06	0.15	0.00	0.19	0.08	1.52	0.01	0.60	0.69	0.63	0.27	0.16	0.08
Jul	I	0.29	0.03	0.30	0.37	0.18	1.36	0.01	0.00	0.26	0.02	0.46	0.16	0.15	0.32	0.13
	II	0.01	0.00	0.18	0.64	0.33	0.86	0.11	0.03	0.01	0.04	0.10	0.85	0.94	0.79	0.48
	III	1.30	0.63	0.13	0.17	0.14	0.15	0.00	0.27	0.28	0.02	0.47	0.27	0.36	0.70	0.11
Aug	I	0.90	0.22	0.04	0.13	0.03	1.00	0.01	0.14	1.36	0.95	1.64	0.13	0.24	1.04	1.32
	II	0.17	0.10	0.52	0.22	0.27	0.35	0.07	0.03	0.07	1.16	1.31	0.62	0.49	0.99	0.29
	III	0.13	0.15	0.03	0.18	0.02	0.15	0.00	0.14	0.00	0.35	0.54	0.30	0.87	0.06	1.27
Sep	I	0.02	0.10	0.01	0.53	0.48	0.44	0.46	0.70	0.20	0.62	0.47	0.08	0.63	0.18	0.05
	II	0.54	0.92	0.16	0.02	0.25	0.24	0.68	1.15	1.66	3.42	0.46	0.03	0.10	1.15	0.50
	III	0.57	1.76	0.08	0.03	0.59	1.14	0.13	0.12	0.09	0.39	0.05	0.12	0.79	0.28	0.65
Oct	I	1.04	0.95	0.00	0.15	0.00	2.12	0.19	0.12	0.00	0.00	0.35	0.18	0.22	0.00	0.65
	II	0.40	0.46	1.90	0.30	0.00	0.49	0.06	0.02	0.04	0.00	0.39	0.08	0.01	0.11	0.08
	III	0.00	0.00	0.02	0.05	0.29	0.29	0.52	0.16	0.28	0.03	0.28	0.00	0.33	1.06	0.03
Nov	I	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.03	0.00	0.04	0.00	0.12	0.00	0.00
	II	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.04	0.04	0.00	0.00	0.23	0.39	0.50	0.00	0.00	0.00	0.06
Dec	I	0.00	0.03	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.08
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.06
Jan	I	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00
	II	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.00	0.00	0.00
Feb	I	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.43	0.02
	II	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.00	0.01	0.00	0.08	0.00	0.00
	III	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	I	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	II	0.00	0.00	0.14	0.19	0.00	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.06	0.10
	III	0.01	0.00	0.01	0.00	0.10	0.00	0.00	1.12	0.01	0.01	0.00	0.01	0.00	0.00	0.00
Apr	I	0.00	0.12	0.00	0.04	0.12	0.01	0.05	0.00	0.04	0.00	0.05	0.01	0.00	0.17	0.35
	II	0.07	0.00	0.00	0.40	0.14	0.00	0.05	0.00	0.03	0.03	0.06	0.14	0.00	0.12	0.02
	III	0.01	0.01	0.04	0.00	0.02	0.14	0.01	0.00	0.02	0.00	0.00	0.09	0.34	0.11	0.28
May	I	0.00	0.53	0.00	0.01	0.11	0.12	0.00	0.06	0.00	0.32	0.00	0.16	0.04	0.45	0.27
	II	0.00	0.10	0.00	0.86	0.11	0.28	0.00	0.00	0.04	0.19	0.26	0.00	0.02	0.77	0.07
	III	0.00	0.00	0.00	0.52	0.01	0.09	0.20	0.14	0.74	0.00	0.00	0.00	0.24	0.14	0.36

Table 5.198:10-Daily Average Flow Series (m^3/s) at Jaldurg Dam Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	104.49	36.96	25.91	32.29	57.01	49.88	6.66	16.48	32.51	1.08	7.11	1.25	0.66	16.69	0.85
	II	197.15	35.18	27.19	20.56	15.93	37.80	9.34	5.13	0.20	1.48	3.39	0.96	0.77	1.14	2.59
	III	19.59	75.56	6.91	28.74	7.80	16.55	1.41	22.67	0.17	8.85	10.20	10.21	4.54	2.62	1.38
JUL	I	31.49	20.84	7.75	35.67	19.62	254.91	257.57	501.56	4.79	0.30	6.87	3.12	2.87	4.98	2.34
	II	1435.23	200.83	61.56	56.02	26.94	627.01	287.48	522.29	1.31	0.58	1.45	12.73	14.59	11.87	7.59
	III	1008.54	464.30	29.03	22.78	24.98	2409.71	300.09	532.31	5.43	0.28	6.97	4.08	5.87	10.59	2.00
AUG	I	325.75	538.26	33.34	386.64	2485.58	7743.06	840.77	241.89	44.32	91.65	351.87	182.64	30.44	400.37	324.63
	II	222.61	877.54	1392.72	276.15	3395.00	3729.57	940.80	396.42	640.92	51.30	52.46	143.05	123.49	107.90	101.89
	III	250.74	924.55	975.34	308.50	1239.11	1858.78	249.24	111.12	41.28	41.30	68.58	131.53	38.61	78.11	128.10
SEP	I	1329.55	375.09	162.97	523.80	176.65	1286.62	31.85	240.64	45.34	102.89	179.53	575.47	187.27	27.14	242.52
	II	255.69	183.55	157.25	206.82	254.68	2943.60	88.09	192.28	256.07	92.08	91.84	103.32	81.99	103.57	99.48
	III	396.94	1069.49	63.99	123.82	379.66	3152.96	198.75	139.49	161.15	86.02	65.90	26.85	37.79	45.39	36.00
OCT	I	999.44	1793.86	54.54	146.89	600.92	1275.10	60.52	87.63	34.31	607.31	123.64	22.64	56.35	43.50	32.93
	II	957.43	762.45	621.73	75.58	160.45	343.50	44.46	26.45	46.34	75.69	35.85	21.20	42.34	30.28	21.01
	III	441.16	255.46	141.10	97.99	88.13	115.33	33.19	29.13	34.81	26.10	44.44	20.08	29.28	35.49	27.05
NOV	I	101.36	60.60	43.76	89.22	86.65	89.91	25.79	28.16	29.23	29.66	27.81	21.52	25.76	24.43	28.88
	II	53.65	66.80	55.40	116.32	91.13	79.92	20.63	28.60	29.06	25.08	23.03	24.87	24.97	24.47	24.11
	III	61.55	66.68	61.26	121.17	86.28	75.03	22.49	26.96	29.10	22.15	28.45	23.80	24.98	21.18	11.43
DEC	I	59.75	63.65	64.74	108.90	87.13	68.47	23.20	22.20	22.11	18.66	17.20	18.78	22.67	17.49	26.72
	II	60.24	62.44	69.40	88.17	85.20	65.14	23.74	21.83	24.55	21.44	17.32	22.42	22.81	24.99	12.81
	III	52.87	61.68	54.26	59.36	74.99	70.30	21.75	26.43	22.80	21.88	19.53	21.07	22.69	26.21	21.32
JAN	I	54.56	64.24	56.01	62.45	69.01	71.93	25.72	27.54	28.10	22.71	21.53	21.47	24.00	11.05	23.90
	II	44.63	55.64	55.80	68.37	67.46	72.46	25.63	24.88	29.32	21.16	23.72	19.25	23.43	26.01	4.60
	III	46.01	51.61	59.63	73.09	75.91	72.06	25.72	26.89	30.01	24.11	23.87	21.33	21.22	26.47	30.03
FEB	I	48.88	55.58	61.14	78.12	82.64	75.66	24.38	27.95	29.72	25.94	24.49	24.83	23.40	21.27	8.92
	II	46.72	49.44	58.95	77.45	53.30	68.24	25.21	24.99	28.41	21.34	25.34	23.73	23.01	26.27	22.65
	III	46.76	46.33	56.77	79.51	55.72	63.22	24.58	25.31	28.15	24.92	24.35	23.77	1.63	25.34	27.12
MAR	I	42.90	45.35	55.41	81.83	56.86	75.61	22.38	28.16	23.41	17.63	23.11	18.96	3.63	3.10	3.52
	II	38.91	40.92	58.95	88.16	64.04	64.82	23.91	24.91	22.35	27.36	22.95	0.00	0.26	21.37	25.02
	III	35.48	37.03	56.45	80.18	58.43	58.61	24.80	26.40	10.14	26.54	22.90	0.10	0.57	2.35	15.67
APR	I	37.78	29.49	50.45	79.51	57.45	55.02	22.98	11.91	14.67	27.87	20.89	0.09	0.57	2.90	53.66
	II	42.02	32.20	53.28	53.89	71.65	57.91	11.21	15.84	3.69	11.73	12.11	2.02	0.57	2.29	0.29
	III	37.45	29.87	55.83	30.22	41.99	24.18	1.33	2.37	0.62	0.00	1.08	1.34	5.93	2.24	4.22
MAY	I	33.02	33.02	37.04	24.56	32.76	13.30	0.43	0.83	0.66	5.49	0.03	2.38	1.48	7.02	3.95
	II	40.44	27.64	35.53	84.09	20.22	21.32	1.41	0.00	1.34	3.54	4.80	0.59	1.05	11.59	2.52
	III	5.83	29.67	23.04	29.78	26.09	42.77	4.15	2.14	11.10	0.13	0.94	0.59	4.25	2.20	5.31
Inflow (MCM) =		7898	7601	4326	3428	9007	23829	3294	3076	1536	1378	1252	1354	819	1091	1214

Table 5.199:10-Daily Inflow Series (MCM) at Jaldurg Dam Site

Period		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	2005-2006	2006-2007	2007-2008	2008-2009	2009-2010	2010-2011	2011-2012	2012-2013	2013-2014	2014-2015
JUN	I	90.28	31.93	22.39	27.90	49.26	43.09	5.75	14.24	28.09	0.93	6.14	1.08	0.57	14.42	0.74
	II	170.34	30.40	23.50	17.76	13.76	32.66	8.07	4.43	0.18	1.28	2.93	0.83	0.67	0.98	2.24
	III	16.92	65.28	5.97	24.83	6.74	14.30	1.22	19.58	0.15	7.65	8.81	8.82	3.92	2.26	1.19
JUL	I	27.21	18.00	6.69	30.82	16.95	220.24	222.54	433.34	4.14	0.26	5.94	2.70	2.48	4.30	2.02
	II	1240.04	173.52	53.19	48.40	23.27	541.74	248.38	451.26	1.13	0.50	1.25	11.00	12.60	10.26	6.56
	III	958.52	441.27	27.59	21.65	23.74	2290.19	285.20	505.91	5.16	0.27	6.63	3.88	5.58	10.06	1.90
AUG	I	281.45	465.06	28.81	334.06	2147.54	6690.01	726.43	208.99	38.29	79.19	304.01	157.80	26.30	345.92	280.48
	II	192.34	758.19	1203.31	238.59	2933.28	3222.35	812.85	342.51	553.76	44.32	45.33	123.60	106.70	93.23	88.03
	III	238.30	878.69	926.96	293.20	1177.65	1766.58	236.88	105.61	39.23	39.25	65.18	125.01	36.69	74.24	121.75
SEP	I	1148.73	324.08	140.81	452.57	152.62	1111.64	27.52	207.91	39.18	88.90	155.12	497.20	161.80	23.45	209.54
	II	220.92	158.58	135.87	178.69	220.05	2543.27	76.11	166.13	221.24	79.56	79.35	89.27	70.84	89.48	85.95
	III	342.95	924.04	55.29	106.98	328.03	2724.16	171.72	120.52	139.24	74.32	56.94	23.20	32.65	39.22	31.10
OCT	I	863.52	1549.89	47.12	126.91	519.20	1101.69	52.29	75.71	29.64	524.72	106.82	19.56	48.69	37.59	28.45
	II	827.22	658.76	537.18	65.30	138.63	296.79	38.41	22.85	40.04	65.39	30.98	18.31	36.58	26.16	18.15
	III	419.27	242.79	134.10	93.13	83.76	109.61	31.54	27.68	33.08	24.81	42.23	19.09	27.82	33.73	25.71
NOV	I	87.57	52.36	37.81	77.09	74.87	77.69	22.28	24.33	25.26	25.63	24.03	18.59	22.26	21.11	24.96
	II	46.35	57.72	47.86	100.50	78.73	69.05	17.83	24.71	25.11	21.67	19.89	21.49	21.57	21.14	20.83
	III	53.18	57.62	52.93	104.69	74.54	64.83	19.43	23.29	25.15	19.13	24.58	20.56	21.59	18.30	9.88
DEC	I	51.63	54.99	55.94	94.09	75.28	59.16	20.04	19.18	19.10	16.12	14.86	16.22	19.59	15.11	23.09
	II	52.05	53.95	59.96	76.18	73.61	56.28	20.51	18.86	21.21	18.53	14.96	19.37	19.71	21.59	11.06
	III	50.25	58.62	51.57	56.42	71.27	66.81	20.68	25.12	21.67	20.80	18.56	20.03	21.56	24.91	20.26
JAN	I	47.14	55.50	48.40	53.95	59.62	62.14	22.22	23.79	24.28	19.62	18.61	18.55	20.73	9.55	20.65
	II	38.56	48.08	48.21	59.07	58.29	62.61	22.14	21.50	25.34	18.29	20.49	16.63	20.25	22.47	3.97
	III	43.73	49.05	56.68	69.46	72.15	68.49	24.44	25.56	28.52	22.91	22.69	20.27	20.17	25.16	28.54
FEB	I	42.24	48.02	52.83	67.49	71.40	65.37	21.06	24.15	25.68	22.41	21.16	21.45	20.21	18.38	7.70
	II	40.37	42.72	50.93	66.91	46.05	58.96	21.79	21.59	24.55	18.44	21.89	20.50	19.88	22.70	19.57
	III	32.32	32.02	39.24	54.96	38.52	43.70	16.99	17.50	19.46	17.22	16.83	16.43	1.12	17.51	18.75
MAR	I	37.07	39.18	47.88	70.70	49.13	65.33	19.34	24.33	20.23	15.23	19.97	16.38	3.14	2.68	3.04
	II	33.62	35.36	50.93	76.17	55.33	56.00	20.66	21.53	19.31	23.64	19.83	0.00	0.23	18.46	21.62
	III	33.72	35.19	53.65	76.21	55.54	55.70	23.57	25.09	9.63	25.22	21.76	0.09	0.54	2.23	14.90
APR	I	32.64	25.48	43.58	68.69	49.64	47.54	19.85	10.29	12.68	24.08	18.05	0.07	0.49	2.50	46.37
	II	36.30	27.82	46.03	46.56	61.91	50.04	9.69	13.68	3.19	10.13	10.46	1.74	0.49	1.98	0.25
	III	32.35	25.81	48.24	26.11	36.28	20.89	1.15	2.05	0.54	0.00	0.93	1.16	5.12	1.94	3.64
MAY	I	28.53	28.53	32.01	21.22	28.30	11.49	0.38	0.72	0.57	4.74	0.02	2.05	1.27	6.07	3.41
	II	34.94	23.88	30.70	72.66	17.47	18.42	1.22	0.00	1.16	3.06	4.14	0.51	0.91	10.01	2.18
	III	5.54	28.20	21.90	28.30	24.79	40.65	3.94	2.04	10.55	0.12	0.90	0.56	4.04	2.09	5.05
Total Inflow (MCM) =		7898	7601	4326	3428	9007	23829	3294	3076	1536	1378	1252	1354	819	1091	1214

5.15.4 90% and 50% Dependable flows

The computation of 90% and 50% dependable years and the corresponding year flows are given in **Table 5.200** and **Table 5.201** respectively.

Table 5.200: Computation of 90% and 50% Dependable Year for Jaldurg Project

m	m/(n+1)	Runoff in descending order (in MCM)	Dependable Year	
1	0.06	23829	2005-2006	
2	0.13	9007	2004-2005	
3	0.19	7898	2000-2001	
4	0.25	7601	2001-2002	
5	0.31	4326	2002-2003	
6	0.38	3428	2003-2004	
7	0.44	3294	2006-2007	
8	**0.50**	**3076**	**2007-2008**	**50% Dependable**
9	0.56	1536	2008-2009	
10	0.63	1378	2009-2010	
11	0.69	1354	2011-2012	
12	0.75	1252	2010-2011	
13	0.81	1214	2014-2015	
14	**0.88**	**1091**	**2013-2014**	**90% Dependable**
15	0.94	819	2012-2013	

Table 5.201:90% and 50% Dependable year flows for Jaldurg Diversion Project

		90% Dependable	50% Dependable
Period		**2013-2014**	**2007-2008**
Jun	**I**	16.69	16.48
	II	1.14	5.13
	III	2.62	22.67
Jul	**I**	4.98	501.56
	II	11.87	522.29
	III	10.59	532.31
Aug	**I**	400.37	241.89
	II	107.90	396.42
	III	78.11	111.12
Sep	**I**	27.14	240.64
	II	103.57	192.28
	III	45.39	139.49
Oct	**I**	43.50	87.63
	II	30.28	26.45
	III	35.49	29.13
Nov	**I**	24.43	28.16
	II	24.47	28.60
	III	21.18	26.96
Dec	**I**	17.49	22.20
	II	24.99	21.83
	III	26.21	26.43
Jan	**I**	11.05	27.54
	II	26.01	24.88
	III	26.47	26.89
Feb	**I**	21.27	27.95
	II	26.27	24.99
	III	25.34	25.31
Mar	**I**	3.10	28.16
	II	21.37	24.91
	III	2.35	26.40
Apr	**I**	2.90	11.91
	II	2.29	15.84
	III	2.24	2.37
May	**I**	7.02	0.83
	II	11.59	0.00
	III	2.20	2.14
Inflow (MCM) =		1091	3076

5.15.5 Elevation Area Capacity Curve

The EAC curve, thus prepared for the dam sites of Jaldurg Diversion, is given in the following section.

5.15.5.1 EAC of Jaldurg Diversion Dam

The EAC curve and the table showing the different values are given in **Figure 5.88** and **Table 5.202** respectively.

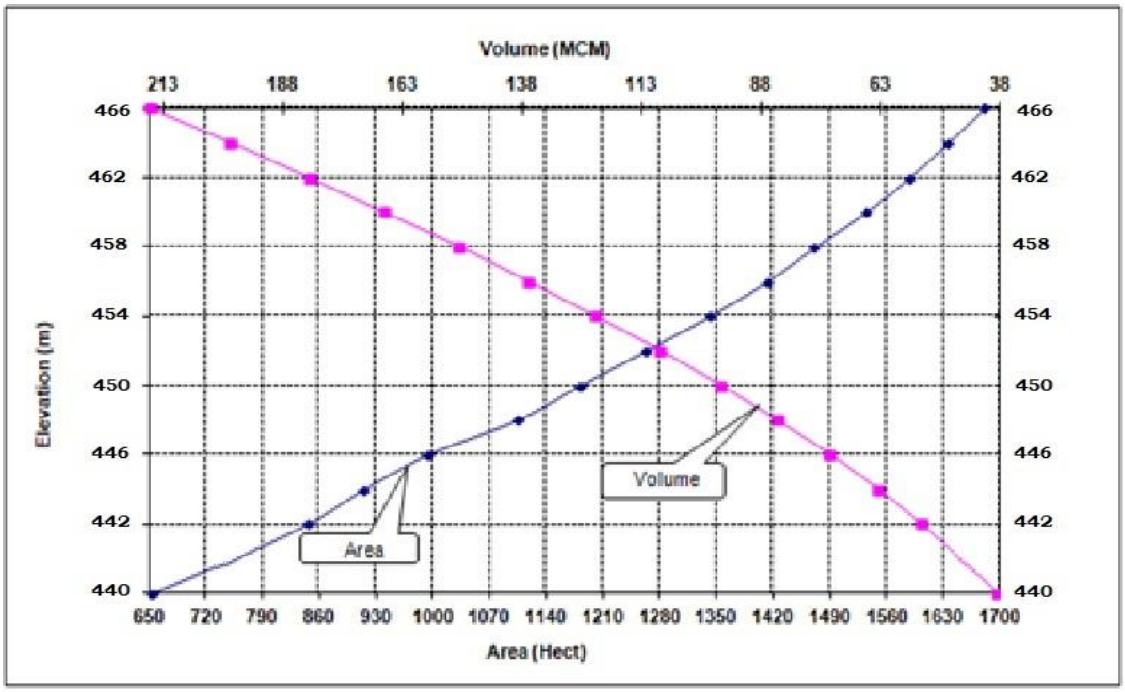


Figure 5.88: EAC curve of Jaldurg Diversion

Table 5.202: EAC data of Jaldurg Diversion

Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
440	7556233.54	755.62	45786594.11	38.23
442	8472511.61	847.25	54259105.72	54.26
444	9159955.59	916.00	63419061.31	63.42
446	9950987.02	995.10	73370048.33	73.37
448	11050897.39	1105.09	84420945.72	84.42
450	11826861.55	1182.69	96247807.27	96.25
452	12634843.65	1263.48	108882650.92	108.88
454	13426816.78	1342.68	122309467.70	122.31
456	14132153.14	1413.22	136441620.84	136.44
458	14722601.60	1472.26	151164222.44	151.16
460	15351659.92	1535.17	166515882.36	166.52
462	15884664.43	1588.47	182400546.80	182.40
464	16357399.88	1635.74	198757946.68	198.76
466	16808476.14	1680.85	215566422.81	215.57

5.15.6 Design Flood

Estimation of design flood is a significant component of hydrological studies. Proper selection of design flood value is important since an over-estimated value results in increase in the cost of hydraulic structures, while an under-estimated value places the structure and population at risk.

5.15.6.1 Computation of Design flood

At present, observed flood peak data are available partially at the project sites. Hence flood peaks from However, flood peaks are available at the downstream location, namely, Huvinhedgi G&D site. Therefore, it has been proposed to transpose the flood peak to the project site based on Dicken's formula, which will then be subjected to frequency analysis. The multiplying factors, as used for transferring the peak flows from Huvinhedgi G&D site to the project site, are given below:

$$\text{Factor} = \left(\frac{A_{Jaldurg}}{A_{\text{Huvinhedgi}}}\right)^{\frac{3}{4}} = 0.896$$

Using the above multiplying factors to the peak flows at the Huvinhedgi G&D site, and assuming an instantaneous peak factor of 30%, the final peak flows at the project site have been derived for the period from 2000 to 2005. Final peak flows for the period from 2006 to 2015 have been derived by multiplying the instantaneous peak factor of 30% with peak flows at Narayanpur Dam. The final peak flows derived are given in **Table 5.203**.

Table5.203: Final Peak Flows at G&D and Project Site

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
1	2000	4831.00	6280.30	5628.15
2	2001	4253.50	5529.55	4955.36
3	2002	3915.84	5090.59	4561.98
4	2003	1369.32	1780.12	1595.27
5	2004	5306.91	6898.98	6182.59

Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)
6	2005	10458.68	13596.28	12184.44
7	2006	9193.01	11950.91	10709.92
8	2007	7771.81	10103.35	9054.22
9	2008	8299.94	10789.92	9669.49
10	2009	13908.77	18081.40	16203.82
11	2010	8097.15	10526.30	9433.24
12	2011	8469.64	11010.53	9867.19
13	2013	6962.03	9050.64	8110.82

5.15.6.2 Statistical Parameters

Details of important statistical parameters for the flood peaks at the dam sites are given below in the following **Table 5.204**.

Table 5.204: Statistical Parameters of Peak Flows at project sites

Parameters	Values
Mean	8319.73
Variance	14276450.02
SD (Sx)	3778.42
Skewness	0.26
Kurtosis	0.52
No. of Data	13

5.15.6.3 Flood Frequency Analysis

For estimating different year return period floods, Gumbel distribution has been used to model the annual maximum flow in the present study. The results of the analysis are shown in the **Table 5.205**.

The detailed procedure for Gumbel distribution method for Jaldurg Diversion site has been shown in **Annexure-15**.

Table 5.205: Detail of different year Return Period Flood (m^3/s) at respective dam sites

Sl No.	Return Period (Years)	Flood (cumec)
1	2	7787
2	5	12083
3	10	14927
4	20	17655
5	25	18520
6	50	21186
7	100	23832
8	500	29947

Annexure-15 (Flood Frequency Analysis for Jaldurg Diversion Dam)

DESIGN FLOOD-Jaldurg

			CA at G&D	55750	55750	CA =	48168		
Sl.No.	Period	Annual Flood Peak at G&D Site	Annual Flood Peak increased for instantaneous factor at G&D Site (cumec)	Annual Flood Peak at Dam Site (cumec)	Ln-stats				
						Conversion factor =		0.896	
1	2000	4831.00	6280.30	5628.15	8.64	Instantaneous Peak =		30%	
2	2001	4253.50	5529.55	4955.36	8.51		X-STAT	Ln-STAT	
3	2002	3915.84	5090.59	4561.98	8.43	Mean(X_m)	8319.73	8.90	
4	2003	1369.32	1780.12	1595.27	7.37	Variance	14276450.02	0.343	
5	2004	5306.91	6898.98	6182.59	8.73	SD (Sx)	3778.42	0.586	
6	2005	10458.68	13596.28	12184.44	9.41	Skewness	0.26	-1.45637	
7	2006	9193.01	11950.91	10709.92	9.28	Kurtosis	0.52	3.08319	
8	2007	7771.81	10103.35	9054.22	9.11	No. of Data	13		
9	2008	8299.94	10789.92	9669.49	9.18				
10	2009	13908.77	18081.40	16203.82	9.69				
11	2010	8097.15	10526.30	9433.24	9.15				
12	2011	8469.64	11010.53	9867.19	9.20				
13	2013	6962.03	9050.64	8110.82	9.00				

X_T = $X_m+K.S_x$

(GUMBEL PROB. DISTRIBUTION METHOD)

	N	=	13		
Reduced mean =	Y_n	=	0.507	From Table (Interpolated)	$f_{(C)}$ = 1.645 (90% confidence probability)
Reduced Std. Dev =	S_n	=	0.997		
Reduced Variate =	Y_T	=	$-(\ln.\ln(T/T-1))$		
Frequency factor =	K	=	$(Y_T-Y_n)/S_n$		
	X_T	=	$X_m+K.S_x$		
Confidence Band =	$f_{(C)}.S_e$				
	Se	=	$b.Sx/\sqrt{n}$		
	b	=	$\sqrt{(1+1.3K+1.1K^2)}$		
	X_{cl}	=	$X_T \pm f_{(C)}.Se$		

Sl No.	Return Period (Years)	Design Flood (cumec)	Y_T	K	b	S_e	Confidence Band	90% CONFIDENCE INTERVAL (X_{cl} Values in cumec) Lower Confidence Limit	Upper Confidence Limit
1	2	**7787**	0.367	-0.141	0.916	959.690	1578.690	6209	9366
2	5	**12083**	1.500	0.996	1.840	1928.266	3171.997	8911	15255
3	10	**14927**	2.250	1.749	2.576	2699.676	4440.966	10486	19368
4	20	**17655**	2.970	2.471	3.305	3463.942	5698.184	11957	23353
5	25	**18520**	3.199	2.700	3.539	3708.947	6101.218	12419	24621
6	50	**21186**	3.902	3.405	4.264	4468.386	7350.495	13835	28536
7	100	**23832**	4.600	4.105	4.988	5226.865	8598.193	15234	32430
8	500	**29947**	6.214	5.724	6.669	6988.992	11496.892	18450	41443

SUMMARY

Sl No.	Return Period (Years)	Flood (cumec)
1	2	7787
2	5	12083
3	10	14927
4	20	17655
5	25	18520
6	50	21186
7	100	23832
8	500	29947

CHAPTER-6
POWER POTENTIAL STUDIES

6.0 Introduction

Power Potential studies are carried out for assessment of available Power Potential of a river/basin based on a set of inflows and available head conditions under various operating policies. These studies play an important role in the optimization and design of new hydro facilities. They are used for examination of various configurations and their integration into existing networks. The studies are carried out for optimization of project parameters and for evaluation of Energy and Power benefits.

6.1 Power Potential Studies of Tupakulagudem Hydroelectric Project:

6.1.1 Power Potential Studies

Power Potential Studies of a hydroelectric scheme forms a primary step in the planning of a hydroelectric project. It is carried out for assessment of the available power potential of a river /basin based on a certain set of inflows and head conditions available at the site in years of different degree of reliability, in different periods of an year and the estimation of generating capacity (KW), which is needed to be provided in power station in order to generate the assessed quantity of energy (kwh) . Moreover, the power potential assessment forms the basis for the planning of layout and design of the scheme and estimation of cost and evaluation of the financial aspect of the scheme. In general, it can be used for examination of various configurations, simulation of integration of new facilities into existing networks, establishment of the performance of the facilities under various operating policies, optimizations of the design of hydraulic components and evaluation of energy and power benefits etc.

Apart from above roles for the case of new hydro facilities, it also plays a very important role in establishing the optimal operation for existing hydro facilities. It permits the identification of policies likely to be able to increase the profitability of the existing projects. It can also be used to examine various approaches concerning the operation of hydro developments like regroupment of several developments in a river system, sequential simulation involving production and/or hydraulic importations from one complex to another, joint operation of numerous complexes acting together to meet a common production objective etc. In the planning of hydropower developments and

deciding its installed capacity, two inter-connection viz, with the water resource development of the river basin and with the power system are to be kept in view because hydroelectric project form an integral part of the overall development of the water resources of the river basin.

In the present chapter, the Power Potential studies have been carried out for Tupakulagudem multipurpose scheme located on River Godavari in Telangana State.

6.1.2 Available Data

Power potential studies have been carried out based on the following data: a) Monthly Discharge Data for the period 1966-67 to 2012-13 (i.e. 47 years data)

6.1.3 Assessment Of Power Potential And Dependable Year

As per Central Electricity Authority (CEA) guideline, the planning of HE Project is carried out based on 50% dependability criteria where the 50% dependable year is defined as a year that has the annual generation, which has the probability of being equal to or exceeded 50 percent during the expected period of operation of the scheme. Hence, if the total energy generation in the year for which hydrological data is available (say N year) is arranged in descending order, the (N+1) x 0.9th year would represent the 90 percent dependable year. On similar logic 90% dependable year worked out. The 90% & 50% dependable year have been determined on the following basis, where N is the number of years for which inflow data is available.

90% year - (N+1) x 0.9 = 23 x 0.9 = 21th Year 50% year - (N+1) x 0.5 = 23 x 0.5 = 12th Year

Based on the above 1985-86 and 1995–96 worked out to be 90% & 50% dependable year respectively.

In the present study for determining 90% & 50% dependable year, annual energy generation for all the 47 years (1966-67 to 2012-13) have been computed assuming unlimited install capacity using Non-Linear optimization for maximization of Annual energy generation.

In the conventional approach, the annual energy for unlimited installed capacity was worked out wherein the net operating head for turbines has been calculated from the following formula.

= MDDL + 2/3(FRL – MDDL) - Average Tail Water Level - Head losses

The details of result for each year power potential and reservoir operation worked out on this basis are given in Annexure 7.1 respectively.

Based on the above methods, 1985-86and 1995 –96 worked out to be 90% & 50% dependable year respectively.

6.1.4 Installed Capacity

The installed capacity has been fixed keeping in view the power requirement of the lift scheme proposed for covering the irrigation requirement of Tupakulagudem command, which has been accessed as about 240 MW. Therefore, it has been planned whenever the adequate supply in the river is available then the power generated from the power house of Tupakulagudem project can be used for the power requirement of the pumps for lifting irrigation water. Purely based on the flow consideration of 50% dependable year has been accessed as 240 MW. However, purely from the irrigation point of view, the installed capacity for the proposed power plant has been adopted as 240 MW.

6.1.5 No. Of Generating Units

Regarding number of units to be installed for the storage based scheme; there are two options: 1. 5 units of 48 MW each 2. 10 units of 24 MW each

Although the first option would be preferable from economic consideration however there can be difficulty in transporting generating equipment for this low head plant. Second option of providing ten units of 24 MW may cost slightly more but it would increase the reliability of power supply and provide more flexibility in part load operation. Second option in this case has been selected keeping in view tail water level as well for keeping lower level of MDDL. Another side advantage can be occurred in terms of easy transportation due to relatively small size of generating units. Therefore, ten units of 24 MW each have been recommended.

6.1.6 Results Of Studies

Annual energy generation in 50% dependable year and that for 90% dependable year are indicated in Annexure 7.1 and also indicated below. Summary of power potential studies is presented below:

i) Installed capacity 10x 24 MW

ii) 50% dependable year

a) Energy generation 786MU

b) Firm Power 5 MW

c) Lean flow L.F. 4.1 %

d) Annual average L.F. 37.38 %

e) Design Energy 752MU

iii) Energy Generation in 90% dependable year 317 MU

6.1.7 Conclusion

Tupakulagudem multipurpose Project is proposed to be run-of-river scheme based development. Installation of 240 MW comprising of ten units of 24 MW each, would be necessary to derive optimum benefits. The project would afford annual energy generation of 786 MU and 317 MU in 50% and 90% dependable years respectively. This energy may be used for lifting the water for irrigation through lift canals.

Inflows at Proposed Barrage Site

Unit : m^3/sec

S.No	Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual (MCM)
1	1966 - 1967	167.2	3410.4	5938.3	7118.9	901.5	524.1	452.6	110.4	65.7	174.8	101.4	25.3	50164.0
2	1967 - 1968	875.8	5306.2	9009.0	3818.5	1616.8	274.2	669.5	278.3	137.3	281.9	58.4	50.3	59474.3
3	1968 - 1969	263.8	1925.6	4569.6	3405.6	1658.9	335.6	143.3	100.8	65.3	45.6	46.6	45.6	33397.7
4	1969 - 1970	67.6	4589.4	7944.3	11604.0	1237.1	578.2	210.6	113.6	86.4	68.2	41.3	28.3	70077.6
5	1970 - 1971	1653.7	3509.9	15487.4	10905.2	2044.0	491.6	238.8	162.9	114.5	101.6	68.9	102.9	92263.2
6	1971 - 1972	741.7	1004.7	1849.6	3170.3	1819.6	320.1	120.8	75.3	46.0	28.5	15.9	9.9	24272.6
7	1972 - 1973	114.7	2166.2	1470.9	1451.9	279.7	151.1	69.0	28.3	17.5	12.2	9.2	6.4	15320.1
8	1973 - 1974	94.7	9049.0	10800.3	5746.8	6953.3	1680.9	373.7	209.3	146.1	84.0	55.7	57.8	93725.0
9	1974 - 1975	84.5	323.9	1994.4	418.7	949.9	266.4	95.7	46.0	45.8	32.4	15.6	10.1	11392.4
10	1975 - 1976	1290.6	4310.5	8713.0	11820.4	4385.7	1153.6	281.4	167.6	109.3	68.8	51.9	37.5	85498.5
11	1976 - 1977	51.3	6887.2	7178.7	8200.3	499.5	258.4	156.9	88.2	71.3	51.3	40.9	68.3	62324.9
12	1977 - 1978	272.2	3468.2	5910.4	4899.5	923.7	445.5	485.2	176.8	148.5	81.1	51.5	58.3	44792.5
13	1978 - 1979	1164.9	7909.2	12750.8	5054.9	1068.4	527.7	338.8	190.9	395.7	170.1	58.7	40.8	78780.0
14	1979 - 1980	1699.9	2003.0	8127.0	2026.8	1389.0	257.2	239.7	135.2	104.7	103.5	60.6	44.6	42998.8
15	1980 - 1981	989.3	3691.1	10609.8	6382.0	759.5	293.6	144.9	152.5	112.0	90.1	63.5	65.7	61854.2
16	1981 - 1982	317.9	3314.4	10505.3	6139.4	2931.6	632.1	228.8	175.5	158.1	71.1	42.3	35.1	65102.0
17	1982 - 1983	191.7	1303.7	3386.1	1774.8	775.2	360.6	121.0	73.7	85.1	56.5	15.9	11.9	21621.2
18	1983 - 1984	582.2	3255.5	13301.1	13673.7	6865.2	624.9	320.4	255.8	151.1	190.9	123.2	90.2	104298.0
19	1984 - 1985	191.0	1158.4	3200.9	739.4	471.5	188.3	88.1	78.3	64.3	44.8	34.0	17.5	16694.5
20	1985 - 1986	308.9	1713.1	3799.7	1169.9	1204.8	243.9	94.1	75.1	108.4	91.9	45.4	34.3	23628.8
21	1986 - 1987	566.2	5292.0	10863.7	1333.4	529.3	301.2	105.0	126.4	77.8	54.0	25.4	18.3	51460.7
22	1987 - 1988	27.1	379.4	561.6	369.3	136.0	74.9	37.7	19.8	14.7	16.1	7.0	6.1	4374.8
23	1988 - 1989	383.7	7929.3	10623.2	9574.2	5027.4	470.6	214.7	135.2	97.1	92.9	63.4	27.7	91846.6
24	1989 - 1990	364.2	5255.8	5510.1	4211.6	1148.0	223.3	116.9	114.0	77.9	66.7	32.6	207.0	45973.7
25	1990 - 1991	2811.8	5987.0	17293.7	8988.1	6387.4	1664.5	336.1	221.4	144.2	105.8	81.9	45.5	116822.1
26	1991 - 1992	241.6	2287.3	4820.8	1013.9	489.5	292.2	109.9	65.7	45.8	31.8	17.2	11.5	25106.4
27	1992 - 1993	514.7	1671.3	8781.6	3923.0	564.9	253.3	121.2	74.3	62.4	60.7	28.9	15.2	42622.1
28	1993 - 1994	76.6	1324.0	2130.9	1567.9	791.6	215.1	89.2	61.7	62.7	34.0	12.5	6.7	16891.2
29	1994 - 1995	277.3	9820.5	8156.0	12415.1	1850.0	572.0	328.1	414.0	216.5	189.8	141.4	132.7	91225.9
30	1995 - 1996	207.5	3899.4	3196.2	5176.2	3438.1	537.6	218.2	163.6	122.2	102.4	67.7	42.8	45454.8
31	1996 - 1997	272.6	977.3	3143.3	2504.9	837.2	272.3	103.4	81.2	61.3	78.9	92.6	32.7	22365.8
32	1997 - 1998	21.5	638.8	2521.3	2005.1	440.4	349.5	522.2	272.5	199.2	54.8	31.9	37.3	18741.9
33	1998 - 1999	256.3	1935.5	4627.9	5849.6	3426.7	1037.4	215.8	135.7	110.1	74.4	58.1	44.3	46949.2
34	1999 - 2000	1115.7	1599.3	5711.7	7001.0	3490.2	586.5	215.9	137.9	114.9	90.9	50.5	31.7	53183.6
35	2000 - 2001	601.0	5659.3	6383.5	2897.7	530.8	198.8	87.7	60.7	46.4	40.6	44.8	19.9	44049.0
36	2001 - 2002	2410.7	3362.9	7856.0	1222.5	1455.2	273.2	122.4	90.4	63.3	40.4	21.5	10.6	44986.6
37	2002 - 2003	897.4	479.2	4292.1	2784.4	373.0	126.2	74.5	46.0	33.6	22.3	14.7	8.2	24172.1
38	2003 - 2004	42.4	4654.8	5937.6	3515.8	2085.3	455.2	182.1	111.2	132.5	45.2	26.3	25.3	45732.8
39	2004 - 2005	414.5	379.7	3013.3	592.1	331.7	81.0	35.6	24.9	116.2	23.7	13.3	10.6	13365.0
40	2005 - 2006	28.0	5341.5	7352.2	7599.7	2659.4	729.5	187.4	107.0	71.5	72.8	65.4	53.9	84254.3
41	2006 - 2007	42.7	4166.2	15179.1	9338.8	3275.4	939.6	248.3	150.2	97.8	52.3	43.3	32.5	88982.8
42	2007 - 2008	148.4	3717.4	5494.6	5016.5	1879.9	327.5	122.9	75.9	91.6	66.9	59.3	4.8	45052.8
43	2008 - 2009	60.0	940.5	4596.7	1672.9	378.9	166.7	86.0	35.7	28.6	16.3	10.5	3.6	21244.4
44	2009 - 2010	0.9	437.9	363.5	356.7	77.1	39.3	19.0	12.6	8.5	5.4	2.2	1.3	3510.5
45	2010 - 2011	57.7	3579.6	10562.8	12693.1	1939.5	880.3	316.4	141.0	97.3	93.4	51.7	30.8	80332.9
46	2011 - 2012	60.9	1052.9	3258.4	7094.6	549.9	191.0	90.0	79.3	48.0	14.7	8.0	3.9	32706.7
47	2012 - 2013	115.9	2662.7	8899.7	8768.7	1615.6	444.5	163.6	104.4	85.6	69.3	31.4	14.7	60708.4
	Average	492.4	3313.4	6759.1	5085.3	1796.7	453.4	198.8	122.5	97.0	73.7	44.8	36.6	48931.9

Inflows at Proposed Barrage Site

Unit : MCM

S.No	Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
1	1966 - 1967	433.29	9134.46	15905.26	18452.21	2414.59	1358.56	1212.30	295.71	159.00	468.06	262.83	67.70	50163.98
2	1967 - 1968	2270.00	14212.10	24129.73	9897.65	4330.54	710.81	1793.06	745.34	344.04	754.96	151.45	134.66	59474.34
3	1968 - 1969	683.83	5157.40	12239.28	8827.25	4443.31	869.82	383.84	270.08	158.00	122.13	120.76	122.02	33397.74
4	1969 - 1970	175.20	12292.20	21277.92	30077.53	3313.37	1498.64	564.01	304.13	209.06	182.76	107.02	75.77	70077.61
5	1970 - 1971	4286.29	9400.87	41481.35	28266.32	5474.53	1274.11	639.54	436.43	277.11	272.24	178.71	275.72	92263.23
6	1971 - 1972	1922.57	2690.93	4953.86	8217.36	4873.49	829.77	323.43	201.66	115.35	76.29	41.32	26.54	24272.56
7	1972 - 1973	297.39	5802.07	3939.55	3763.22	749.22	391.70	184.90	75.85	42.45	32.57	23.94	17.21	15320.08
8	1973 - 1974	245.41	24236.91	28927.48	14895.59	18623.64	4356.90	1000.81	560.70	353.38	225.08	144.32	154.78	93724.99
9	1974 - 1975	218.92	867.60	5341.67	1085.38	2544.19	690.41	256.23	123.24	110.73	86.67	40.40	26.97	11392.43
10	1975 - 1976	3345.23	11545.28	23336.99	30638.42	11746.59	2990.25	753.76	448.98	273.77	184.38	134.43	100.41	85498.48
11	1976 - 1977	133.04	18446.58	19227.34	21255.17	1337.94	669.79	420.17	236.18	172.49	137.36	105.97	182.89	62324.93
12	1977 - 1978	705.67	9289.35	15830.37	12699.45	2473.95	1154.67	1299.46	473.56	359.28	217.23	133.51	156.06	44792.54
13	1978 - 1979	3019.32	21184.05	34151.74	13102.24	2861.47	1367.80	907.52	511.32	957.35	455.70	152.13	109.38	78780.04
14	1979 - 1980	4406.06	5364.93	21767.39	5253.34	3720.30	666.54	641.93	362.13	262.24	277.14	157.20	119.56	42998.76
15	1980 - 1981	2564.20	9886.11	28417.25	16542.08	2034.18	760.92	388.19	408.55	270.92	241.37	164.51	175.92	61854.19
16	1981 - 1982	823.91	8877.38	28137.47	15913.39	7852.05	1638.33	612.78	470.07	382.46	190.42	109.74	94.01	65102.02
17	1982 - 1983	496.86	3491.87	9069.35	4600.39	2076.26	934.60	324.11	197.30	205.99	151.37	41.16	31.93	21621.19
18	1983 - 1984	1509.00	8719.52	35625.76	35442.12	18387.71	1619.76	858.22	685.08	378.64	511.24	319.22	241.72	104297.99
19	1984 - 1985	495.06	3102.66	8573.31	1916.44	1263.00	487.99	236.02	209.60	155.61	120.04	88.00	46.79	16694.51
20	1985 - 1986	800.75	4588.47	10177.03	3032.41	3226.96	632.13	252.04	201.12	262.26	246.03	117.72	91.92	23628.83
21	1986 - 1987	1467.56	14173.97	29097.37	3456.14	1417.60	780.74	281.19	338.48	188.10	144.67	65.94	48.91	51460.66
22	1987 - 1988	70.13	1016.10	1504.31	957.35	364.19	194.08	101.02	52.98	36.76	43.25	18.20	16.45	4374.82
23	1988 - 1989	994.65	21237.88	28453.13	24816.34	13465.27	1219.91	575.18	362.00	234.97	248.70	164.34	74.26	91846.62
24	1989 - 1990	944.08	14077.04	14758.19	10916.57	3074.82	578.69	312.99	305.44	188.38	178.58	84.47	554.43	45973.68
25	1990 - 1991	7288.17	16035.67	46319.41	23297.27	17107.94	4314.37	900.16	592.87	348.79	283.26	212.37	121.78	116822.05
26	1991 - 1992	626.18	6126.22	12911.97	2627.92	1311.07	757.39	294.35	176.09	114.73	85.14	44.62	30.71	25106.38
27	1992 - 1993	1334.01	4476.44	23520.67	10168.43	1513.14	656.55	324.74	198.91	151.05	162.47	74.97	40.67	42622.06
28	1993 - 1994	198.47	3546.30	5707.31	4064.09	2120.16	557.50	238.96	165.34	151.62	91.01	32.47	17.98	16891.21
29	1994 - 1995	718.78	26303.33	21845.09	32179.82	4955.06	1482.65	878.67	1108.85	523.68	508.27	366.43	355.32	91225.95
30	1995 - 1996	537.80	10444.15	8560.77	13416.75	9208.65	1393.40	584.45	438.22	306.24	274.14	175.51	114.69	45454.76
31	1996 - 1997	706.68	2617.61	8419.09	6492.61	2242.33	705.75	276.91	217.61	148.27	211.29	240.09	87.58	22365.82
32	1997 - 1998	55.69	1711.00	6753.07	5197.18	1179.52	905.89	1398.70	729.88	481.96	146.66	82.57	99.79	18741.92
33	1998 - 1999	664.33	5183.99	12395.27	15162.18	9178.09	2688.88	577.96	363.57	266.32	199.32	150.60	118.65	46949.16
34	1999 - 2000	2892.00	4283.65	15298.16	18146.61	9348.08	1520.27	578.22	389.29	287.97	243.58	130.89	84.94	53183.64
35	2000 - 2001	1557.84	15157.95	17097.45	7510.96	1421.80	515.29	234.78	162.49	112.27	108.69	116.10	53.37	44048.98
36	2001 - 2002	6248.63	9007.28	21041.51	3168.60	3897.48	708.13	327.94	242.03	153.08	108.10	55.61	28.26	44986.64
37	2002 - 2003	2325.95	1283.54	11495.83	7217.19	999.00	327.16	199.57	123.09	81.27	59.66	38.02	21.84	24172.13
38	2003 - 2004	109.89	12467.43	15903.16	9112.83	5585.34	1179.86	487.74	297.80	331.88	120.97	68.19	67.73	45732.83
39	2004 - 2005	1074.47	1017.00	8070.71	1534.85	888.45	210.06	95.24	66.74	281.07	63.57	34.59	28.27	13365.02
40	2005 - 2006	72.66	14306.68	19692.18	19698.49	7122.88	1890.89	501.87	286.66	173.04	194.98	169.62	144.35	64254.30
41	2006 - 2007	110.67	11158.73	40655.77	24206.25	8772.76	2435.36	665.14	402.23	236.52	140.09	112.21	87.10	88982.85
42	2007 - 2008	384.68	9956.55	14716.75	13002.78	5035.22	848.96	329.08	203.38	229.49	179.26	153.69	12.96	45052.82
43	2008 - 2009	155.48	2518.91	12311.74	4336.24	1014.77	431.99	230.24	95.49	69.25	43.65	27.09	9.57	21244.42
44	2009 - 2010	2.45	1172.85	973.54	924.54	206.45	101.90	50.82	33.76	20.45	14.59	5.71	3.45	3510.51
45	2010 - 2011	149.67	9587.64	28291.40	32900.43	5194.85	2281.70	847.49	377.71	235.37	250.09	134.13	82.40	80332.88
46	2011 - 2012	157.77	2820.15	8727.40	18389.28	1472.78	495.12	241.10	212.47	120.21	39.25	20.62	10.51	32706.65
47	2012 - 2013	300.38	7131.89	23836.95	22728.59	4327.20	1152.11	438.27	279.55	207.09	185.60	81.43	39.37	60708.41
	Average	1276.19	8874.70	18103.58	13181.03	4812.17	1175.28	532.45	328.08	236.81	197.49	116.06	98.03	48931.86

Assessment of 50% and 90% dependable year

Sr No.	Year			Energy Potential (GWh)	Energy Potential in Descending Order	Exceedence Probabilty	
1	1966	-	1967	1037.11	2362.73	2.08	
2	1967	-	1968	1229.60	2109.43	4.17	
3	1968	-	1969	690.48	1895.59	6.25	
4	1969	-	1970	1448.82	1866.03	8.33	
5	1970	-	1971	1907.49	1857.60	10.42	
6	1971	-	1972	501.82	1845.05	12.50	
7	**1972**	-	**1973**	**316.73**	1799.68	14.58	90% Dep. Year
8	1973	-	1974	1937.72	1729.21	16.67	
9	1974	-	1975	235.53	1624.74	18.75	
10	1975	-	1976	1767.64	1593.33	20.83	
11	1976	-	1977	1288.54	1417.32	22.92	
12	1977	-	1978	926.06	1316.69	25.00	
13	1978	-	1979	1628.74	1299.55	27.08	
14	1979	-	1980	888.98	1260.52	29.17	
15	1980	-	1981	1278.80	1251.00	31.25	
16	1981	-	1982	1345.95	1227.83	33.33	
17	1982	-	1983	447.01	1202.87	35.42	
18	1983	-	1984	2156.31	1075.64	37.50	
19	1984	-	1985	345.15	1040.79	39.58	
20	1985	-	1986	488.51	1014.57	41.67	
21	1986	-	1987	1063.92	949.55	43.75	
22	1987	-	1988	90.45	929.82	45.83	
23	1988	-	1989	1898.88	924.95	47.92	
24	1989	-	1990	950.48	**919.32**	**50.00**	
25	1990	-	1991	2415.23	911.19	52.08	
26	1991	-	1992	519.06	909.86	54.17	
27	1992	-	1993	881.19	905.93	56.25	
28	1993	-	1994	349.22	890.89	58.33	
29	1994	-	1995	1886.05	869.65	60.42	
30	**1995**	-	**1996**	**939.75**	862.03	62.50	50% Dep. Year
31	1996	-	1997	462.40	675.47	64.58	
32	1997	-	1998	387.48	661.49	66.67	
33	1998	-	1999	970.65	507.78	68.75	
34	1999	-	2000	1099.54	490.91	70.83	
35	2000	-	2001	910.69	488.88	72.92	
36	2001	-	2002	930.08	477.89	75.00	
37	2002	-	2003	499.75	452.35	77.08	
38	2003	-	2004	945.50	437.29	79.17	
39	2004	-	2005	276.31	429.67	81.25	
40	2005	-	2006	1328.42	379.06	83.33	
41	2006	-	2007	1839.67	341.63	85.42	
42	2007	-	2008	931.44	337.65	87.50	
43	2008	-	2009	439.22	309.85	**89.58**	
44	2009	-	2010	72.58	270.31	91.67	
45	2010	-	2011	1660.84	230.41	93.75	
46	2011	-	2012	676.19	88.48	95.83	
47	2012	-	2013	1255.11	71.00	97.92	

Unrestricted Power Potential

Unit: MW continuos

S.No.	Year			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
1	1966	-	1967	12.44	253.83	441.98	529.85	67.10	39.01	33.69	8.22	4.89	13.01	7.55	1.88
2	1967	-	1968	65.18	394.93	670.52	284.21	120.34	20.41	49.83	20.71	10.22	20.98	4.35	3.74
3	1968	-	1969	19.64	143.32	340.11	253.47	123.47	24.98	10.67	7.51	4.86	3.39	3.47	3.39
4	1969	-	1970	5.03	341.58	591.28	863.66	92.07	43.03	15.67	8.45	6.43	5.08	3.07	2.11
5	1970	-	1971	123.08	261.23	1152.70	811.65	152.13	36.59	17.77	12.13	8.53	7.57	5.13	7.66
6	1971	-	1972	55.21	74.78	137.66	235.96	135.43	23.83	8.99	5.60	3.43	2.12	1.19	0.74
7	1972	-	1973	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48
8	1973	-	1974	7.05	673.50	803.84	427.72	517.52	125.11	27.81	15.58	10.87	6.25	4.14	4.30
9	1974	-	1975	6.29	24.11	148.44	31.17	70.70	19.82	7.12	3.42	3.41	2.41	1.16	0.75
10	1975	-	1976	96.06	320.82	648.49	879.77	326.42	85.86	20.95	12.48	8.13	5.12	3.86	2.79
11	1976	-	1977	3.82	512.60	534.29	610.33	37.18	19.23	11.68	6.56	5.31	3.82	3.04	5.08
12	1977	-	1978	20.26	258.13	439.90	364.66	68.75	33.16	36.11	13.16	11.05	6.04	3.83	4.34
13	1978	-	1979	86.70	588.67	949.02	376.22	79.52	39.28	25.22	14.21	29.45	12.66	4.37	3.04
14	1979	-	1980	126.52	149.08	604.88	150.85	103.38	19.14	17.84	10.06	7.79	7.70	4.51	3.32
15	1980	-	1981	73.63	274.72	789.67	475.00	56.53	21.85	10.79	11.35	8.33	6.71	4.72	4.89
16	1981	-	1982	23.66	246.69	781.89	456.95	218.19	47.04	17.03	13.06	11.77	5.29	3.15	2.61
17	1982	-	1983	14.27	97.03	252.02	132.10	57.70	26.84	9.01	5.48	6.34	4.21	1.18	0.89
18	1983	-	1984	43.33	242.30	989.98	1017.70	510.96	46.51	23.85	19.04	11.25	14.21	9.17	6.72
19	1984	-	1985	14.22	86.22	238.24	55.03	35.10	14.01	6.56	5.82	4.79	3.34	2.53	1.30
20	1985	-	1986	22.99	127.51	282.80	87.07	89.67	18.15	7.00	5.59	8.07	6.84	3.38	2.55
21	1986	-	1987	42.14	393.87	808.57	99.24	39.39	22.42	7.81	9.41	5.79	4.02	1.89	1.36
22	1987	-	1988	2.01	28.24	41.80	27.49	10.12	5.57	2.81	1.47	1.09	1.20	0.52	0.46
23	1988	-	1989	28.56	590.16	790.66	712.59	374.18	35.03	15.98	10.06	7.23	6.91	4.72	2.06
24	1989	-	1990	27.11	391.18	410.10	313.46	85.44	16.62	8.70	8.49	5.80	4.96	2.43	15.41
25	1990	-	1991	209.28	445.60	1287.14	668.97	475.40	123.89	25.01	16.47	10.73	7.87	6.10	3.38
26	1991	-	1992	17.98	170.24	358.80	75.46	36.43	21.75	8.18	4.89	3.41	2.37	1.28	0.85
27	1992	-	1993	38.31	124.39	653.60	291.98	42.05	18.85	9.02	5.53	4.65	4.51	2.15	1.13
28	1993	-	1994	5.70	98.55	158.60	116.70	58.92	16.01	6.64	4.59	4.66	2.53	0.93	0.50
29	1994	-	1995	20.64	730.92	607.04	924.03	137.69	42.57	24.42	30.81	16.11	14.12	10.52	9.87
30	1995	-	1996	15.44	290.22	237.89	385.26	255.89	40.01	16.24	12.18	9.10	7.62	5.04	3.19
31	1996	-	1997	20.29	72.74	233.95	186.43	62.31	20.27	7.69	6.05	4.56	5.87	6.89	2.43
32	1997	-	1998	1.60	47.55	187.66	149.23	32.78	26.01	38.87	20.28	14.83	4.08	2.37	2.77
33	1998	-	1999	19.08	144.05	344.44	435.38	255.04	77.21	16.06	10.10	8.19	5.54	4.32	3.30
34	1999	-	2000	83.04	119.04	425.11	521.07	259.77	43.65	16.07	10.26	8.55	6.77	3.76	2.36
35	2000	-	2001	44.73	421.21	475.11	215.67	39.51	14.80	6.52	4.52	3.45	3.02	3.33	1.48
36	2001	-	2002	179.43	250.30	584.71	90.98	108.30	20.33	9.11	6.73	4.71	3.00	1.60	0.79
37	2002	-	2003	66.79	35.67	319.45	207.24	27.76	9.39	5.55	3.42	2.50	1.66	1.09	0.61
38	2003	-	2004	3.16	346.45	441.92	261.67	155.21	33.88	13.55	8.28	9.86	3.36	1.96	1.88
39	2004	-	2005	30.85	28.26	224.27	44.07	24.69	6.03	2.65	1.85	8.65	1.77	0.99	0.79
40	2005	-	2006	2.09	397.56	547.21	565.63	197.93	54.30	13.95	7.97	5.32	5.42	4.87	4.01
41	2006	-	2007	3.18	310.08	1129.75	695.07	243.78	69.93	18.48	11.18	7.28	3.89	3.22	2.42
42	2007	-	2008	11.05	276.68	408.95	373.37	139.92	24.38	9.14	5.65	6.82	4.98	4.41	0.36
43	2008	-	2009	4.46	70.00	342.12	124.51	28.20	12.40	6.40	2.65	2.13	1.21	0.78	0.27
44	2009	-	2010	0.07	32.59	27.05	26.55	5.74	2.93	1.41	0.94	0.63	0.41	0.16	0.10
45	2010	-	2011	4.30	266.42	786.17	944.72	144.36	65.52	23.55	10.50	7.24	6.95	3.85	2.29
46	2011	-	2012	4.53	78.37	242.52	528.04	40.93	14.22	6.70	5.90	3.57	1.09	0.59	0.29
47	2012	-	2013	8.63	198.18	662.39	652.64	120.25	33.08	12.18	7.77	6.37	5.16	2.34	1.09
	Average			36.65	246.61	503.07	378.49	133.72	33.75	14.80	9.12	7.22	5.49	3.33	2.72

Unrestricted Energy

Unit :GWh

S.No.	Year			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual
1	1966	-	1967	8.96	188.85	328.83	381.49	49.92	28.09	25.06	6.11	3.29	9.68	5.43	1.40	1037.11
2	1967	-	1968	46.93	293.83	498.87	204.63	89.53	14.70	37.07	15.41	7.11	15.61	3.13	2.78	1229.60
3	1968	-	1969	14.14	106.63	253.04	182.50	91.86	17.98	7.94	5.58	3.27	2.53	2.50	2.52	690.48
4	1969	-	1970	3.62	254.13	439.91	621.84	68.50	30.98	11.66	6.29	4.32	3.78	2.21	1.57	1448.82
5	1970	-	1971	88.62	194.36	857.61	584.39	113.18	26.34	13.22	9.02	5.73	5.63	3.69	5.70	1907.49
6	1971	-	1972	39.75	55.63	102.42	169.89	100.76	17.16	6.69	4.17	2.38	1.58	0.85	0.55	501.82
7	1972	-	1973	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73
8	1973	-	1974	5.07	501.09	598.06	307.96	385.03	90.08	20.69	11.59	7.31	4.65	2.98	3.20	1937.72
9	1974	-	1975	4.53	17.94	110.44	22.44	52.60	14.27	5.30	2.55	2.29	1.79	0.84	0.56	235.53
10	1975	-	1976	69.16	238.69	482.48	633.43	242.85	61.82	15.58	9.28	5.66	3.81	2.78	2.08	1767.64
11	1976	-	1977	2.75	381.37	397.52	439.44	27.66	13.85	8.69	4.88	3.57	2.84	2.19	3.78	1288.54
12	1977	-	1978	14.59	192.05	327.28	262.55	51.15	23.87	26.87	9.79	7.43	4.49	2.76	3.23	926.06
13	1978	-	1979	62.42	437.97	706.07	270.88	59.16	28.28	18.76	10.57	19.79	9.42	3.15	2.26	1628.74
14	1979	-	1980	91.09	110.92	450.03	108.61	76.92	13.78	13.27	7.49	5.42	5.73	3.25	2.47	888.98
15	1980	-	1981	53.01	204.39	587.51	342.00	42.06	15.73	8.03	8.45	5.60	4.99	3.40	3.64	1278.80
16	1981	-	1982	17.03	183.54	581.73	329.00	162.34	33.87	12.67	9.72	7.91	3.94	2.27	1.94	1345.95
17	1982	-	1983	10.27	72.19	187.50	95.11	42.93	19.32	6.70	4.08	4.26	3.13	0.85	0.66	447.01
18	1983	-	1984	31.20	180.27	736.54	732.75	380.16	33.49	17.74	14.16	7.83	10.57	6.60	5.00	2156.31
19	1984	-	1985	10.24	64.15	177.25	39.62	26.11	10.09	4.88	4.33	3.22	2.48	1.82	0.97	345.15
20	1985	-	1986	16.56	94.86	210.40	62.69	66.72	13.07	5.21	4.16	5.42	5.09	2.43	1.90	488.51
21	1986	-	1987	30.34	293.04	601.57	71.45	29.31	16.14	5.81	7.00	3.89	2.99	1.36	1.01	1063.92
22	1987	-	1988	1.45	21.01	31.10	19.79	7.53	4.01	2.09	1.10	0.76	0.89	0.38	0.34	90.45
23	1988	-	1989	20.56	439.08	588.25	513.06	278.39	25.22	11.89	7.48	4.86	5.14	3.40	1.54	1898.88
24	1989	-	1990	19.52	291.04	305.12	225.69	63.57	11.96	6.47	6.31	3.89	3.69	1.75	11.46	950.48
25	1990	-	1991	150.68	331.53	957.63	481.66	353.70	89.20	18.61	12.26	7.21	5.86	4.39	2.52	2415.23
26	1991	-	1992	12.95	126.66	266.95	54.33	27.11	15.66	6.09	3.64	2.37	1.76	0.92	0.63	519.06
27	1992	-	1993	27.58	92.55	486.28	210.23	31.28	13.57	6.71	4.11	3.12	3.36	1.55	0.84	881.19
28	1993	-	1994	4.10	73.32	118.00	84.02	43.83	11.53	4.94	3.42	3.13	1.88	0.67	0.37	349.22
29	1994	-	1995	14.86	543.81	451.64	665.30	102.44	30.65	18.17	22.92	10.83	10.51	7.58	7.35	1886.05
30	1995	-	1996	11.12	215.93	176.99	277.38	190.38	28.81	12.08	9.06	6.33	5.67	3.63	2.37	939.75
31	1996	-	1997	14.61	54.12	174.06	134.23	46.36	14.59	5.73	4.50	3.07	4.37	4.96	1.81	462.40
32	1997	-	1998	1.15	35.37	139.62	107.45	24.39	18.73	28.92	15.09	9.96	3.03	1.71	2.06	387.48
33	1998	-	1999	13.73	107.18	256.27	313.47	189.75	55.59	11.95	7.52	5.51	4.12	3.11	2.45	970.65
34	1999	-	2000	59.79	88.56	316.28	375.17	193.27	31.43	11.95	7.63	5.95	5.04	2.71	1.76	1099.54
35	2000	-	2001	32.21	313.38	353.48	155.29	29.40	10.65	4.85	3.36	2.32	2.25	2.40	1.10	910.69
36	2001	-	2002	129.19	186.22	435.02	65.51	80.58	14.64	6.78	5.00	3.16	2.23	1.15	0.58	930.08
37	2002	-	2003	48.09	26.54	237.67	149.21	20.65	6.76	4.13	2.54	1.68	1.23	0.79	0.45	499.75
38	2003	-	2004	2.27	257.76	328.79	188.40	115.47	24.39	10.08	6.16	6.86	2.50	1.41	1.40	945.50
39	2004	-	2005	22.21	21.03	166.86	31.73	18.37	4.34	1.97	1.38	5.81	1.31	0.72	0.58	276.31
40	2005	-	2006	1.50	295.78	407.13	407.26	147.26	39.09	10.38	5.93	3.58	4.03	3.51	2.98	1328.42
41	2006	-	2007	2.29	230.70	840.54	500.45	181.37	50.35	13.75	8.32	4.89	2.90	2.32	1.80	1839.67
42	2007	-	2008	7.95	205.85	304.26	268.83	104.10	17.55	6.80	4.20	4.74	3.71	3.18	0.27	931.44
43	2008	-	2009	3.21	52.08	254.54	89.65	20.98	8.93	4.76	1.97	1.43	0.90	0.56	0.20	439.22
44	2009	-	2010	0.05	24.25	20.13	19.11	4.27	2.11	1.05	0.70	0.42	0.30	0.12	0.07	72.58
45	2010	-	2011	3.09	198.22	584.91	680.20	107.40	47.17	17.52	7.81	4.87	5.17	2.77	1.70	1660.84
46	2011	-	2012	3.26	58.31	180.43	380.19	30.45	10.24	4.98	4.39	2.49	0.81	0.43	0.22	676.19
47	2012	-	2013	6.21	147.45	492.82	469.90	89.46	23.82	9.06	5.78	4.28	3.84	1.68	0.81	1255.11
Average				26.38	183.48	374.28	272.51	99.49	24.30	11.01	6.78	4.90	4.08	2.40	2.03	1011.64

Scheme Restricted Energy

Unit :GWh

S.No.	Year			Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Annual	Lean Period
1	1966	-	1967	8.96	178.56	178.56	172.80	49.92	28.09	25.06	6.11	3.29	9.68	5.43	1.40	667.86	19.08
2	1967	-	1968	46.93	178.56	178.56	172.80	89.53	14.70	37.07	15.41	7.11	15.61	3.13	2.78	762.19	38.13
3	1968	-	1969	14.14	106.63	178.56	172.80	91.86	17.98	7.94	5.58	3.27	2.53	2.50	2.52	606.30	11.38
4	1969	-	1970	3.62	178.56	178.56	172.80	68.50	30.98	11.66	6.29	4.32	3.78	2.21	1.57	662.86	14.39
5	1970	-	1971	88.62	178.56	178.56	172.80	113.18	26.34	13.22	9.02	5.73	5.63	3.69	5.70	801.06	20.38
6	1971	-	1972	39.75	55.63	102.42	169.89	100.76	17.16	6.69	4.17	2.38	1.58	0.85	0.55	501.82	8.13
7	1972	-	1973	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73	3.12
8	1973	-	1974	5.07	178.56	178.56	172.80	178.56	90.08	20.69	11.59	7.31	4.65	2.98	3.20	854.06	23.55
9	1974	-	1975	4.53	17.94	110.44	22.44	52.60	14.27	5.30	2.55	2.29	1.79	0.84	0.56	235.53	6.63
10	1975	-	1976	69.16	178.56	178.56	172.80	178.56	61.82	15.58	9.28	5.66	3.81	2.78	2.08	878.66	18.75
11	1976	-	1977	2.75	178.56	178.56	172.80	27.66	13.85	8.69	4.88	3.57	2.84	2.19	3.78	600.13	11.29
12	1977	-	1978	14.59	178.56	178.56	172.80	51.15	23.87	26.87	9.79	7.43	4.49	2.76	3.23	674.09	21.71
13	1978	-	1979	62.42	178.56	178.56	172.80	59.16	28.28	18.76	10.57	19.79	9.42	3.15	2.26	743.74	39.79
14	1979	-	1980	91.09	110.92	178.56	108.61	76.92	13.78	13.27	7.49	5.42	5.73	3.25	2.47	617.51	18.64
15	1980	-	1981	53.01	178.56	178.56	172.80	42.06	15.73	8.03	8.45	5.60	4.99	3.40	3.64	674.82	19.04
16	1981	-	1982	17.03	178.56	178.56	172.80	162.34	33.87	12.67	9.72	7.91	3.94	2.27	1.94	781.61	21.56
17	1982	-	1983	10.27	72.19	178.56	95.11	42.93	19.32	6.70	4.08	4.26	3.13	0.85	0.66	438.06	11.47
18	1983	-	1984	31.20	178.56	178.56	172.80	178.56	33.49	17.74	14.16	7.83	10.57	6.60	5.00	835.07	32.56
19	1984	-	1985	10.24	64.15	177.25	39.62	26.11	10.09	4.88	4.33	3.22	2.48	1.82	0.97	345.15	10.03
20	1985	-	1986	16.56	94.86	178.56	62.69	66.72	13.07	5.21	4.16	5.42	5.09	2.43	1.90	456.67	14.67
21	1986	-	1987	30.34	178.56	178.56	71.45	29.31	16.14	5.81	7.00	3.89	2.99	1.36	1.01	526.43	13.88
22	1987	-	1988	1.45	21.01	31.10	19.79	7.53	4.01	2.09	1.10	0.76	0.89	0.38	0.34	90.45	2.75
23	1988	-	1989	20.56	178.56	178.56	172.80	178.56	25.22	11.89	7.48	4.86	5.14	3.40	1.54	788.57	17.48
24	1989	-	1990	19.52	178.56	178.56	172.80	63.57	11.96	6.47	6.31	3.89	3.69	1.75	11.46	658.55	13.90
25	1990	-	1991	150.68	178.56	178.56	172.80	178.56	89.20	18.61	12.26	7.21	5.86	4.39	2.52	999.20	25.32
26	1991	-	1992	12.95	126.66	178.56	54.33	27.11	15.66	6.09	3.64	2.37	1.76	0.92	0.63	430.67	7.77
27	1992	-	1993	27.58	92.55	178.56	172.80	31.28	13.57	6.71	4.11	3.12	3.36	1.55	0.84	536.04	10.59
28	1993	-	1994	4.10	73.32	118.00	84.02	43.83	11.53	4.94	3.42	3.13	1.88	0.67	0.37	349.22	8.43
29	1994	-	1995	14.86	178.56	178.56	172.80	102.44	30.65	18.17	22.92	10.83	10.51	7.58	7.35	755.22	44.26
30	1995	-	1996	11.12	178.56	176.99	172.80	178.56	28.81	12.08	9.06	6.33	5.67	3.63	2.37	785.98	21.06
31	1996	-	1997	14.61	54.12	174.06	134.23	46.36	14.59	5.73	4.50	3.07	4.37	4.96	1.81	462.40	11.93
32	1997	-	1998	1.15	35.37	139.62	107.45	24.39	18.73	28.92	15.09	9.96	3.03	1.71	2.06	387.48	28.09
33	1998	-	1999	13.73	107.18	178.56	172.80	178.56	55.59	11.95	7.52	5.51	4.12	3.11	2.45	741.08	17.14
34	1999	-	2000	59.79	88.56	178.56	172.80	178.56	31.43	11.95	7.63	5.95	5.04	2.71	1.76	744.74	18.62
35	2000	-	2001	32.21	178.56	178.56	155.29	29.40	10.65	4.85	3.36	2.32	2.25	2.40	1.10	600.95	7.93
36	2001	-	2002	129.19	178.56	178.56	65.51	80.58	14.64	6.78	5.00	3.16	2.23	1.15	0.58	665.95	10.40
37	2002	-	2003	48.09	26.54	178.56	149.21	20.65	6.76	4.13	2.54	1.68	1.23	0.79	0.45	440.64	5.46
38	2003	-	2004	2.27	178.56	178.56	172.80	115.47	24.39	10.08	6.16	6.86	2.50	1.41	1.40	700.47	15.52
39	2004	-	2005	22.21	21.03	166.86	31.73	18.37	4.34	1.97	1.38	5.81	1.31	0.72	0.58	276.31	8.51
40	2005	-	2006	1.50	178.56	178.56	172.80	147.26	39.09	10.38	5.93	3.58	4.03	3.51	2.98	748.18	13.54
41	2006	-	2007	2.29	178.56	178.56	172.80	178.56	50.35	13.75	8.32	4.89	2.90	2.32	1.80	795.09	16.10
42	2007	-	2008	7.95	178.56	178.56	172.80	104.10	17.55	6.80	4.20	4.74	3.71	3.18	0.27	682.43	12.66
43	2008	-	2009	3.21	52.08	178.56	89.65	20.98	8.93	4.76	1.97	1.43	0.90	0.56	0.20	363.24	4.31
44	2009	-	2010	0.05	24.25	20.13	19.11	4.27	2.11	1.05	0.70	0.42	0.30	0.12	0.07	72.58	1.42
45	2010	-	2011	3.09	178.56	178.56	172.80	107.40	47.17	17.52	7.81	4.87	5.17	2.77	1.70	727.43	17.85
46	2011	-	2012	3.26	58.31	178.56	172.80	30.45	10.24	4.98	4.39	2.49	0.81	0.43	0.22	466.93	7.69
47	2012	-	2013	6.21	147.45	178.56	172.80	89.46	23.82	9.06	5.78	4.28	3.84	1.68	0.81	643.76	13.90
Average				26.38	128.40	164.39	136.09	82.73	24.30	11.01	6.78	4.90	4.08	2.40	2.03	593.49	15.76

Restricted Power Potential

Unit: MW continuos

S.No.	Year	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Lean Period
1	1966 - 1967	12.44	240.00	240.00	240.00	67.10	39.01	33.69	8.22	4.89	13.01	7.55	1.88	8.71
2	1967 - 1968	65.18	240.00	240.00	240.00	120.34	20.41	49.83	20.71	10.22	20.98	4.35	3.74	17.30
3	1968 - 1969	19.64	143.32	240.00	240.00	123.47	24.98	10.67	7.51	4.86	3.39	3.47	3.39	5.25
4	1969 - 1970	5.03	240.00	240.00	240.00	92.07	43.03	15.67	8.45	6.43	5.08	3.07	2.11	6.65
5	1970 - 1971	123.08	240.00	240.00	240.00	152.13	36.59	17.77	12.13	8.53	7.57	5.13	7.66	9.41
6	1971 - 1972	55.21	74.78	137.66	235.96	135.43	23.83	8.99	5.60	3.43	2.12	1.19	0.74	3.72
7	1972 - 1973	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48	1.44
8	1973 - 1974	7.05	240.00	240.00	240.00	240.00	125.11	27.81	15.58	10.87	6.25	4.14	4.30	10.90
9	1974 - 1975	6.29	24.11	148.44	31.17	70.70	19.82	7.12	3.42	3.41	2.41	1.16	0.75	3.08
10	1975 - 1976	96.06	240.00	240.00	240.00	240.00	85.86	20.95	12.48	8.13	5.12	3.86	2.79	8.58
11	1976 - 1977	3.82	240.00	240.00	240.00	37.18	19.23	11.68	6.56	5.31	3.82	3.04	5.08	5.23
12	1977 - 1978	20.26	240.00	240.00	240.00	68.75	33.16	36.11	13.16	11.05	6.04	3.83	4.34	10.08
13	1978 - 1979	86.70	240.00	240.00	240.00	79.52	39.28	25.22	14.21	29.45	12.66	4.37	3.04	18.78
14	1979 - 1980	126.52	149.08	240.00	150.85	103.38	19.14	17.84	10.06	7.79	7.70	4.51	3.32	8.52
15	1980 - 1981	73.63	240.00	240.00	240.00	56.53	21.85	10.79	11.35	8.33	6.71	4.72	4.89	8.80
16	1981 - 1982	23.66	240.00	240.00	240.00	218.19	47.04	17.03	13.06	11.77	5.29	3.15	2.61	10.04
17	1982 - 1983	14.27	97.03	240.00	132.10	57.70	26.84	9.01	5.48	6.34	4.21	1.18	0.89	5.34
18	1983 - 1984	43.33	240.00	240.00	240.00	240.00	46.51	23.85	19.04	11.25	14.21	9.17	6.72	14.83
19	1984 - 1985	14.22	86.22	238.24	55.03	35.10	14.01	6.56	5.82	4.79	3.34	2.53	1.30	4.65
20	1985 - 1986	22.99	127.51	240.00	87.07	89.67	18.15	7.00	5.59	8.07	6.84	3.38	2.55	6.83
21	1986 - 1987	42.14	240.00	240.00	99.24	39.39	22.42	7.81	9.41	5.79	4.02	1.89	1.36	6.40
22	1987 - 1988	2.01	28.24	41.80	27.49	10.12	5.57	2.81	1.47	1.09	1.20	0.52	0.46	1.26
23	1988 - 1989	28.56	240.00	240.00	240.00	240.00	35.03	15.98	10.06	7.23	6.91	4.72	2.06	8.07
24	1989 - 1990	27.11	240.00	240.00	240.00	85.44	16.62	8.70	8.49	5.80	4.96	2.43	15.41	6.42
25	1990 - 1991	209.28	240.00	240.00	240.00	240.00	123.89	25.01	16.47	10.73	7.87	6.10	3.38	11.69
26	1991 - 1992	17.98	170.24	240.00	75.46	36.43	21.75	8.18	4.89	3.41	2.37	1.28	0.85	3.56
27	1992 - 1993	38.31	124.39	240.00	240.00	42.05	18.85	9.02	5.53	4.65	4.51	2.15	1.13	4.90
28	1993 - 1994	5.70	98.55	158.60	116.70	58.92	16.01	6.64	4.59	4.66	2.53	0.93	0.50	3.93
29	1994 - 1995	20.64	240.00	240.00	240.00	137.69	42.57	24.42	30.81	16.11	14.12	10.52	9.87	20.35
30	1995 - 1996	15.44	240.00	237.89	240.00	240.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	9.63
31	1996 - 1997	20.29	72.74	233.95	186.43	62.31	20.27	7.69	6.05	4.56	5.87	6.89	2.43	5.49
32	1997 - 1998	1.60	47.55	187.66	149.23	32.78	26.01	38.87	20.28	14.83	4.08	2.37	2.77	13.06
33	1998 - 1999	19.08	144.05	240.00	240.00	240.00	77.21	16.06	10.10	8.19	5.54	4.32	3.30	7.95
34	1999 - 2000	83.04	119.04	240.00	240.00	240.00	43.65	16.07	10.26	8.55	6.77	3.76	2.36	8.53
35	2000 - 2001	44.73	240.00	240.00	215.67	39.51	14.80	6.52	4.52	3.45	3.02	3.33	1.48	3.66
36	2001 - 2002	179.43	240.00	240.00	90.98	108.30	20.33	9.11	6.73	4.71	3.00	1.60	0.79	4.81
37	2002 - 2003	66.79	35.67	240.00	207.24	27.76	9.39	5.55	3.42	2.50	1.66	1.09	0.61	2.53
38	2003 - 2004	3.16	240.00	240.00	240.00	155.21	33.88	13.55	8.28	9.86	3.36	1.96	1.88	7.17
39	2004 - 2005	30.85	28.26	224.27	44.07	24.69	6.03	2.65	1.85	8.65	1.77	0.99	0.79	4.09
40	2005 - 2006	2.09	240.00	240.00	240.00	197.93	54.30	13.95	7.97	5.32	5.42	4.87	4.01	6.24
41	2006 - 2007	3.18	240.00	240.00	240.00	240.00	69.93	18.48	11.18	7.28	3.89	3.22	2.42	7.45
42	2007 - 2008	11.05	240.00	240.00	240.00	139.92	24.38	9.14	5.65	6.82	4.98	4.41	0.36	5.82
43	2008 - 2009	4.46	70.00	240.00	124.51	28.20	12.40	6.40	2.65	2.13	1.21	0.78	0.27	2.00
44	2009 - 2010	0.07	32.59	27.05	26.55	5.74	2.93	1.41	0.94	0.63	0.41	0.16	0.10	0.66
45	2010 - 2011	4.30	240.00	240.00	240.00	144.36	65.52	23.55	10.50	7.24	6.95	3.85	2.29	8.23
46	2011 - 2012	4.53	78.37	240.00	240.00	40.93	14.22	6.70	5.90	3.57	1.09	0.59	0.29	3.52
47	2012 - 2013	8.63	198.18	240.00	240.00	120.25	33.08	12.18	7.77	6.37	5.16	2.34	1.09	6.43
	Average	36.65	172.58	220.96	189.02	111.19	33.75	14.80	9.12	7.22	5.49	3.33	2.72	7.28

Power Potential With Different Installed Capacity in a 50% Dependable Year

S.No.	Particulars		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total energy (GWh)	Lean Period Power (MWc) (Jan-Mar)	Increamental Energy(GWh)	Increamental Capacity(MWc)	dE/dP (GWh/MWc)
1	Inflows (Cumecs)		207.5	3899.4	3196.2	5176.2	3438.1	537.6	218.2	163.6	122.2	102.4	67.7	42.8					
2	Power Potential (MWc)		15.44	290.22	237.89	385.26	255.89	40.01	16.24	12.18	9.10	7.62	5.04	3.19					
3	Unrestricted Energy(GWh)		11.12	215.93	176.99	277.38	190.38	28.81	12.08	9.06	6.11	5.67	3.63	2.37	939.54				
4	Installed Capacity 120	Power(MWc)	15.44	120.00	120.00	120.00	120.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	433.09	9.63			
		Energy(GWh)	11.12	89.28	89.28	86.40	89.28	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
5	Installed Capacity 140	Power(MWc)	15.44	140.00	140.00	140.00	140.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	492.13	9.63	59.04	20.00	2952.00
		Energy(GWh)	11.12	104.16	104.16	100.80	104.16	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
6	Installed Capacity 160	Power(MWc)	15.44	160.00	160.00	160.00	160.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	551.17	9.63	59.04	20.00	2952.00
		Energy(GWh)	11.12	119.04	119.04	115.20	119.04	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
7	Installed Capacity 180	Power(MWc)	15.44	180.00	180.00	180.00	180.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	610.21	9.63	59.04	20.00	2952.00
		Energy(GWh)	11.12	133.92	133.92	129.60	133.92	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
8	Installed Capacity 200	Power(MWc)	15.44	200.00	200.00	200.00	200.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	669.25	9.63	59.04	20.00	2952.00
		Energy(GWh)	11.12	148.80	148.80	144.00	148.80	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
9	Installed Capacity 220	Power(MWc)	15.44	220.00	220.00	220.00	220.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	728.29	9.63	59.04	20.00	2952.00
		Energy(GWh)	11.12	163.68	163.68	158.40	163.68	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
10	Installed Capacity 240	Power(MWc)	15.44	240.00	237.89	240.00	240.00	40.01	16.24	12.18	9.10	7.62	5.04	3.19	785.76	9.63	57.47	20.00	2873.47
		Energy(GWh)	11.12	178.56	176.99	172.80	178.56	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
11	Installed Capacity 260	Power(MWc)	15.44	260.00	237.89	260.00	255.89	40.01	16.24	12.18	9.10	7.62	5.04	3.19	826.86	9.63	41.10	20.00	2055.20
		Energy(GWh)	11.12	193.44	176.99	187.20	190.38	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
12	Installed Capacity 280	Power(MWc)	15.44	280.00	237.89	280.00	255.89	40.01	16.24	12.18	9.10	7.62	5.04	3.19	856.14	9.63	29.28	20.00	1464.00
		Energy(GWh)	11.12	208.32	176.99	201.60	190.38	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
13	Installed Capacity 300	Power(MWc)	15.44	290.22	237.89	300.00	255.89	40.01	16.24	12.18	9.10	7.62	5.04	3.19	878.15	9.63	22.01	20.00	1100.36
		Energy(GWh)	11.12	215.93	176.99	216.00	190.38	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
14	Installed Capacity 320	Power(MWc)	15.44	290.22	237.89	320.00	255.89	40.01	16.24	12.18	9.10	7.62	5.04	3.19	892.55	9.63	14.40	20.00	720.00
		Energy(GWh)	11.12	215.93	176.99	230.40	190.38	28.81	12.08	9.06	6.11	5.67	3.63	2.37					
15	Installed Capacity 340	Power(MWc)	15.44	290.22	237.89	340.00	255.89	40.01	16.24	12.18	9.10	7.62	5.04	3.19	906.95	9.63	14.40	20.00	720.00
		Energy(GWh)	11.12	215.93	176.99	244.80	190.38	28.81	12.08	9.06	6.11	5.67	3.63	2.37					

Power Potential With Different Installed Capacity in a 90% Dependable Year

S.No.	Particulars		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total energy (GWh)	Lean Period Power (MWc) (Jan-Mar)	Increamental Energy(GWh)	Increamental Capacity(MWc)	dE/dP (GWh/MWc)
1	Inflows (Cumecs)		114.7	2166.2	1470.9	1451.9	279.7	151.1	69.0	28.3	17.5	12.2	9.2	6.4					
2	Power Potential (MWc)		8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48					
3	Unrestricted Energy(GWh)		6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.91	0.67	0.49	0.36	316.77				
4	Installed	Power(MWc)	8.54	120.00	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 120	Energy(GWh)	6.15	89.28	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	286.06				
5	Installed	Power(MWc)	8.54	140.00	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 140	Energy(GWh)	6.15	104.16	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	300.94		14.88	20.00	744.00
6	Installed	Power(MWc)	8.54	160.00	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 160	Energy(GWh)	6.15	119.04	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	315.82		14.88	20.00	744.00
7	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 180	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.91	20.00	45.73
8	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 200	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00
9	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 220	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00
10	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 240	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00
11	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 260	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00
12	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 280	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00
13	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 300	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00
14	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 320	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00
15	Installed	Power(MWc)	8.54	161.23	109.47	108.06	20.82	11.25	5.14	2.11	1.31	0.91	0.69	0.48		1.44			
	Capacity 340	Energy(GWh)	6.15	119.95	81.45	77.80	15.49	8.10	3.82	1.57	0.88	0.67	0.49	0.36	316.73		0.00	20.00	0.00

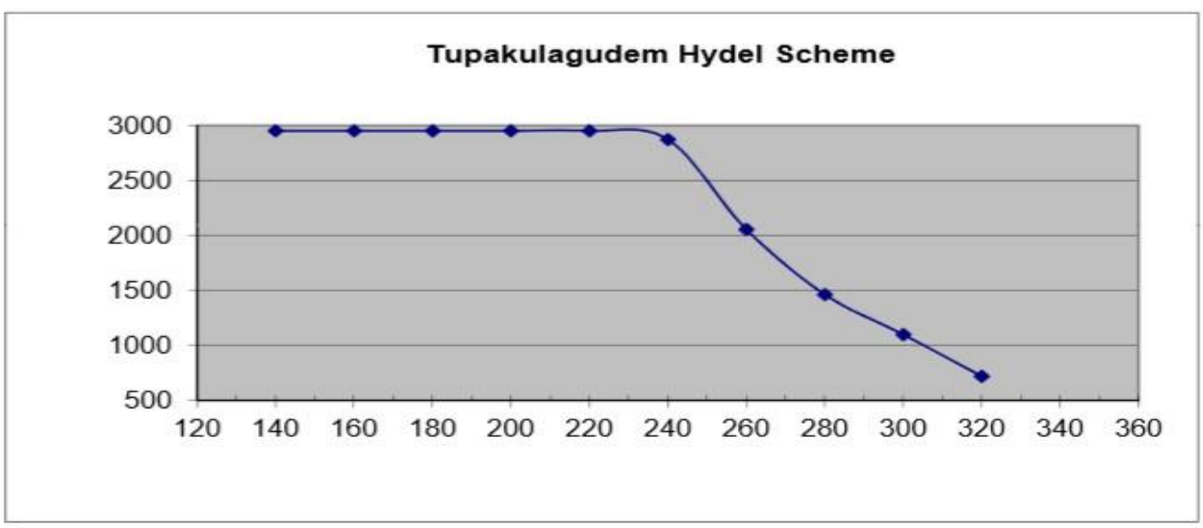
Capacity and Energy Benefit in 90% Dependable Year

Months	Inflows (Cumecs)	Potential (MWc)	Output for Installed Capacity(200MW)		Design Energy	
			MWc	GWh	MWc	GWh
Jun	207.49	15.44	15.44	11.12	15.44	11.12
Jul	3899.40	290.22	240.00	178.56	228.00	169.63
Aug	3196.22	237.89	237.89	176.99	228.00	169.63
Sep	5176.22	385.26	240.00	172.80	228.00	164.16
Oct	3438.11	255.89	240.00	178.56	228.00	169.63
Nov	537.58	40.01	40.01	28.81	40.01	28.81
Dec	218.21	16.24	16.24	12.08	16.24	12.08
Jan	163.61	12.18	12.18	9.06	12.18	9.06
Feb	122.22	9.10	9.10	6.11	9.10	6.11
Mar	102.35	7.62	7.62	5.67	7.62	5.67
Apr	67.71	5.04	5.04	3.63	5.04	3.63
May	42.82	3.19	3.19	2.37	3.19	2.37
Total*	**45444.20**	**939.54**		**785.76**		**751.91**

* Total of inflows is in MCM and Potential in GWh

Incremental Energy Benefits (90% Dependable Year)

S. NO.	Installed Capacity (MW)	Annual Energy Generation (GWh)	ANNUAL Load Factor (%)	Lean Flow Load Factor (%)	KWh/ KW	d (KWh)/ d (KW)
1	120	433.09	41.20	1.20	3609.09	-
2	140	492.13	40.13	1.03	3515.22	2952.00
3	160	551.17	39.32	0.90	3444.81	2952.00
4	180	610.21	38.70	0.80	3390.06	2952.00
5	200	669.25	38.20	0.72	3346.25	2952.00
6	220	728.29	37.79	0.65	3310.41	2952.00
7	240	785.76	37.37	0.60	3274.00	2873.47
8	260	826.86	36.30	0.55	3180.24	2055.20
9	280	856.14	34.90	0.51	3057.66	1464.00
10	300	878.15	33.42	0.48	2927.17	1100.36
11	320	892.55	31.84	0.45	2789.22	720.00
12	340	906.95	30.45	0.42	2667.50	



Summary of Power Potential Studies

Sr No.	Year	ANNUAL INFLOWS (MCM)	ENERGY POTENTIAL (GWh)	ENERGY GEN. with IC=90MW (GWh)	ANNUAL Load Factor (%)	LEAN FLOW	
						MWc	LF(%)
1	1966 - 1967	50163.98	1037.11	667.86	31.77	8.71	3.63
2	1967 - 1968	59474.34	1229.60	762.19	36.25	17.30	7.21
3	1968 - 1969	33397.74	690.48	606.30	28.84	5.25	2.19
4	1969 - 1970	70077.61	1448.82	662.86	31.53	6.65	2.77
5	1970 - 1971	92263.23	1907.49	801.06	38.10	9.41	3.92
6	1971 - 1972	24272.56	501.82	501.82	23.87	3.72	1.55
7	1972 - 1973	15320.08	316.73	316.73	15.07	1.44	0.60
8	1973 - 1974	93724.99	1937.72	854.06	40.62	10.90	4.54
9	1974 - 1975	11392.43	235.53	235.53	11.20	3.08	1.28
10	1975 - 1976	85498.48	1767.64	878.66	41.79	8.58	3.57
11	1976 - 1977	62324.93	1288.54	600.13	28.54	5.23	2.18
12	1977 - 1978	44792.54	926.06	674.09	32.06	10.08	4.20
13	1978 - 1979	78780.04	1628.74	743.74	35.38	18.78	7.82
14	1979 - 1980	42998.76	888.98	617.51	29.37	8.52	3.55
15	1980 - 1981	61854.19	1278.80	674.82	32.10	8.80	3.67
16	1981 - 1982	65102.02	1345.95	781.61	37.18	10.04	4.18
17	1982 - 1983	21621.19	447.01	438.06	20.84	5.34	2.23
18	1983 - 1984	104297.99	2156.31	835.07	39.72	14.83	6.18
19	1984 - 1985	16694.51	345.15	345.15	16.42	4.65	1.94
20	1985 - 1986	23628.83	488.51	456.67	21.72	6.83	2.85
21	1986 - 1987	51460.66	1063.92	526.43	25.04	6.40	2.67
22	1987 - 1988	4374.82	90.45	90.45	4.30	1.26	0.52
23	1988 - 1989	91846.62	1898.88	788.57	37.51	8.07	3.36
24	1989 - 1990	45973.68	950.48	658.55	31.32	6.42	2.67
25	1990 - 1991	116822.05	2415.23	999.20	47.53	11.69	4.87
26	1991 - 1992	25106.38	519.06	430.67	20.48	3.56	1.48
27	1992 - 1993	42622.06	881.19	536.04	25.50	4.90	2.04
28	1993 - 1994	16891.21	349.22	349.22	16.61	3.93	1.64
29	1994 - 1995	91225.95	1886.05	755.22	35.92	20.35	8.48
30	1995 - 1996	45454.76	939.75	785.98	37.38	9.63	4.01
31	1996 - 1997	22365.82	462.40	462.40	21.99	5.49	2.29
32	1997 - 1998	18741.92	387.48	387.48	18.43	13.06	5.44
33	1998 - 1999	46949.16	970.65	741.08	35.25	7.95	3.31
34	1999 - 2000	53183.64	1099.54	744.74	35.42	8.53	3.55
35	2000 - 2001	44048.98	910.69	600.95	28.58	3.66	1.53
36	2001 - 2002	44986.64	930.08	665.95	31.68	4.81	2.01
37	2002 - 2003	24172.13	499.75	440.64	20.96	2.53	1.05
38	2003 - 2004	45732.83	945.50	700.47	33.32	7.17	2.99
39	2004 - 2005	13365.02	276.31	276.31	13.14	4.09	1.70
40	2005 - 2006	64254.30	1328.42	748.18	35.59	6.24	2.60
41	2006 - 2007	88982.85	1839.67	795.09	37.82	7.45	3.10
42	2007 - 2008	45052.82	931.44	682.43	32.46	5.82	2.42
43	2008 - 2009	21244.42	439.22	363.24	17.28	2.00	0.83
44	2009 - 2010	3510.51	72.58	72.58	3.45	0.66	0.27
45	2010 - 2011	80332.88	1660.84	727.43	34.60	8.23	3.43
46	2011 - 2012	32706.65	676.19	466.93	22.21	3.52	1.47
47	2012 - 2013	60708.41	1255.11	643.76	30.62	6.43	2.68

6.2 Power Potential Studies of Dummugudem Hydroelectric Project:

6.2.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In earlier DPR studies the FRL & TWL was considered as at EL 60 m and 45.72 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking into account of inflows, environmental aspects and the topography of the area. Also, after carrying out studies MDDL is considered at EL 52 m and the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Dummugudem Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e. 0.12 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 438.00 MCum. The Elevation Area capacity Table is shown as below.

