Joint Committee Inspection Report

In the Matter of

Original Application No.14/2023
‘Jheel Sanrakhan Samiti Vs State of Rajasthan &Ors’

w.r.t.

Hon`ble National Green Tribunal Central Bench, Bhopal Order dated 18th July, 2023

Date of Visit: **12th to 13th August, 2023**
Location: **Udaipur, Rajasthan**

CENTRAL POLLUTION CONTROL BOARD
REGIONAL DIRECTORATE, BHOPAL

Original Application No.14/2023
'Jheel Sanrakhan Samiti Vs State of Rajasthan & Ors'

w.r.t.

Hon`ble National Green Tribunal Central Bench, Bhopal Order dated 18th July, 2023

INDEX

22/8/2023

(P. Jagan)

Regional Director

CPCB, Bhopal

Glossary

BOD	Biochemical oxygen demand
COD	Chemical Oxygen Demand
CPCB	Central Pollution Control Board
CWC	Central Water Commission
DEM	Digital elevation model
EC	Environmental Clearance
FC	Faecal Coliform
HAM	Hybrid Annuity Model
IIT	Indian Institute of Technology
KM	Kilo Meter
KM	Kilo Meter
MLD	Million Litre Day
PR	Project Report
RCC	Reinforced Cement Concrete
SBR	Sequencing Batch Reactor
SRTM	Shuttle Radar Topography Mission
STP	Sewage Treatment Plant
TC	Total Coliform
TSS	Total Suspended Solid
WAPCOS	Water and Power Consultancy Services Limited

Background:

An application was filed by Jheel Sanrakshan Samiti in Central Zone Bench, Bhopal and same was accepted by Hon'ble NGT in O.A. No. 14/2023 in the matter of Jheel Sanrakshan Samiti Vs State of Rajasthan. Further, the Hon'ble NGT passed an order dated 16.02.2023 and directed to constitute a Joint Committee consisting of

- District Collector, Udaipur
- Representative from WRD, Govt. of Rajasthan
- Representative of RSPCB

The committee was directed to visit the place and submit the factual and action taken report within six weeks. The said committee submitted report on 17.04.2023.Subsequently, the learned counsel appearing for applicant has filed objection to the joint committee report stating that the committee included District Collector, Udaipur who is also a Vice Chancellor and Member of the Board of Udaipur Smart City Limited.

Further, the Hon'ble NGT vide order dated 18.07.2023 directed to constitute a joint committee comprising (i) Integrated Regional Office, MoEF&CC, Jaipur, (ii) a nominee of Vice Chancellor, University of Roorkee (IIT Roorkee), who is expert in River Hydrology (iii) Central Pollution Control Board and (iv) a nominee of Central Water Commission, Government of India, who is expert in the field of River Hydrology and directed the said Committee to submit factual report within one month. Hon'ble NGT also directed to committee to consider the following issues raised by the applicant in the petition, the issues are as:

i. Reduction in carrying capacity of water during peak monsoon
ii. Increase in the chances of flash floods in the city of Udaipur due to reduction in the carrying capacity of the river,
iii. The concretization will increase the run off which will cause flooding in the area,
iv. The concretization will not give the river to spread which is a natural phenomenon for the rivers during monsoon,
v. Reduction in the ground water rechargeable capacity and
vi. Demarcation of flood plain zone keeping it free from any permanent development and non-development

The order of the Hon'ble NGT dated 18.07.2023 is enclosed as **Annexure-01**

Committee Constitution

In this regards, CPCB issued letters on 20.7.2023 to the IIT- Roorkee, CWC and MoEF&CC and sought nomination of members for committee. The nomination received from respective originations are enclosed as **Annexure-02**

Accordingely the joint committee has been constituted and the committee comprised of the following officers:

1. Prof. Brijesh Kumar Yadav, Head Department of Hydrology, IIT Roorkee
2. Sh. Mahesh Purohit, Scientist-D, MoEF&CC, Jaipur
3. Sh. Vijay Singh Meena, Deputy Director, CWC, Delhi
4. Dr. Anoop Chaturvedi, Scientist-B, CPCB, Bhopal

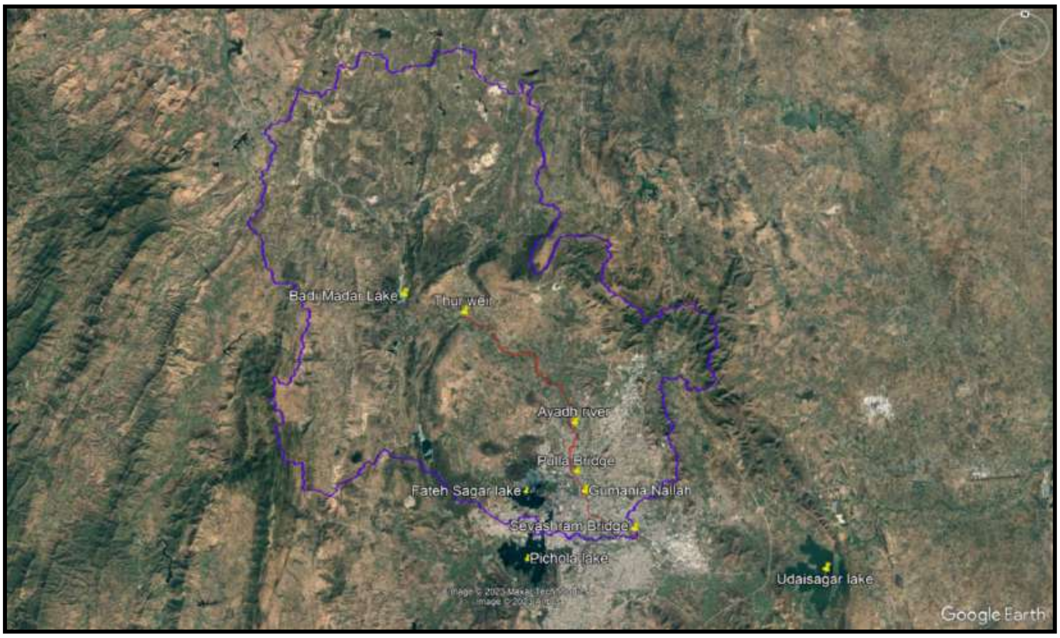
In compliance of Hon'ble NGT order dated 18.7.2023 a meeting of all committee members has been organised through video confernicng on August, 04, 2023. During the meeting committee members interacted with each other and following points were discussed:

1. To collect DPRs from Udaipur smart city Limited.
2. To collect rainfall, water flow, STP construction, project progress related data from Udaipur Smart City Limited.
3. Water sampling locations in and around the river.
4. Discussion on previously submitted (April 2023)Report on Construction activities in Ayad River under Ayad Smart Front Development and Rejuvenation Project.
5. Finilization of the date of field visit.

Thereafter, the joint committee visited Ayad River Udaipur during 12th and 13th August 2023 to assess the factual status of points mentioned in above mentioned order dated 18.07.2023.

For better coordination, the committee informed to the applicant well in advance regarding the proposed visit. The members of Jheel Sanrakhan Samiti Dr. Tez Razdan, Dr. Anil Mehta, and Ms. Bhagya Shree Pancholy along with their other colleagues were present and discussed the issues mentioned in the petition. The relevant issues were also discussed with officials of Udaipur Smart City Corporation who are present during the field visit. The other officers who are presented during the inspection are Shri P. Jagan, Regional Director, CPCB, Shri Saket Krishna, Deputy Director, CWC, Jaipur & Shri Lalit Gupta representative of Udaipur Smart City Ltd. The attendance sheet of Member and stakeholders present during filed survey is enclosed as **Annexure-03**.

<u>About the River</u>: Ayad River is a non-perennial river and it is a tributary of Barech River which further tributary of Chambal River. From its origin to its submergence in Udaisagar Lake the total length of the river is about 26 km having total catchment area of about 560 Km^2. Out of the total length of 26 Km, about 11 Km of rivers length flows through the Udaipur city. As the river is non-perennial in nature, during monsoon season, the river carries good discharge whereas in non-monsoon season, it mostly remains dry and carrying only city sewage. The lakes in Udaipur namely Fatehsagar, Pichhola, Rang Sagar and Swaroop Sagar are interconnected. The spill water of Pichola Lake and Fateh Sagar Lake gets into the Ayad River through *Gumania Nallah* and further the river submerged into the terminal lake Udai sagar. As per the interim report prepared by WAPCOS in June, 2013, the average width of the river is 70 m (varying between 27m to 145 m). Average width of the river in 5 km stretch from Pulla Bridge to Sevashram Bridge is observed as 30 to 40 metres.



Catchment area of Ayad River till Sevashram Bridge

The water inflow and exchange in water bodies are being controlled through canals and is manually operated through gates. The recharging of Pichola and Fateh Sagar depends upon the rainfall received in their respective microwatersheds which are part of the Ayad river catchment. The surplus water in one of the water body is being released to other interconnected water body depending upon the water levels and requirement. The combined flow from Pichola and Fateh Sagar lakes ultimately goes into Ayad River. In addition, to that domestic waste water of Udaipur city is also discharged into the river. The Length of River Ayad from Thur Pick-up Weir below Madar to Udai Sagar Lake is 26 km. Out of this 11 km is flows through populated urban area out of this 05 km length of River Ayad in urban area has been selected for river front development.

Proposed activities as per Project Report

As per project report the major problems which currently faced by the Ayad river are the Degradation of catchment area, Insufficient flow in the river, River bed encroachment, direct Wastewater discharge and solid waste disposal in the river, siltation and excessive weed growth. Due to these reasons, the river during the non-monsoon remains dry and carries wastewater through the concern 5 Km stretch which creates lots of health hazards to the surrounding locality. Hence, measures are proposed to restore quality water flow, in the river and restore the ecological system through executing the said smart city project. However, this PR has been changed from time to time as per field conditions. The River Front Development Project comprises of the following three components:

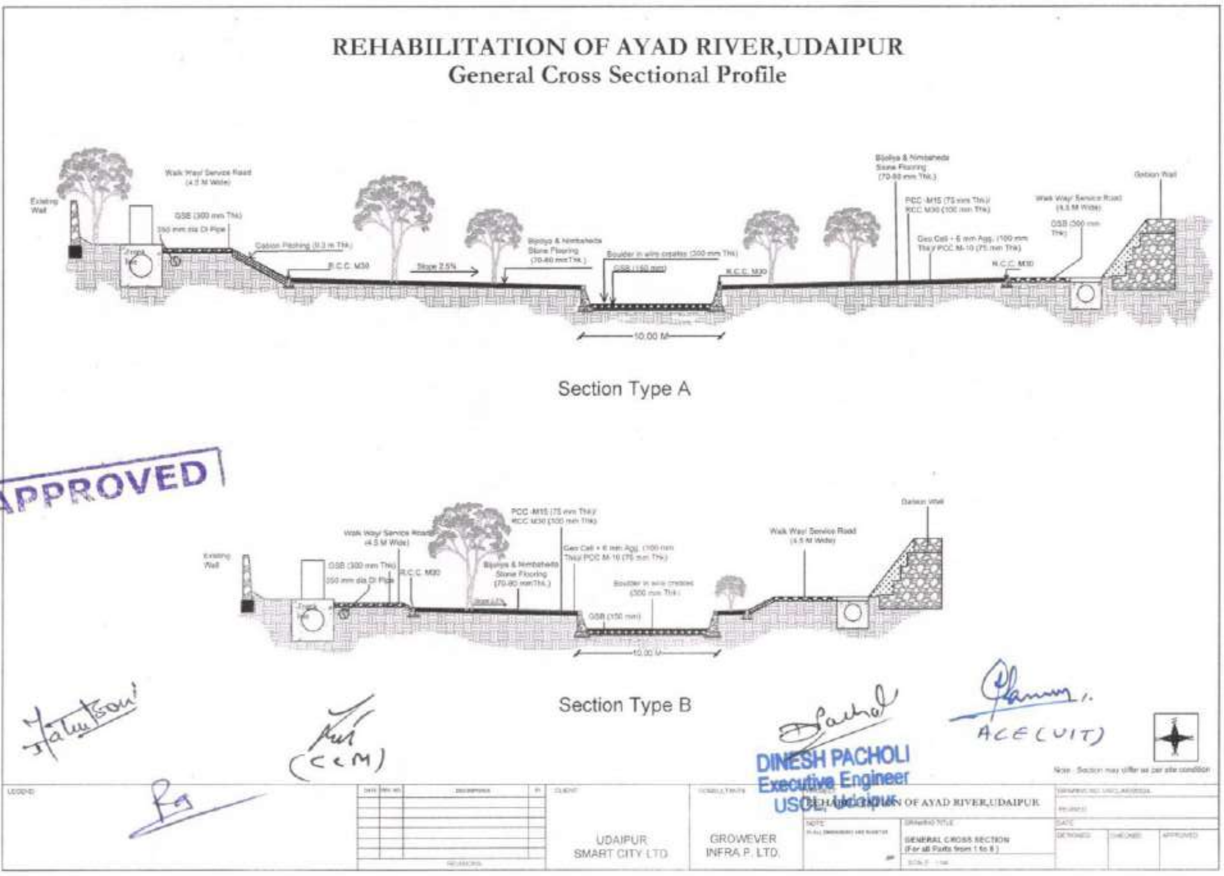
i) Channelization to maintain perennial flow: The river channelization aspect comprises of availability of water during the lean period from October to May when practically there is no rainfall and consequent runoff which can sustain the environmental and ecological balance of the river channel.

For lean period flow, it is considered that domestic waste water generated from the city can contribute substantially if the same is treated to a reasonably good level and made available in the river for reuse for various purposes. Two STP's of capacity 5 and 10 MLD are under construction/commissioned, along the River bank in Hybrid Annuity Model (HAM) by Udaipur Smart City Limited and as per HAM the treated effluent of both the STP's will be left in the Ayad river. So to make use of this water effectively **a central channel of 9m width with porous base** and three feet high concert wall on both sides has been proposed.

ii) Protection of banks and Walkways on both sides: The protection of the banks of the river is essential to ensure the two aspects. The first aspect is to keep the river boundary intact and safe from encroachments and slope protection. The second aspect is of beautification. Both the Sides/Banks have been proposed to be protected by **Coir Mat with Grass** and **Gabion wall** in the ratio of 80% and 20% area respectively for beautification keeping in mind the economic aspects. A walkway of width 2.4 meters has been proposed on both the sides using the encasing of existing sewer trunk line laid along the River Ayad. However, as informed by smart city representative the width of walk way has been changed and now it becomes to 4.5 meter each side.

iii) River Front Landscaping and Beautification: Conocarpus tree plantation has been proposed along the upper edges of the Bank on both the sides. Plantation within the River bed has also been proposed with the support of RCC pipe embedded in the ground. **Stone flooring using Bijoliya stone and plantation** in alternate stretch on both side of the centre channel.

General cross-sectional profile



APPROVED

(CCM)

DINESH PACHOLI
Executive Engineer
USCL, Udaipur

ACE (UIT)

Earlier studies:

A. Water and Power Consultancy Services (India) Limited under the administrative control of the Ministry of Jal Shakti carried out a study to check the efficacy of flooding using 50-year return flood considering different scenarios in its Interim Report titled "Urban Improvement Trust, Udaipur Government of Rajasthan, Ayad River Front Development Project through Abatement of Pollution, River Flow Channelization and River-Front Beautification in Udaipur, June, 2013" is attached as **Annexure-04**.