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	47.08	14218167.59	1421.82	27081689.98	27.08
2	48	16258167.59	1625.82	40162378.14	40.16
3	48.92	19245627.49	1924.56	57868320.19	57.87
4	49.84	20859449.63	2085.94	76929946.5	76.93
5	50.76	22093769.94	2209.38	97058683.33	97.06
6	51.68	23739530.35	2373.95	118504113.1	118.50
7	52	26727637.59	2672.76	142137297.3	120.61
8	53.52	31791732.56	3179.17	169360108.6	169.36

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
9	54.44	36259333.32	3625.93	200574182.6	200.57
10	55.36	43886005.01	4388.60	236678447.6	236.68
11	56.28	54111888.49	5411.19	279916726.8	279.92
12	57.2	66994284.79	6699.43	332276260.6	332.28
13	58.12	79429964.7	7943.00	395523147.2	395.52
14	59.04	84311002.21	8431.10	469994126.6	469.99
15	59.96	90311002.21	9031.10	554920079.6	554.92
16	60	92311002.21	9231.10	558612604.2	558.61

6.2.2 Hydrology

Hydrological Series data is developed for 15 years from 2000-01 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. The outflows of Singareddi HE Projects which is in the Upstream of Dummugudem HE Project and the Intermediate Inflows has been considered for the studies. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Singareddi Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=D-C
Jun	I	340.19	0.43	340.62	68.12	272.50
	II	550.13	0.62	550.75	110.15	440.60
	III	487.58	8.49	496.07	99.21	396.86
Jul	I	1247.76	22.6	1270.36	381.11	889.25
	II	1613.80	28.18	1641.98	492.59	1149.39
	III	1073.39	33.57	1106.96	332.09	774.87

Period (10 Daily)		Singareddi Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=D-C
Aug	I	2367.98	56.36	2424.34	727.30	1697.04
	II	4120.64	103.45	4224.09	1267.23	2956.86
	III	3065.12	120.08	3185.20	955.56	2229.64
Sep	I	4600.48	140.43	4740.91	1422.27	3318.64
	II	4391.78	98.79	4490.57	1347.17	3143.40
	III	1339.80	26.18	1365.98	409.79	956.19
Oct	I	1143.65	13.5	1157.15	347.15	810.01
	II	627.59	12.56	640.15	192.05	448.11
	III	1200.59	21.62	1222.21	366.66	855.55
Nov	I	640.88	6.88	647.76	161.94	485.82
	II	714.76	5.48	720.24	180.06	540.18
	III	566.51	3.97	570.48	142.62	427.86
Dec	I	517.85	3.82	521.67	130.42	391.25
	II	534.82	3.32	538.14	134.54	403.61
	III	552.87	2.56	555.43	138.86	416.57
Jan	I	554.90	2.45	557.35	139.34	418.01
	II	536.65	1.9	538.55	134.64	403.91
	III	542.14	1.62	543.76	135.94	407.82
Feb	I	551.08	1.48	552.56	110.51	442.05
	II	558.76	1.52	560.28	112.06	448.22
	III	567.50	1.32	568.82	113.76	455.06
Mar	I	582.30	1.23	583.53	116.71	466.82
	II	587.59	0.87	588.46	117.69	470.77
	III	605.55	0.81	606.36	121.27	485.09
Apr	I	633.18	0.81	633.99	126.80	507.19
	II	646.21	0.6	646.81	129.36	517.45
	III	650.82	0.49	651.31	130.26	521.05
May	I	626.69	0.41	627.10	125.42	501.68
	II	626.01	0.36	626.37	125.27	501.10
	III	976.57	0.29	976.86	195.37	781.49

6.2.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.2.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a RoR based Project. The study indicates that the firm power during 90% dependable year is 58.44 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity

varying from 300 MW to 400 MW in steps of 10 MW. The results are tabulated in as below:

DUMMUGUDEM HYDROELECTRIC PROJECT

POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR
(WITHOUT ENVIRONMENTAL FLOW RELEASE)

FRL	60	m	RATED HEAD	11.61	m	EFF.	93 %
MDDL	52	m	WC LOSSES	0.12	m		
Av. TWL	45.72	m	NET RATED HEAD	11.50	m		

MONTH	INFLOWS	POWER POTENTIAL	RESTRICTED ENERGY	INSTALLED CAP. 300 MW		INSTALLED CAP. 310 MW		INSTALLED CAP. 320 MW		INSTALLED CAP. 330 MW		INSTALLED CAP. 340 MW		INSTALLED CAP. 350 MW		INSTALLED CAP. 360 MW		INSTALLED CAP. 370 MW		INSTALLED CAP. 380 MW		INSTALLED CAP. 390 MW		INSTALLED CAP. 400 MW	
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)
Jun	340.62	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97	33.23	7.97
	550.75	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89	53.73	12.89
	496.07	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61	48.39	11.61
Jul	1270.36	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74	123.92	29.74
	1641.98	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44	160.18	38.44
	1106.96	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51	107.98	28.51
Aug	2424.34	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76	236.49	56.76
	4224.09	412.06	98.89	300.00	72.00	310.00	74.40	320.00	76.80	330.00	79.20	340.00	81.60	350.00	84.00	360.00	86.40	370.00	88.80	380.00	91.20	390.00	93.60	400.00	96.00
	3185.20	310.72	82.03	300.00	79.20	310.00	81.84	310.72	82.03	310.72	82.03	310.72	82.03	310.72	82.03	310.72	82.03	310.72	82.03	310.72	82.03	310.72	82.03	310.72	82.03	310.72	82.03
Sep	4740.91	462.48	110.99	300.00	72.00	310.00	74.40	320.00	76.80	330.00	79.20	340.00	81.60	350.00	84.00	360.00	86.40	370.00	88.80	380.00	91.20	390.00	93.60	400.00	96.00		
	4490.57	438.05	105.13	300.00	72.00	310.00	74.40	320.00	76.80	330.00	79.20	340.00	81.60	350.00	84.00	360.00	86.40	370.00	88.80	380.00	91.20	390.00	93.60	400.00	96.00		
	1365.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98	133.25	31.98		
Oct	1157.15	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09	112.88	27.09		
	640.15	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99	62.45	14.99		
	1222.21	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48	119.23	31.48		
Nov	647.76	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17	63.19	15.17		
	720.24	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86	70.26	16.86		
	570.48	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36	55.65	13.36		
Dec	521.67	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21	50.89	12.21		
	538.14	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60	52.50	12.60		
	555.43	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30	54.18	14.30		
Jan	557.35	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05	54.37	13.05		
	538.55	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61	52.54	12.61		
	543.76	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00	53.04	14.00		
Feb	552.56	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94	53.90	12.94		
	560.28	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12	54.66	13.12		
	568.82	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65	55.49	10.65		
Mar	583.53	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66	56.92	13.66		
	588.46	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78	57.40	13.78		
	606.36	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62	59.15	15.62		
Apr	633.99	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84	61.85	14.84		
	646.81	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14	63.10	15.14		
	651.31	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25	63.54	15.25		
May	627.10	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68	61.17	14.68		
	626.37	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66	61.10	14.66		
	976.86	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16	95.29	25.16		
	29296.45																										
Total energy (GWh)			992.18		890.33		900.17		907.56		914.76		921.96		929.16		936.36		943.56		950.76		957.96		965.16
Firm Power (MWc) Nov to Jan)				58.44		58.44		58.44		58.44		58.44		58.44		58.44		58.44		58.44		58.44		58.44	
Incr. Energy(GWh)					-		9.84		7.39		7.20		7.20		7.20		7.20		7.20		7.20		7.20		7.20
Incr. Cap.(MW)					-		10		10		10		10		10		10		10		10		10		10
Incr. Energy/Incr. Power (kWh/kW)					-		984.00		738.90		720.00		720.00		720.00		720.00		720.00		720.00		720.00		720.00

DUMMUGUDEM HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL LOAD FACTOR (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	300	890.33	33.88	19.48	2967.76	-	
2	310	900.17	33.15	18.85	2903.77	984.00	91%
3	320	907.56	32.38	18.26	2836.12	738.90	91%
4	330	914.76	31.64	17.71	2771.99	720.00	92%
5	340	921.96	30.95	17.19	2711.64	720.00	93%
6	**350**	**929.16**	**30.31**	**16.70**	**2654.73**	**720.00**	**94%**
7	360	936.36	29.69	16.23	2600.99	720.00	94%
8	370	943.56	29.11	15.80	2550.15	720.00	95%
9	380	950.76	28.56	15.38	2501.99	720.00	96%
10	390	957.96	28.04	14.99	2456.30	720.00	96%
11	400	965.16	27.54	14.61	2412.89	720.00	97%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't shows any fall. However, the Annual Load Factor of 30.31 % justifies the installed capacity of 350 MW.

6.2.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 46.76 MW continuous .

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 252 MW to 272 MW in steps of 2 MW. The results are tabulated in as below:

DUMMUGUDEM HYDROELECTRIC PROJECT

POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR
(WITH ENVIRONMENTAL FLOW RELEASED)

FRL	60	m	RATED HEAD		11.61	m	EFF.	93	%
MDDL	52	m	WC LOSSES		0.12	m			
Av. TWL	45.72	m	NET RATED HEAD		11.50	m			

MONTH	INFLOWS	POWER POTENTIAL	RESTRICTED ENERGY	INSTALLED CAP. 252 MW		INSTALLED CAP. 254 MW		INSTALLED CAP. 256 MW		INSTALLED CAP. 258 MW		INSTALLED CAP. 260 MW		INSTALLED CAP. 262 MW		INSTALLED CAP. 264 MW		INSTALLED CAP. 266 MW		INSTALLED CAP. 268 MW		INSTALLED CAP. 270 MW		INSTALLED CAP. 272 MW	
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)
Jun	272.50	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38	26.58	6.38
	440.60	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32	42.98	10.32
	396.86	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29	38.71	9.29
Jul	889.25	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82	86.75	20.82
	1149.39	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91	112.12	26.91
	774.87	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96	75.59	19.96
Aug	1697.04	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73	165.55	39.73
	2956.86	288.44	69.23	252.00	60.48	254.00	60.96	256.00	61.44	258.00	61.92	260.00	62.40	262.00	62.88	264.00	63.36	266.00	63.84	268.00	64.32	270.00	64.80	272.00	65.28
	2229.64	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42	217.50	57.42
Sep	3318.64	323.73	77.70	252.00	60.48	254.00	60.96	256.00	61.44	258.00	61.92	260.00	62.40	262.00	62.88	264.00	63.36	266.00	63.84	268.00	64.32	270.00	64.80	272.00	65.28
	3143.40	306.64	73.59	252.00	60.48	254.00	60.96	256.00	61.44	258.00	61.92	260.00	62.40	262.00	62.88	264.00	63.36	266.00	63.84	268.00	64.32	270.00	64.80	272.00	65.28
	956.19	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39	93.28	22.39
Oct	810.01	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96	79.02	18.96
	448.11	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49	43.71	10.49
	855.55	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03	83.46	22.03
Nov	485.82	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37	47.39	11.37
	540.18	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65	52.69	12.65
	427.86	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02	41.74	10.02
Dec	391.25	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16	38.17	9.16
	403.61	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45	39.37	9.45
	416.57	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73	40.64	10.73
Jan	418.01	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79	40.78	9.79
	403.91	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46	39.40	9.46
	407.82	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50	39.78	10.50
Feb	442.05	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35	43.12	10.35
	448.22	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49	43.72	10.49
	455.06	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52	44.39	8.52
Mar	466.82	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93	45.54	10.93
	470.77	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02	45.92	11.02
	485.09	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49	47.32	12.49
Apr	507.19	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87	49.48	11.87
	517.45	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11	50.48	12.11
	521.05	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20	50.83	12.20
May	501.68	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75	48.94	11.75
	501.10	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73	48.88	11.73
	781.49	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13	76.23	20.13
Total energy (GWh)			721.93		682.86		684.30		685.74		687.18		688.62		690.06		691.50		692.94		694.38		695.82		697.26
Firm Power (MWc) Nov to Jan)				46.76		46.76		46.76		46.76		46.76		46.76		46.76		46.76		46.76		46.76		46.76	
Incr. Energy(GWh)					-		1.44		1.44		1.44		1.44		1.44		1.44		1.44		1.44		1.44		1.44
Incr. Cap.(MW)					-		2		2		2		2		2		2		2		2		2		2
Incr. Energy/Incr. Power (kWh/kW)					-		720.00		720.00		720.00		720.00		720.00		720.00		720.00		720.00		720.00		720.00

DUMMUGUDEM HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	A.L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	252	682.86	30.93	18.55	2709.75	-	
2	254	684.30	30.75	18.41	2694.08	720.00	95%
3	256	685.74	30.58	18.26	2678.66	720.00	95%
4	258	687.18	30.40	18.12	2663.47	720.00	95%
5	260	688.62	30.23	17.98	2648.52	720.00	95%
6	**262**	**690.06**	**30.07**	**17.85**	**2633.80**	**720.00**	**96%**
7	264	691.50	29.90	17.71	2619.30	720.00	96%
8	266	692.94	29.74	17.58	2605.02	720.00	96%
9	268	694.38	29.58	17.45	2590.96	720.00	96%
10	270	695.82	29.42	17.32	2577.10	720.00	96%
11	272	697.26	29.26	17.19	2563.44	720.00	96%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesnt show a steep fall. Also, the Annual Load Factor of 30.02% justifies the installed capacity of 262 MW.

6.2.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	929.16	690.06
Firm Power (MW continuous)	58.44	46.76
Installed Capacity	350	***262(4x65.5 MW)***
Load factor (%)	30.31	30.07

Regarding the number of generating units to be installed, the following options are possible.

- 4x65.5 MW
- 3x87.33 MW

Although, installation of 3 units of 87.33 MW would be economical but considering the reliability of the Project, installation of 4 units of 65.5 MW has been chosen.

6.3 Power Potential Studies of Bodhghat Hydroelectric Project:

6.3.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 456 m, 426.8 m and 350.6 m. respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. Also, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Bodhghat Hydroelectric Project has the HRT of 2347 m the head losses has been considered as 3.52 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 2198.93 MCum. The Elevation Area capacity Table is shown as below.

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	426.80	43703142.82	4370.31	518705380.48	518.71
2	428.75	48334710.58	4833.47	609785055.37	609.79
3	430.70	53527851.23	5352.79	710422294.99	710.42
4	432.65	58472134.33	5847.21	820579959.13	820.58
5	434.60	62731824.39	6273.18	939347121.36	939.35
6	436.55	66646870.21	6664.69	1065847168.84	1065.85
7	438.50	70611687.54	7061.17	1199951683.73	1199.95
8	440.45	74413104.07	7441.31	1341184418.95	1341.18

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
9	442.40	78180713.53	7818.07	1489732962.70	1489.73
10	444.35	81739846.09	8173.98	1645313014.02	1645.31
11	446.30	85502760.12	8550.28	1807498043.37	1807.50
12	448.25	88806461.54	8880.65	1976745747.90	1976.75
13	450.20	92790060.57	9279.01	2152854497.19	2152.85
14	452.15	96102213.75	9610.22	2335902628.16	2335.90
15	454.10	99983452.51	9998.35	2525817354.35	2525.82
16	456.00	101834389.26	10183.44	2717636240.62	2717.64

6.3.2 Hydrology

With the abundance of water available during the monsoon months (June to Nov). Hydrological data series is developed for 25 years from 1990-1991 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
Jun	**I**	20.83	5.21	15.62
	II	3.47	0.87	2.60
	III	18.23	4.56	13.67
Jul	**I**	83.97	25.19	58.78

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
	II	484.2	145.25	338.93
	III	1161	348.44	813.02
Aug	I	227.1	68.14	159.00
	II	312.9	93.86	219.01
	III	1098	329.32	768.41
Sep	I	614.3	184.28	430.00
	II	115.9	34.76	81.10
	III	75.51	22.65	52.86
Oct	I	181	45.26	135.78
	II	59.28	14.82	44.46
	III	25.84	6.46	19.38
Nov	I	16.06	4.02	12.05
	II	29.75	7.44	22.31
	III	33.83	8.46	25.37
Dec	I	13.06	2.61	10.45
	II	9.45	1.89	7.56
	III	5.98	1.20	4.78
Jan	I	5.64	1.13	4.51
	II	8.53	1.71	6.82
	III	5.99	1.20	4.79
Feb	I	3.62	0.72	2.90
	II	2.62	0.52	2.10
	III	2.15	0.43	1.72
Mar	I	1.55	0.31	1.24

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
	II	1.43	0.29	1.14
	III	1.47	0.29	1.18
April	I	0.96	0.19	0.77
	II	0.93	0.19	0.74
	III	1.29	0.26	1.03
May	I	6.56	1.31	5.25
	II	3.68	0.74	2.94
	III	14.47	2.89	11.58

6.3.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.3.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 124.67 MW continuous (July2 to May 3).

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 368 MW to 384 MW in steps of 2 MW. The results are tabulated in as below

BODHGHAT HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		456		2717.64						T.G.EFF.	=	0.93				
	M.D.D.L		426.80		518.86						Firm Power exep.(MW)	=	124.67				
	Av. T.W.L.		350.60								Installed Capacity (MW)	=	376.00				
											W.C.Losses	=	3.52				
YEAR	MONTH	INITIAL LEVEL	INITAL STORAGE	INFLOW	INFLOW	WITH-DRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	426.80	518.86	20.83	18.00	18.00	426.80	518.86	350.60	72.68	20.83	13.81	0.00	0.00	3.31	0.00	3.31
90% Yr.	JUN 2	426.80	518.86	3.47	3.00	3.00	426.80	518.86	350.60	72.68	3.47	2.30	0.00	0.00	0.55	0.00	0.55
90% Yr.	JUN3	426.80	518.86	18.23	15.75	15.75	426.80	518.86	350.60	72.68	18.23	12.09	0.00	0.00	2.90	0.00	2.90
90% Yr.	JUL 1	426.80	518.86	83.97	72.55	72.55	426.80	518.86	350.60	72.68	83.97	55.68	0.00	0.00	13.36	0.00	13.36
90% Yr.	JUL2	426.80	518.86	484.18	418.33	157.02	431.92	780.17	350.60	75.19	181.74	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	JUL3	431.92	780.17	1161.45	1103.84	153.81	445.35	1730.20	350.60	84.44	161.84	124.67	0.00	0.00	32.91	0.00	32.91
90% Yr.	AUG1	445.35	1730.20	227.14	196.25	128.85	446.17	1797.60	350.60	91.64	149.13	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	AUG2	446.17	1797.60	312.87	270.32	127.14	447.82	1940.78	350.60	92.86	147.15	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	AUG3	447.82	1940.78	1097.73	1043.28	132.00	457.28	2852.07	350.60	98.39	138.88	124.67	0.00	0.00	32.91	0.00	32.91
90% Yr.	SEP1	457.28	2852.07	614.28	530.74	112.35	461.15	3270.45	350.60	105.08	130.04	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	SEP2	461.15	3270.45	115.86	100.10	110.36	461.06	3260.20	350.60	106.99	127.73	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	SEP3	461.06	3260.20	75.51	65.24	110.61	460.65	3214.83	350.60	106.74	128.03	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	OCT1	460.65	3214.83	181.04	156.42	110.61	461.07	3260.63	350.60	106.74	128.03	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	OCT2	461.07	3260.63	59.28	51.22	110.68	460.53	3201.17	350.60	106.68	128.10	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	OCT3	460.53	3201.17	25.84	24.56	122.57	459.62	3103.16	350.60	105.96	128.97	124.67	0.00	0.00	32.91	0.00	32.91
90% Yr.	NOV1	459.62	3103.16	16.06	13.88	112.39	458.71	3004.64	350.60	105.05	130.08	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	NOV2	458.71	3004.64	29.75	25.70	113.32	457.90	2917.03	350.60	104.19	131.16	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	NOV3	457.90	2917.03	33.83	29.23	114.21	457.08	2832.04	350.60	103.37	132.19	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	DEC1	457.08	2832.04	13.06	11.28	115.23	456.08	2728.10	350.60	102.46	133.37	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	DEC2	456.08	2728.10	9.45	8.16	116.40	455.03	2619.87	350.60	101.44	134.72	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	DEC3	455.03	2619.87	5.98	5.68	129.51	453.77	2496.04	350.60	100.28	136.26	124.67	0.00	0.00	32.91	0.00	32.91
90% Yr.	JAN1	453.77	2496.04	5.64	4.87	119.17	452.61	2381.75	350.60	99.07	137.93	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	JAN2	452.61	2381.75	8.53	7.37	120.60	451.42	2268.51	350.60	97.90	139.59	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	JAN3	451.42	2268.51	5.99	5.69	134.43	450.04	2139.78	350.60	96.61	141.44	124.67	0.00	0.00	32.91	0.00	32.91
90% Yr.	FEB1	450.04	2139.78	3.62	3.13	123.95	448.70	2018.96	350.60	95.25	143.46	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	FEB2	448.70	2018.96	2.62	2.26	125.76	447.30	1895.46	350.60	93.89	145.55	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	FEB3	447.30	1895.46	2.15	1.49	102.00	446.13	1794.95	350.60	92.60	147.57	124.67	0.00	0.00	23.94	0.00	23.94
90% Yr.	MAR1	446.13	1794.95	1.55	1.34	129.39	444.59	1666.89	350.60	91.25	149.76	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	MAR2	444.59	1666.89	1.43	1.24	131.67	442.97	1536.46	350.60	89.67	152.40	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	MAR3	442.97	1536.46	1.47	1.40	147.71	441.10	1390.14	350.60	87.92	155.42	124.67	0.00	0.00	32.91	0.00	32.91
90% Yr.	APR1	441.10	1390.14	0.96	0.83	137.21	439.23	1253.76	350.60	86.05	158.80	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	APR2	439.23	1253.76	0.93	0.80	140.35	437.24	1114.22	350.60	84.12	162.44	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	APR3	437.24	1114.22	1.29	1.11	143.88	435.09	971.45	350.60	82.06	166.53	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	MAY1	435.09	971.45	6.56	5.67	147.90	432.78	829.22	350.60	79.83	171.17	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	MAY2	432.78	829.22	3.68	3.18	152.66	430.09	679.74	350.60	77.34	176.69	124.67	0.00	0.00	29.92	0.00	29.92
90% Yr.	MAY3	430.09	679.74	14.47	13.75	174.63	426.80	518.86	350.60	74.37	183.74	124.66	-0.01	0.00	32.91	0.00	32.91
TOTAL					4217.67	4217.67									992.57	0.00	992.57

BODHGHAT HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	368.00	992.57	30.79	33.88	2697.20	-	100.00%
2	370.00	992.57	30.62	33.70	2682.62	0.00	100.00%
3	372.00	992.57	30.46	33.51	2668.20	0.00	100.00%
4	374.00	992.57	30.30	33.33	2653.93	0.00	100.00%
5	**376.00**	**992.57**	**30.13**	**33.16**	**2639.81**	**0.00**	**100.00%**
6	378.00	992.57	29.98	32.98	2625.84	0.00	100.00%
7	380.00	992.57	29.82	32.81	2612.02	0.00	100.00%
8	382.00	992.57	29.66	32.64	2598.35	0.00	100.00%
9	384.00	992.57	29.51	32.47	2584.82	0.00	100.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't show any fall. However, the Annual Load factor of 30.13% the Installed capacity of 376 MW. Hence, justifies the installed capacity of 376 MW.

6.3.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 83.37MW continuous (July 3 to May 3).

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 244 MW to 260 MW in steps of 2 MW. The results are tabulated in as below:

BODHGHAT HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		456		2717.84						T.G.EFF.	=	0.93					
	M.D.D.L		426.80		518.86						Firm Power exep.(MW)	=	83.37					
	Av. T.W.L.		350.60								Installed Capacity (MW)	=	252.00					
											W.C.Losses	=	3.52					
YEAR	MONTH	INITIAL LEVEL M	INITAL STORAGE MCUM	INFLOW CUMECS	INFLOW MCUM	WITH-DRAWAL MCUM	FINAL LEVEL M	FINAL STORAGE MCUM	TWL M	NET HEAD M	DISCHARGE CUMECS	FIRM POWER MW	SEC. POWER MW	SPILL POWER MW	FIRM ENERGY GWh	SEC. ENERGY GWh	TOTAL ENERGY GWh
90% Yr.	JUN 1	426.80	518.86	15.62	13.50	13.50	426.80	518.86	350.60	72.68	15.62	10.36	0.00	0.00	2.49	0.00	2.49
90% Yr.	JUN 2	426.80	518.86	2.60	2.25	2.25	426.80	518.86	350.60	72.68	2.60	1.73	0.00	0.00	0.41	0.00	0.41
90% Yr.	JUN3	426.80	518.86	13.67	11.81	11.81	426.80	518.86	350.60	72.68	13.67	9.07	0.00	0.00	2.18	0.00	2.18
90% Yr.	JUL 1	426.80	518.86	58.78	50.79	50.79	426.80	518.86	350.60	72.68	58.78	38.97	0.00	0.00	9.35	0.00	9.35
90% Yr.	JUL2	426.80	518.86	338.93	292.83	105.93	430.57	705.77	350.60	74.54	122.60	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	JUL3	430.57	705.77	813.02	772.69	106.51	440.86	1371.94	350.60	81.54	112.07	83.37	0.00	0.00	22.01	0.00	22.01
90% Yr.	AUG1	440.86	1371.94	159.00	137.37	90.72	441.46	1418.60	350.60	87.04	105.00	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	AUG2	441.46	1418.60	219.01	189.22	89.75	442.74	1518.07	350.60	87.97	103.88	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	AUG3	442.74	1518.07	768.41	730.30	94.07	450.19	2154.30	350.60	92.32	98.98	83.37	0.00	0.00	22.01	0.00	22.01
90% Yr.	SEP1	450.19	2154.30	430.00	371.52	80.90	453.25	2444.91	350.60	97.60	93.64	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	SEP2	453.25	2444.91	81.10	70.07	79.69	453.16	2435.30	350.60	99.08	92.23	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	SEP3	453.16	2435.30	52.86	45.67	79.87	452.81	2401.10	350.60	98.86	92.44	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	OCT1	452.81	2401.10	135.78	117.31	79.85	453.19	2438.56	350.60	98.88	92.42	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	OCT2	453.19	2438.56	44.46	38.41	79.87	452.77	2397.11	350.60	98.86	92.44	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	OCT3	452.77	2397.11	19.38	18.42	88.37	452.05	2327.16	350.60	98.29	92.98	83.37	0.00	0.00	22.01	0.00	22.01
90% Yr.	NOV1	452.05	2327.16	12.05	10.41	80.94	451.29	2256.63	350.60	97.55	93.68	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	NOV2	451.29	2256.63	22.31	19.28	81.54	450.62	2194.37	350.60	96.84	94.37	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	NOV3	450.62	2194.37	25.37	21.92	82.09	449.98	2134.20	350.60	96.18	95.01	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	DEC1	449.98	2134.20	10.45	9.03	82.71	449.17	2060.51	350.60	95.46	95.73	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	DEC2	449.17	2060.51	7.56	6.53	83.45	448.30	1983.60	350.60	94.62	96.58	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	DEC3	448.30	1983.60	4.78	4.55	92.71	447.30	1895.44	350.60	93.68	97.55	83.37	0.00	0.00	22.01	0.00	22.01
90% Yr.	JAN1	447.30	1895.44	4.51	3.90	85.16	446.36	1814.18	350.60	92.71	98.57	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	JAN2	446.36	1814.18	6.82	5.90	86.04	445.40	1734.03	350.60	91.76	99.59	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	JAN3	445.40	1734.03	4.79	4.55	95.72	444.30	1642.86	350.60	90.73	100.72	83.37	0.00	0.00	22.01	0.00	22.01
90% Yr.	FEB1	444.30	1642.86	2.90	2.50	88.07	443.24	1557.29	350.60	89.65	101.93	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	FEB2	443.24	1557.29	2.10	1.81	89.15	442.12	1469.95	350.60	88.56	103.19	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	FEB3	442.12	1469.95	1.72	1.19	72.15	441.21	1398.99	350.60	87.55	104.39	83.37	0.00	0.00	16.01	0.00	16.01
90% Yr.	MAR1	441.21	1398.99	1.24	1.07	91.30	439.98	1308.76	350.60	86.48	105.67	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	MAR2	439.98	1308.76	1.14	0.99	92.63	438.72	1217.12	350.60	85.24	107.21	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	MAR3	438.72	1217.12	1.18	1.12	103.56	437.24	1114.68	350.60	83.87	108.96	83.37	0.00	0.00	22.01	0.00	22.01
90% Yr.	APR1	437.24	1114.68	0.77	0.66	95.80	435.83	1019.55	350.60	82.42	110.88	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	APR2	435.83	1019.55	0.74	0.64	97.54	434.30	922.65	350.60	80.95	112.89	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	APR3	434.30	922.65	1.03	0.89	99.46	432.69	824.08	350.60	79.38	115.12	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	MAY1	432.69	824.08	5.25	4.53	101.60	430.95	727.02	350.60	77.71	117.59	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	MAY2	430.95	727.02	2.94	2.54	104.05	429.03	625.51	350.60	75.89	120.43	83.37	0.00	0.00	20.01	0.00	20.01
90% Yr.	MAY3	429.03	625.51	11.58	11.00	117.66	426.80	518.86	350.60	73.81	123.80	83.37	-0.01	0.00	22.01	0.00	22.01
TOTAL					2977.18	2977.18									664.74	0.00	664.74

BODHGHAT HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	244.00	664.74	31.10	34.17	2724.33	-	100.00%
2	246.00	664.74	30.85	33.89	2702.18	0.00	100.00%
3	248.00	664.74	30.60	33.62	2680.39	0.00	100.00%
4	250.00	664.74	30.35	33.35	2658.94	0.00	100.00%
5	**252.00**	**664.74**	**30.11**	**33.08**	**2637.84**	**0.00**	**100.00%**
6	254.00	664.74	29.88	32.82	2617.07	0.00	100.00%
7	256.00	664.74	29.64	32.57	2596.62	0.00	100.00%
8	258.00	664.74	29.41	32.32	2576.49	0.00	100.00%
9	260.00	664.74	29.19	32.07	2556.68	0.00	100.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity Doesn't show any fall. However, the Anuual Load factor of 30.11 % the Installed capacity of 252 MW. Hence, justifies the installed capacity of 252 MW.

6.3.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	992.57	664.74
Firm Power (MW continuous)	124.67	83.37
Installed Capacity	376	***252(4 x 63 MW)***
Annual load factor (%)	30.13	30.11

Regarding the number of generating units to be installed, the following options are possible.

- 3x84MW
- 4x63 MW

Although, installation of 3 units of 84 MW would be economical but considering the reliability of the Project, installation of 4 units of 63 MW has been chosen.

6.4 Power Potential Studies of Kutru-I Hydroelectric Project:

6.4.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 347 m, 342.57 m & 317 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. In addition, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Kutru-I Hydroelectric Project being a dam toe project the head losses has been considered as 1% of Head i.e. 0.3 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 129.66 MCum. The Elevation Area capacity Table is shown as below:

S. No	Elevation (m)	Area (Sqm)	Area (Hect.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	342.57	22307004.88	2230.70	133441827.60	133.44
2	342.88	23307004.88	2330.70	140356944.70	140.36
3	343.19	25114754.81	2511.48	147805541.10	147.81
4	343.5	26114754.81	2611.48	155591053.70	155.59
5	343.81	27114754.81	2711.48	163376566.40	163.38
6	344.12	28265371.49	2826.54	171540137.70	171.54
7	344.43	29265371.49	2926.54	180302333.90	180.30
8	344.74	30265371.49	3026.54	189064530.00	189.06
9	345.05	31497712.58	3149.77	197988303.80	197.99
10	345.36	32497712.58	3249.77	207752517.80	207.75
11	345.67	32997712.58	3299.77	217517693.00	217.52
12	345.98	33397712.58	3339.77	227281907.00	227.28
13	346.29	33993158.62	3399.32	238117831.90	238.12
14	346.60	34193158.62	3419.32	249027625.20	249.03
15	346.91	34793158.62	3479.32	259937418.40	259.94
16	347.00	35193158.62	3519.32	263104673.80	263.10

6.4.2 Hydrology

Hydrological data series is developed for 25 years from 1990-1991 to 2014-2015. The outflows of Bodhghat Hydroelectic Project which is in the Upstream of Kutru-I Hydroelectric Project and the Intermediate Inflows has been considered for the studies. The water inflows on 10 daily basis for all these

years is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Bodghat Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Jun	I	20.83	3.18	24.01	7.20	16.81
	II	3.47	0.53	4.00	1.20	2.80
	III	18.23	2.79	21.02	6.31	14.71
Jul	I	83.97	12.86	96.83	29.05	67.78
	II	181.74	74.13	255.87	76.76	179.11
	III	161.84	177.83	339.67	101.90	237.77
Aug	I	149.13	34.78	183.91	55.17	128.73
	II	147.15	47.91	195.06	58.52	136.55
	III	138.88	168.07	306.95	92.09	214.87
Sep	I	130.04	94.05	224.09	67.23	156.86
	II	127.73	17.74	145.47	43.64	101.83
	III	128.03	11.56	139.59	41.88	97.71
Oct	I	128.03	27.71	155.74	38.93	116.80
	II	128.10	9.08	137.18	34.29	102.88
	III	128.97	3.95	132.92	33.23	99.69
Nov	I	130.08	2.46	132.54	33.14	99.41
	II	131.16	4.56	135.72	33.93	101.79
	III	132.19	5.17	137.36	34.34	103.02
Dec	I	133.37	1.99	135.36	27.07	108.29
	II	134.72	1.45	136.17	27.23	108.93
	III	136.26	0.91	137.17	27.43	109.74
Jan	I	137.93	0.86	138.79	27.76	111.03
	II	139.59	1.31	140.90	28.18	112.72
	III	141.44	0.92	142.36	28.47	113.89
Feb	I	143.46	0.56	144.02	28.80	115.22
	II	145.55	0.40	145.95	29.19	116.76
	III	147.57	0.33	147.90	29.58	118.32
Mar	I	149.76	0.24	150.00	30.00	120.00
	II	152.40	0.22	152.62	30.52	122.09
	III	155.42	0.23	155.65	31.13	124.52
Apr	I	158.80	0.14	158.94	31.79	127.16
	II	162.44	0.14	162.58	32.52	130.07
	III	166.53	0.19	166.72	33.34	133.37
May	I	171.17	1.00	172.17	34.43	137.74
	II	176.69	0.56	177.25	35.45	141.80
	III	183.74	2.22	185.96	37.19	148.77

6.4.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.4.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 37.50 MW continuous (July 2 to May 3).

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 124 MW to 140 MW in steps of 2 MW. The results are tabulated in as below:

KUTRU-I HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED) **ANNEX- 7.2**

RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		347.00		263.1						T.G.EFF.	=	0.93				
	M.D.D.L		342.57		133.44						Firm Power exep.(MW)	=	37.50				
	Av. T.W.L.		317.00								Installed Capacity (MW)	=	132.00				
											W.C.Losses (m)		0.3				
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	342.57	133.44	24.01	20.74	20.74	342.57	133.44	317.00	25.31	24.01	5.55	0.00	0.00	1.33	0.00	1.33
90% Yr.	JUN 2	342.57	133.44	4.00	3.46	3.46	342.57	133.44	317.00	25.31	4.00	0.92	0.00	0.00	0.22	0.00	0.22
90% Yr.	JUN3	342.57	133.44	21.02	18.16	18.16	342.57	133.44	317.00	25.31	21.02	4.85	0.00	0.00	1.17	0.00	1.17
90% Yr.	JUL 1	342.57	133.44	96.83	83.66	83.66	342.57	133.44	317.00	25.31	96.83	22.36	0.00	0.00	5.37	0.00	5.37
90% Yr.	JUL2	342.57	133.44	255.87	221.07	132.42	345.82	222.09	317.00	26.82	153.26	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	JUL3	345.82	222.09	339.67	322.82	281.81	347.00	263.10	317.00	29.11	296.52	37.50	41.26	0.00	9.90	10.89	20.79
90% Yr.	AUG1	347.00	263.10	183.91	158.90	158.90	347.00	263.10	317.00	29.70	183.91	37.50	12.33	0.00	9.00	2.96	11.96
90% Yr.	AUG2	347.00	263.10	195.06	168.54	168.54	347.00	263.10	317.00	29.70	195.06	37.50	15.36	0.00	9.00	3.69	12.69
90% Yr.	AUG3	347.00	263.10	306.95	291.73	291.73	347.00	263.10	317.00	29.70	306.95	37.50	45.67	0.00	9.90	12.06	21.96
90% Yr.	SEP1	347.00	263.10	224.09	193.61	193.61	347.00	263.10	317.00	29.70	224.09	37.50	23.22	0.00	9.00	5.57	14.57
90% Yr.	SEP2	347.00	263.10	145.47	125.68	125.68	347.00	263.10	317.00	29.70	145.47	37.50	1.92	0.00	9.00	0.46	9.46
90% Yr.	SEP3	347.00	263.10	139.59	120.60	120.60	347.00	263.10	317.00	29.70	139.59	37.50	0.32	0.00	9.00	0.08	9.08
90% Yr.	OCT1	347.00	263.10	155.74	134.56	134.56	347.00	263.10	317.00	29.70	155.74	37.50	4.70	0.00	9.00	1.13	10.13
90% Yr.	OCT2	347.00	263.10	137.18	118.52	119.57	346.97	262.05	317.00	29.70	138.40	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	OCT3	346.97	262.05	132.92	126.33	131.91	346.81	256.46	317.00	29.61	138.80	37.50	0.00	0.00	9.90	0.00	9.90
90% Yr.	NOV1	346.81	256.46	132.54	114.52	120.60	346.64	250.38	317.00	29.45	139.58	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	NOV2	346.64	250.38	135.72	117.26	121.18	346.53	246.46	317.00	29.31	140.26	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	NOV3	346.53	246.46	137.36	118.68	121.58	346.44	243.55	317.00	29.21	140.72	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	DEC1	346.44	243.55	135.36	116.95	122.05	346.30	238.46	317.00	29.10	141.26	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	DEC2	346.30	238.46	136.17	117.65	122.65	346.16	233.46	317.00	28.96	141.95	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	DEC3	346.16	233.46	137.17	130.37	135.58	346.01	228.25	317.00	28.81	142.65	37.50	0.00	0.00	9.90	0.00	9.90
90% Yr.	JAN1	346.01	228.25	138.79	119.91	123.83	345.89	224.34	317.00	28.68	143.32	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	JAN2	345.89	224.34	140.90	121.74	124.27	345.81	221.81	317.00	28.58	143.83	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	JAN3	345.81	221.81	142.36	135.30	137.01	345.75	220.11	317.00	28.51	144.16	37.50	0.00	0.00	9.90	0.00	9.90
90% Yr.	FEB1	345.75	220.11	144.02	124.43	124.70	345.74	219.84	317.00	28.48	144.33	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	FEB2	345.74	219.84	145.95	126.10	124.62	345.79	221.32	317.00	28.50	144.24	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	FEB3	345.79	221.32	147.90	102.23	99.48	345.88	224.06	317.00	28.56	143.93	37.50	0.00	0.00	7.20	0.00	7.20
90% Yr.	MAR1	345.88	224.06	150.00	129.60	123.79	346.05	229.87	317.00	28.69	143.28	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	MAR2	346.05	229.87	152.62	131.86	122.88	346.31	238.85	317.00	28.90	142.23	37.50	0.00	0.00	9.00	0.00	9.00
90% Yr.	MAR3	346.31	238.85	155.65	147.93	133.67	346.72	253.11	317.00	29.22	140.65	37.50	0.00	0.00	9.90	0.00	9.90
90% Yr.	APR1	346.72	253.11	158.94	137.33	127.34	347.00	263.10	317.00	29.56	147.38	37.50	2.25	0.00	9.00	0.54	9.54
90% Yr.	APR2	347.00	263.10	162.58	140.47	140.47	347.00	263.10	317.00	29.70	162.58	37.50	6.55	0.00	9.00	1.57	10.57
90% Yr.	APR3	347.00	263.10	166.72	144.04	144.04	347.00	263.10	317.00	29.70	166.72	37.50	7.67	0.00	9.00	1.84	10.84
90% Yr.	MAY1	347.00	263.10	172.17	148.76	148.76	347.00	263.10	317.00	29.70	172.17	37.50	9.15	0.00	9.00	2.20	11.20
90% Yr.	MAY2	347.00	263.10	177.25	153.15	153.15	347.00	263.10	317.00	29.70	177.25	37.50	10.53	0.00	9.00	2.53	11.53
90% Yr.	MAY3	347.00	263.10	185.96	176.74	176.74	347.00	263.10	317.00	29.70	185.96	37.50	12.89	0.00	9.90	3.40	13.30
TOTAL					4863.40	4733.74									300.58	48.91	349.50

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	124.00	349.50	32.17	30.24	2818.53	-	100.00%
2	126.00	349.50	31.66	29.76	2773.79	0.00	100.00%
3	128.00	349.50	31.17	29.30	2730.45	0.00	100.00%
4	130.00	349.50	30.69	28.85	2688.44	0.00	100.00%
5	**132.00**	**349.50**	**30.22**	**28.41**	**2647.71**	**0.00**	**100.00%**
6	134.00	349.50	29.77	27.99	2608.19	0.00	100.00%
7	136.00	349.50	29.34	27.57	2569.83	0.00	100.00%
8	138.00	349.50	28.91	27.17	2532.59	0.00	100.00%
9	140.00	349.50	28.50	26.79	2496.41	0.00	100.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't show any fall. However, the Annual Load factor of 30.22 % the Installed capacity of 132 MW. Hence, justifies the installed capacity of 132 MW.

6.4.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 29.47 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 88 MW to 104 MW in steps of 2 MW. The results are tabulated in as below:

KUTRU-I HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		347.00		263.1						T.G.EFF. =		0.93				
	M.D.D.L		342.57		133.44						Firm Power exep.(MW) =		29.47				
	Av. T.W.L.		317.00								Installed Capacity (MW) =		96.00				
											W.C.Losses =		0.3				
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	342.57	133.44	19.21	16.60	16.60	342.57	133.44	317.00	25.31	19.21	4.44	0.00	0.00	1.06	0.00	1.06
90% Yr.	JUN 2	342.57	133.44	3.20	2.76	2.76	342.57	133.44	317.00	25.31	3.20	0.74	0.00	0.00	0.18	0.00	0.18
90% Yr.	JUN3	342.57	133.44	16.82	14.53	14.53	342.57	133.44	317.00	25.31	16.82	3.88	0.00	0.00	0.93	0.00	0.93
90% Yr.	JUL 1	342.57	133.44	67.78	58.56	58.56	342.57	133.44	317.00	25.31	67.78	15.65	0.00	0.00	3.76	0.00	3.76
90% Yr.	JUL2	342.57	133.44	179.11	154.75	106.48	344.48	181.71	317.00	26.21	123.24	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	JUL3	344.48	181.71	237.77	225.97	144.58	347.00	263.10	317.00	28.45	152.13	29.47	10.02	0.00	7.78	2.64	10.43
90% Yr.	AUG1	347.00	263.10	128.73	111.23	111.23	347.00	263.10	317.00	29.70	128.73	29.47	5.41	0.00	7.07	1.30	8.37
90% Yr.	AUG2	347.00	263.10	136.55	117.97	117.97	347.00	263.10	317.00	29.70	136.55	29.47	7.53	0.00	7.07	1.81	8.88
90% Yr.	AUG3	347.00	263.10	214.87	204.21	204.21	347.00	263.10	317.00	29.70	214.87	29.47	28.75	0.00	7.78	7.59	15.37
90% Yr.	SEP1	347.00	263.10	156.86	135.53	135.53	347.00	263.10	317.00	29.70	156.86	29.47	13.03	0.00	7.07	3.13	10.20
90% Yr.	SEP2	347.00	263.10	101.83	87.98	94.20	346.82	256.87	317.00	29.63	109.03	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	SEP3	346.82	256.87	97.71	84.42	94.95	346.52	246.34	317.00	29.40	109.90	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	OCT1	346.52	246.34	116.80	100.92	95.20	346.69	252.06	317.00	29.32	110.19	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	OCT2	346.69	252.06	102.88	88.89	95.21	346.51	245.74	317.00	29.32	110.19	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	OCT3	346.51	245.74	99.69	94.74	105.58	346.20	234.91	317.00	29.08	111.09	29.47	0.00	0.00	7.78	0.00	7.78
90% Yr.	NOV1	346.20	234.91	99.41	85.89	97.03	345.87	223.76	317.00	28.77	112.31	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	NOV2	345.87	223.76	101.79	87.94	98.13	345.54	213.57	317.00	28.44	113.58	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	NOV3	345.54	213.57	103.02	89.01	99.25	345.22	203.33	317.00	28.12	114.88	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	DEC1	345.22	203.33	108.29	93.56	100.21	345.00	196.68	317.00	27.85	115.98	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	DEC2	345.00	196.68	108.93	94.12	101.02	344.76	189.77	317.00	27.63	116.92	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	DEC3	344.76	189.77	109.74	104.30	112.15	344.49	181.92	317.00	27.38	118.00	29.47	0.00	0.00	7.78	0.00	7.78
90% Yr.	JAN1	344.49	181.92	111.03	95.93	102.94	344.24	174.91	317.00	27.11	119.14	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	JAN2	344.24	174.91	112.72	97.39	103.85	344.00	168.45	317.00	26.88	120.20	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	JAN3	344.00	168.45	113.89	108.24	115.30	343.73	161.39	317.00	26.63	121.31	29.47	0.00	0.00	7.78	0.00	7.78
90% Yr.	FEB1	343.73	161.39	115.22	99.55	105.86	343.48	155.08	317.00	26.37	122.52	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	FEB2	343.48	155.08	116.76	100.88	106.84	343.24	149.13	317.00	26.13	123.65	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	FEB3	343.24	149.13	118.32	81.78	86.17	343.06	144.74	317.00	25.91	124.67	29.47	0.00	0.00	5.66	0.00	5.66
90% Yr.	MAR1	343.06	144.74	120.00	103.68	108.47	342.86	139.95	317.00	25.73	125.55	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	MAR2	342.86	139.95	122.09	105.49	109.25	342.69	136.19	317.00	25.55	126.44	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	MAR3	342.69	136.19	124.52	118.35	120.83	342.58	133.71	317.00	25.41	127.13	29.47	0.00	0.00	7.78	0.00	7.78
90% Yr.	APR1	342.58	133.71	127.16	109.86	110.13	342.57	133.44	317.00	25.34	127.47	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	APR2	342.57	133.44	130.07	112.38	109.95	342.68	135.87	317.00	25.39	127.26	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	APR3	342.68	135.87	133.37	115.24	109.18	342.94	141.92	317.00	25.56	126.37	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	MAY1	342.94	141.92	137.74	119.01	107.70	343.41	153.22	317.00	25.92	124.65	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	MAY2	343.41	153.22	141.80	122.52	105.46	344.07	170.28	317.00	26.47	122.06	29.47	0.00	0.00	7.07	0.00	7.07
90% Yr.	MAY3	344.07	170.28	148.77	141.39	112.51	345.09	199.17	317.00	27.29	118.38	29.47	0.00	0.00	7.78	0.00	7.78
TOTAL					3685.57	3619.84									235.82	16.47	252.29

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	88.00	252.29	32.73	33.49	2866.89	-	100.00%
2	90.00	252.29	32.00	32.75	2803.18	0.00	100.00%
3	92.00	252.29	31.30	32.04	2742.24	0.00	100.00%
4	94.00	252.29	30.64	31.35	2683.89	0.00	100.00%
5	**96.00**	**252.29**	**30.00**	**30.70**	**2627.98**	**0.00**	**100.00%**
6	98.00	252.29	29.39	30.07	2574.35	0.00	100.00%
7	100.00	252.29	28.80	29.47	2522.86	0.00	100.00%
8	102.00	252.29	28.24	28.90	2473.39	0.00	100.00%
9	104.00	252.29	27.69	28.34	2425.83	0.00	100.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't show any fall. However, the Annual Load factor of 30.00 % the Installed capacity of 96 MW. Hence, justifies the installed capacity of 96 MW.

6.4.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	349.50	252.29
Firm Power (MW continuous)	37.50	29.47
Installed Capacity	***132***	***96(3x32 MW)***
Annual load factor (%)	30.22	30.00

Regarding the number of generating units to be installed, the following options are possible.

- 3x32 MW
- 4x24 MW

Although, installation of 4 units of 24 MW would be economical but considering the reliability of the Project, installation of 3 units of 32 MW has been chosen.

6.5 Power Potential Studies of Kutru-II Hydroelectric Project:

6.5.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 317.0 m, 295.7 m and 274.39 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same levels after taking into account of inflows, environmental aspects and the topography of the area. Also, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Kutru-II Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e. 0.43 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 1258.40 MCum. The Elevation Area capacity Table is shown as below.

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	295.7	22957982	2295.8	199647363.3	199.65
2	297.22	27877415	2787.74	238774263.1	238.77
3	298.74	30090550	3009.05	282785326.1	282.79
4	300.26	34305463	3430.55	332103138.5	332.1
5	301.78	37243784	3724.38	386538951.5	386.54
6	303.3	43113850	4311.39	447954510.6	447.95
7	304.82	46294527	4629.45	516096582.9	516.1
8	306.34	53969106	5396.91	592491418	592.49
9	307.86	58836874	5883.69	678710075.3	678.71
10	309.38	67552265	6755.23	775642835.5	775.64
11	310.9	72795778	7279.58	883040666.1	883.04
12	312.42	85592693	8559.27	1005236269	1005.24

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
13	313.94	91191283.94	9119.13	1140598911	1140.6
14	315.46	104203312.1	10420.33	1291856031	1291.86
15	316.98	109925899.1	10992.59	1355855298	1355.86
16	317	109925899.1	10992.59	1458052609	1458.05

6.5.2 Hydrology

Hydrological data series is developed for 25 years from 1990-1991 to 2014-2015. The outflows of Kutru-I Hydroelectric Project which is in the Upstream of Kutru-II Hydroelectric Project and the Intermediate Inflows has been considered for the studies. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Kutru-I Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Jun	I	24.01	473.30	497.31	149.19	348.12
	II	4.00	432.78	436.78	131.03	305.75
	III	21.02	837.20	858.22	257.47	600.75
Jul	I	96.83	1445.50	1542.33	462.70	1079.63
	II	153.26	2536.13	2689.40	806.82	1882.58
	III	296.52	92.27	388.79	116.64	272.15
Aug	I	183.91	502.65	686.55	205.97	480.59
	II	195.06	832.07	1027.14	308.14	719.00
	III	306.95	766.49	1073.45	322.03	751.41
Sep	I	224.09	10.51	113.58	67.23	156.86
	II	145.47	93.04	238.51	71.55	166.95
	III	139.59	623.82	763.40	229.02	534.38

Period (10 Daily)		Kutru-I Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Oct	I	155.74	381.07	536.81	134.20	402.61
	II	138.40	93.18	231.57	57.89	173.68
	III	138.80	126.04	264.84	66.21	198.63
Nov	I	139.58	193.27	332.85	83.21	249.64
	II	140.26	252.86	393.12	98.28	294.84
	III	140.72	116.83	257.55	64.39	193.16
Dec	I	141.26	44.05	185.31	37.06	148.25
	II	141.95	32.87	174.82	34.96	139.85
	III	142.65	23.78	166.43	33.29	133.14
Jan	I	143.32	16.28	159.60	31.92	127.68
	II	143.83	58.34	202.17	40.43	161.73
	III	144.16	25.10	169.25	33.85	135.40
Feb	I	144.33	21.72	166.05	33.21	132.84
	II	144.24	21.10	165.34	33.07	132.27
	III	143.93	18.21	162.14	32.43	129.71
Mar	I	143.28	9.08	152.36	30.47	121.88
	II	142.23	8.92	151.15	30.23	120.92
	III	140.65	7.83	148.48	29.70	118.78
Apr	I	147.38	6.49	153.87	30.77	123.10
	II	162.58	5.18	167.76	33.55	134.21
	III	166.72	4.62	171.34	34.27	137.07
May	I	172.17	10.75	182.93	45.73	137.19
	II	177.25	3.35	180.61	45.15	135.45
	III	185.96	127.86	313.82	78.46	235.37

6.5.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following two (2) Cases.

6.5.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 82.72 MW continuous (July 1 to May 3).

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 404 MW to 420 MW in steps of 2 MW. The results are tabulated in as below:

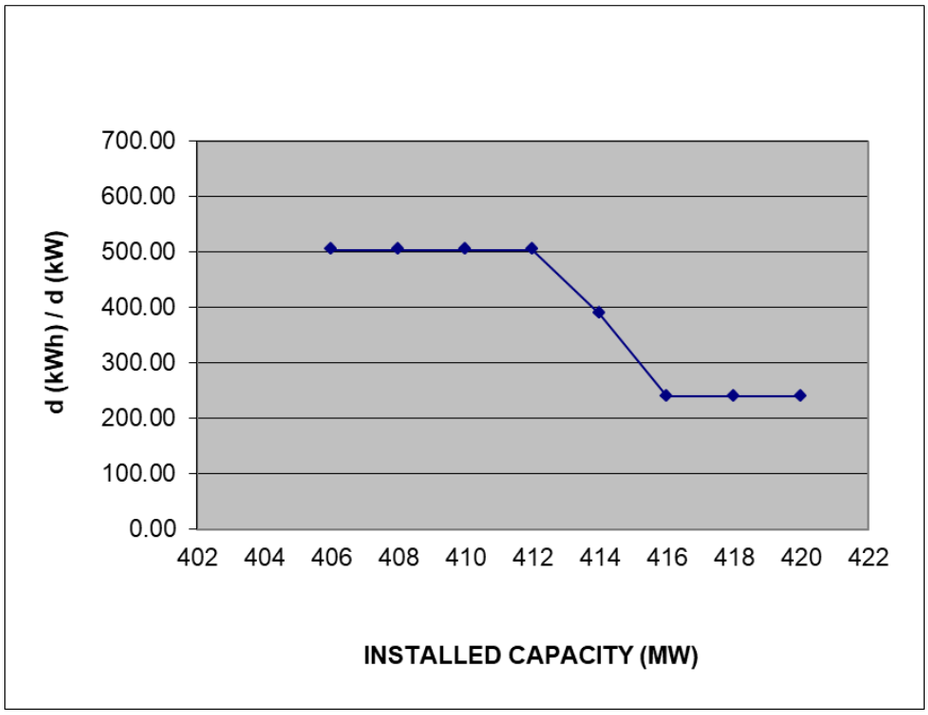
KUTRU-II HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		317.00		1458.05						T.G.EFF. =			0.93			
	M.D.D.L		295.70		199.65						Firm Power exep.(MW) =			82.72			
	Av. T.W.L.		274.39								Installed Capacity (MW) =			412.00			
											W.C.Losses (m) =			0.43			
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	295.70	199.65	497.31	429.68	352.19	298.54	277.14	274.39	22.24	407.63	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	JUN 2	298.54	277.14	436.78	377.38	316.71	300.42	337.81	274.39	24.73	366.56	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	JUN3	300.42	337.81	858.22	741.50	259.18	310.01	820.12	274.39	30.22	299.98	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	JUL 1	310.01	820.12	1542.33	1332.58	694.65	317.00	1458.05	274.39	38.72	803.99	82.72	201.32	0.00	19.85	48.32	68.17
90% Yr.	JUL2	317.00	1458.05	2689.40	2323.64	924.94	317.00	1458.05	274.39	42.18	1070.53	82.72	329.28	623.03	19.85	79.03	98.88
90% Yr.	JUL3	317.00	1458.05	388.79	369.51	369.51	317.00	1458.05	274.39	42.18	388.79	82.72	66.91	0.00	21.84	17.66	39.50
90% Yr.	AUG1	317.00	1458.05	686.55	593.18	593.18	317.00	1458.05	274.39	42.18	686.55	82.72	181.51	0.00	19.85	43.56	63.41
90% Yr.	AUG2	317.00	1458.05	1027.14	887.45	887.45	317.00	1458.05	274.39	42.18	1027.14	82.72	312.58	0.00	19.85	75.02	94.87
90% Yr.	AUG3	317.00	1458.05	1073.45	1020.20	1017.43	317.00	1458.05	274.39	42.18	1070.53	82.72	329.28	1.12	21.84	86.93	108.77
90% Yr.	SEP1	317.00	1458.05	224.09	193.61	193.61	317.00	1458.05	274.39	42.18	224.09	82.72	3.53	0.00	19.85	0.85	20.70
90% Yr.	SEP2	317.00	1458.05	238.51	206.07	206.07	317.00	1458.05	274.39	42.18	238.51	82.72	9.07	0.00	19.85	2.18	22.03
90% Yr.	SEP3	317.00	1458.05	763.40	659.58	659.58	317.00	1458.05	274.39	42.18	763.40	82.72	211.08	0.00	19.85	50.66	70.51
90% Yr.	OCT1	317.00	1458.05	536.81	463.80	463.80	317.00	1458.05	274.39	42.18	536.81	82.72	123.88	0.00	19.85	29.73	49.58
90% Yr.	OCT2	317.00	1458.05	231.57	200.08	200.08	317.00	1458.05	274.39	42.18	231.57	82.72	6.41	0.00	19.85	1.54	21.39
90% Yr.	OCT3	317.00	1458.05	264.84	251.70	251.70	317.00	1458.05	274.39	42.18	264.84	82.72	19.21	0.00	21.84	5.07	26.91
90% Yr.	NOV1	317.00	1458.05	332.85	287.58	287.58	317.00	1458.05	274.39	42.18	332.85	82.72	45.38	0.00	19.85	10.89	30.74
90% Yr.	NOV2	317.00	1458.05	393.12	339.65	339.65	317.00	1458.05	274.39	42.18	393.12	82.72	68.58	0.00	19.85	16.46	36.31
90% Yr.	NOV3	317.00	1458.05	257.55	222.52	222.52	317.00	1458.05	274.39	42.18	257.55	82.72	16.40	0.00	19.85	3.94	23.79
90% Yr.	DEC1	317.00	1458.05	185.31	160.11	185.71	316.99	1432.45	274.39	42.18	214.94	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	DEC2	316.99	1432.45	174.82	151.04	185.73	316.99	1397.76	274.39	42.18	214.97	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	DEC3	316.99	1397.76	166.43	158.17	204.47	316.88	1351.46	274.39	42.14	215.14	82.72	0.00	0.00	21.84	0.00	21.84
90% Yr.	JAN1	316.88	1351.46	159.60	137.89	188.69	315.67	1300.66	274.39	41.51	218.39	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	JAN2	315.67	1300.66	202.17	174.67	192.32	315.37	1283.01	274.39	40.73	222.59	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	JAN3	315.37	1283.01	169.25	160.86	213.68	314.84	1230.19	274.39	40.33	224.83	82.72	0.00	0.00	21.84	0.00	21.84
90% Yr.	FEB1	314.84	1230.19	166.05	143.47	196.84	314.30	1176.82	274.39	39.80	227.82	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	FEB2	314.30	1176.82	165.34	142.85	199.63	313.71	1120.04	274.39	39.24	231.06	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	FEB3	313.71	1120.04	162.14	112.07	162.09	313.15	1070.03	274.39	38.66	234.50	82.72	0.00	0.00	15.88	0.00	15.88
90% Yr.	MAR1	313.15	1070.03	152.36	131.64	206.28	312.30	995.38	274.39	37.97	238.75	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	MAR2	312.30	995.38	151.15	130.59	211.37	311.29	914.60	274.39	37.06	244.64	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	MAR3	311.29	914.60	148.48	141.11	239.93	309.95	815.79	274.39	35.91	252.45	82.72	0.00	0.00	21.84	0.00	21.84
90% Yr.	APR1	309.95	815.79	153.87	132.94	226.69	308.54	722.04	274.39	34.55	262.38	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	APR2	308.54	722.04	167.76	144.95	236.57	307.01	630.42	274.39	33.11	273.80	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	APR3	307.01	630.42	171.34	148.04	249.25	305.08	529.21	274.39	31.43	288.48	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	MAY1	305.08	529.21	182.93	158.05	267.29	302.61	419.97	274.39	29.31	309.36	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	MAY2	302.61	419.97	180.61	156.04	298.31	298.56	277.70	274.39	26.26	345.27	82.72	0.00	0.00	19.85	0.00	19.85
90% Yr.	MAY3	298.56	277.70	313.82	298.26	376.31	295.70	199.65	274.39	22.90	395.95	82.71	-0.01	0.00	21.84	0.00	21.83
TOTAL					13682.47	12280.99									724.59	471.83	1196.42

KUTRU-II HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ALF(%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	404.00	1192.39	33.69	20.47	2951.46	-	88.57%
2	406.00	1193.40	33.55	20.37	2939.41	504.00	88.65%
3	408.00	1194.41	33.42	20.27	2927.47	504.00	88.72%
4	410.00	1195.42	33.28	20.17	2915.65	504.00	88.80%
5	**412.00**	**1196.42**	**33.15**	**20.08**	**2903.94**	**504.00**	**88.87%**
6	414.00	1197.20	33.01	19.98	2891.79	388.21	88.93%
7	416.00	1197.68	32.87	19.88	2879.04	240.00	88.96%
8	418.00	1198.16	32.72	19.79	2866.41	240.00	89.00%
9	420.00	1198.64	32.58	19.69	2853.90	240.00	89.04%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 412 MW. Also, the Annual Load Factor of 33.15% and the Energy harness of 88.87% justifies the installed capacity of 412 MW.

6.5.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 70.65 MW continuous (July 3 to May 3).

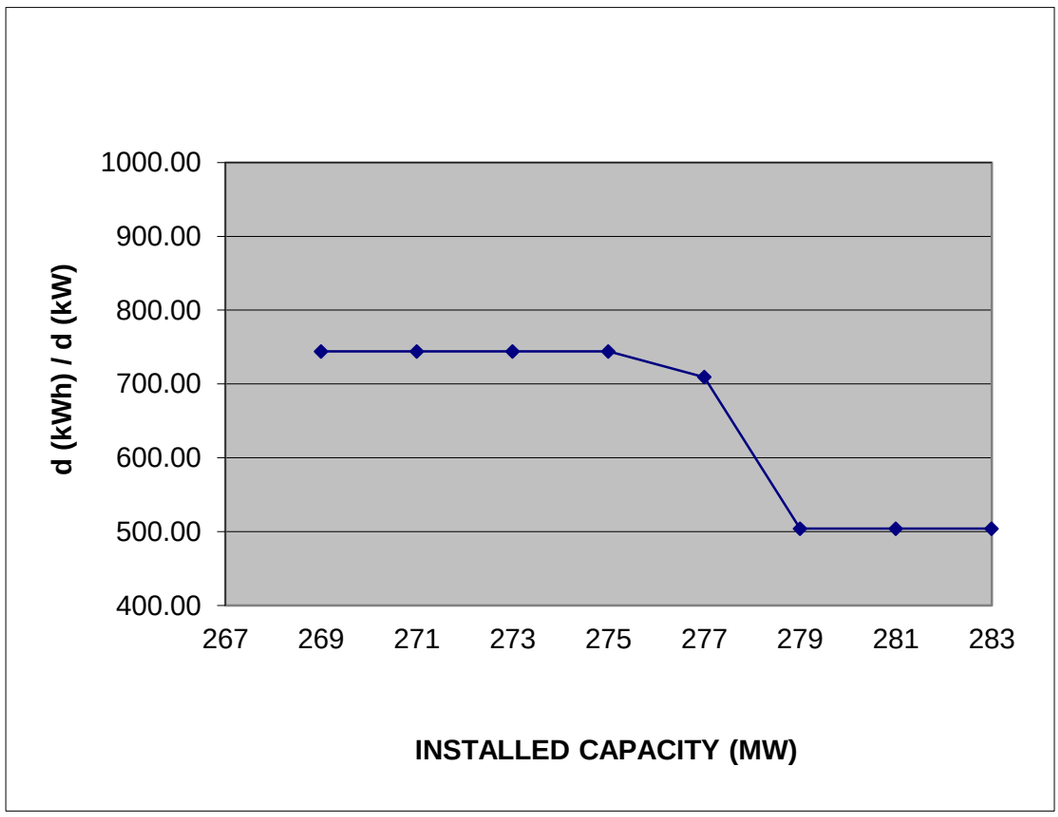
The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 267 MW to 283 MW in steps of 2 MW. The results are tabulated in as below:

KUTRU-II HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		317.00		1458.1						T.G.EFF.	=	0.93				
	M.D.D.L		295.70		199.65						Firm Power exep.(MW)	=	70.65				
	Av. T.W.L.		274.39								Installed Capacity (MW)	=	275.00				
											W.C.Losses	=	0.43				
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	295.70	199.65	348.12	300.78	300.78	295.70	199.65	274.39	21.10	348.12	67.00	0.00	0.00	16.08	0.00	16.08
90% Yr.	JUN 2	295.70	199.65	305.75	264.17	264.17	295.70	199.65	274.39	21.10	305.75	58.85	0.00	0.00	14.12	0.00	14.12
90% Yr.	JUN3	295.70	199.65	600.75	519.05	275.02	303.19	443.68	274.39	24.33	318.30	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	JUL 1	303.19	443.68	1079.63	932.80	197.64	314.32	1178.84	274.39	33.85	228.75	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	JUL2	314.32	1178.84	1882.58	1626.55	637.39	317.00	1458.05	274.39	40.86	737.71	70.65	204.35	306.31	16.96	49.04	66.00
90% Yr.	JUL3	317.00	1458.05	272.15	258.65	258.65	317.00	1458.05	274.39	42.18	272.15	70.65	34.09	0.00	18.65	9.00	27.65
90% Yr.	AUG1	317.00	1458.05	480.59	415.23	415.23	317.00	1458.05	274.39	42.18	480.59	70.65	114.30	0.00	16.96	27.43	44.39
90% Yr.	AUG2	317.00	1458.05	719.00	621.21	617.37	317.00	1458.05	274.39	42.18	714.55	70.65	204.35	1.71	16.96	49.04	66.00
90% Yr.	AUG3	317.00	1458.05	751.41	714.14	679.11	317.00	1458.05	274.39	42.18	714.55	70.65	204.35	14.19	18.65	53.95	72.60
90% Yr.	SEP1	317.00	1458.05	156.86	135.53	158.62	317.00	1434.96	274.39	42.18	183.59	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	SEP2	317.00	1434.96	166.95	144.25	158.63	316.99	1420.57	274.39	42.18	183.60	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	SEP3	316.99	1420.57	534.38	461.71	424.23	317.00	1458.05	274.39	42.18	491.00	70.65	118.30	0.00	16.96	28.39	45.35
90% Yr.	OCT1	317.00	1458.05	402.61	347.85	347.85	317.00	1458.05	274.39	42.18	402.61	70.65	84.29	0.00	16.96	20.23	37.19
90% Yr.	OCT2	317.00	1458.05	173.68	150.06	158.62	317.00	1449.49	274.39	42.18	183.58	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	OCT3	317.00	1449.49	198.63	188.78	180.22	317.00	1458.05	274.39	42.18	189.63	70.65	2.33	0.00	18.65	0.61	19.27
90% Yr.	NOV1	317.00	1458.05	249.64	215.69	215.69	317.00	1458.05	274.39	42.18	249.64	70.65	25.42	0.00	16.96	6.10	23.06
90% Yr.	NOV2	317.00	1458.05	294.84	254.74	254.74	317.00	1458.05	274.39	42.18	294.84	70.65	42.82	0.00	16.96	10.28	27.23
90% Yr.	NOV3	317.00	1458.05	193.16	166.89	166.89	317.00	1458.05	274.39	42.18	193.16	70.65	3.69	0.00	16.96	0.89	17.84
90% Yr.	DEC1	317.00	1458.05	148.25	128.08	158.62	316.99	1427.51	274.39	42.18	183.59	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	DEC2	316.99	1427.51	139.85	120.83	158.65	316.99	1389.70	274.39	42.17	183.62	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	DEC3	316.99	1389.70	133.14	126.54	175.15	316.63	1341.09	274.39	42.02	184.29	70.65	0.00	0.00	18.65	0.00	18.65
90% Yr.	JAN1	316.63	1341.09	127.68	110.31	162.20	315.43	1289.20	274.39	41.25	187.73	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	JAN2	315.43	1289.20	161.73	139.74	165.14	315.18	1263.80	274.39	40.52	191.13	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	JAN3	315.18	1263.80	135.40	128.69	183.44	314.63	1209.05	274.39	40.12	193.01	70.65	0.00	0.00	18.65	0.00	18.65
90% Yr.	FEB1	314.63	1209.05	132.84	114.77	169.05	314.08	1154.77	274.39	39.58	195.66	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	FEB2	314.08	1154.77	132.27	114.28	171.55	313.46	1097.50	274.39	39.00	198.56	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	FEB3	313.46	1097.50	129.71	89.66	139.35	312.90	1047.81	274.39	38.41	201.61	70.65	0.00	0.00	13.57	0.00	13.57
90% Yr.	MAR1	312.90	1047.81	121.88	105.31	177.35	312.05	975.76	274.39	37.73	205.27	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	MAR2	312.05	975.76	120.92	104.47	181.64	311.09	898.60	274.39	36.84	210.23	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	MAR3	311.09	898.60	118.78	112.89	205.96	309.80	805.53	274.39	35.74	216.71	70.65	0.00	0.00	18.65	0.00	18.65
90% Yr.	APR1	309.80	805.53	123.10	106.36	194.27	308.47	717.61	274.39	34.44	224.86	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	APR2	308.47	717.61	134.21	115.96	202.29	307.02	631.28	274.39	33.08	234.14	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	APR3	307.02	631.28	137.07	118.43	212.42	305.24	537.29	274.39	31.50	245.86	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	MAY1	305.24	537.29	137.19	118.54	227.03	302.83	428.79	274.39	29.47	262.76	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	MAY2	302.83	428.79	135.45	117.03	251.99	299.08	293.83	274.39	26.55	291.66	70.65	0.00	0.00	16.96	0.00	16.96
90% Yr.	MAY3	299.08	293.83	235.37	223.69	317.88	295.70	199.65	274.39	23.15	334.47	70.64	-0.01	0.00	18.65	0.00	18.65
TOTAL					9913.65	9164.83									615.20	254.96	870.16

KUTRU-II HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ALF(%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	267.00	864.21	36.95	26.46	3236.75	-	91.18%
2	269.00	865.70	36.74	26.26	3218.21	744.00	91.33%
3	271.00	867.19	36.53	26.07	3199.95	744.00	91.49%
4	273.00	868.68	36.32	25.88	3181.96	744.00	91.65%
5	**275.00**	**870.16**	**36.12**	**25.69**	**3164.23**	**744.00**	**91.81%**
6	277.00	871.58	35.92	25.51	3146.51	709.18	91.96%
7	279.00	872.59	35.70	25.32	3127.56	504.00	92.06%
8	281.00	873.60	35.49	25.14	3108.89	504.00	92.17%
9	283.00	874.61	35.28	24.97	3090.48	504.00	92.27%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 275 MW. Also, the Annual Load Factor of 36.12 % and the Energy harness of 91.81% justifies the installed capacity of 275 MW.

6.5.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	**Without Environmental Flows**	**With Environmental Flows**
Annual Energy Generation (GWh)	1196.42	870.16
Firm Power (MW continuous)	82.72	70.65
Installed Capacity	412	**275 (4x68.75MW)**
Annual load factor (%)	33.15	36.12

Regarding the number of generating units to be installed, the following options are possible.

- 3x91.67 MW
- 4x68.75MW

Although, installation of 3 units of 91.67 MW would be economical but considering the reliability of the Project, installation of 4 units of 68.75 MW has been chosen.

6.6 Power Potential Studies of Nugur-I Hydroelectric Project:

6.6.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 273.7 m, 266.8 m & 243.15 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. Also, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Nugur-I Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the Head i.e. 0.31 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 140.76 MCum. The Elevation Area capacity Table is shown as below.

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	266.8	10224944	1022.49	119895212.2	119.9
2	267.29	11805369	1180.54	125653992.2	125.65
3	267.78	12805369	1280.54	131928497.8	131.93
4	268.27	13229440	1322.94	138587487	138.59
5	268.76	14229440	1422.94	145560207.8	145.56
6	269.25	15973833	1597.38	152968592.8	152.97
7	269.74	17973833	1797.38	160795615.1	160.8
8	270.23	19689945	1968.99	169477871.4	169.48
9	270.72	21689945	2168.99	179125752.3	179.13
10	271.21	23822194	2382.22	189641370.1	189.64
11	271.7	25822194	2582.22	201314739.6	201.31
12	272.19	27178011	2717.8	213814997.9	213.81
13	272.68	28178011	2817.8	227621948.1	227.62
14	273.17	30315795	3031.58	242473264	242.47

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
15	273.66	32315795	3231.58	259287668.6	259.29
16	273.7	34315795	3431.58	260660593.7	260.66

6.6.2 Hydrology

Hydrological data series is developed for 25 years from 1990-1991 to 2014-2015. The outflows of Kutru-II Hydroelectric Project which is in the Upstream of Nugur-I Hydroelectric Project and the Intermediate Inflows has been considered for the studies. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Kutru-II Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Jun	I	407.63	54.76	462.39	115.60	346.79
	II	366.56	48.09	414.66	103.66	310.99
	III	299.98	94.49	394.47	98.62	295.85
Jul	I	803.99	169.82	973.81	292.14	681.67
	II	1070.53	340.71	1411.24	423.37	987.87
	III	388.79	157.62	546.41	163.92	382.49
Aug	I	686.55	84.18	770.73	231.22	539.51
	II	1027.14	131.34	1158.47	347.54	810.93
	III	1070.53	223.76	1294.29	388.29	906.01
Sep	I	224.09	65.82	289.91	86.97	202.94
	II	238.51	24.95	263.46	79.04	184.42
	III	763.40	78.27	841.67	252.50	589.17
Oct	I	536.81	64.94	601.75	150.44	451.31
	II	231.57	17.79	249.36	62.34	187.02
	III	264.84	17.16	281.99	70.50	211.50
Nov	I	332.85	23.32	356.17	89.04	267.13
	II	393.12	31.62	424.73	106.18	318.55
	III	257.55	17.16	274.71	68.68	206.03
Dec	I	214.94	6.51	221.45	44.29	177.16
	II	214.97	4.82	219.79	43.96	175.83
	III	215.14	3.38	218.52	43.70	174.81
Jan	I	218.39	2.51	220.90	44.18	176.72
	II	222.59	7.51	230.10	46.02	184.08
	III	224.83	3.52	228.36	45.67	182.68
Feb	I	227.82	2.85	230.67	46.13	184.54

Period (10 Daily)		Kutru-II Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
	II	231.06	2.66	233.71	46.74	186.97
	III	234.50	2.28	236.78	47.36	189.42
Mar	I	238.75	1.20	239.95	47.99	191.96
	II	244.64	1.16	245.81	49.16	196.64
	III	252.45	1.05	253.50	50.70	202.80
Apr	I	262.38	0.84	263.21	52.64	210.57
	II	273.80	0.69	274.49	54.90	219.59
	III	288.48	0.67	289.16	57.83	231.33
May	I	309.36	2.02	311.38	62.28	249.10
	II	345.27	0.84	346.11	69.22	276.88
	III	395.95	15.92	411.86	82.37	329.49

6.6.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.6.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 62.70 MW continuous.

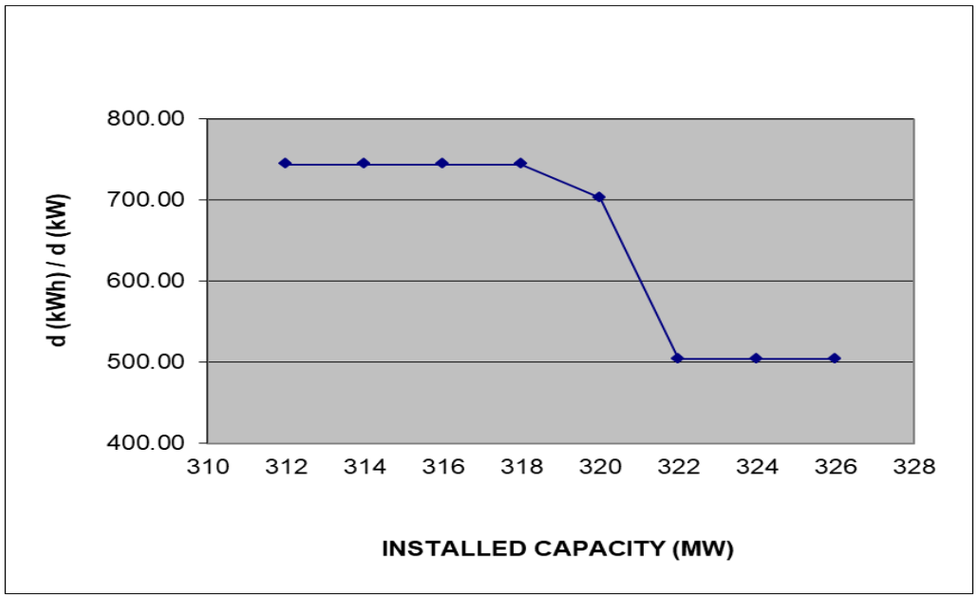
The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 310 MW to 326 MW in steps of 2 MW. The results are tabulated in as below:

NUGUR-I HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		273.70		260.66						T.G.EFF.	=	0.93				
	M.D.D.L		266.80		119.9						Firm Power exep.(MW)	=	62.70				
	Av. T.W.L.		243.15								Installed Capacity (MW)	=	318.00				
											W.C.Losses (m)	=	0.31				
YEAR	MONTH	INITIAL LEVEL	INITAL STORAGE	INFLOW	INFLOW	WITH-DRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	266.80	119.90	462.39	399.50	258.74	273.70	260.66	243.15	26.83	299.47	62.70	10.60	0.00	15.05	2.54	17.59
90% Yr.	JUN 2	273.70	260.66	414.66	358.26	358.26	273.70	260.66	243.15	30.24	414.66	62.70	51.72	0.00	15.05	12.41	27.46
90% Yr.	JUN3	273.70	260.66	394.47	340.82	340.82	273.70	260.66	243.15	30.24	394.47	62.70	46.15	0.00	15.05	11.08	26.12
90% Yr.	JUL 1	273.70	260.66	973.81	841.37	841.37	273.70	260.66	243.15	30.24	973.81	62.70	206.00	0.00	15.05	49.44	64.49
90% Yr.	JUL2	273.70	260.66	1411.24	1219.31	995.73	273.70	260.66	243.15	30.24	1152.47	62.70	255.30	71.40	15.05	61.27	76.32
90% Yr.	JUL3	273.70	260.66	546.41	519.31	519.31	273.70	260.66	243.15	30.24	546.41	62.70	88.07	0.00	16.55	23.25	39.80
90% Yr.	AUG1	273.70	260.66	770.73	665.91	665.91	273.70	260.66	243.15	30.24	770.73	62.70	149.97	0.00	15.05	35.99	51.04
90% Yr.	AUG2	273.70	260.66	1158.47	1000.92	995.73	273.70	260.66	243.15	30.24	1152.47	62.70	255.30	1.66	15.05	61.27	76.32
90% Yr.	AUG3	273.70	260.66	1294.29	1230.10	1095.31	273.70	260.66	243.15	30.24	1152.47	62.70	255.30	39.13	16.55	67.40	83.95
90% Yr.	SEP1	273.70	260.66	280.79	242.60	242.60	273.70	260.66	243.15	30.24	280.79	62.70	14.78	0.00	15.05	3.55	18.59
90% Yr.	SEP2	273.70	260.66	239.96	207.32	207.32	273.70	260.66	243.15	30.24	239.96	62.70	3.51	0.00	15.05	0.84	15.89
90% Yr.	SEP3	273.70	260.66	763.79	659.91	659.91	273.70	260.66	243.15	30.24	763.79	62.70	148.05	0.00	15.05	35.53	50.58
90% Yr.	OCT1	273.70	260.66	601.75	519.91	519.91	273.70	260.66	243.15	30.24	601.75	62.70	103.34	0.00	15.05	24.80	39.85
90% Yr.	OCT2	273.70	260.66	249.36	215.45	215.45	273.70	260.66	243.15	30.24	249.36	62.70	6.11	0.00	15.05	1.47	16.51
90% Yr.	OCT3	273.70	260.66	281.99	268.01	268.01	273.70	260.66	243.15	30.24	281.99	62.70	15.11	0.00	16.55	3.99	20.54
90% Yr.	NOV1	273.70	260.66	356.17	307.73	307.73	273.70	260.66	243.15	30.24	356.17	62.70	35.58	0.00	15.05	8.54	23.59
90% Yr.	NOV2	273.70	260.66	424.73	366.97	366.97	273.70	260.66	243.15	30.24	424.73	62.70	54.50	0.00	15.05	13.08	28.13
90% Yr.	NOV3	273.70	260.66	274.71	237.35	237.35	273.70	260.66	243.15	30.24	274.71	62.70	13.10	0.00	15.05	3.14	18.19
90% Yr.	DEC1	273.70	260.66	221.45	191.33	196.61	273.55	255.38	243.15	30.20	227.56	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	DEC2	273.55	255.38	219.79	189.90	197.84	273.31	247.43	243.15	30.01	228.98	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	DEC3	273.31	247.43	218.52	207.68	219.72	272.94	235.39	243.15	29.73	231.18	62.70	0.00	0.00	16.55	0.00	16.55
90% Yr.	JAN1	272.94	235.39	220.90	190.86	202.32	272.55	223.93	243.15	29.35	234.16	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	JAN2	272.55	223.93	230.10	198.80	204.40	272.35	218.33	243.15	29.05	236.58	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	JAN3	272.35	218.33	228.35	217.03	226.89	271.98	208.47	243.15	28.79	238.73	62.70	0.00	0.00	16.55	0.00	16.55
90% Yr.	FEB1	271.98	208.47	230.67	199.30	208.98	271.59	198.79	243.15	28.41	241.88	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	FEB2	271.59	198.79	233.71	201.93	211.93	271.17	188.79	243.15	28.02	245.29	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	FEB3	271.17	188.79	236.78	163.66	172.08	270.78	180.37	243.15	27.60	248.96	62.70	0.00	0.00	12.04	0.00	12.04
90% Yr.	MAR1	270.78	180.37	239.95	207.31	218.60	270.21	169.08	243.15	27.16	253.01	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	MAR2	270.21	169.08	245.81	212.38	223.32	269.57	158.13	243.15	26.59	258.47	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	MAR3	269.57	158.13	253.50	240.93	251.58	268.89	147.48	243.15	25.96	264.71	62.70	0.00	0.00	16.55	0.00	16.55
90% Yr.	APR1	268.89	147.48	263.21	227.42	234.06	268.43	140.83	243.15	25.37	270.91	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	APR2	268.43	140.83	274.49	237.16	236.54	268.47	141.46	243.15	25.10	273.77	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	APR3	268.47	141.46	289.16	249.83	232.20	269.63	159.08	243.15	25.57	268.75	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	MAY1	269.63	159.08	311.37	269.03	217.57	272.06	210.54	243.15	27.29	251.82	62.70	0.00	0.00	15.05	0.00	15.05
90% Yr.	MAY2	272.06	210.54	346.10	299.03	248.91	273.70	260.66	243.15	29.43	288.09	62.70	14.66	0.00	15.05	3.52	18.57
90% Yr.	MAY3	273.70	260.66	411.87	391.45	391.45	273.70	260.66	243.15	30.24	411.87	62.70	50.95	0.00	16.55	13.45	30.00
TOTAL					13695.77	13191.45									549.25	436.57	985.82

NUGUR I HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harnessed
1	310.00	979.87	36.08	20.23	3160.86	-	96.66%
2	312.00	981.36	35.91	20.10	3145.37	744.00	96.81%
3	314.00	982.84	35.73	19.97	3130.07	744.00	96.96%
4	316.00	984.33	35.56	19.84	3114.97	744.00	97.10%
5	**318.00**	**985.82**	**35.39**	**19.72**	**3100.06**	**744.00**	**97.25%**
6	320.00	987.22	35.22	19.59	3085.08	702.88	97.39%
7	322.00	988.23	35.03	19.47	3069.05	504.00	97.49%
8	324.00	989.24	34.85	19.35	3053.21	504.00	97.59%
9	326.00	990.25	34.68	19.23	3037.57	504.00	97.69%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 318 MW. Also, the Annual Load Factor of 35.39 % and the Energy harness of 97.25% justifies the installed capacity of 318 MW.