After carrying out the high flood level study for the existing condition (i.e. unlined condition) and lined condition, it was concluded by WAPCOS that for unlined condition, flood water level for 50-year return period is higher than the river banks practically in entire river stretch. However, for the Lined Condition, flood water level for 50 year return period flood restrains within the designed sections of the river.

B. The Udaipur Smart City Limited has also prepared a project report in which necessity of the project, characteristics of area and data related to Udaipur master plan included but no specific detailed technical study related to design flood, high flood level study etc. was conducted by the Udaipur Smart City Limited. The project report is attached as **Annexure-05**.

C. Report of Dr. SK Singh Professor and Head Civil Engineering Deptt. MBM University Jodhpur titled "Report on Construction Activities in Ayad River under Ayad Smart Front Development and Rejuvenation Project by Udaipur Smart City Ltd., April 2023" is attached as **Annexure-06.**

D. The document provided by the Udaipur Smart City Limited vide letter dated 17.8.2023 regarding progress of project and revised drawing with the provision of dry sand stone over compacted earth in the place of earlier provision is attached as **Annexure-07**

Observations from field visit of the Committee:

As per the directions of Hon'ble NGT, a committee has been constituted in respect to the Original Application No. 14/2023 "Jheel Sanrakshan Samiti Vs State of Rajasthan & Ors.". The said committee visited the reach between New Pulla Bridge to Sevasharam Bridge of Ayad River, Udaipur and following observations are made:

- It is observed that out of an average width of 40 metre of river cross section, a 9 m wide and 3 feet deep centre concert channel with porous bed has been created to restrain the lean flow during non-monsoon season to avoid accumulation of water in small patches which further lead to creation of marshy land with stagnant water in small patches act as breeding ground for mosquitoes.

- As the flow in the river increases during monsoon season, it is freely allowed to flow in the whole river cross section that is of 40-50 metres wide in 5 kilometer stretch.

- It was further informed as well as observed that the bed of the river in the 9m channel constructed for lean period flow will not be concretised whereas the remaining section of the river will be concretised/Bijoliya stone flooring with alternate patches left for plantation or ground water recharge.

- Gabion walls and retaining walls are constructed along the river to trap the chances of slope failure and to reduce the bank erosion, as and when required.

- It is observed that on both banks of the river in the river bed, surfaced manholes (sewer) of the sewer trench line laid along both the banks of river were seen.

- The committee also collected surface and ground water samples from representative locations to assess the present water quality.

- A 5 MLD STP located at Karzali found operational, it is based on SBR technology and operated on 3.5 MLD capacity. Entire treated water of this STP discharged into Gumaniya drain which is joined Ayad River near Krishnapura colony.

- Solid waste dumping was observed on the banks of Ayad river at various location of the surveyed stretch.

- As per the information provided by the Smart City Project officers, overall 30% work and approx. 20 Cr rupees spent till 31.07.2023. The details of the works completed and physical progress so far provided by the smart city is attached as **Annexure-08**.

Water Sampling and analysis

To evaluate the current water quality conditions, samples were collected from four locations of Ayad river i.e. near pulla, near Krishnapura, Gumaniya nala before confluence, near CP School, as well as the surrounding groundwater i.e Mahadev temple and Sewashram bridge. One sample of Karzali STP outlet was also collected. Sampling conducted in the ongoing monsoon period and analysed mainly for pH, TSS, COD, BOD, TC/FC etc. The compilation of this analysis can be found in Table 1. It is important to note that due to the existing high flow, most of the water quality parameters exhibit minimal variation along the 5 Km stretch of the river. The presence of Total coliform and faecal coliform indicates the mixing of untreated city sewage. Moreover, groundwater samples collected from a depth of 110 feet showed no significant deterioration in quality w.r.t. BIS standards of drinking water quality IS-10500:2012, except Total coliform at both locations and TDS is slightly higher at one location. The analysis results of each location are enclosed as Annexure-**09.**

Additionally, during the field trip, it was observed that a 5 MLD STP situated at Karzali was operational, utilizing Sequencing Batch Reactor (SBR) technology at a capacity of 3.5 MLD. The entirety of the treated water from this STP is discharged into *Gumaniya* drain, which subsequently joins Ayad River near Krishnapura colony. The water quality from this STP was found to be compliant with the prescribed discharge standards. Meanwhile, a 10 MLD capacity STP located at FCI go down was undergoing maintenance.

Points of verification as per Hon’ble NGT order:

Point No. 1. Reduction in carrying capacity of water during peak monsoon

The committee has not identified any reduction in the river's cross-sectional area within the 5 Km reach, spanning from Pulla Bridge to Sevashram Bridge, resulting from the activities associated with the "Riverfront Development of Ayad River" project executed by Udaipur Smart City Limited. In view of this, it is stated

that there will be no reduction in water carrying capacity of the river during peak monsoon due to the proposed activities by Udaipur Smart City limited. Rather, the side retention/protection walls provided in patches would help in converging the river flow within the city. Moreover, the filling of substantial depressions on the riverbed and the associated smoothing process has led to a reduction in Manning's roughness coefficient "n". This reduction in "n" results in an elevated flow velocity, consequently leading to a slight increase in the river's carrying capacity.

Point No. 2. Increase in the chances of flash flood in the city of Udaipur due to reduction in the carrying capacity of the river

As no reduction in the river cross section was observed during the field visit of by the committee on 12th August 2023, the likelihood of flash flood in Udaipur due to project activities planned by Udaipur Smart City limited are ruled out. However, Udaipur Smart City limited is strongly recommended to conduct a hydrodynamic model study for 100-years return period flood event. Accordingly, the Flood water level at various stretches needs to be assessed and compared for the present and post project scenarios.

Point No. 3. The concretization will increase the run off which will cause flooding in the area.

Runoff within any catchment is influenced by the land use and land cover of the area. The Ayad River's catchment area, extending up to Sevashram Bridge, encompasses approximately 347 Km^2 (delineated using SRTM 90m DEM). Since the Udaipur Smart City Limited does not have any project activities scheduled for the catchment area, the generated runoff from this 347 KM^2 region would remain unaffected. The scope of the project activities is confined to a 5-kilometer stretch of the riverbed (5 Km * 30 m= 0.15 KM^2).Consequently, the impact of the planned project activities is limited to merely <0.15 Km^2 out of the entire catchment area. As a result, the overall runoff would be marginally affected. Any slight alteration in the runoff would be offset by the riverbed smoothing activities intended by the riverfront development project.

Point No. 4. The concretization will not give the river to spread which is a natural phenomenon for the rivers during monsoon

During the investigation of the 5 Km stretch of the river section from Pulla Bridge to Sevashram Bridge, it was noted that the Udaipur Smart City Limited's project activities would affect the flow of the river within the 9-meter-wide and 3 feet high RCC centre channel solely during non-monsoon periods. In the rainy season, when river discharge increases, the water is free to spread across the entire cross section of the river. Consequently, the proposed project activities by Udaipur Smart City Limited will not impede the river's spread throughout its 30-40mwide cross section within the 5 KM stretch of concern.

Point No. 5. Reduction in the ground water rechargeable capacity

The river plays a significant role in replenishing the underlying groundwater resources of the region, and this natural process would be disrupted by the proposed concretization. The intended concrete bed will certainly damage the natural processes of the river hyporheic zone and associated recharge process, especially during the monsoon period, happening across the 0.15 KM^2 area of the river bed area within the 5-kilometer stretch. Further, to ensure adequate groundwater recharge during non-monsoon periods, it is recommended that the existing 9-meter-wide center channel's bed remains porous. Consequently, the committee advises against concretizing the riverbed.

Point No. 6. **Demarcation of flood plain zone keeping it free from any permanent development and non-development.**

The demarcation of floodplain zones through survey from flood zoning authority would effectively prevent river encroachment by local residents and other anthropogenic activities. As the committee members do not possess a report for the urban stretch of 5 Km. As informed by the Udaipur Smart City Limited there is no such demarcation done for Flood Plain Zone of Ayad River.

Therefore, it is challenging to provide insights into the existing state of development and construction along the riverbanks. During visit retaining walls in small patches on the river bank was observed.

Conclusion: The committee's assessment finds no evidence of river cross-section shrinkage over the 5 km stretch due to ongoing or planned activities associated with the "Riverfront Development of Ayad River" project, being implemented by Udaipur Smart City Limited. Given the absence of alterations in the river cross-section, the likelihood of increased flash floods in Udaipur city due to project activities is dismissed by the committee. Also, the activities along the 5 km stretch are not anticipated to contribute excessive runoff that could lead to flooding in the area. However, the committee strongly recommends that Udaipur Smart City Limited should conduct a hydrodynamic model study for a 100-year return period flood analysis by any independent Institute of Repute. This study should assess and compare floodwater levels at various stretches under both present and post-project scenarios.

The use of concrete and any other construction on riverbed is strongly discouraged by the committee, as it could have adverse impacts on groundwater recharge and the river hyporheic zone. Further, it is essential to carry out a technical study to evaluate the effect of project activities on water levels across different river stretches. Finally, Udaipur Smart City Limited should be reminded to adhere to all applicable statutory guidelines.

Prof. Brijesh Kumar Yadav
IIT Roorkee

Sh. Mahesh Dutt Purohit
Scientist-D MoEFCC Jaipur

Sh. Vijay Singh Meena
Deputy Director CWC, Delhi

अनूप चतुर्वेदी
22-8-2023
Dr. Anoop Chaturvedi
Scientist-B CPCB, Bhopal

Photograph of the committee visit

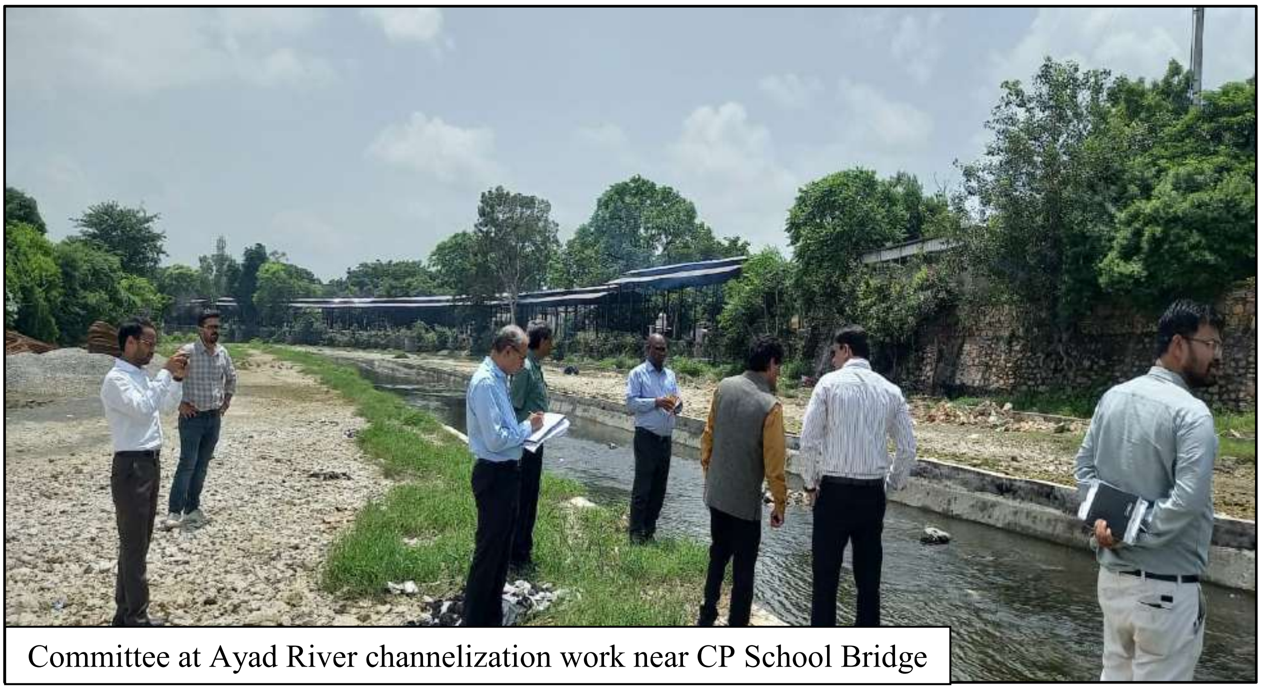
Committee members and Applicants visited Ayad River

Field visit of Committee members with Applicants and project authority

Project starting point neat Pulla bridge

View of gabion wall constructed on river bank

Joint committee visiting Ayad river area near



Committee at Ayad River channelization work near CP School Bridge

Applicant explaining about project

Stone work done at River near Sewashram (260 meter pilot project)

GW sampling at Mahadev temple

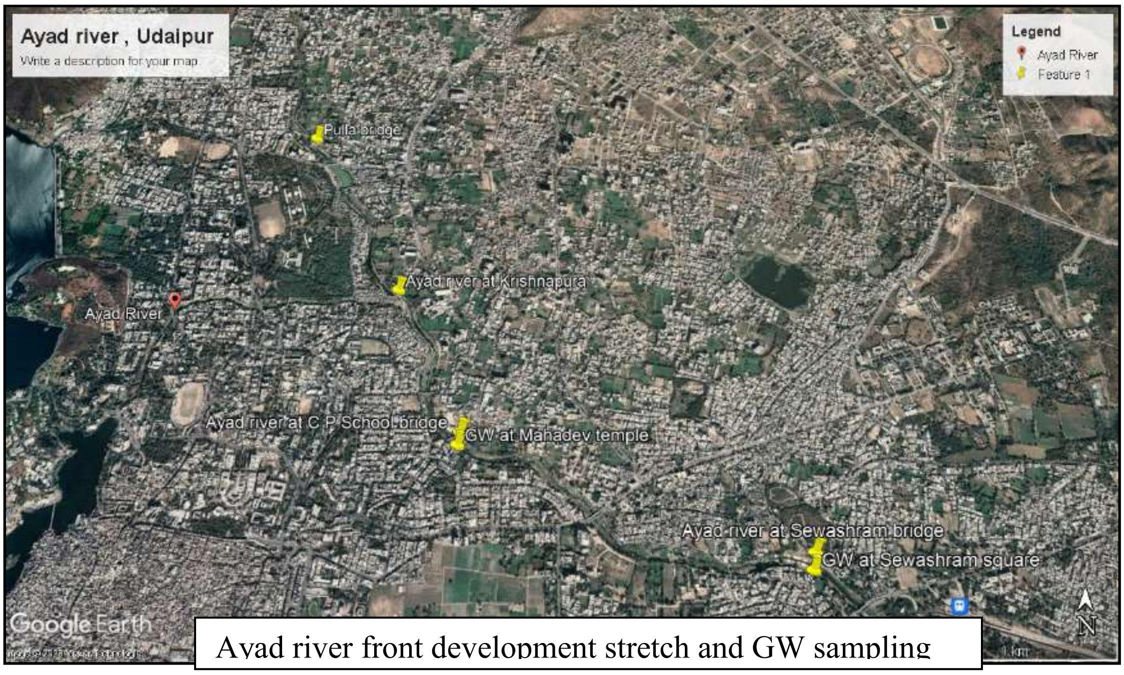
River water sampling at Krishnapura

Gumaniya nala B/c to Ayad river at Krishnapura

Sewashram site visit

Solid waste dumping at Ayad river bank

Width measurement of Ayad River



Ayad river front development stretch and GW sampling

S.No.	Location	Coordinates	Remarks
01	Ayad River near Pulla	N-24.363240 E-73.414024	No anthropogenic activity was observed, the average DO was found 8.0 mg/l. No stagnation was observed. At some stretches city solid waste found dumped.
02	Ayad River near Krishnapura before confluence to Gumaniya nala	N-24.355524 E-73.420160	
03	Gumaniya nala near Krishnapura before confluence to Ayad River	N-24.355508 E-73.420010	
04	Ayad River near Central Public School bridge	N-24.352827 E-73.421825	
05	Final treated water of 05 MLD STP at Karzali	--	STP found operation and treated water is being discharged in to Gumanniya nala.
06	Ground water near Sandeshwar Mahadev Mandir	N-24.352415 E-73.421825	Bore well water is being used for drinking purpose. Average depth of bore well is about 110 ft.
07	Ground water near Sewashram square	N-24.350322 E-73.431930	