6.6.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 50.69 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity

varying from 264 MW to 280 MW in steps of 2 MW. The results are tabulated in as below:

KUTRU-II HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		273.70		260.66						T.G.EFF.	=	0.93				
	M.D.D.L		266.80		119.9						Firm Power exep.(MW)	=	50.69				
	Av. T.W.L.		243.15								Installed Capacity (MW)	=	272.00				
											W.C.Losses (m)	=	0.31				
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	266.80	119.90	346.79	299.63	183.72	272.95	235.80	243.15	26.13	212.64	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	JUN 2	272.95	235.80	310.99	268.70	243.84	273.70	260.66	243.15	29.87	282.22	50.69	26.23	0.00	12.17	6.29	18.46
90% Yr.	JUN3	273.70	260.66	295.85	255.62	255.62	273.70	260.66	243.15	30.24	295.85	50.69	30.94	0.00	12.17	7.43	19.59
90% Yr.	JUL 1	273.70	260.66	681.67	588.96	588.96	273.70	260.66	243.15	30.24	681.67	50.69	137.40	0.00	12.17	32.98	45.14
90% Yr.	JUL2	273.70	260.66	987.87	853.52	851.70	273.70	260.66	243.15	30.24	985.76	50.69	221.31	0.58	12.17	53.11	65.28
90% Yr.	JUL3	273.70	260.66	382.49	363.52	363.52	273.70	260.66	243.15	30.24	382.49	50.69	54.85	0.00	13.38	14.48	27.86
90% Yr.	AUG1	273.70	260.66	539.51	466.14	466.14	273.70	260.66	243.15	30.24	539.51	50.69	98.18	0.00	12.17	23.56	35.73
90% Yr.	AUG2	273.70	260.66	810.93	700.65	700.65	273.70	260.66	243.15	30.24	810.93	50.69	173.07	0.00	12.17	41.54	53.70
90% Yr.	AUG3	273.70	260.66	906.01	861.07	861.07	273.70	260.66	243.15	30.24	906.01	50.69	199.30	0.00	13.38	52.62	66.00
90% Yr.	SEP1	273.70	260.66	202.94	175.34	175.34	273.70	260.66	243.15	30.24	202.94	50.69	5.31	0.00	12.17	1.27	13.44
90% Yr.	SEP2	273.70	260.66	184.42	159.34	159.34	273.70	260.66	243.15	30.24	184.42	50.69	0.20	0.00	12.17	0.05	12.21
90% Yr.	SEP3	273.70	260.66	589.17	509.04	509.04	273.70	260.66	243.15	30.24	589.17	50.69	111.88	0.00	12.17	26.85	39.02
90% Yr.	OCT1	273.70	260.66	451.31	389.94	389.94	273.70	260.66	243.15	30.24	451.31	50.69	73.84	0.00	12.17	17.72	29.89
90% Yr.	OCT2	273.70	260.66	187.02	161.59	161.59	273.70	260.66	243.15	30.24	187.02	50.69	0.91	0.00	12.17	0.22	12.39
90% Yr.	OCT3	273.70	260.66	211.50	201.01	201.01	273.70	260.66	243.15	30.24	211.50	50.69	7.67	0.00	13.38	2.02	15.41
90% Yr.	NOV1	273.70	260.66	267.13	230.80	230.80	273.70	260.66	243.15	30.24	267.13	50.69	23.02	0.00	12.17	5.52	17.69
90% Yr.	NOV2	273.70	260.66	318.55	275.23	275.23	273.70	260.66	243.15	30.24	318.55	50.69	37.21	0.00	12.17	8.93	21.10
90% Yr.	NOV3	273.70	260.66	206.03	178.01	178.01	273.70	260.66	243.15	30.24	206.03	50.69	6.16	0.00	12.17	1.48	13.64
90% Yr.	DEC1	273.70	260.66	177.16	153.06	159.03	273.53	254.69	243.15	30.19	184.07	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	DEC2	273.53	254.69	175.83	151.92	160.10	273.29	246.50	243.15	29.98	185.31	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	DEC3	273.29	246.50	174.81	166.14	177.83	272.92	234.82	243.15	29.70	187.11	50.69	0.00	0.00	13.38	0.00	13.38
90% Yr.	JAN1	272.92	234.82	176.72	152.69	163.69	272.55	223.82	243.15	29.33	189.45	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	JAN2	272.55	223.82	184.08	159.04	165.39	272.32	217.47	243.15	29.03	191.42	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	JAN3	272.32	217.47	182.68	173.62	183.73	271.94	207.37	243.15	28.74	193.32	50.69	0.00	0.00	13.38	0.00	13.38
90% Yr.	FEB1	271.94	207.37	184.54	159.44	169.30	271.54	197.51	243.15	28.36	195.95	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	FEB2	271.54	197.51	186.97	161.54	171.76	271.10	187.30	243.15	27.95	198.79	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	FEB3	271.10	187.30	189.42	130.93	139.54	270.70	178.68	243.15	27.52	201.88	50.69	0.00	0.00	9.73	0.00	9.73
90% Yr.	MAR1	270.70	178.68	191.96	165.85	177.40	270.10	167.13	243.15	27.06	205.33	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	MAR2	270.10	167.13	196.64	169.90	181.55	269.41	155.48	243.15	26.44	210.13	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	MAR3	269.41	155.48	202.80	192.74	205.27	268.58	142.95	243.15	25.73	215.98	50.69	0.00	0.00	13.38	0.00	13.38
90% Yr.	APR1	268.58	142.95	210.57	181.93	192.56	267.81	132.32	243.15	24.93	222.88	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	APR2	267.81	132.32	219.59	189.73	198.19	267.14	123.86	243.15	24.22	229.39	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	APR3	267.14	123.86	231.33	199.87	202.24	266.94	121.49	243.15	23.74	234.08	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	MAY1	266.94	121.49	249.10	215.22	199.42	268.17	137.29	243.15	24.07	230.81	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	MAY2	268.17	137.29	276.88	239.23	183.49	271.35	193.03	243.15	26.16	212.37	50.69	0.00	0.00	12.17	0.00	12.17
90% Yr.	MAY3	271.35	193.03	329.49	313.15	245.52	273.70	260.66	243.15	29.08	258.33	50.69	17.85	0.00	13.38	4.71	18.10
TOTAL					10214.08	10071.50									444.05	300.79	744.84

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harnessed
1	264.00	742.92	32.12	19.20	2814.09	-	99.72%
2	266.00	743.40	31.90	19.06	2794.74	240.00	99.79%
3	268.00	743.88	31.69	18.91	2775.67	240.00	99.85%
4	270.00	744.36	31.47	18.77	2756.89	240.00	99.92%
5	**272.00**	**744.84**	**31.26**	**18.64**	**2738.38**	**240.00**	**99.98%**
6	274.00	744.98	31.04	18.50	2718.91	69.86	100.00%
7	276.00	744.98	30.81	18.37	2699.20	0.00	100.00%
8	278.00	744.98	30.59	18.23	2679.78	0.00	100.00%
9	280.00	744.98	30.37	18.10	2660.64	0.00	100.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 272 MW. Also, the Annual Load Factor of 31.26 % and the Energy harness of 99.98% justifies the installed capacity of 272MW.

6.6.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	985.82	744.84
Firm Power (MW continuous)	62.70	50.69
Installed Capacity	318	***272(4x68MW)***
Annual load factor (%)	35.39	31.26

Regarding the number of generating units to be installed, the following options are possible.

- 3x90.66 MW
- 4x68 MW

Although, installation of 3 units of 90.66 MW would be economical but considering the reliability of the Project, installation of 4 units of 68 MW has been chosen.

6.7 Power Potential Studies of Kotri Hydroelectric Project:

6.7.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 290 m, 277 m and 245 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. There is spillage during the month of August and September but in order to avoid submergence of habitated areas the FRL of the project has been fixed same at 261 m. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. In addition, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Kotri Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e.0.45 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 608.47 MCum. The Elevation Area capacity Table is shown as below.

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	277	15800051	1580.01	108578855.4	108.58
2	277.92	18299691	1829.97	125414816.9	125.41
3	278.84	21590272	2159.03	145014296.2	145.01
4	279.76	24432779	2443.28	167037969.3	167.04
5	280.68	28169557	2816.96	192056689.9	192.06
6	281.6	32262352	3226.24	220428762.7	220.43
7	282.52	37058730	3705.87	252603638.9	252.6

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
8	283.44	42826406	4282.64	289235959.4	289.24
9	284.36	49595441	4959.54	331072274.3	331.07
10	285.28	55615805	5561.58	378386440.7	378.39
11	286.2	62782190	6278.22	430987092.9	430.99
12	287.12	70726366	7072.64	489698897.2	489.7
13	288.04	75736297	7573.63	555088569.2	555.09
14	288.96	78736297	7873.63	627524616.8	627.52
15	289.88	86376120	8637.61	706686148.5	706.69
16	290	86376120	8637.61	717050861.1	717.05

6.7.2 Hydrology

With the abundance of water available during the monsoon months (June to Nov). Hydrological data series is developed for 25 years from 1990-1991 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
		2009-2010		
Jun	I	22.18	5.55	16.63
	II	48.29	12.07	36.22
	III	12.12	3.03	9.09
Jul	I	31.4	9.42	21.98
	II	184.2	55.26	128.94
	III	314.54	94.36	220.18
Aug	I	65.39	19.62	45.77
	II	75.32	22.6	52.72
	III	443.65	133.1	310.55
Sep	I	493.59	148.08	345.51
	II	78.53	23.56	54.97
	III	163.45	49.03	114.42
Oct	I	145.36	36.34	109.02
	II	50.92	12.73	38.19
	III	26.08	6.52	19.56
Nov	I	21.43	5.36	16.07
	II	29.62	7.41	22.21
	III	25.84	6.46	19.38
Dec	I	13.55	2.71	10.84
	II	10.03	2.01	8.02
	III	7.03	1.41	5.62
Jan	I	5.22	1.04	4.18
	II	15.63	3.13	12.5
	III	7.34	1.47	5.87
Feb	I	5.94	1.19	4.75

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
	II	5.53	1.11	4.42
	III	4.74	0.95	3.79
Mar	I	2.49	0.5	1.99
	II	2.42	0.48	1.94
	III	2.18	0.44	1.74
April	I	1.74	0.35	1.39
	II	1.43	0.29	1.14
	III	1.4	0.28	1.12
May	I	4.2	0.84	3.36
	II	1.74	0.35	1.39
	III	33.14	6.63	26.51

6.7.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.7.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 15.46 MW continuous (July 2 to May 3).

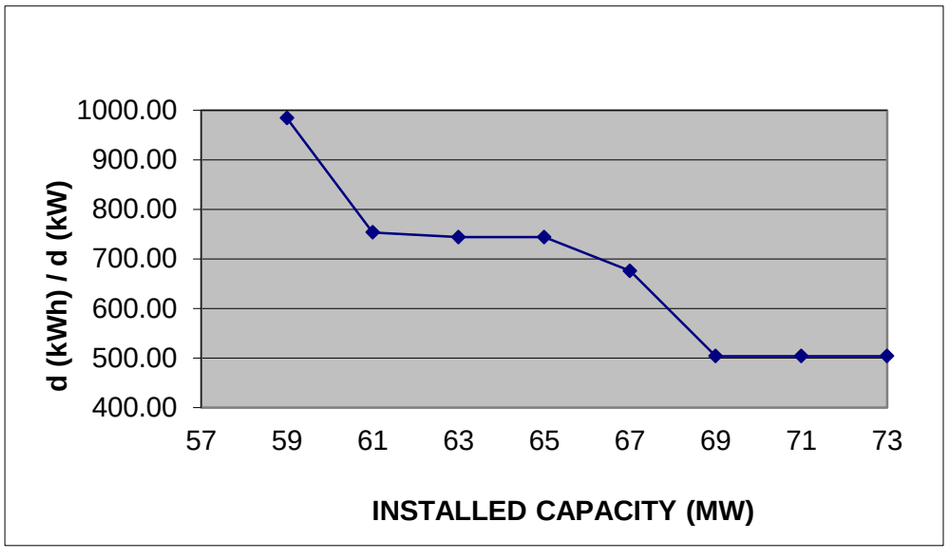
The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 57 MW to 73 MW in steps of 2 MW. The results are tabulated in as below:

KOTRI HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		290.00		717.05						T.G.EFF. =			0.93			
	M.D.D.L		277.00		108.58						Firm Power exep.(MW) =			15.46			
	Av. T.W.L.		245.00								Installed Capacity (MW) =			65.00			
											W.C.Losses =			0.45	0.00		
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	277.00	108.58	22.18	19.16	19.16	277.00	108.58	245.00	31.68	22.18	6.41	0.00	0.00	1.54	0.00	1.54
90% Yr.	JUN 2	277.00	108.58	48.29	41.72	41.72	277.00	108.58	245.00	31.68	48.29	13.96	0.00	0.00	3.35	0.00	3.35
90% Yr.	JUN3	277.00	108.58	12.12	10.47	10.47	277.00	108.58	245.00	31.68	12.12	3.50	0.00	0.00	0.84	0.00	0.84
90% Yr.	JUL 1	277.00	108.58	31.40	27.13	27.13	277.00	108.58	245.00	31.68	31.40	9.08	0.00	0.00	2.18	0.00	2.18
90% Yr.	JUL2	277.00	108.58	184.20	159.15	43.08	281.72	224.64	245.00	33.98	49.87	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	JUL3	281.72	224.64	314.54	298.94	41.35	287.00	482.24	245.00	38.95	43.50	15.46	0.00	0.00	4.08	0.00	4.08
90% Yr.	AUG1	287.00	482.24	65.39	56.50	35.07	287.32	503.66	245.00	41.74	40.59	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	AUG2	287.32	503.66	75.32	65.08	34.77	287.74	533.97	245.00	42.11	40.24	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	AUG3	287.74	533.97	443.65	421.64	155.90	290.00	717.05	245.00	43.43	164.04	15.46	49.54	34.46	4.08	13.08	17.16
90% Yr.	SEP1	290.00	717.05	493.59	426.46	138.17	290.00	717.05	245.00	44.55	159.92	15.46	49.54	135.62	3.71	11.89	15.60
90% Yr.	SEP2	290.00	717.05	78.53	67.85	67.85	290.00	717.05	245.00	44.55	78.53	15.46	16.46	0.00	3.71	3.95	7.66
90% Yr.	SEP3	290.00	717.05	163.45	141.22	138.17	290.00	717.05	245.00	44.55	159.92	15.46	49.54	1.43	3.71	11.89	15.60
90% Yr.	OCT1	290.00	717.05	145.36	125.59	125.59	290.00	717.05	245.00	44.55	145.36	15.46	43.62	0.00	3.71	10.47	14.18
90% Yr.	OCT2	290.00	717.05	50.92	43.99	43.99	290.00	717.05	245.00	44.55	50.92	15.46	5.24	0.00	3.71	1.26	4.97
90% Yr.	OCT3	290.00	717.05	26.08	24.79	36.20	289.87	705.64	245.00	44.49	38.09	15.46	0.00	0.00	4.08	0.00	4.08
90% Yr.	NOV1	289.87	705.64	21.43	18.52	33.02	289.70	691.14	245.00	44.34	38.22	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	NOV2	289.70	691.14	29.62	25.59	33.11	289.61	683.61	245.00	44.21	38.33	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	NOV3	289.61	683.61	25.84	22.33	33.19	289.49	672.75	245.00	44.11	38.42	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	DEC1	289.49	672.75	13.55	11.71	33.33	289.23	651.12	245.00	43.92	38.58	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	DEC2	289.23	651.12	10.03	8.67	33.54	288.94	626.25	245.00	43.65	38.82	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	DEC3	288.94	626.25	7.03	6.68	37.18	288.56	595.75	245.00	43.32	39.12	15.46	0.00	0.00	4.08	0.00	4.08
90% Yr.	JAN1	288.56	595.75	5.22	4.51	34.09	288.18	566.17	245.00	42.94	39.46	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	JAN2	288.18	566.17	15.63	13.50	34.35	287.90	545.32	245.00	42.61	39.76	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	JAN3	287.90	545.32	7.34	6.98	38.11	287.46	514.19	245.00	42.26	40.09	15.46	0.00	0.00	4.08	0.00	4.08
90% Yr.	FEB1	287.46	514.19	5.94	5.13	35.00	287.04	484.33	245.00	41.83	40.51	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	FEB2	287.04	484.33	5.53	4.78	35.38	286.56	453.73	245.00	41.38	40.94	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	FEB3	286.56	453.73	4.74	3.28	28.60	286.15	428.40	245.00	40.95	41.38	15.46	0.00	0.00	2.97	0.00	2.97
90% Yr.	MAR1	286.15	428.40	2.49	2.15	36.19	285.56	394.36	245.00	40.45	41.88	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	MAR2	285.56	394.36	2.42	2.09	36.74	284.92	359.71	245.00	39.84	42.53	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	MAR3	284.92	359.71	2.18	2.07	41.15	284.13	320.64	245.00	39.14	43.29	15.46	0.00	0.00	4.08	0.00	4.08
90% Yr.	APR1	284.13	320.64	1.74	1.50	38.18	283.31	283.96	245.00	38.34	44.19	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	APR2	283.31	283.96	1.43	1.24	39.09	282.33	246.11	245.00	37.45	45.24	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	APR3	282.33	246.11	1.40	1.21	40.22	281.17	207.10	245.00	36.40	46.55	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	MAY1	281.17	207.10	4.20	3.63	41.63	279.84	169.10	245.00	35.17	48.18	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	MAY2	279.84	169.10	1.74	1.50	43.55	278.00	127.05	245.00	33.61	50.41	15.46	0.00	0.00	3.71	0.00	3.71
90% Yr.	MAY3	278.00	127.05	33.14	31.50	49.96	277.00	108.58	245.00	32.20	52.57	15.45	-0.01	0.00	4.08	0.00	4.07
TOTAL					2108.25	1734.26									128.48	52.53	181.01

KOTRI HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	57.00	174.56	34.96	27.12	3062.47	-	78.28%
2	59.00	176.53	34.16	26.20	2992.02	984.00	79.16%
3	61.00	178.04	33.32	25.34	2918.63	753.67	79.84%
4	63.00	179.52	32.53	24.54	2849.59	744.00	80.50%
5	**65.00**	**181.01**	**31.79**	**23.78**	**2784.80**	**744.00**	**81.17%**
6	67.00	182.36	31.07	23.07	2721.85	675.97	81.78%
7	69.00	183.37	30.34	22.40	2657.57	504.00	82.23%
8	71.00	184.38	29.65	21.77	2596.91	504.00	82.68%
9	73.00	185.39	28.99	21.18	2539.57	504.00	83.13%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 65 MW. Also, the Annual Load Factor of 31.79 % and the Energy harness of 81.17% justifies the installed capacity of 65 MW.

6.7.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 14.56 MW continuous (July 2 to May 3).

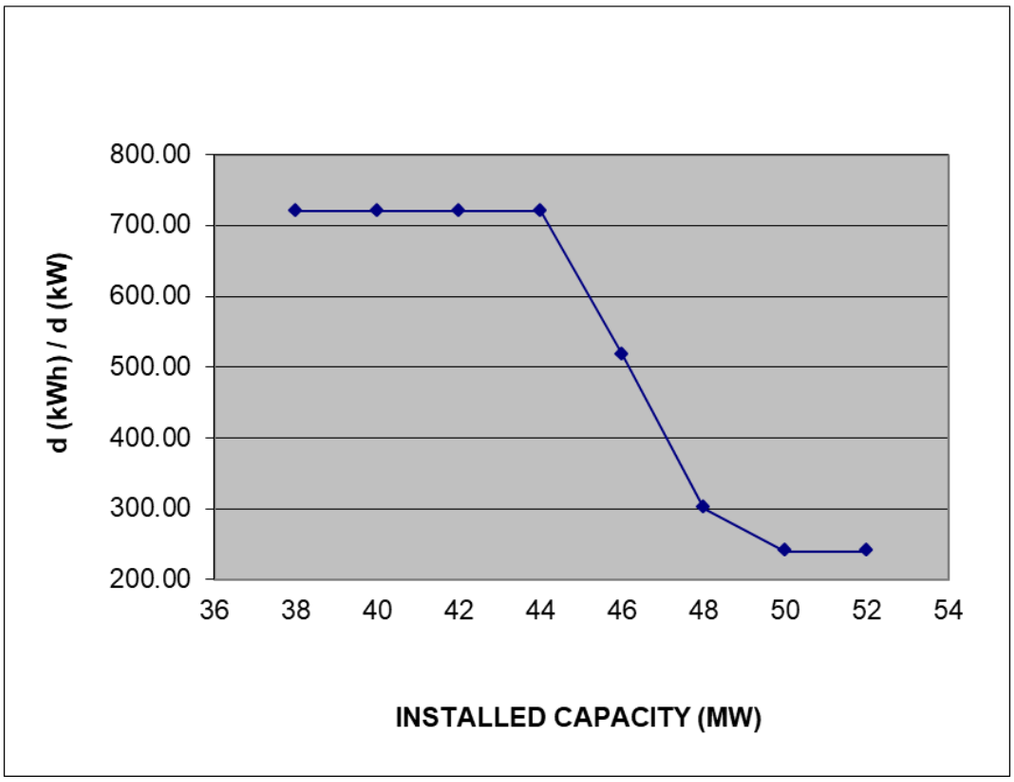
The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 36 MW to 52 MW in steps of 2 MW. The results are tabulated in as below:

KOTRI HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		290.00		717.05						T.G.EFF. =		0.93				
	M.D.D.L		277.00		108.58						Firm Power exep.(MW) =		14.56				
	Av. T.W.L.		245.00								Installed Capacity (MW) =		44.00				
											W.C.Losses (m) =		0.45				
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	277.00	108.58	16.63	14.37	14.37	277.00	108.58	245.00	31.68	16.63	4.81	0.00	0.00	1.15	0.00	1.15
90% Yr.	JUN 2	277.00	108.58	36.22	31.29	31.29	277.00	108.58	245.00	31.68	36.22	10.47	0.00	0.00	2.51	0.00	2.51
90% Yr.	JUN3	277.00	108.58	9.09	7.85	7.85	277.00	108.58	245.00	31.68	9.09	2.63	0.00	0.00	0.63	0.00	0.63
90% Yr.	JUL 1	277.00	108.58	21.98	18.99	18.99	277.00	108.58	245.00	31.68	21.98	6.35	0.00	0.00	1.52	0.00	1.52
90% Yr.	JUL2	277.00	108.58	128.94	111.40	41.49	280.18	178.49	245.00	33.23	48.02	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	JUL3	280.18	178.49	220.18	209.26	40.95	284.67	346.80	245.00	37.03	43.09	14.56	0.00	0.00	3.84	0.00	3.84
90% Yr.	AUG1	284.67	346.80	45.77	39.55	35.06	284.75	351.28	245.00	39.32	40.58	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	AUG2	284.75	351.28	52.72	45.55	34.94	284.96	361.89	245.00	39.46	40.44	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	AUG3	284.96	361.89	310.55	295.15	36.55	288.87	620.49	245.00	41.49	38.46	14.56	0.00	0.00	3.84	0.00	3.84
90% Yr.	SEP1	288.87	620.49	345.51	298.52	94.72	290.00	717.05	245.00	43.99	109.63	14.56	29.44	49.81	3.49	7.07	10.56
90% Yr.	SEP2	290.00	717.05	54.97	47.49	47.49	290.00	717.05	245.00	44.55	54.97	14.56	7.79	0.00	3.49	1.87	5.36
90% Yr.	SEP3	290.00	717.05	114.42	98.86	93.53	290.00	717.05	245.00	44.55	108.26	14.56	29.44	2.51	3.49	7.07	10.56
90% Yr.	OCT1	290.00	717.05	109.02	94.19	93.53	290.00	717.05	245.00	44.55	108.26	14.56	29.44	0.31	3.49	7.07	10.56
90% Yr.	OCT2	290.00	717.05	38.19	33.00	33.00	290.00	717.05	245.00	44.55	38.19	14.56	0.97	0.00	3.49	0.23	3.73
90% Yr.	OCT3	290.00	717.05	19.56	18.59	34.11	289.82	701.53	245.00	44.46	35.89	14.56	0.00	0.00	3.84	0.00	3.84
90% Yr.	NOV1	289.82	701.53	16.07	13.88	31.14	289.62	684.28	245.00	44.27	36.04	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	NOV2	289.62	684.28	22.21	19.19	31.26	289.48	672.22	245.00	44.11	36.18	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	NOV3	289.48	672.22	19.38	16.74	31.37	289.31	657.59	245.00	43.95	36.30	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	DEC1	289.31	657.59	10.84	9.37	31.52	289.05	635.44	245.00	43.74	36.48	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	DEC2	289.05	635.44	8.02	6.93	31.72	288.75	610.65	245.00	43.46	36.71	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	DEC3	288.75	610.65	5.62	5.34	35.16	288.37	580.83	245.00	43.12	37.00	14.56	0.00	0.00	3.84	0.00	3.84
90% Yr.	JAN1	288.37	580.83	4.18	3.61	32.24	288.00	552.20	245.00	42.75	37.32	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	JAN2	288.00	552.20	12.50	10.80	32.50	287.69	530.50	245.00	42.42	37.61	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	JAN3	287.69	530.50	5.87	5.58	36.06	287.27	500.02	245.00	42.06	37.94	14.56	0.00	0.00	3.84	0.00	3.84
90% Yr.	FEB1	287.27	500.02	4.75	4.10	33.12	286.83	471.01	245.00	41.63	38.33	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	FEB2	286.83	471.01	4.42	3.82	33.47	286.36	441.36	245.00	41.18	38.74	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	FEB3	286.36	441.36	3.79	2.62	27.06	285.95	416.91	245.00	40.75	39.16	14.56	0.00	0.00	2.79	0.00	2.79
90% Yr.	MAR1	285.95	416.91	1.99	1.72	34.24	285.39	384.39	245.00	40.27	39.62	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	MAR2	285.39	384.39	1.94	1.68	34.75	284.75	351.32	245.00	39.67	40.22	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	MAR3	284.75	351.32	1.74	1.65	38.90	283.99	314.08	245.00	38.98	40.93	14.56	0.00	0.00	3.84	0.00	3.84
90% Yr.	APR1	283.99	314.08	1.39	1.20	36.08	283.19	279.20	245.00	38.21	41.76	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	APR2	283.19	279.20	1.14	0.98	36.91	282.25	243.28	245.00	37.35	42.71	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	APR3	282.25	243.28	1.12	0.97	37.93	281.14	206.32	245.00	36.35	43.90	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	MAY1	281.14	206.32	3.36	2.90	39.20	279.87	170.02	245.00	35.17	45.37	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	MAY2	279.87	170.02	1.39	1.20	40.91	278.15	130.32	245.00	33.70	47.34	14.56	0.00	0.00	3.49	0.00	3.49
90% Yr.	MAY3	278.15	130.32	26.51	25.20	46.93	277.00	108.58	245.00	32.28	49.38	14.54	-0.01	0.00	3.84	0.00	3.84
TOTAL					1503.55	1390.33									119.36	23.30	142.66

KOTRI HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP. (MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	36.00	136.90	43.41	40.44	3802.73	-	88.16%
2	38.00	138.34	41.56	38.31	3640.48	720.00	89.08%
3	40.00	139.78	39.89	36.39	3494.45	720.00	90.01%
4	42.00	141.22	38.38	34.66	3362.34	720.00	90.94%
5	**44.00**	**142.66**	**37.01**	**33.08**	**3242.23**	**720.00**	**91.87%**
6	46.00	143.69	35.66	31.65	3123.75	517.25	92.53%
7	48.00	144.29	34.32	30.33	3006.12	300.63	92.92%
8	50.00	144.77	33.05	29.11	2895.48	240.00	93.23%
9	52.00	145.25	31.89	27.99	2793.34	240.00	93.54%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 44 MW. Also, the Annual Load Factor of 37.01 % and the Energy harness of 91.87 % justifies the installed capacity of 44 MW

6.7.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	181.01	142.66
Firm Power (MW continuous)	15.46	14.56
Installed Capacity	65	***44(2x22MW)***
Annual load factor (%)	31.79	37.01

Regarding the number of generating units to be installed, the following options are possible.

- 2x22 MW
- 3x19.34 MW

Although, installation of 3 units of 19.34 MW would be economical but considering the reliability of the Project, installation of 2 units of 22 MW has been chosen.

6.8 Power Potential Studies of Wainganga Hydroelectric Project:

6.8.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 222.4 m, 212 m and 198 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. In addition, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Wainganga Hydroelectric Project being a dam toe project the head losses has been considered as 1% of Head i.e. 0.25 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 3366.69 MCum. The Elevation Area capacity Table is shown as below.

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	212	83950689.6	8395.07	359764917	359.76
2	212.74	106785615	10678.56	438786859	438.79
3	213.48	136237400	13623.74	531943903	531.94
4	214.22	169363964	16936.4	640048211	640.05
5	214.96	189363964	18936.4	765378475	765.38
6	215.7	209228565	20922.86	918611254	918.61
7	216.44	252701251	25270.13	1092569629	1092.57
8	217.18	307191702	30719.17	1289373969	1289.37

S.No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
9	217.92	347191702	34719.17	1516697516	1516.7
10	218.66	366897485	36689.75	1783427099	1783.43
11	219.4	438912654	43891.27	2083733283	2083.73
12	220.14	514069986	51407	2419053039	2419.05
13	220.88	554069986	55407	2799467652	2799.47
14	221.62	594823091	59482.31	3229940952	3229.94
15	222.36	676196174	67619.62	3699407666	3699.41
16	222.4	676196174	67619.62	3726450973	3726.45

6.8.2 Hydrology

With the abundance of water available during the monsoon months (June to Nov). Hydrological data series is developed for 25 years from 1990-1991 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
		2009-2010		
Jun	I	6.24	1.25	4.99
	II	4.41	0.88	3.53
	III	5.35	1.07	4.28
Jul	I	84.26	25.28	58.98
	II	1717.33	429.33	1288.00
	III	1990.02	497.5	1492.52
Aug	I	233.95	58.49	175.46
	II	501.46	125.36	376.10
	III	1479.1	443.73	1035.37
Sep	I	1181.9	354.57	827.33
	II	673.3	201.99	471.31
	III	312.95	93.89	219.06
Oct	I	313.08	78.27	234.81
	II	255.34	63.84	191.50
	III	99.08	24.77	74.31
Nov	I	102.08	25.52	76.56
	II	86.03	21.51	64.52
	III	386.89	96.72	290.17
Dec	I	68.3	17.07	51.23
	II	49.25	12.31	36.94
	III	23.78	5.95	17.83
Jan	I	33.15	6.63	26.52
	II	29.38	5.88	23.50
	III	32	6.4	25.60
Feb	I	23.47	4.69	18.78
	II	16.02	3.2	12.82

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
		2009-2010		
	III	31.51	6.3	25.21
Mar	I	18.54	3.71	14.83
	II	16.59	3.32	13.27
	III	14.22	2.84	11.38
April	I	9.14	1.83	7.31
	II	7.38	1.48	5.90
	III	4.75	0.95	3.80
May	I	7.1	1.42	5.68
	II	12.63	2.53	10.10
	III	10.72	2.14	8.58

6.8.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.8.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 45.15 MW continuous (July 2 to May 3).

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 168 MW to 184 MW in steps of 2 MW. The results are tabulated in as below:

WAINGANGA HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		222.40		3726.45						T.G.E.FF. =		0.93				
	M.D.D.L		212.00		359.76						Firm Power exep.(MW) =		45.15				
	Av. T.W.L.		198.00								Installed Capacity (MW) =		176.00				
											W.C.Losses (m) =		0.25				
YEAR	MONTH	INITIAL LEVEL M	INITAL STORAGE MCUM	INFLOW CUMECS	INFLOW MCUM	WITH-DRAWAL MCUM	FINAL LEVEL M	FINAL STORAGE MCUM	TWL M	NET HEAD M	DISCHARGE CUMECS	FIRM POWER MW	SEC. POWER MW	SPILL POWER MW	FIRM ENERGY GWh	SEC. ENERGY GWh	TOTAL ENERGY GWh
90% Yr.	JUN 1	212.00	359.76	6.24	5.39	5.39	212.00	359.76	198.00	14.85	6.24	0.85	0.00	0.00	0.20	0.00	0.20
90% Yr.	JUN 2	212.00	359.76	4.41	3.81	3.81	212.00	359.76	198.00	14.85	4.41	0.60	0.00	0.00	0.14	0.00	0.14
90% Yr.	JUN 3	212.00	359.76	5.35	4.62	4.62	212.00	359.76	198.00	14.85	5.35	0.72	0.00	0.00	0.17	0.00	0.17
90% Yr.	JUL 1	212.00	359.76	84.26	72.80	72.80	212.00	359.76	198.00	14.85	84.26	11.42	0.00	0.00	2.74	0.00	2.74
90% Yr.	JUL2	212.00	359.76	1717.33	1483.77	239.71	218.16	1603.82	198.00	17.84	277.45	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	JUL3	218.16	1603.82	1990.02	1891.32	207.25	221.71	3287.89	198.00	22.70	218.06	45.15	0.00	0.00	11.92	0.00	11.92
90% Yr.	AUG1	221.71	3287.89	233.95	202.13	174.62	221.75	3315.40	198.00	24.49	202.11	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	AUG2	221.75	3315.40	501.46	433.26	173.04	222.16	3575.62	198.00	24.71	200.28	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	AUG3	222.16	3575.62	1479.10	1405.74	732.51	222.40	3726.45	198.00	25.03	770.74	45.15	130.85	125.52	11.92	34.54	46.46
90% Yr.	SEP1	222.40	3726.45	1181.90	1021.16	662.84	222.40	3726.45	198.00	25.15	767.17	45.15	130.85	95.14	10.84	31.40	42.24
90% Yr.	SEP2	222.40	3726.45	673.30	581.73	581.73	222.40	3726.45	198.00	25.15	673.30	45.15	109.31	0.00	10.84	26.24	37.07
90% Yr.	SEP3	222.40	3726.45	312.95	270.39	270.39	222.40	3726.45	198.00	25.15	312.95	45.15	26.64	0.00	10.84	6.39	17.23
90% Yr.	OCT1	222.40	3726.45	313.08	270.50	270.50	222.40	3726.45	198.00	25.15	313.08	45.15	26.67	0.00	10.84	6.40	17.24
90% Yr.	OCT2	222.40	3726.45	255.34	220.61	220.61	222.40	3726.45	198.00	25.15	255.34	45.15	13.43	0.00	10.84	3.22	14.06
90% Yr.	OCT3	222.40	3726.45	99.08	94.17	187.57	222.26	3633.05	198.00	25.08	197.36	45.15	0.00	0.00	11.92	0.00	11.92
90% Yr.	NOV1	222.26	3633.05	102.08	88.20	171.45	222.12	3549.79	198.00	24.94	198.44	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	NOV2	222.12	3549.79	86.03	74.33	172.43	221.97	3451.69	198.00	24.80	199.57	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	NOV3	221.97	3451.69	386.89	334.27	172.09	222.23	3613.87	198.00	24.85	199.18	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	DEC1	222.23	3613.87	68.30	59.01	171.82	222.05	3501.06	198.00	24.89	198.86	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	DEC2	222.05	3501.06	49.25	42.55	173.14	221.84	3370.48	198.00	24.70	200.39	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	DEC3	221.84	3370.48	23.78	22.60	192.29	221.57	3200.79	198.00	24.46	202.32	45.15	0.00	0.00	11.92	0.00	11.92
90% Yr.	JAN1	221.57	3200.79	33.15	28.64	176.69	221.32	3052.74	198.00	24.20	204.50	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	JAN2	221.32	3052.74	29.38	25.38	178.58	221.05	2899.55	198.00	23.94	206.69	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	JAN3	221.05	2899.55	32.00	30.41	198.77	220.75	2731.19	198.00	23.66	209.14	45.15	0.00	0.00	11.92	0.00	11.92
90% Yr.	FEB1	220.75	2731.19	23.47	20.28	183.08	220.43	2568.39	198.00	23.36	211.90	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	FEB2	220.43	2568.39	16.02	13.84	185.66	220.09	2396.58	198.00	23.03	214.88	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	FEB3	220.09	2396.58	31.51	21.78	150.55	219.81	2267.80	198.00	22.72	217.81	45.15	0.00	0.00	8.67	0.00	8.67
90% Yr.	MAR1	219.81	2267.80	18.54	16.02	190.97	219.42	2092.85	198.00	22.39	221.03	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	MAR2	219.42	2092.85	16.59	14.33	194.52	218.98	1912.66	198.00	21.98	225.14	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	MAR3	218.98	1912.66	14.22	13.51	218.74	218.45	1707.44	198.00	21.50	230.15	45.15	0.00	0.00	11.92	0.00	11.92
90% Yr.	APR1	218.45	1707.44	9.14	7.90	203.89	217.90	1511.45	198.00	20.97	235.99	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	APR2	217.90	1511.45	7.38	6.38	209.87	217.24	1307.95	198.00	20.37	242.90	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	APR3	217.24	1307.95	4.75	4.10	217.53	216.45	1094.53	198.00	19.66	251.77	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	MAY1	216.45	1094.53	7.10	6.13	227.54	215.48	873.13	198.00	18.79	263.35	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	MAY2	215.48	873.13	12.63	10.91	241.46	214.23	642.58	198.00	17.71	279.47	45.15	0.00	0.00	10.84	0.00	10.84
90% Yr.	MAY3	214.23	642.58	10.72	10.19	293.01	212.00	359.76	198.00	16.05	308.30	45.14	-0.01	0.00	11.92	0.00	11.92
TOTAL					8812.19	7931.47									355.44	108.20	463.64

WAINGANGA HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	168.00	459.61	31.23	26.88	2735.75	-	88.45%
2	170.00	460.61	30.93	26.56	2709.50	504.00	88.65%
3	172.00	461.62	30.64	26.25	2683.85	504.00	88.84%
4	174.00	462.63	30.35	25.95	2658.80	504.00	89.03%
5	**176.00**	**463.64**	**30.07**	**25.65**	**2634.31**	**504.00**	**89.23%**
6	178.00	464.65	29.80	25.37	2610.37	504.00	89.42%
7	180.00	465.65	29.53	25.08	2586.97	504.00	89.62%
8	182.00	466.66	29.27	24.81	2564.08	504.00	89.81%
9	184.00	467.67	29.01	24.54	2541.69	504.00	90.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does not show any drop in different Installed capacity. However, the annual Load Factor of 30.07 % justifies the installed capacity of 176 MW.

6.8.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 42.52 MW continuous (July 2 to May 3).

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 130 MW to 146 MW in steps of 2 MW. The results are tabulated in as below:

WAINGANGA HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		222.40		3726.45						T.G.EFF.	=	0.93					
	M.D.D.L		212.00		359.76						Firm Power exe p.(MW)	=	42.52					
	Av. T.W.L.		198.00								Installed Capacity (MW)	=	138.00					
											W.C.Losses (m)	=	0.25					
YEAR	MONTH	INITIAL LEVEL M	INITAL STORAGE MCUM	INFLOW CUMECS	INFLOW MCUM	WITH-DRAWAL MCUM	FINAL LEVEL M	FINAL STORAGE MCUM	TWL M	NET HEAD M	DISCHARGE CUMECS	FIRM POWER MW	SEC. POWER MW	SPILL POWER MW	FIRM ENERGY GWh	SEC. ENERGY GWh	TOTAL ENERGY GWh	
90% Yr.	JUN 1	212.00	359.76	4.99	4.31	4.31	212.00	359.76	198.00	14.85	4.99	0.68	0.00	0.00	0.16	0.00	0.16	
90% Yr.	JUN 2	212.00	359.76	3.53	3.05	3.05	212.00	359.76	198.00	14.85	3.53	0.48	0.00	0.00	0.11	0.00	0.11	
90% Yr.	JUN3	212.00	359.76	4.28	3.70	3.70	212.00	359.76	198.00	14.85	4.28	0.58	0.00	0.00	0.14	0.00	0.14	
90% Yr.	JUL 1	212.00	359.76	58.98	50.96	50.96	212.00	359.76	198.00	14.85	58.98	7.99	0.00	0.00	1.92	0.00	1.92	
90% Yr.	JUL2	212.00	359.76	1288.00	1112.83	233.36	216.99	1239.23	198.00	17.26	270.10	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	JUL3	216.99	1239.23	1492.52	1418.49	207.31	220.20	2450.41	198.00	21.37	218.13	42.52	0.00	0.00	11.23	0.00	11.23	
90% Yr.	AUG1	220.20	2450.41	175.46	151.60	175.48	220.15	2426.53	198.00	22.95	203.10	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	AUG2	220.15	2426.53	376.10	324.95	174.56	220.45	2576.92	198.00	23.07	202.04	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	AUG3	220.45	2576.92	1035.37	984.02	185.30	221.85	3375.63	198.00	23.90	194.97	42.52	0.00	0.00	11.23	0.00	11.23	
90% Yr.	SEP1	221.85	3375.63	827.33	714.81	364.00	222.40	3726.45	198.00	24.87	421.29	42.52	53.08	0.00	10.20	12.74	22.94	
90% Yr.	SEP2	222.40	3726.45	471.31	407.21	407.21	222.40	3726.45	198.00	25.15	471.31	42.52	65.60	0.00	10.20	15.75	25.95	
90% Yr.	SEP3	222.40	3726.45	219.06	189.27	189.27	222.40	3726.45	198.00	25.15	219.06	42.52	7.73	0.00	10.20	1.86	12.06	
90% Yr.	OCT1	222.40	3726.45	234.81	202.88	202.88	222.40	3726.45	198.00	25.15	234.81	42.52	11.35	0.00	10.20	2.72	12.93	
90% Yr.	OCT2	222.40	3726.45	191.50	165.46	165.46	222.40	3726.45	198.00	25.15	191.50	42.52	1.41	0.00	10.20	0.34	10.54	
90% Yr.	OCT3	222.40	3726.45	74.31	70.62	176.71	222.24	3620.36	198.00	25.07	185.93	42.52	0.00	0.00	11.23	0.00	11.23	
90% Yr.	NOV1	222.24	3620.36	76.56	66.15	161.65	222.08	3524.86	198.00	24.91	187.10	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	NOV2	222.08	3524.86	64.52	55.75	162.68	221.92	3417.92	198.00	24.75	188.29	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	NOV3	221.92	3417.92	290.17	250.71	162.79	222.05	3505.84	198.00	24.74	188.41	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	DEC1	222.05	3505.84	51.23	44.26	162.94	221.87	3387.16	198.00	24.71	188.59	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	DEC2	221.87	3387.16	36.94	31.92	164.24	221.66	3254.84	198.00	24.52	190.09	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	DEC3	221.66	3254.84	17.83	16.95	182.46	221.38	3089.32	198.00	24.28	191.99	42.52	0.00	0.00	11.23	0.00	11.23	
90% Yr.	JAN1	221.38	3089.32	26.52	22.91	167.69	221.13	2944.54	198.00	24.01	194.09	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	JAN2	221.13	2944.54	23.50	20.30	169.46	220.87	2795.39	198.00	23.76	196.13	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	JAN3	220.87	2795.39	25.60	24.33	188.66	220.55	2631.06	198.00	23.48	198.51	42.52	0.00	0.00	11.23	0.00	11.23	
90% Yr.	FEB1	220.55	2631.06	18.78	16.23	173.81	220.25	2473.47	198.00	23.17	201.17	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	FEB2	220.25	2473.47	12.82	11.08	176.28	219.90	2308.27	198.00	22.84	204.03	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	FEB3	219.90	2308.27	25.21	17.43	142.97	219.62	2182.72	198.00	22.53	206.85	42.52	0.00	0.00	8.16	0.00	8.16	
90% Yr.	MAR1	219.62	2182.72	14.83	12.81	181.36	219.23	2014.17	198.00	22.20	209.91	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	MAR2	219.23	2014.17	13.27	11.47	184.72	218.80	1840.92	198.00	21.80	213.80	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	MAR3	218.80	1840.92	11.38	10.82	207.68	218.27	1644.05	198.00	21.33	218.52	42.52	0.00	0.00	11.23	0.00	11.23	
90% Yr.	APR1	218.27	1644.05	7.31	6.32	193.63	217.72	1456.73	198.00	20.80	224.11	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	APR2	217.72	1456.73	5.90	5.10	199.28	217.08	1262.55	198.00	20.21	230.64	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	APR3	217.08	1262.55	3.80	3.28	206.45	216.30	1059.38	198.00	19.50	238.95	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	MAY1	216.30	1059.38	5.68	4.91	215.81	215.36	848.48	198.00	18.66	249.78	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	MAY2	215.36	848.48	10.10	8.73	228.73	214.14	628.48	198.00	17.61	264.73	42.52	0.00	0.00	10.20	0.00	10.20	
90% Yr.	MAY3	214.14	628.48	8.58	8.15	276.87	212.00	359.76	198.00	16.00	291.32	42.51	-0.01	0.00	11.22	0.00	11.22	
TOTAL					6453.73	6453.73									333.99	33.40	367.39	

WAINGANGA HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	130.00	367.39	32.26	32.71	2826.11	-	100.00%
2	132.00	367.39	31.77	32.21	2783.29	0.00	100.00%
3	134.00	367.39	31.30	31.73	2741.75	0.00	100.00%
4	136.00	367.39	30.84	31.27	2701.43	0.00	100.00%
5	**138.00**	**367.39**	**30.39**	**30.81**	**2662.28**	**0.00**	**100.00%**
6	140.00	367.39	29.96	30.37	2624.25	0.00	100.00%
7	142.00	367.39	29.54	29.94	2587.28	0.00	100.00%
8	144.00	367.39	29.13	29.53	2551.35	0.00	100.00%
9	146.00	367.39	28.73	29.12	2516.40	0.00	100.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does not show any drop in different Installed capacity. However, the Annual Load Factor of 30.39 % justifies the installed capacity of 138 MW.

6.8.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	463.64	367.39
Firm Power (MW continuous)	45.15	42.52
Installed Capacity	176	***138(5x27.6MW)***
Annual load factor (%)	30.07	30.39

Regarding the number of generating units to be installed, the following options are possible.

- 4x34.50 MW
- 5x27.60 MW

Although, installation of 4 units of 34.50 MW would be economical but considering the reliability of the Project, installation of 5 units of 27.60 MW has been chosen.

6.9 Power Potential Studies of Samda Hydroelectric Project:

6.9.1 Conceptual Planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL& TWL has been considered as at EL 197.5 m, 196.35 m and 186 m respectively. Further, studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. Also, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Samda Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e. 0.11 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 15.41 MCum. The Elevation Area capacity Table is shown as below.

S. No.	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	196.35	11447059.69	1144.71	26066575.54	26.07
2	196.43	11528905.16	1152.89	26936423.52	26.94
3	196.50	11658019.95	1165.80	27806446.17	27.81
4	196.58	11809865.42	1180.99	28676468.82	28.68
5	196.65	11908980.21	1190.90	29546491.47	29.55
6	196.73	12010825.68	1201.08	30416339.45	30.42
7	196.81	12192671.15	1219.27	31286362.1	31.29
8	196.88	12351785.94	1235.18	32156384.75	32.16
9	196.96	12533631.41	1253.36	33026232.73	33.03

10	197.03	12792746.20	1279.27	33985123.41	33.99
11	197.11	12974591.67	1297.46	35053822.77	35.05
12	197.19	13156437.14	1315.64	36122522.13	36.12
13	197.26	13315551.93	1331.56	37191006.93	37.19
14	197.34	13597397.40	1359.74	38259706.28	38.26
15	197.41	13756512.18	1375.65	39328405.64	39.33
16	197.49	14038357.66	1403.84	40397105.00	40.44
17	197.50	14061088.34	1406.11	41437638.64	41.48

6.9.2 Hydrology

Hydrological Series data is developed for 15 years from 2000-01 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. The outflows of Wainganga HE Project which is in the Upstream of Samda Hydroelectric Project and the Intermediate Inflows has been considered for the studies. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		**Wainganga Outflows**	**Intermediate Inflows**	**Final Inflows**	**Environment Flows**	**Net Flows**
		A	**B**	**C=A+B**	**D**	**E=C-D**
Jun	I	6.24	0.40	6.64	1.33	5.31
	II	4.41	0.28	4.69	0.94	3.75
	III	5.35	0.34	5.69	1.14	4.55
Jul	I	84.26	5.37	89.63	26.89	62.74
	II	277.45	109.31	386.76	116.03	270.73
	III	218.06	126.67	344.74	103.42	241.31
Aug	I	202.11	14.89	217.00	65.10	151.90
	II	200.28	31.92	232.20	69.66	162.54

	III	770.74	94.15	864.89	259.47	605.42
Sep	I	767.17	75.23	842.40	252.72	589.68
	II	673.30	42.86	716.16	214.85	501.31
	III	312.95	19.92	332.87	99.86	233.01
Oct	I	313.08	19.93	333.01	99.90	233.11
	II	255.34	16.25	271.59	81.48	190.12
	III	197.36	6.30	203.66	61.10	142.56
Nov	I	198.44	6.50	204.94	51.23	153.70
	II	199.57	5.48	205.05	51.26	153.79
	III	199.18	24.62	223.80	55.95	167.85
Dec	I	198.86	4.34	203.21	50.80	152.41
	II	200.39	3.14	203.53	50.88	152.65
	III	202.32	1.51	203.84	50.96	152.88
Jan	I	204.50	2.11	206.62	41.32	165.29
	II	206.69	1.87	208.56	41.71	166.84
	III	209.14	2.04	211.18	42.24	168.94
Feb	I	211.90	1.49	213.39	42.68	170.71
	II	214.88	1.02	215.91	43.18	172.73
	III	217.81	2.01	219.82	43.96	175.86
Mar	I	221.03	1.18	222.21	44.44	177.77
	II	225.14	1.06	226.20	45.24	180.96
	III	230.15	0.90	231.06	46.21	184.84
Apr	I	235.99	0.58	236.57	47.31	189.26
	II	242.90	0.47	243.37	48.67	194.70
	III	251.77	0.31	252.07	50.41	201.66
May	I	263.35	0.45	263.80	52.76	211.04
	II	279.47	0.81	280.28	56.06	224.22
	III	308.30	0.68	308.98	61.80	247.18

6.9.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.9.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a RoR based Project. The study indicates that the firm power during 90% dependable year is 19.41 MW continuous .

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 57 MW to 77 MW in steps of 2 MW. The results are tabulated in as below:

SAMDA HYDROELECTRIC PROJECT

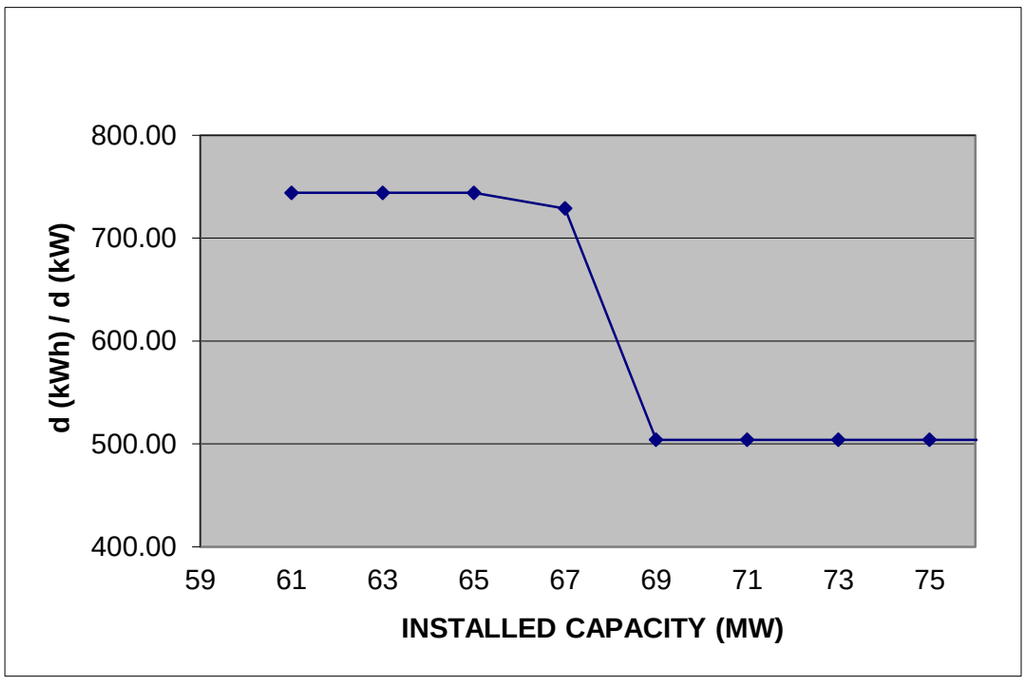
POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR

FRL	197.5	m	RATED HEAD		11.12	m		EFF.	93	%	
MDDL	196.35	m	WC LOSSES		0.11	m					
Av. TWL	185	m	NET RATED HEAD		11.01	m					

MONTH	INFLOWS	POWER	RESTRICTED	INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.	
		POTENTIAL	ENERGY	35	MW	37	MW	39	MW	41	MW	43	MW	45	MW	47	MW	49	MW	51	MW	53	MW	55	MW
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)
Jun	5.31	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12	0.50	0.12
	3.75	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08	0.35	0.08
	4.55	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10	0.42	0.10
Jul	62.74	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41	5.86	1.41
	270.73	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07	25.28	6.07
	241.31	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95	22.53	5.95
Aug	151.90	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40	14.18	3.40
	162.54	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64	15.18	3.64
	605.42	56.53	14.92	35.00	9.24	37.00	9.77	39.00	10.30	41.00	10.82	43.00	11.35	45.00	11.88	47.00	12.41	49.00	12.94	51.00	13.46	53.00	13.99	55.00	14.52
Sep	589.68	55.06	13.22	35.00	8.40	37.00	8.88	39.00	9.36	41.00	9.84	43.00	10.32	45.00	10.80	47.00	11.28	49.00	11.76	51.00	12.24	53.00	12.72	55.00	13.20
	501.31	46.81	11.23	35.00	8.40	37.00	8.88	39.00	9.36	41.00	9.84	43.00	10.32	45.00	10.80	46.81	11.23	46.81	11.23	46.81	11.23	46.81	11.23	46.81	11.23
	233.01	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22	21.76	5.22
Oct	233.11	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22	21.77	5.22
	190.12	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26	17.75	4.26
	142.56	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51	13.31	3.51
Nov	153.70	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44	14.35	3.44
	153.79	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45	14.36	3.45
	167.85	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76	15.67	3.76
Dec	152.41	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42	14.23	3.42
	152.65	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42	14.25	3.42
	152.88	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77	14.28	3.77
Jan	165.29	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70	15.43	3.70
	166.84	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74	15.58	3.74
	168.94	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16	15.78	4.16
Feb	170.71	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83	15.94	3.83
	172.73	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87	16.13	3.87
	175.86	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15	16.42	3.15
Mar	177.77	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98	16.60	3.98
	180.96	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06	16.90	4.06
	184.84	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56	17.26	4.56
Apr	189.26	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24	17.67	4.24
	194.70	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36	18.18	4.36
	201.66	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52	18.83	4.52
May	211.04	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73	19.71	4.73
	224.22	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02	20.94	5.02
	247.18	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09	23.08	6.09
Total energy (GWh)			163.65		150.32		151.81		153.29		154.78		156.27		157.76		159.20		160.21		161.22		162.23		163.23
Firm Power (MWc) (Lean Period Nov to Jan)				14.88		14.88		14.88		14.88		14.88		14.88		14.88		14.88		14.88		14.88		14.88	
Incr. Energy(GWh)					-		1.49		1.49		1.49		1.49		1.49		1.44		1.01		1.01		1.01		1.01
Incr. Cap.(MW)					-		2		2		2		2		2		2		2		2		2		2
Incr. Energy/Incr. Power (kWh/kW)					-		744.00		744.00		744.00		744.00		744.00		721.39		504.00		504.00		504.00		504.00

SAMDA HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	57	206.44	41.34	34.05	3621.70	-	
2	59	207.92	40.23	32.90	3524.15	744.00	94%
3	61	209.41	39.19	31.82	3433.00	744.00	95%
4	63	210.90	38.21	30.81	3347.63	744.00	96%
5	65	212.39	37.30	29.86	3267.52	744.00	96%
6	**67**	**213.85**	**36.44**	**28.97**	**3191.74**	**728.84**	**97%**
7	69	214.85	35.55	28.13	3113.83	504.00	98%
8	71	215.86	34.71	27.34	3040.32	504.00	98%
9	73	216.87	33.91	26.59	2970.83	504.00	98%
10	75	217.88	33.16	25.88	2905.05	504.00	98%
11	77	218.89	32.45	25.21	2842.68	504.00	99%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 67 MW. Also, the Annual Load Factor of 36.44 % and the Energy harness of 97% justifies the installed capacity of 67 MW.

6.9.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 14.88 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 35 MW to 55 MW in steps of 2 MW. The results are tabulated in as below:

SAMDA HYDROELECTRIC PROJECT

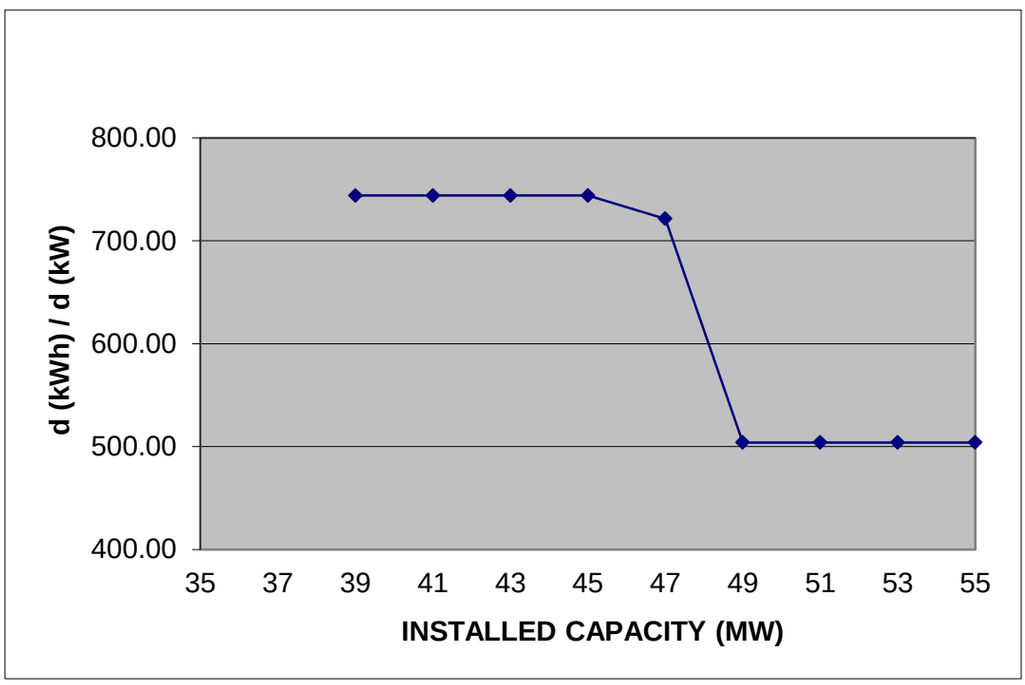
POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR

FRL	197.5	m	RATED HEAD	11.12	m		EFF.	93	%
MDDL	196.35	m	WC LOSSES	0.11	m				
Av. TWL	185	m	NET RATED HEAD	11.01	m				

MONTH	INFLOWS	POWER	RESTRICTED	INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.	
		POTENTIAL	ENERGY	57	MW	59	MW	61	MW	63	MW	65	MW	67	MW	69	MW	71	MW	73	MW	75	MW	77	MW		
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY		
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)		
Jun	6.64	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15	0.62	0.15		
	4.69	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11	0.44	0.11		
	5.69	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13	0.53	0.13		
Jul	89.63	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01	8.37	2.01		
	386.76	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67	36.11	8.67		
	344.74	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50	32.19	8.50		
Aug	217.00	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86	20.26	4.86		
	232.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20	21.68	5.20		
	864.89	80.76	21.32	57.00	15.05	59.00	15.58	61.00	16.10	63.00	16.63	65.00	17.16	67.00	17.69	69.00	18.22	71.00	18.74	73.00	19.27	75.00	19.80	77.00	20.33		
Sep	842.40	78.66	18.88	57.00	13.68	59.00	14.16	61.00	14.64	63.00	15.12	65.00	15.60	67.00	16.08	69.00	16.56	71.00	17.04	73.00	17.52	75.00	18.00	77.00	18.48		
	716.16	66.87	16.05	57.00	13.68	59.00	14.16	61.00	14.64	63.00	15.12	65.00	15.60	66.87	16.05	66.87	16.05	66.87	16.05	66.87	16.05	66.87	16.05	66.87	16.05		
	332.87	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46	31.08	7.46		
Oct	333.01	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46	31.10	7.46		
	271.59	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09	25.36	6.09		
	203.66	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02	19.02	5.02		
Nov	204.94	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59	19.14	4.59		
	205.05	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60	19.15	4.60		
	223.80	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02	20.90	5.02		
Dec	203.21	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55	18.98	4.55		
	203.53	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56	19.01	4.56		
	203.84	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02	19.03	5.02		
Jan	206.62	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63	19.29	4.63		
	208.56	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67	19.47	4.67		
	211.18	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21	19.72	5.21		
Feb	213.39	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78	19.93	4.78		
	215.91	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84	20.16	4.84		
	219.82	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94	20.53	3.94		
Mar	222.21	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98	20.75	4.98		
	226.20	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07	21.12	5.07		
	231.06	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70	21.58	5.70		
Apr	236.57	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30	22.09	5.30		
	243.37	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45	22.73	5.45		
	252.07	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65	23.54	5.65		
May	263.80	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91	24.63	5.91		
	280.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28	26.17	6.28		
	308.98	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62	28.85	7.62		
Total energy (GWh)			220.28		206.44		207.92		209.41		210.90		212.39		213.85		214.85		215.86		216.87		217.88		218.89		
Firm Power (MWc) Nov to Jan)				19.41		19.41		19.41		19.41		19.41		19.41		19.41		19.41		19.41		19.41		19.41			
Incr. Energy(GWh)					-		1.49		1.49		1.49		1.49		1.46		1.01		1.01		1.01		1.01		1.01		
Incr. Cap.(MW)					-		2		2		2		2		2		2		2		2		2		2		
Incr. Energy/Incr. Power (kWh/kW)					-		744.00		744.00		744.00		744.00		728.84		504.00		504.00		504.00		504.00		504.00		

SAMDA HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	Annual L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	35	150.32	49.03	42.52	4294.82	-	
2	37	151.81	46.84	40.22	4102.88	744.00	93%
3	39	153.29	44.87	38.16	3930.63	744.00	94%
4	41	154.78	43.10	36.30	3775.19	744.00	95%
5	43	156.27	41.49	34.61	3634.20	744.00	95%
6	**45**	**157.76**	**40.02**	**33.07**	**3505.75**	**744.00**	**96%**
7	47	159.20	38.67	31.66	3387.27	721.39	97%
8	49	160.21	37.32	30.37	3269.58	504.00	98%
9	51	161.22	36.09	29.18	3161.13	504.00	99%
10	53	162.23	34.94	28.08	3060.86	504.00	99%
11	55	163.23	33.88	27.06	2967.88	504.00	99%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 45 MW. Also, the Annual Load

Factor of 40.02 % and the Energy harness of 96% justifies the installed capacity of 45 MW.

6.9.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	**Without Environmental Flows**	**With Environmental Flows**
Annual Energy Generation (GWh)	213.85	157.76
Firm Power (MW continuous)	19.41	14.88
Installed Capacity	67	***45(3x15MW)***
Annual load factor (%)	36.44	40.02

Regarding the number of generating units to be installed, the following options are possible.

- 2x22.5 MW
- 3x15 MW

Although, installation of 2 units of 22.5 MW would be economical but considering the reliability of the Project, installation of 3 units of 15 MW has been chosen.

6.10 Power Potential Studies of Kunghara Hydroelectric Project:

6.10.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 160 m, 153 m and 145 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking into account of inflows, environmental aspects and the topography of the area. Also, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Kunghara Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e. 0.16 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 721.29 MCum. The Elevation Area capacity Table is shown as below.

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	153.0	14504883.39	1450.49	2659719680	2659.72
2	153.5	14723741.07	1472.37	2706209845	2706.21
3	154.0	15023718.39	1502.37	2752981134	2752.98
4	154.5	15244571.68	1524.46	2800023471	2800.02
5	155.0	15465831.71	1546.58	2847317977	2847.32
6	155.25	15771463.07	1577.15	2894884506	2894.88
7	156.0	15994725.16	1599.47	2942735575	2942.74
8	156.5	16218396.16	1621.84	2990840163	2990.84

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
9	157.0	16530058.35	1653.01	3039206872	3039.21
10	157.5	16755742.92	1675.57	3087872623	3087.87
11	158.0	16981838.57	1698.18	3136794260	3136.79
12	158.5	17208345.30	1720.83	3185969762	3185.97
13	159.0	17527364.22	1752.74	3235452405	3235.45
14	159.5	17755893.97	1775.59	3285194822	3285.19
15	159.75	17984836.98	1798.48	3335193455	3335.19
16	160.0	18214193.24	1821.42	3377629485	3381.01

6.10.2 Hydrology

Hydrological Series data is developed for 15 years from 2000-01 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. The outflows of Samda Hydroelectric Project which is in the Upstream of Kunghara Hydroelectric Project and the Intermediate Inflows has been considered for the studies. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Samda Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Jun	I	6.64	1.27	7.91	1.98	5.93
	II	4.69	82.49	87.18	21.79	65.38
	III	5.69	1.09	6.77	1.69	5.08
Jul	I	89.63	17.10	106.72	32.02	74.71
	II	386.76	348.45	735.21	220.56	514.64
	III	344.74	403.78	748.51	224.55	523.96

Period (10 Daily)		Samda Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Aug	I	217.00	47.46	264.46	79.34	185.12
	II	232.20	101.75	333.94	100.18	233.76
	III	864.89	300.11	1165.00	349.50	815.50
Sep	I	842.40	239.81	1082.21	324.66	757.55
	II	716.16	136.61	852.77	255.83	596.94
	III	332.87	63.50	396.37	118.91	277.46
Oct	I	333.01	63.52	396.54	118.96	277.57
	II	271.59	51.81	323.40	97.02	226.38
	III	203.66	20.10	223.76	67.13	156.63
Nov	I	204.94	20.71	225.65	56.41	169.23
	II	205.05	17.45	222.50	55.62	166.87
	III	223.80	78.50	302.30	75.57	226.72
Dec	I	203.21	13.86	217.07	43.41	173.65
	II	203.53	10.00	213.52	42.70	170.82
	III	203.84	4.83	208.66	41.73	166.93
Jan	I	206.62	6.73	213.34	42.67	170.68
	II	208.56	5.96	214.52	42.90	171.62
	III	211.18	6.49	217.66	43.53	174.13
Feb	I	213.39	4.76	218.15	43.63	174.52
	II	215.91	3.25	219.16	43.83	175.33
	III	219.82	6.39	226.22	45.24	180.97
Mar	I	222.21	3.76	225.97	45.19	180.78
	II	226.20	3.36	229.56	45.91	183.65
	III	231.06	2.88	233.94	46.79	187.15
Apr	I	236.57	1.85	238.42	47.68	190.74
	II	243.37	1.50	244.87	48.97	195.89
	III	252.07	0.96	253.04	50.61	202.43
May	I	263.80	1.44	265.24	53.05	212.19
	II	280.28	2.57	282.85	56.57	226.28
	III	308.98	2.18	311.16	62.23	248.92

6.10.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.10.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a RoR based Project. The study indicates that the firm power during 90% dependable year is 33.88 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 130 MW to 146 MW in steps of 2 MW. The results are tabulated in as below:

KUNGHARA HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		160.00		3381.01						T.G.EFF.	=	0.93				
	M.D.D.L		153.00		2659.72						Firm Power exep.(MW)	=	33.88				
	Av. T.W.L.		145.00								Installed Capacity (MW)	=	138.00				
											W.C.Losses (m)	=	0.16				
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	153.00	2659.72	7.91	6.83	6.83	153.00	2659.72	145.00	8.91	7.91	0.64	0.00	0.00	0.15	0.00	0.15
90% Yr.	JUN 2	153.00	2659.72	87.18	75.32	75.32	153.00	2659.72	145.00	8.91	87.18	7.09	0.00	0.00	1.70	0.00	1.70
90% Yr.	JUN3	153.00	2659.72	6.77	5.85	5.85	153.00	2659.72	145.00	8.91	6.77	0.55	0.00	0.00	0.13	0.00	0.13
90% Yr.	JUL 1	153.00	2659.72	106.72	92.21	92.21	153.00	2659.72	145.00	8.91	106.72	8.68	0.00	0.00	2.08	0.00	2.08
90% Yr.	JUL2	153.00	2659.72	735.21	635.22	309.67	156.44	2985.27	145.00	10.36	358.42	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	JUL3	156.44	2985.27	748.51	711.38	315.64	160.00	3381.01	145.00	14.08	332.11	33.88	8.78	0.00	8.94	2.32	11.26
90% Yr.	AUG1	160.00	3381.01	264.46	228.49	228.49	160.00	3381.01	145.00	15.84	264.46	33.88	4.34	0.00	8.13	1.04	9.17
90% Yr.	AUG2	160.00	3381.01	333.94	288.52	288.52	160.00	3381.01	145.00	15.84	333.94	33.88	14.38	0.00	8.13	3.45	11.58
90% Yr.	AUG3	160.00	3381.01	1165.00	1107.22	907.57	160.00	3381.01	145.00	15.84	954.93	33.88	104.12	30.36	8.94	27.49	36.43
90% Yr.	SEP1	160.00	3381.01	1082.21	935.03	825.06	160.00	3381.01	145.00	15.84	954.93	33.88	104.12	18.39	8.13	24.99	33.12
90% Yr.	SEP2	160.00	3381.01	852.77	736.79	736.79	160.00	3381.01	145.00	15.84	852.77	33.88	89.35	0.00	8.13	21.45	29.58
90% Yr.	SEP3	160.00	3381.01	396.37	342.46	342.46	160.00	3381.01	145.00	15.84	396.37	33.88	23.40	0.00	8.13	5.62	13.75
90% Yr.	OCT1	160.00	3381.01	396.54	342.61	342.61	160.00	3381.01	145.00	15.84	396.54	33.88	23.42	0.00	8.13	5.62	13.75
90% Yr.	OCT2	160.00	3381.01	323.40	279.42	279.42	160.00	3381.01	145.00	15.84	323.40	33.88	12.85	0.00	8.13	3.08	11.22
90% Yr.	OCT3	160.00	3381.01	223.76	212.66	223.13	159.94	3370.54	145.00	15.82	234.77	33.88	0.00	0.00	8.94	0.00	8.94
90% Yr.	NOV1	159.94	3370.54	225.65	194.96	203.51	159.90	3361.99	145.00	15.77	235.55	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	NOV2	159.90	3361.99	222.50	192.24	204.23	159.83	3350.00	145.00	15.71	236.37	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	NOV3	159.83	3350.00	302.30	261.19	230.18	160.00	3381.01	145.00	15.76	266.41	33.88	4.42	0.00	8.13	1.06	9.19
90% Yr.	DEC1	160.00	3381.01	217.07	187.55	203.02	159.92	3365.54	145.00	15.80	234.97	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	DEC2	159.92	3365.54	213.52	184.48	204.24	159.81	3345.78	145.00	15.71	236.39	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	DEC3	159.81	3345.78	208.66	198.31	226.46	159.66	3317.63	145.00	15.59	238.28	33.88	0.00	0.00	8.94	0.00	8.94
90% Yr.	JAN1	159.66	3317.63	213.34	184.33	207.62	159.55	3294.33	145.00	15.45	240.30	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	JAN2	159.55	3294.33	214.52	185.35	209.60	159.35	3270.07	145.00	15.31	242.60	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	JAN3	159.35	3270.07	217.66	206.86	234.06	159.07	3242.88	145.00	15.08	246.28	33.88	0.00	0.00	8.94	0.00	8.94
90% Yr.	FEB1	159.07	3242.88	218.15	188.48	216.77	158.79	3214.59	145.00	14.80	250.89	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	FEB2	158.79	3214.59	219.16	189.35	221.24	158.47	3182.70	145.00	14.50	256.06	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	FEB3	158.47	3182.70	226.22	156.36	180.57	158.22	3158.50	145.00	14.22	261.24	33.88	0.00	0.00	6.51	0.00	6.51
90% Yr.	MAR1	158.22	3158.50	225.97	195.24	230.42	157.86	3123.32	145.00	13.93	266.69	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	MAR2	157.86	3123.32	229.56	198.34	236.70	157.47	3084.96	145.00	13.56	273.96	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	MAR3	157.47	3084.96	233.94	222.34	268.74	156.99	3038.55	145.00	13.13	282.77	33.88	0.00	0.00	8.94	0.00	8.94
90% Yr.	APR1	156.99	3038.55	238.42	205.99	253.58	156.50	2990.97	145.00	12.65	293.49	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	APR2	156.50	2990.97	244.87	211.57	264.21	155.93	2938.32	145.00	12.14	305.80	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	APR3	155.93	2938.32	253.04	218.63	280.07	155.16	2876.88	145.00	11.46	324.16	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	MAY1	155.16	2876.88	265.24	229.17	296.67	154.60	2809.38	145.00	10.82	343.37	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	MAY2	154.60	2809.38	282.85	244.38	315.01	153.85	2738.75	145.00	10.19	364.59	33.88	0.00	0.00	8.13	0.00	8.13
90% Yr.	MAY3	153.85	2738.75	311.16	295.73	374.76	153.00	2659.72	145.00	9.42	394.32	33.88	-0.01	0.00	8.94	0.00	8.94
TOTAL					10350.87	10041.25									268.35	96.11	364.45

KUNGARA HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL LOAD FACTOR (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	130.00	360.42	31.65	26.06	2772.48	-	95.63%
2	132.00	361.43	31.26	25.67	2738.11	504.00	95.90%
3	134.00	362.44	30.88	25.28	2704.77	504.00	96.17%
4	136.00	363.45	30.51	24.91	2672.40	504.00	96.43%
5	**138.00**	**364.45**	**30.15**	**24.55**	**2640.98**	**504.00**	**96.70%**
6	140.00	365.46	29.80	24.20	2610.45	504.00	96.97%
7	142.00	366.47	29.46	23.86	2580.78	504.00	97.24%
8	144.00	367.48	29.13	23.53	2551.94	504.00	97.50%
9	146.00	368.49	28.81	23.21	2523.88	504.00	97.77%

The Annual Load Factor of 30.15 % justifies the installed capacity of 138MW.

6.10.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 26.93 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 90 MW to 106 MW in steps of 2 MW. The results are tabulated in as below:

KUNGHARA HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		160.00		3381.01						T.G.EFF.	=	0.93					
	M.D.D.L		153.00		2659.72						Firm Power exep.(MW)	=	26.93					
	Av. T.W.L.		145.00								Installed Capacity (MW)	=	98.00					
											W.C.Losses (m)	=	0.16					
YEAR	MONTH	INITIAL LEVEL	INITAL STORAGE	INFLOW	INFLOW	WITH-DRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY	
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh	
90% Yr.	JUN 1	153.00	2659.72	6.33	5.47	5.47	153.00	2659.72	145.00	8.91	6.33	0.51	0.00	0.00	0.12	0.00	0.12	
90% Yr.	JUN 2	153.00	2659.72	69.74	60.26	60.26	153.00	2659.72	145.00	8.91	69.74	5.67	0.00	0.00	1.36	0.00	1.36	
90% Yr.	JUN3	153.00	2659.72	5.42	4.68	4.68	153.00	2659.72	145.00	8.91	5.42	0.44	0.00	0.00	0.11	0.00	0.11	
90% Yr.	JUL 1	153.00	2659.72	74.70	64.54	64.54	153.00	2659.72	145.00	8.91	74.70	6.07	0.00	0.00	1.46	0.00	1.46	
90% Yr.	JUL2	153.00	2659.72	514.65	444.66	261.23	154.96	2843.14	145.00	9.76	302.35	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	JUL3	154.96	2843.14	523.96	497.97	232.01	157.72	3109.10	145.00	12.09	244.12	26.93	0.00	0.00	7.11	0.00	7.11	
90% Yr.	AUG1	157.72	3109.10	185.12	159.95	189.63	157.41	3079.41	145.00	13.45	219.48	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	AUG2	157.41	3079.41	233.76	201.97	191.19	157.52	3090.19	145.00	13.34	221.28	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	AUG3	157.52	3090.19	815.50	775.05	484.24	160.00	3381.01	145.00	14.61	509.51	26.93	41.00	0.00	7.11	10.82	17.93	
90% Yr.	SEP1	160.00	3381.01	757.55	654.52	585.91	160.00	3381.01	145.00	15.84	678.14	26.93	71.07	11.48	6.46	17.06	23.52	
90% Yr.	SEP2	160.00	3381.01	596.94	515.76	515.76	160.00	3381.01	145.00	15.84	596.94	26.93	59.34	0.00	6.46	14.24	20.70	
90% Yr.	SEP3	160.00	3381.01	277.46	239.72	239.72	160.00	3381.01	145.00	15.84	277.46	26.93	13.17	0.00	6.46	3.16	9.62	
90% Yr.	OCT1	160.00	3381.01	277.58	239.83	239.83	160.00	3381.01	145.00	15.84	277.58	26.93	13.18	0.00	6.46	3.16	9.63	
90% Yr.	OCT2	160.00	3381.01	226.38	195.59	195.59	160.00	3381.01	145.00	15.84	226.38	26.93	5.79	0.00	6.46	1.39	7.85	
90% Yr.	OCT3	160.00	3381.01	156.63	148.86	177.90	159.84	3351.97	145.00	15.77	187.19	26.93	0.00	0.00	7.11	0.00	7.11	
90% Yr.	NOV1	159.84	3351.97	169.24	146.22	163.03	159.75	3335.16	145.00	15.64	188.69	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	NOV2	159.75	3335.16	166.88	144.18	164.02	159.65	3315.32	145.00	15.55	189.84	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	NOV3	159.65	3315.32	226.73	195.89	163.70	159.82	3347.51	145.00	15.58	189.47	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	DEC1	159.82	3347.51	162.80	140.66	163.42	159.70	3324.75	145.00	15.61	189.15	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	DEC2	159.70	3324.75	160.14	138.36	164.73	159.57	3298.38	145.00	15.48	190.66	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	DEC3	159.57	3298.38	156.50	148.73	183.51	159.28	3263.60	145.00	15.29	193.09	26.93	0.00	0.00	7.11	0.00	7.11	
90% Yr.	JAN1	159.28	3263.60	170.67	147.46	169.64	159.06	3241.43	145.00	15.03	196.34	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	JAN2	159.06	3241.43	171.62	148.28	172.26	158.82	3217.44	145.00	14.80	199.38	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	JAN3	158.82	3217.44	174.13	165.49	192.79	158.54	3190.13	145.00	14.55	202.86	26.93	0.00	0.00	7.11	0.00	7.11	
90% Yr.	FEB1	158.54	3190.13	174.52	150.79	178.68	158.26	3162.24	145.00	14.27	206.80	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	FEB2	158.26	3162.24	175.33	151.48	182.44	157.94	3131.28	145.00	13.98	211.16	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	FEB3	157.94	3131.28	180.98	125.09	148.95	157.70	3107.42	145.00	13.70	215.50	26.93	0.00	0.00	5.17	0.00	5.17	
90% Yr.	MAR1	157.70	3107.42	180.78	156.19	190.16	157.35	3073.45	145.00	13.41	220.10	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	MAR2	157.35	3073.45	183.65	158.67	195.36	156.97	3036.76	145.00	13.05	226.12	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	MAR3	156.97	3036.76	187.15	177.87	221.78	156.52	2992.84	145.00	12.65	233.36	26.93	0.00	0.00	7.11	0.00	7.11	
90% Yr.	APR1	156.52	2992.84	190.74	164.80	209.12	156.06	2948.52	145.00	12.20	242.03	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	APR2	156.06	2948.52	195.90	169.25	219.34	155.31	2898.44	145.00	11.63	253.86	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	APR3	155.31	2898.44	202.43	174.90	230.95	154.95	2842.39	145.00	11.04	267.30	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	MAY1	154.95	2842.39	212.19	183.33	241.08	154.34	2784.65	145.00	10.58	279.02	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	MAY2	154.34	2784.65	226.28	195.51	255.97	153.69	2724.19	145.00	9.96	296.26	26.93	0.00	0.00	6.46	0.00	6.46	
90% Yr.	MAY3	153.69	2724.19	248.93	236.58	301.05	153.00	2659.72	145.00	9.31	316.76	26.92	-0.01	0.00	7.11	0.00	7.10	
TOTAL					7628.56	7559.95									213.09	49.83	262.92	

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	A.L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	90.00	261.00	33.11	29.92	2900.05	-	98.24%
2	92.00	261.48	32.45	29.27	2842.22	240.00	98.42%
3	94.00	261.96	31.81	28.65	2786.85	240.00	98.60%
4	96.00	262.44	31.21	28.05	2733.79	240.00	98.78%
5	98.00	262.92	30.63	27.48	2682.90	240.00	98.96%
6	**100.00**	**263.40**	**30.07**	**26.93**	**2634.04**	**240.00**	**99.14%**
7	102.00	263.88	29.53	26.40	2587.10	240.00	99.32%
8	104.00	264.36	29.02	25.89	2541.96	240.00	99.51%
9	106.00	264.84	28.52	25.40	2498.53	240.00	99.69%

The Annual Load Factor of 30.07% justifies the installed capacity of 100 MW.

6.10.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	364.45	263.40
Firm Power (MW continuous)	33.88	26.93
Installed Capacity	138	***100(4x25MW)***
Load factor (%)	30.15	30.07

Regarding the number of generating units to be installed, the following options are possible.

- 3x33.33 MW
- 4x25 MW

Although, installation of 3 units of 33.33 MW would be economical but considering the reliability of the Project, installation of 4 units of 25 MW has been chosen.

6.11 Power Potential Studies of Pranhita Hydroelectric Project:

6.11.1 Conceptual planning

Fixation of FRL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL, MDDL & TWL was considered as at EL 144.50 m, 131.32 m and 113 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. In addition, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. The head loss of 0.32 m has been considered for this particular project.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 140.76 MCum. The Elevation Area capacity Table is shown as below.

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	131.32	84178954.32	8417.90	119895212.2	119.90
2	132.26	97910532.93	9791.05	125653992.2	125.65
3	133.2	113115968.90	11311.60	131928497.8	131.93
4	134.14	128662392.90	12866.24	138587487	138.59
5	135.08	143837769.32	14383.78	145560207.8	145.56
6	136.02	160856171.96	16085.62	152968592.8	152.97
7	136.96	165856171.96	16585.62	160795615.1	160.80
8	137.9	178214623.27	17821.46	169477871.4	169.48
9	138.84	195438745.95	19543.87	179125752.3	179.13

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
10	139.78	215601189.75	21560.12	189641370.1	189.64
11	140.72	240275384.26	24027.54	201314739.6	201.31
12	141.66	265336595.50	26533.66	213814997.9	213.81
13	142.6	292714270.87	29271.43	227621948.1	227.62
14	143.54	324252375.97	32425.24	242473264	242.47
15	144.48	337155372.56	33715.54	259287668.6	259.29
16	144.5	357155372.56	35715.54	260660593.7	260.66

6.11.2 Hydrology

Hydrological Series data is developed for 25 years from 1990-91 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. The outflows of Kunghara Hydroelectric Project which is in the Upstream of Pranhita Hydroelectric Project and the Intermediate Inflows has been considered for the studies. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Kunghara Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Jun	I	7.91	10.63	18.54	3.71	14.83
	II	87.18	0.00	87.18	17.44	69.74
	III	6.77	74.22	80.99	16.20	64.79
Jul	I	106.72	135.83	242.55	72.76	169.78
	II	358.42	53.05	411.47	123.44	288.03
	III	332.11	299.47	631.59	189.48	442.11
Aug	I	264.46	104.26	368.72	110.62	258.11
	II	333.94	0.00	333.94	100.18	233.76
	III	954.93	0.00	954.93	286.48	668.45

Period (10 Daily)		Kunghara Outflows	Intermediate Inflows	Final Inflows	Environment Flows	Net Flows
		A	B	C=A+B	D	E=C-D
Sep	I	954.93	412.81	1367.74	410.32	957.42
	II	852.77	0.00	852.77	255.83	596.94
	III	396.37	19.72	416.09	124.83	291.26
Oct	I	396.54	0.00	396.54	99.14	297.41
	II	323.40	3.16	326.56	81.64	244.92
	III	234.77	0.00	234.77	58.69	176.08
Nov	I	235.55	0.00	235.55	58.89	176.66
	II	236.37	0.00	236.37	59.09	177.28
	III	266.41	0.00	266.41	66.60	199.81
Dec	I	234.97	6.79	241.76	60.44	181.32
	II	236.39	14.86	251.25	62.81	188.44
	III	238.28	16.21	254.49	63.62	190.87
Jan	I	240.30	13.51	253.8	50.76	203.05
	II	242.60	14.14	256.74	51.35	205.39
	III	246.28	8.54	254.81	50.96	203.85
Feb	I	250.89	8.38	259.28	51.86	207.42
	II	256.06	15.60	271.67	54.33	217.34
	III	261.24	0.00	261.24	52.25	208.99
Mar	I	266.69	11.12	277.81	55.56	222.25
	II	273.96	4.12	278.08	55.62	222.46
	III	282.77	1.89	284.66	56.93	227.73
Apr	I	293.49	0.70	294.19	58.84	235.35
	II	305.80	0.00	305.80	61.16	244.64
	III	324.16	1.69	325.85	65.17	260.68
May	I	343.37	0.00	343.37	68.67	274.70
	II	364.59	0.00	364.59	72.92	291.67
	III	394.32	0.00	394.32	78.86	315.45

6.11.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.11.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 68.90 MW continuous (July 2 to May 3).

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 282 MW to 298 MW in steps of 2 MW. The results are tabulated in as below:

PRANHITA HYDEL SCHEME (WITHOUT ENVIRONMENTAL FLOWS RELEASED)

RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		144.50		260.66						T.G.EFF.	=	0.93					
	M.D.D.L		131.32		119.9						Firm Power exep.(MW)	=	68.90					
	Av. T.W.L.		113.00								Installed Capacity (MW)	=	282.00					
											W.C.Losses (m)	=	0.32					
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL	
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY	
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh	
90% Yr.	JUN 1	131.32	119.90	18.54	16.02	16.02	131.32	119.90	113.00	18.14	18.54	3.07	0.00	0.00	0.74	0.00	0.74	
90% Yr.	JUN 2	131.32	119.90	87.18	75.32	75.32	131.32	119.90	113.00	18.14	87.18	14.43	0.00	0.00	3.46	0.00	3.46	
90% Yr.	JUN3	131.32	119.90	80.99	69.98	69.98	131.32	119.90	113.00	18.14	80.99	13.40	0.00	0.00	3.22	0.00	3.22	
90% Yr.	JUL 1	131.32	119.90	242.55	209.56	209.56	131.32	119.90	113.00	18.14	242.55	40.13	0.00	0.00	9.63	0.00	9.63	
90% Yr.	JUL2	131.32	119.90	411.47	355.51	355.51	131.32	119.90	113.00	18.14	411.47	68.08	0.00	0.00	16.34	0.00	16.34	
90% Yr.	JUL3	131.32	119.90	631.59	600.26	459.50	144.50	260.66	113.00	24.66	483.48	68.90	39.88	0.00	18.19	10.53	28.72	
90% Yr.	AUG1	144.50	260.66	368.72	318.58	318.58	144.50	260.66	113.00	31.19	368.72	68.90	36.00	0.00	16.54	8.64	25.18	
90% Yr.	AUG2	144.50	260.66	333.94	288.52	288.52	144.50	260.66	113.00	31.19	333.94	68.90	26.11	0.00	16.54	6.27	22.80	
90% Yr.	AUG3	144.50	260.66	954.93	907.57	907.57	144.50	260.66	113.00	31.19	954.93	68.90	202.79	0.00	18.19	53.54	71.73	
90% Yr.	SEP1	144.50	260.66	1367.74	1181.73	856.38	144.50	260.66	113.00	31.19	991.18	68.90	213.10	107.14	16.54	51.14	67.68	
90% Yr.	SEP2	144.50	260.66	852.77	736.79	736.79	144.50	260.66	113.00	31.19	852.77	68.90	173.72	0.00	16.54	41.69	58.23	
90% Yr.	SEP3	144.50	260.66	416.09	359.50	359.50	144.50	260.66	113.00	31.19	416.09	68.90	49.48	0.00	16.54	11.88	28.41	
90% Yr.	OCT1	144.50	260.66	396.54	342.61	342.61	144.50	260.66	113.00	31.19	396.54	68.90	43.92	0.00	16.54	10.54	27.08	
90% Yr.	OCT2	144.50	260.66	326.56	282.15	282.15	144.50	260.66	113.00	31.19	326.56	68.90	24.01	0.00	16.54	5.76	22.30	
90% Yr.	OCT3	144.50	260.66	234.77	223.13	230.93	144.12	252.86	113.00	31.08	242.98	68.90	0.00	0.00	18.19	0.00	18.19	
90% Yr.	NOV1	144.12	252.86	235.55	203.51	212.97	143.59	243.40	113.00	30.64	246.49	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	NOV2	143.59	243.40	236.37	204.23	217.47	142.76	230.16	113.00	30.01	251.70	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	NOV3	142.76	230.16	266.41	230.18	218.93	143.47	241.41	113.00	29.81	253.39	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	DEC1	143.47	241.41	241.76	208.88	217.48	142.93	232.82	113.00	30.00	251.71	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	DEC2	142.93	232.82	251.25	217.08	220.44	142.72	229.46	113.00	29.60	255.14	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	DEC3	142.72	229.46	254.49	241.87	243.90	142.59	227.43	113.00	29.43	256.62	68.90	0.00	0.00	18.19	0.00	18.19	
90% Yr.	JAN1	142.59	227.43	253.81	219.29	223.09	142.33	223.63	113.00	29.25	258.21	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	JAN2	142.33	223.63	256.74	221.82	224.91	142.12	220.55	113.00	29.01	260.31	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	JAN3	142.12	220.55	254.81	242.17	250.26	141.56	212.46	113.00	28.68	263.32	68.90	0.00	0.00	18.19	0.00	18.19	
90% Yr.	FEB1	141.56	212.46	259.28	224.01	232.16	140.95	204.32	113.00	28.11	268.70	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	FEB2	140.95	204.32	271.67	234.72	235.46	140.89	203.58	113.00	27.71	272.52	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	FEB3	140.89	203.58	261.24	180.57	190.83	140.08	193.32	113.00	27.35	276.09	68.90	0.00	0.00	13.23	0.00	13.23	
90% Yr.	MAR1	140.08	193.32	277.81	240.03	243.78	139.77	189.57	113.00	26.77	282.15	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	MAR2	139.77	189.57	278.08	240.26	247.61	139.12	182.22	113.00	26.35	286.59	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	MAR3	139.12	182.22	284.66	270.54	279.73	138.25	173.03	113.00	25.66	294.32	68.90	0.00	0.00	18.19	0.00	18.19	
90% Yr.	APR1	138.25	173.03	294.19	254.18	263.30	137.30	163.91	113.00	24.78	304.74	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	APR2	137.30	163.91	305.80	264.21	274.01	136.16	154.12	113.00	23.81	317.14	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	APR3	136.16	154.12	325.85	281.53	284.80	135.75	150.85	113.00	22.91	329.62	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	MAY1	135.75	150.85	343.37	296.67	282.26	137.44	165.26	113.00	23.12	326.69	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	MAY2	137.44	165.26	364.59	315.01	248.41	142.87	231.86	113.00	26.27	287.51	68.90	0.00	0.00	16.54	0.00	16.54	
90% Yr.	MAY3	142.87	231.86	394.32	374.76	486.72	131.32	119.90	113.00	30.38	512.12	68.90	73.03	0.00	18.19	19.28	37.47	
TOTAL					11132.75	10807.40									554.29	219.26	773.55	

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harnessed
1	282.00	762.71	30.88	24.43	2704.66	-	96.74%
2	284.00	763.19	30.68	24.26	2687.30	240.00	96.80%
3	286.00	763.67	30.48	24.09	2670.18	240.00	96.86%
4	288.00	764.15	30.29	23.92	2653.31	240.00	96.92%
5	**290.00**	**775.47**	**30.53**	**23.76**	**2674.03**	**240.00**	**97.02%**
6	292.00	766.11	29.91	23.60	2620.25	240.00	97.04%
7	294.00	766.59	29.73	23.44	2604.06	240.00	97.10%
8	296.00	777.15	29.54	23.28	2588.08	240.00	97.16%
9	298.00	777.39	29.36	23.12	2572.32	240.00	97.23%

The Annual Load Factor of 30.53 % justifies the installed capacity of 290 MW.