Table 1 Analysis Result of Ayad River and Ground water

Date of sample collection: 12 & 13 August, 2023

S. No.	Parameters	Unit	Ayad River near Pulla bridge	Ayad River near Krishnapura before confluence to Gumaniyanala	GumaniyaNala near Krishnapura before confluence to Ayad River	Ayad River near Central Public School bridge	Final treated water of 05 MLD STP at Karzali	Ground water near Sandeshwar Mahadev Mandir	Ground water near Sewashram square
1	Temperature	Centigrade	27	28	27	28	--	28	27
2	Colour	--	Clear	Clear	Clear	Clear	Clear	Less turbid	Clear
3	pH	pH Units	7.57	7.77	7.71	8.01	7.59	7.05	7.07
4	Sp. Conductance	micromho/cm	1124	1183	587	1149	--	938	1286
5	Chloride as Cl^-	mg/l	193	194	85	189	--	97	203
6	Total Alkalinity	mg/l	71	83	53	82	--	89	92
7	Dissolved Oxygen	mg/l	8.04	8.13	8.01	8.14	--	--	--
8	Total Solids	mg/l	596	614	312	589		492	656
9	Suspended Solids	mg/l	16	19	14	18	12	18	14
10	Total Dissolved Solids	mg/l	580	595	298	571	--	474	642
11	B.O.D.	mg/l	1.4	2.7	3.3	3.7	2.3	--	--
12	C.O.D	mg/l	16	12	16	12	14	04	04
13	Nitrite as NO_2^- -N	mg/l	0.07	0.07	0.05	0.06	--	0.06	0.01
14	Nitrate as NO_3^- -N	mg/l	0.27	0.26	0.21	0.25	--	0.14	0.04
15	PO_4^{3-}–P	mg/l	0.14	0.15	0.15	0.16	--	0.12	0.13
16	Sulphate as SO_4^{2-}	mg/l	62	72	31	94	--	67	107
17	Total Coliform	MPN/100ml	350	430	540	540	94	32	17
18	Fecal Coliform	MPN/100ml	94	120	150	120	12	< 1.8	< 1.8

Note: -- Not done

List of Annexure

Annexure-1

Item No.04

BEFORE THE NATIONAL GREEN TRIBUNAL
CENTRALZONALBENCH, BHOPAL

(BY VIRTUAL MODE)

Original Application No.14/2023(CZ)

Jheel Sanrakhan Samiti Applicant(s)

Versus

State of Rajasthan& Ors. Respondent(s)

Date of hearing: 18.07.2023

CORAM: HON'BLE MR. JUSTICE SUDHIR AGARWAL, JUDICIAL MEMBER
HON'BLE DR. AFROZ AHMAD, EXPERT MEMBER

For Applicant(s) :	Mr. Rahul Choudhary, Advocate
For Respondent(s) :	Mr. Arvind Soni, Advocate for RSPCB Mr. Nishant Kesharwani, Adv. for Shoeb Khan, Advocate for R-1,2,5,6 Mr. Om Shankar Shrivastav, Advocate for R-3 Ms. Meenakshi Patidar, Advocate for R-4 Ms. Aparna Gupta, CEO, Udaipur Smart City Limited (R-4)

ORDER

1. Learned Counsel appearing for applicant has filed objections to joint Committee report dated 17.04.2023, stating that Committee included District Collector, Udaipur who is also Vice Chancellor and Member of the Board of Udaipur Smart City Limited, therefore, being interested person, report submitted by such Committee should not be accepted. Reliance is placed on Supreme Court's judgment dated 23.01.2023 in *Civil Appeal No. 2201/2021, Bonani Kakkar vs. Oil India Limited & Ors.*

2. We are of the view that the issue of substantial question relating to environment, raised in this application, is a serious one. Act of concretization of river bed is involved. Hence, we should obtain a fresh factual report for which purpose, we constitute a joint Committee

comprising (i) Integrated Regional Office, MoEF&CC, Jaipur, (ii) a nominee of Vice Chancellor, University of Roorkee who is expert in River Hydrology, (iii) Central Pollution Control Board (hereinafter referred to as 'CPCB') and (iv) a nominee of Central Water Commission, Government of India, who is expert in the field of River Hydrology.

3. CPCB shall be the nodal agency for co-ordination and compliance of this order. Logistic and financial support shall be provided by CPCB.

4. The said Committee shall submit factual report within one month, also considering following issues raised by applicant on account of concretisation of flood plain of river belt of Ayad river between Bridge New Pulla to Sevashram Bridge located in Udaipur (State of Rajasthan):

(i) Reduction in carrying capacity of water during peak monsoon
(ii) Increase in the chances of flash floods in the city of Udaipur due to reduction in the carrying capacity of the river,
(iii) The concretization will increase the run off which will cause flooding in the area,
(iv) The concretization will not give the river to spread which is a natural phenomena for the rivers during monsoon,
(v) Reduction in the ground water rechargeable capacity and
(vi) Demarcation of flood plain zone keeping it free from any permanent development and non-development.

5. Committee shall visit the site, collect relevant informations and submit report within one month by e-mail at ngtczbbho-mp@gov.in preferably in the form of searchable PDF/OCR support PDF and not in the form of Image PDF.

6. A copy of this order be forwarded to Integrated Regional Office, MoEF&CC, Jaipur, Vice Chancellor, University of Roorkee, CPCB and Central Water Commission, Government of India.

7. List the case on 28.08.2023.

Sudhir Agarwal, JM

Dr. Afroz Ahmad, EM

July 18, 2023
Original Application No. 14/2023(CZ)
R

Annexure-2

भारत सरकार
जल शक्ति मंत्रालय
जल संसाधन नदी विकास एवं गंगा संरक्षण विभाग
केंद्रीय जल आयोग
नदी प्रबन्ध समन्वय निदेशालय

सत्यमेव जयते

Government of India
Ministry of Jal Shakti
Dept. of Water Resources, RD&GR
Central Water Commission
River Management Co-ordn. Directorate

दिनांक: 27.07.2023

सेवा में,

मुख्य अभियंता
यमुना बेसिन संगठन
केंद्रीय जल आयोग, नई दिल्ली

विषय: राष्ट्रीय हरित अधिकरण (मध्य), भोपाल में दर्ज मूल आवेदन (Original Application) संख्या 14/2023 के संबंध में ।

संदर्भ: 1. आपका ई-मेल दिनांक 24.07.2023.

2. केंद्रीय प्रदूषण नियंत्रण बोर्ड के क्षेत्रीय निदेशक (भोपाल) का पत्र दिनांक 20.07.2023.