6.11.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 52.36 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 206 MW to 222 MW in steps of 2 MW. The results are tabulated in as below:

PRANHITA HYDEL SCHEME (WITH ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		144.50		260.66						T.G.EFF.	=	0.93				
	M.D.D.L		131.32		119.9						Firm Power exep.(MW)	=	52.36				
	Av. T.W.L.		113.00								Installed Capacity (MW)	=	214.00				
											W.C.Losses (m)	=	0.32				
		INITIAL	INITAL	INFLOW	INFLOW	WITH-	FINAL	FINAL	TWL	NET	DISCHARGE	FIRM	SEC.	SPILL	FIRM	SEC.	TOTAL
YEAR	MONTH	LEVEL	STORAGE			DRAWAL	LEVEL	STORAGE		HEAD		POWER	POWER	POWER	ENERGY	ENERGY	ENERGY
		M	MCUM	CUMECS	MCUM	MCUM	M	MCUM	M	M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN 1	131.32	119.90	14.83	12.81	12.81	131.32	119.90	113.00	18.14	14.83	2.45	0.00	0.00	0.59	0.00	0.59
90% Yr.	JUN 2	131.32	119.90	69.74	60.26	60.26	131.32	119.90	113.00	18.14	69.74	11.54	0.00	0.00	2.77	0.00	2.77
90% Yr.	JUN3	131.32	119.90	64.79	55.98	55.98	131.32	119.90	113.00	18.14	64.79	10.72	0.00	0.00	2.57	0.00	2.57
90% Yr.	JUL 1	131.32	119.90	169.78	146.69	146.69	131.32	119.90	113.00	18.14	169.78	28.09	0.00	0.00	6.74	0.00	6.74
90% Yr.	JUL2	131.32	119.90	288.03	248.86	248.86	131.32	119.90	113.00	18.14	288.03	47.66	0.00	0.00	11.44	0.00	11.44
90% Yr.	JUL3	131.32	119.90	442.11	420.18	279.42	144.50	260.66	113.00	24.18	294.00	52.36	12.51	0.00	13.82	3.30	17.12
90% Yr.	AUG1	144.50	260.66	258.11	223.00	223.00	144.50	260.66	113.00	31.19	258.11	52.36	21.08	0.00	12.57	5.06	17.62
90% Yr.	AUG2	144.50	260.66	233.76	201.97	201.97	144.50	260.66	113.00	31.19	233.76	52.36	14.15	0.00	12.57	3.40	15.96
90% Yr.	AUG3	144.50	260.66	668.45	635.30	635.30	144.50	260.66	113.00	31.19	668.45	52.36	137.82	0.00	13.82	36.39	50.21
90% Yr.	SEP1	144.50	260.66	957.42	827.21	649.87	144.50	260.66	113.00	31.19	752.17	52.36	161.64	58.39	12.57	38.79	51.36
90% Yr.	SEP2	144.50	260.66	596.94	515.76	515.76	144.50	260.66	113.00	31.19	596.94	52.36	117.48	0.00	12.57	28.19	40.76
90% Yr.	SEP3	144.50	260.66	291.26	251.65	251.65	144.50	260.66	113.00	31.19	291.26	52.36	30.51	0.00	12.57	7.32	19.89
90% Yr.	OCT1	144.50	260.66	297.41	256.96	256.96	144.50	260.66	113.00	31.19	297.41	52.36	32.26	0.00	12.57	7.74	20.31
90% Yr.	OCT2	144.50	260.66	244.92	211.61	211.61	144.50	260.66	113.00	31.19	244.92	52.36	17.33	0.00	12.57	4.16	16.72
90% Yr.	OCT3	144.50	260.66	176.08	167.35	175.65	144.09	252.36	113.00	31.05	184.81	52.36	0.00	0.00	13.82	0.00	13.82
90% Yr.	NOV1	144.09	252.36	176.66	152.64	162.08	143.56	242.92	113.00	30.59	187.59	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	NOV2	143.56	242.92	177.28	153.17	165.41	142.79	230.68	113.00	29.98	191.44	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	NOV3	142.79	230.68	199.81	172.64	167.00	143.15	236.31	113.00	29.69	193.29	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	DEC1	143.15	236.31	181.32	156.66	167.49	142.45	225.49	113.00	29.60	193.85	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	DEC2	142.45	225.49	188.44	162.81	171.13	141.89	217.17	113.00	28.97	198.07	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	DEC3	141.89	217.17	190.87	181.40	192.49	141.08	206.08	113.00	28.34	202.53	52.36	0.00	0.00	13.82	0.00	13.82
90% Yr.	JAN1	141.08	206.08	203.05	175.43	178.65	140.84	202.87	113.00	27.76	206.77	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	JAN2	140.84	202.87	205.39	177.46	180.08	140.63	200.24	113.00	27.53	208.43	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	JAN3	140.63	200.24	203.85	193.74	200.43	140.09	193.54	113.00	27.21	210.89	52.36	0.00	0.00	13.82	0.00	13.82
90% Yr.	FEB1	140.09	193.54	207.42	179.21	185.90	139.53	186.85	113.00	26.67	215.17	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	FEB2	139.53	186.85	217.34	187.78	188.50	139.47	186.13	113.00	26.30	218.17	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	FEB3	139.47	186.13	208.99	144.45	152.80	138.71	177.78	113.00	25.96	221.06	52.36	0.00	0.00	10.05	0.00	10.05
90% Yr.	MAR1	138.71	177.78	222.25	192.02	195.13	138.41	174.67	113.00	25.41	225.85	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	MAR2	138.41	174.67	222.46	192.21	198.26	137.81	168.62	113.00	25.01	229.47	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	MAR3	137.81	168.62	227.73	216.43	223.77	137.01	161.27	113.00	24.37	235.45	52.36	0.00	0.00	13.82	0.00	13.82
90% Yr.	APR1	137.01	161.27	235.35	203.34	210.23	136.19	154.39	113.00	23.59	243.32	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	APR2	136.19	154.39	244.64	211.37	217.38	135.44	148.38	113.00	22.81	251.60	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	APR3	135.44	148.38	260.68	225.23	220.58	136.03	153.02	113.00	22.48	255.30	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	MAY1	136.03	153.02	274.70	237.34	206.68	139.25	183.67	113.00	23.99	239.22	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	MAY2	139.25	183.67	291.67	252.01	175.66	144.49	260.02	113.00	28.23	203.31	52.36	0.00	0.00	12.57	0.00	12.57
90% Yr.	MAY3	144.49	260.02	315.45	299.81	439.93	131.32	119.90	113.00	31.18	462.89	52.36	79.32	0.00	13.82	20.94	34.76
TOTAL					8302.72	8125.38									419.94	155.29	575.23

PRANHITA HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS RELEASED)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harnessed
1	206.00	573.31	31.15	25.42	2729.06	-	97.24%
2	208.00	573.79	30.88	25.17	2705.12	240.00	97.33%
3	210.00	574.27	30.61	24.93	2681.65	240.00	97.41%
4	212.00	574.75	30.35	24.70	2658.61	240.00	97.49%
5	**214.00**	**575.23**	**30.68**	**24.47**	**2687.98**	**240.00**	**97.62%**
6	216.00	575.71	29.84	24.24	2613.82	240.00	97.66%
7	218.00	576.19	29.59	24.02	2592.04	240.00	97.74%
8	220.00	569.39	29.35	23.80	2570.66	240.00	97.82%
9	222.00	577.15	29.11	23.58	2549.67	240.00	97.91%

The Annual Load Factor of 30.68 % and the Energy harness of 97.62% justifies the installed capacity of 214 MW.

6.11.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	775.47	575.23
Firm Power (MW continuous)	68.90	52.36
Installed Capacity	290.00	**214 (4x53.5MW)**
Annual load factor (%)	30.53	30.68

Regarding the number of generating units to be installed, the following options are possible.

- 3x71.33MW
- 4x53.5 MW

Although, installation of 3 units of 71.33 MW would be economical but considering the reliability of the Project, installation of 4 units of 53.5 MW has been chosen.

6.12 Power Potential Studies of Balimela Hydroelectric Project:

6.12.1 Conceptual planning

Fixation of FRL, TWL, & Live Storage of Reservoir

In previous studies the FRL, MDDL & TWL was considered as at EL 462.1 m, 438.9 m, and 411.5 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking in to account of environmental aspects. In addition, the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. The head loss of 0.36 m has been considered for this particular project.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 888.03 MCum. The Elevation Area capacity Table is shown as below.

S. No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	438.9	20740136.80	2074.01	1431802714	1431.80
2	440.65	27672457.12	2767.25	1467046684	1467.05
3	442.30	30513704.86	3051.37	1503506322	1503.51
4	443.95	33900528.59	3390.05	1541021972	1541.02
5	445.60	37649764.86	3764.98	1579631869	1579.63
6	447.25	42585840.75	4258.58	1619421146	1619.42
7	448.90	48969847.81	4896.98	1660333238	1660.33
8	450.55	55932212.69	5593.22	1702585586	1702.59
9	452.20	65815710.60	6581.57	1745983910	1745.98

S. No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
10	453.85	75241028.93	7524.10	1790591192	1790.59
11	455.50	80125465.73	8012.55	1836432549	1836.43
12	457.15	98925402.20	9892.54	1883391272	1883.39
13	458.80	108266220.20	10826.62	1931390659	1931.39
14	460.45	120026743.60	12002.67	2041413457	2041.41
15	462.10	144417133.20	14441.71	2319826113	2319.83
16	463.10	174417133.20	17441.71	2399826113	2399.83

6.12.2 Hydrology

The water inflows on monthly basis for is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (Monthly)		Inflows	Environment Flows	Net Flows
		A	B	C=A+B
Jun	I	111.93	33.58	78.35
Jul	I	165.83	49.75	116.08
Aug	I	168.41	50.52	117.89
Sep	I	144.86	43.46	101.40
Oct	I	91.34	22.84	68.51
Nov	I	24.89	4.98	19.91
Dec	I	4.43	0.89	3.54
Jan	I	6.74	1.35	5.39
Feb	I	9.85	1.97	7.88
Mar	I	21.37	4.27	17.10
Apr	I	75.42	18.85	56.56
May	I	108.61	27.15	81.46

6.12.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.12.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a storage based Project. The study indicates that the firm power during 90% dependable year is 10.92 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 28 MW to 44 MW in steps of 2 MW. The results are tabulated in as below:

BALIMELA HEP (WITHOUT ENVIRONMENTAL FLOWS RELEASED)
RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		462.10			3595.5							T.G.EFF.	=	0.93				
	M.D.D.L		438.90			940.59							Firm Power exep.(MW)	=	10.92				
	Av. T.W.L.		411.50										Installed Capacity (MW)	=	36.00				
													W.C.Losses	=	0.36				

YEAR	MONTH	INITIAL LEVEL	INITAL STORAGE	INFLOW ACTUAL	INFLOW 50%	INFLOW	WITH-DRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE REGULATED	DISCHARGE REGULATED AFTER RELEASING 50%	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM		CUMECS	MCUM	MCUM	M	MCUM	M		M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN	438.90	940.59	111.93	43.50	112.75	112.75	438.90	940.59	411.50	27.52	87.00	43.50	10.92	0.00	0.00	7.86	0.00	7.86
90% Yr.	JUL	438.90	940.59	165.83	40.56	108.62	108.62	438.90	940.59	411.50	29.52	81.11	40.56	10.92	0.00	0.00	8.13	0.00	8.13
90% Yr.	AUG	438.90	940.59	168.41	36.74	98.40	98.40	438.90	940.59	411.50	32.58	73.48	36.74	10.92	0.00	0.00	8.13	0.00	8.13
90% Yr.	SEP	438.90	940.59	144.86	34.05	88.26	88.26	438.90	940.59	411.50	35.15	68.10	34.05	10.92	0.00	0.00	7.86	0.00	7.86
90% Yr.	OCT	438.90	940.59	91.34	32.74	87.68	87.68	438.90	940.59	411.50	36.57	65.47	32.74	10.92	0.00	0.00	8.13	0.00	8.13
90% Yr.	NOV	438.90	940.59	24.89	32.89	85.24	85.24	438.90	940.59	411.50	36.40	65.78	32.89	10.92	0.00	0.00	7.86	0.00	7.86
90% Yr.	DEC	438.90	940.59	4.43	34.24	91.70	91.70	438.90	940.59	411.50	34.96	68.47	34.24	10.92	0.00	0.00	8.13	0.00	8.13
90% Yr.	JAN	438.90	940.59	6.74	36.23	97.05	97.05	438.90	940.59	411.50	33.04	72.46	36.23	10.92	0.00	0.00	8.13	0.00	8.13
90% Yr.	FEB	438.90	940.59	9.85	38.66	93.53	93.53	438.90	940.59	411.50	30.96	77.32	38.66	10.92	0.00	0.00	7.34	0.00	7.34
90% Yr.	MAR	438.90	940.59	21.37	41.60	111.42	111.42	438.90	940.59	411.50	28.78	83.20	41.60	10.92	0.00	0.00	8.13	0.00	8.13
90% Yr.	APR	438.90	940.59	75.42	43.82	113.57	113.57	438.90	940.59	411.50	27.30	87.63	43.82	10.92	-0.01	0.00	7.86	0.00	7.86
90% Yr.	MAY	438.90	940.59	108.61	54.30	145.45	145.45	438.90	940.59	411.50	27.46	108.61	54.30	10.92	2.69	0.00	8.13	2.00	10.12
TOTAL						1233.68	1233.68										95.67	1.99	97.66

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harnessed
1	28	97.66	39.82	39.00	3487.92	-	100.00%
2	30	97.66	37.16	36.40	3255.39	0.00	100.00%
3	32	97.66	34.84	34.13	3051.93	0.00	100.00%
4	34	97.66	32.79	32.12	2872.40	0.00	100.00%
5	**36**	**97.66**	**30.97**	**30.34**	**2712.83**	**0.00**	**100.00%**
6	38	97.66	29.34	28.74	2570.05	0.00	100.00%
7	40	97.66	27.87	27.30	2441.54	0.00	100.00%
8	42	97.66	26.54	26.00	2325.28	0.00	100.00%
9	44	97.66	25.34	24.82	2219.59	0.00	100.00%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't shows any change. However, the Annual Load Factor of 30.97 % justifies the installed capacity of 36 MW.

6.12.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 7.45MW continuous .

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 18 MW to 34 MW in steps of 2 MW. The results are tabulated in as below:

BALIMELA HEP (WITH ENVIRONMENTAL FLOWS RELEASED)

RESERVOIR OPERATION TABLE IN 90% DEPENDABLE YEAR

	F.R.L		462.10			3595.5							T.G.EFF.	=	0.93				
	M.D.D.L		438.90			940.59							Firm Power exep.(MW)	=	7.45				
	Av. T.W.L.		411.50										Installed Capacity (MW)	=	26.00				
													W.C.Losses	=	0.36				

YEAR	MONTH	INITIAL LEVEL	INITAL STORAGE	INFLOW ACTUAL	INFLOW 50%	INFLOW	WITH-DRAWAL	FINAL LEVEL	FINAL STORAGE	TWL	NET HEAD	DISCHARGE REGULATED	DISCHARGE REGULATED AFTER RELEASING 50%	FIRM POWER	SEC. POWER	SPILL POWER	FIRM ENERGY	SEC. ENERGY	TOTAL ENERGY
		M	MCUM		CUMECS	MCUM	MCUM	M	MCUM	M		M	CUMECS	MW	MW	MW	GWh	GWh	GWh
90% Yr.	JUN	438.90	940.59	78.35	30.11	78.05	78.05	438.90	940.59	411.50	27.13	60.23	30.11	7.45	0.00	0.00	5.37	0.00	5.37
90% Yr.	JUL	438.90	940.59	116.08	28.60	76.61	76.61	438.90	940.59	411.50	28.56	57.21	28.60	7.45	0.00	0.00	5.55	0.00	5.55
90% Yr.	AUG	438.90	940.59	117.89	26.57	71.17	71.17	438.90	940.59	411.50	30.75	53.14	26.57	7.45	0.00	0.00	5.55	0.00	5.55
90% Yr.	SEP	438.90	940.59	101.40	25.04	64.91	64.91	438.90	940.59	411.50	32.63	50.08	25.04	7.45	0.00	0.00	5.37	0.00	5.37
90% Yr.	OCT	438.90	940.59	68.51	24.24	64.92	64.92	438.90	940.59	411.50	33.71	48.47	24.24	7.45	0.00	0.00	5.55	0.00	5.55
90% Yr.	NOV	438.90	940.59	19.91	24.31	63.01	63.01	438.90	940.59	411.50	33.61	48.62	24.31	7.45	0.00	0.00	5.37	0.00	5.37
90% Yr.	DEC	438.90	940.59	3.54	25.17	67.40	67.40	438.90	940.59	411.50	32.47	50.33	25.17	7.45	0.00	0.00	5.55	0.00	5.55
90% Yr.	JAN	438.90	940.59	5.39	26.41	70.73	70.73	438.90	940.59	411.50	30.94	52.82	26.41	7.45	0.00	0.00	5.55	0.00	5.55
90% Yr.	FEB	438.90	940.59	7.88	27.81	67.27	67.27	438.90	940.59	411.50	29.38	55.62	27.81	7.45	0.00	0.00	5.01	0.00	5.01
90% Yr.	MAR	438.90	940.59	17.10	29.38	78.70	78.70	438.90	940.59	411.50	27.81	58.77	29.38	7.45	0.00	0.00	5.55	0.00	5.55
90% Yr.	APR	438.90	940.59	56.56	30.39	78.76	78.76	438.90	940.59	411.50	26.87	60.77	30.39	7.45	-0.01	0.00	5.37	0.00	5.36
90% Yr.	MAY	438.90	940.59	81.46	40.73	109.09	109.09	438.90	940.59	411.50	27.21	81.46	40.73	7.45	2.66	0.00	5.55	1.98	7.52
TOTAL						890.62	890.62										65.30	1.97	67.27

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't shows any change. However, the Annual Load Factor

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harnessed
1	18	67.27	42.66	41.41	3737.27	-	100.00%
2	20	67.27	38.40	37.27	3363.54	0.00	100.00%
3	22	67.27	34.91	33.88	3057.77	0.00	100.00%
4	24	67.27	32.00	31.06	2802.90	0.00	100.00%
5	**26**	**67.27**	**29.54**	**28.67**	**2587.29**	**0.00**	**100.00%**
6	28	67.27	27.43	26.62	2402.53	0.00	100.00%
7	30	67.27	25.60	24.85	2242.36	0.00	100.00%
8	32	67.27	24.00	23.29	2102.23	0.00	100.00%
9	34	67.27	22.59	21.92	1978.57	0.00	100.00%

of 29.54 % justifies the installed capacity of 26 MW.

6.12.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	Without Environmental Flows	With Environmental Flows
Annual Energy Generation (GWh)	97.66	67.27
Firm Power (MW continuous)	10.92	7.45
Installed Capacity	36	**26(3x8.67MW)**
Annual load factor (%)	30.97	29.54

Regarding the number of generating units to be installed, the following options are possible.

- 2x13MW
- 3x8.67 MW

Although, installation of 2 units of 13 MW would be economical but considering the reliability of the Project, installation of 3 units of 8.67 MW has been chosen.

6.13 Power Potential Studies of Konta Hydroelectric Project:

6.13.1 Conceptual Planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In previous studies the FRL & TWL was considered as at EL 67 m and 45.7 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking into account of inflows, environmental aspects and the topography of the area. Also, after carrying out studies MDDL is considered at EL 60 m and the friction losses are considered to compute the head losses in the water conducting system. The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Konta Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e. 0.19 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 329.31 MCum. The Elevation Area capacity Table is shown as below.

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	59.50	30069082.25	3006.91	223080519.5	223.08
2	60.00	32189082.25	3218.91	253688519.5	253.69
3	60.50	33378546.79	3337.85	271367292.9	271.37
4	61.00	35357546.79	3535.75	289046066.3	289.05
5	61.50	36531647.5	3653.16	308311890.1	308.31
6	62.00	38531647.5	3853.16	327577713.8	327.58
7	62.50	40515203.44	4051.52	348845315.8	348.85
8	63.00	42535203.94	4253.52	370112917.7	370.11

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
9	63.50	44082366.49	4408.24	393554201	393.55
10	64.00	46882566.49	4688.26	416995484.2	417.00
11	64.50	48930848.43	4893.08	442463908.4	442.46
12	65.00	50936848.43	5093.68	467932332.7	467.93
13	65.50	54891558.1	5489.16	495378111.7	495.38
14	66.00	56491558.1	5649.16	522823890.8	522.82
15	66.50	60173584.81	6017.36	552910683.2	552.91
16	67	61133584.81	6113.36	582997475.6	583.00

6.13.2 Hydrology

Hydrological Series data is developed for 15 years from 2000-01 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. Water flows determined with and without Environment Flows in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
		2009-2010		
Jun	I	143	35.76	107.27
	II	149.5	37.38	112.13

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
		2009-2010		
	III	154.6	38.64	115.91
Jul	I	161.1	48.32	112.76
	II	429.2	128.76	300.43
	III	405.3	121.6	283.74
Aug	I	916.1	274.84	641.28
	II	1634	490.33	1144.09
	III	1612	483.52	1128.21
Sep	I	759.5	227.86	531.67
	II	344.1	103.23	240.88
	III	307.7	92.32	215.40
Oct	I	613.4	184.02	429.37
	II	291	87.29	203.67
	III	219.8	65.95	153.89
Nov	I	231.7	57.92	173.78
	II	201.7	50.42	151.25

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
		2009-2010		
	III	193.6	48.39	145.19
Dec	I	163.8	40.95	122.84
	II	156.9	39.22	117.66
	III	119.3	29.83	89.47
Jan	I	73.57	14.71	58.86
	II	58.31	11.66	46.65
	III	70.76	14.15	56.61
Feb	I	81.44	16.29	65.15
	II	102.6	20.51	82.05
	III	100.8	20.15	80.62
Mar	I	93.78	18.76	75.02
	II	67.34	13.47	53.87
	III	60.23	12.05	48.18
April	I	110.4	27.6	82.78
	II	144.8	36.2	108.59

Period (10 Daily)		Inflows	Environment Flows	Net Flows
		A	B	C=A-B
		2009-2010		
	III	145.5	36.38	109.13
May	I	126.7	31.67	95.02
	II	225.6	56.39	169.18
	III	130.6	32.66	97.97

6.13.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable for following 2 Cases.

6.13.3.1 Power Potential Studies without Environment flows released

Net inflows have been considered for power potential studies as given above. This is a RoR based Project. The study indicates that the firm power during 90% dependable year is 16.42 MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 88 MW to 108 MW in steps of 2 MW. The results are tabulated in as below:

KONTA HYDROELECTRIC PROJECT

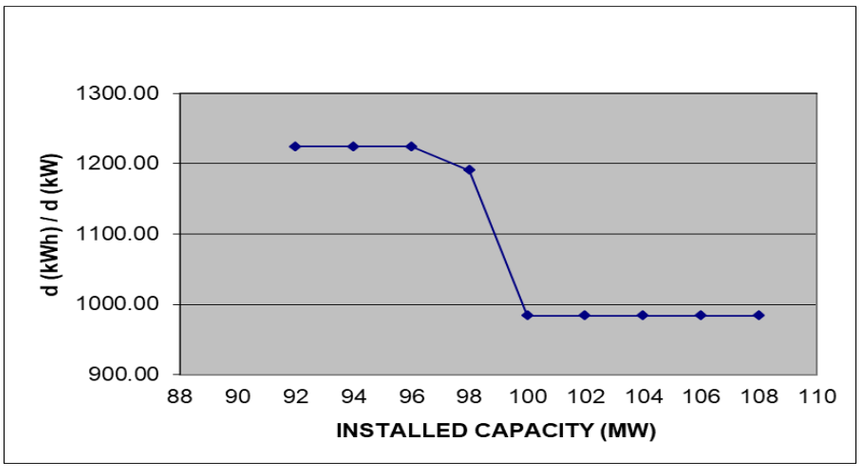
POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR

FRL	67	m	RATED HEAD	18.97	m	EFF.	93	%
MDDL	60	m	WC LOSSES	0.19	m			
Av. TWL	45.7	m	NET RATED HEAD	18.78	m			

MONTH	INFLOWS	POWER	RESTRICTED	INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.	
		POTENTIAL	ENERGY	88	MW	90	MW	92	MW	94	MW	96	MW	98	MW	100	MW	102	MW	104	MW	106	MW	108	MW		
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)
Jun	143.03	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47	22.79	5.47
	149.51	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72	23.82	5.72
	154.55	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91	24.62	5.91
Jul	161.08	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16	25.66	6.16
	429.19	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41	68.38	16.41
	405.34	64.58	15.50	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05	64.58	17.05
Aug	916.12	145.95	35.03	88.00	21.12	90.00	21.60	92.00	22.08	94.00	22.56	96.00	23.04	98.00	23.52	100.00	24.00	102.00	24.48	104.00	24.96	106.00	25.44	108.00	25.92		
	1634.42	260.39	62.49	88.00	21.12	90.00	21.60	92.00	22.08	94.00	22.56	96.00	23.04	98.00	23.52	100.00	24.00	102.00	24.48	104.00	24.96	106.00	25.44	108.00	25.92		
	1611.73	256.78	61.63	88.00	23.23	90.00	23.76	92.00	24.29	94.00	24.82	96.00	25.34	98.00	25.87	100.00	26.40	102.00	26.93	104.00	27.46	106.00	27.98	108.00	28.51		
Sep	759.53	121.01	29.04	88.00	21.12	90.00	21.60	92.00	22.08	94.00	22.56	96.00	23.04	98.00	23.52	100.00	24.00	102.00	24.48	104.00	24.96	106.00	25.44	108.00	25.92		
	344.11	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16	54.82	13.16		
	307.72	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77	49.03	11.77		
Oct	613.39	97.72	23.45	88.00	21.12	90.00	21.60	92.00	22.08	94.00	22.56	96.00	23.04	97.72	23.45	97.72	23.45	97.72	23.45	97.72	23.45	97.72	23.45	97.72	23.45		
	290.96	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12	46.35	11.12		
	219.84	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25	35.02	9.25		
Nov	231.70	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86	36.91	8.86		
	201.67	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71	32.13	7.71		
	193.58	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40	30.84	7.40		
Dec	163.79	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26	26.09	6.26		
	156.88	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00	24.99	6.00		
	119.30	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02	19.01	5.02		
Jan	73.57	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81	11.72	2.81		
	58.31	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23	9.29	2.23		
	70.76	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98	11.27	2.98		
Feb	81.44	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11	12.97	3.11		
	102.56	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92	16.34	3.92		
	100.77	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08	16.05	3.08		
Mar	93.78	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59	14.94	3.59		
	67.34	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57	10.73	2.57		
	60.23	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53	9.60	2.53		
Apr	110.38	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22	17.59	4.22		
	144.79	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54	23.07	5.54		
	145.51	23.18	5.56	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12	23.18	6.12		
May	126.69	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84	20.18	4.84		
	225.57	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63	35.94	8.63		
	130.63	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49	20.81	5.49		
Total energy (GWh)			414.47		312.64		315.09		317.54		319.98		322.43		324.81		326.78		328.75		330.72		332.69		334.65		
Firm Power (MWc) (Lean Period Dec to Feb)				16.42		16.42		16.42		16.42		16.42		16.42		16.42		16.42		16.42		16.42		16.42			
Incr. Energy(GWh)					-		2.45		2.45		2.45		2.45		2.38		1.97		1.97		1.97		1.97		1.97		
Incr. Cap.(MW)					-		2		2		2		2		2		2		2		2		2		2		
Incr. Energy/Incr. Power (kWh/kW)					-		1224.00		1224.00		1224.00		1224.00		1190.76		984.00		984.00		984.00		984.00		984.00		

KONTA HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL LOAD FACTOR (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	88	312.64	40.56	18.65	3552.74	-	
2	90	315.09	39.97	18.24	3500.99	1224.00	76%
3	92	317.54	39.40	17.84	3451.49	1224.00	77%
4	94	319.98	38.86	17.46	3404.09	1224.00	77%
5	96	322.43	38.34	17.10	3358.67	1224.00	78%
6	**98**	**324.81**	**37.84**	**16.75**	**3314.43**	**1190.76**	**78%**
7	100	326.78	37.30	16.42	3267.82	984.00	79%
8	102	328.75	36.79	16.09	3223.04	984.00	79%
9	104	330.72	36.30	15.78	3179.98	984.00	80%
10	106	332.69	35.83	15.49	3138.55	984.00	80%
11	108	334.65	35.37	15.20	3098.65	984.00	80%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 98 MW. In addition, the Annual Load Factor of 37.84 % justifies the installed capacity of 98 MW.

6.13.3.2 Power Potential Studies with Environment flows released

Power potential study is required to be carried out for 90% dependable year considering e-flow as per latest guidelines from Ministry of Environment, Forest and Climate Change (MoEF & CC). Net flow after considering e-flow has been considered for power potential studies as given above. For determination of power potential, the combined efficiency of Turbine and Generator have been considered as 93.00 %. The study indicates that the firm power during 90% dependable year is 12.74MW continuous.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 60 MW to 80 MW in steps of 2 MW. The results are tabulated in as below:

KONTA HYDROELECTRIC PROJECT

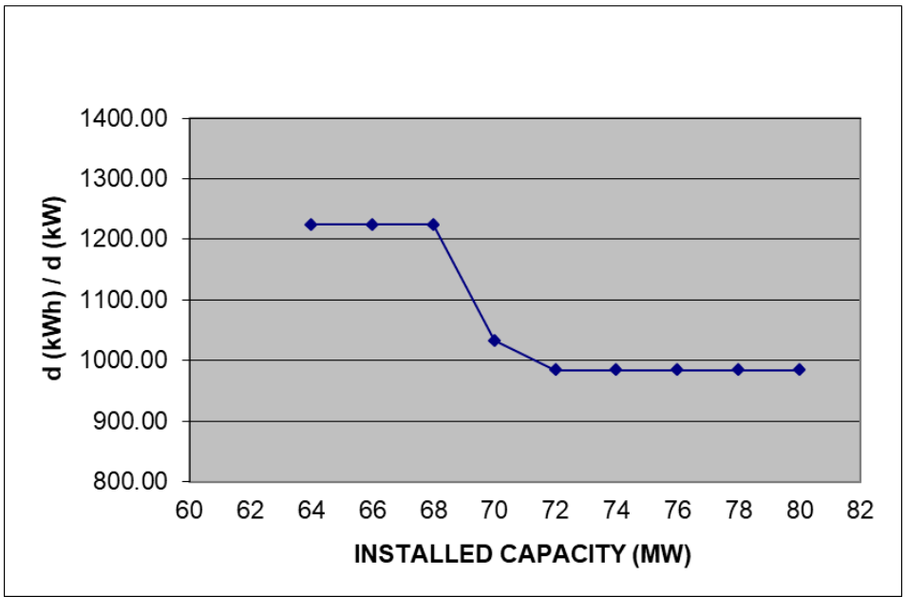
POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR

FRL	67	m	RATED HEAD	18.97	m	EFF.	93	%
MDDL	60	m	WC LOSSES	0.19	m			
Av. TWL	45.7	m	NET RATED HEAD	18.78	m			

MONTH	INFLOWS	POWER POTENTIAL	RESTRICTED ENERGY	INSTALLED CAP. 60 MW		INSTALLED CAP. 62 MW		INSTALLED CAP. 64 MW		INSTALLED CAP. 66 MW		INSTALLED CAP. 68 MW		INSTALLED CAP. 70 MW		INSTALLED CAP. 72 MW		INSTALLED CAP. 74 MW		INSTALLED CAP. 76 MW		INSTALLED CAP. 78 MW		INSTALLED CAP. 80 MW	
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)
Jun	107.27	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10	17.09	4.10
	112.13	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29	17.86	4.29
	115.91	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43	18.47	4.43
Jul	112.76	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31	17.96	4.31
	300.43	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49	47.86	11.49
	283.74	45.20	10.85	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93	45.20	11.93
Aug	641.28	102.17	24.52	60.00	14.40	62.00	14.88	64.00	15.36	66.00	15.84	68.00	16.32	70.00	16.80	72.00	17.28	74.00	17.76	76.00	18.24	78.00	18.72	80.00	19.20
	1144.09	182.27	43.75	60.00	14.40	62.00	14.88	64.00	15.36	66.00	15.84	68.00	16.32	70.00	16.80	72.00	17.28	74.00	17.76	76.00	18.24	78.00	18.72	80.00	19.20
	1128.21	179.74	43.14	60.00	15.84	62.00	16.37	64.00	16.90	66.00	17.42	68.00	17.95	70.00	18.48	72.00	19.01	74.00	19.54	76.00	20.06	78.00	20.59	80.00	21.12
Sep	531.67	84.70	20.33	60.00	14.40	62.00	14.88	64.00	15.36	66.00	15.84	68.00	16.32	70.00	16.80	72.00	17.28	74.00	17.76	76.00	18.24	78.00	18.72	80.00	19.20
	240.88	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21	38.38	9.21
	215.40	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24	34.32	8.24
Oct	429.37	68.41	16.42	60.00	14.40	62.00	14.88	64.00	15.36	66.00	15.84	68.00	16.32	68.41	16.42	68.41	16.42	68.41	16.42	68.41	16.42	68.41	16.42	68.41	16.42
	203.67	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79	32.45	7.79
	153.89	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47	24.52	6.47
Nov	173.78	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64	27.69	6.64
	151.25	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78	24.10	5.78
	145.19	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55	23.13	5.55
Dec	122.84	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70	19.57	4.70
	117.66	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50	18.75	4.50
	89.47	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76	14.25	3.76
Jan	58.86	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25	9.38	2.25
	46.65	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78	7.43	1.78
	56.61	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38	9.02	2.38
Feb	65.15	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49	10.38	2.49
	82.05	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14	13.07	3.14
	80.62	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47	12.84	2.47
Mar	75.02	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87	11.95	2.87
	53.87	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06	8.58	2.06
	48.18	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03	7.68	2.03
Apr	82.78	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17	13.19	3.17
	108.59	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15	17.30	4.15
	109.13	17.39	4.17	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59	17.39	4.59
May	95.02	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63	15.14	3.63
	169.18	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47	26.95	6.47
	97.97	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12	15.61	4.12
Total energy (GWh)			297.44		224.23		226.68		229.13		231.58		234.02		236.09		238.06		240.03		241.99		243.96		245.93
Firm Power (MWc) (Lean Period Dec to Feb)				12.74		12.74		12.74		12.74		12.74		12.74		12.74		12.74		12.74		12.74		12.74	
Incr. Energy(GWh)					-		2.45		2.45		2.45		2.45		2.07		1.97		1.97		1.97		1.97		1.97
Incr. Cap.(MW)					-		2		2		2		2		2		2		2		2		2		2
Incr. Energy/Incr. Power (kWh/kW)					-		1224.00		1224.00		1224.00		1224.00		1032.69		984.00		984.00		984.00		984.00		984.00

KONTA HYDROELECTRIC PROJECT (WITH ENVIRONMENTAL FLOWS RELESED

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	A.L.F (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	60	224.23	42.66	21.24	3737.20	-	
2	62	226.68	41.74	20.55	3656.13	1224.00	76%
3	64	229.13	40.87	19.91	3580.13	1224.00	77%
4	66	231.58	40.05	19.31	3508.73	1224.00	78%
5	**68**	**234.02**	**39.29**	**18.74**	**3441.53**	**1224.00**	**79%**
6	70	236.09	38.50	18.21	3372.71	1032.69	79%
7	72	238.06	37.74	17.70	3306.36	984.00	80%
8	74	240.03	37.03	17.22	3243.59	984.00	81%
9	76	241.99	36.35	16.77	3184.13	984.00	81%
10	78	243.96	35.70	16.34	3127.71	984.00	81%
11	80	245.93	35.09	15.93	3074.12	984.00	82%



The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity does show a steep fall at 68 MW. Also, the Annual Load Factor of 39.29 % justifies the installed capacity of 68 MW.

6.13.4 Results of Studies

Annual energy generation in a 90% year as computed with and without Environment flows are summarized below.

90% dependable year	**Without Environmental Flows**	**With Environmental Flows**
Annual Energy Generation (GWh)	324.81	234.02
Firm Power (MW continuous)	16.42	12.74
Installed Capacity	98	**68 (3x22.67MW)**
Load factor (%)	37.84	39.29

Regarding the number of generating units to be installed, the following options are possible.

- 3x22.67MW
- 2x34 MW

Although, installation of 2 units of 34 MW would be economical but considering the reliability of the Project, installation of 3 units of 22.67 MW has been chosen

6.14 Power Potential Studies of Tamankal Hydroelectric Project:

6.14.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL & TWL was considered as at EL 492.25 m and 402.12 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking into account of inflows, environmental aspects and the topography of the area. Also, after carrying out studies MDDL is considered at EL 485.55 m and the friction losses are considered to compute the head losses in the water conducting system. Tamankal Hydroelectric Project utilizes the surplus water of Narayanpur dam.

The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Tamankal Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e. 0.88 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 113.23 MCum. The Elevation Area capacity Table is shown as below.

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	485.55	14604887.52	1460.49	141616606.12	141.62
2	486.49	15354043.52	1535.40	158711024.52	158.71
3	487.63	15887130.78	1588.71	176550706.62	176.55
4	488.77	16359939.63	1635.99	195025841.22	195.03
5	489.91	16811085.92	1681.11	214086956.83	214.09
6	491.05	17173042.81	1717.30	233675575.17	233.68
7	492.19	17911167.07	1791.12	253773345.83	253.77

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
8	492.25	17911167.07	1791.12	254847972.12	254.85

6.14.2 Hydrology

Hydrological Series data is developed for 25 years from 1990-91 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Chapter 5**. Water flows determined in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Inflows
		A
Jun	I	0.00
	II	0.12
	III	0.10
Jul	I	2.36
	II	0.09
	III	2.58
Aug	I	15.38
	II	602.57
	III	15.13
Sep	I	14.92
	II	215.32
	III	122.17
Oct	I	0.00
	II	8.71
	III	123.84
Nov	I	0.31
	II	0.00
	III	2.13
Dec	I	0.00
	II	0.00
	III	0.00
Jan	I	0.00
	II	0.00
	III	0.00
Feb	I	0.00
	II	0.00
	III	0.00
Mar	I	0.02
	II	0.00
	III	0.12

Period (10 Daily)		Inflows A
Apr	I	0.38
	II	0.28
	III	0.30
May	I	0.14
	II	0.53
	III	6.84

6.14.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable. There is no Environmental releases through the Tamankal HE project because the same has been considered in Narayanpur Dam.

6.14.3.1 Power Potential Studies

The inflow has been considered for power potential studies as given above. This is a Storage based Project.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 250 MW to 350 MW in steps of 10 MW. The results are tabulated in as below:

TAMANKAL HYDROELECTRIC PROJECT

POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR

FRL	492.25	m	RATED HEAD		88.02	m			EFF.	93	%
MDDL	485.55	m	WC LOSSES		0.88	m					
Av. TWL	402.12	m	NET RATED HEAD		87.14	m					

MONTH	INFLOWS	POWER	RESTRICTED	INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.		INSTALLED CAP.	
		POTENTIAL	ENERGY	250	MW	260	MW	270	MW	280	MW	290	MW	300	MW	310	MW	320	MW	330	MW	340	MW	350	MW
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)
Jun	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.12	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02
	0.10	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02
Jul	2.36	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42	1.74	0.42
	0.09	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02	0.07	0.02
	2.58	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50	1.91	0.50
Aug	15.38	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73	11.37	2.73
	602.57	445.49	106.92	250.00	60.00	260.00	62.40	270.00	64.80	280.00	67.20	290.00	69.60	300.00	72.00	310.00	74.40	320.00	76.80	330.00	79.20	340.00	81.60	350.00	84.00
	15.13	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95	11.19	2.95
Sep	14.92	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65	11.03	2.65
	215.32	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21	159.19	38.21
	122.17	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68	90.32	21.68
Oct	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	8.71	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55	6.44	1.55
	123.84	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17	91.56	24.17
Nov	0.31	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2.13	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38	1.57	0.38
Dec	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.02	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.12	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02
Apr	0.38	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07	0.28	0.07
	0.28	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05	0.21	0.05
	0.30	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05	0.22	0.05
May	0.14	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02	0.10	0.02
	0.53	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09	0.39	0.09
	6.84	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34	5.06	1.34
Total energy (GWh)			203.91		156.99		159.39		161.79		164.19		166.59		168.99		171.39		173.79		176.19		178.59		180.99
Incr. Energy(GWh)					-		2.40		2.40		2.40		2.40		2.40		2.40		2.40		2.40		2.40		2.40
Incr. Cap.(MW)					-		10		10		10		10		10		10		10		10		10		10
Incr. Energy/Incr. Power (kWh/kW)					-		240.00		240.00		240.00		240.00		240.00		240.00		240.00		240.00		240.00		240.00

TAMANKAL HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL LOAD FACTOR (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	250	156.99	7.17	-	627.97	-	
2	260	159.39	7.00	-	613.04	240.00	78%
3	270	161.79	6.84	-	599.23	240.00	79%
4	280	164.19	6.69	-	586.40	240.00	81%
5	290	166.59	6.56	-	574.45	240.00	82%
6	**300**	**168.99**	**6.43**	**-**	**563.30**	**240.00**	**83%**
7	310	171.39	6.31	-	552.88	240.00	84%
8	320	173.79	6.20	-	543.10	240.00	85%
9	330	176.19	6.09	-	533.91	240.00	86%
10	340	178.59	6.00	-	525.27	240.00	86%
11	350	180.99	5.90	-	517.12	240.00	88%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't show any shows any fall. However, In the earlier PFR the Tamankal HEP has the installed capacity of 300 MW and the same has been retained in this studies.

6.14.4Results of Studies

Annual energy generation in a 90% year as is summarized below.

90% dependable year	
Annual Energy Generation (GWh)	168.99
Firm Power (MW continuous)	-
Installed Capacity	300
Load factor (%)	-

Installation of 2 units of 150 MW has been chosen.

6.15 Power Potential Studies of Jaldurg Hydroelectric Project:

6.15.1 Conceptual planning

Fixation of FRL, MDDL, TWL, & Live Storage of Reservoir

In pre-feasibility studies the FRL & TWL was considered as at EL 466 m and 381 m respectively. The same is reviewed in details using the toposheets of 1:25k/50k and found to be in order. Therefore, further studies of hydrology and power potential studies has been carried out with same layout after taking into account of inflows, environmental aspects and the topography of the area. Also, after carrying out studies MDDL is considered at EL 440 m and the friction losses are considered to compute the head losses in the water conducting system. Jaldurg utilities the waters downstream of Narayanpur Barrage and the water available due to the intermediate catchment between the Narayanpur barrage and Jaldurg diversion and also the water of the streams joining the Krishna river on the right bank.

The head loss majorly depends on the length of the water conducting system, roughness co-efficient and discharge. Jaldurg Hydroelectric Project being a dam toe project the head losses has been considered as 1% of the head i.e.0.76 m.

The live storage between FRL and MDDL as assessed from Area-Capacity Curve is 177.34 MCum. The Elevation Area capacity Table is shown as below.

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
1	440	7556233.54	755.62	45786594.11	38.23
2	442	8472511.61	847.25	54259105.72	54.26
3	444	9159955.59	916.00	63419061.31	63.42
4	446	9950987.02	995.10	73370048.33	73.37
5	448	11050897.39	1105.09	84420945.72	84.42
6	450	11826861.55	1182.69	96247807.27	96.25

S.No	Elevation (m)	Area (Sqm)	Area (Ha.)	Cumulative Volume (m^3)	Cumulative Volume (MCM)
7	452	12634843.65	1263.48	108882650.92	108.88
8	454	13426816.78	1342.68	122309467.70	122.31
9	456	14132153.14	1413.22	136441620.84	136.44
10	458	14722601.60	1472.26	151164222.44	151.16
11	460	15351659.92	1535.17	166515882.36	166.52
12	462	15884664.43	1588.47	182400546.80	182.40
13	464	16357399.88	1635.74	198757946.68	198.76
14	466	16808476.14	1680.85	215566422.81	215.57

6.15.2 Hydrology

Hydrological Series data is developed for 15 years from 2000-01 to 2014-15. The water inflows on 10 daily basis for all these years is attached in **Hydrology Section 6.0**. Jaldurg utilities the waters downstream of Narayanpur Barrage and the water available due to the intermediate catchment between the Narayanpur barrage and Jaldurg diversion and also the water of the streams joining the Krishna river on the right bank. Water flows determined in 90% dependable year have been utilized for computing power benefits are as follows:

Period (10 Daily)		Tamankal Outflows	Intermediate Inflows	Final Inflows
		A	B	C=A+B
Jun	I	0.00	0.07	0.07
	II	0.12	5.96	6.08
	III	0.10	0.91	1.01
Jul	I	2.36	4.75	7.11

Period (10 Daily)		Tamankal Outflows	Intermediate Inflows	Final Inflows
		A	B	C=A+B
	II	0.09	7.08	7.17
	III	2.58	3.90	6.48
Aug	I	15.38	4.19	19.57
	II	602.57	134.67	737.24
	III	15.13	70.34	85.47
Sep	I	14.92	12.43	27.35
	II	215.32	10.81	226.13
	III	122.17	4.70	126.87
Oct	I	0.00	0.93	0.93
	II	8.71	68.94	77.65
	III	123.84	42.77	166.61
Nov	I	0.31	0.10	0.41
	II	0.00	0.36	0.36
	III	2.13	0.00	2.13
Dec	I	0.00	0.14	0.14
	II	0.00	0.17	0.17
	III	0.00	0.04	0.04
Jan	I	0.00	0.00	0.00
	II	0.00	0.00	0.00
	III	0.00	0.00	0.00
Feb	I	0.00	0.07	0.07
	II	0.00	0.00	0.00
	III	0.00	0.00	0.00
Mar	I	0.02	0.00	0.02
	II	0.00	2.11	2.11
	III	0.12	0.17	0.29
Apr	I	0.38	0.19	0.57
	II	0.28	0.00	0.28
	III	0.30	0.65	0.95
May	I	0.14	0.07	0.21
	II	0.53	0.71	1.24
	III	6.84	0.18	7.02

6.15.3 Power Potential Studies and Installed Capacity

The power potential assessment is carried in a 90% Dependable. There is no Environmental releases through the Jaldurg HE project because the same has been considered in Narayanpur Dam.

6.15.3.1 Power Potential Studies without Environment flows released

The inflow has been considered for power potential studies as given above. This is a RoR based Project.

The annual energy generation (kWh), Incremental Energy generation (dkWh), and ratio of Incremental Energy Generation to Incremental Installed Capacity (dkWh/dkW) is computed for 90% dependable year for installed capacity varying from 220 MW to 320 MW in steps of 10 MW. The results are tabulated in as below:

JALDURG HYDROELECTRIC PROJECT

POWER POTENTIAL WITH DIFFERENT INSTALLED CAPACITY IN A 90% DEPENDABLE YEAR

		FRL	466	m	RATED HEAD		76.33	m			EFF.	93	%												
		MDDL	440	m	WC LOSSES		0.76	m																	
		Av. TWL	381	m	NET RATED HEAD		75.57	m																	
MONTH	INFLOWS	POWER POTENTIAL	RESTRICTED ENERGY	INSTALLED CAP. 220 MW		INSTALLED CAP. 230 MW		INSTALLED CAP. 240 MW		INSTALLED CAP. 250 MW		INSTALLED CAP. 260 MW		INSTALLED CAP. 270 MW		INSTALLED CAP. 280 MW		INSTALLED CAP. 290 MW		INSTALLED CAP. 300 MW		INSTALLED CAP. 310 MW		INSTALLED CAP. 320 MW	
				POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY	POWER	ENERGY
	(CUMECS)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)	(MWc)	(GWh)
Jun	0.07	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01
	6.08	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94	3.90	0.94
	1.01	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16	0.65	0.16
Jul	7.11	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09	4.56	1.09
	7.17	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10	4.60	1.10
	6.48	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10	4.15	1.10
Aug	19.57	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01	12.55	3.01
	737.24	472.71	113.45	220.00	52.80	230.00	55.20	240.00	57.60	250.00	60.00	260.00	62.40	270.00	64.80	280.00	67.20	290.00	69.60	300.00	72.00	310.00	74.40	320.00	76.80
	85.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47	54.80	14.47
Sep	27.35	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21	17.54	4.21
	226.13	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80	144.99	34.80
	126.87	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52	81.35	19.52
Oct	0.93	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14	0.60	0.14
	77.65	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95	49.79	11.95
	166.61	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20	106.83	28.20
Nov	0.41	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06	0.26	0.06
	0.36	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06	0.23	0.06
	2.13	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33	1.37	0.33
Dec	0.14	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02	0.09	0.02
	0.17	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03	0.11	0.03
	0.04	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01
Jan	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb	0.07	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar	0.02	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
	2.11	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32	1.35	0.32
	0.29	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05	0.19	0.05
Apr	0.57	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09	0.37	0.09
	0.28	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04	0.18	0.04
	0.95	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15	0.61	0.15
May	0.21	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03	0.13	0.03
	1.24	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19	0.80	0.19
	7.02	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19	4.50	1.19
Total energy (GWh)			236.73		176.08		178.48		180.88		183.28		185.68		188.08		190.48		192.88		195.28		197.68		200.08
Incr. Energy(GWh)					-		2.40		2.40		2.40		2.40		2.40		2.40		2.40		2.40		2.40		2.40
Incr. Cap.(MW)					-		10		10		10		10		10		10		10		10		10		10
Incr. Energy/Incr. Power (kWh/kW)					-		240.00		240.00		240.00		240.00		240.00		240.00		240.00		240.00		240.00		240.00

JALDURG HYDROELECTRIC PROJECT (WITHOUT ENVIRONMENTAL FLOWS)

S. NO.	INST. CAP.(MW)	ANNUAL ENERGY GEN (GWh)	ANNUAL LOAD FACTOR (%)	L.F (%)	KWh/ KW	d (KWh)/ d (KW)	% Energy Harness
1	220	176.08	9.14	-	800.35	-	
2	230	178.48	8.86	-	775.99	240.00	75%
3	240	180.88	8.60	-	753.66	240.00	76%
4	250	183.28	8.37	-	733.11	240.00	77%
5	260	185.68	8.15	-	714.14	240.00	78%
6	**270**	**188.08**	**7.95**	**-**	**696.58**	**240.00**	**79%**
7	280	190.48	7.77	-	680.28	240.00	80%
8	290	192.88	7.59	-	665.09	240.00	81%
9	300	195.28	7.43	-	650.92	240.00	82%
10	310	197.68	7.28	-	637.67	240.00	82%
11	320	200.08	7.14	-	625.24	240.00	84%

The graphical representation of incremental (dkWh/dkW) ratio with increase in installed capacity doesn't show any shows any fall. However, In the earlier studies the Jaldurg HEP has the installed capacity of 270 MW and the same has been retained in this studies.

6.15.4Results of Studies

Annual energy generation in a 90% year as computed is summarized below.

90% dependable year	Without Environmental Flows
Annual Energy Generation (GWh)	188.08
Firm Power (MW continuous)	-
Installed Capacity	270
Load factor (%)	-

Installation of 2 units of 135 has been chosen.

6.16 Possibility of developing Hydroelectric Projects having environmental issues with adjustment of project components

6.16.1 Lower Moyar Hydroelectric Project, Tamil Nadu

Lower Moyar project consists of total 2 dams, out of which 1 dams is located on the boundary of Bandipur Wildlife Sanctuary (Protected area) and the powerhouse site is falling 0.5 km inside Bandipur Wildlife Sanctuary (Protected area). Efforts have been made by shifting the dams and Powerhouse but the dams cannot be relocated as all the dams are interconnected and a single power house for the same.

6.16.2 Nugur-II Hydroelectric Project, Chhattisgarh

Dam site and Powerhouse site of Nugur-II hydroelectric project are located on the boundary of Indravati National Park (Protected Area). Efforts have been made by shifting the dam and Powerhouse but the dam and powerhouse cannot be relocated as both the components falls within the protected area.

6.16.3 Bhopalpatnam Hydroelectric Project, Chhattisgarh

Dam site and Powerhouse site of Bhopalpatnam hydroelectric project are located on the boundary of Indravati National Park (Protected Area). Efforts have been made by shifting the dam and Powerhouse but the dam and powerhouse cannot be relocated as both the components falls within the protected area.

CHAPTER - 7

PROJECT PROFILE OF PROJECTS TAKEN FOR FURTHER STUDIES

7.1 TUPAKULAGUDEM HYDROELECTRIC PROJECT (10x24MW=240 MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was envisaged as Inchampally Hydroelectric Project which had an interstate issue. Presently, the project is named as Tupakulagudem Hydroelectric Project. Tupakulagudem Hydroelectric Project is a storage type of development which is located near Tupakulagudem village approximately 1 km. from the project site in Mulugu district of Telangana. The project envisages utilization of water of Godavari River for power generation. The project is designed to generate power, utilizing rated head of 8.3m. The project has 10 units of 24 MW in surface powerhouse with installed capacity of 240 MW to generate annual energy of 317 GWh in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Godavari river having Latitude 18°35'9.24"N and Longitude 80°23'35.57"E and the forebay is located at Latitude 18°34'28.20"N and Longitude 80°22'29.60"E. The Power house is located at Latitude 18°33'46.10"N and Longitude 80°22'53.40"E. The Nearest Railway station is Warangal and the Airport is Hyderabad.

3. PROJECT FEATURES

Tupakulagudem Hydroelectric Project envisages construction of a dam of height of 83m and length of 1132 m across the river Godavari. The project would have live storage of 11535 Mcum at Full Reservoir Level (FRL) of 83 m. The water conductor system would comprise of 1 no of Head Race Tunnel (HRT) which would carry water to the surface powerhouse. The Surface Power House would have an installed capacity 240 MW operated under rated head of 8.3 m. 1 no of Tail Race Tunnel/Channel would carry powerhouse discharge back to the river.

4. HYDROLOGY

The catchment area of the river upto the dam site is 268000 Sq. Km.

5. POWER & ENERGY BENEFITS

According to reassessment study in 1978-87, the project was identified having installed capacity of 975 MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 240MW and 317GWh.

SALIENT FEATURES
TUPAKULAGUDEM HYDROELECTRIC PROJECT

GENERAL:

State	Telangana
District	Mulugu
River	Godavari
Type of Development	Storage
Nearest Railhead	Warangal
Nearest Airport	Hyderabad

LOCATION:

Dam : Latitude & Longitude	18°35'9.24"N, 80°23'35.57"E
Forebay : Latitude & Longitude	18°34'28.20"N,80°22'29.60"E
Power House : Latitude & Longitude	18°33'46.10"N,80°22'53.40"E

HYDROLOGY:

Catchment Area (Sq. Km)	268000
Design Flood (Cumec)	85000

GEOLOGY:

Type of Rock	Quartzo-schistic

DAM:

Length (m)	1132
Height (m)	83

RESERVOIR:

Full Reservoir Level (FRL) (m)	83
Live Storage (Mcum)	11535

INTAKE:

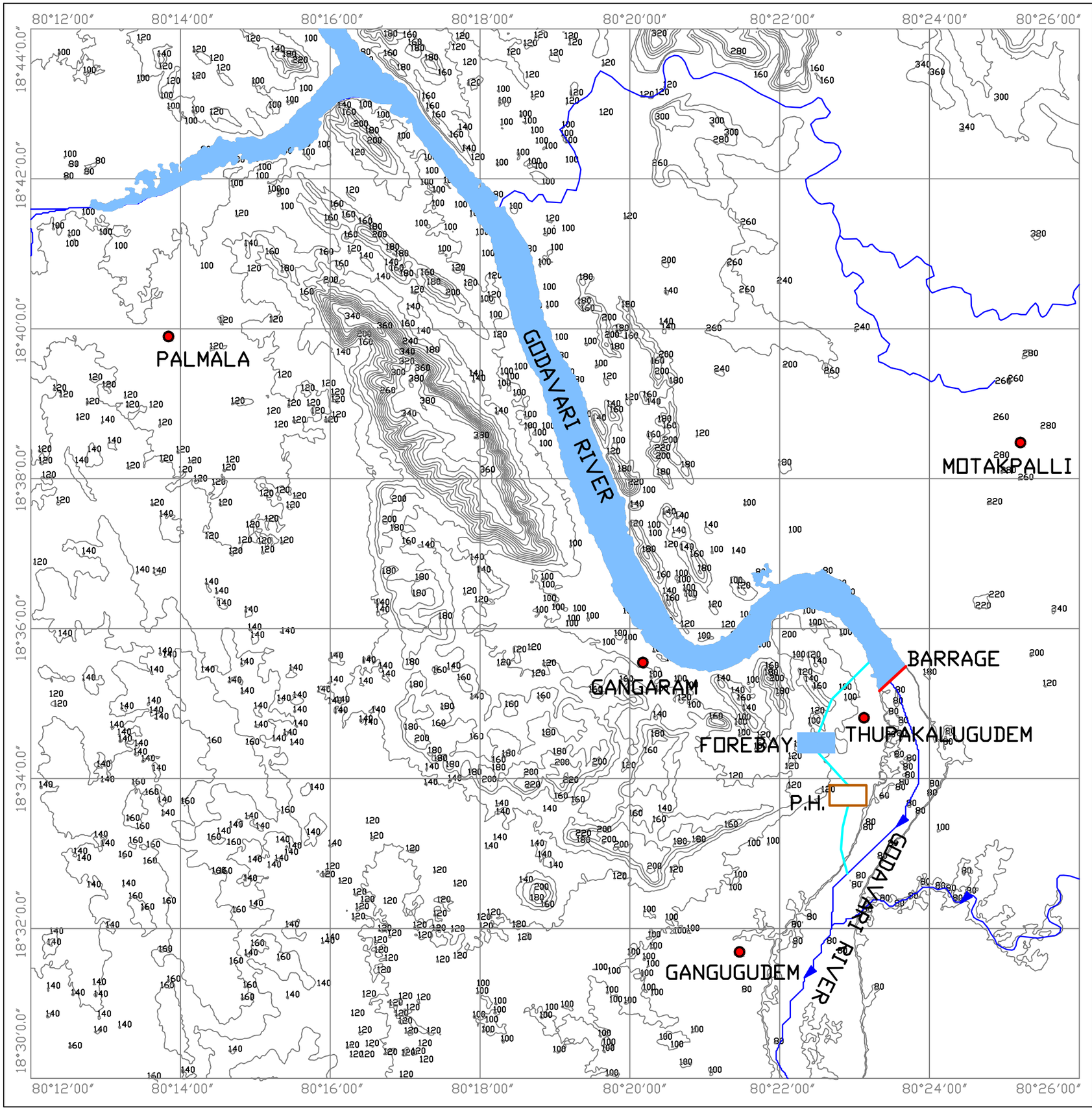
Type	Vertical Lift Wheel
Number	12
Size (m)	12 x 6.12

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Number	1
TAIL RACE TUNNEL/CHANNEL	
Number	1

POWER HOUSE:

Type	Surface
No. of Generating Units	10
Capacity of each Unit (MW)	24
Firm Power (MW)	5
Installed Capacity (MW)	240
Rated Head (m)	8.3
Average Gross Head (Max.) (m)	9
Average Gross Head (Min.) (m)	8
Type of Turbine	Blub type axial flow turbine
Tail Water Level (TWL) (Max.) (m)	87.25
Tail Water Level (TWL) (Min.) (m)	69
Annual Energy (GWh)	317
Design energy (Gwh)	752



N
W E
S

LEGENDS.

CONTOUR

RIVER

BARRAGE

CANAL

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

TUPAKULAGUDEM BARRAGE

FRL- 83 M

DAM HEIGHT - 83 M

LIVE STORAGE - 11535 MCuM

POWER HOUSE

TWL - 69 M

RATED HEAD - 8.3 M

INST. CAPACITY- 240 MW

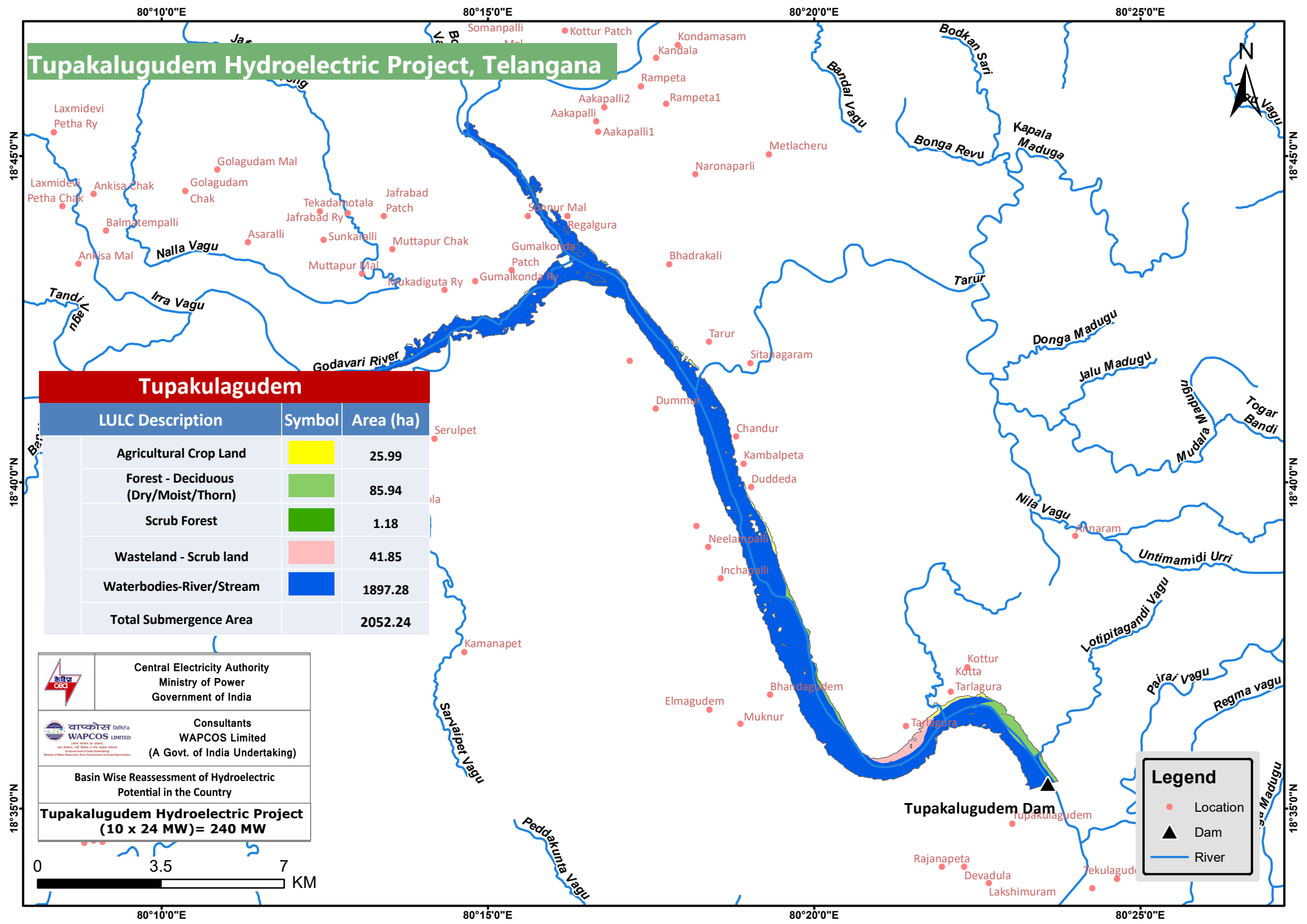
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

TUPAKULAGUDEM HYDROELECTRIC PROJECT
(10X24) = 240 MW

Tupakalugudem Hydroelectric Project, Telangana



Tupakulagudem

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		25.99
Forest - Deciduous (Dry/Moist/Thorn)		85.94
Scrub Forest		1.18
Wasteland - Scrub land		41.85
Waterbodies-River/Stream		1897.28
Total Submergence Area		2052.24

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Tupakalugudem Hydroelectric Project (10 x 24 MW)= 240 MW

7.2 DUMMUGUDEM HYDROELECTRIC PROJECT (4 x 65.5MW=262MW)

1. INTRODUCTION

Dummugudem Hydroelectric Project is a RoR type of development which is located near Dummugudem village approximately 1.5km from project site in Khamman district of Telangana. The project utilize the water of the river Godavari for power generation. The spillway is proposed approximately 200 m downstream of the existing Dummugudem Anicut and the power house is proposed in line with the spillway axis on the right bank. The project is designed to generate power, utilizing net head of 11.5m. The project with a proposed installation of 4 units of 65.5 MW with installed capacity of 262 MW would afford an annual energy generation of 690.06 GWh in a 90% dependable year.

2. LOCATION/ACCESSIBILITY

The Dam site of the project is located at Latitude 17°52'25.3"N & Longitude 80°53'07.6"E and the Power house is located at Latitude 17°52'35.4"N & Longitude 80°52'42.8"E. The nearest railway station is Bhadrachalam and the nearest airport is Vijaywada.

3. PROJECT FEATURES

The Dummugudem Hydroelectric project envisages construction of a dam across the Godavari River. The reservoir has live storage of 438 Mcum between Full Reservoir Level (FRL) of 60 m and Minimum Draw Down Level (MDDL) of 52 m. The powerhouse could be located on the right bank of river with an installation of 262 MW under net head of 11.5 m.

4. HYDROLOGY

The catchment area of the river upto dam site is 277001 Sq. Km.

5. POWER & ENERGY BENEFITS

The DPR with installed capacity of 320MW was returned on 08/06 due to non-replying of various comments such as Hydro Planning, cost of E&M works, Hydel Civil Engineering and Geological aspects etc. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 262MW and 690.06 GWh.

SALIENT FEATURES
DUMMUGUDEM HYDROELECTRIC PROJECT

GENERAL:

State	Telangana
District	Khamman
River	Godavari
Type of Development	RoR
Nearest Railhead	Bhadrachalam
Nearest Airport	Vijaywada

LOCATION:

Dam : Latitude & Longitude	17°52'25.3"N, 80°53'07.6"E
Power House : Latitude & Longitude	17°52'35.4"N, 80°52'42.8"E

HYDROLOGY:

Catchment Area (Sq. Km)	277001
Avg. Annual Rainfall (mm)	1351

RESERVOIR:

Full Reservoir Level (FRL) (m)	60
Minimum Draw Down Level (MDDL) (m)	52
Live Storage (Mcum)	438

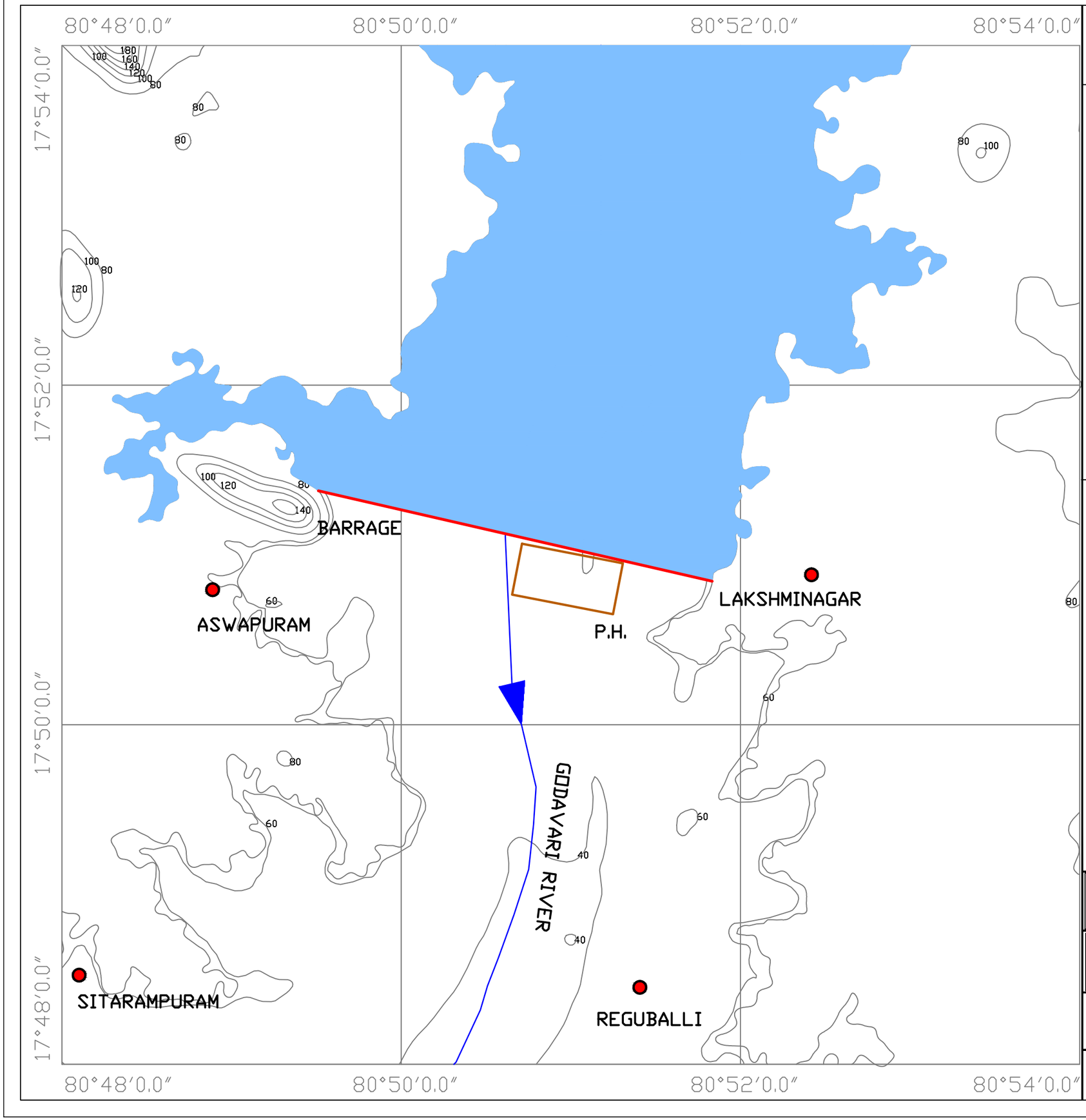
INTAKE:

Number	8
Size (m)	163
Diameter (m)	6.2

POWER HOUSE:

No. of Generating Units	4
Capacity of each Unit (MW)	65.5
Firm Power (MW)	46.76
Installed Capacity (MW)	262
Net Head (m)	11.5
Normal Tail Water Level (TWL) (m)	45.72

Tail Water Level (TWL) (Min.) (m)	42.34
Type of Turbine	Bulb Turbine
Annual Energy (GWh)	690.06



N

W E

S

LEGENDS.

CONTOUR

RIVER

BARRAGE

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

DUMMUGUDEM BARRAGE

FRL- 60 M

MDDL- 52 M

LIVE STORAGE - 438 MCuM

POWER HOUSE

TWL- 45.72 M

NET HEAD - 11.5 M

INST. CAPACITY- 262 MW

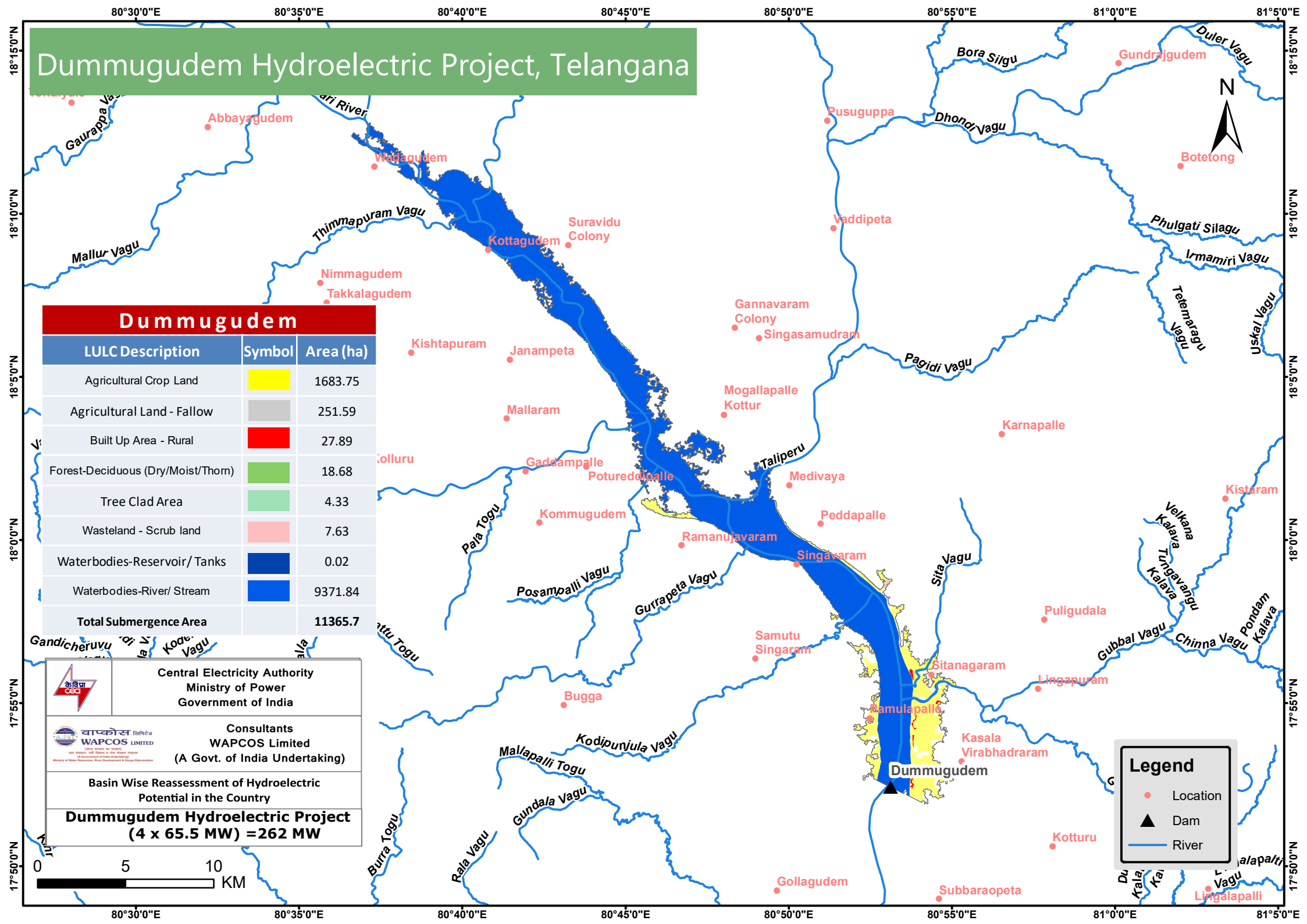
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

DUMMUGUDEM BARRAGE HYDROELECTRIC PROJECT
(4X65.5) = 262 MW

Dummugudem Hydroelectric Project, Telangana



Dummugudem

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		1683.75
Agricultural Land - Fallow		251.59
Built Up Area - Rural		27.89
Forest-Deciduous (Dry/Moist/Thorn)		18.68
Tree Clad Area		4.33
Wasteland - Scrub land		7.63
Waterbodies-Reservoir/ Tanks		0.02
Waterbodies-River/ Stream		9371.84
Total Submergence Area		**11365.7**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Dummugudem Hydroelectric Project (4 x 65.5 MW) =262 MW

0 5 10 KM

Legend
- Location
- Dam
- River

7.3 BODHGHAT HYDROELECTRIC PROJECT (4x63MW=252MW)

1. INTRODUCTION

The Bodhghat Hydroelectric Project is a storage type of development near Sadar village, approximately 2348 m from the project site located in Dantewada of Chhattisgarh. The project would utilize water of Godavari River for power generation by utilizing a Net head (max) of 99.08 m. The Underground powerhouse has 4 units of 63 MW enabling installed capacity of 252 MW to generate annual energy of 664.74 MU in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Godavari River at Latitude 19°11'19.3"N & Longitude 81°24'08.0"E. The power house is located at Latitude 19°09'54.5"N & Longitude 81°23'29.9"E in Dantewada district of Chhattisgarh. The nearest railway station is Geedam and the nearest airport is Raipur.

3. PROJECT FEATURES

The Bodhghat Hydroelectric Project envisage construction of 90 m high Roller Compacted Concrete gravity dam with rock fill flanks. The reservoir would have live storage of 2198.93 Mcum between Full reservoir Level (FRL) of 456 m and Minimum draw down level (MDDL) at 426.8 m. The water conductor system would comprise of a Head race tunnel (HRT) of length 2.35 km, surge shaft and Pressure Shaft of length 220 m. A Penstock Assembly Chamber with pressure shafts lead water to the turbines. The Project has a power house operated under rated net head (max) of 99.08 m enabling installed capacity of 252 MW. The discharged water from powerhouse would be carried back to the river by 4800 m long Tail Race Channel.

4. HYDROLOGY

The Catchment area of the river upto the diversion site is 15719 Sq.Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 560MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 252 MW and 664.74 GWh respectively in 90% dependable year.

SALIENT FEATURES
BODHGHAT HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Dantewada
River	Indravati
Type of Development	Storage
Nearest Railhead	Geedam road railway station
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19°11'19.3"N, 81°24'08.0"E
Power House : Latitude & Longitude	19°09'54.5"N, 81°23'29.9"E

HYDROLOGY:

Catchment Area (Sq. Km)	15719
Design Flood (Cumecs) (PMF)	47200

DAM:

Type	Roller Compacted Concrete gravity dam with rock fill flanks
Length (m)	951
Height (m)	90

RESERVOIR:

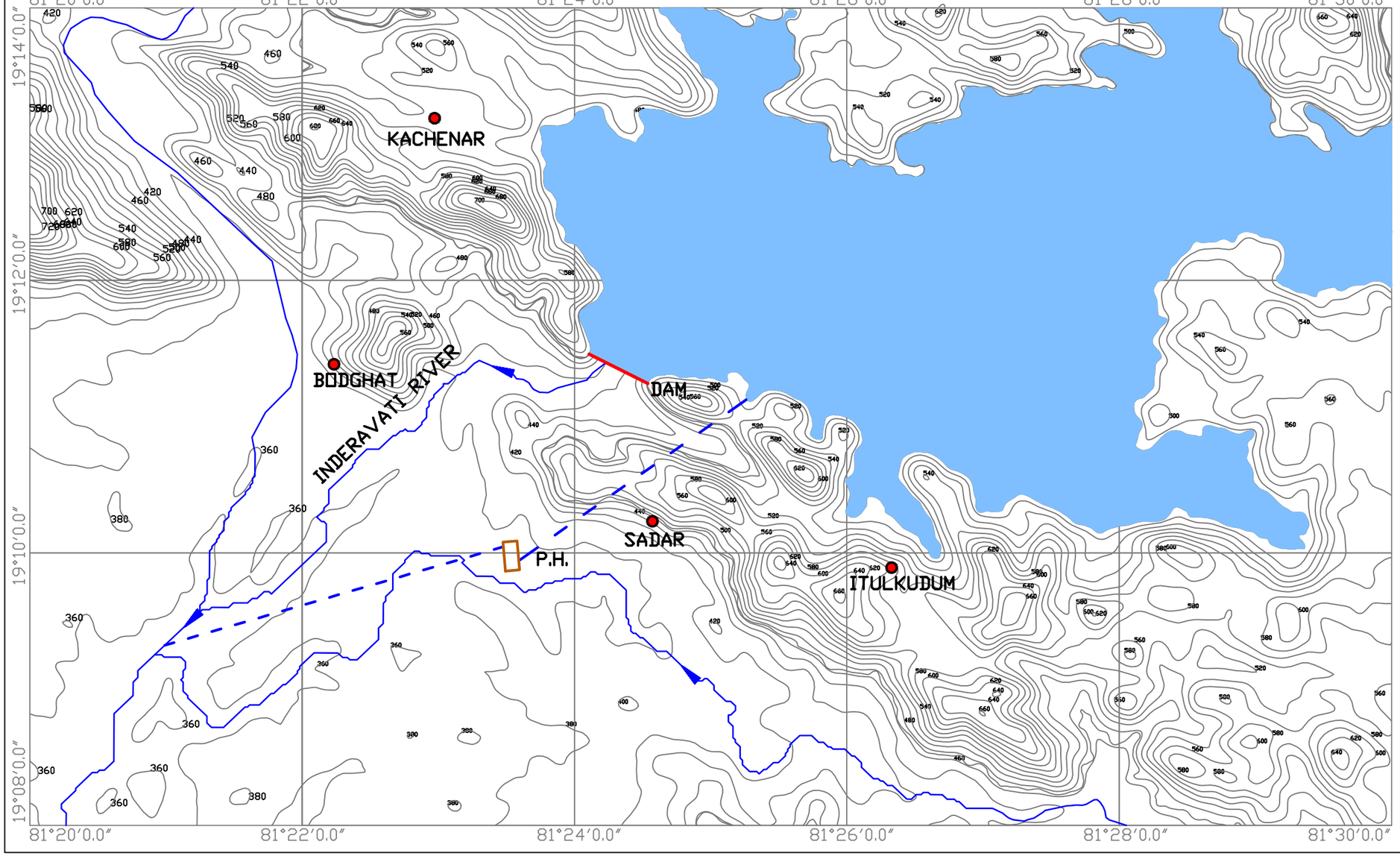
Full Reservoir Level (FRL) (m)	456
Minimum Draw Down Level (MDDL) (m)	426.8
Live Storage (Mcum)	2198.93

WATER CONDUCTOR SYSTEM:

HEAD RACE TUNNEL/CHANNEL	
Length (m)	2347
PRESSURE SHAFT	
Length (m)	220

POWER HOUSE:

No. of Generating Units	4
Capacity of each Unit (MW)	63
Firm Power (MW)	83.37
Installed Capacity (MW)	252
Net Head (Max.) (m)	99.08
Type of Turbine	Francis
Tail Water Level (TWL) (m)	350.6
Design Discharge (Cumecs)	610
Annual Energy (GWh)	664.74



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BODHGHAT DAM

FRL- 456 M

MDDL - 426.8 M

DAM HEIGHT- 90 M

LIVE STORAGE - 2198.93 MCuM

POWER HOUSE

TWL- 350.6 M

NET HEAD (MAX.)- 99.08 M

INST. CAPACITY- 252 MW

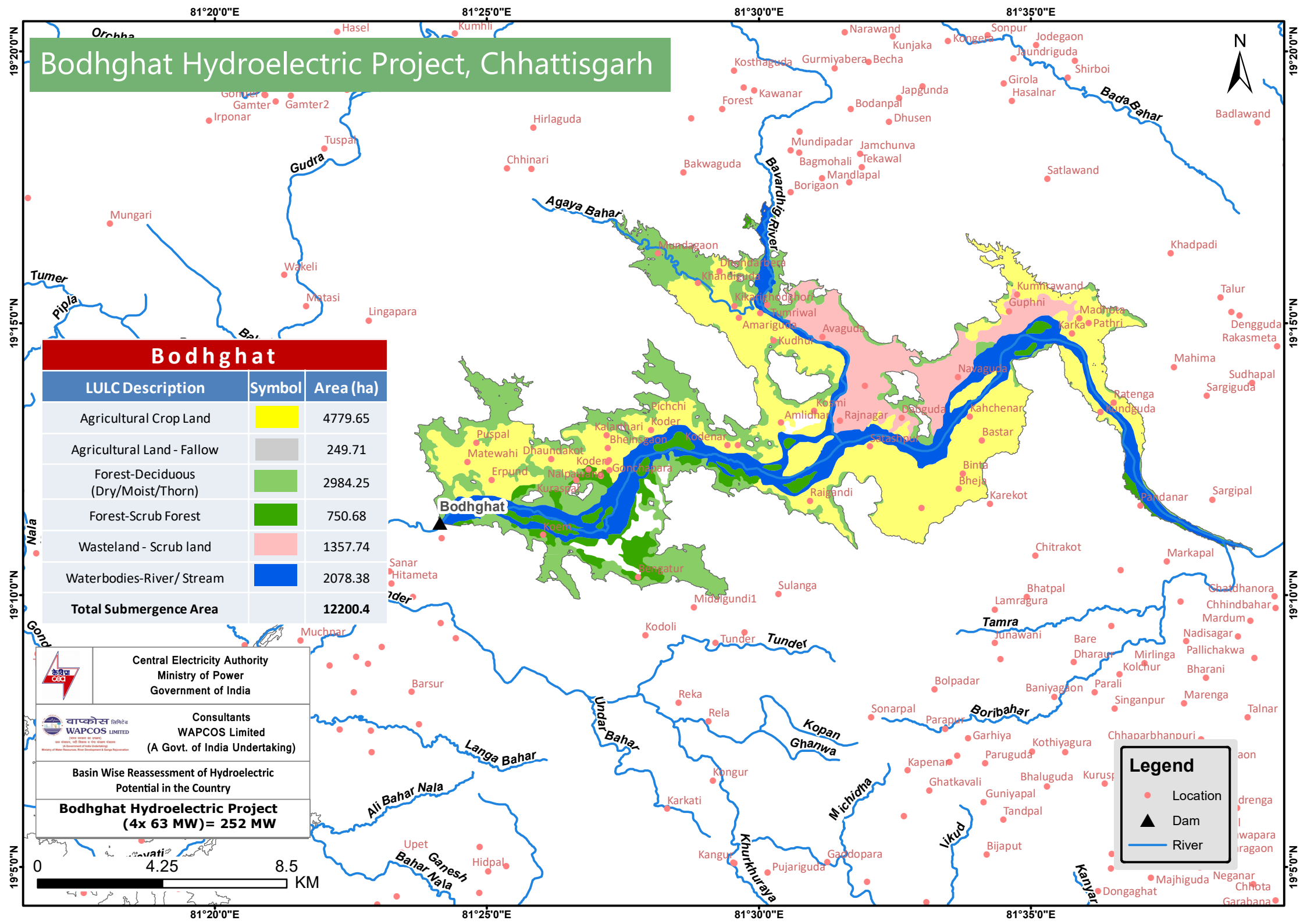
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BODHGHAT HYDROELECTRIC PROJECT
(4X63) = 252MW

Bodhghat Hydroelectric Project, Chhattisgarh



7.4 KUTRU-I HYDROELECTRIC PROJECT (3x32MW=96MW)

1. INTRODUCTION

Kutru-I Hydroelectric Project is a storage type of development near Tumnar village, approximately 2323 m from the project site site located in Bastar district of Chhattisgarh. The project would utilize water of Indravati River for power generation, utilizing net head (max) of about 29.7m. The powerhouse has 3 units of 32 MW enabling installed capacity of 96 MW to generate annual energy of 252.29 MU in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Indravati River at Latitude 19°3'15''N & Longitude 81°14'E and a dam toe power house in Bastar district of Chhattisgarh. The nearest railway station is Dantewara and the nearest airport is Raipur.