महोदय,

कृपया संदर्भित ई-मेल एवं पत्र का संज्ञान लें । मूल आवेदन संख्या 14/2023 (झील संरक्षण समिति बनाम राजस्थान व अन्य) में राष्ट्रीय हरित अधिकरण (मध्य), भोपाल द्वारा जारी आदेश दिनांक 18.07.2023 की अनुपालना में निम्नलिखित अधिकारी को चार-सदस्यीय संयुक्त समिति में चौथे सदस्य के रूप में नामित किया है ।

नाम एवं पद	कार्यालय	मोबाइल नंबर	ई-मेल
श्री विजय सिंह मीना, उप-निदेशक	जल विज्ञान (उत्तर) निदेशालय, केंद्रीय जल आयोग (मुख्यालय), नई दिल्ली	8447813794	vijaysinghmeena-cwc@nic.in

इसके अतिरिक्त श्री साकेत कृष्णा, उप-निदेशक, प्रबोधन एवं मूल्यांकन निदेशालय, जयपुर को श्री विजय सिंह मीना को सहयोग प्रदान करने हेतु नामित किया गया है ।

8800155634

यह अध्यक्ष, केंद्रीय जल आयोग के अनुमोदन से जारी है।

भवदीय,

27/6/2023

(अभय कुमार)

निदेशक

प्रतिलिपि:

1. Sr. PPS to the Chairman, CWC, New Delhi.
2. PPS to the Member (RM), CWC, New Delhi.
3. PPS to the Member (D & R), CWC, New Delhi.
4. The Chief Engineer, HSO, CWC, New Delhi.
5. Director, Hydrology (North) Directorate, CWC, New Delhi.
6. Director, D & R Coordination Directorate, CWC, New Delhi.
7. Director, M & A Directorate, CWC, Jaipur.

द्वितीय तल(दक्षिण), सेवा भवन
राम कृष्ण पुरम, नई दिल्ली-110066
दूरभाष: 011-29583211
ई मेल: rmdte@nic.in
♦जल संरक्षण-सुरक्षित भविष्य♦

2nd Floor(South), Sewa Bhawan,
R.K. Puram, New Delhi-110066
Tel: 011-29583211
E-mail: rmdte@nic.in
♦Conserve Water-Save Life♦

IRO/JPR/GEN/NGT/EnvCommittee/

I/49848/2023

भारत सरकार
GOVERNMENT OF INDIA
पर्यावरण,वन एवं जलवायु परिवर्तन मंत्रालय
MINISTRY OF ENVIRONMENT, FOREST & CLIMATE CHANGE
क्षेत्रीय कार्यालय, गांधीनगर/उप क्षेत्रीय कार्यालय,जयपुर /Regional Office, Gandhinagar/**(Sub-Regional Office, Jaipur)**

ए 218&बी216 "अरण्यभवन ", झालानासंस्थानिक क्षेत्र, जयपुर - ३०२००४/ A-218& B2-216,
"ARANYA BHAWAN" ,Jhalana Institutional Area, Jaipur-302004
दूरभाष/Tel No: 0141-2713858, 2713786 Email: iro.jaipur-mefcc@gov.in

Dated:02nd August, 2023

To
The Regional Director,
Regional Directorate, Bhopal,
Central Pollution Control Board,
Vithal Market, Paryavaran Parisar,
E-5, Arera Colony, Bhopal,
Madhya Pradesh – 462016

Sub: Nomination of an official as a member of committee constituted by Hon'ble NGT vide order dated 18.07.2023 in the matter of O.A. No. 14/2023; Jheel Sanrakshan Samiti Vs. State of Rajasthan - Reg.

Ref: Letter received from CPCB, Bhopal dated 20.07.2023.

Sir,

In reference to the above cited subject, and captioned letter regarding nomination of the Officer from Ministry of Environment, Forests and Climate Change, Government of India in O.A. No. 14/2023; Jheel Sanrakshan Samiti Vs State of Rajasthan, this is to inform that the undersigned has been nominated (Mob: 9413845550; email: mahesdutt.purohit@gov.in) from this office for the said committee.

2. This issues with the approval of the Competent authority.

Sincerely,

(Er. Mahesh Dutt Purohit)
Joint Director(S)/Scientist 'D'
Ministry of Environment, Forests and Climate Change
SRO, Jaipur

Copy to:

1. **Shruti Rai Bhardwaj, Director/Scientist 'F', Monitoring cell, MoEF&CC, New Delhi- For information please.**

anoop chaturvedi <anoopc1974@gmail.com>

Fwd: Compliance of Hon'ble NGT order dated 18.07.2023 in O.A.No.14/2023 titled as "Jheel Sanrakshan Samiti Vs State of Rajasthan & Ors."-reg.

3 messages

POULAMI C PATIL, Sc. B <poulamicp.cpcb@nic.in> Fri, Jul 21, 2023 at 4:15 PM
To: anoopc1974 <anoopc1974@gmail.com>

PFA

DR. POULAMI C. PATIL
Scientist B
CENTRAL POLLUTION CONTROL BOARD
REGIONAL DIRECTORATE (CENTRAL)
PARIVESH BHAWAN
E-5, ARERA COLONY
BHOPAL 462016

From: "cpcb bhopal" <cpcb.bhopal@gmail.com>
To: registrar@iitr.ac.in
Cc: "Sunil Kr Meena" <sunil.cpcb@gov.in>, "POULAMI C PATIL, Sc. B" <poulamicp.cpcb@nic.in>, "P. K. Mishra" <eepkm.cpcb@nic.in>, "DH Law, CPCB" <law.cpcb@gov.in>
Sent: Thursday, July 20, 2023 7:27:38 PM
Subject: Compliance of Hon'ble NGT order dated 18.07.2023 in O.A.No.14/2023 titled as "Jheel Sanrakshan Samiti Vs State of Rajasthan & Ors."-reg.

Sir,

With reference to the Hon'ble NGT order dated 18.07.2023 in O.A.No.14/2023 titled as "Jheel Sanrakshan Samiti Vs State of Rajasthan & Ors." A 4 member committee has been constituted which comprising :

(i) Integrated Regional Office, MoEF&CC, Jaipur,
(ii) A nominee of Vice Chancellor, University of Roorkee who is expert in River Hydrology,
(iii) Central Pollution Control Board
(iv) A nominee of Central Water Commission, Government of India, who is expert in the field of River Hydrology and directed under para 4 to submit the report on 6 points which are as below :

(i) Reduction in carrying capacity of water during peak monsoon (ii) Increase in the chances of flash floods in the city of Udaipur due to reduction in the carrying capacity of the river, (iii) The concretization will increase the runoff which will cause flooding in the area, (iv) The concretization will not give the river to spread which is a natural phenomena for the rivers during monsoon, (v) Reduction in the ground water rechargeable capacity and (vi) Demarcation of flood plain zone keeping it free from any permanent development and non-development.

The committee is to submit its **factual report within one month** by 20.08.2023. CPCB is the Nodal Agency in this matter. (A letter in this regard is attached)

Therefore, it is kindly requested to nominate the expert member in compliance of order so that report may be submitted in a given time line.

regards

भवदीय,
Regards,

पी. जगन
P. Jagan
क्षेत्रीय निदेशक
Regional Director
केंद्रीय प्रदूषण नियंत्रण बोर्ड
Central Pollution Control Board
क्षेत्रीय निदेशालय (मध्य)
Regional Directorate (Central)
परिवेश भवन, पर्यावरण परिसर
Parivesh Bhawan, Paryavaran Parisar
ई-5, अरेरा कालोनी, भोपाल - 462016
E-5, Arera Colony, Bhopal - 462016
Telephone (दूरभाष) : 0755-2775386/85
Telefax: 0755-2775587
Mobile (मोबाइल) : +91-9755559745

IIT Roorkee.pdf
1135K

Regional Directorate, Bhopal <cpcb.bhopal@gmail.com> Wed, Jul 26, 2023 at 5:19 PM
To: registrar@iitr.ac.in
Cc: director@iitr.ac.in, head@hy.iitr.ac.in, anoop chaturvedi <anoopc1974@gmail.com>

R. Sir,

In continuation of our earlier mail, dt. 21.07.2023, it is to inform that the nomination from IIT Roorkee (Hydrology Department) is yet to be received.

It is once again requested to kindly provide the nomination of the expert member for timely compliance of order of Hon'ble NGT.