3. PROJECT FEATURES

Kutru-I Hydroelectric Project consists of a 48.56 m high, 920 m long composite gravity dam with earthfill/rock fill side flank. The reservoir would have live storage of 129.66 Mcum between Full Reservoir Level (FRL) of 347 m and Minimum Draw down Level (MDDL) of 342.57 m. The Project has a dam toe power house operated under net head (max.) of 29.70 m enabling installed capacity of 96 MW. The Hydroelectric Project has a tail water level (TWL) at 317 m.

4. HYDROLOGY

The catchment area of the river upto the diversion site is 18309 Sq.Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 180MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 96 MW and 252.29 GWh respectively in 90% dependable year.

SALIENT FEATURES
KUTRU-I HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Bastar
River	Indravati
Type of Development	Storage
Nearest Railhead	Dantewara
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19° 3'15''N, 81°14'E
Power House : Latitude & Longitude	Dam Toe

HYDROLOGY:

Catchment Area (Sq. Km)	18309

DAM:

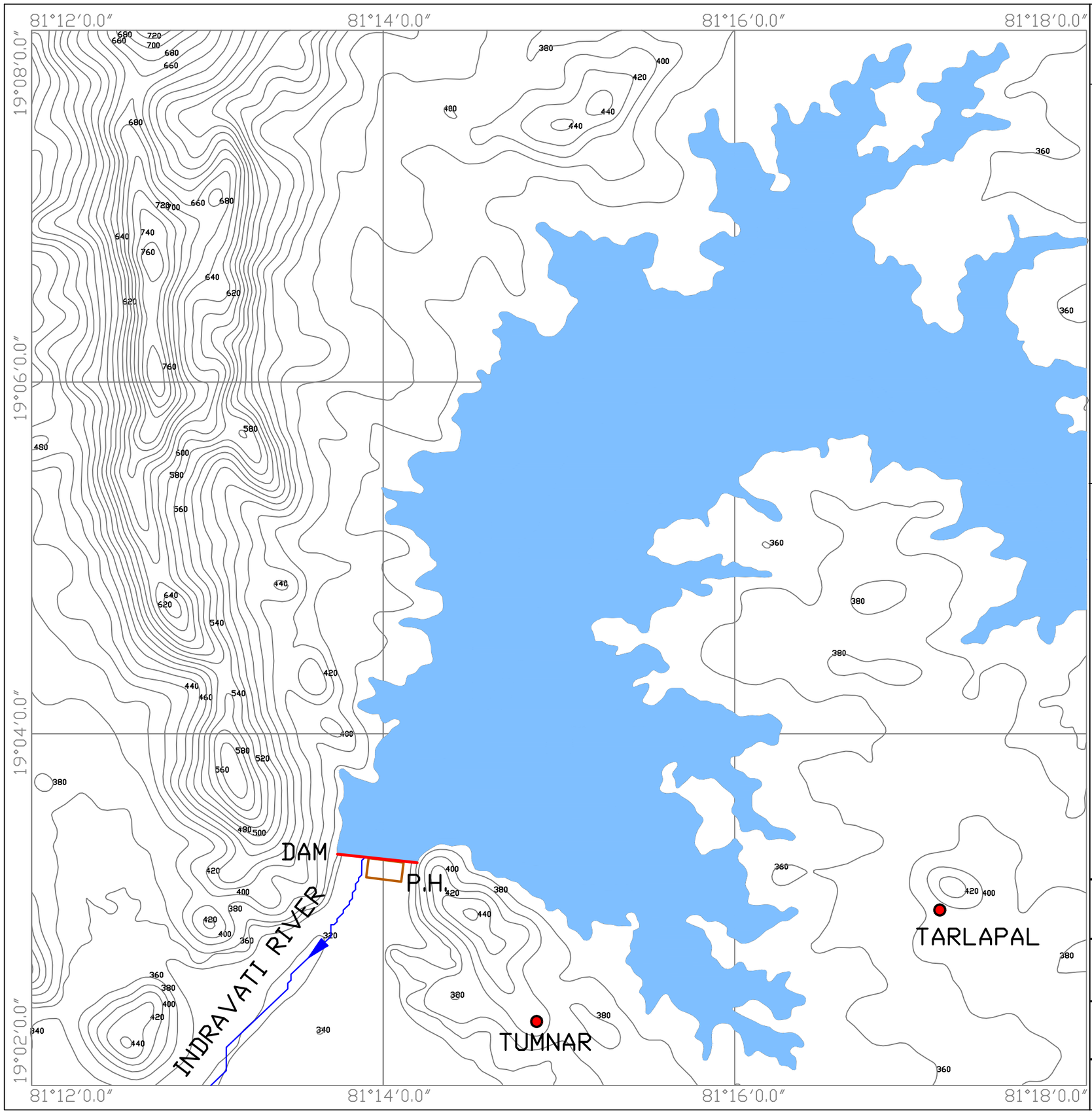
Type	Composite gravity
Length (m)	920
Height (m)	48.56

RESERVOIR:

Full Reservoir Level (FRL) (m)	347
Minimum Draw Down Level (MDDL) (m)	342.57
Live Storage (Mcum)	129.66

POWER HOUSE:

No. of Generating Units	3
Capacity of each Unit (MW)	32
Firm Power (MW)	29.47
Installed Capacity (MW)	96
Net Head (Max.) (m)	29.7
Type of Turbine	Francis
Tail Water Level (TWL) (m)	317
Annual Energy (GWh)	252.29



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KUTRU-I DAM

FRL- 347 M

MDDL - 342.7 M

DAM HEIGHT- 48.56 M

LIVE STORAGE -129.66 MCuM

POWER HOUSE

TWL- 317 M

NET HEAD (MAX.)- 29.7 M

INST. CAPACITY- 96 MW

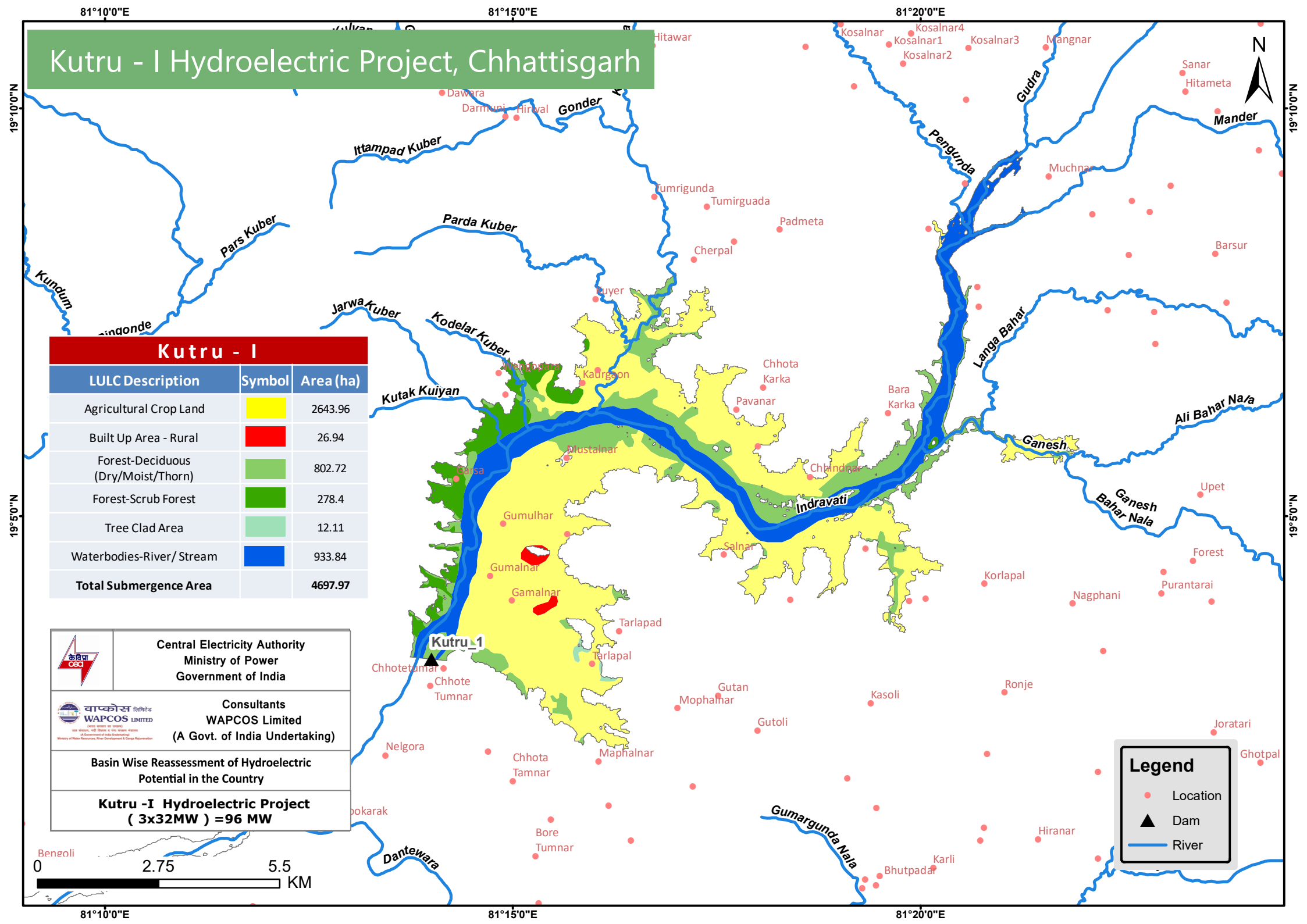
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUTRU-I HYDROELECTRIC PROJECT.
(3X32) = 96MW

Kutru - I Hydroelectric Project, Chhattisgarh



Kutru - I

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		2643.96
Built Up Area - Rural		26.94
Forest-Deciduous (Dry/Moist/Thorn)		802.72
Forest-Scrub Forest		278.4
Tree Clad Area		12.11
Waterbodies-River/ Stream		933.84
Total Submergence Area		**4697.97**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Kutru -I Hydroelectric Project
(3x32MW) =96 MW

Legend
- Location
- Dam
- River

7.5 KUTRU-II HYDROELECTRIC PROJECT (4X68.75MW=275MW)

1. INTRODUCTION

Kutru-II Hydroelectric Project is a storage type of development near Ponodwaya village, approximately 2369 m from the project site site located in Bastar district of Chhattisgarh. The project would utilize water of Indravati River for power generation by utilizing a net head (max.) of about 42.18 m. The powerhouse has 4 units of 68.75 MW enabling installed capacity of 275 MW to generate annual energy of 870.16 MU in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Indravati River Latitude 19°05'54.97"N & Longitude 80°53'32.89"E and a dam toe power house in Bastar district of Chhattisgarh. The nearest railway station is Dantewara and the nearest airport is Raipur.

3. PROJECT FEATURES

Kutru-II Hydroelectric Project envisage construction of a 37.36 m high, 1250 m long composite gravity dam with earthfill/rock fill side flank. The reservoir would have live storage of 1258.4 Mcum between Full Reservoir Level (FRL) of 317 m and Minimum Draw down Level (MDDL) of 295.7 m. The Project has a dam toe power house operated under net head (max) of 42.18 m enabling installed capacity of 275 MW. The hydroelectric project has a Tail Water Level (TWL) at 274.39 m.

4. HYDROLOGY

The Catchment area of the river upto the diversion site is 21189 Sq.Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 300 MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 275 MW and 870.16 GWh respectively in 90% dependable year.

SALIENT FEATURES
KUTRU-II HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Bastar
River	Indravati
Type of Development	Storage
Nearest Railhead	Dantewara
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19°05'54.97"N,80°53'32.89"E
Power House : Latitude & Longitude	19°05'54.97"N,80°53'32.89"E

HYDROLOGY:

Catchment Area (Sq. Km)	21189

DAM:

Type	Composite Gravity
Length (m)	1250
Height (m)	37.36

RESERVOIR:

Full Reservoir Level (FRL) (m)	317
Minimum Draw Down Level (MDDL) (m)	295.7
Live Storage (Mcum)	1258.4

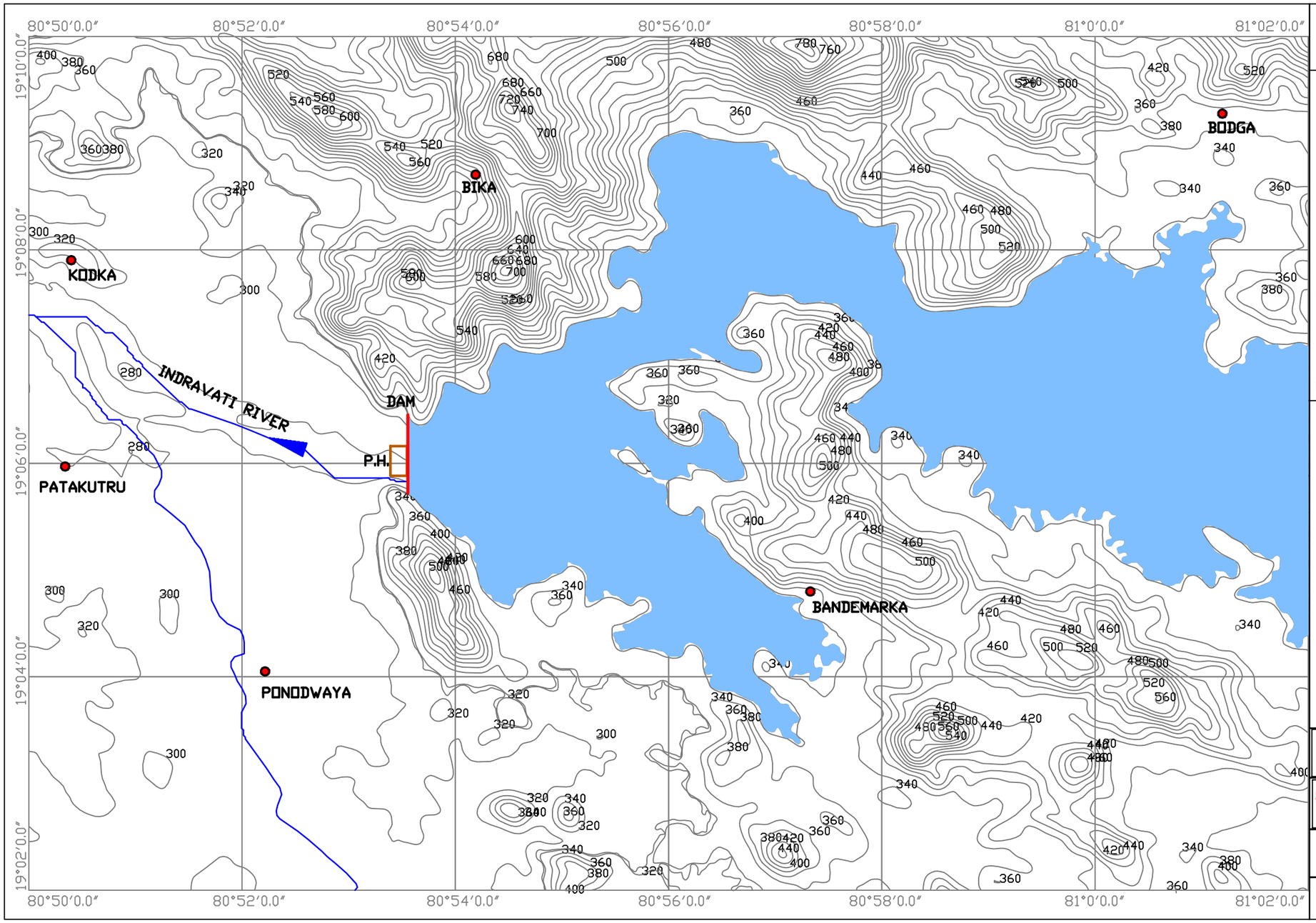
WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	4
Diameter (m)	5.85

POWER HOUSE:

Type	Dam toe
No. of Generating Units	4
Capacity of each Unit (MW)	68.75

Firm Power (MW)	70.65
Installed Capacity (MW)	275
Net Head (max.) (m)	42.18
Type of Turbine	Francis
Tail Water Level (TWL) (m)	274.39
Annual Energy (GWh)	870.16



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KUTRU-II DAM

FRL- 317 M

MDDL - 295.7 M

DAM HEIGHT- 37.36 M

LIVE STORAGE- 1258.4 MCuM

POWER HOUSE

TWL- 274.39 M

NET HEAD (MAX.)- 42.18 M

INST. CAPACITY- 275 MW

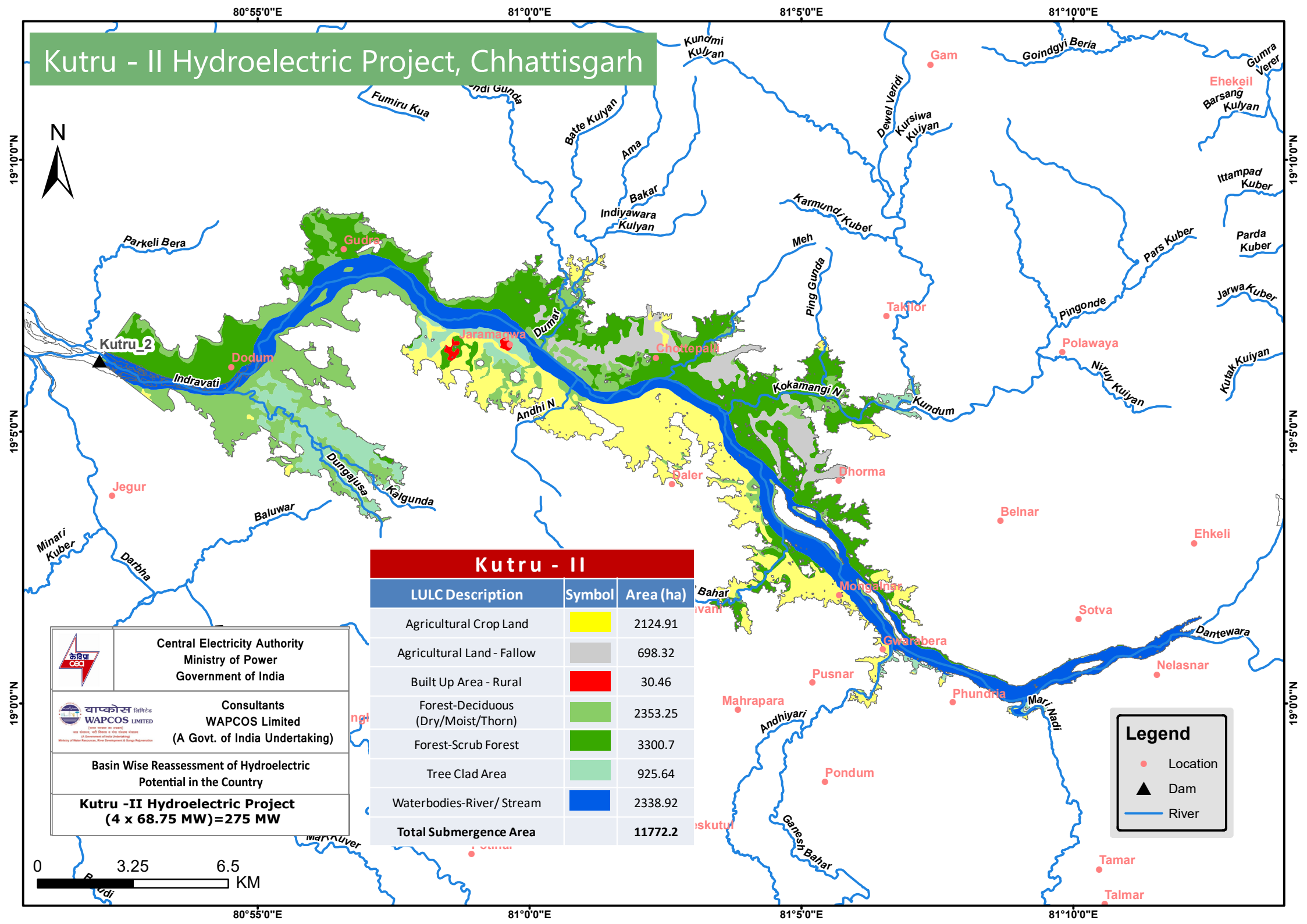
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUTRU-II HYDROELECTRIC PROJECT
(4X68.75) = 275MW

Kutru - II Hydroelectric Project, Chhattisgarh



Kutru - II		
LULC Description	**Symbol**	**Area (ha)**
Agricultural Crop Land		2124.91
Agricultural Land - Fallow		698.32
Built Up Area - Rural		30.46
Forest-Deciduous (Dry/Moist/Thorn)		2353.25
Forest-Scrub Forest		3300.7
Tree Clad Area		925.64
Waterbodies-River/ Stream		2338.92
Total Submergence Area		**11772.2**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Kutru -II Hydroelectric Project
(4 x 68.75 MW)=275 MW

Legend
- Location
- Dam
- River

7.6 NUGUR-I HYDROELECTRIC PROJECT (4 X68MW=272MW)

1. INTRODUCTION

Nugur-I Hydroelectric Project is a storage type development near Lanka approximately 3292 m in Dantewada district of Chhattisgarh. The project would utilize water of Indravati River discharged from powerhouse of Kutru-II hydroelectric project by utilizing net head (max.) of 30.24 m for power generation. The surface Powerhouse has 4 units of 68 MW each enabling installed capacity of 272 MW to generate annual energy of 744.84 MW in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Pravara River having Latitude 19°13' 00''N & Longitude 80°45'00''E and a dam toe Power in Dantewada district of Chhattisgarh. The nearest railway station is Raipur railway station & the nearest airport to the project site is Raipur.

3. PROJECT FEATURES

The Nugur-I Hydroelectric Project envisages construction of 31m high composite Roller compacted concrete (RCC) gravity dam and earth & rock fill dam across river Indravati. The reservoir would have live storage of 140.76 M cum between Full reservoir Level (FRL) at 273.70 m and Minimum draw down level (MDDL) at 266.80 m. The water conductor system would comprise of Penstock of length 76 m and 5.95 m diameter which would carry water to the powerhouse. The project has a surface powerhouse operated under net head (max.) of 30.24 m enabling an installed capacity of 272 MW. The discharged water from surface powerhouse would be carried back to the river by Tail Race Channel/Tunnel.

4. HYDROLOGY

The catchment area of the river upto the diversion site is 23522 Sq. Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 230 MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 272 MW and 744.84 GWh respectively in 90% dependable year.

SALIENT FEATURES
NUGUR-I HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Dantewada
River	Indravati
Type of Development	Storage
Nearest Railhead	Raipur
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19°13'00''N, 80°45'00'' E
Power House : Latitude & Longitude	19°13'00''N, 80°45'00'' E

HYDROLOGY:

Catchment Area (Sq. Km)	23522

DAM:

Type	Composite Roller Compacted Concrete Gravity
Length (m)	2110
Height (m)	31

RESERVOIR:

Full Reservoir Level (FRL) (m)	273.70
Minimum Draw Down Level (MDDL) (m)	266.80
Live Storage (Mcum)	140.76

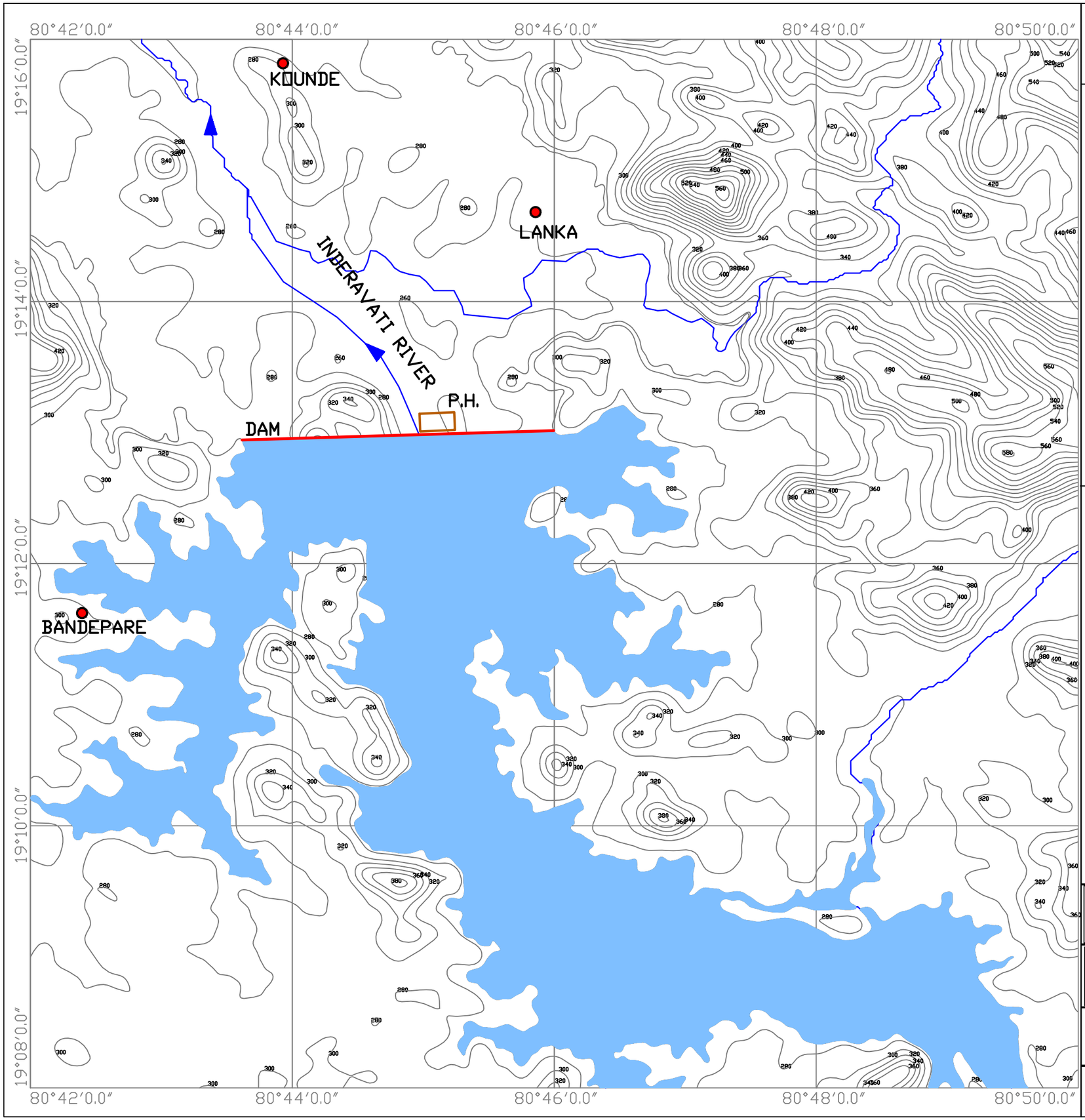
WATER CONDUCTOR SYSTEM:

PENSTOCK	
Diameter (m)	5.95
Length (m)	76

POWER HOUSE:

Type	Surface
No. of Generating Units	4

Capacity of each Unit (MW)	68
Firm Power (MW)	50.69
Installed Capacity (MW)	272
Net Head (max) (m)	30.24
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	243.15
Annual Energy (GWh)	744.84



N
W
E
S

LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NUGUR-I DAM

FRL- 273.7 M

MDDL - 268.8 M

DAM HEIGHT- 31 M

LIVE STORAGE -140.76 MCuM

POWER HOUSE

TWL- 243.15 M

NET HEAD (MAX.)- 30.24 M

INST. CAPACITY- 272 MW

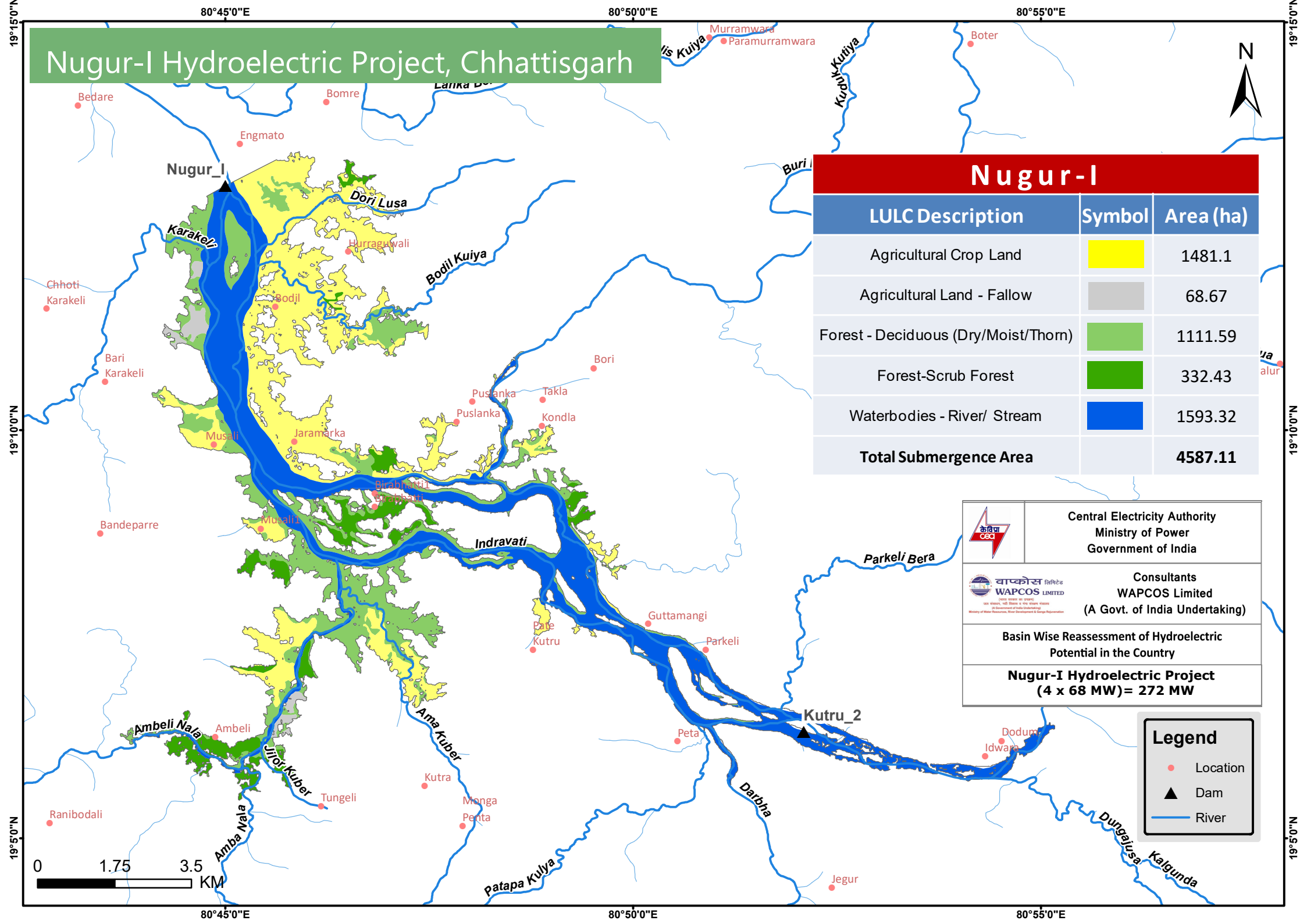
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

NUGUR-I HYDROELECTRIC PROJECT
(4X68) = 272MW

Nugur-I Hydroelectric Project, Chhattisgarh



Nugur-I

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		1481.1
Agricultural Land - Fallow		68.67
Forest - Deciduous (Dry/Moist/Thorn)		1111.59
Forest-Scrub Forest		332.43
Waterbodies - River/ Stream		1593.32
Total Submergence Area		**4587.11**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Nugur-I Hydroelectric Project (4 x 68 MW)= 272 MW

Legend

- Location
- Dam
- River

7.7 KOTRI HYDROELECTRIC PROJECT (2x22MW=44MW)

1. INTRODUCTION

Kotri Hydroelectric Project is a storage type of development near Mungbeda village, approximately 4786 m from the project site site located in Bastar district of Chhattisgarh. The project would utilize water of Indravati River for power generation by utilizing a Net Head (max) of about 44.55 m. The powerhouse has 2 units of 22 MW enabling installed capacity of 44 MW to generate annual energy of 142.66 GWh in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site of the project is located on Indravati River Latitude 19°39'48.8"N & Longitude 80°40'06.6"E and a dam toe power house in Bastar district of Chhattisgarh. The nearest railway station is Dantewara and the nearest airport is Raipur.

3. PROJECT FEATURES

Kotri Hydroelectric Project envisage construction of a 73 m high composite Gravity and Earth & Rockfill Gravity dam across river Kotri River, a tributary of Indravati River. The reservoir would have live storage of 608.47 Mcum between Full Reservoir Level (FRL) at 290.0 m and Minimum Drawn Down Level (MDDL) of 277 m. The Project has a dam toe surface power house operated under net head (max) of 44.55 m enabling installed capacity of 44 MW. The Hydroelectric Project has a Tail Water Level (TWL) at 245 m. The discharged water from powerhouse would be carried back to the river by Tail Race Tunnel/ Channel.

4. HYDROLOGY

The Catchment area of the river upto the diversion site is 6091 Sq.Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 111 MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 44 MW and 142.66 GWh respectively in 90% dependable year.

SALIENT FEATURES
KOTRI HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Bastar
River	Kotri
Type of Development	Storage
Nearest Railhead	Dantewara
Nearest Airport	Raipur

LOCATION:

Dam : Latitude & Longitude	19°39'48.8"N, 80°40'06.6"E
Power House : Latitude & Longitude	Dam Toe

HYDROLOGY:

Catchment Area (Sq. Km)	6091

DAM:

Type	Composite Concrete Gravity dam with Earthfill / Rockfill Embankments on both sides
Length (m)	1194
Height (m)	73

RESERVOIR:

Full Reservoir Level (FRL) (m)	290
Minimum Draw Down Level (MDDL) (m)	277
Live Storage (Mcum)	608.47

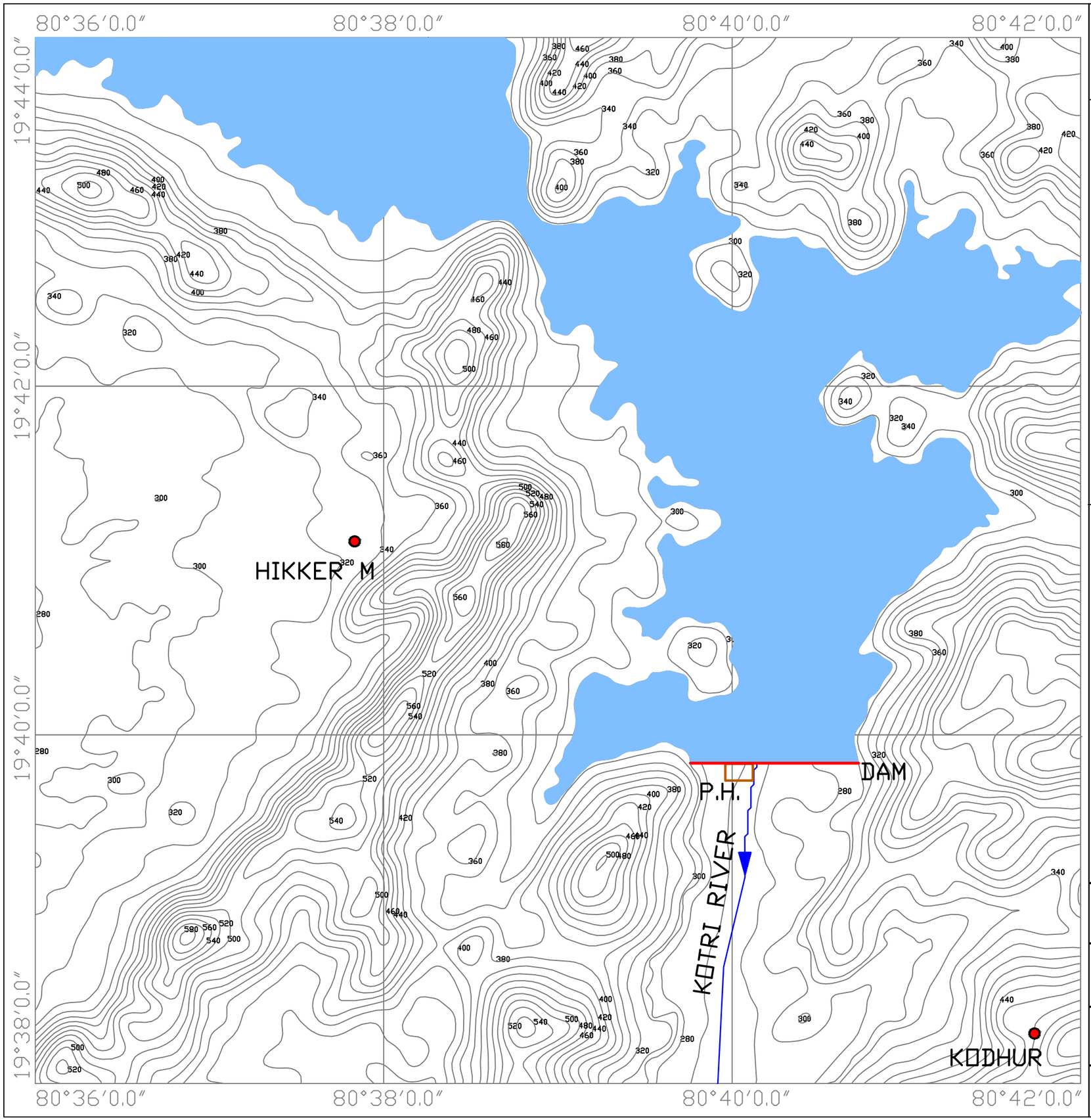
WATER CONDUCTOR SYSTEM:

PENSTOCK	
Diameter (m)	68
Length (m)	5.5

POWER HOUSE:

Type	Surface

No. of Generating Units	2
Capacity of each Unit (MW)	22
Firm Power (MW)	14.56
Installed Capacity (MW)	44
Net Head (max.) (m)	44.55
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	245
Annual Energy (GWh)	142.66





LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KOTRI DAM

FRL- 290 M

MDDL - 277 M

DAM HEIGHT- 73 M

LIVE STORAGE -608.47 MCuM

POWER HOUSE

TWL- 245 M

NET HEAD (MAX.)- 44.55 M

INST. CAPACITY- 44 MW

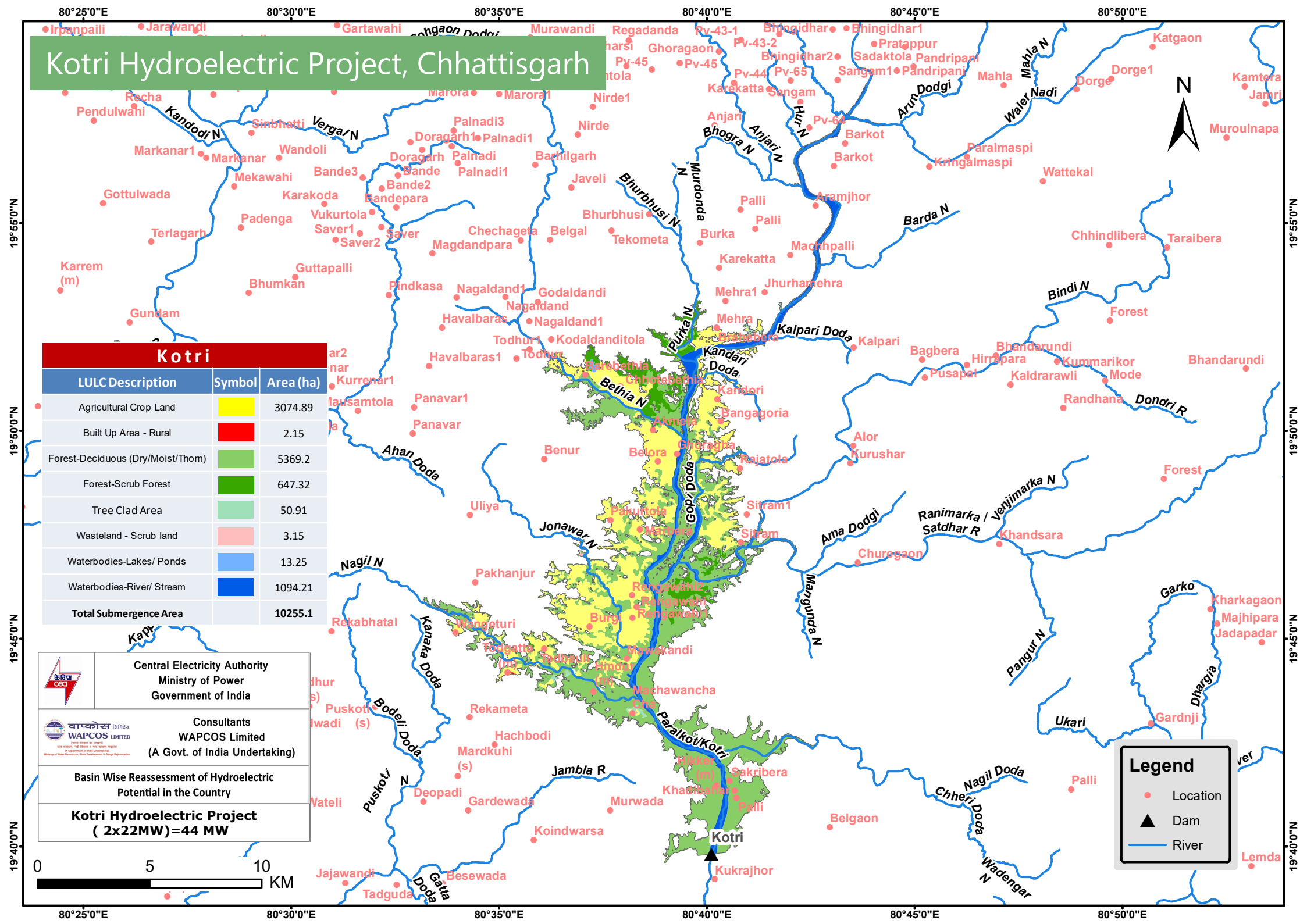
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KOTRI HYDROELECTRIC PROJECT
(2X22) = 44MW

Kotri Hydroelectric Project, Chhattisgarh



7.8 WAINGANGA HYDROELECTRIC PROJECT (5x27.6MW=138MW)

1. INTRODUCTION

The Wainganga Hydroelectric Project is a storage type of development which is located near Halda village approximately 2.75km from project site on the border of Gadchiroli and Chandrapur districts of Maharashtra. The project utilizes the water of the river Wainganga, a tributary of Godavari for power generation. The project is designed to generate power, harnessing a Net head (max) of 25.15 m. The project with a proposed installation of 138 MW (5 x 27.6 MW) would afford an annual energy generation of 367.39 GWh in a 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site is located at Latitude 20°23'0''N & Longitude 79° 57' 35''E. The Power house having Latitude of 20°23'0'' N & Longitude of 79°57'35"E. The nearest railway station is Bramhapuri and the nearest Airport is Nagpur.

3. PROJECT FEATURES

The Wainganga Hydroelectric project envisages construction of a 32 m high concrete dam across river Wainganga. The reservoir would have live storage of 3366.69 Mcum between Full Reservoir Level (FRL) of 222.4 m and Minimum Draw Down Level (MDDL) of 212.0 m. The Water conductor system would consist 5 nos. of penstock of length 70 m which carry water to the powerhouse. A dam toe surface power house would have an installation of 5 units of 27.6 MW each using Kaplan turbine operating under a Net head (max) of 25.15m. A 300 m long Tail Race Channel would carry the power house releases back to the river.

4. HYDROLOGY

The catchment area of the river upto dam site is 43264 Sq. km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 105 MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 138 MW and 367.39 GWh in 90% dependable year.

SALIENT FEATURES
WAINGANGA HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Gadchiroli/Chandrapur
River	Wainganga
Type of Development	Storage
Nearest Railhead	Bramhapuri
Nearest Airport	Nagpur

LOCATION:

Dam : Latitude & Longitude	20°23'0"N, 79°57'35"E
Power House : Latitude & Longitude	20°23'0"N, 79°57'35"E

HYDROLOGY:

Catchment Area (Sq. Km)	43264

DAM:

Type	Concrete & Composite Earthen dam
Length (m)	6030
Height (m)	32

RESERVOIR:

Full Reservoir Level (FRL) (m)	222.4
Minimum Draw Down Level (MDDL) (m)	212
Live Storage (Mcum)	3366.69

INTAKE:

Gate No	5
Size (m)	5.5 x 5.5

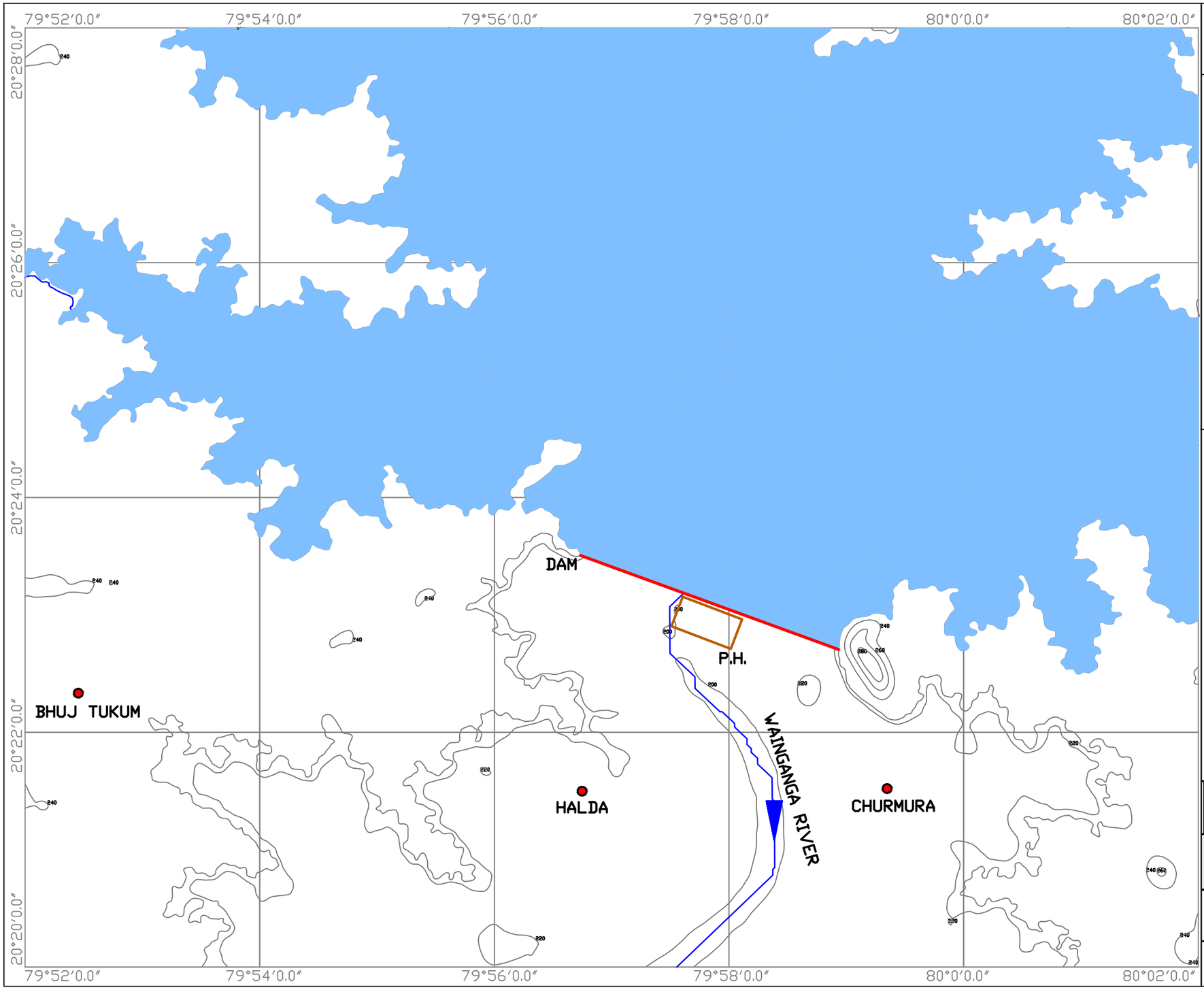
WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	5
Diameter (m)	5

Length (m)	70
TAIL RACE CHANNEL	
Type	Trapizoidal
Type of lining	Concrete
Width (m)	60
Length (m)	300

POWER HOUSE:

Type	Surface
No. of Generating Units	5
Capacity of each Unit (MW)	27.6
Firm Power (MW)	42.52
Installed Capacity (MW)	138
Net Head (Max.) (m)	25.15
Type of Turbine	Kaplan
Tail Water Level (TWL) (m) (Max.)	198
Tail Water Level (TWL) (m) (Min.)	197
Annual Energy (GWh)	367.39



LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

WAINGANGA DAM

FRL- 222.4 M

MDDL- 212 M

DAM HEIGHT- 32 M

LIVE STORAGE -3366.69 MCuM

POWER HOUSE

TWL- 198 M

NET HEAD (MAX.)- 25.15 M

INST. CAPACITY- 138 MW

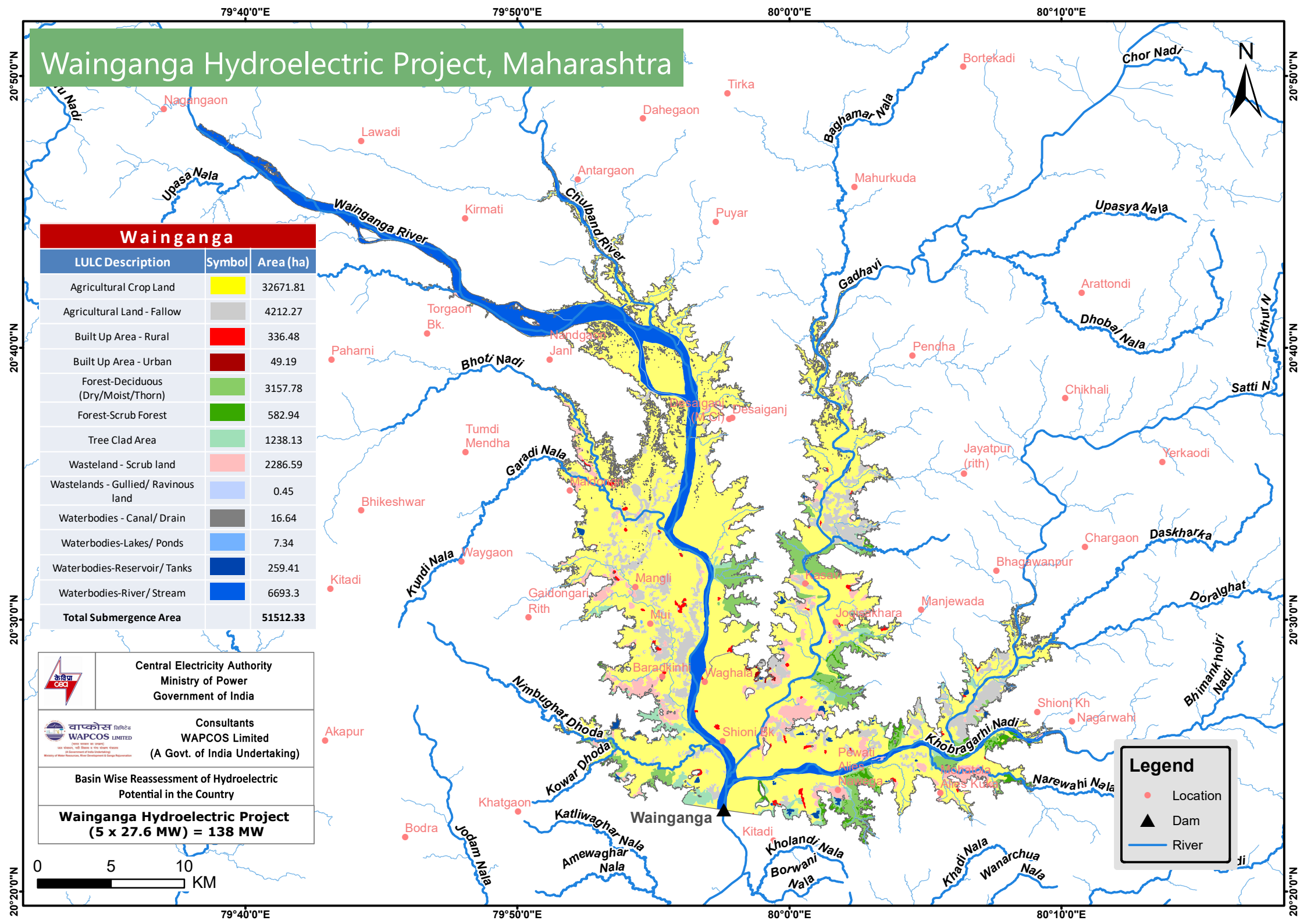
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

WAINGANGA HYDROELECTRIC PROJECT
(5X27.6) = 138MW

Wainganga Hydroelectric Project, Maharashtra



Wainganga

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		32671.81
Agricultural Land - Fallow		4212.27
Built Up Area - Rural		336.48
Built Up Area - Urban		49.19
Forest-Deciduous (Dry/Moist/Thorn)		3157.78
Forest-Scrub Forest		582.94
Tree Clad Area		1238.13
Wasteland - Scrub land		2286.59
Wastelands - Gullied/ Ravinous land		0.45
Waterbodies - Canal/ Drain		16.64
Waterbodies-Lakes/ Ponds		7.34
Waterbodies-Reservoir/ Tanks		259.41
Waterbodies-River/ Stream		6693.3
Total Submergence Area		**51512.33**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Wainganga Hydroelectric Project (5 x 27.6 MW) = 138 MW

Legend
- Location
- Dam
- River

7.9 SAMDA HYDROELECTRIC PROJECT (3x15MW=45MW)

1. INTRODUCTION

The Samda Hydroelectric Project is a RoR type of development which is located near Kotgal village approximately 2.5km from project site on the border of Gadchiroli and Chandrapur districts of Maharashtra. The project utilize the water of the river Wainganga, a tributary of Godavari for power generation and also utilizing the regulated releases from Wainganga Hydroelectric project (proposed upstream). The project is designed to generate power, harnessing net head of 11.01 m. The project with a proposed installation of 45 MW (3 x 15 MW) would afford an annual energy generation of 157.76 GWh in a 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site is located at Latitude 20°11'54''N & Longitude 79°56'47"E. The Power house is located at Latitude of 20°11'54''N & Longitude of 79°56'47''E. The nearest railway station is Bramhapuri and the nearest Airport is Nagpur.

3. PROJECT FEATURES

The Samda Hydroelectric project envisages construction of a 14.5 m high and 2473m long dam across river Wainganga. The reservoir would have live storage of 15.41 Mcum between Full Reservoir Level (FRL) of 197.5 m and Minimum Draw Down Level (MDDL) of 196.35 m. A dam toe surface power house would have installation of 3 Kaplan vertical axis turbines driven generating units of 15 MW each operating under a net head of 11.01 m. A 300 m long Tail Race Channel would carry the power house releases back to the river.

4. HYDROLOGY

The catchment area of the river upto dam site is 50990 Sq. km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 52MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 45 MW and 157.76 GWh in 90% dependable year.

SALIENT FEATURES
SAMDA HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Gadchiroli/Chandrapur
River	Wainganga
Type of Development	RoR
Nearest Railhead	Bramhapuri
Nearest Airport	Nagpur

LOCATION:

Dam : Latitude & Longitude	20°11'54"N, 79°56'47"E
Power House : Latitude & Longitude	20°11'54"N, 79°56'47"E

HYDROLOGY:

Catchment Area (Sq. Km)	50990

DAM:

Type	Concrete & modified Homogeneous Earthen Section
Length (m)	2473
Height (m)	14.5

RESERVOIR:

Full Reservoir Level (FRL) (m)	197.5
Minimum Draw Down Level (MDDL) (m)	196.35
Live Storage (Mcum)	15.41

INTAKE:

Number	8
Size (m)	7.5 x 7.5

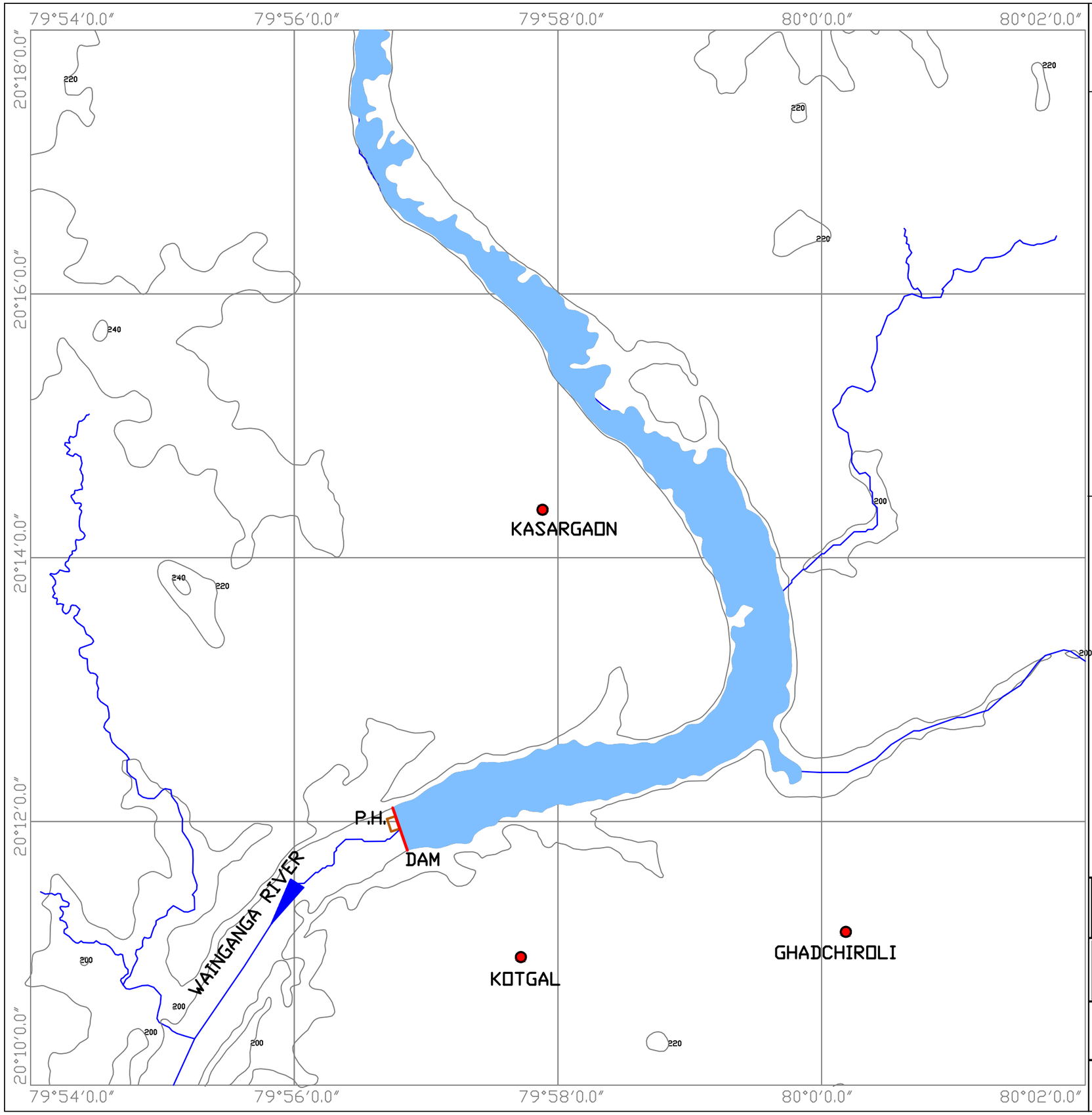
WATER CONDUCTOR SYSTEM:

TAIL RACE CHANNEL	
Type	Trapezoidal

Length (m)	300
Width (m)	80

POWER HOUSE:

Type	Surface
No. of Generating Units	3
Capacity of each Unit (MW)	15
Firm Power (MW)	14.88
Installed Capacity (MW)	45
Net Head (m)	11.01
Type of Turbine	Kaplan
Tail Water Level (TWL) (m)	186
Annual Energy (GWh)	157.76



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

SAMDA DAM

FRL- 197.5 M

MDDL - 196.35 M

DAM HEIGHT- 14.5 M

LIVE STORAGE -15.41 MCuM

POWER HOUSE

TWL- 186 M

NET HEAD- 11.01 M

INST. CAPACITY- 45 MW

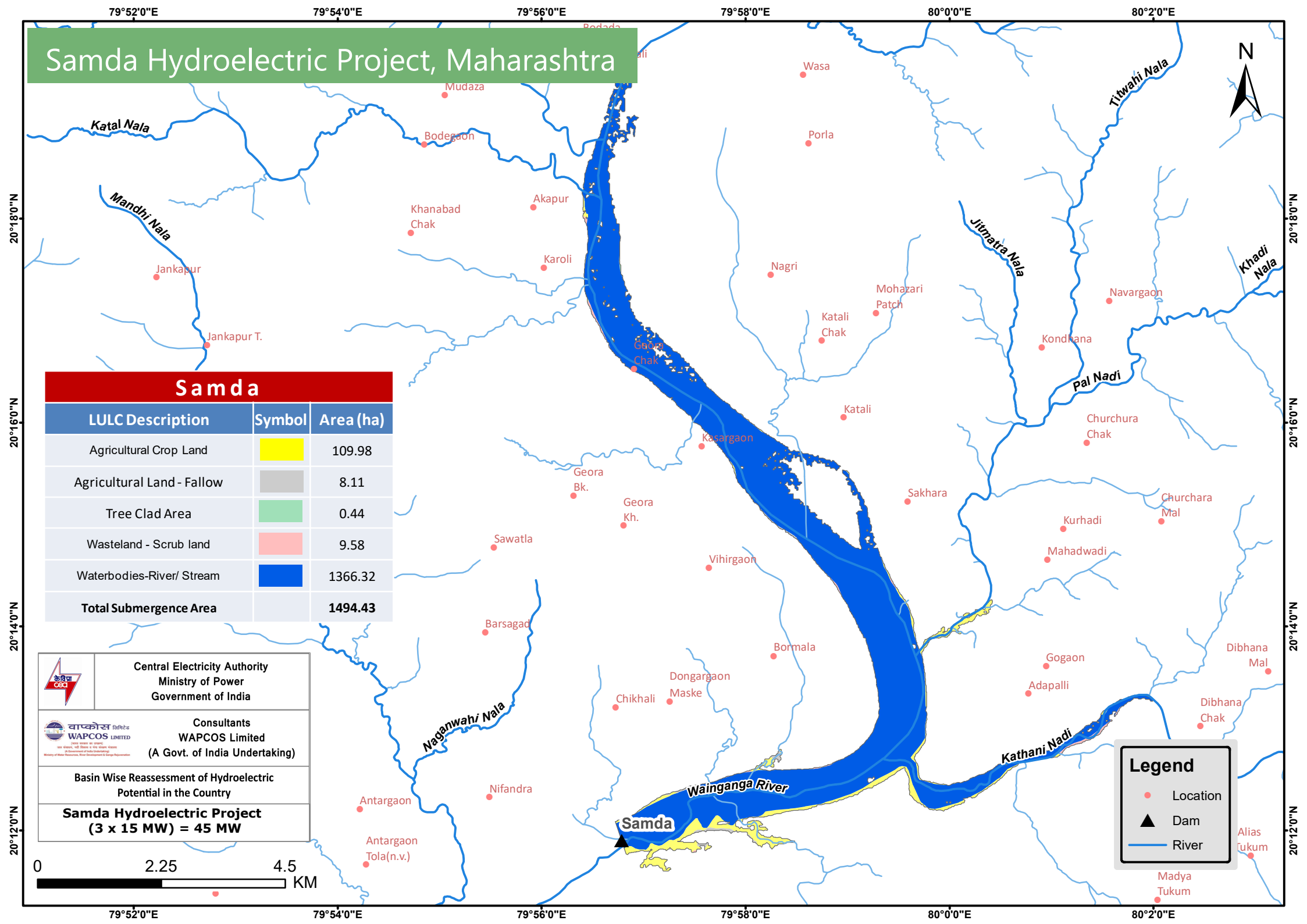
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

SAMDA HYDROELECTRIC PROJECT
(3X15) = 45MW

Samda Hydroelectric Project, Maharashtra



Samda

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		109.98
Agricultural Land - Fallow		8.11
Tree Clad Area		0.44
Wasteland - Scrub land		9.58
Waterbodies-River/ Stream		1366.32
Total Submergence Area		**1494.43**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Samda Hydroelectric Project
(3 x 15 MW) = 45 MW

Legend
- Location
- Dam
- River

7.10 KUNGHARA HYDROELECTRIC PROJECT (4x25MW=100MW)

1. INTRODUCTION

The Kunghara Hydroelectric Project is a RoR type of development which is located near Ramangatta village approximately 1.6km from project site on the border of Garhchiroli and Chandrapur Districts of Maharashtra. The project utilize the water of the river Wainganga, a tributary of Godavari for power generation. The project is designed to generate power, harnessing a net head of 15.84 m. The project with a proposed installation of 100 MW (4 x 25 MW) would afford an annual energy generation of 263.4 GWh in a 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site is located at Latitude 19°37'13''N & Longitude 79°47'30''E. The Power house is located at Latitude of 19°37'13''N & Longitude of 79°47'30”E. The nearest railway station is Chandrapur and the nearest Airport is Nagpur.

3. PROJECT FEATURES

The Kunghara Hydroelectric project envisages construction of a 17.5m high and 2800 m long dam across river Wainganga. The reservoir woud have live storage of 721.29 Mcum between Full Reservoir Level (FRL) of 160 m and Minimum Draw Down Level (MDDL) of 153 m. A dam toe surface power house would have an installation of 4 Kaplan vertical axis turbines driven generating units of 25 MW each operating under a head of 15.84 m. A 200 m long Tail Race Channel would be available to carry the power house releases back to the river.

4. HYDROLOGY

The catchment area of the river upto dam site is 52243 Sq. Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 72 MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 100 MW and 263.4 GWh in 90% dependable year.

SALIENT FEATURES
KUNGHARA HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Gadchiroli/Chandrapur
River	Wainganga
Type of Development	RoR
Nearest Railhead	Chandrapur
Nearest Airport	Nagpur

LOCATION:

Dam : Latitude & Longitude	19°37'13" N, 79°47'30"E
Power House : Latitude & Longitude	19°37'13"N, 79°47'30"E

HYDROLOGY:

Catchment Area (Sq. Km)	52243

DAM:

Type	Concrete gravity type
Length (m)	2800
Height (m)	17.5

RESERVOIR:

Full Reservoir Level (FRL) (m)	160
Minimum Draw Down Level (MDDL) (m)	153
Live Storage (Mcum)	721.29

INTAKE:

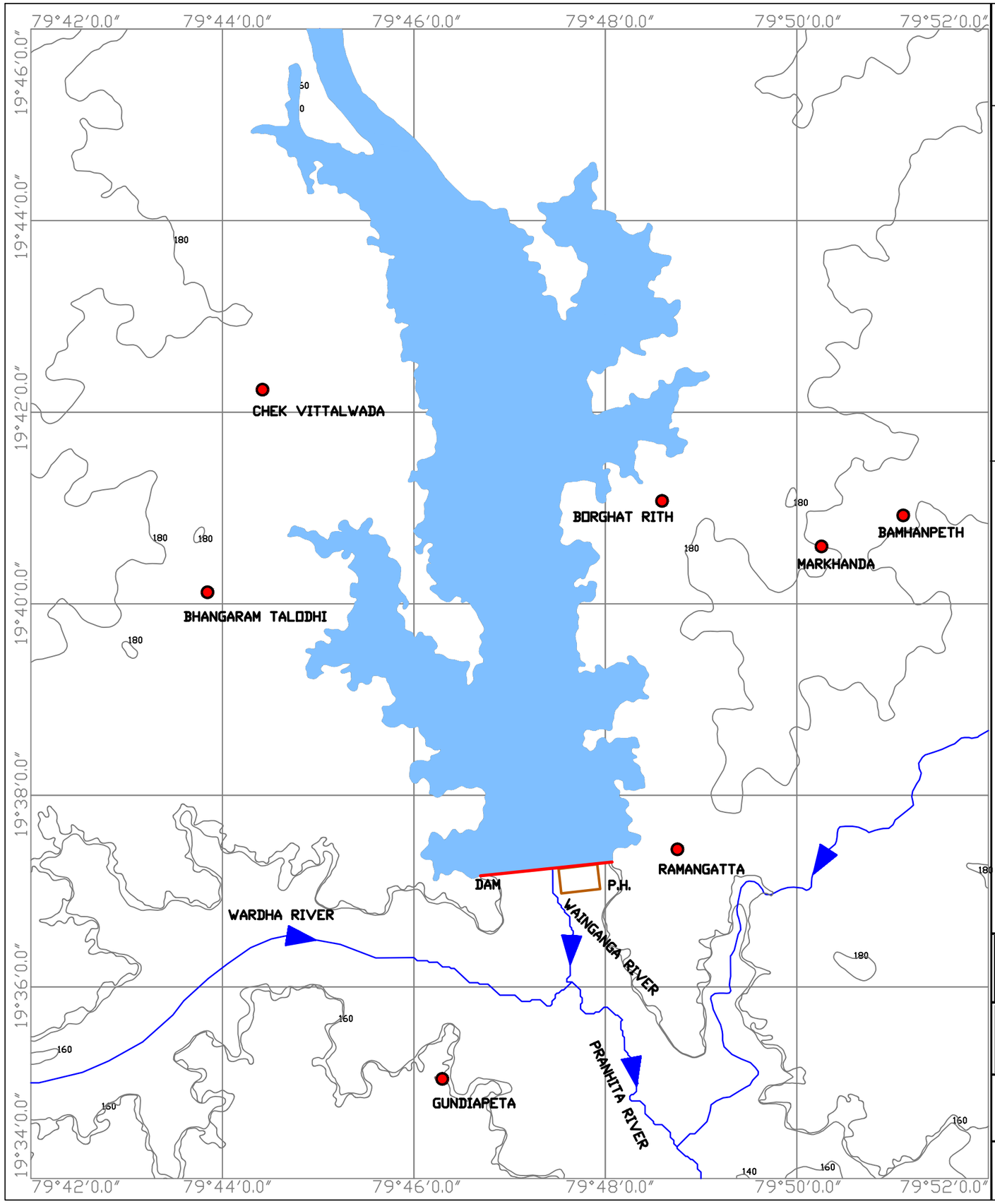
Number	8
Size (m)	9 x 10

WATER CONDUCTOR SYSTEM:

TAIL RACE CHANNEL	
Type	Trapezoidal
Length (m)	200

POWER HOUSE:

Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	25
Firm Power (MW)	26.93
Installed Capacity (MW)	100
Net Head (m)	15.84
Type of Turbine	Kaplan
Tail Water Level (TWL) (Min.)(m)	144
Tail Water Level (TWL) (Max.) (m)	145
Annual Energy (GWh)	263.4



LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

KUNGHARA DAM

FRL- 160 M

MDDL-153 M

DAM HEIGHT- 17.5 M

LIVE STORAGE- 721.29 MCuM

POWER HOUSE

TWL- 145 M

NET HEAD(MAX.) - 15.84 M

INST. CAPACITY - 100 MW

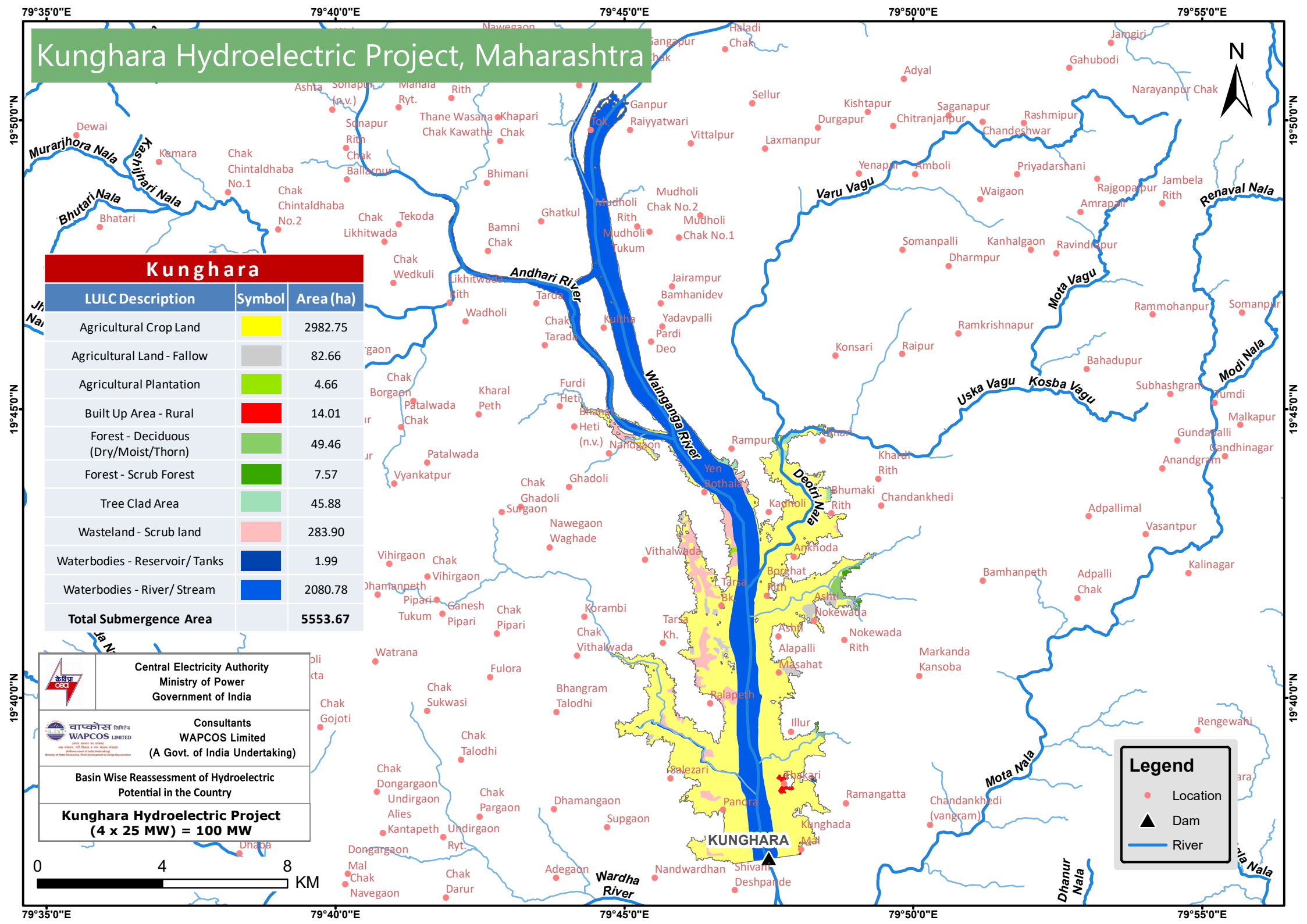
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KUNGHARA HYDROELECTRIC PROJECT
(4X25) = 100 MW

Kunghara Hydroelectric Project, Maharashtra



7.11 PRANHITA HYDROELECTRIC PROJECT (4x53.5MW=214MW)

1. INTRODUCTION

The Pranhita Hydroclectric Project is a Storage type of development which is located near Talai village approximately 1.65km from project site in Gadchiroli district of Maharashtra. The project utilize water of the river Pranhita, a tributary of river Godavari for power generation. The project is designed to generate power, harnessing net head (max.) of 31.19 m. The project with a proposed installation of 214 MW (4x53.5 MW) would afford an average annual energy generation of 575.23 GWh in 90% dependable year.

2. LOCATION/ACCESSIBILITY

The dam site is located at Latitude 19°16'52'' N & Longitude 79°56'51''E. The Power house is located at Latitude of 19°16'52''N & Longitude of 79°56'51''E. The nearest railway station is Chandrapur and the nearest Airport is Nagpur.

3. PROJECT FEATURES

The Pranhita Hydroelectric project envisages construction of a concrete gravity dam with height of 38m and length 1325m across Pranhita River. The reservoir would have live storage of 140.76 Mcum between Full reservoir Level (FRL) of 144.5 m and Minimum Draw Down Level (MDDL) of 131.32 m. The water conductor system would comprise of 4 nos. of penstock of length 70m which would carry water to the powerhouse. A dam toe surface power house would have an installation of 4 Kaplan turbines driven generating unit of 53.5MW each operating under net head (max) of 31.19 m. A 600 m long open Tail Race Channel would carry the power house releases back to the river.

4. HYDROLOGY

The catchment area of the river upto dam site is 102174 Sq. Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 48MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 214 MW and 575.23 GWh in 90% dependable year.

SALIENT FEATURES
PRANHITA HYDROELECTRIC PROJECT

GENERAL:

State	Maharashtra
District	Gadchiroli
River	Pranhita
Type of Development	Storage
Nearest Railhead	Chandrapur
Nearest Airport	Nagpur

LOCATION:

Dam : Latitude & Longitude	19°16'52"N, 79°56'51"E
Power House : Latitude & Longitude	19°16'52"N, 79°56'51"E

HYDROLOGY:

Catchment Area (Sq. Km)	102174

DAM:

Type	Concrete
Length (m)	1325
Height (m)	38

RESERVOIR:

Full Reservoir Level (FRL) (m)	144.5
Minimum Draw Down Level (MDDL) (m)	131.32
Live Storage (Mcum)	140.76

INTAKE:

Number	2
Type	Semi-circular
Size (m)	5 x 5

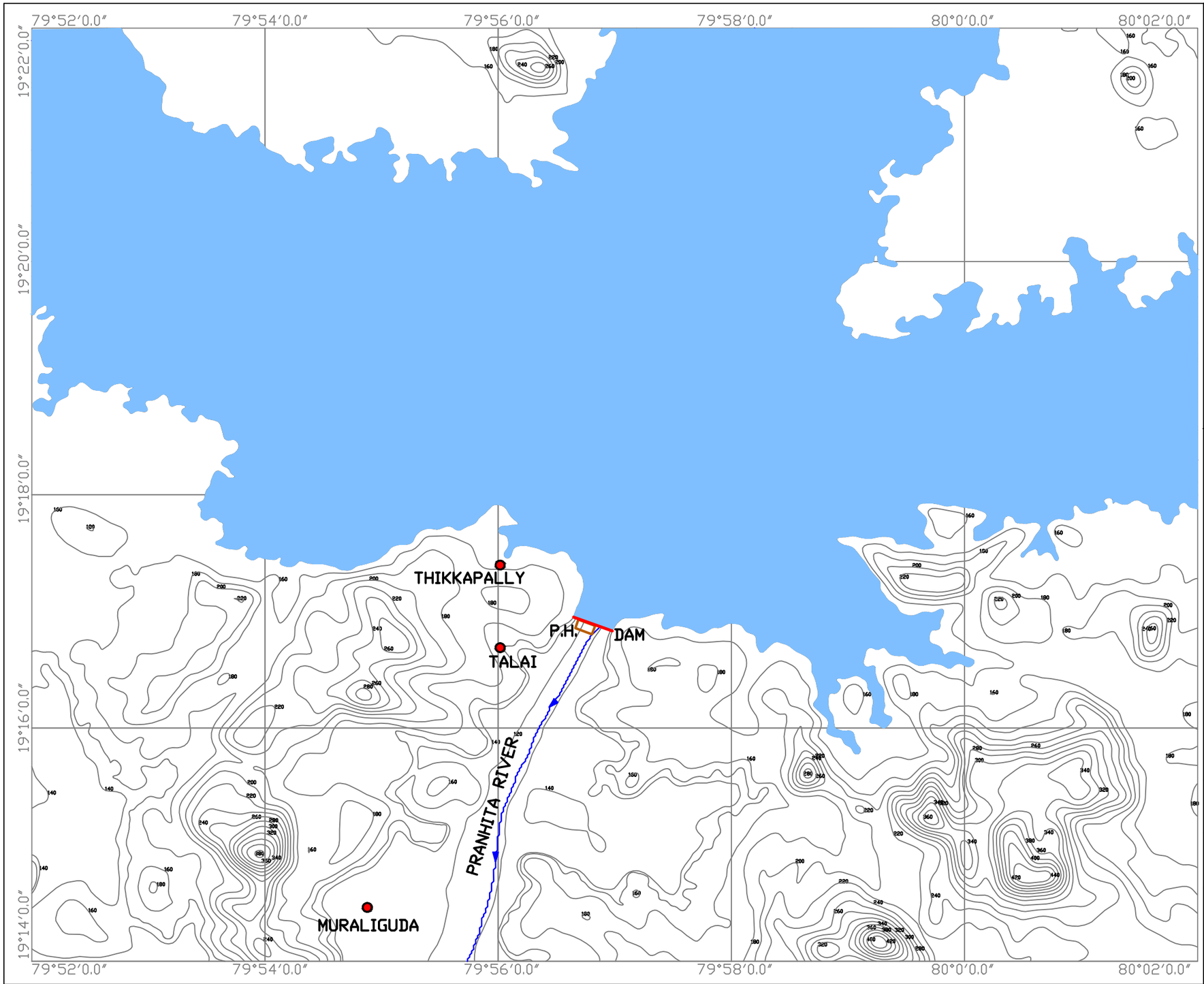
WATER CONDUCTOR SYSTEM:

PENSTOCK	
Number	4
Length (m)	70

TAIL RACE CHANNEL	
Type	Trapizoidal
Length (m)	600
Width (m)	50

POWER HOUSE:

Type	Surface
No. of Generating Units	4
Capacity of each Unit (MW)	53.5
Firm Power (MW)	52.38
Installed Capacity (MW)	214
Net Head (Max.) (m)	31.19
Type of Turbine	Kaplan
Tail water Level (m)	113
Annual Energy (GWh)	575.23



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

PRANHITA DAM

FRL- 144.5 M

MDDL - 131.32 M

DAM HEIGHT- 38 M

LIVE STORAGE -140.76 MCuM

POWER HOUSE

TWL- 113 M

NET HEAD(MAX.)- 31.19 M

INST. CAPACITY- 214 MW

CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

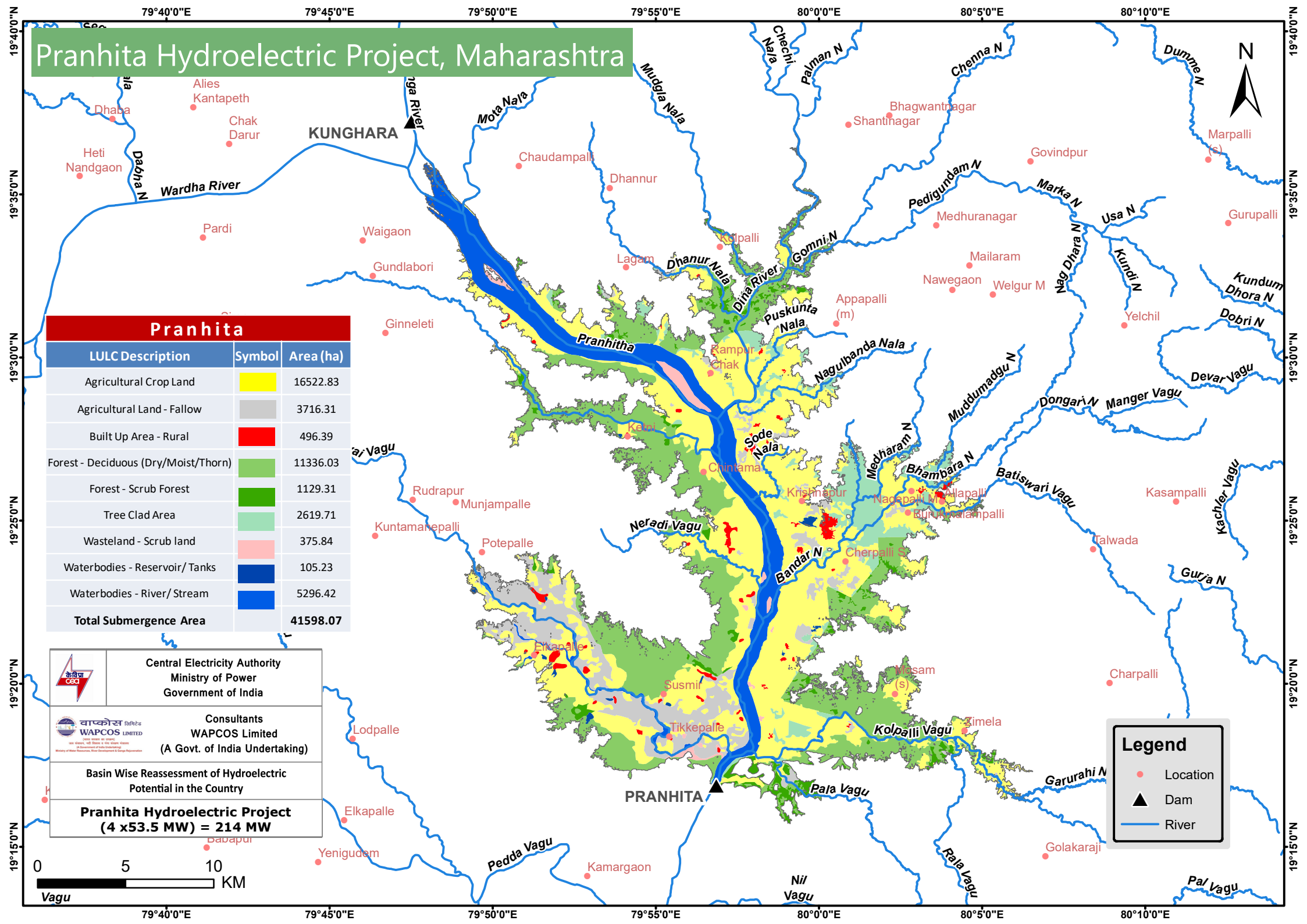
वाप्कोस लिमिटेड
WAPCOS LIMITED

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

PRANHITA HYDROELECTRIC PROJECT
(4X53.5) = 214 MW

Pranhita Hydroelectric Project, Maharashtra



Pranhita		
LULC Description	Symbol	Area (ha)
Agricultural Crop Land		16522.83
Agricultural Land - Fallow		3716.31
Built Up Area - Rural		496.39
Forest - Deciduous (Dry/Moist/Thorn)		11336.03
Forest - Scrub Forest		1129.31
Tree Clad Area		2619.71
Wasteland - Scrub land		375.84
Waterbodies - Reservoir/ Tanks		105.23
Waterbodies - River/ Stream		5296.42
Total Submergence Area		**41598.07**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Pranhita Hydroelectric Project
(4 x53.5 MW) = 214 MW

7.12 BALIMELA HYDROELECTRIC PROJECT (3x8.67MW=26MW)

1. INTRODUCTION

Balimela Hydroelectric Project is a storage type of development on Sileru River which is located near Chitrakonda village approximately 3.8 Km. from project site. The project is in Andhra Pradesh and envisages utilization of water of Sileru River and the water of the exisiting Balimela Hydroelectric project (510 MW) for further power generation. The project contemplates construction of a dam across Sileru River for utilizing the tail water releases of Machkund. The project would utilize the water of Sileru River for power generation, harnessing net head (max.) of 33.71 m. The powerhouse would generate annual energy of 67.27 GWh in 90% dependable year with an installed capacity of 26 MW.

2. LOCATION/ACCESSIBILITY

The dam site is located on Sileru River having latitude of 18°08'20.5"N and Longitude of 82°07'20.5"E. The Power house is located at Latitude 18°08'48.1"N and Longitude 82°06'43.5"E. The Nearest Railway station from the project site is Darliput and Airport is Rajahmundry.

3. PROJECT FEATURES

Balimela Hydroelectric Project would involve construction of a dam of height 50.6m across the river Sileru. The reservoir would have live storage of 888.03 Mcum between Full Reservoir Level (FRL) of 462.1m and Minimum Draw Down Level (MDDL) of 438.9m. The powerhouse would operate under net head (max.) of 33.71 m and would enable firm power generaion of 7.45 MW. The project would generate annual energy of 67.27 Gwh in 90% dependable year.

4. HYDROLOGY

The catchment area of the river up to the dam site is 4908 Sq. Km.

5. POWER & ENERGY BENEFITS

According to reassessment study in 1978-87, the project was identified having installed capacity of 65 MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 26MW and 67.27GWh.

In 1971, DPR was prepared for Balimela Hydroelectric project with Installed Capacity of 2 x 30 MW and annul energy of 140 MU. The project could not be implemented due to various reasons. The DPR is being revised by APGENCO and the revised details of the project would be known after the study.