भवदीय,
Regards,

पी. जगन
P. Jagan
क्षेत्रीय निदेशक
Regional Director
केंद्रीय प्रदूषण नियंत्रण बोर्ड
Central Pollution Control Board
क्षेत्रीय निदेशालय (मध्य)
Regional Directorate (Central)
परिवेश भवन, पर्यावरण परिसर
Parivesh Bhawan, Paryavaran Parisar
ई-5, अरेरा कालोनी, भोपाल - 462016
E-5, Arera Colony, Bhopal - 462016
Telephone (दूरभाष) : 0755-2775386/85
Telefax: 0755-2775587
Mobile (मोबाइल) : +91-9755559745

[Quoted text hidden]

IITR.pdf
1594K

K K Pant Director IIT Roorkee <director@iitr.ac.in> Tue, Aug 1, 2023 at 6:35 PM
To: "Regional Directorate, Bhopal" <cpcb.bhopal@gmail.com>
Cc: anoop chaturvedi <anoopc1974@gmail.com>, Head Hydrology <head@hy.iitr.ac.in>, Brijesh Kumar <brijesh.yadav@hy.iitr.ac.in>, Registrar IITR <registrar@iitr.ac.in>

Dear Shri P. Jagan,

Kindly refer to your email dated 26th July, 2023 on the above subject. I am nominating following colleague from Indian Institute of Technology Roorkee for the same. His contact details are as follows:

Prof. Brijesh Kumar Yadav
Department of Hydrology
Mobile: 8979534484
Email: brijesh.yadav@hy.iitr.ac.in

With kind regards,

Yours sincerely,

K.K. Pant
Director, Indian Institute of Technology,
(IIT) Roorkee
http://web.iitd.ac.in/~kkpant/
-

From: "Regional Directorate, Bhopal" <cpcb.bhopal@gmail.com>
To: "Registrar IITR" <registrar@iitr.ac.in>
Cc: director@iitr.ac.in, "Head Hydrology" <head@hy.iitr.ac.in>, "anoop chaturvedi" <anoopc1974@gmail.com>

Sent: Wednesday, July 26, 2023 5:19:52 PM
Subject: Re: Compliance of Hon'ble NGT order dated 18.07.2023 in O.A.No.14/2023 titled as "Jheel Sanrakshan Samiti Vs State of Rajasthan & Ors."-reg.

[Quoted text hidden]

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Annexure-3

Date: 12.8.2023
Loc : Udaipur

Attendance Sheet

NGT OA 14/2023 Committee & Stakeholders.

1) Dr. Anoop Chaturvedi — CPCB, Bhopal — AC.

2) Vijay Singh Meena — Vijay

3) Saket Krishna

4) Mahesh Dutt Purohit MoEF&CC, GoI

5) Prof. Brijesh K. Yadav

6) Dr Anil Mehta — A

7) DR. T. RAZDAN

8) Bhagyashree Pancholy

9) Lalit Gupta PMC (Udaipur Smart City)

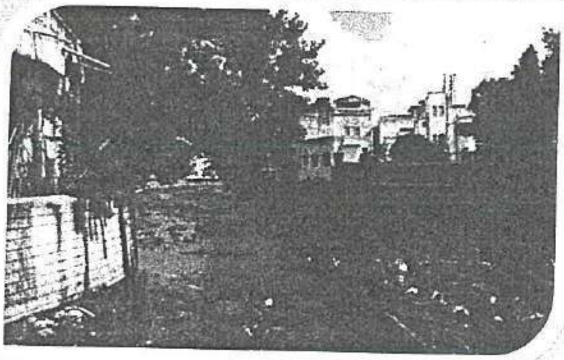
10) Kaushal Kumar Bhai RSPCB — Kaushal

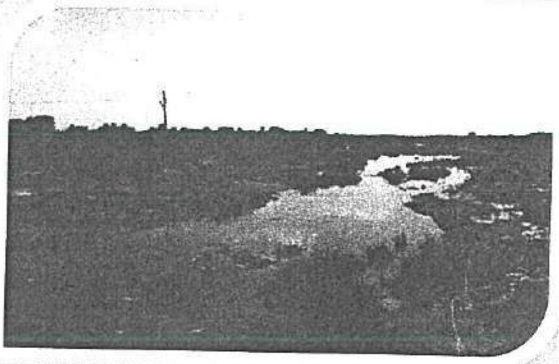
11) P. Jagan, RD, CPCB, Bhopal — जगन

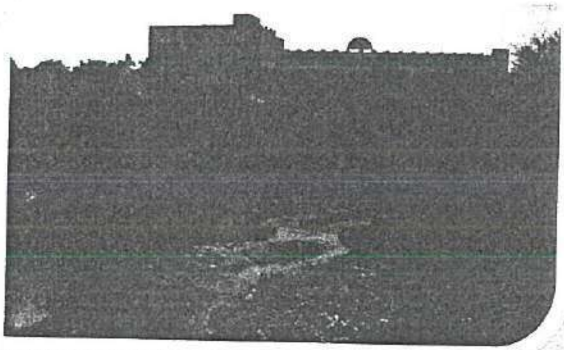
Annexure-4

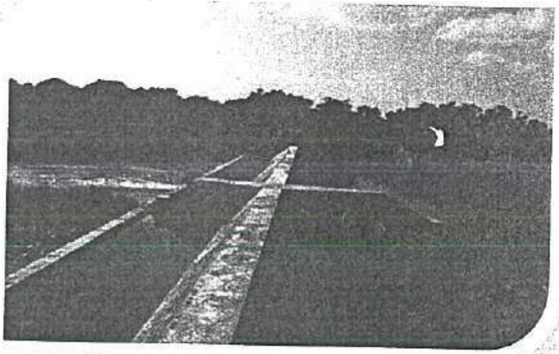
Urban Improvement Trust, Udaipur
Government of Rajasthan

Ayad River Front Development Project through Abatement of Pollution, River Flow Channelization and River-Front Beautification in Udaipur (Rajasthan)









INTERIM REPORT

VOLUME – I (A) : RIVER CHANNELIZATION AND POLLUTION ABATEMENT

वाप्कोस
लिमिटेड
(भारत सरकार का उपक्रम – जल संसाधन मंत्रालय)
WAPCOS
LIMITED
(A Government of India Undertaking - Ministry of Water Resources)

WAPCOS LIMITED
(International Consultant in Water Resources, Power and Infrastructure Development)
Corporate Office: 76-C, Institutional Area, Sector-18, Gurgaon, Haryana - 122015, India.
Registered Office: "KAILASH", 5^{th} Floor, KG Marg, New Delhi-110 001, India.

JUNE, 2013

INTERIM REPORT
ON
AYAD RIVER FRONT DEVELOPMENT PROJECT THROUGH ABATEMENT OF POLLUTION, RIVER FLOW CHANNELIZATION AND RIVER-FRONT BEAUTIFICATION IN UDAIPUR (RAJASTHAN)

CONTENT

VOLUME – I (A): RIVER CHANNELIZATION AND POLLUTION ABATEMENT

CHAPTER – I : PROJECT BACKGROUND

CHAPTER – II : THE PROJECT

CHAPTER – III: PHYSIO-CLIMATOLOGICAL CHARATERISTICS OF PROJECT AREA

CHAPTER – IV: DATA COLLECTION AND SUMMARY OF PROJECT RELATED REPORTS & DOCUMENTS

CHAPTER – V: RIVER CHANNELIZATION

CHAPTER – VI: ABATEMENT OF POLLUTION

CHAPTER – VII: ENVIRONMENTAL AND ECOLOGICAL ASPECTS

ANNEXURES

PLATES

VOLUME – I (B): AYAD RIVER SURVEY DRAWINGS

TOPOGRAPHICAL SURVEY OF AYAD RIVER, UDAIPUR

VOLUME – II (A): LANDSCAPE PLAN

VOLUME – II (B)

DRAWINGS OF LANDSCAPE PLAN (30 Nos.)

CHAPTER- I
PROJECT BACKGROUND

CHAPTER-1

PROJECT BACKGROUND

1.1 GENERAL

With the rapid growth of population in the country, all the cities are bursting out of their municipal limits with the result that urban infrastructural development planning has not been keeping pace with that of the required facilities. Udaipur city is no exception to this fallacy.