SALIENT FEATURES
BALIMELA HYDROELECTRIC PROJECT

GENERAL:

State	Andhra Pradesh
River	Sileru
Type of Development	Storage
Nearest Railhead	Darliput
Nearest Airport	Rajahmundry

LOCATION:

Dam : Latitude & Longitude	18°08'20.5"N, 82°07'20.5"E
Power House : Latitude & Longitude	18°08'48.1"N, 82°06'43.5"E

HYDROLOGY:

Catchment Area (Sq. Km)	4908

DAM:

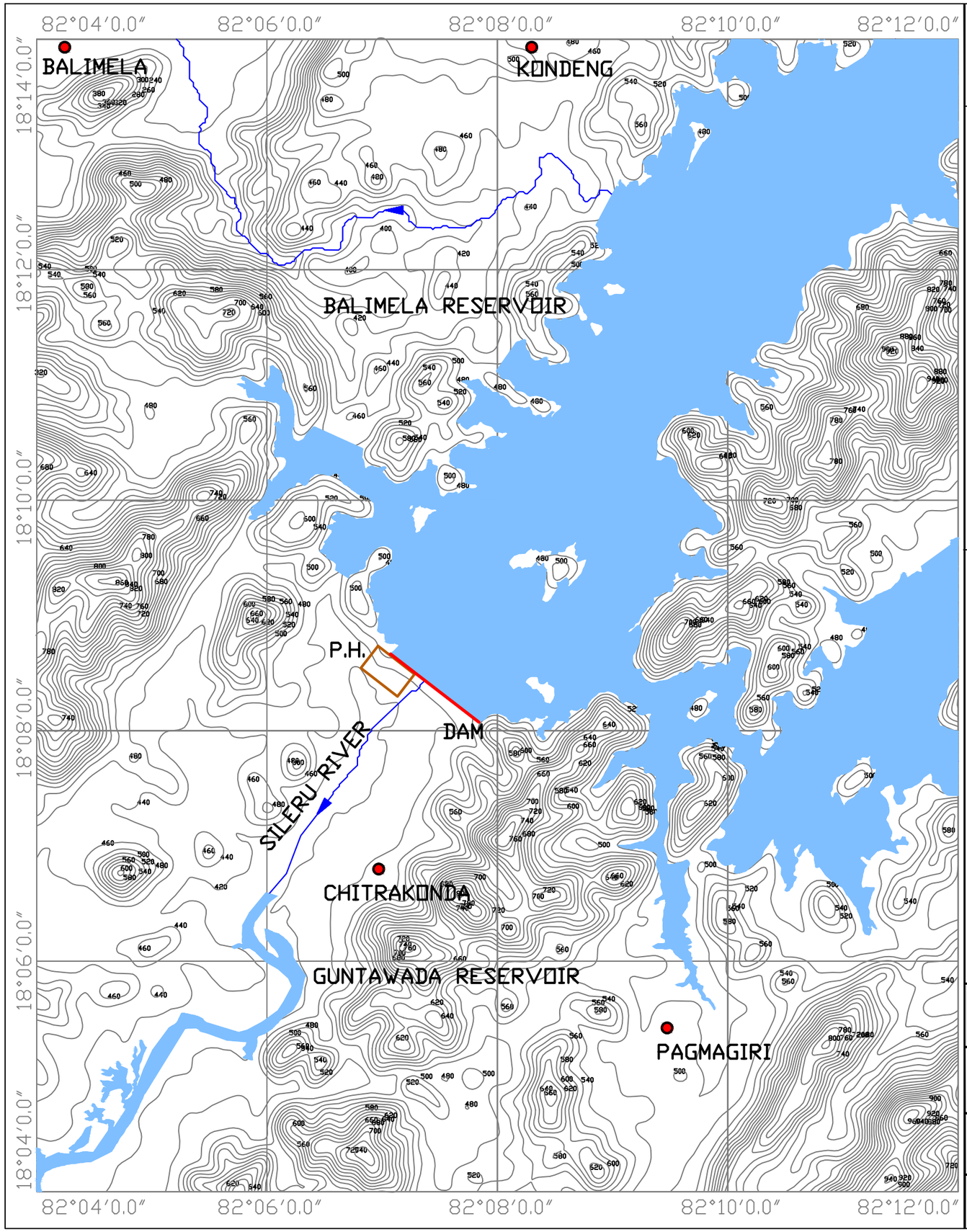
Height (m)	50.6

RESERVOIR:

Full Reservoir Level (FRL) (m)	462.1
Minimum Draw Down Level (MDDL) (m)	438.9
Live Storage (Mcum)	888.03

POWER HOUSE:

No. of Generating Units	3
Capacity of each Unit (MW)	8.67
Firm Power (MW)	7.45
Installed Capacity (MW)	26
Net Head (Max.) (m)	33.71
Tail Water Level (TWL) (m)	411.5
Annual Energy (GWh)	67.27



N
W
E
S

LEGENDS.

CONTOUR

RIVER

DAM

POWER HOUSE

RESERVOIR

TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BALIMELA DAM

FRL- 462.1 M
MDDL- 438.9 M
DAM HEIGHT- 50.6 M
LIVE STORAGE-888.03 MCuM

POWER HOUSE

TWL- 411.5 M
NET HEAD(MAX.)- 33.71 M
INST. CAPACITY- 26 MW

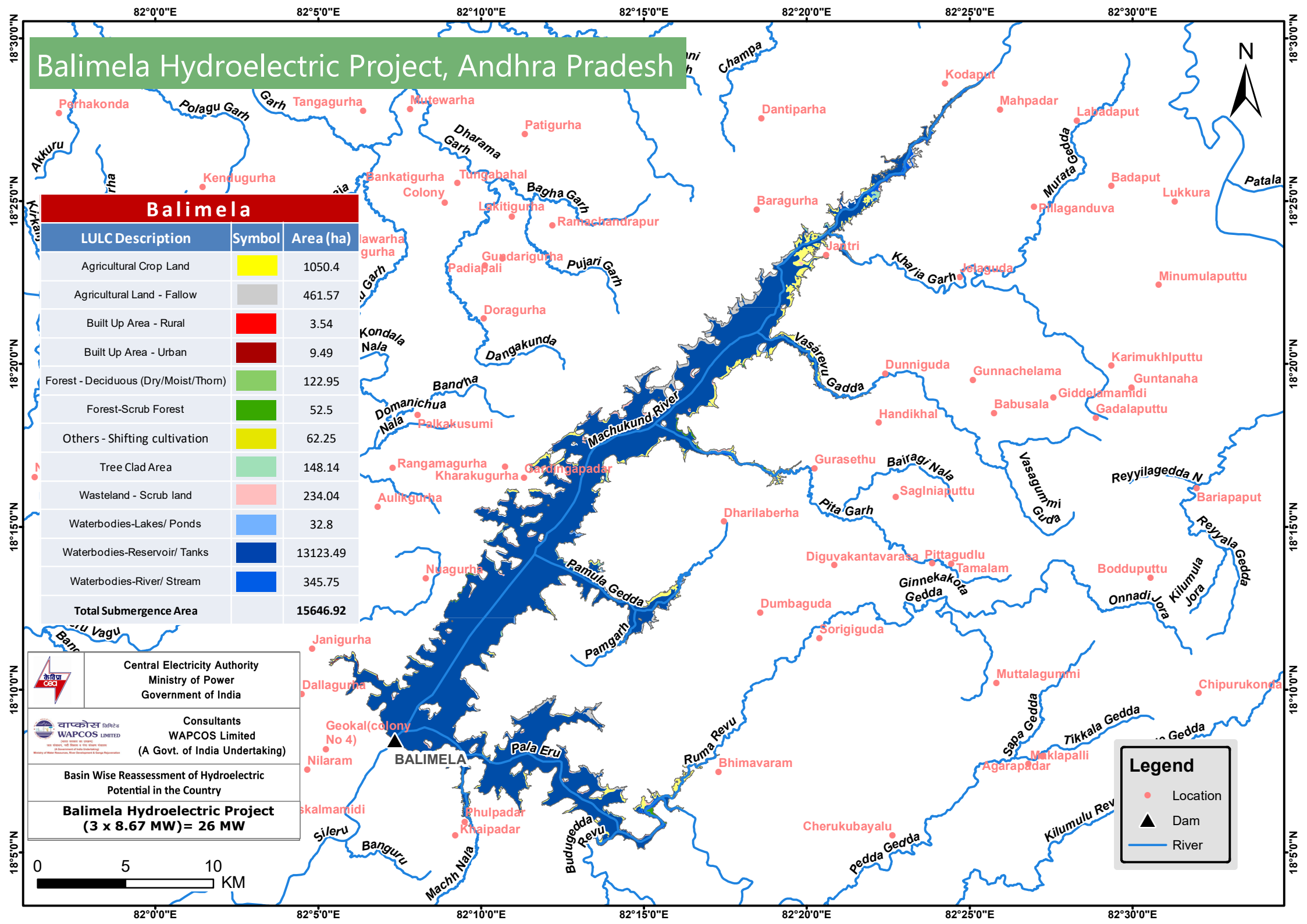
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

BALIMELA HYDROELECTRIC PROJECT
(3X8.67) = 26 MW

Balimela Hydroelectric Project, Andhra Pradesh



Balimela

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		1050.4
Agricultural Land - Fallow		461.57
Built Up Area - Rural		3.54
Built Up Area - Urban		9.49
Forest - Deciduous (Dry/Moist/Thorn)		122.95
Forest-Scrub Forest		52.5
Others - Shifting cultivation		62.25
Tree Clad Area		148.14
Wasteland - Scrub land		234.04
Waterbodies-Lakes/ Ponds		32.8
Waterbodies-Reservoir/ Tanks		13123.49
Waterbodies-River/ Stream		345.75
Total Submergence Area		**15646.92**

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Balimela Hydroelectric Project
(3 x 8.67 MW)= 26 MW

Legend
- Location
- Dam
- River

7.13 KONTA HYDROELECTRIC PROJECT (3x22.67MW=68MW)

1. INTRODUCTION

Konta Hydroelectric Project is a Run of River (RoR) type of development on Sabari river which is located near Dhondhara village approximately 2.95 km. from project in Dantewada district of Chhattisgarh. The project has been identified across sabari river 4 kms upstream of its confluence with Sileru River and thus forms the final stage of the hydroelectric development of Sabari/Sileru River. The project would utilize the water of Sabri River for power generation, harnessing rated head of 18.7m. The powerhouse would generate annual energy of 234.02 GWh in 90 % dependable year with an installed capacity of 68 MW.

2. LOCATION/ACCESSIBILITY

This hydroelectric project consist of two dams, the first dam is located at Latitude of 17°50'31.37"N & Longitude of 81°23'57.60"E and the second dam is located at Latitude of 17°49'36"N & Longitude of 81°25'40.5"E. The Power house is located at Latitude 17°50'33.16"N & Longitude 81°23'46.48"E. The Nearest Railway station from the project site is Kirandul and Airport is Rajahmundry.

3. PROJECT FEATURES

The project would involve construction of 21.1m high and 3.2 km long dam across Sabari river. The reservoir would have live storage of 329.31 Mcum between Full Reservoir Level (FRL) of 67 m and Minimum Draw Down Level (MDDL) of 60m. The regulated discharge of Sileru river would also be diverted to Banigudem reservoir by providing a 21.1m high dam across Sileru river near Peda Maduguru and an interconnecting tunnel of length 2.4km. The powerhouse would operate under net head of 18.7 m and would enable firm power of 12.7 MW. The project would generate annual energy of 234.02 GWh in 90 % dependable year.

4. HYDROLOGY

The catchment area of the river upto the dam site is 19400 Sq. Km.

5. POWER & ENERGY BENEFITS

According to reassessment study in 1978-87, the project was identified having installed capacity of 65MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 68MW and 234.02 GWh.

SALIENT FEATURES
KONTA HYDROELECTRIC PROJECT

GENERAL:

State	Chhattisgarh
District	Dantewada
River	Sabari
Type of development	RoR
Nearest Railhead	Kirandul
Nearest Airport	Rajahmundry Airport

LOCATION:

Banigudem Dam : Latitude & Longitude	17°50'31.37"N, 81°23'57.60"E
Pedda Maduguru Dam : Latitude & Longitude	17°49'36"N, 81°25'40.5"E
Power House : Latitude & Longitude	17°50'33.16"N, 81°23'46.48"E

HYDROLOGY:

Catchment Area (Sq. Km)	19400

DAM (Banigudem Dam):

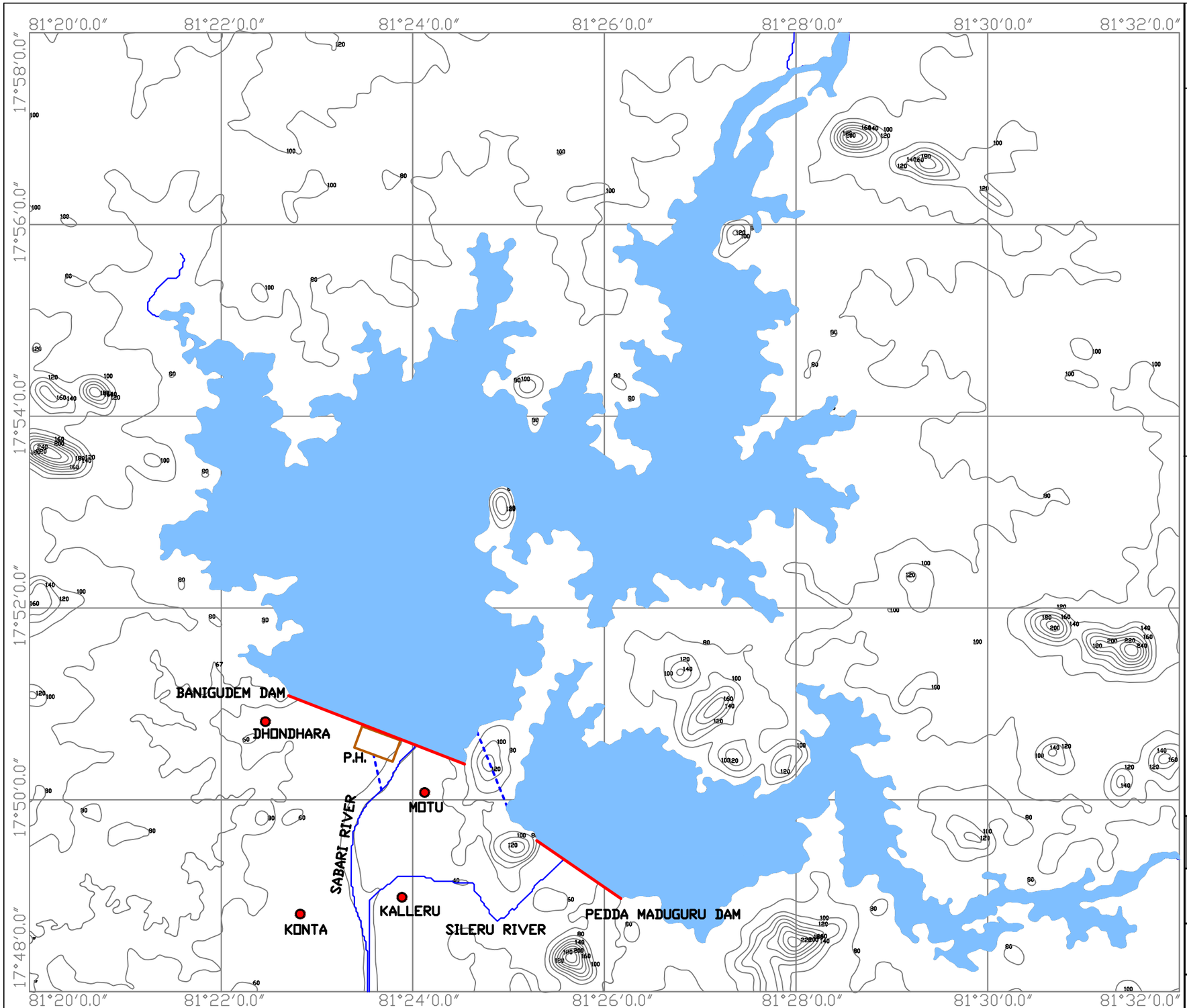
Length (m)	3200
Height (m)	21.1

RESERVOIR:

Full Reservoir Level (FRL) (m)	67
Minimum Draw Down Level (MDDL) (m)	60
Live Storage (Mcum)	329.31

POWER HOUSE:

No. of Generating Units	3
Capacity of each Unit (MW)	22.67
Firm Power (MW)	12.74
Installed Capacity (MW)	68
Net Head (m)	18.7
Tail Water Level (TWL) (m)	45.7
Annual Energy (GWh)	234.02



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

BANIGUDEM DAM

FRL- 67 M
MDDL - 60 M
DAM HEIGHT- 21.1 M
LIVE STORAGE - 329.31 MCuM

POWER HOUSE

TWL- 45.7 M
NET HEAD- 18.7 M
INST. CAPACITY- 68 MW

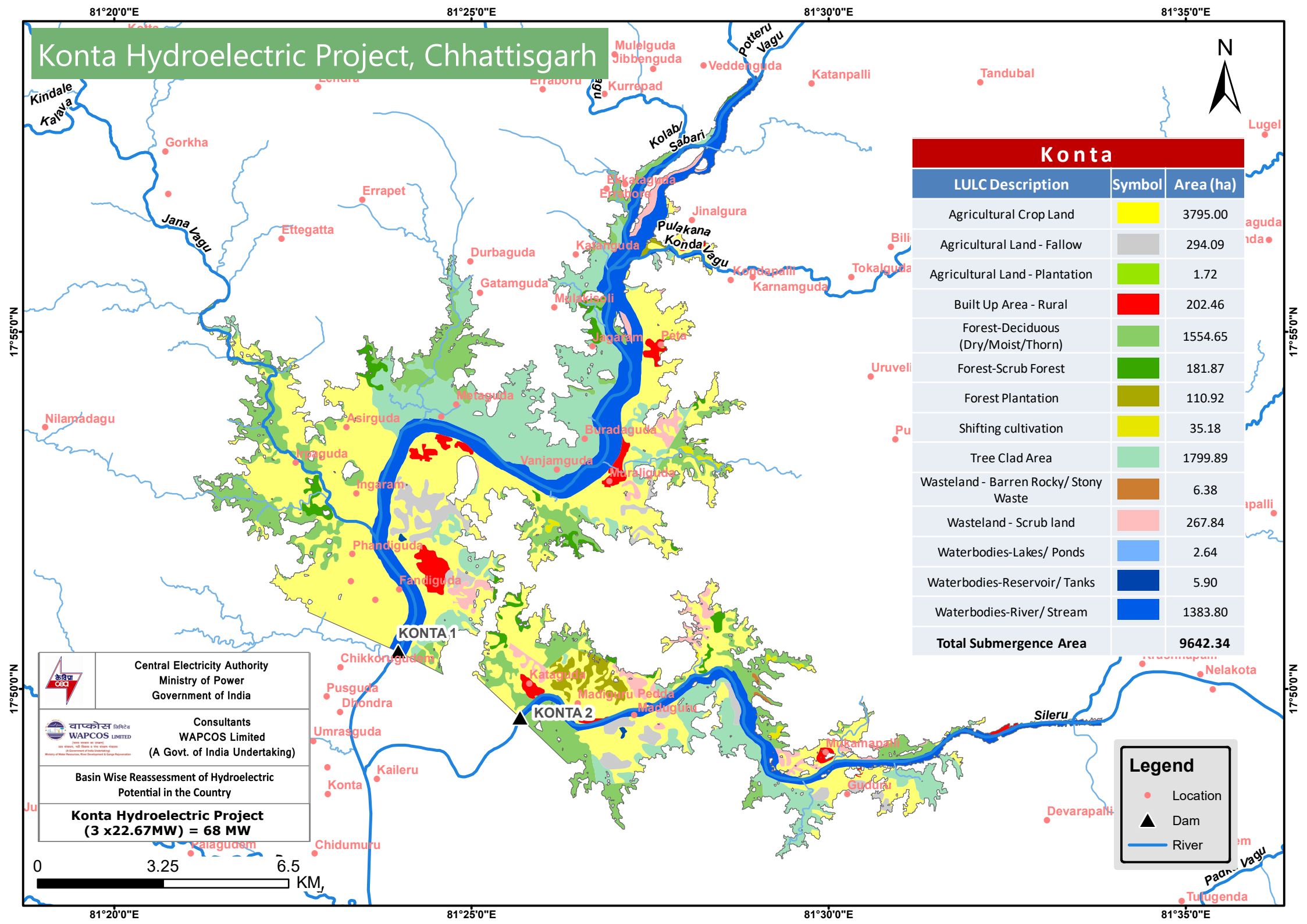
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

वाप्कोस लिमिटेड
WAPCOS LIMITED
CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

KONTA HYDROELECTRIC PROJECT
(3X22.67) = 68 MW

Konta Hydroelectric Project, Chhattisgarh



Konta

LULC Description	Symbol	Area (ha)
Agricultural Crop Land		3795.00
Agricultural Land - Fallow		294.09
Agricultural Land - Plantation		1.72
Built Up Area - Rural		202.46
Forest-Deciduous (Dry/Moist/Thorn)		1554.65
Forest-Scrub Forest		181.87
Forest Plantation		110.92
Shifting cultivation		35.18
Tree Clad Area		1799.89
Wasteland - Barren Rocky/ Stony Waste		6.38
Wasteland - Scrub land		267.84
Waterbodies-Lakes/ Ponds		2.64
Waterbodies-Reservoir/ Tanks		5.90
Waterbodies-River/ Stream		1383.80
Total Submergence Area		**9642.34**

Legend

- Location
- Dam
- River

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Konta Hydroelectric Project
(3 x22.67MW) = 68 MW

7.14 TAMANKAL HYDROELECTRIC PROJECT (2x150MW=300 MW)

1. INTRODUCTION

As per Reassesment studies done by Central Electricity Authority (CEA) (1978-87), the project was identified as Narayanpur Hydroelectric Project. Presently, the project is named as Tamankal Hydroelectric Project. Tamankal Hydroelectric Project is a storage type of development which is located near Veereshnagar village approximately 4 Km. from project site in near Lingasugur taluk in Raichur district of Karnataka. The project would utiilize the water of Krishna River for power generation, harnessing net head (max.) of 87.14 m. The powerhouse would generate annual energy of 168.99 GWh in 90% dependable year with installed capacity of 300 MW.

2. LOCATION/ACCESSIBILITY

The dam site is located on Krishna River having Latitude of 16°13'28.5" N and Longitude of 76°20'39.7"E. The Power house is located at Latitude of 16°14' 40.5"N and Longitude of 76°25'8.5"E. The Nearest Railway station from the project site is Almatti and Airport is Hubli.

3. PROJECT FEATURES

Tamankal Hydroelectric Project proposes utilization of surplus water from Narayanpur Dam and the bed fall in the river of about 88m in a short distance of about 8km downstream of Narayanpur dam for generation of power. The project consists of a power canal of 6.82 km long with Full Reservior Level (FRL) (m) and Minimum Draw Down Level (MDDL) is 492.25m and 485.55m. Respectively equal to that of Narayanpur irrigation dam. The canal leads the waters to a forebay of length 1.12 km near village Jaladurg of Lingasugur taluk. The Full Reservior Level (FRL) of the forebay is proposed to be 492.25 m. An intake is proposed at the forebay dam for drawal of water. The powerhouse would operate under net head (max.) of 87.14 m and would generate annual energy of 168.99 GWh in 90 % dependable year. A Tail Race Tunnel of length 3900 m would carry powerhouse release back to the river near Jaldurg village.

4. HYDROLOGY

The catchment area of the river upto the dam site is 48104 Sq. Km.

5. POWER & ENERGY BENEFITS

According to the PFR study, the project had an installed capacity of 300MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 300 MW and 168.99 GWh.

In Tamankal (300MW) Hydroelectric Project, an underground powerhouse is proposed for this project and cumulative length of water conducting system is about 11.84 kms. It is observed that generation is mainly being done in only three months of August, September and October in a year. For these three months, restricted energy for 300MW operation is 165.94 MU at load factor of 15.36 whereas annual generation is 168.99 MU at annual load factor of 6.43 %. **Thus the project may not be commercially viable**.

SALIENT FEATURES
TAMANKAL HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Raichur
River	Krishna
Type of Development	Storage
Nearest Railhead	Almatti
Nearest Airport	Hubli

LOCATION:

Dam : Latitude & Longitude	16°13'28.5"N, 76°20'39.7"E
Power House : Latitude & Longitude	16°14'40.5"N, 76°25'08.5"E

HYDROLOGY:

Catchment Area (Sq. Km)	48104

DAM:

Height (m)	29.72

RESERVOIR:

Full Reservoir Level (FRL) (m)	492.25
Minimum Draw Down Level (MDDL) (m)	485.55
Live Storage (Mcum)	113.23

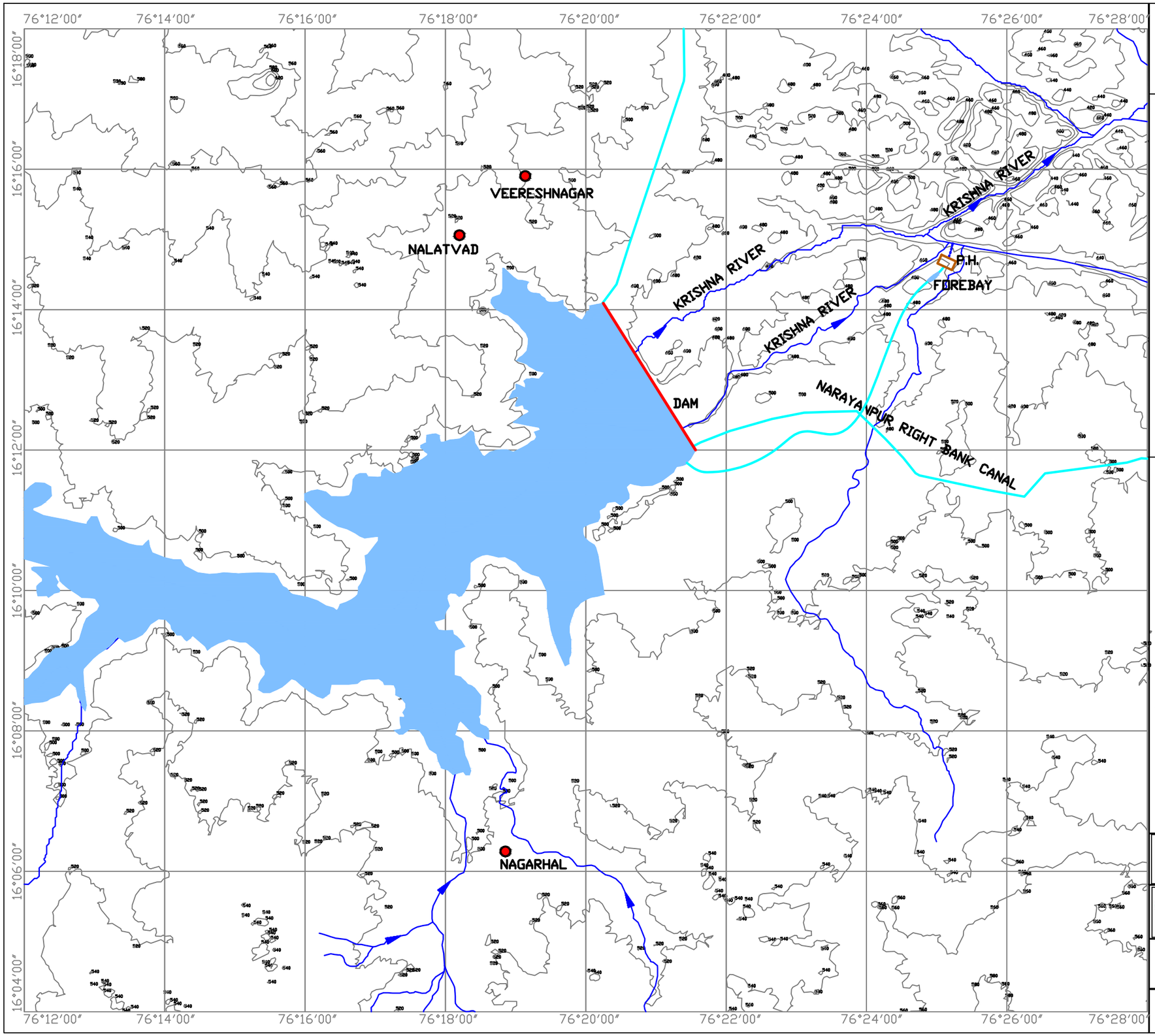
WATER CONDUCTOR SYSTEM:

POWER CANAL	
Length (m)	6820
FOREBAY	
Length (m)	1120
TAIL RACE TUNNEL	
Length (m)	3900

POWER HOUSE:

Type	Underground
No. of Generating Units	2

Capacity of each Unit (MW)	150
Installed Capacity (MW)	300
Net Head (Max.) (m)	87.14
Type of Turbine	Francis
Tail Water Level (TWL) (m)	402.12
Annual Energy (GWh)	168.99



N
W
E
S

LEGENDS.

- CONTOUR
- RIVER
- RIVER
- DAM
- POWER HOUSE
- HRT
- TRT
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

NARAYANPUR DAM

FRL- 492.25 M

MDDL-485.55 M

DAM HEIGHT- 29.72 M

LIVE STORAGE-113.23 MCuM

POWER HOUSE

TWL- 402.12 M

NET HEAD(MAX.) - 87.14 M

INST. CAPACITY- 300 MW

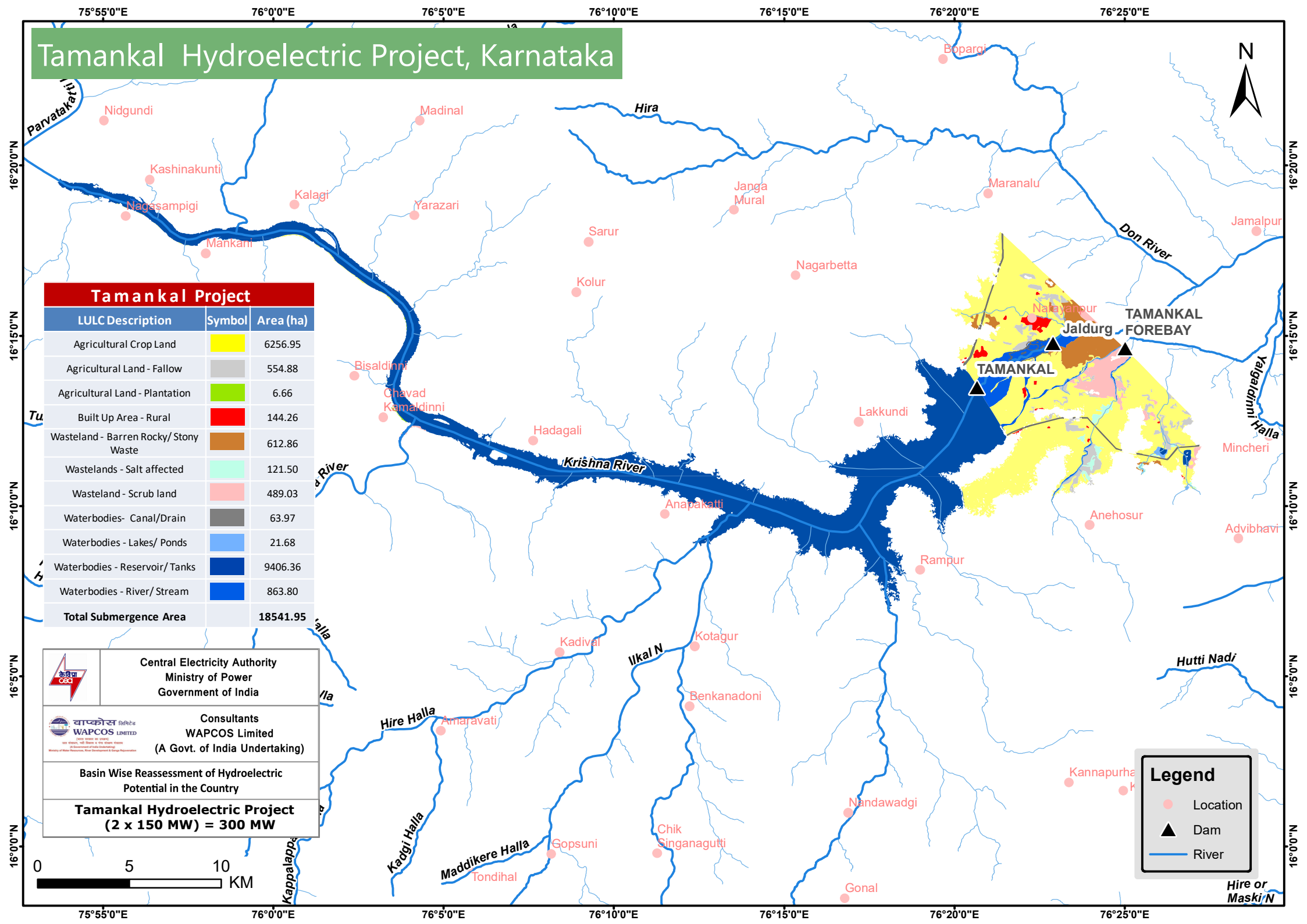
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

TAMANKAL HYDROELECTRIC PROJECT
(2X150) = 300 MW

Tamankal Hydroelectric Project, Karnataka



7.15 JALDURG HYDROELECTRIC PROJECT (2x135MW=270MW)

1. INTRODUCTION

Jaldurg Hydroelectric Project is a Run of River (RoR) type of development on Krishna river which is located near Narayanpur Rural village approximately 1.60 km. from project site in Raichur district of Karnataka. The Hydroelectric Project consist of a Barrage near Narayanpur Township at a site where river bed level is of the order of 464.8m. The water from the Jaldurg diversion together with the water of streams, where small diversions would be provided and carried in a 36.6 km long channel to be dropped near confluence near Kutti Nadi with Krishna. The project would utilize water of Krishna River for further power generation, harnessing rated net head of 75.57m. The powerhouse would generate annual energy of 188.08 GWh in 90% dependable year with installed capacity of 270 MW.

2. LOCATION/ACCESSIBILITY

The project consists of a major Jaldurg diversion and five small diversions for power generation. Jaldurg diversion is located at Latitude of 16°14'46.7"N & Longitude of 76°22'53.6"E. The Latitude and Longitude of five small diversions is as follows –

Small Diversion 1- 16°12'35.23"N, 76°29'1.46"E

Small Diversion 2- 16°14'25.98"N, 76°31'43.34"E

Small Diversion 3- 16°15'30.29"N, 76°32'55.60"E

Small Diversion 4- 16°17'1.37"N, 76°34'53.05"E

Small Diversion 5- 16°17'36.97"N, 76°36'28.82"E

Power house is located at Latitude of 16°18.6'N & Longitude of 76°39.3'E.

The nearest railway station from the project site is Almatti railway station nearest airport is Hubli Airport.

3. PROJECT FEATURES

Jaldurg Hydroelectric project propose to utilize the water of Krishna River by constructing a diversion structure and diverting the waters through 36.6 km long channel and dropping it near confluence of Kutti Nadi with Krishna River. The reservoir would have live storage of 177.34 Mcum between Full Reservoir Level (FRL) of 466 m and Minimum Draw Down Level (MDDL) of 440 m.

4. HYDROLOGY

The catchment area of the river upto dam site is 48.16 Sq. km.

5. POWER & ENERGY BENEFITS

According to reassessment study in 1978-87, the project was identified having installed capacity of 270MW. As per updated hydrology and power potential studies, the revised installed capacity and annual energy are 270MW and 188.08 GWh.

In Jaldurg (270 MW) Hydroelectric Project, a Surface powerhouse is proposed for this project with five diversion dams and the length of water conducting system is about 36.6 kms. It is observed that generation is mainly being done in only three months of August, September and October in a year at load factor of about 29.88% whereas annual load factor is about 7.95%. **Thus the project may not be commercially viable**.

SALIENT FEATURES
JALDURG HYDROELECTRIC PROJECT

GENERAL:

State	Karnataka
District	Raichur
River	Krishna
Type of Development	RoR
Nearest Railhead	Almatti
Nearest Airport	Hubli

LOCATION:

Jaldurg Diversion : Latitude & Longitude	16°14'46.7"N, 76°22'53.6"E
Small Diversion 1 : Latitude & Longitude	16°12'35.23"N, 76°29'1.46"E
Small Diversion 2 : Latitude & Longitude	16°14'25.98"N, 76°31'43.34"E
Small Diversion 3 : Latitude & Longitude	16°15'30.29"N, 76°32'55.60"E
Small Diversion 4 : Latitude & Longitude	16°17'1.37"N, 76°34'53.05"E
Small Diversion 5 : Latitude & Longitude	16°17'36.97"N, 76°36'28.82"E
Power House : Latitude & Longitude	16°18.6'N ,76°39.3'E

HYDROLOGY:

Catchment Area (Sq. Km)	48.16

RESERVOIR:

Full Reservoir Level (FRL) (m)	466
Minimum Draw Down Level (MDDL) (m)	440
Live Storage (Mcum)	177.34

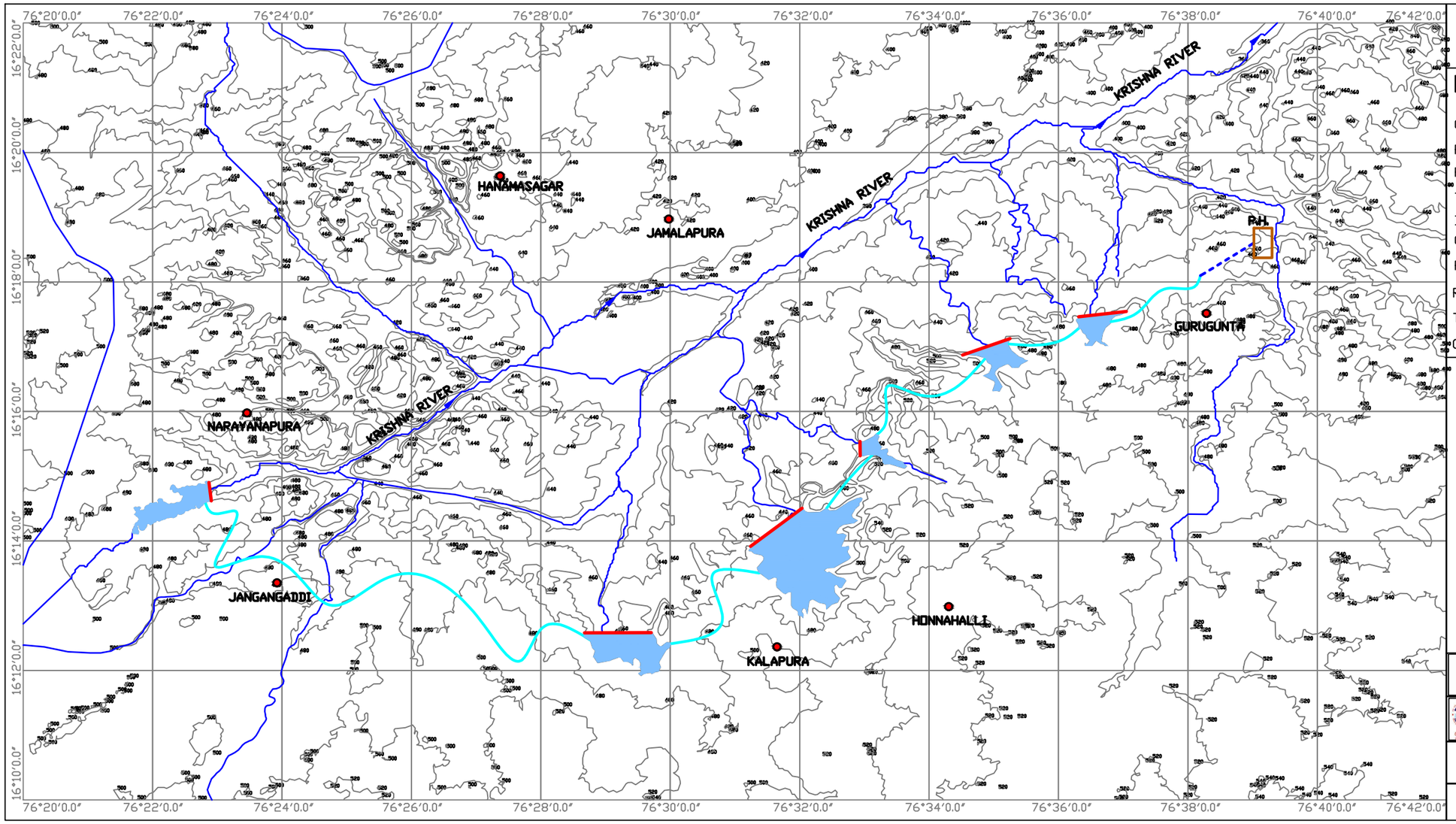
WATER CONDUCTOR SYSTEM:

CHANNEL	
Length (m)	36600

POWER HOUSE:

No. of Generating Units	2
Capacity of each Unit (MW)	135
Installed Capacity (MW)	270

Net Head (m)	75.57
Tail Water Level (TWL) (m)	381
Annual Energy (Gwh)	188.08



LEGENDS.

- CONTOUR
- RIVER
- HRT
- TRT
- DAM
- CHANNEL
- POWER HOUSE
- RESERVOIR
- TOWN/VILLAGE

CONTOUR INTERVAL - 20M

JALDURG DAM

FRL - 466 M

MDDL - 440 M

LIVE STORAGE - 177.34 M

POWER HOUSE

TWL- 381 M

NET HEAD - 75.57 M

INST. CAPACITY - 270 MW

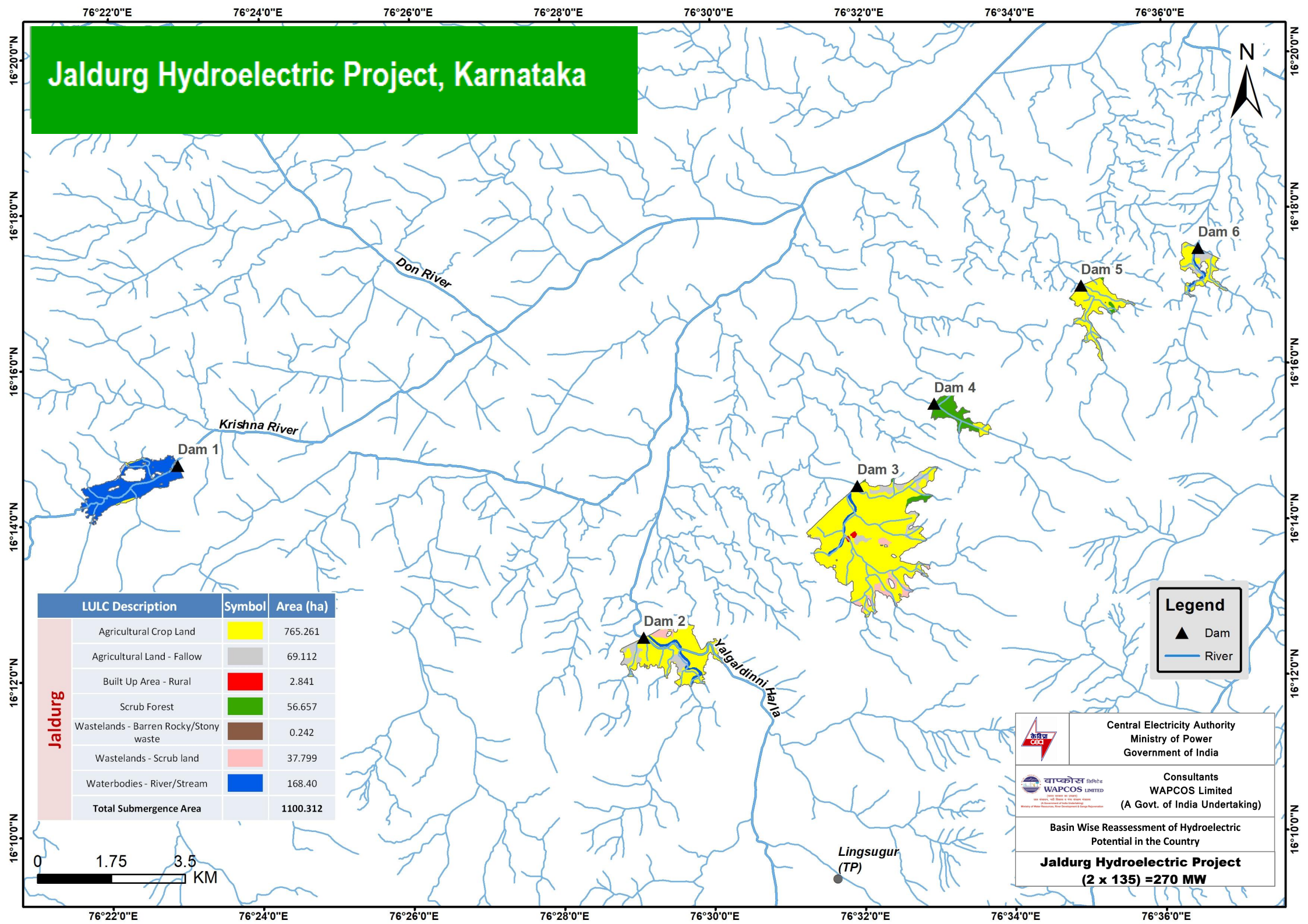
CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA

CONSULTANTS
WAPCOS LIMITED
(A GOVT. OF INDIA UNDERTAKING)

BASIN WISE REASSESSMENT OF HYDROELECTRIC POTENTIAL IN THE COUNTRY

JALDURG HYDROELECTRIC PROJECT
(2X135) = 270 MW

Jaldurg Hydroelectric Project, Karnataka



Jaldurg	LULC Description	Symbol	Area (ha)
	Agricultural Crop Land		765.261
	Agricultural Land - Fallow		69.112
	Built Up Area - Rural		2.841
	Scrub Forest		56.657
	Wastelands - Barren Rocky/Stony waste		0.242
	Wastelands - Scrub land		37.799
	Waterbodies - River/Stream		168.40
	Total Submergence Area		**1100.312**

Legend

- Dam
- River

Central Electricity Authority
Ministry of Power
Government of India

Consultants
WAPCOS Limited
(A Govt. of India Undertaking)

Basin Wise Reassessment of Hydroelectric Potential in the Country

Jaldurg Hydroelectric Project
(2 x 135) =270 MW

CHAPTER-8

8.1 Exploration of river profiles for identifying new potential sites for Hydroelectric Projects development

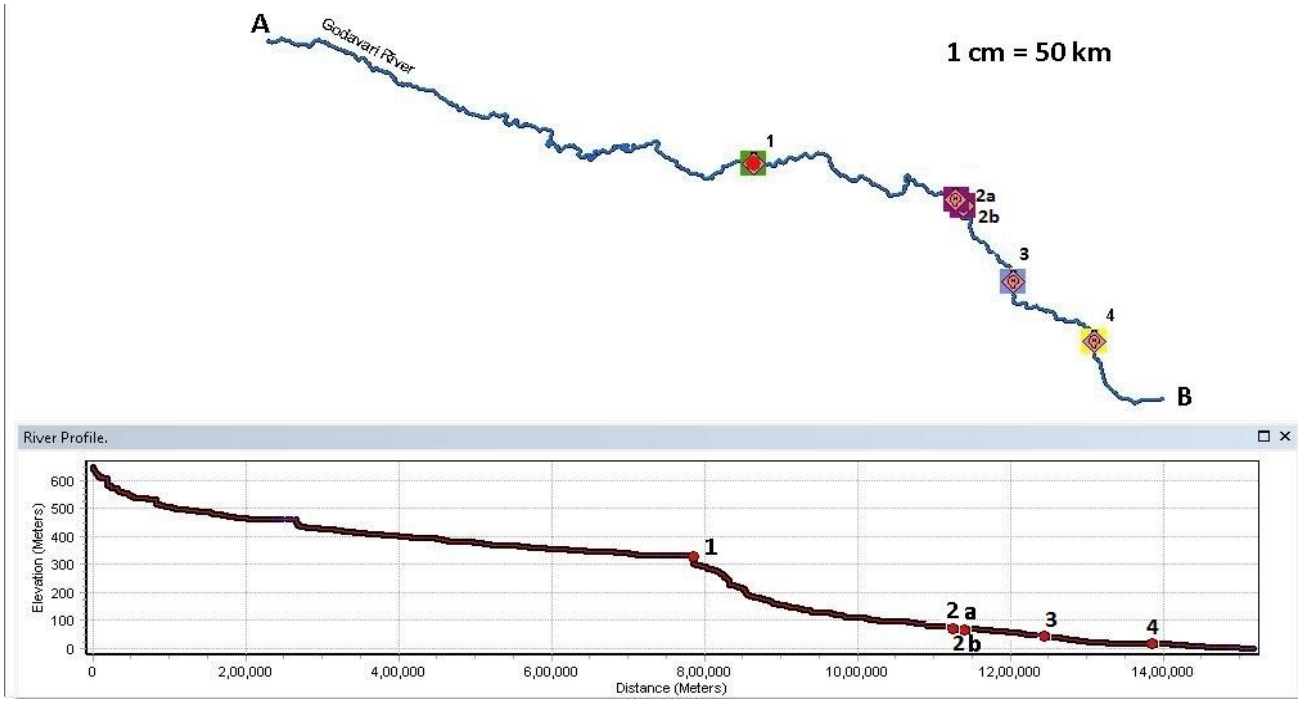
The L-Sections of all major rivers and tributary have been developed as explained in the methodology section (**refer Section 1.3 in Chapter 1**) with an objective to explore the possibility of identifying new potential sites for Hydroelectric projects developments. The longitudinal sections are checked for any steep fall/drop available within a short distance which can be utilised as a water head in the course of river/tributary. The concept is that at the site where sufficient head is available with adequate hydrology, the site may be further explored as a potential site for hydroelectric project development. As the scope of the studies includes projects of minimum 25 MW installed capacity or above, therefore it is envisaged that if any site is found to have a head of 60 m and than it found that must be checked for hydrology of minimum 10 cumecs of flow yields which would lead to a potential of 25 MW for peaking operation for nearly 4 hours in a day. Any such site found is to be further studied for hydrology and power potential studies.

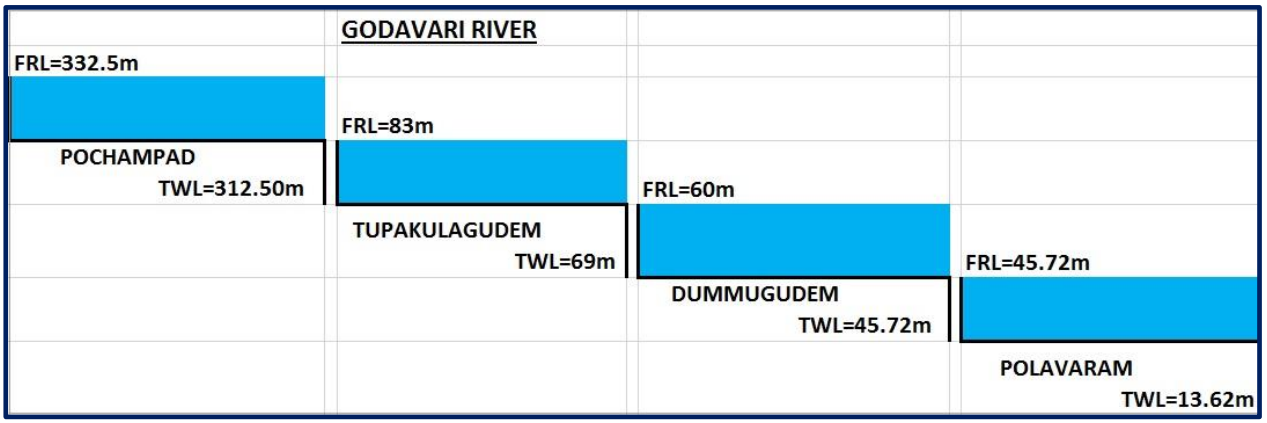
Hydrology and power potential studies are to be carried out for all such sites found in L-Sections developed.

The longitudinal sections of all major rivers in East Flowing Rivers of Peninsular India Basin are shown on coming pages:

Godavari Sub-Basin:

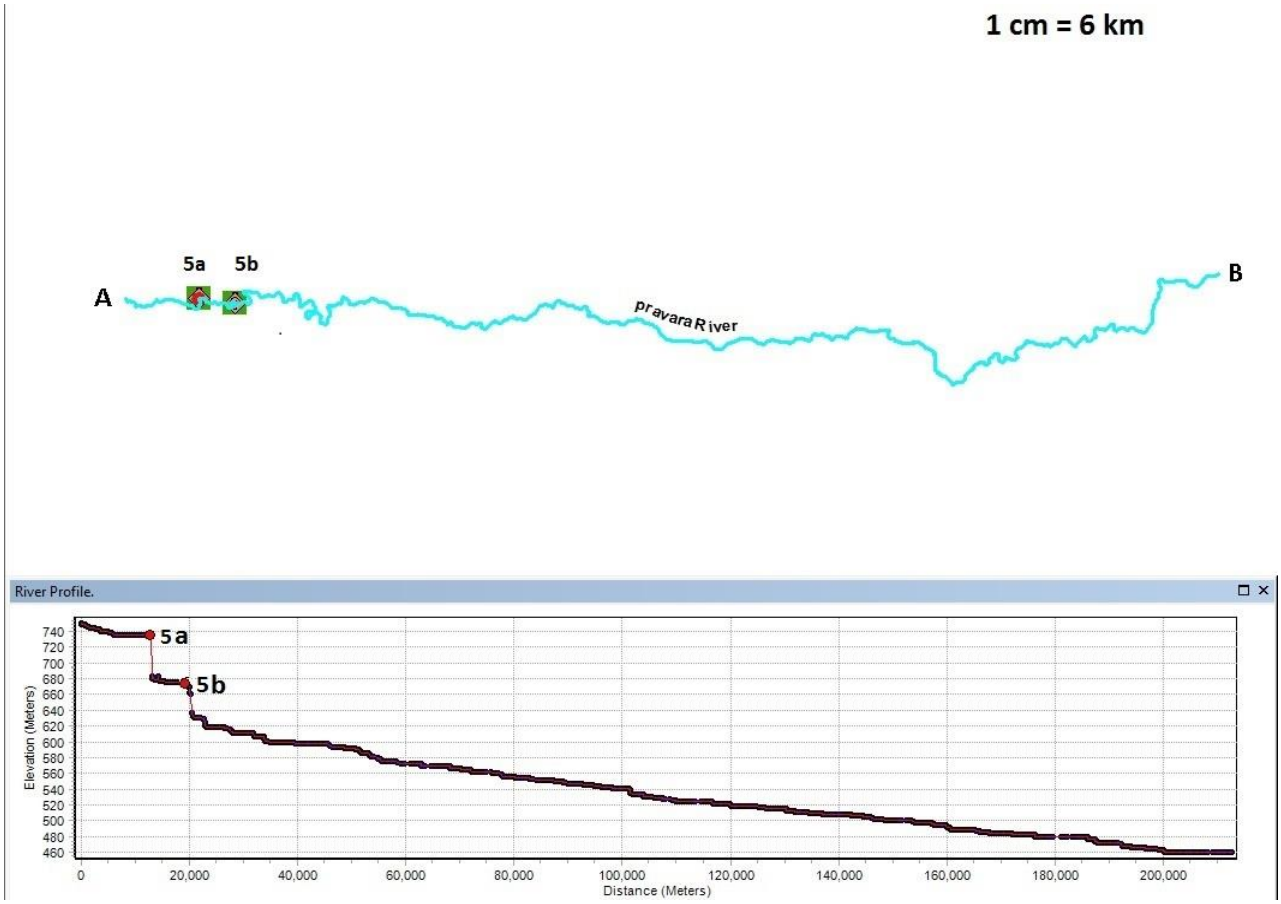
1. Godavari River

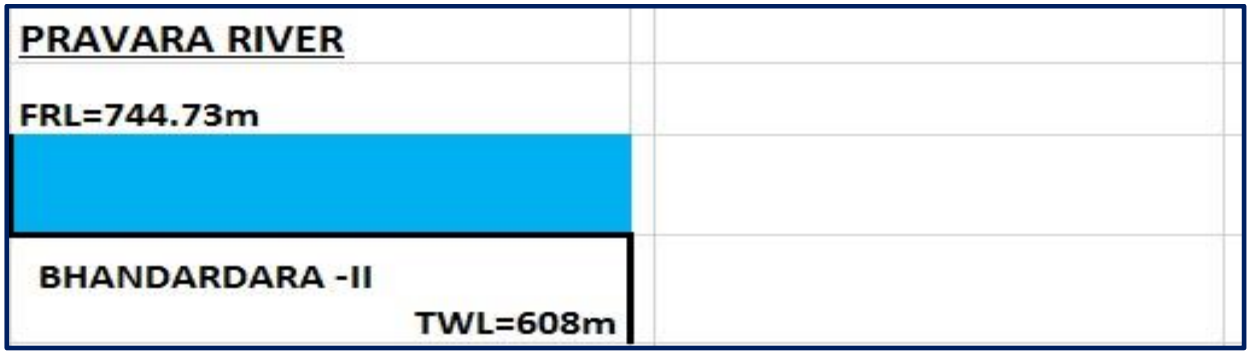




UID	Project Name	State	River	Type	Status
1	Pochampad	Telangana	Godavari	Storage	In Operation
2a	Tupakulagudem (Barrage)	Telangana	Godavari	Storage	Under S&I
2b	Tupakulagudem (Forebay)				
3	Dummugudem	Telangana	Godavari	RoR	DPR Returned for Re-submission
4	Polavaram	Andhra Pradesh	Godavari	Storage	Under Construction

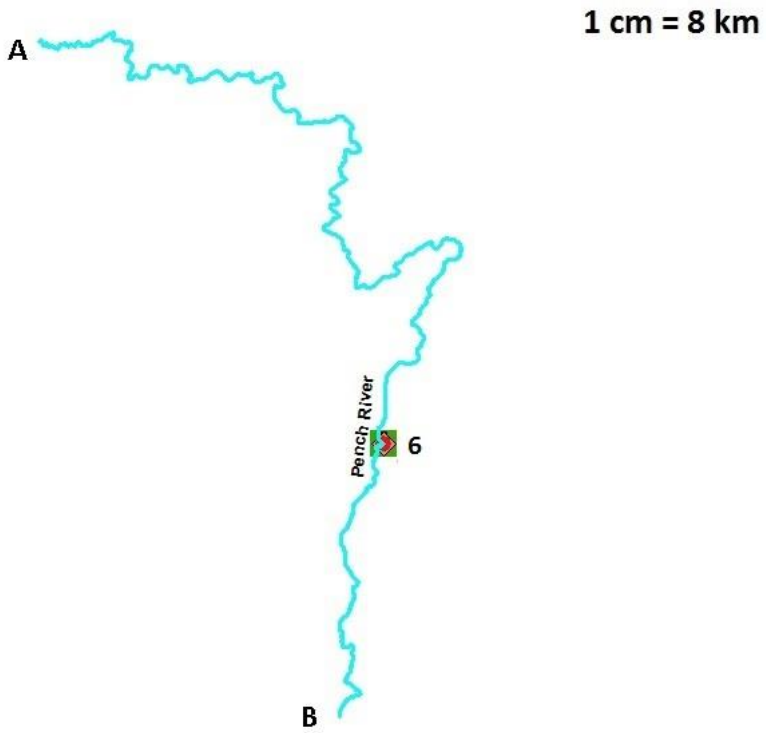
2. Pravara River





UID	Project Name	State	River	Type	Status
5a	Bhandardara St- II (Bhandardara Dam)	Maharashtra	Pravara	RoR with Pondage	In Operation
5b	Bhandardara St- II (Randha Pickup Weir)				

3. Pench River

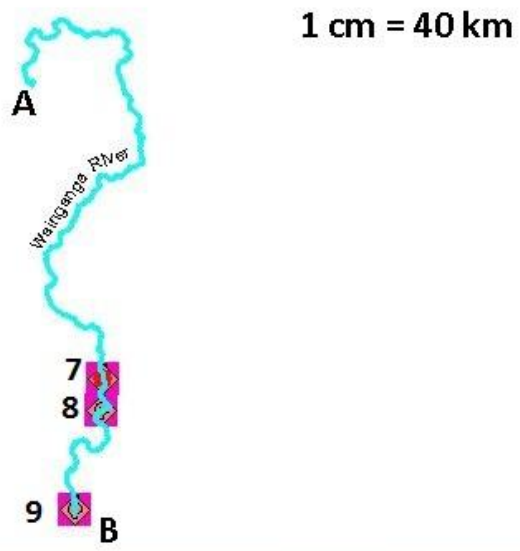


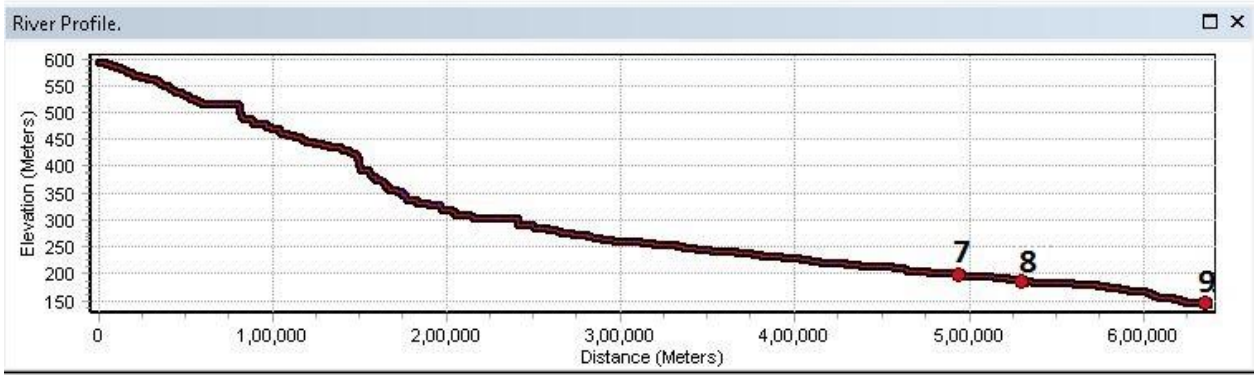


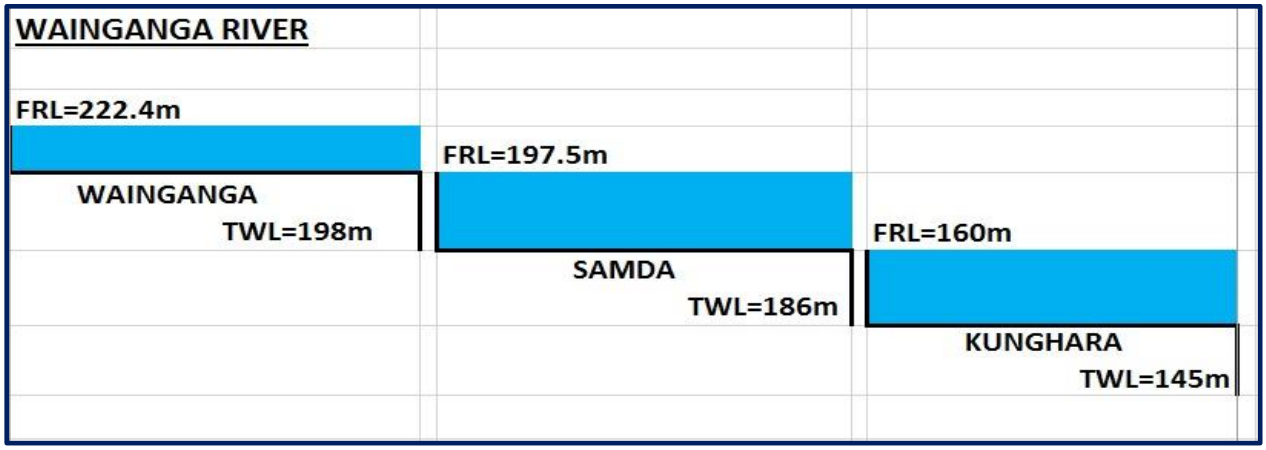


UID	Project Name	State	River	Type	Status
6	Pench	Maharashtra	Pench	Storage	In Operation

4. Wainganga River

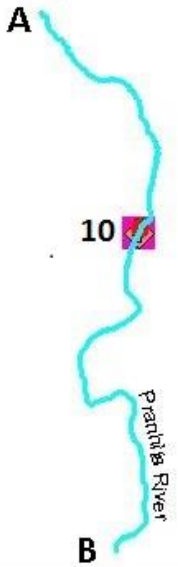






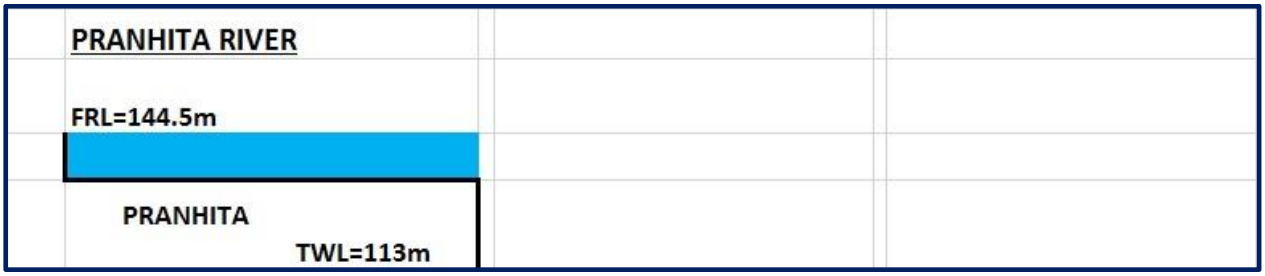
UID	Project Name	State	River	Type	Status
7	Wainganga	Maharashtra	Wainganga	Storage	PFR
8	Samda	Maharashtra	Wainganga	RoR	PFR
9	Kunghara	Maharashtra	Wainganga	RoR	PFR

5. Pranhita River



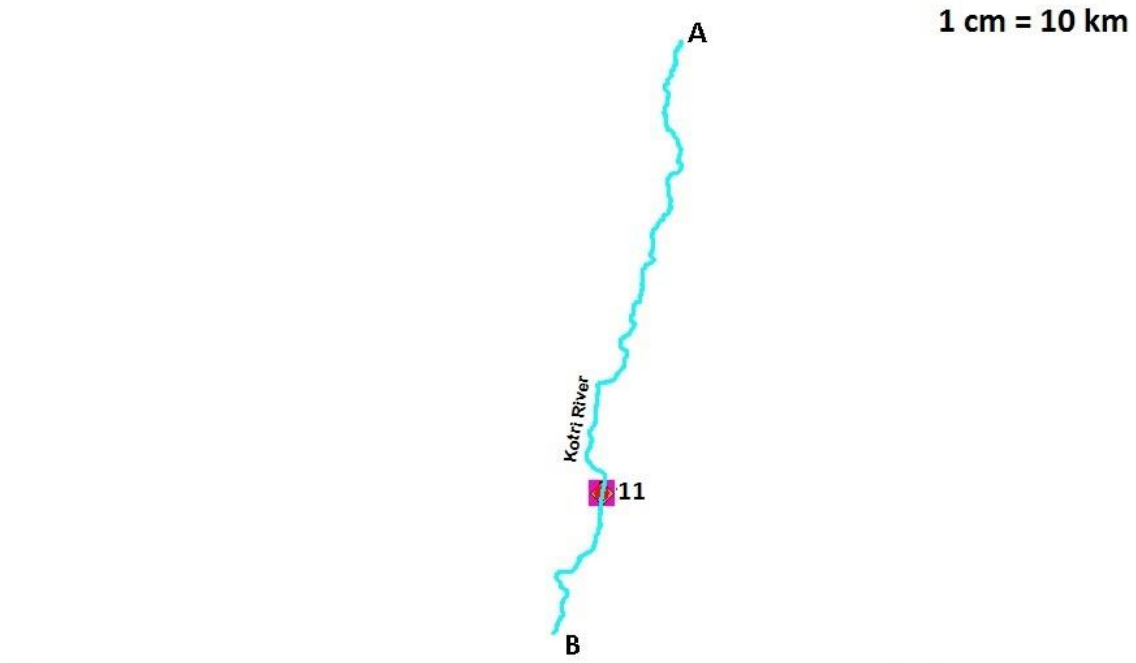
1 cm = 10 km

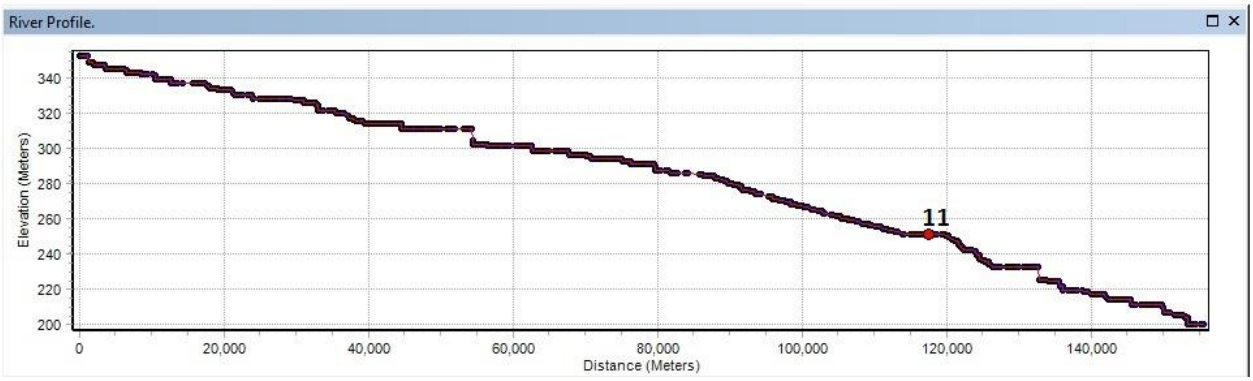


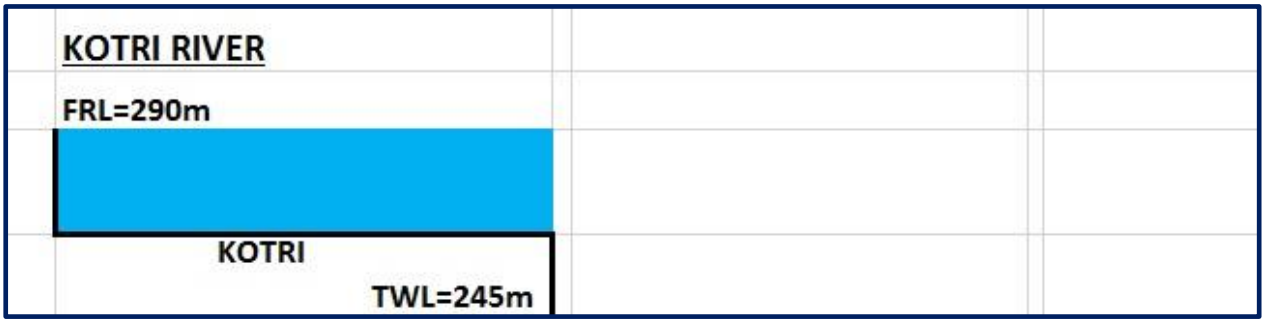


UID	Project Name	State	River	Type	Status
10	Pranhita	Maharashtra	Pranhita	Storage	PFR

6. Kotri River

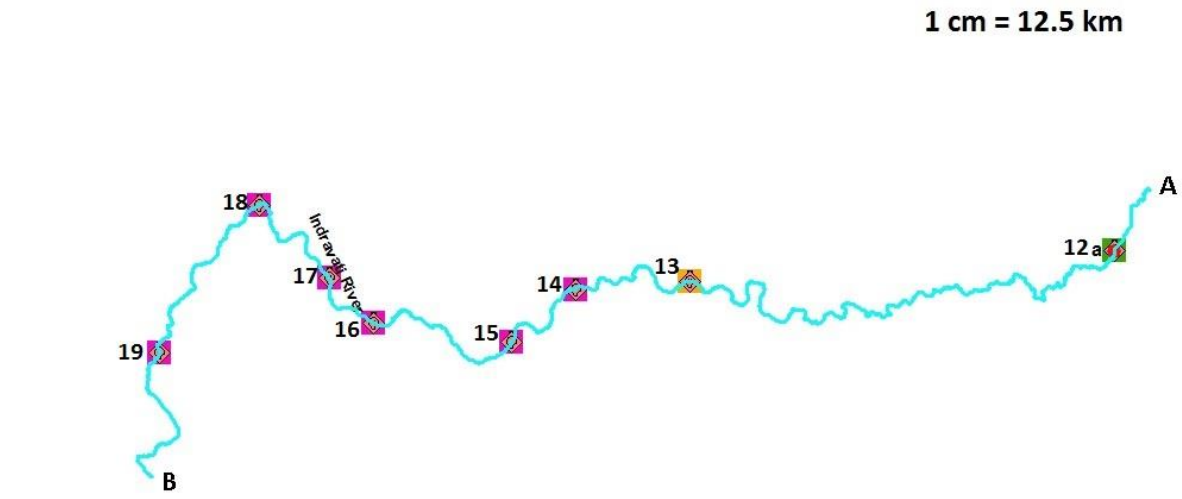


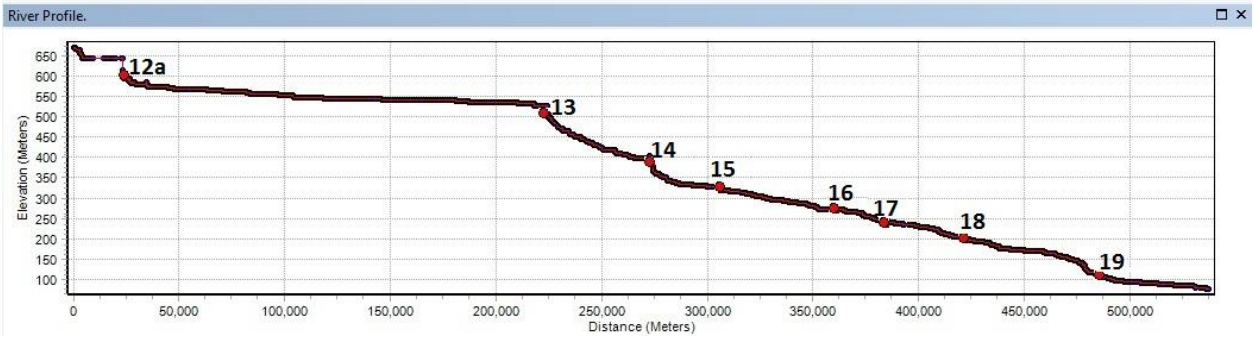


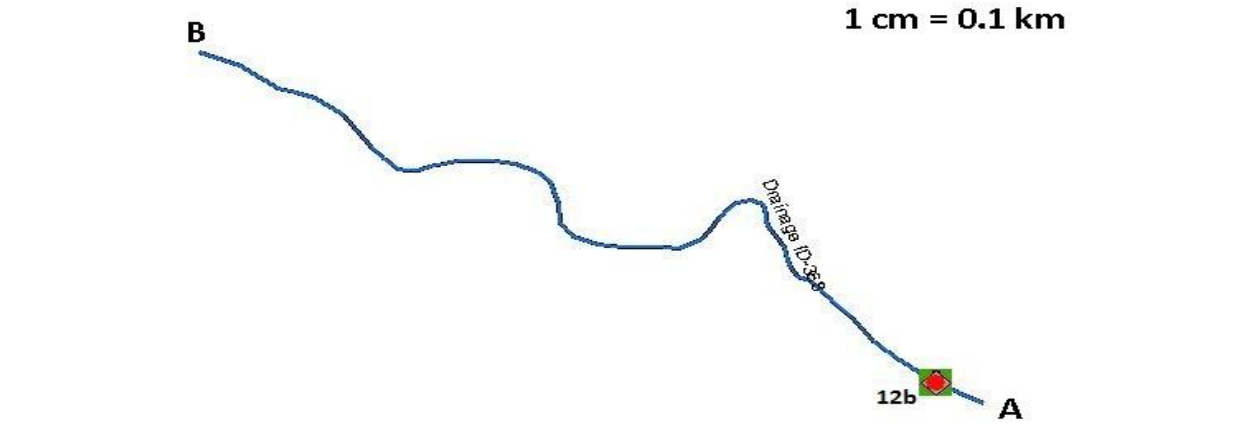


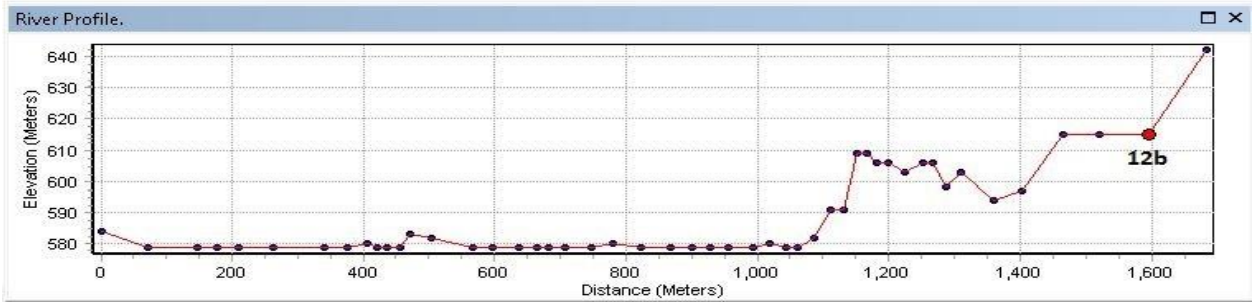
UID	Project Name	State	River	Type	Status
11	Kotri	Chhattisgarh	Kotri	Storage	PFR

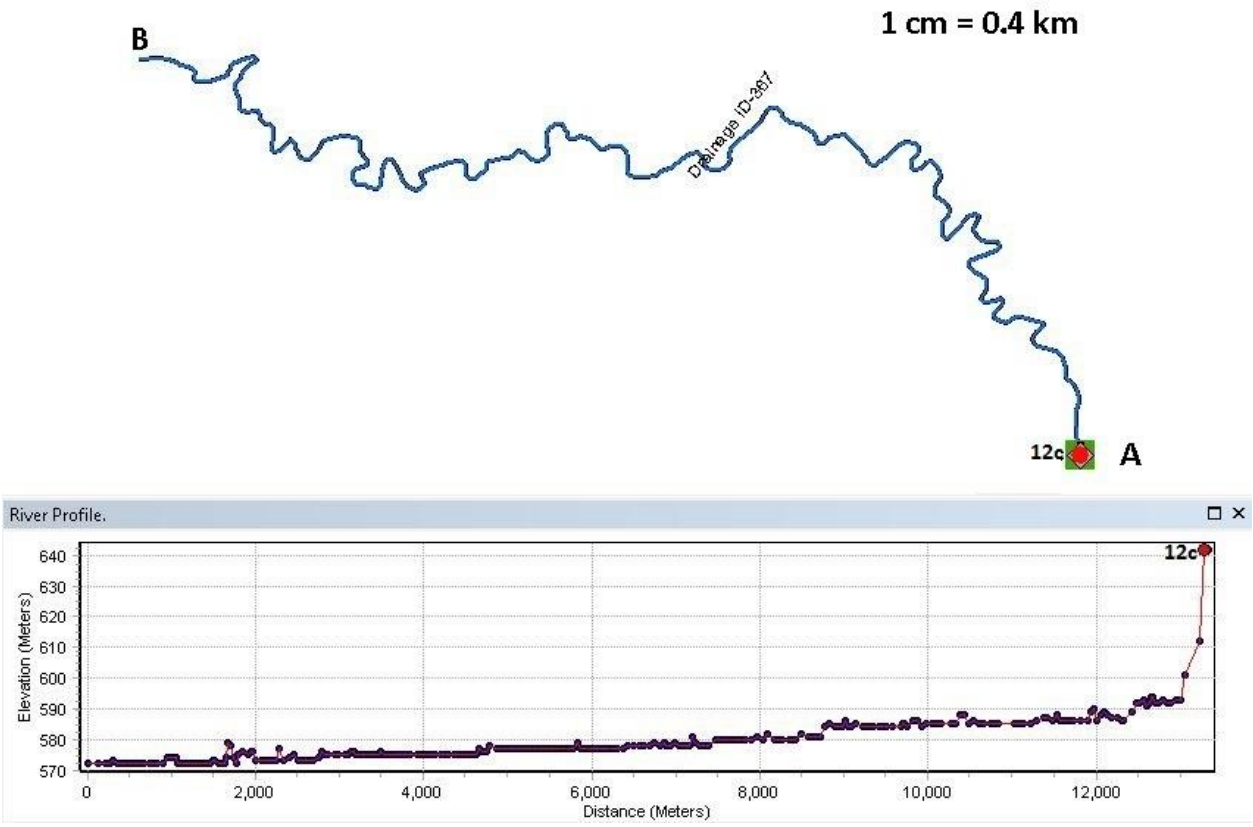
7. Indravati River

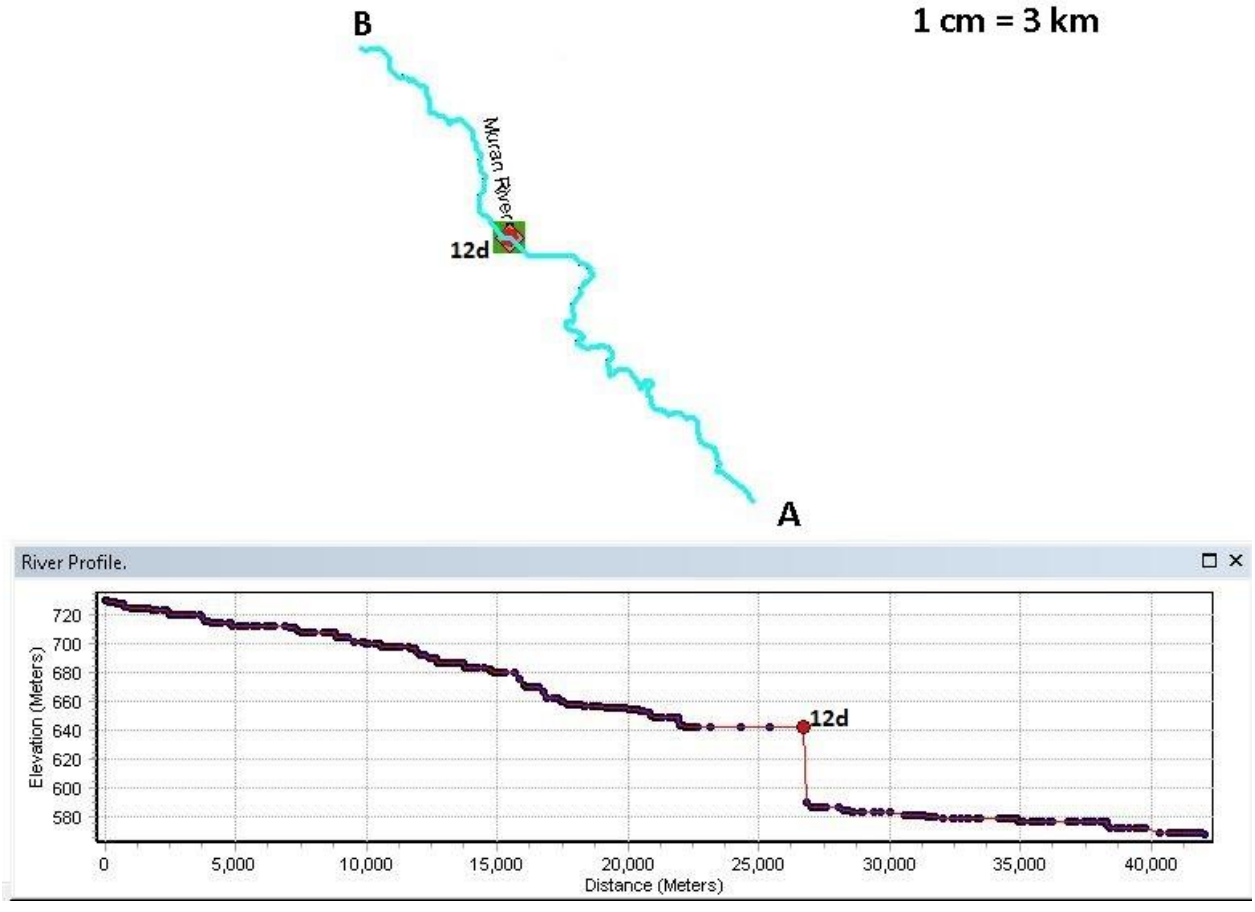


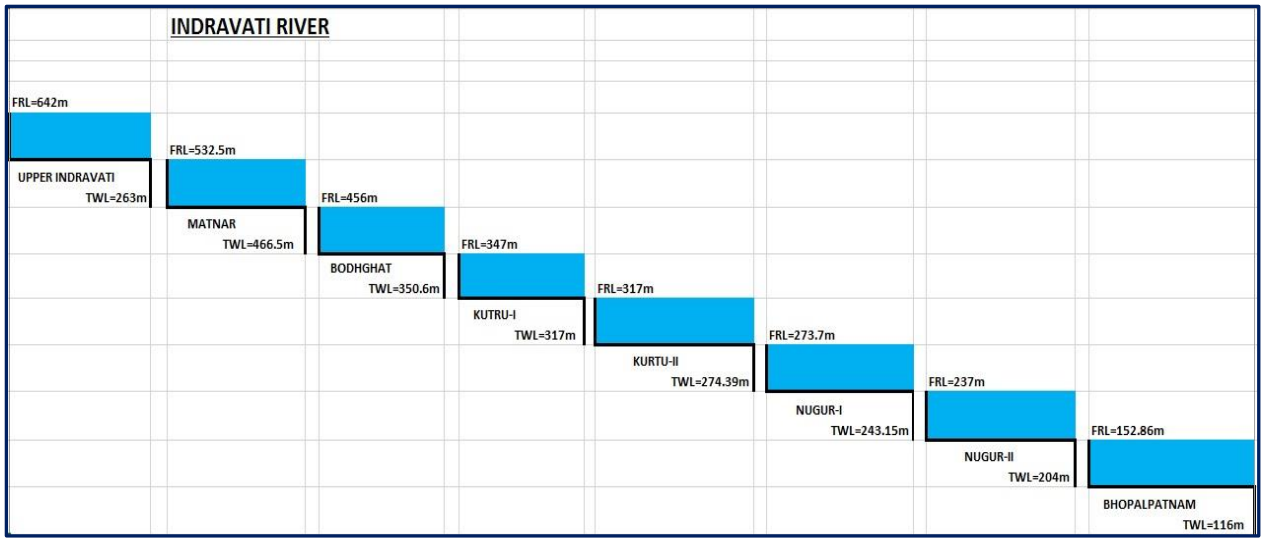






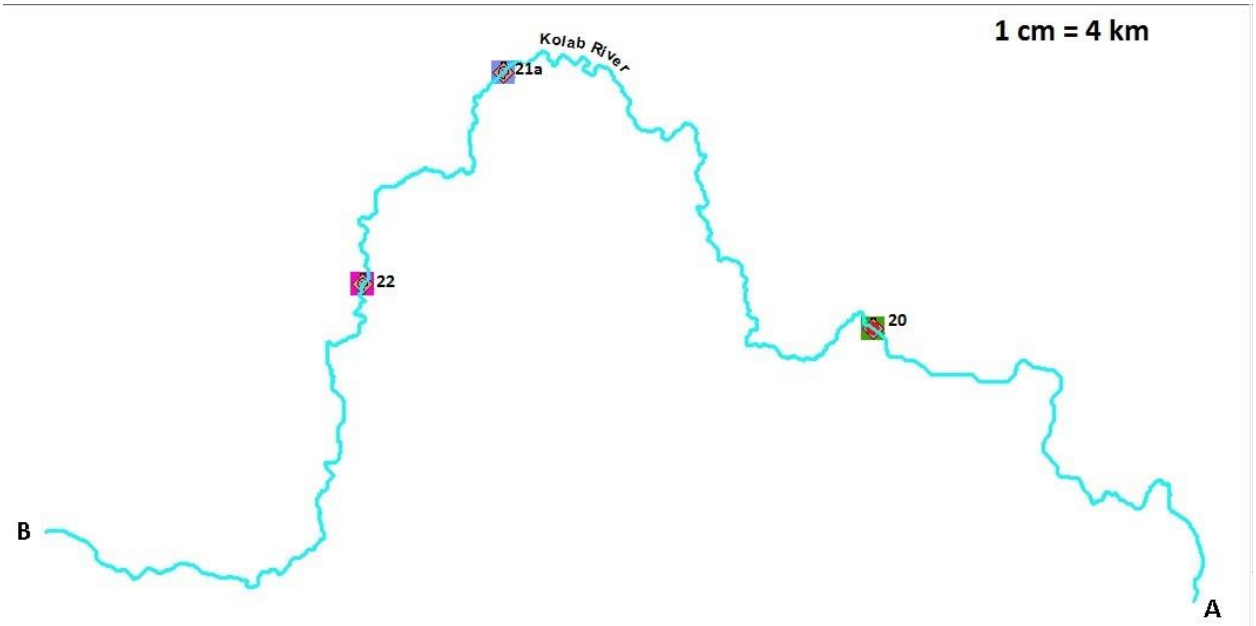

1 cm = 0.4 km
B
Drainage ID-367
12c
A
River Profile.
12c
Elevation (Meters)
640
630
620
610
600
590
580
570
0
2,000
4,000
6,000
8,000
10,000
12,000
Distance (Meters)


1 cm = 3 km
B
Muran River
12d
A
River Profile.
12d
Elevation (Meters)
720
700
680
660
640
620
600
580
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
40,000
Distance (Meters)



UID	Project Name	State	River	Type	Status
12a	Upper Indravati (Upper Indravati Dam	Odisha	Indravati & Muran	Storage	In Operation
12b	Upper Indravati (Podagada Dam)				
12c	Upper Indravati (Kapur dam)				
12d	Upper Indravati (Muran Dam)				
13	Matnar	Chhattisgarh	Indravati	RoR	Concurred
14	Bodhghat	Chhattisgarh	Indravati	Storage	PFR
15	Kutru-I	Chhattisgarh	Indravati	Storage	PFR
16	Kutru-II	Chhattisgarh	Indravati	Storage	PFR
17	Nugur-I	Chhattisgarh	Indravati	Storage	PFR
18	Nugur-II	Chhattisgarh	Indravati	Storage	PFR
19	Bhopalpatnam	Chhattisgarh	Indravati	Storage	PFR

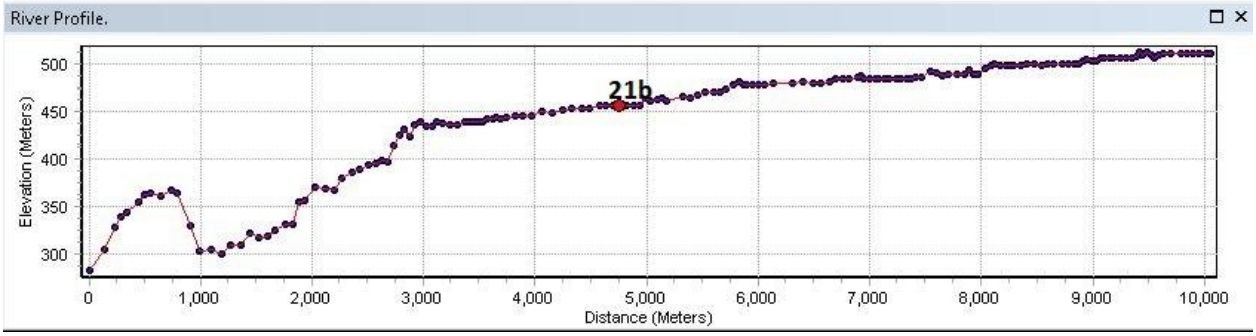
8. Kolab River

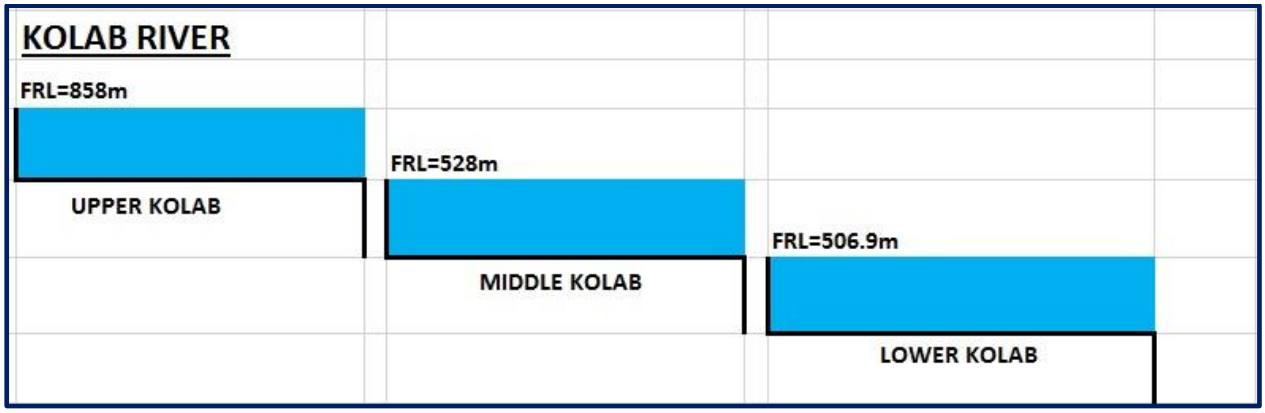




1 cm = 0.4 km



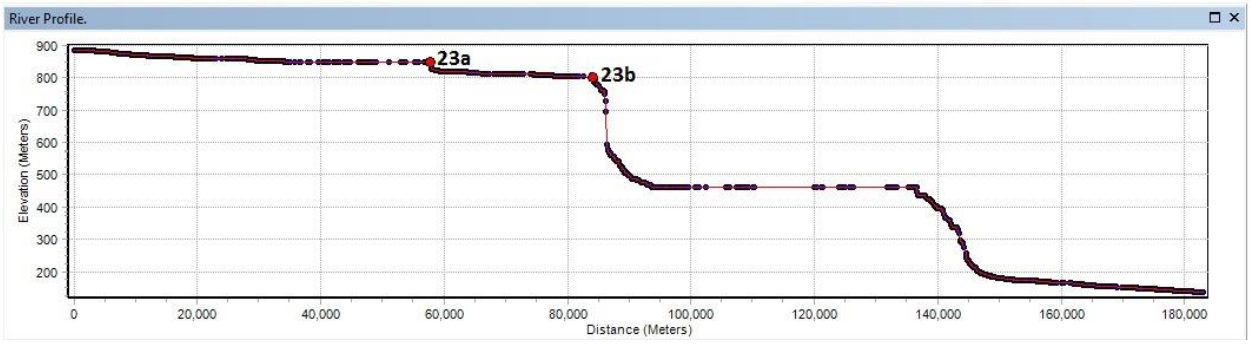




UID	Project Name	State	River	Type	Status
20	Upper Kolab	Odisha	Kolab	Storage	In Operation
21a	Middle Kolab (Diversion Barrage)	Odisha	Kolab & Kerajodi Nallah	Storage	DPR Returned for Re-submission
21b	Middle Kolab (Kerajodi dam)				
22	Lower Kolab	Odisha	Kolab	Storage	PFR

9. Machkund River



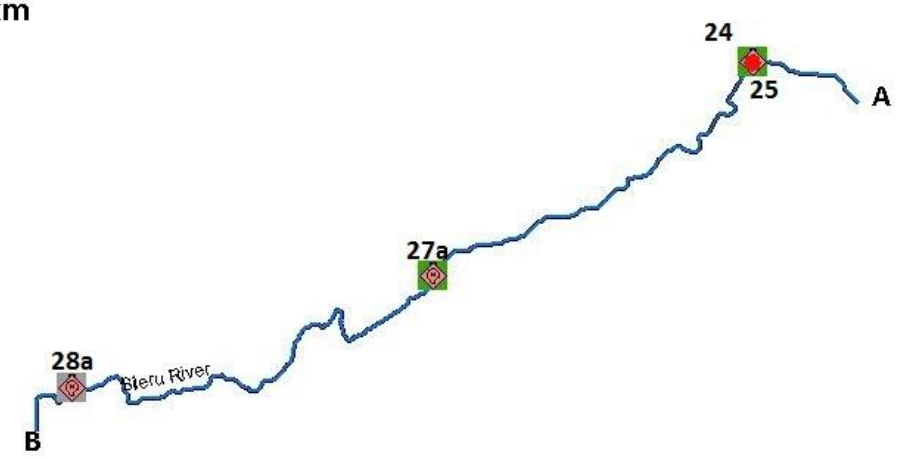


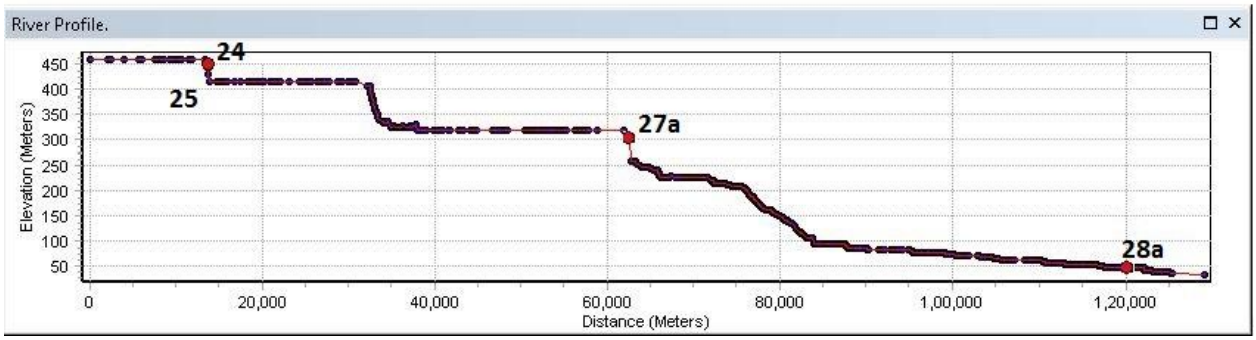


ID	Project Name	State	River	Type	Status
23a	Machkund (Jalaput Dam)	Odisha	Machkund	Storage	In Operation
23b	Machkund (Diversion Dam)				

10. Sileru River

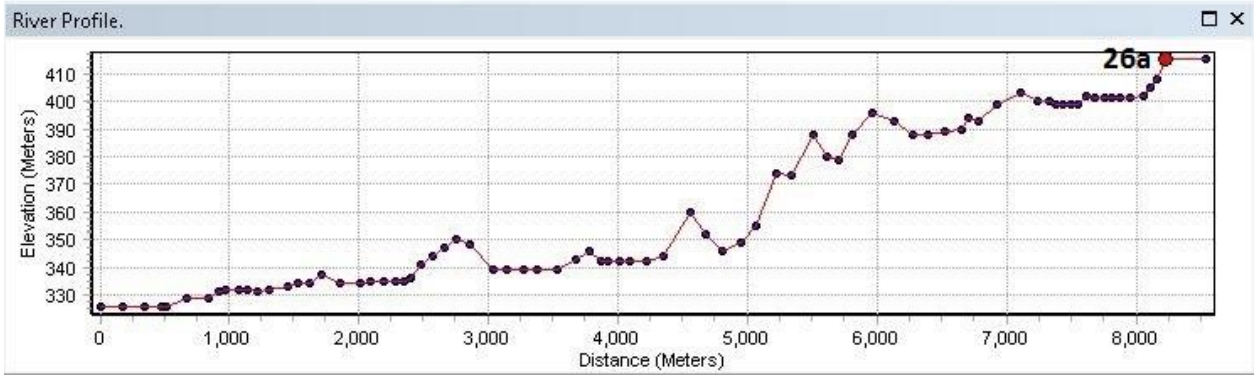
1 cm = 6 km

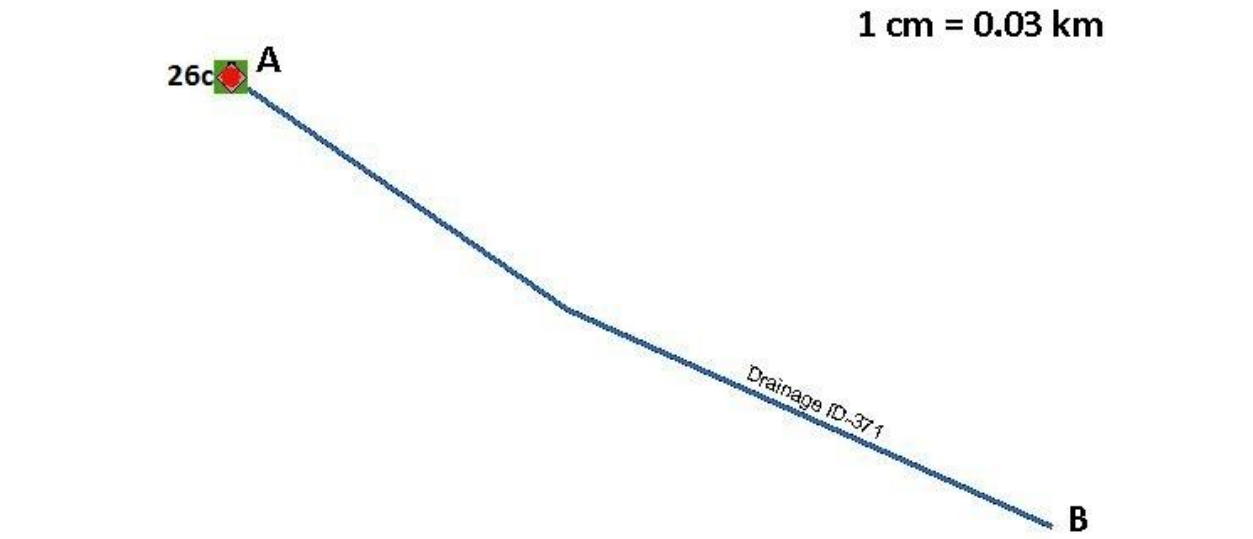


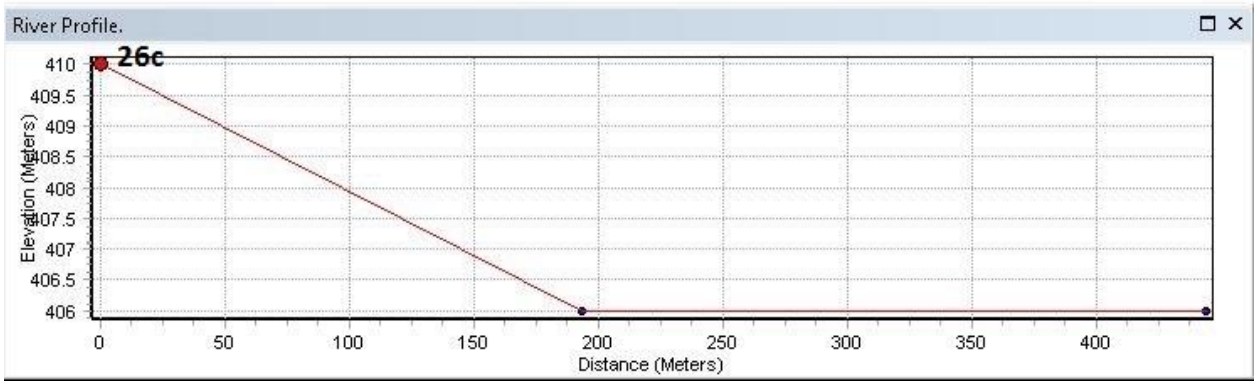


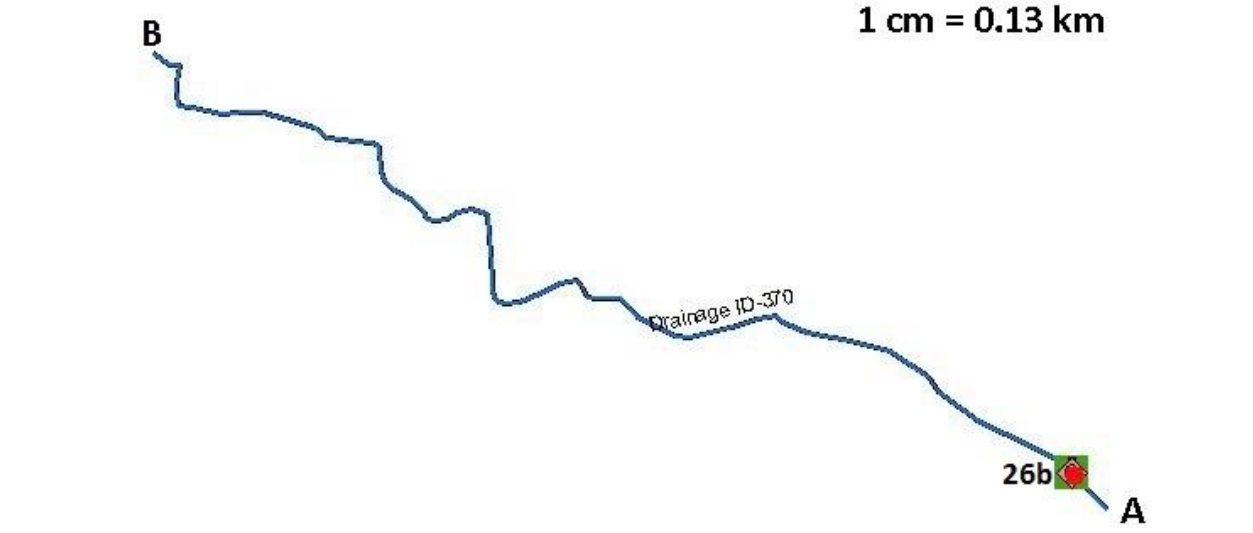
1 cm = 0.5 km

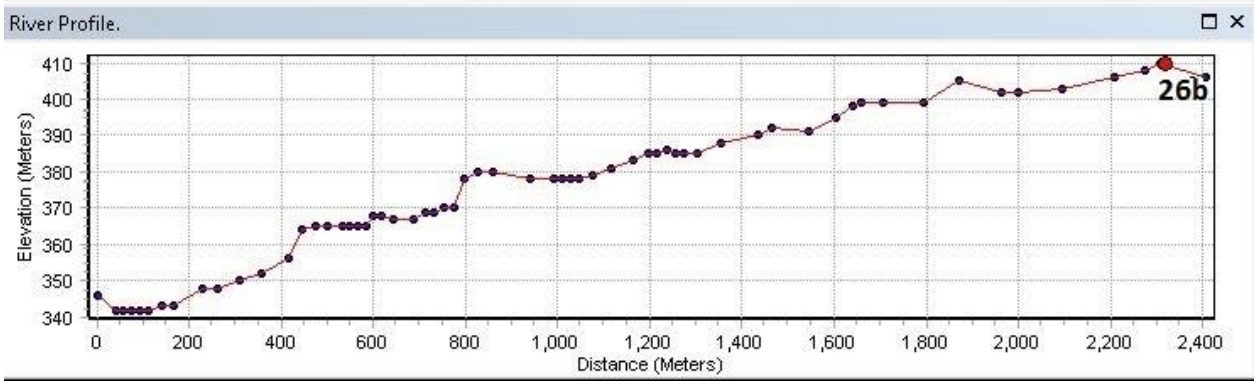





1 cm = 0.03 km
26c
A
Drainage ID-371
B

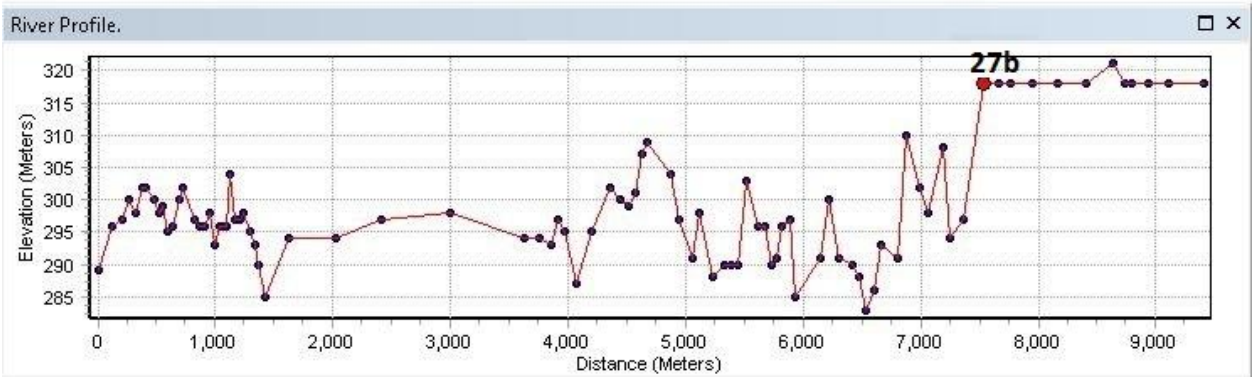

River Profile.
26c
Elevation (Meters)
410
409.5
409
408.5
408
407.5
407
406.5
406
0
50
100
150
200
250
300
350
400
Distance (Meters)


1 cm = 0.13 km
B
Drainage ID-370
26b
A

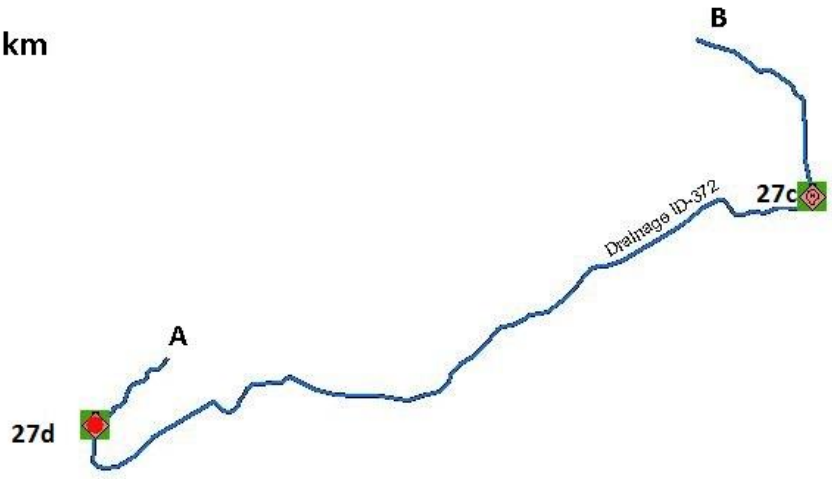

River Profile.
26b
Elevation (Meters)
410
400
390
380
370
360
350
340
0
200
400
600
800
1,000
1,200
1,400
1,600
1,800
2,000
2,200
2,400
Distance (Meters)

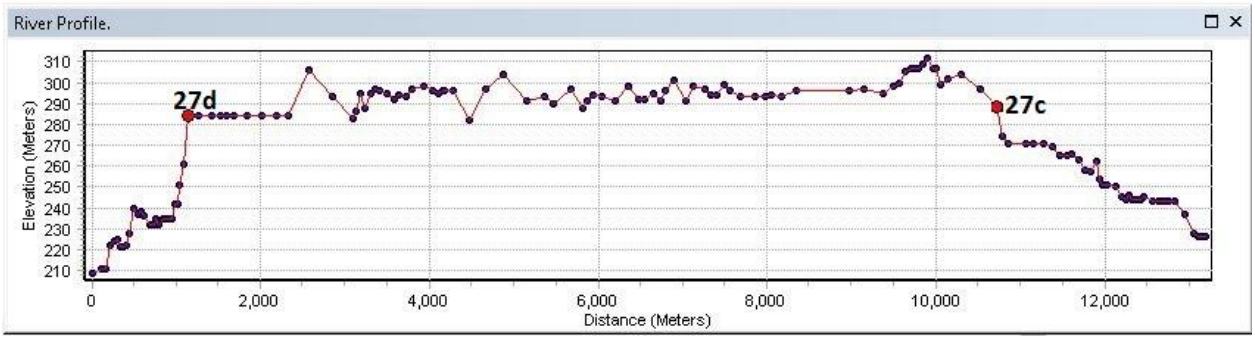
1 cm = 0.8 km

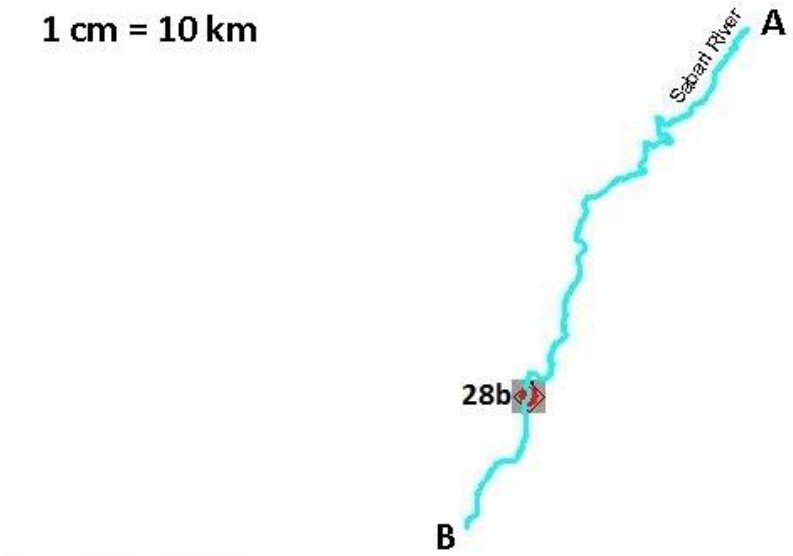


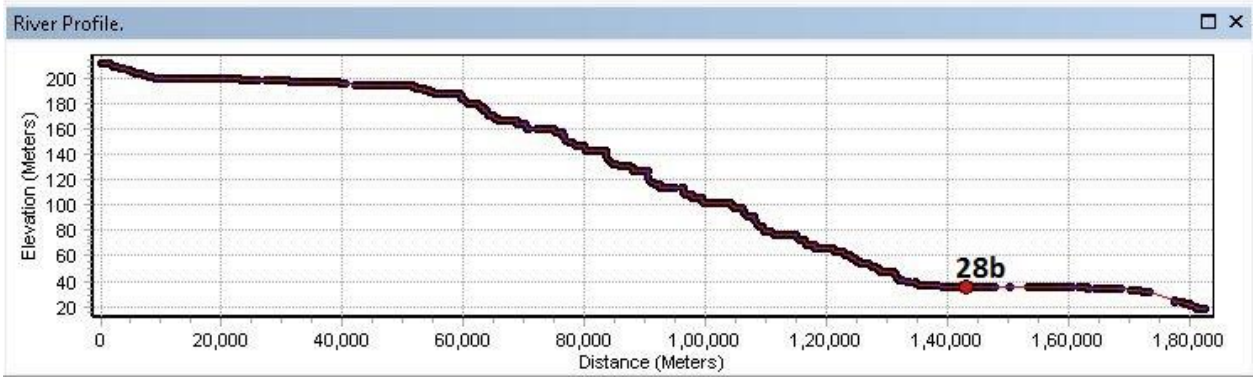


1 cm = 0.6 km









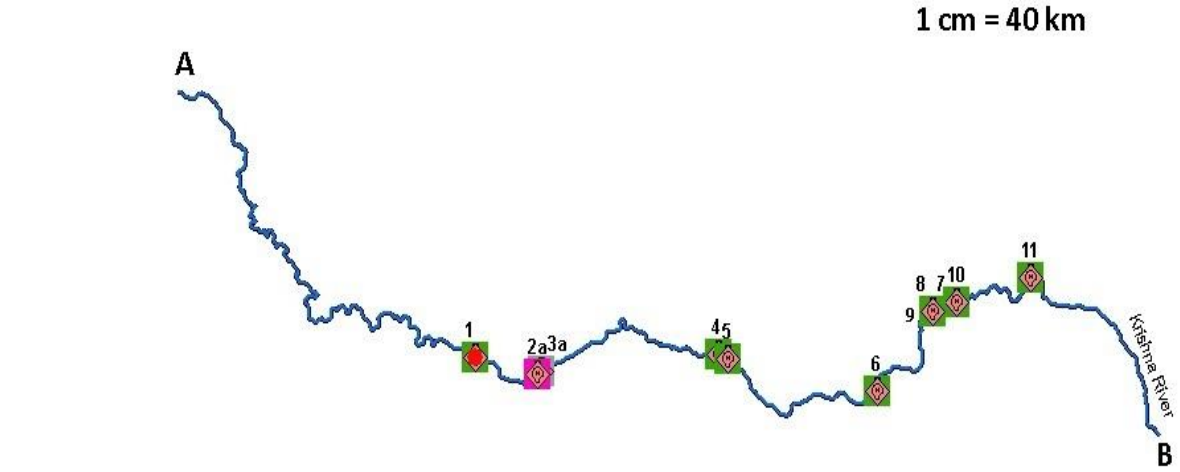


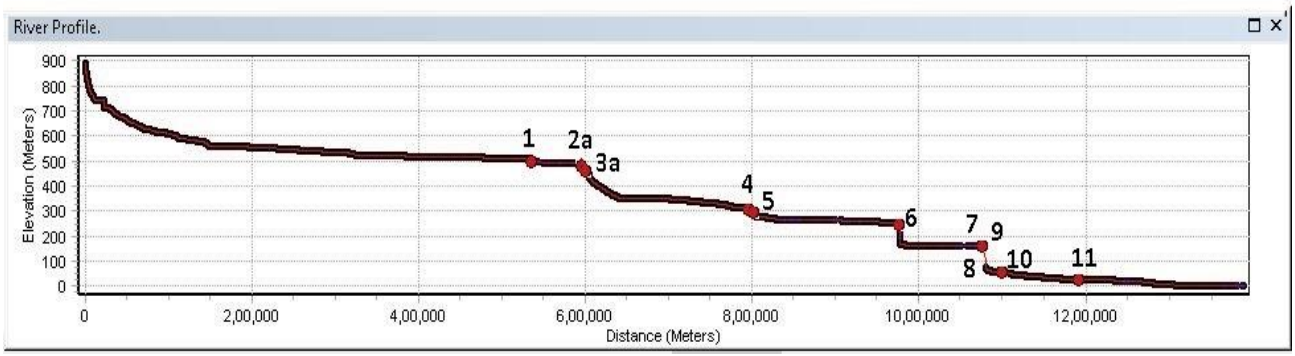
UID	Project Name	State	River	Type	Status
24	Balimela	Odisha	Sileru	Storage	In Operation
25	Balimela	Andhra Pradesh	Sileru	Storage	Balance
26a	Upper Sileru -I &II (Guntawada Weir)	Andhra Pradesh	Sileru	Storage	In Operation
26b	Upper Sileru -I &II (Forebay Embankment 1)				
26c	Upper Sileru -I &II (Forebay Embankment 2)				

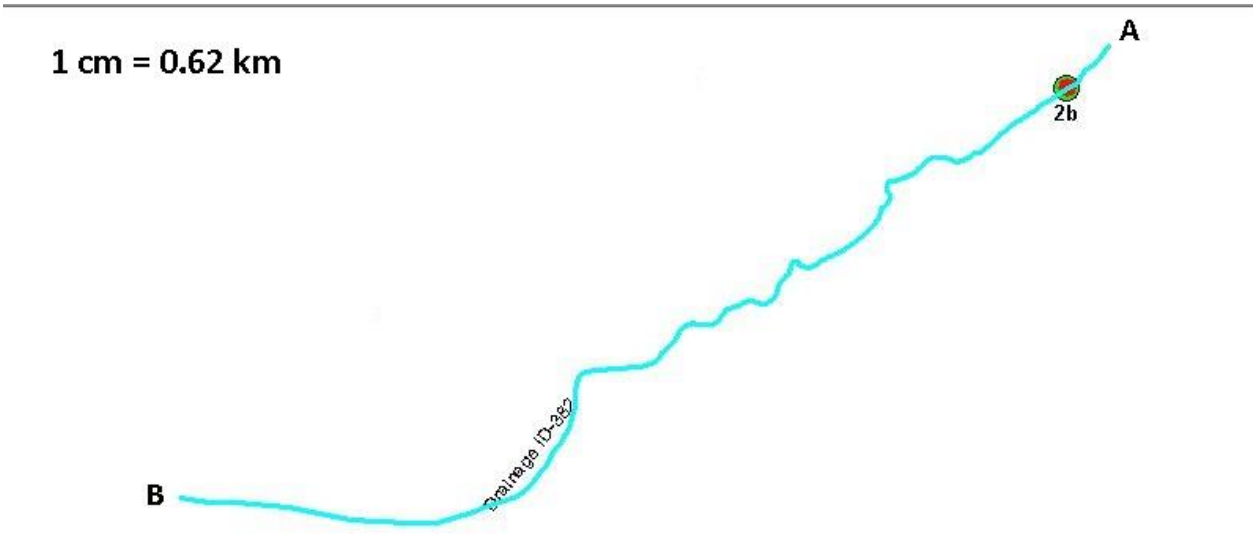
27a	Lower Sileru (Left flank Saddle Dam)	Andhra Pradesh	Sileru	Storage	In Operation
27b	Lower Sileru (Alimeru Vagu Pickup Dam)				
27c	Lower Sileru (Forebay Dam)				
27d	Lower Sileru (Left flank Saddle Dam)				
28a	Konta (PedaMuduguru)	Chhattisgarh	Sabari /Sileru	RoR	Balance
28b	Konta (Banigudam)				

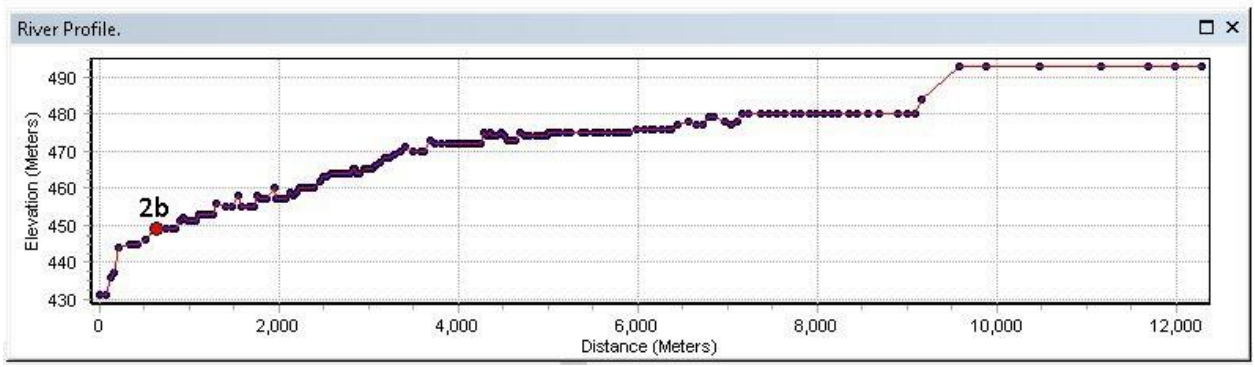
Krishna Sub-Basin:

1. Krishna River



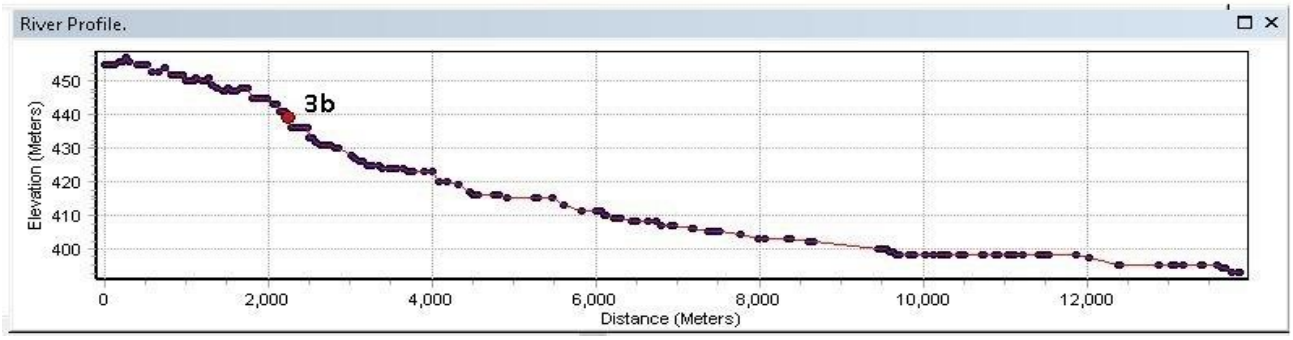






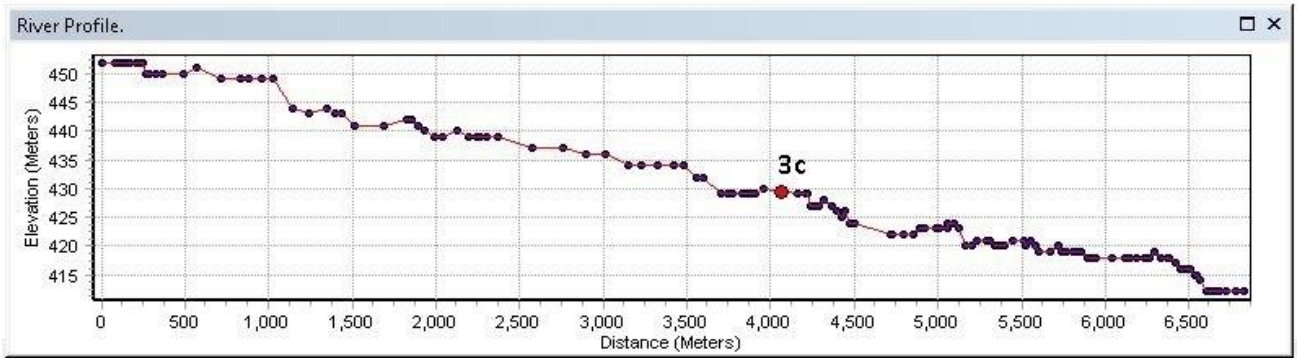


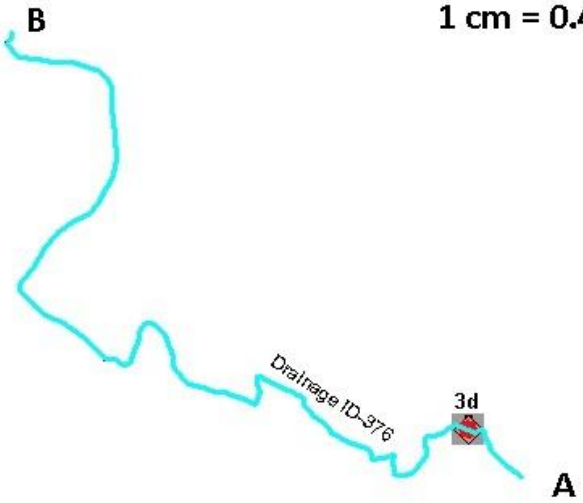
1 cm = 1.25 km

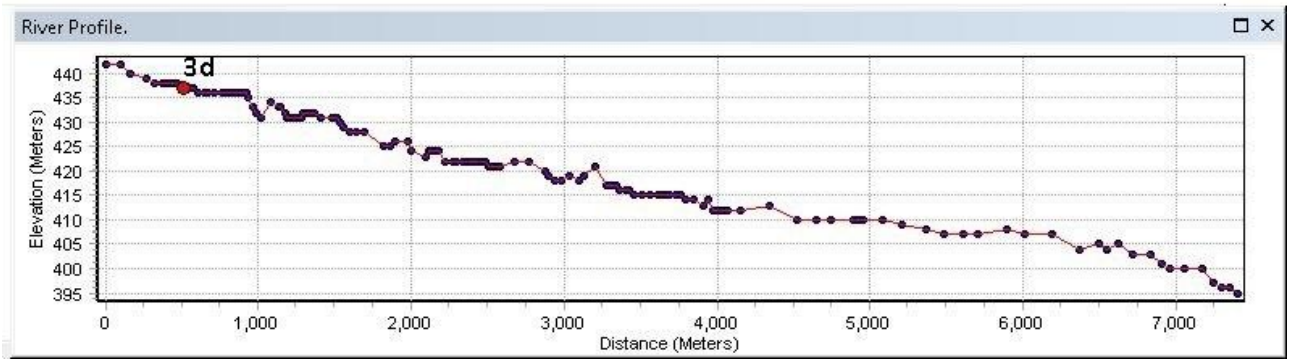


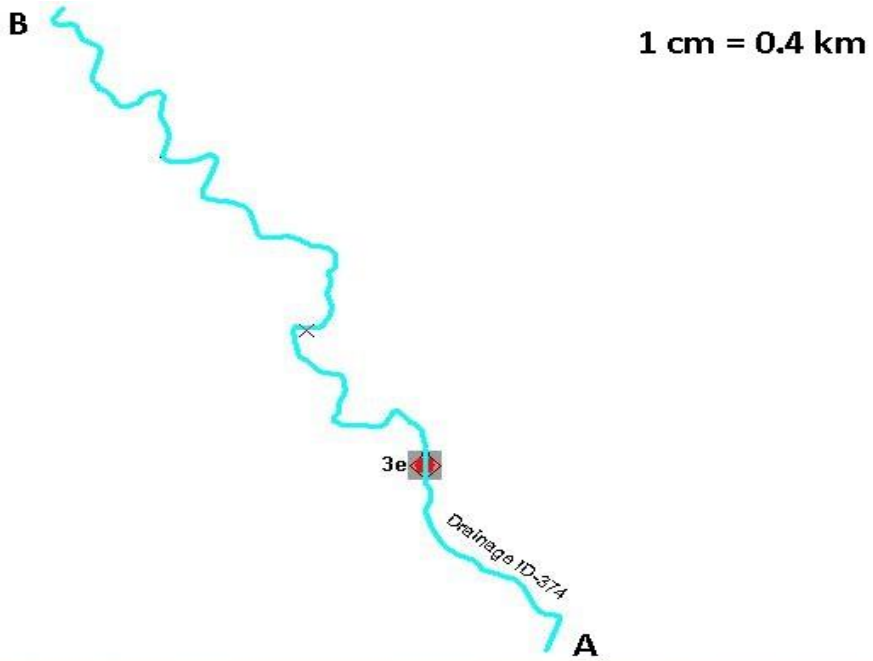


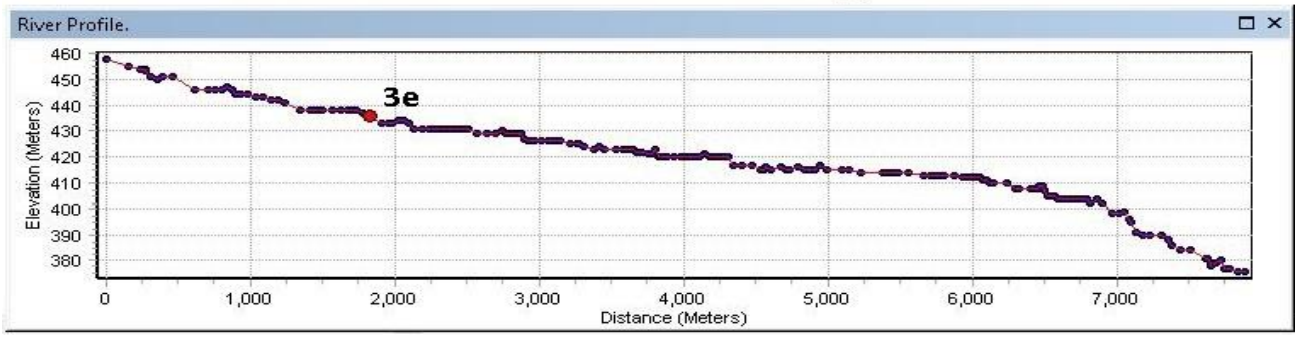
1 cm = 0.6 km

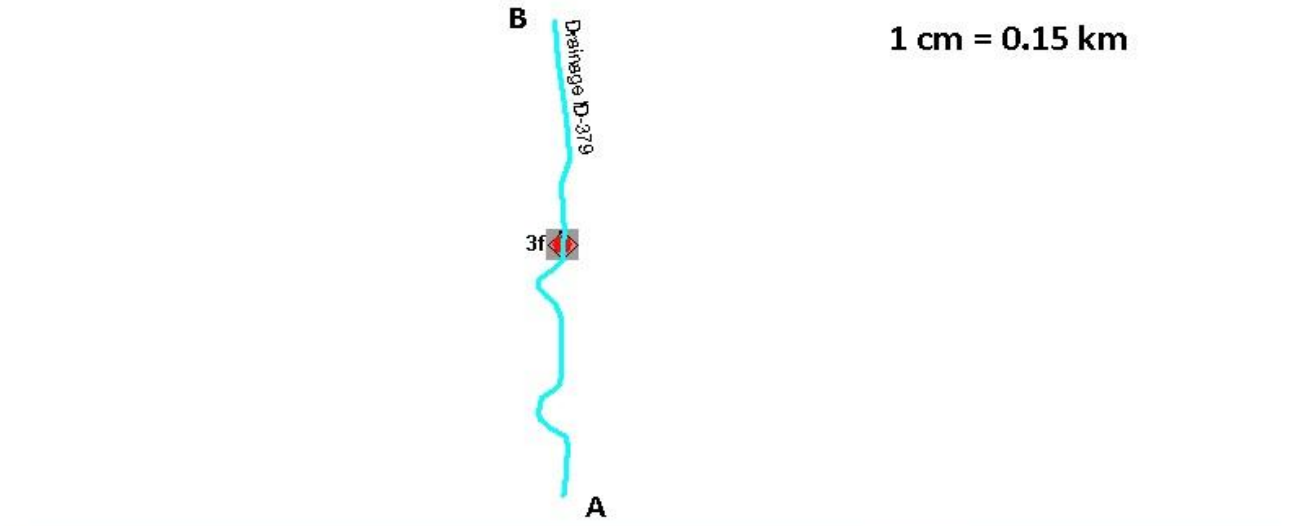


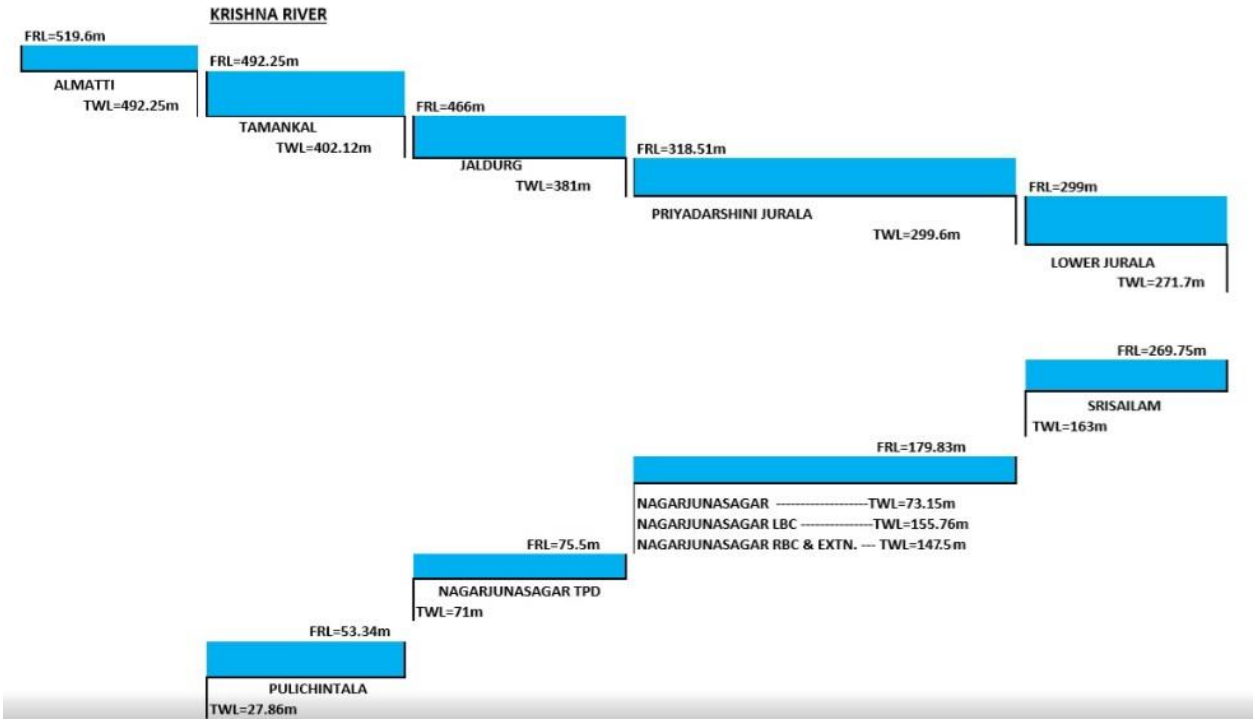

B
1 cm = 0.4 km
Drainage ID-376
3d
A


River Profile.
3d
Elevation (Meters)
440
435
430
425
420
415
410
405
400
395
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
Distance (Meters)


B
1 cm = 0.4 km
3e
Drainage ID-374
A


River Profile.
3e
Elevation (Meters)
460
450
440
430
420
410
400
390
380
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
Distance (Meters)

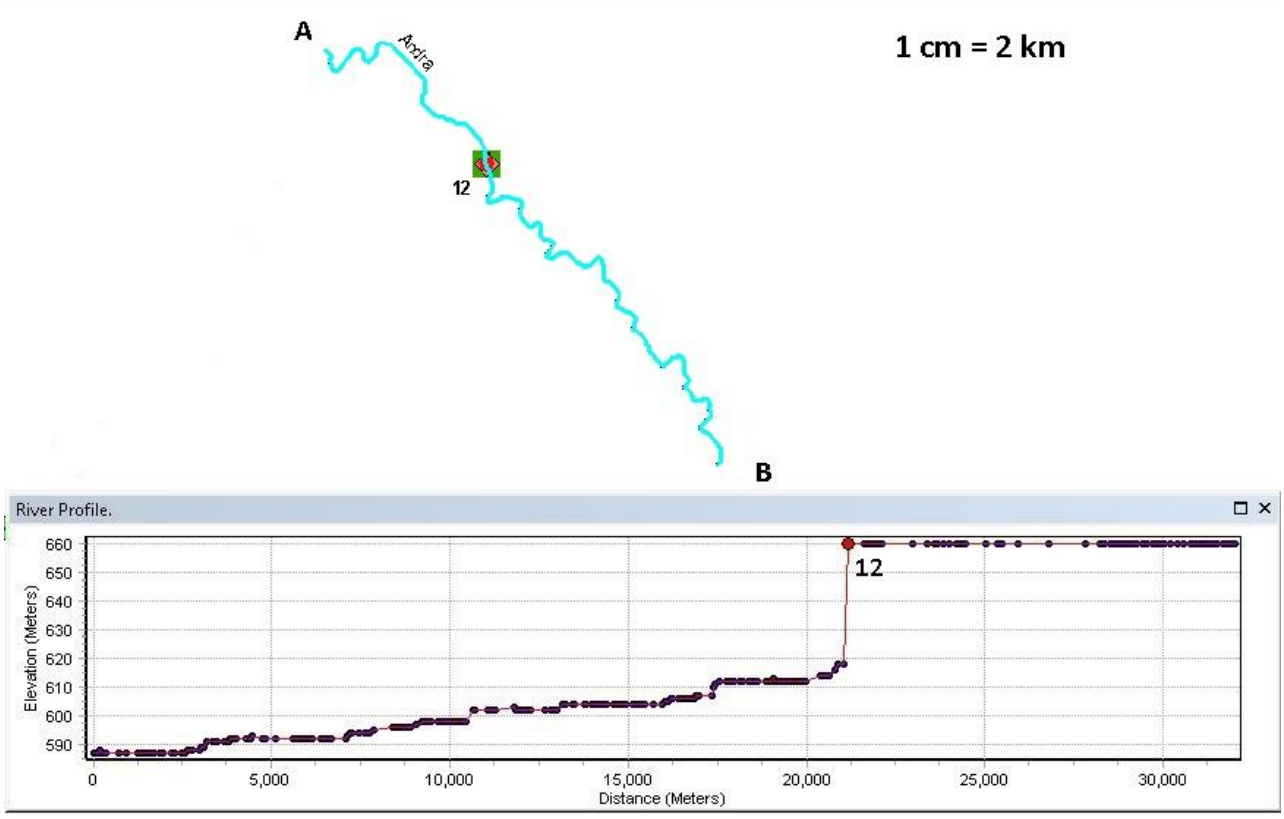




UID	Project Name	State	River	Type	Status
1	Almatti	Karnataka	Krishna	Storage	In Operation
2a	Tamankal (Narayanpur Dam)	Karnataka	Krishna	Storage	PFR
2b	Tamankal (Forebay)				

3a	Jaldurg (Jaldurg Diversion)	Karnataka	Krishna	RoR	Balance
3b	Jaldurg (Diversion 1)				
3c	Jaldurg (Diversion 2)				
3s	Jaldurg (Diversion3)				
3e	Jaldurg (Diversion 4)				
3f	Jaldurg (Diversion5)				
4	Priyadarshini Jurala	Telangana	Krishna	RoR	In Operation
5	Lower Jurala	Telangana	Krishna	RoR	In Operation
6	Srisailam	Andhra Pradesh	Krishna	Storage	In Operation
7	Nagarjunasagar LBC	Telangana	Krishna	Storage	In Operation
8	Nagarjunsagar	Telangana	Krishna	Storage	In Operation
9	Nagarjunasagar RBC & Ext	Andhra Pradesh	Krishna	Storage	In Operation
10	Nagarjunasagar TPD	Andhra Pradesh	Krishna	RoR	In Operation
11	Pulichintala	Telangana	Krishna	Storage	In Operation

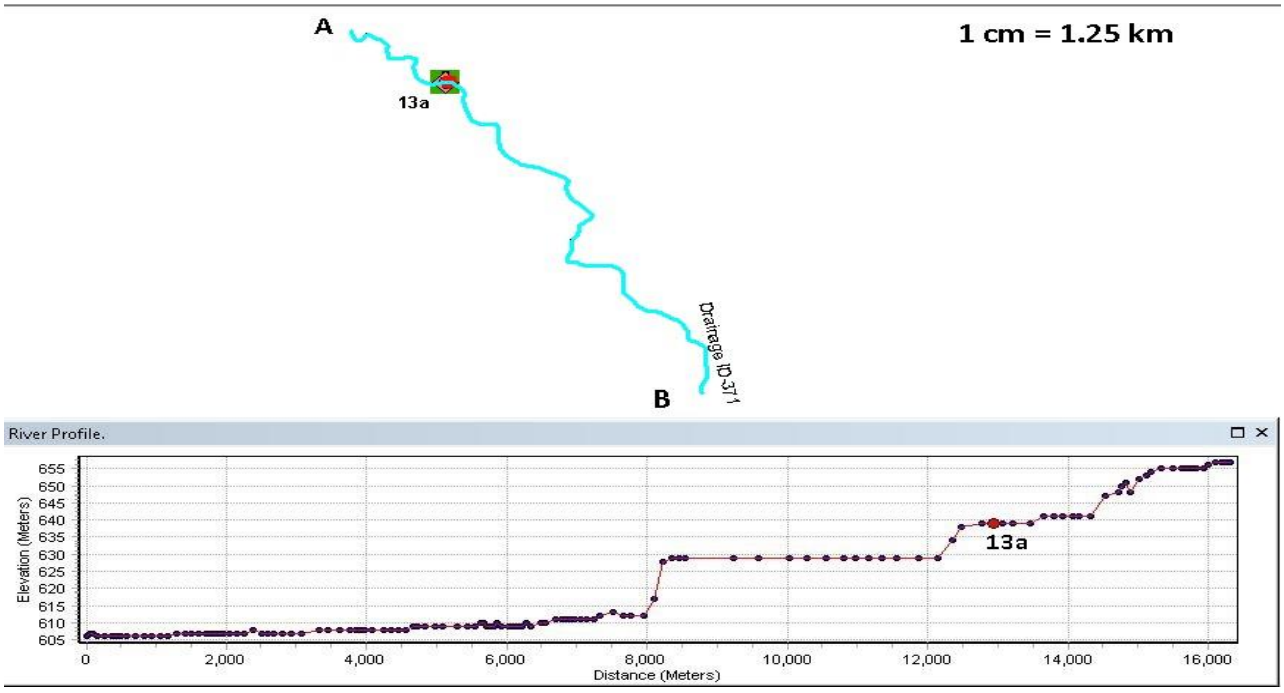
2. Andhra River

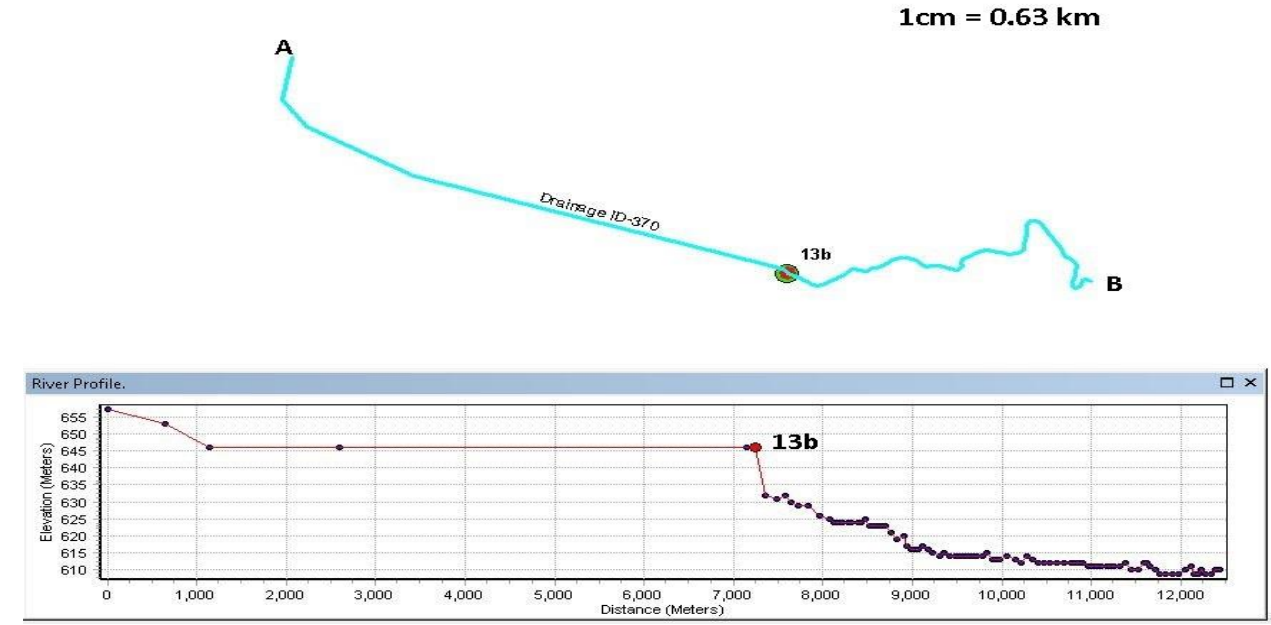




UID	Project Name	State	River	Type	Status
12	Bhivpuri	Maharashtra	Andhra	Conventional	In Operation

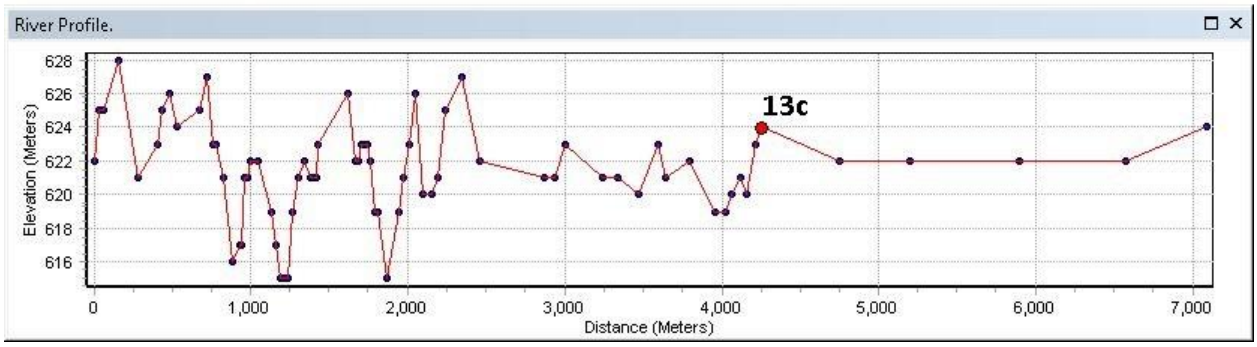
3. Indrayani River



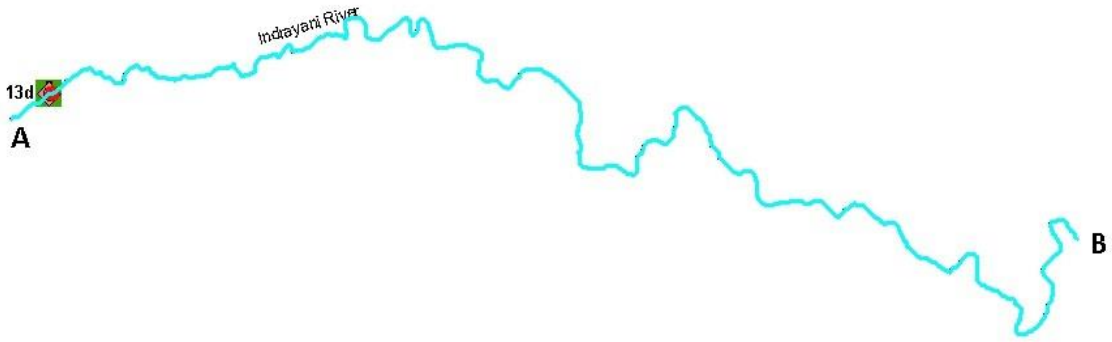


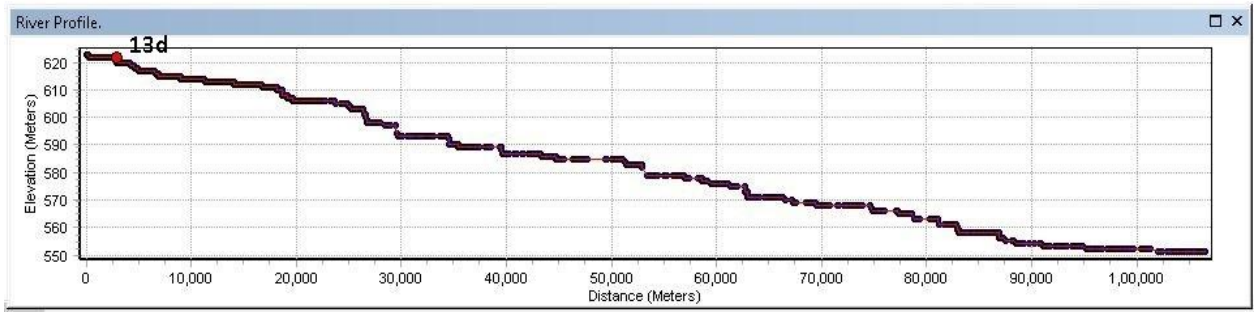
1 cm = 0.8 km

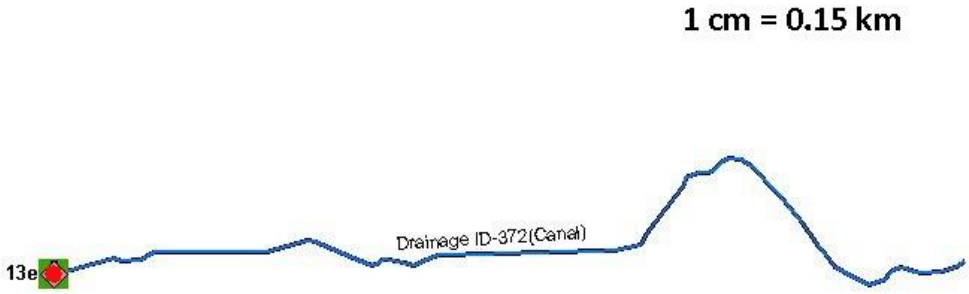




1 cm = 3 km







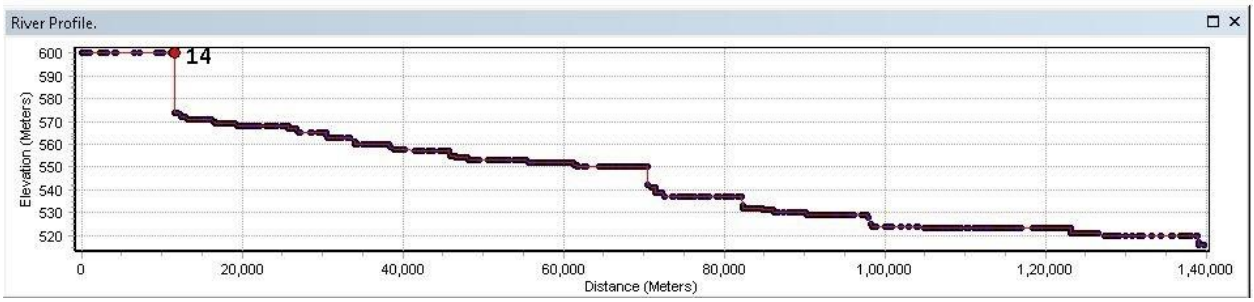


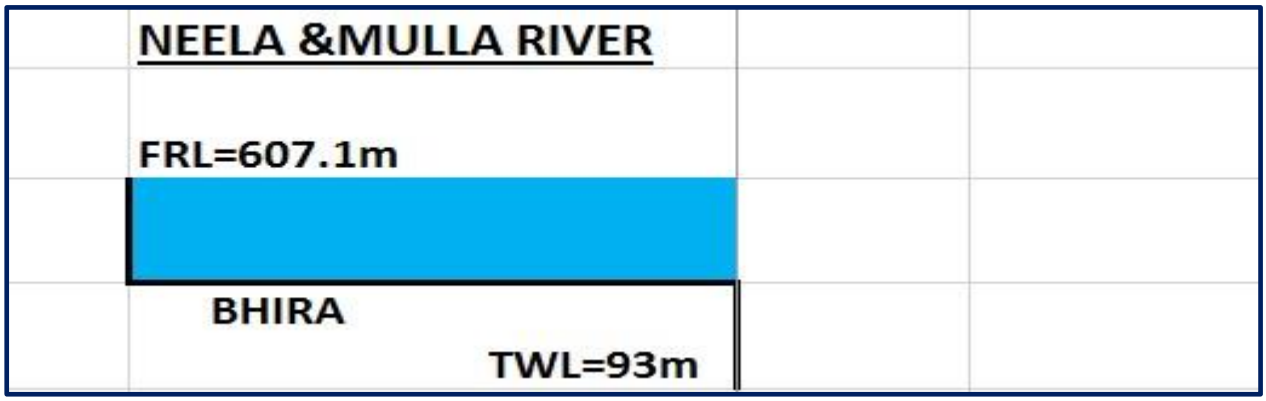


UID	Project Name	State	River	Type	Status
13a	Khopoli (Kundli Dam)	Maharashtra	Indrayani	Conventional	In Operation
13b	Khopoli (Shirwata Dam)	Maharashtra	Indrayani	Conventional	In Operation
13c	Khopoli (Walwahn Dam)	Maharashtra	Indrayani	Conventional	In Operation
13d	Khopoli (Lonavala Dam)	Maharashtra	Indrayani	Conventional	In Operation
13e	Khopoli (Forebay)	Maharashtra	Indrayani	Conventional	In Operation

4. Mula River

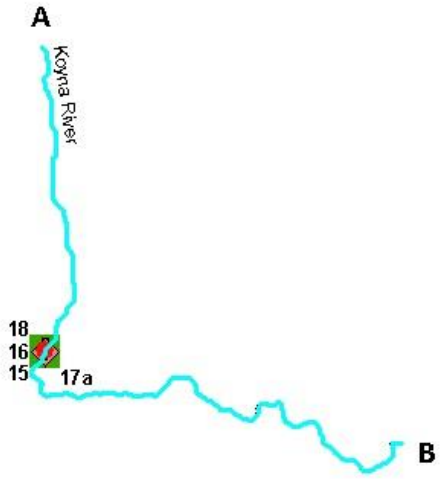


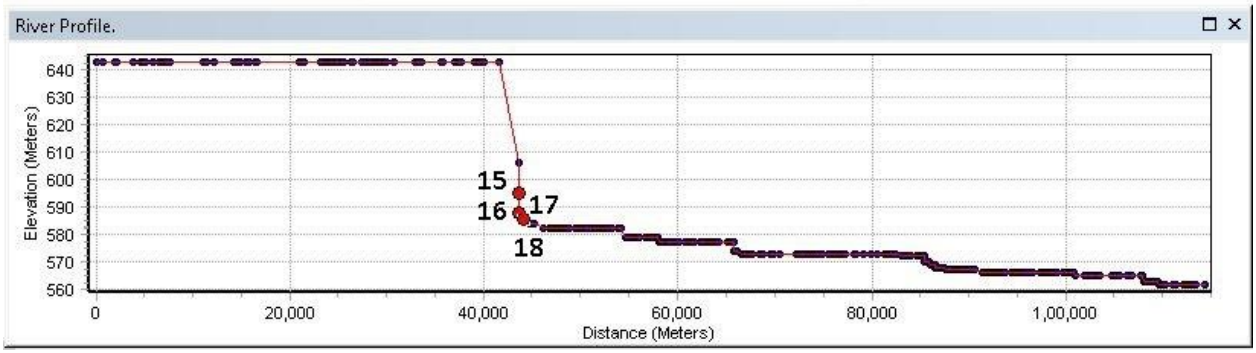




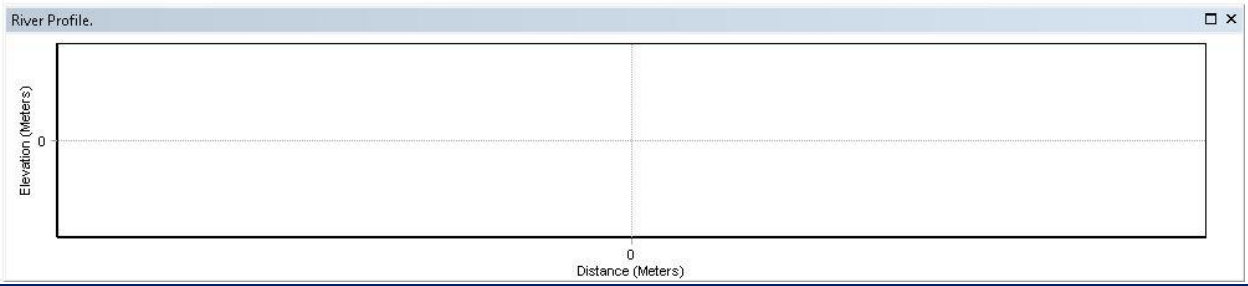
UID	Project Name	State	River	Type	Status
14	Bhira	Maharashtra	Mula	Conventionl	In Operation

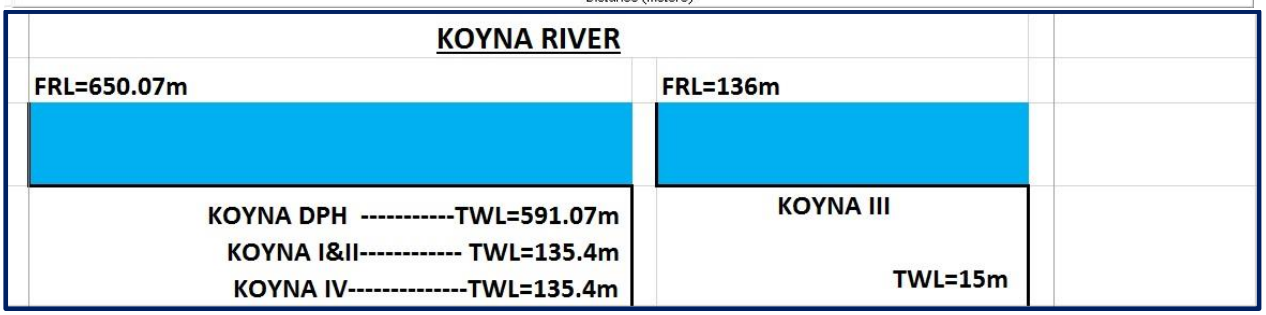
5. Koyna River





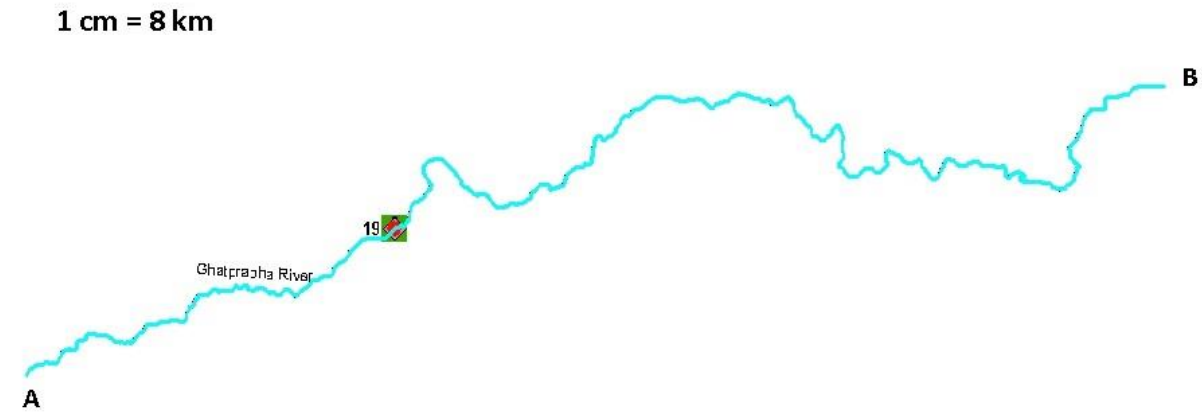


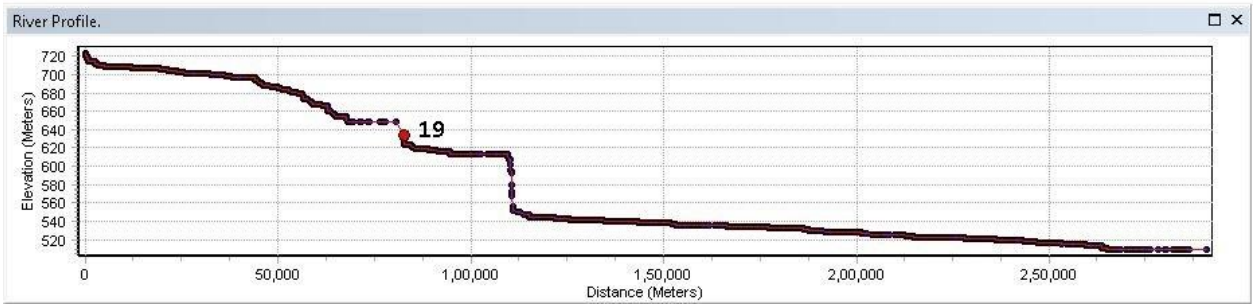




UID	Project Name	State	River	Type	Status
15	Koyna St. I & II	Maharashtra	Koyna	Storage	In Operation
16	Koyna Dam P/H	Maharashtra	Koyna	Storage	In Operation
17a	Koyna St. III (Koyna Dam)	Maharashtra	Koyna	RoR with storage	In Operation
17b	Koyna St. III (Kolkewadi Dam)	Maharashtra	Koyna		In Operation
18	Koyna St. IV	Maharashtra	Koyna	Storage	In Operation

6. Ghatprabha River

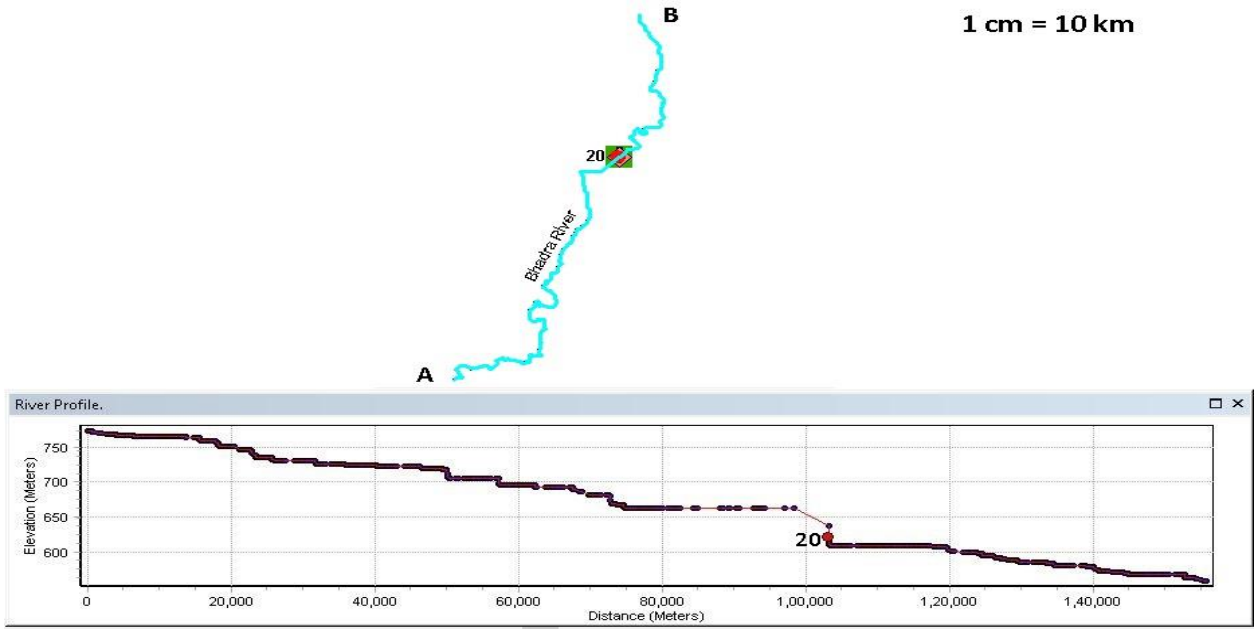


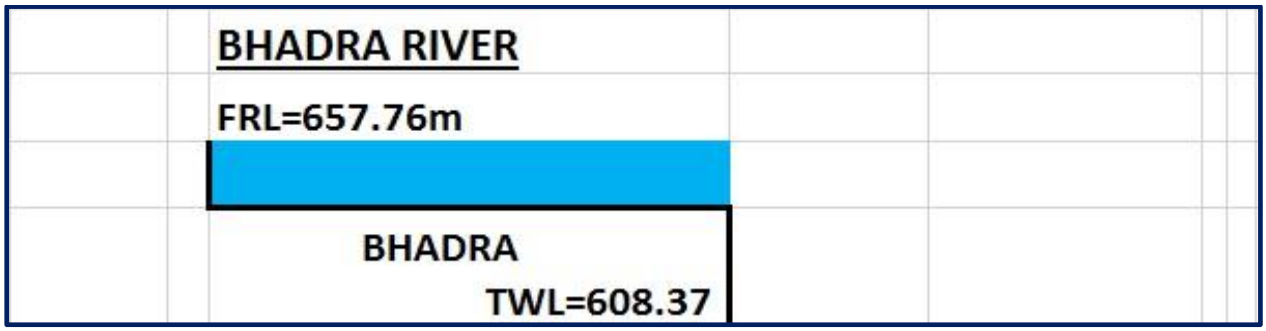




UID	Project Name	State	River	Type	Status
19	Ghtaprabha	Karnataka	Ghatprabha	Storage	In Operation

7. Bhadra River



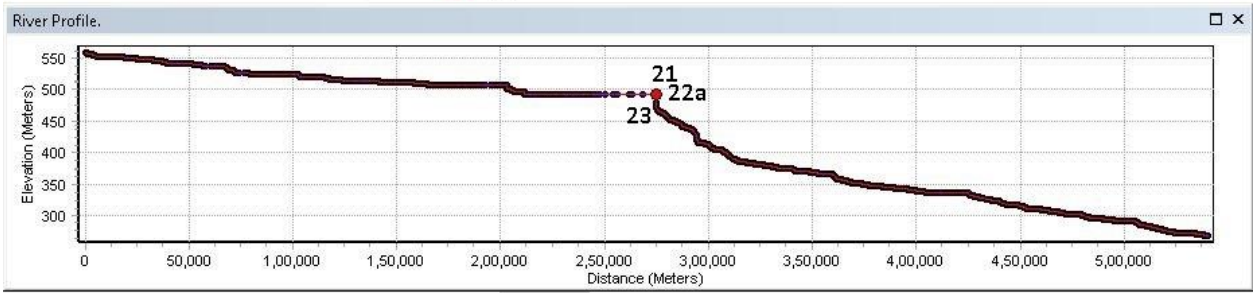


UID	Project Name	State	River	Type	Status
20	Bhadra	Karnataka	Bhadra	Storage	In Operation

8. Tungabhadra River

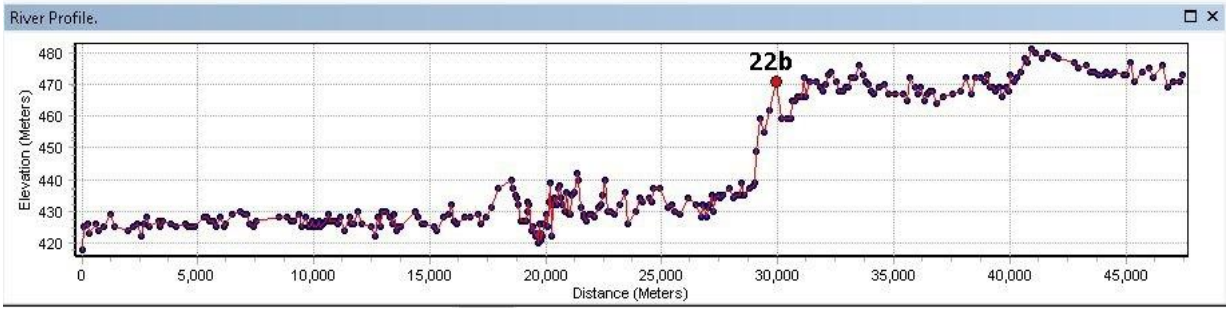
1 cm = 25 km

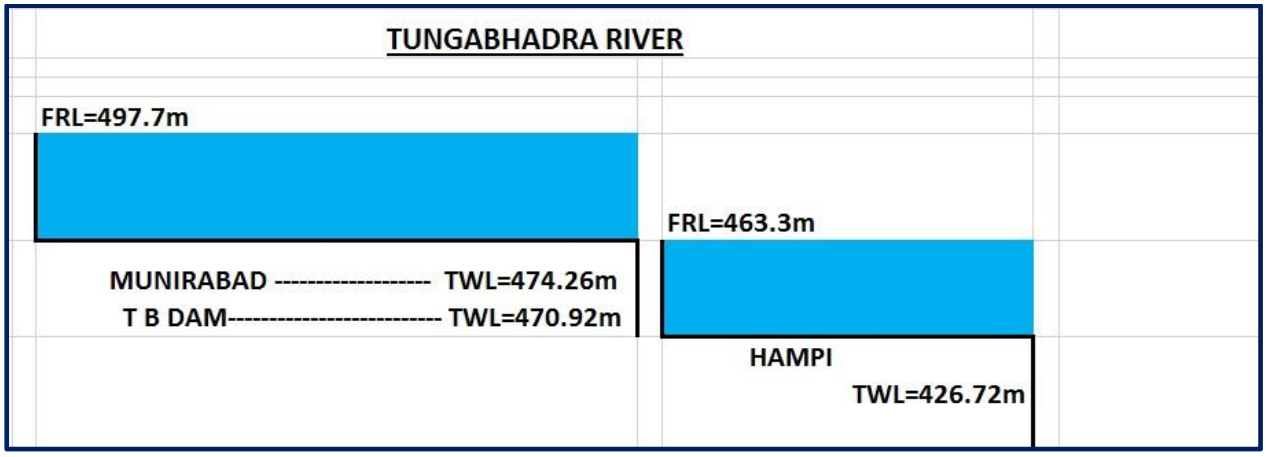




1 cm = 1.5 km



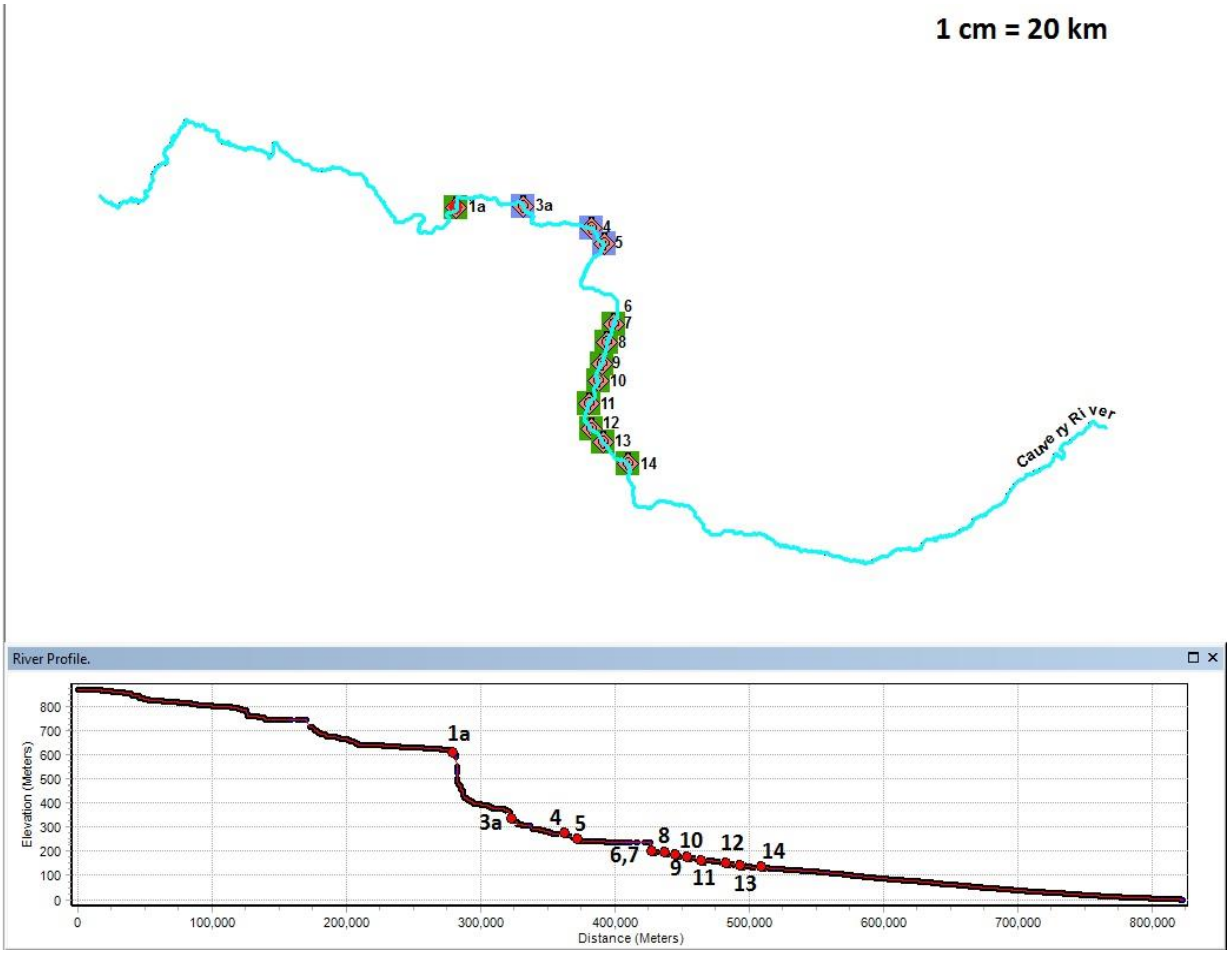




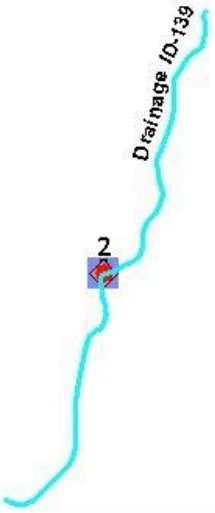
UID	Project Name	State	River	Type	Status
21	Munirabad	Karnataka	Tungabhadra	Storage	In Operation
22a	Hampi (Tungabhadra Dam)	Karnataka	Tungabhadra	Storage	In Operation
22b	Hampi (Forebay)	Karnataka	Tungabhadra	Storage	In Operation
23	T B Dam	Karnataka	Tungabhadra	Storage	In Operation

Cauvery Sub-Basin:

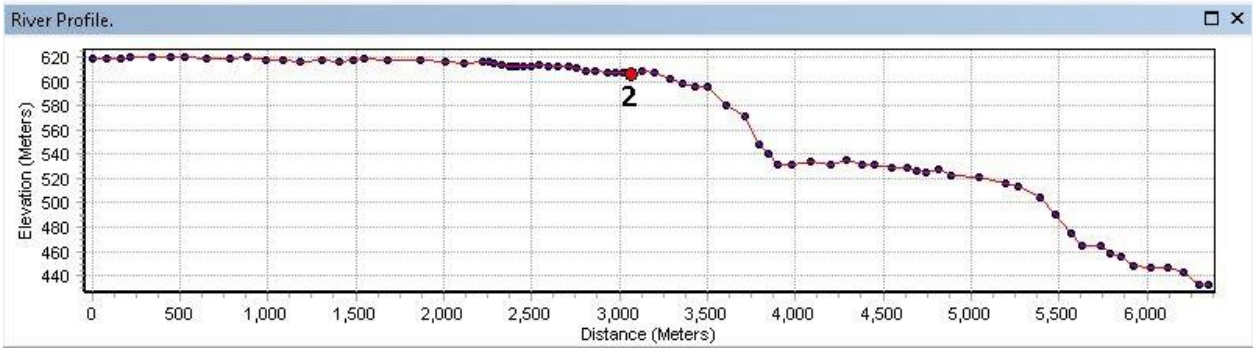
1. Cauvery River





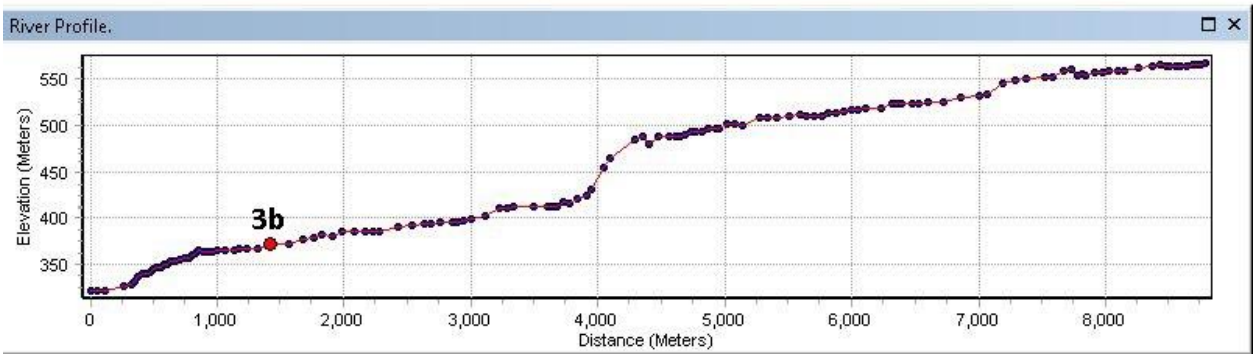


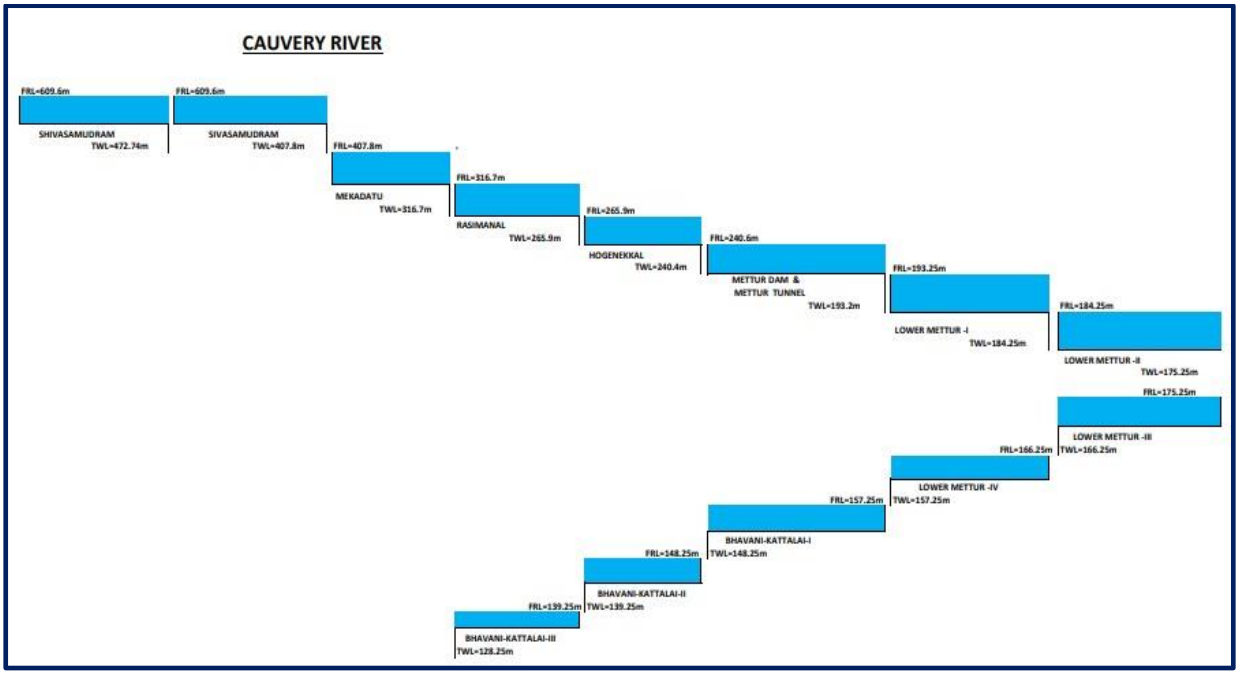
1 cm = 0.63 km



1 cm = 0.5 km



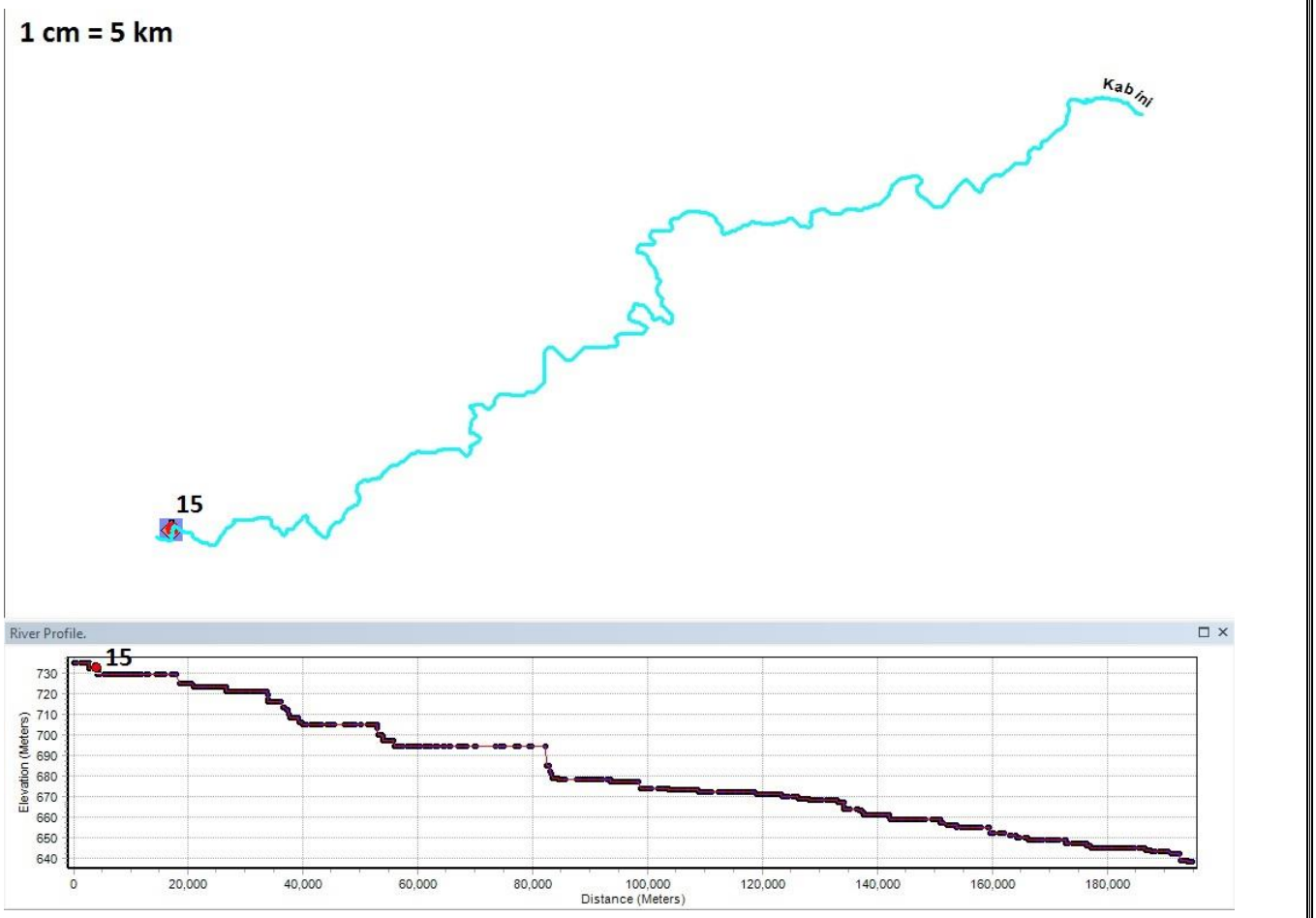


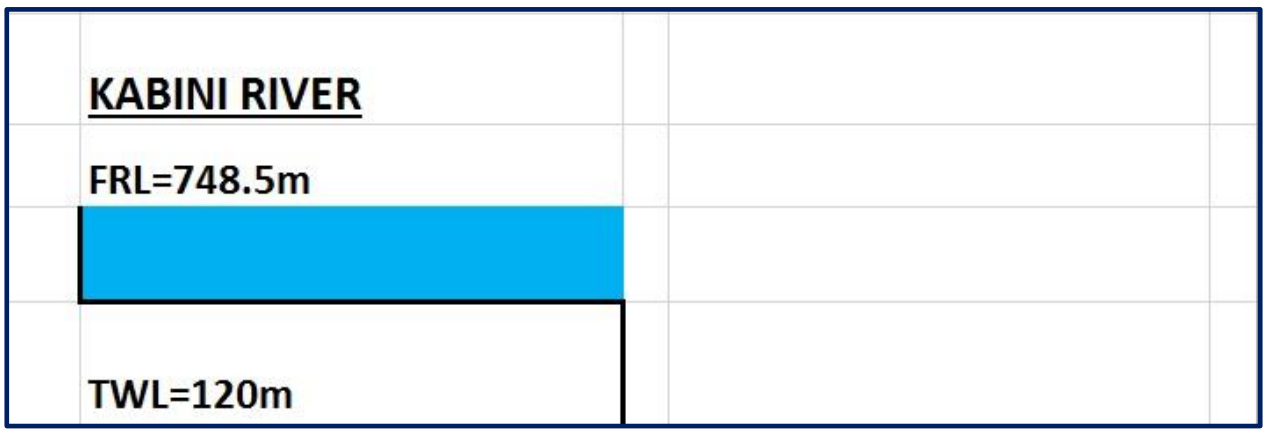


UID	Project Name	State	River	Type	Status
1a	Shivasamudram (Shiva Anicut)	Karnataka	Cauvery	RoR	In Operation
1b	Shivasamudram (Balancing Reservoir)			RoR	DPR Returned for Re-submission
1c	Shivasamudram (Forebay)			RoR	
2	Sivasamudram			RoR	
3a	Mekadatu (Lifting dam)			RoR	
3b	Mekadatu (Forebay Dam)			RoR	
4	Rasimanal	Tamil Nadu		RoR	
5	Hogenekkal			RoR	
6	Mettur Dam			Storage	In Operation
7	Mettur Tunnel			Storage	
8	Lower Mettur-I			RoR	
9	Lower Mettur-II			RoR	
10	Lower Mettur-III			RoR	
11	Lower Mettur-IV			RoR	
12	Bhavani Kattalai Barrage -I			RoR	

13	Bhavani Kattalai Barrage -II			RoR	
14	Bhavani Kattalai Barrage-III			RoR	

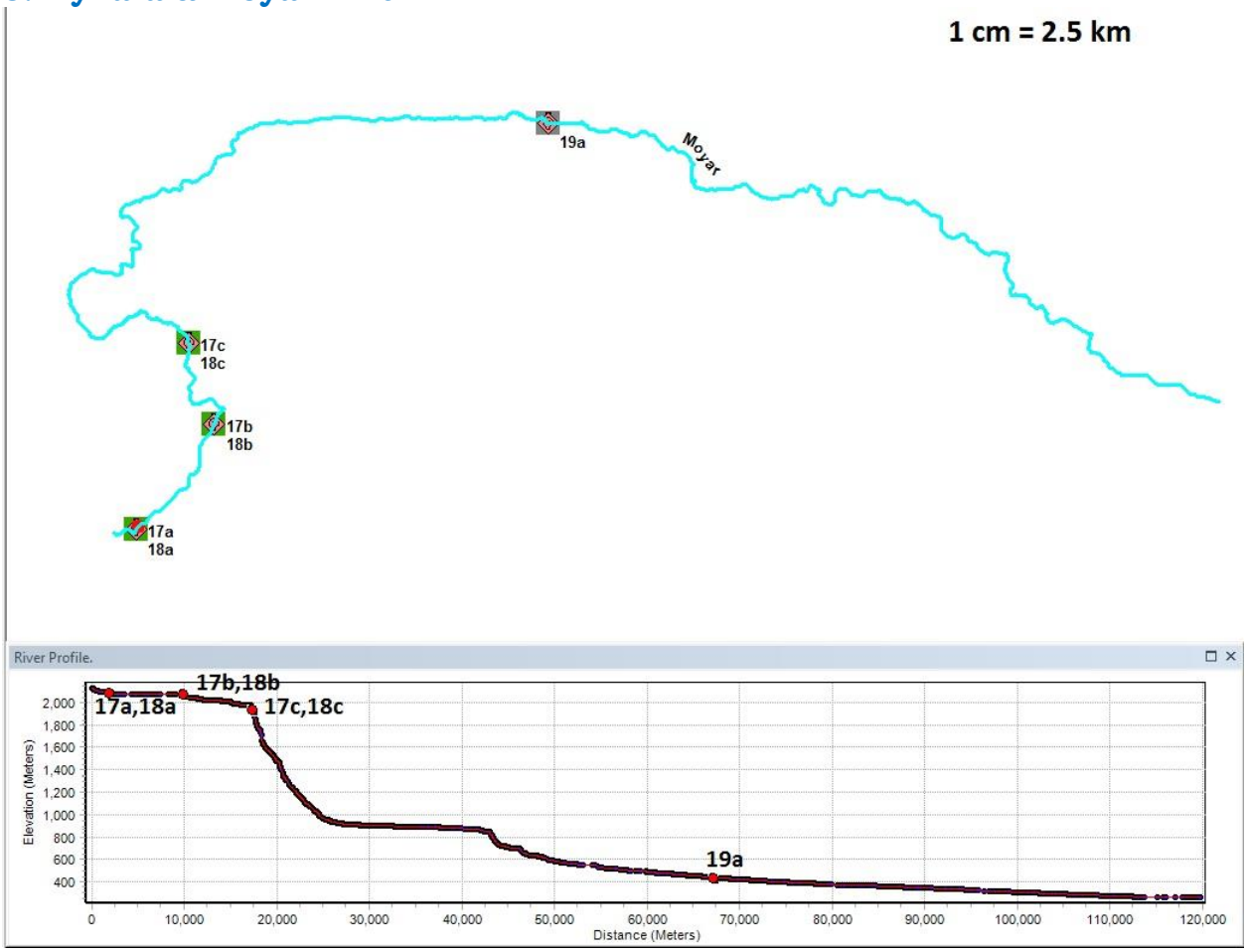
2. Kabini River

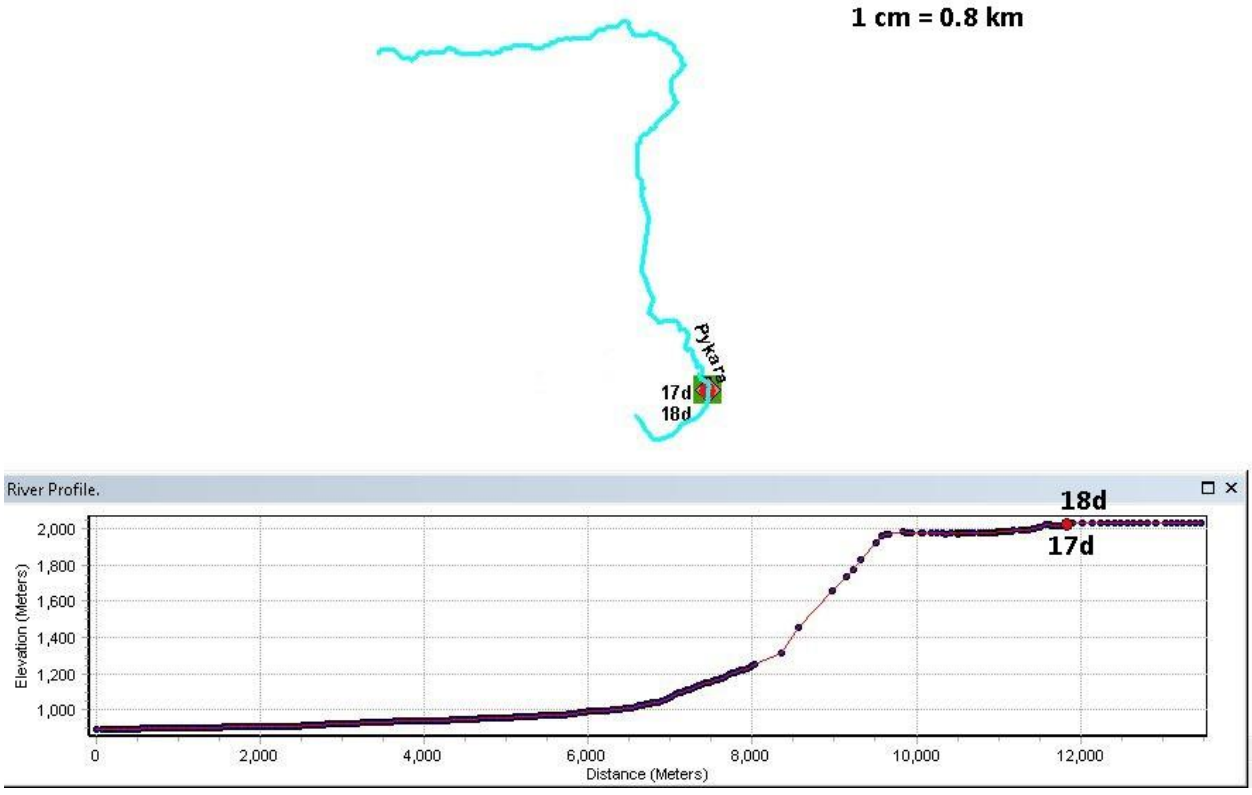




UID	Project Name	State	River	Type	Status
15	Mananthavady	Kerala	Kabini	Storage	DPR Returned for Re-submission

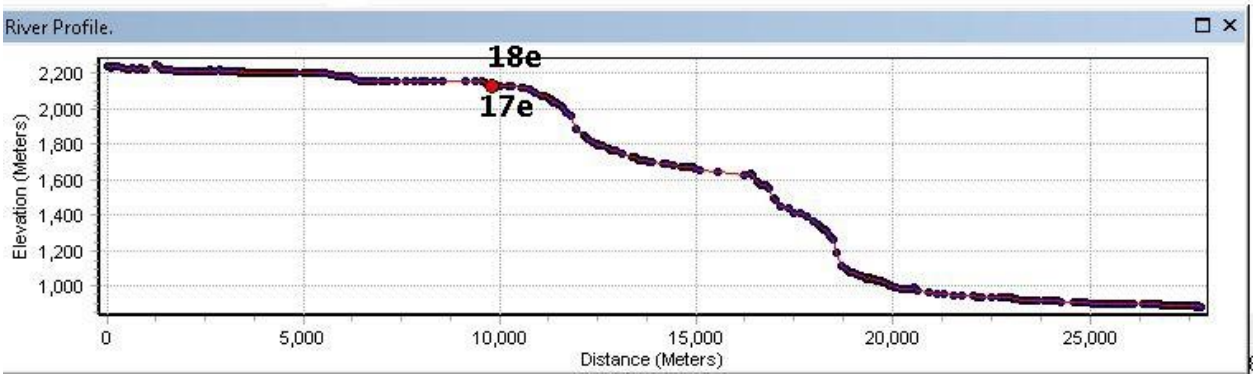
3. Pykara & Moyar River





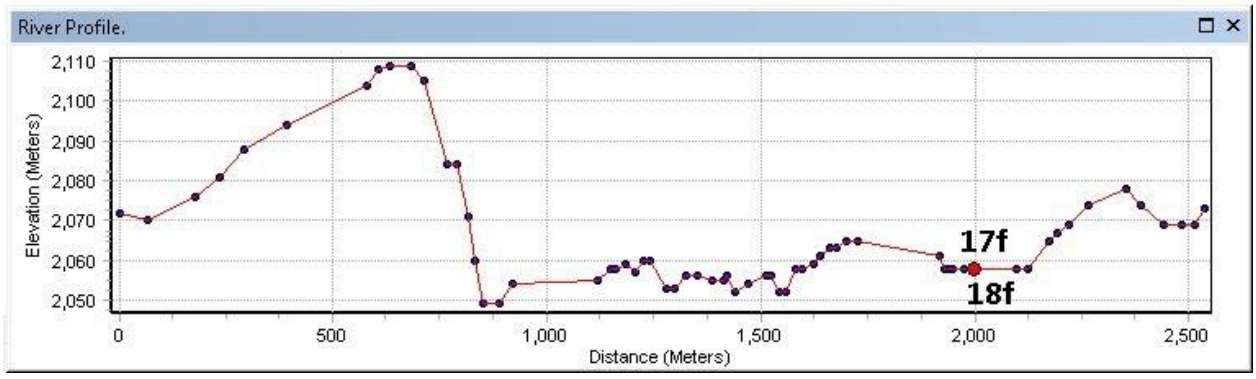
1 cm = 2.5 km



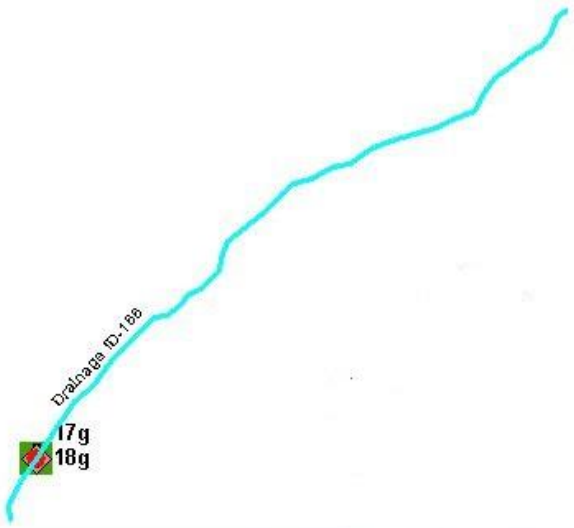


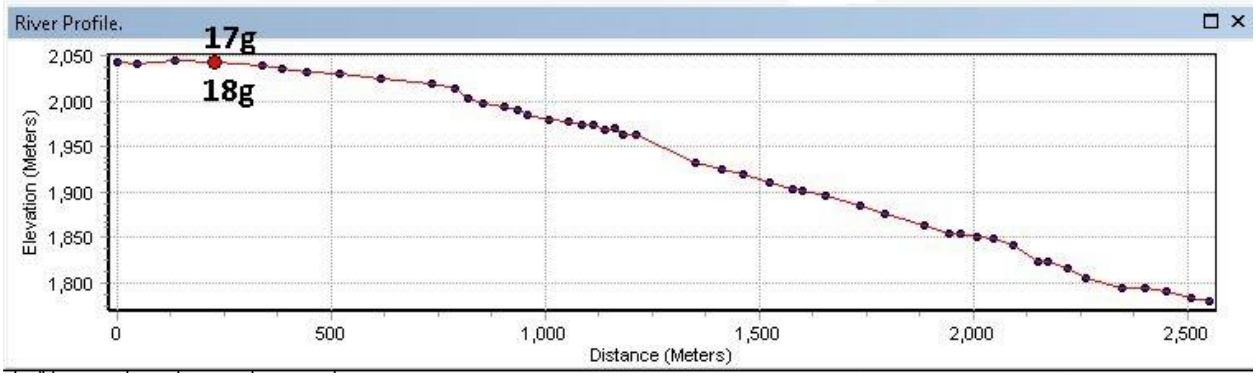
1 cm = 0.25 km





1 cm = 0.2 km





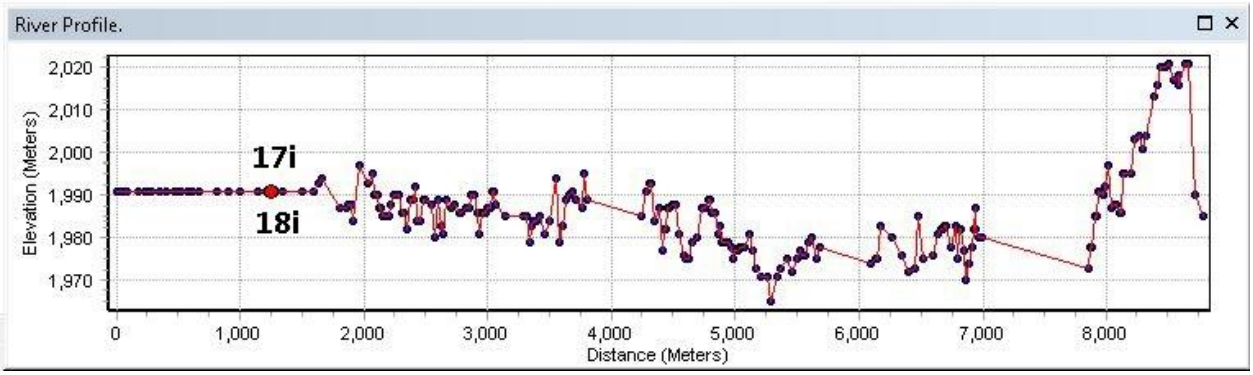
1 cm = 0.5 km





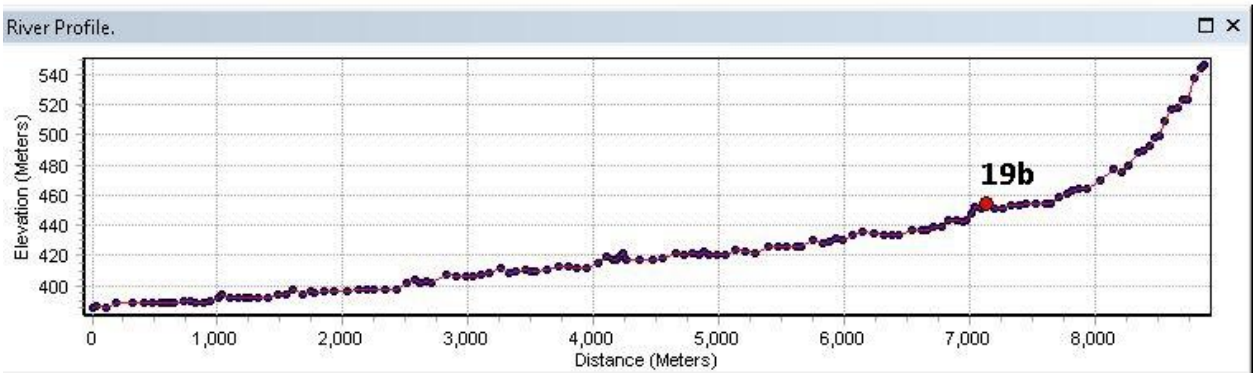
1 cm = 0.5 km



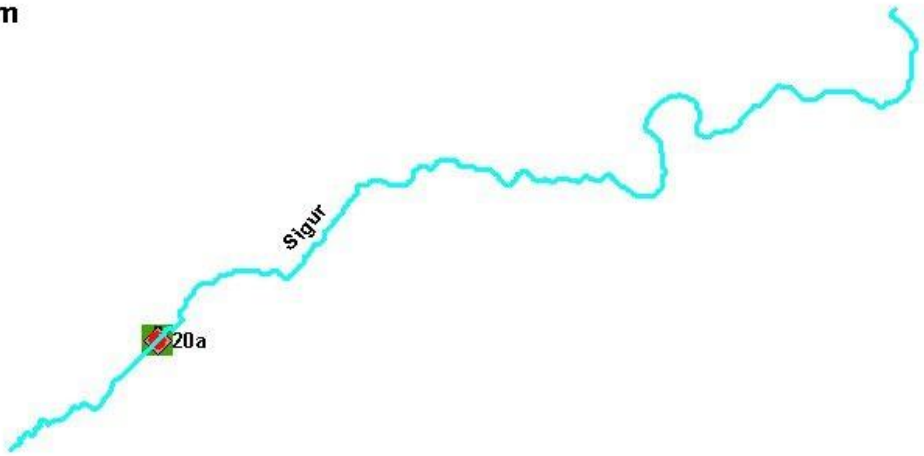


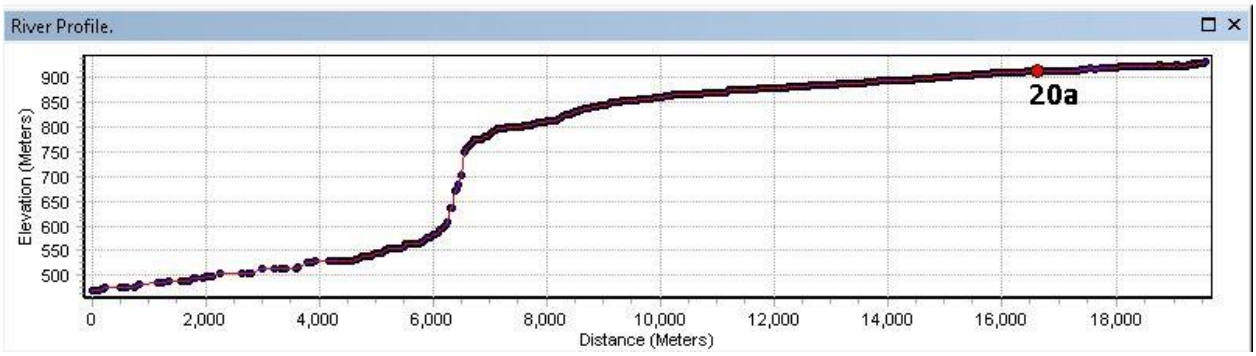
1 cm = 0.4 km





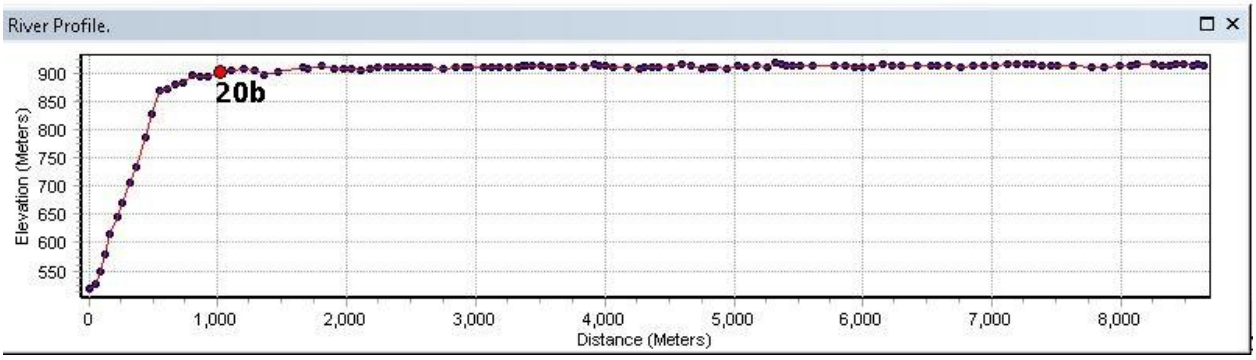
1 cm = 0.8 km

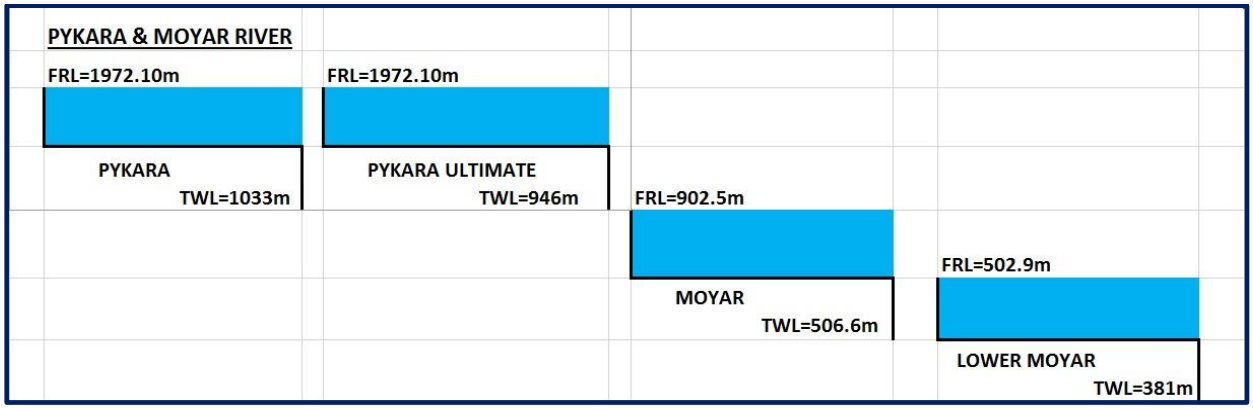




1 cm = 0.6 km





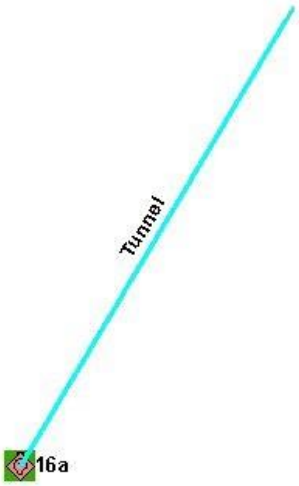


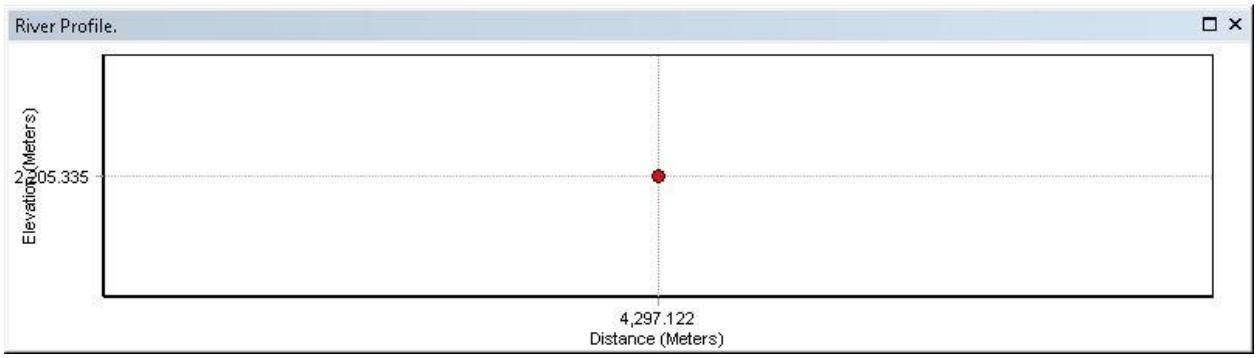
UID	Project Name	State	River	Type	Status
17a	Pykara Ultimate (Mukurthi dam)	Tamil Nadu	Pykara	Storage	In Operation
17b	Pykara Ultimate (Pykara Dam)	Tamil Nadu	Pykara	Storage	In Operation
17c	Pykara Ultimate (Glenmorgan dam)	Tamil Nadu	Pykara	Storage	In Operation
17d	Pykara Ultimate (Glenmorgan Forebay)	Tamil Nadu	Pykara	Storage	In Operation
17e	Pykara Ultimate (Sandynallah Dam)	Tamil Nadu	Pykara	Storage	In Operation
17f	Pykara Ultimate (Melkomund Weir)	Tamil Nadu	Pykara	Storage	In Operation
17g	Pykara Ultimate (Lone Valley Arm I Weir)	Tamil Nadu	Pykara	Storage	In Operation
17h	Pykara Ultimate (Lone Valley Arm II Weir)	Tamil Nadu	Pykara	Storage	In Operation
17i	Pykara Ultimate (Naduvattam Diversion Weir)	Tamil Nadu	Pykara	Storage	In Operation
18a	Pykara (Mukurthi dam)	Tamil Nadu	Pykara	Storage	In Operation
18b	Pykara (Pykara Dam)	Tamil Nadu	Pykara	Storage	In Operation
18c	Pykara (Glenmorgan	Tamil Nadu	Pykara	Storage	In Operation

	dam)				
18d	Pykara (Glenmorgan Forebay)	Tamil Nadu	Pykara	Storage	In Operation
18e	Pykara (Sandynallah Dam)	Tamil Nadu	Pykara	Storage	In Operation
18f	Pykara (Melkomund Weir)	Tamil Nadu	Pykara	Storage	In Operation
18g	Pykara (Lone Valley Arm I Weir)	Tamil Nadu	Pykara	Storage	In Operation
18h	Pykara (Lone Valley Arm II Weir)	Tamil Nadu	Pykara	Storage	In Operation
18i	Pyakra (Naduvattam Diversion Weir)	Tamil Nadu	Pykara	Storage	In Operation
19a	Lower Moyar (Pickup Dam)	Tamil Nadu	Moyar	Storage	Balance
19b	Lower Moyar (Forebay Dam)	Tamil Nadu	Moyar	Storage	Balance
20a	Moyar (Maravakandy Dam)	Tamil Nadu	Moyar	Storage	In Operation
20b	Moyar (Forebay)	Tamil Nadu	Moyar	Storage	In Operation

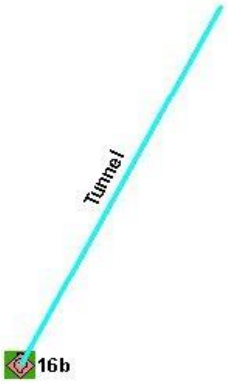
4. Bhavani River

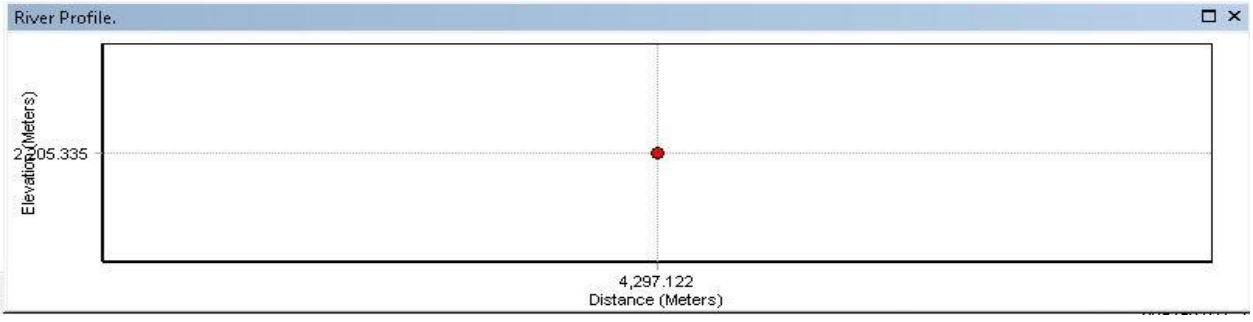
1 cm = 0.2 km





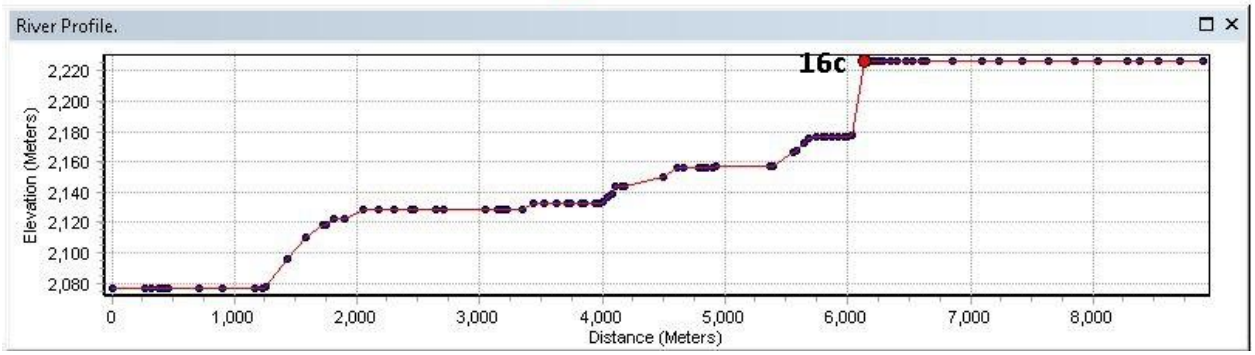
1 cm = 0.4 km





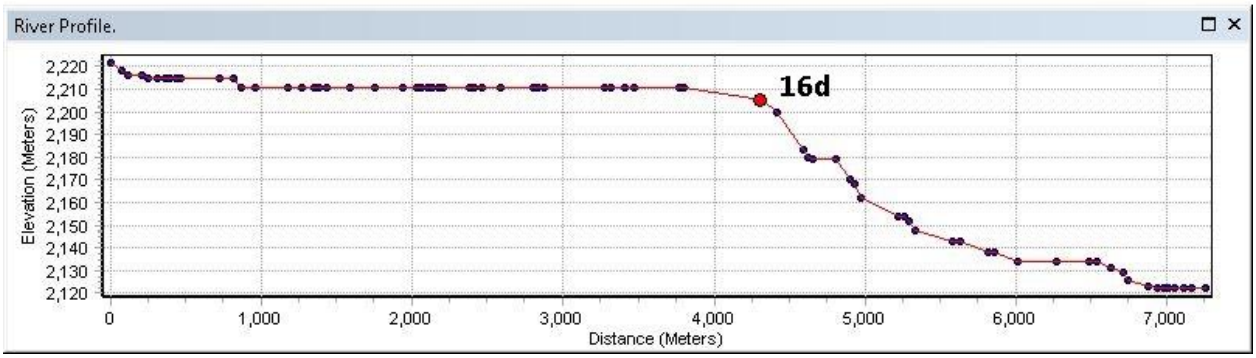
1 cm = 0.8 km



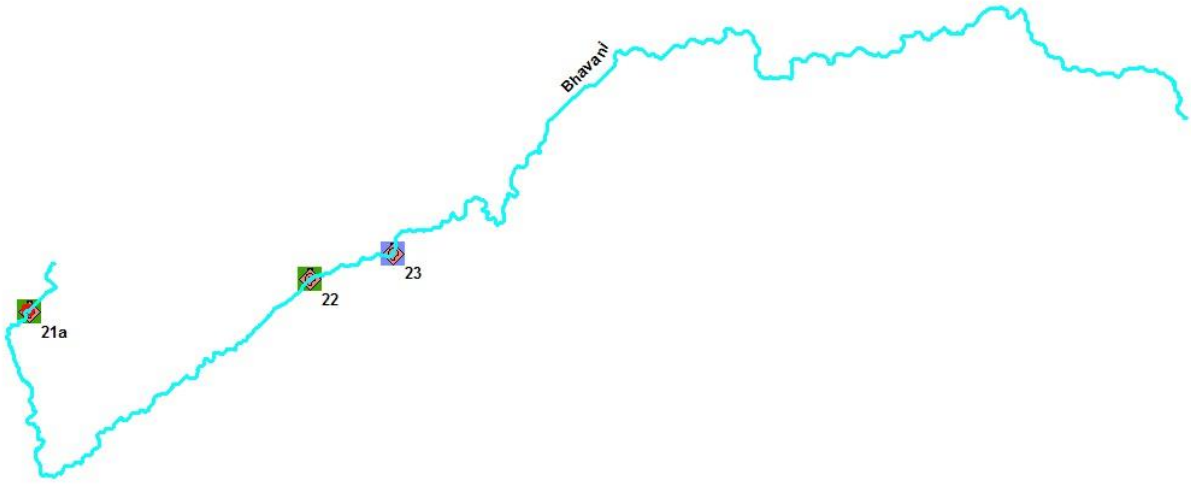


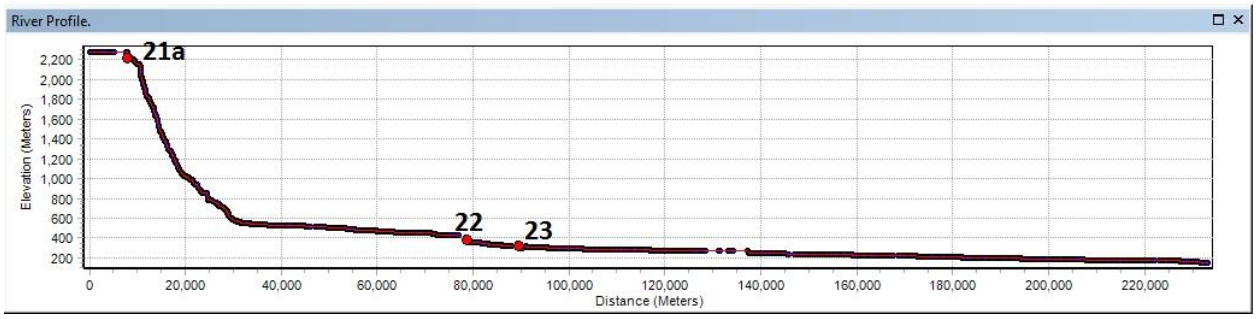
1 cm = 0.3 km

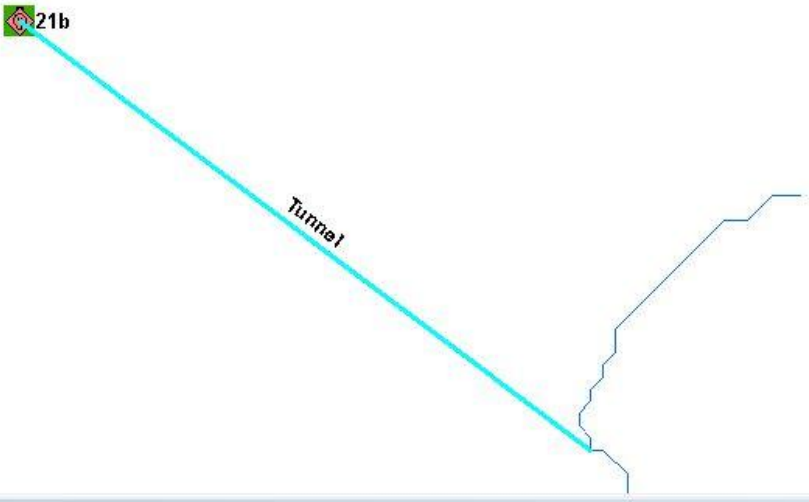


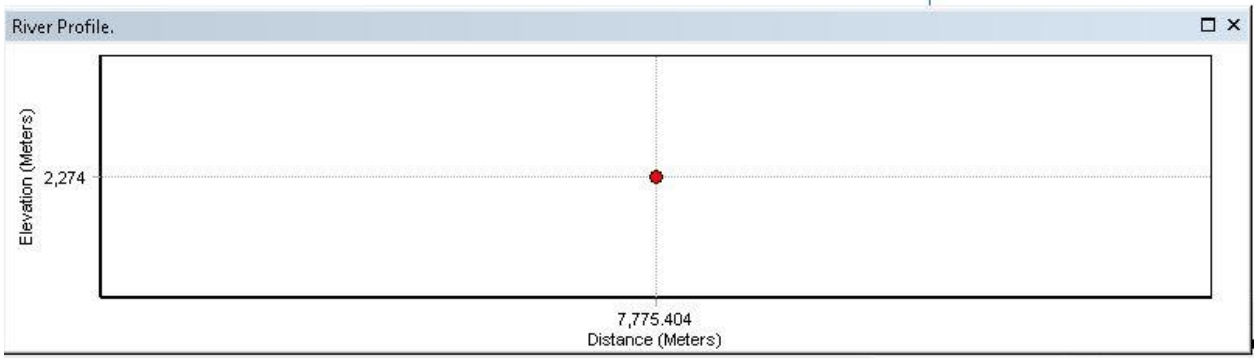


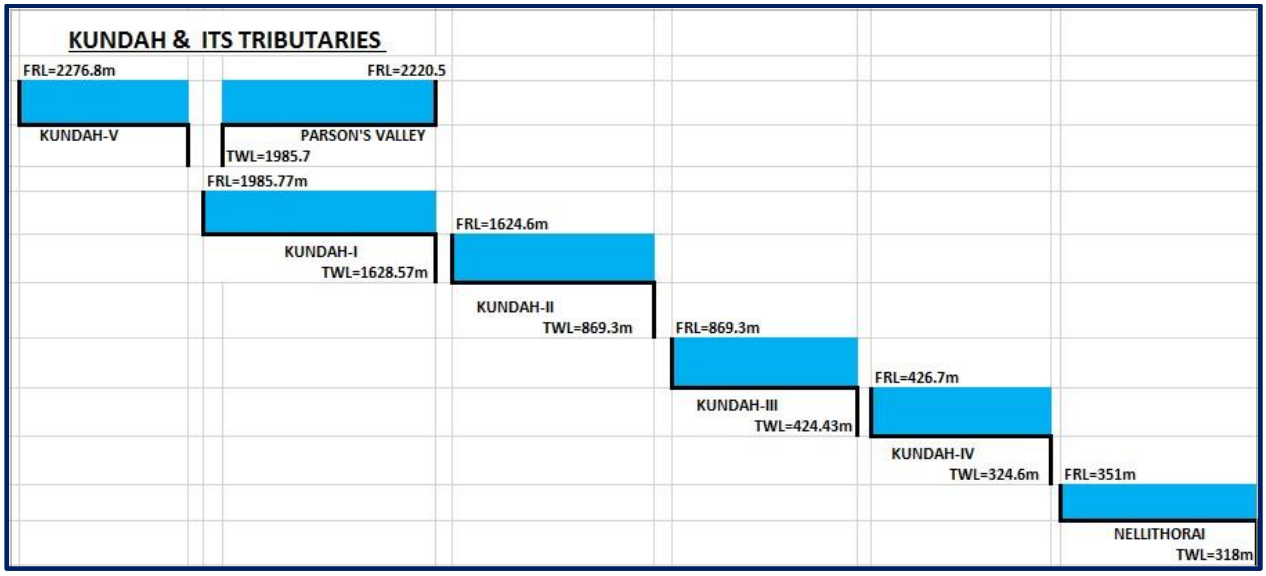
1 cm = 5 km


Bhavani
21a
22
23


River Profile.
21a
22
23
Elevation (Meters)
2,200
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
200
0
20,000
40,000
60,000
80,000
100,000
120,000
140,000
160,000
180,000
200,000
220,000
Distance (Meters)

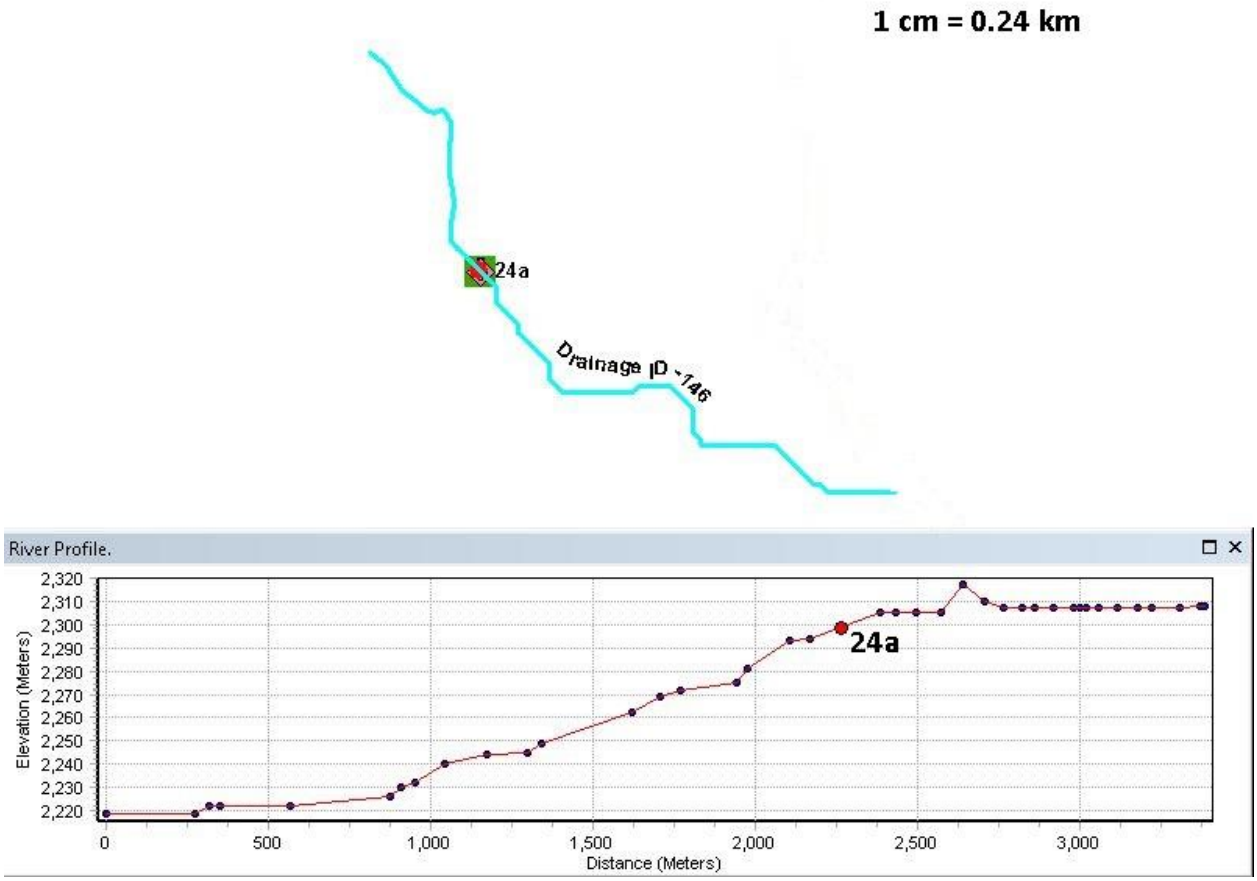

21b
Tunnel

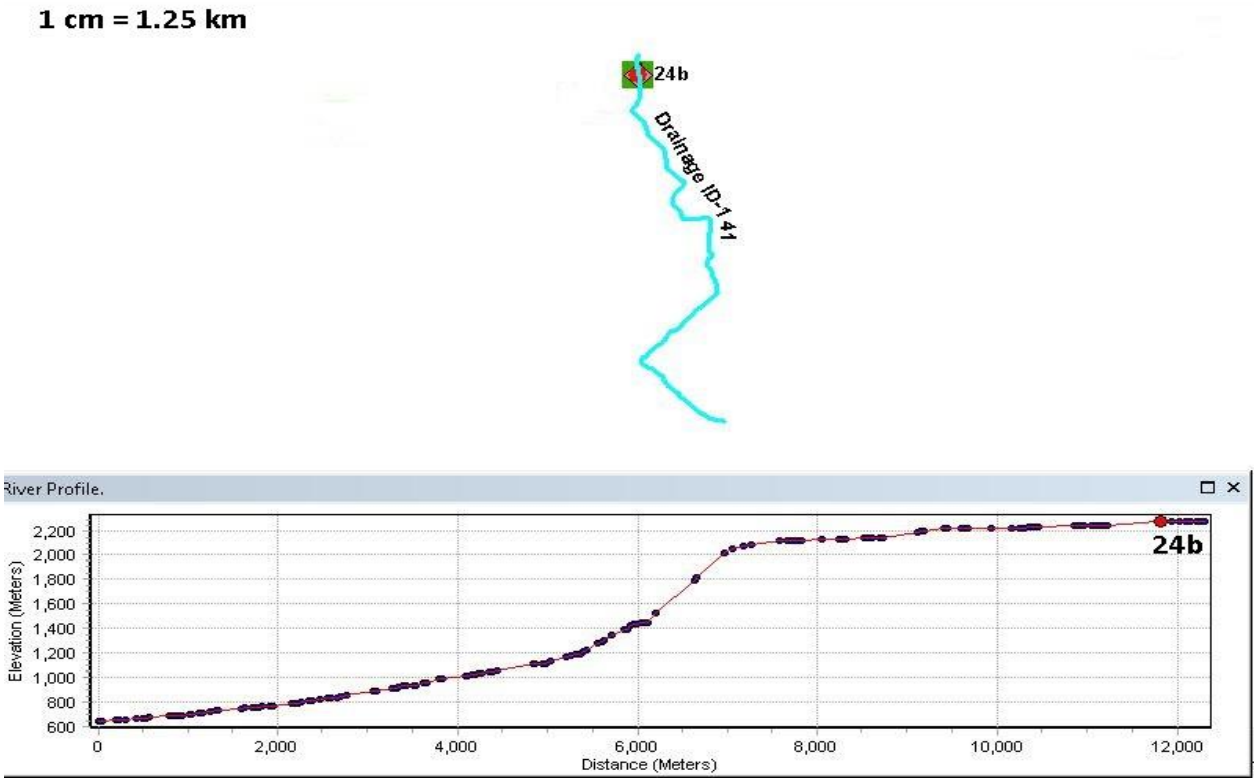

River Profile.
Elevation (Meters)
2,274
7,775.404
Distance (Meters)

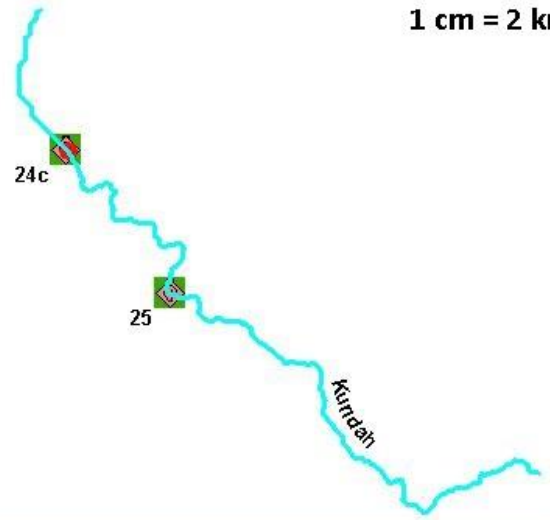


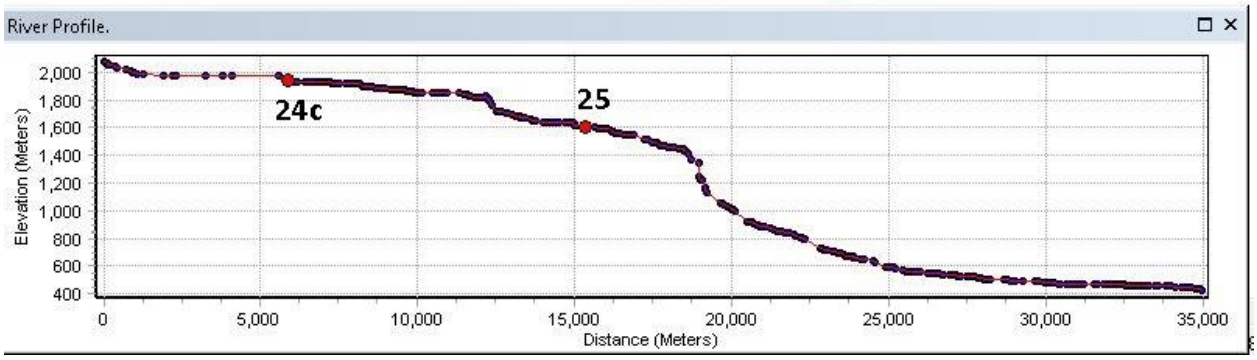
UID	Project Name	State	River	Type	Status
16a	Parson's Valley (Western Catchment 2)	Tamil Nadu	Bhavani	Storage	In Operation
16b	Parson's Valley (Western catchment 3)	Tamil Nadu	Bhavani	Storage	In Operation
16c	Parson's Valley (Porthimund Dam)	Tamil Nadu	Bhavani	Storage	In Operation
16d	Parson's Valley (Parson's Valley Dam)	Tamil Nadu	Bhavani	Storage	In Operation
21a	Kundah-V (Upper Bhavani Dam)	Tamil Nadu	Bhavani	Storage	In Operation
21b	Kundah-V (Western catchment No. 1)	Tamil Nadu	Bhavani	Storage	In Operation
22	Kundah-IV	Tamil Nadu	Bhavani	Storage	In Operation
23	Nellithorai	Tamil Nadu	Bhavani	Storage	DPR Returned for Re-submission

5. Avalanche Stream

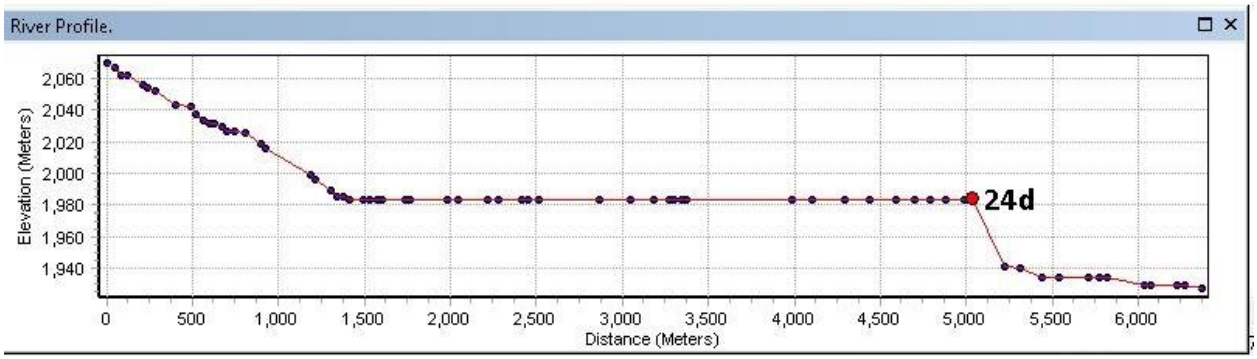


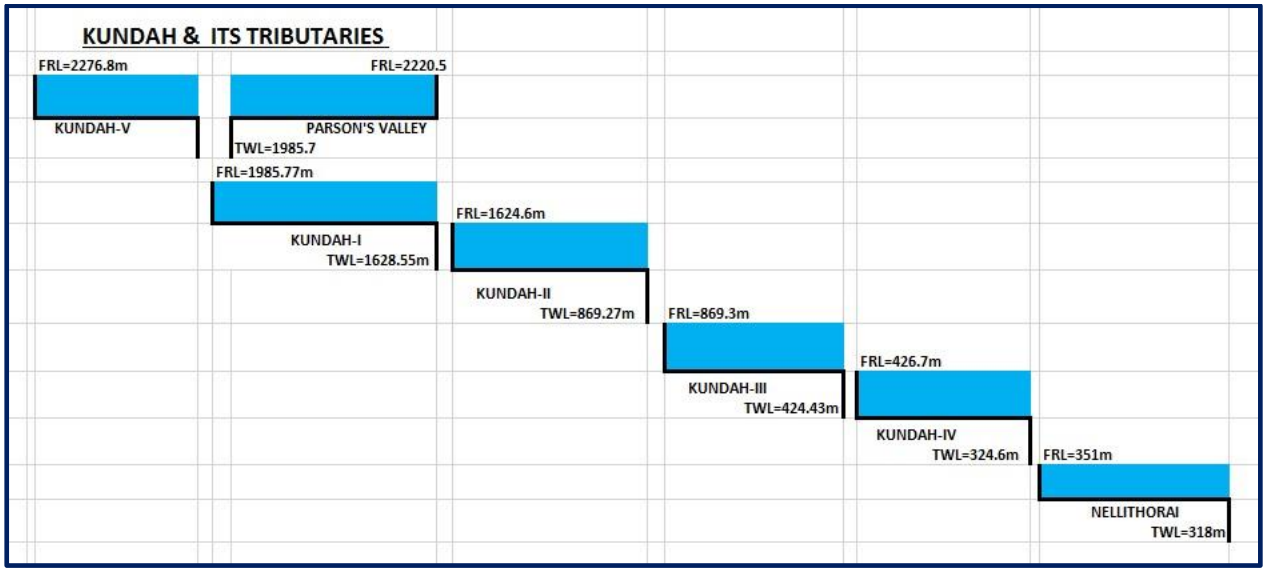



1 cm = 2 km
24c
25
Kundah


River Profile.
Elevation (Meters)
2,000
1,800
1,600
1,400
1,200
1,000
800
600
400
24c
25
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Distance (Meters)


1 cm = 0.4 km
24d
Avalanche Stream


River Profile.
Elevation (Meters)
2,060
2,040
2,020
2,000
1,980
1,960
1,940
24d
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
5,500
6,000
Distance (Meters)

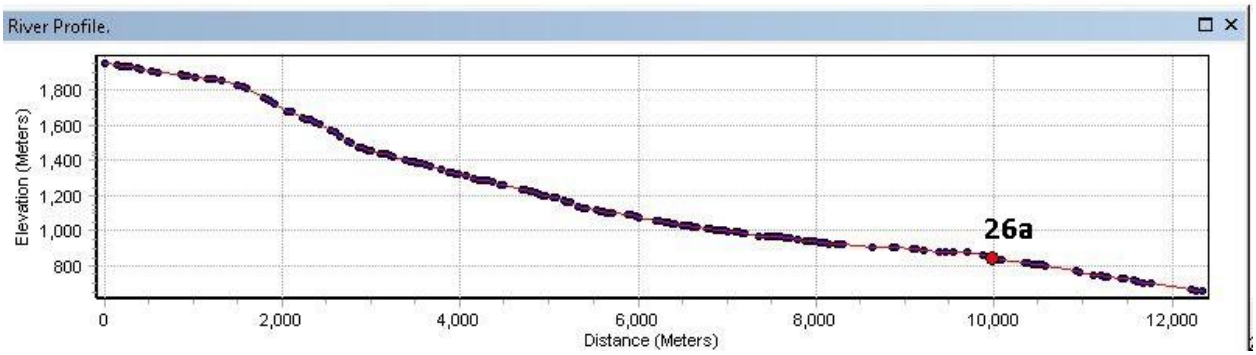


UID	Project Name	State	River	Type	Status
24a	Kundah-I (East Varahapallam dam)	Tamil Nadu	Avalanche Stream	Storage	In Operation
24b	Kundah-I (Emerald Dam)	Tamil Nadu	Avalanche Stream	Storage	In Operation
24c	Kundah-I (Avalanche Dam)	Tamil Nadu	Avalanche Stream	Storage	In Operation
25	Kundah-II	Tamil Nadu	Avalanche Stream	Storage	In Operation

6. Pegumbahallah River

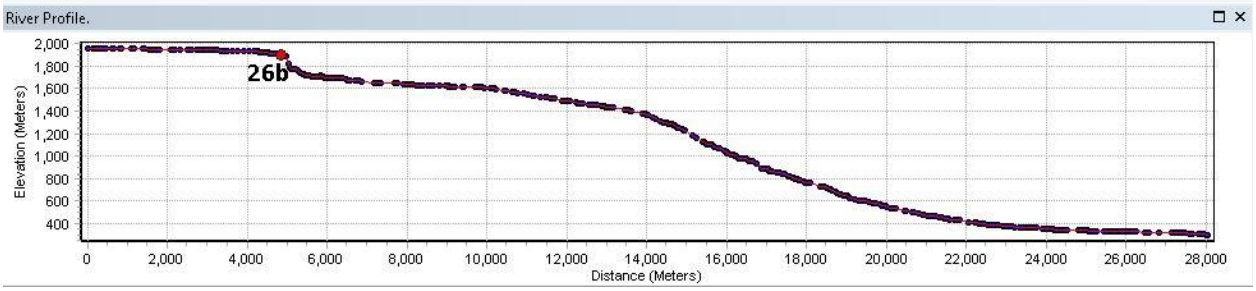
1 cm = 0.62 km

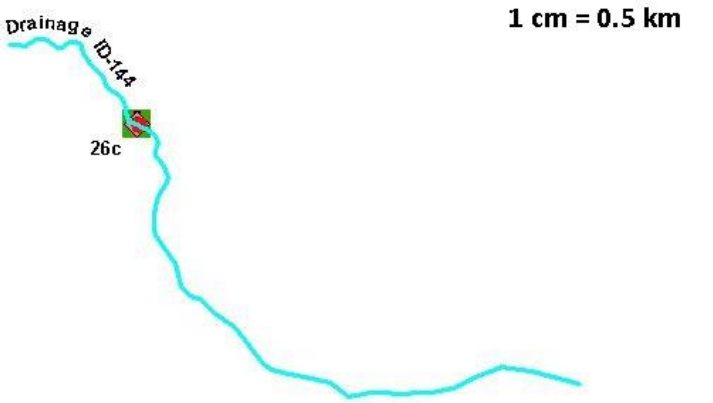


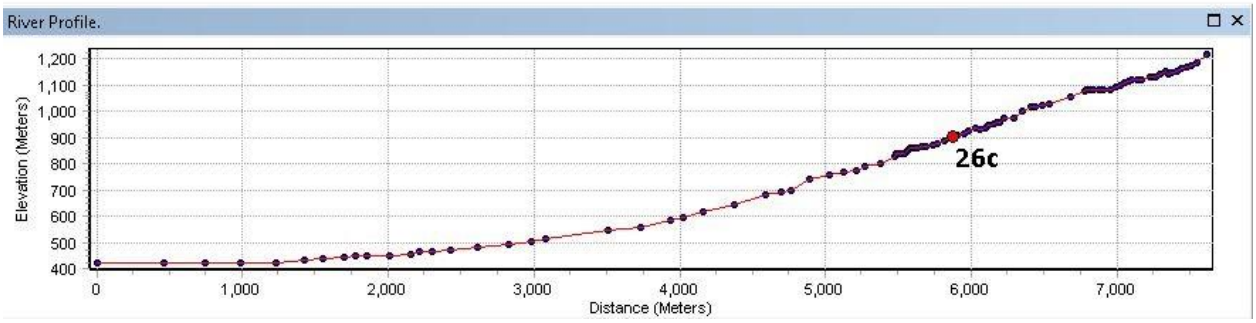


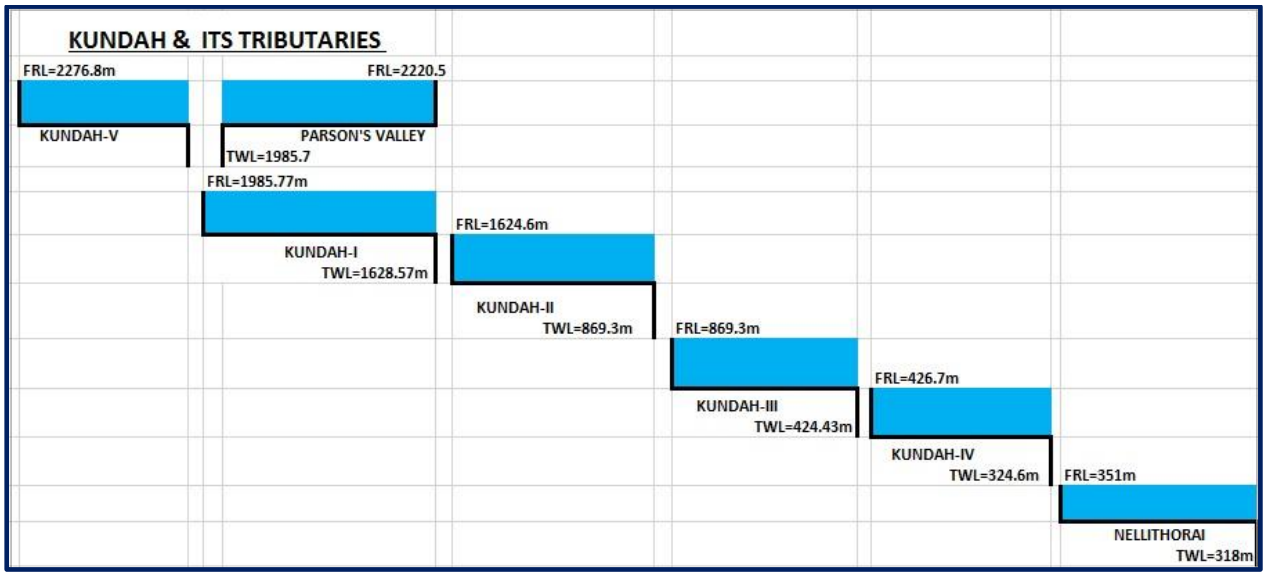
1 cm = 1 km











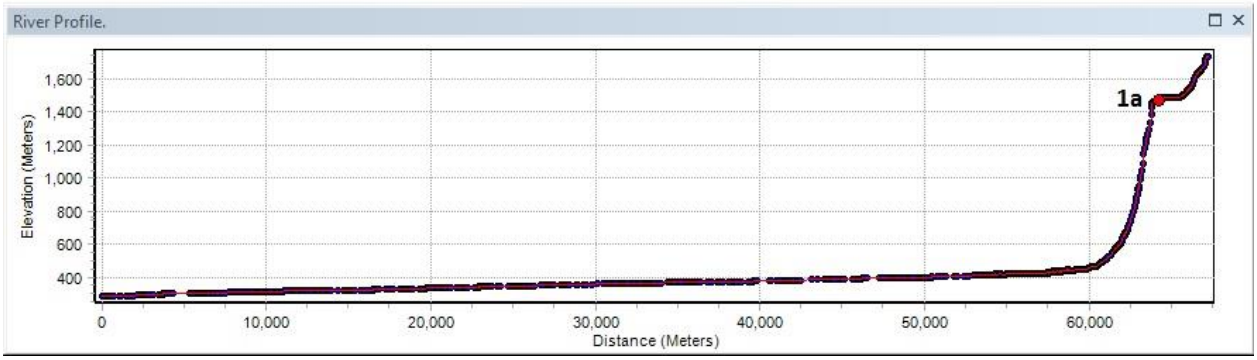
UID	Project Name	State	River	Type	Status
26a	Kundah-III (Pengumbahalla Dam)	Tamil Nadu	Pegumbah allah	Storage	In Operation
26b	Kundah-III (Niralapallam D. W)	Tamil Nadu	Pegumbaha llah	Storage	In Operation
26c	Kundah-III (Katteri Halla D. W)	Tamil Nadu	Pegumbaha llah	Storage	In Operation

South of Cauvery Sub-Basin:

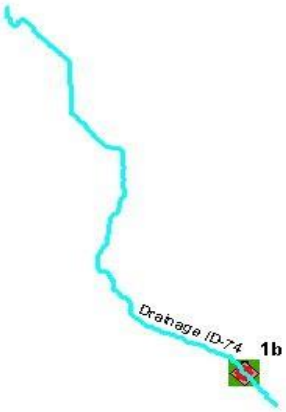
1. Suruli River

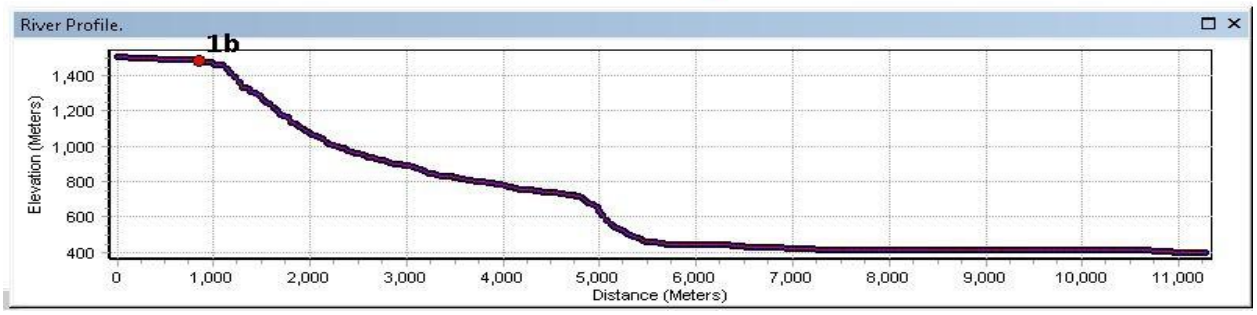
1 cm = 4 km





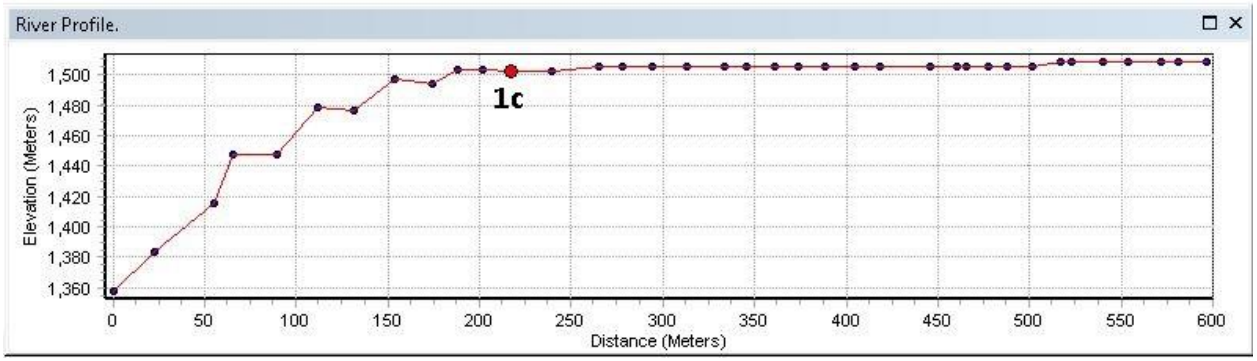
1 cm = 1 km





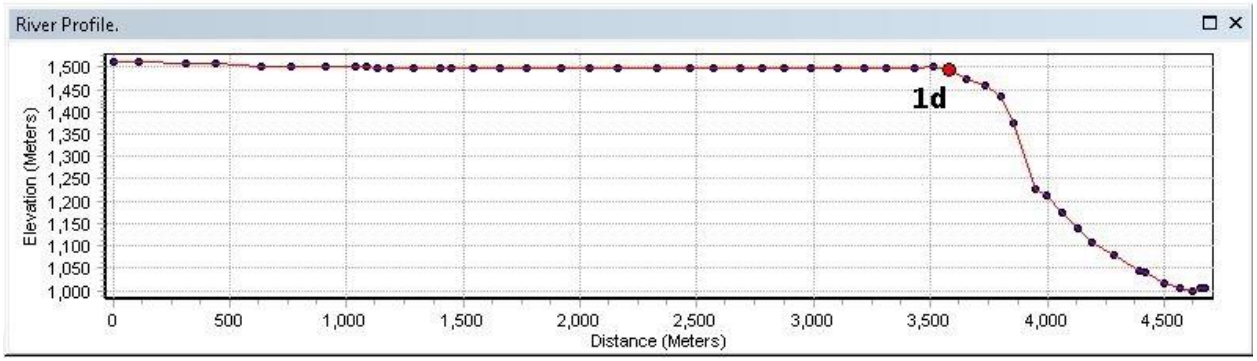
1 cm = 0.03 km

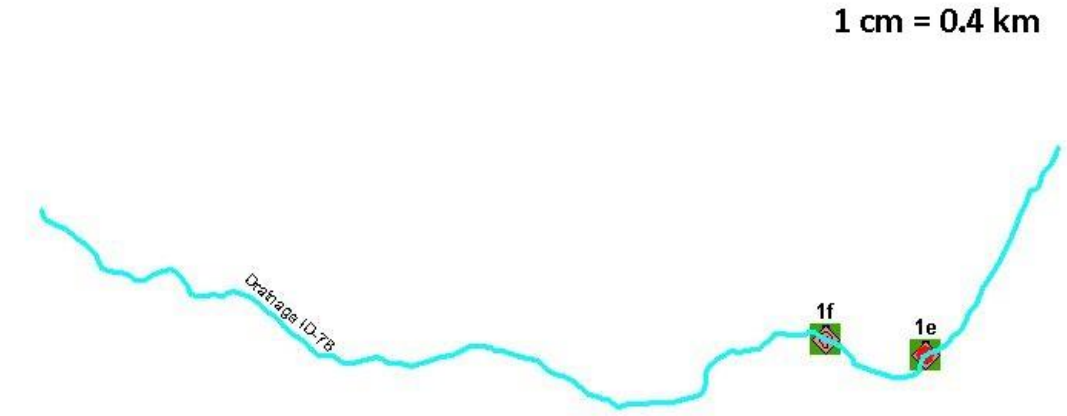


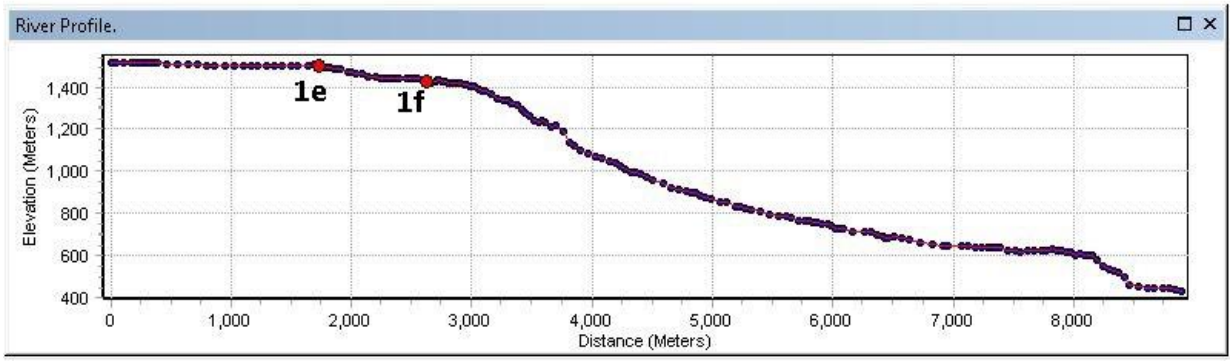


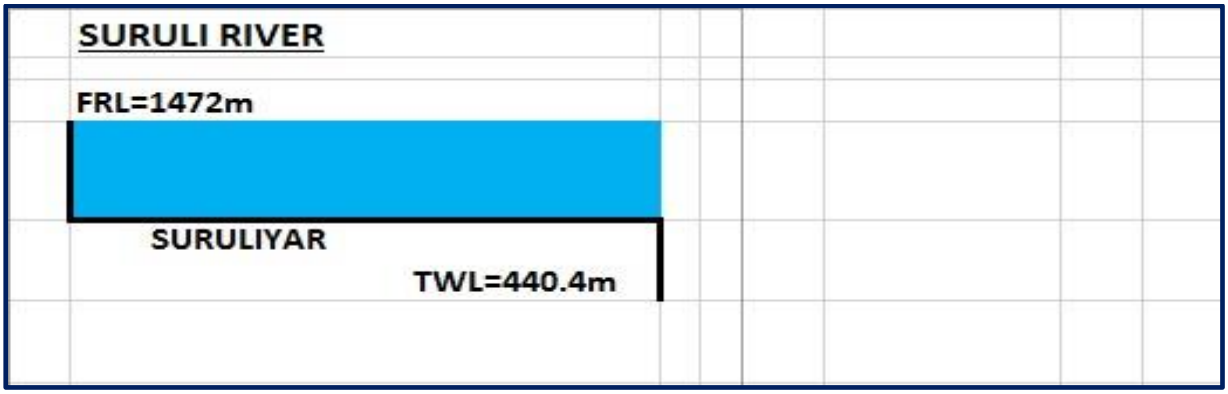
1 cm = 0.5 km







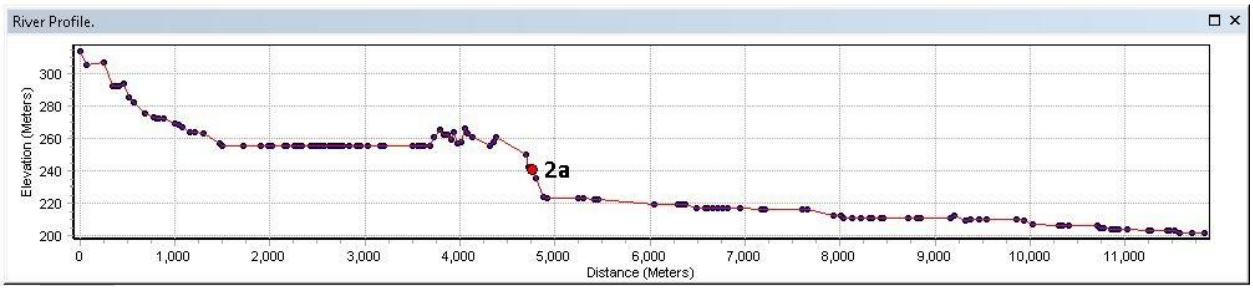




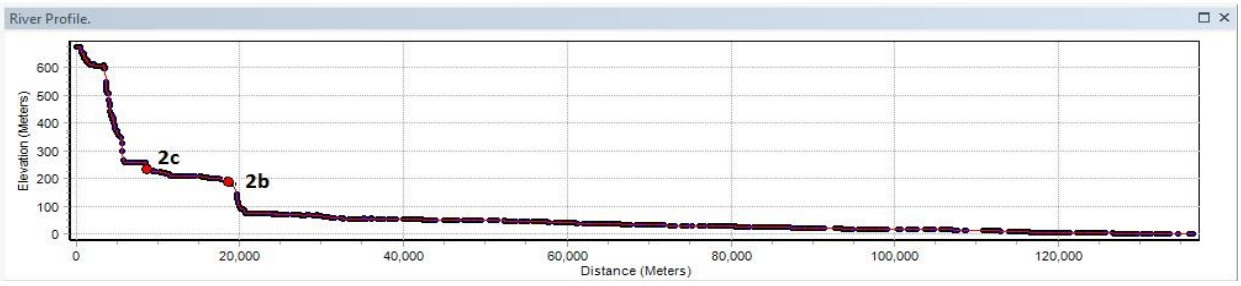
UID	Project Name	State	River	Type	Status
1a	Suruliyar (Eravangalar Dam)	Tamil Nadu	Suruli	Storage	In Operation
1b	Suruliyar (Vennriar dam)	Tamil Nadu	Suruli	Storage	In Operation
1c	Suruliyar (Vennirar Weir)	Tamil Nadu	Suruli	Storage	In Operation
1d	Suruliyar (Manalar Dam)	Tamil Nadu	Suruli	Storage	In Operation
1e	Suruliyar (Highwavys Dam)	Tamil Nadu	Suruli	Storage	In Operation
1f	Suruliyar (Highwavys Weir)	Tamil Nadu	Suruli	Storage	In Operation

2. Thamirabarani River









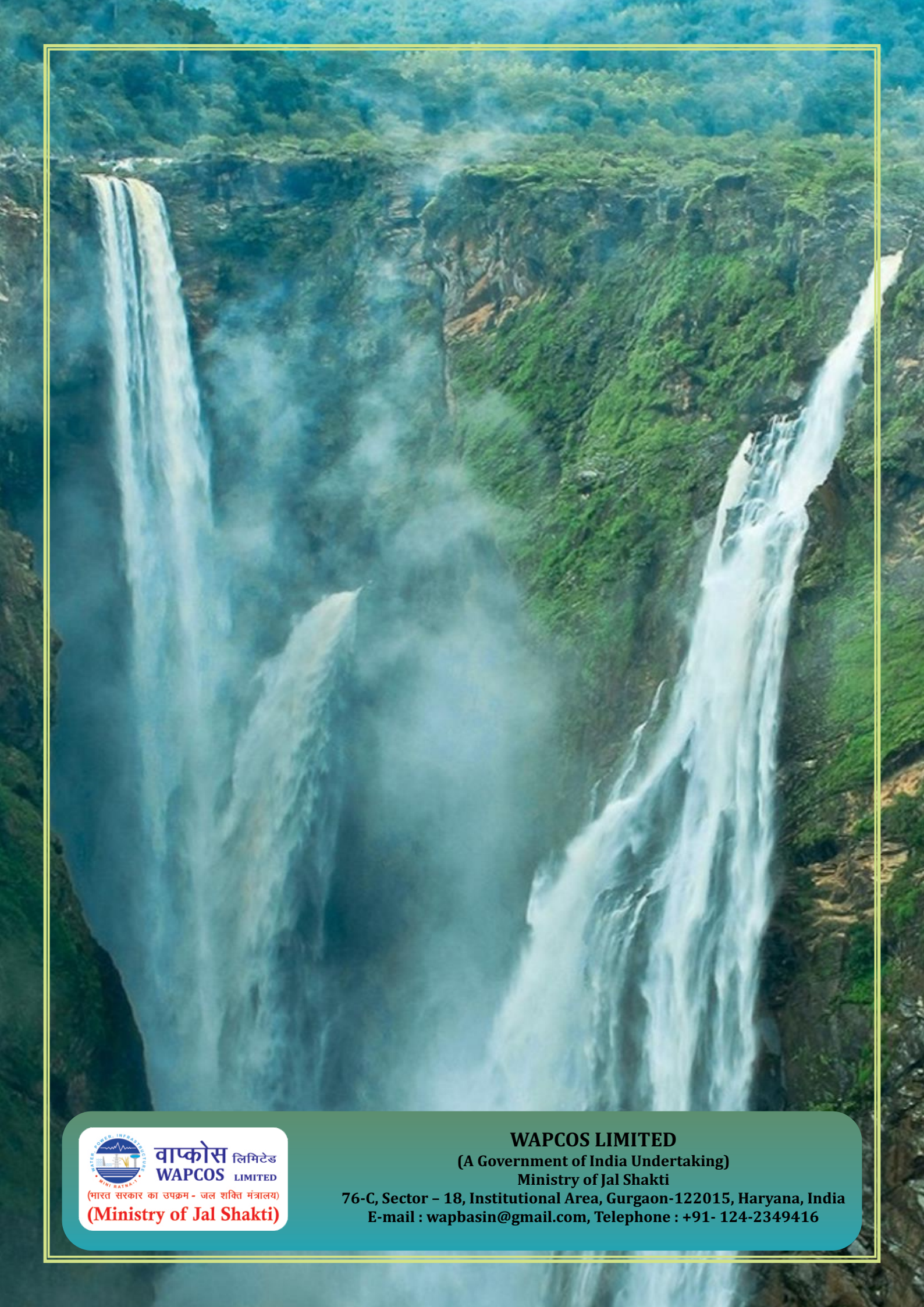


UID	Project Name	State	River	Type	Status
2a	Papanasam (Servalar Dam)	Tamil Nadu	Suruli	Storage	In Operation
2b	Papanasam (Diversion Weir)	Tamil Nadu	Suruli	Storage	In Operation
2c	Papanasam (Thambraparni Dam)	Tamil Nadu	Suruli	Storage	In Operation

8.2 Outcome of river profile exploration:

The river profiles (Longitudinal sections developed) for every major river and its tributary where the possibility of adequate hydrology (during substantial part of year) is anticipated was explored for new potential site. However, it was observed that all the potential which is 25 MW and above has already been explored in East Flowing Rivers of Peninsular India Basin.

No new probable site suitable for hydroelectric project could be found.



वाप्कोस लिमिटेड
WAPCOS LIMITED
(भारत सरकार का उपक्रम - जल शक्ति मंत्रालय)
(Ministry of Jal Shakti)

WAPCOS LIMITED
(A Government of India Undertaking)
Ministry of Jal Shakti
76-C, Sector – 18, Institutional Area, Gurgaon-122015, Haryana, India
E-mail : wapbasin@gmail.com, Telephone : +91- 124-2349416