Udaipur, known to be city of lakes, attract lot of national and international tourists due to the presence of such lakes and other water bodies but the development scenario of the city continue to be far from satisfactory.

The human activities has not only resulted in over exploitation of lakes but has made them highly polluted due to disposal of waste water thereby leading to their overall degradation in terms of quantity and quality of water.

The human activities have also not spared Ayad River which flows on the north-east side of Udaipur City and receives polluted overflow not only from city lakes (mainly Pichola and Fatehsagar) but solid & liquid wastes directly as well. As on date, Ayad River is also rated to be equally polluted as the city lakes.

Of late, the city administrations viz Municipal councils/ Municipal corporations/ Urban Improvement Trusts (UIT) have started giving a serious thought to it and are exploring all possibilities for correcting the situation with engineering interventions and mobilizing central funding.

The Ministry of Environment and Forests (MOEF), Govt. of India has launched a centrally sponsored scheme namely "National River Conservation Plan (NRCP)" for river-cleaning programme with the objective to improve the water quality of major rivers, which are the main fresh water sources in the country, through implementation of pollution of abatement schemes. MOEF has constituted National River Conservation Authority (NRCA) under the chairmanship of Prime Minister with chief Ministers of concerned states as its members in 1995 (Earlier it was named as Central Ganga Authority (CGA) constituted with the launching of Ganga Action plan in 1985). NRCA has been given larger mandate to cover all the river action plan programmes in the country. The authority is supported by the National River Conservation Directorate (NRCD) under the MOEF. The functions of the NRCA are; to approve appropriate policies for long and short term programmes, to mobilize necessary financial resources, to review the progress of implementation and to take all such measures as may be necessary to achieve the objectives.

The Rural Urban Infrastructure Finance & Development Corporation (RUIFDCO), Govt. of Rajasthan is accordingly formulating this scheme to remove the prevailing anomalies of pollution, water quantity& quality of Ayad River including environmental concerns with its likely funding under centrally sponsored NRCP.

1.2 ABOUT UDAIPUR CITY

Udaipur district is located between 23° 46' & 25° 05' North latitude and 73°09'& 74°35' East longitude covering an area of 11630.66 sq. km. the district is bounded by Sirohi, Pali and Bhilwara Districts on the north, Chittaurgarh District on the east, Banswara and Dungarpur on the south and state of Gujarat on the west. The city of Udaipur is located in the northern part of Udaipur District and is approx 420km from Jaipur and 692 km from Delhi by road. The district of Udaipur is divided into seven sub-divisions namely Girwa, Dhariyawad, Mavali, Vallabhnagar, Kotra, Jharol and Salumbar. Administratively the district is divided into 10 Tehsils and 11 Development blocks. The names of the 10 Tehsils are; Girwa, Dhariyawad, Mavali, Bhinder (Vallabnagar), Kotra, Jharol, Salumber, Kherwara, Sarara and Gogunda. The names of 11 Development blocks are same as those of Tehsils with one additional name i.e. Badgaon. Total number of villages in the district is 2406 and 9 urban towns. Urban and rural population of the district is 4.9 lakh and 21.4 lakh respectively.

Rajasthan State Map showing Udaipur District is given in Plate – 1.1

1.3 MALADY REMEDY OF UDAIPUR CITY

Udaipur City is facing lot of problems due to changed scenario during the past few years such as;

- The lush green Udaipur has transformed into basically a drought prone area of Rajasthan.
- The drought that occurred during the last few years has significantly affected the socio-economic profile of the area. Due to failure of monsoons, the water level in the lakes has receded considerably and ground water table also fallen.
- Shortage of water had multifaceted effects on the economy of the area.
- Udaipur is on the world tourist Map, but its drying lakes, inadequate inflow in Ayad River and no proper management of disposal of waste water has reduced the influx of tourists in the city.
- The over exploitation of groundwater for the purpose of irrigation has costed quantity and quality of groundwater. The problem of fluorides and salinity has developed in the area.
- Industrial development has also been affected due to non-availability of adequate quantity of water.
- Fulfilling the requirement of drinking water has become a herculean task. It requires steps to be taken for augmentation of water supply.
- Service sector has been significantly affected due to migration of tribal population to adjoining Gujarat State for better employment opportunities.

In view of the above, the planning policies conceptualized by Govt. of Rajasthan in their Master Plan for Udaipur City are highlighted below:

(i) While maintaining the importance of historical & religions places and tourists spots in the walled city, there is need to make adequate transportation arrangements in the narrow lanes of the city and the narrow roads widened, where feasible alongwith parking lots.

(ii) All the city lakes like Pichhola, Fatehsagar, Rangsagar and Swaroopsagar located on the west side which have special importance from the environmental angle need to the protected by proper land use planning of the surrounding areas.

(iii) Keeping the importance of tourism in view, there is need to provide better tourist facilities in the city like hotels, transportation, parks, tourist complexes etc.

(iv) Industries causing pollution need not be allowed to the set up near the city from tourism angle.

(v) The development and location of commercial centres need to be planned and provided in such a way that the local area demands could be met without commuting long distances.

(vi) In order to reduce the influx of heavy vehicles in the narrow roads of the city, land outside the city needs to the reserved for major establishments like Whole Sale Trade, Transport Nagar, Godowns & Storages etc which encourage deployment of heavy transport vehicles

(vii) Ayad River which is passing through the city area need to be protected from environmental angle. Both the banks of the river should be developed with tree plantation and greenery. In order that water keeps flowing throughout the year in the river, Mansi Wakal Project needs to be given practical shape.

(viii) Afforestation needs to be done in the entire Udaipur Valley and surrounding bald hills in order to check the inflow of sediment into Ayad River as well as the city lakes.

For Projects of this nature as is "Ayad River Front Development, Udaipur", it is necessary to adopt three – pronged strategy i.e. identification / appraisal of the problems, evolving appropriate / feasible solutions and then implementing the solutions in order to remedy the maladies. The same process is being adopted for the project. The major problems have been identified and the feasible solutions have been thought of which are elaborated in the subsequent paragraphs.

1.3.1 Identified Problems

The major problems identified by the team are:

1. **Insufficient Flow**: The water flow in the river is insufficient due to limited catchment area, lower average rainfall, degradation of the catchment area and increasing water demand for domestic purposes.

2. **Degradation of Catchment Area:** Due to increased human interference in the catchment area, forest is getting depleted. This has resulted in reduced vegetative cover, reduction in subsurface water flows- essential for flow maintenance during lean period. This is also causing excessive soil erosion and thus siltation of lakes and river.

3. **Encroachment:** The river bed and banks have been encroached by the people over the passage of time because there was no firm demarcation of river boundary. In some of the stretches multi storied buildings have come up right over the side wall of the river. This has resulted in reduction of the river cross section considerably thereby affecting the smooth flow of water in the river and also leading to flood like situations during the period of high rainfall.

4. **Waste Water Discharge:** The city does not have proper sewerage system and is mainly using septic tanks at domestic levels. The overflow from the septic tanks through various open drains finds its way into the river. Some of the populated areas on the banks of river are discharging waste water directly into the river. It is estimated that approximately 150 MLD (Million litres per day) untreated domestic waste water is discharged into this river. In addition 30-40 MLD of untreated / partially treated waste water from industries is also entering the river.

5. **Solid Waste:** The city lacks scientific solid waste management system and significant part of the solid waste is dumped into the river which is further aggravating the river water quality situation and obstruction in smooth flow of river water.

6. **Ground Water Contamination:** As a consequence of waste water and solid waste disposal into the river, the ground water has become highly contaminated. Use of contaminated water ground water has led to reduction in agriculture productivity, contamination of vegetables.

7. **Siltation and Weed Growth:** Most of the river stretches specially in the city area is experiencing siltation and deposit of organic solids causing heavy growth of aquatic weed. This has led to hyper eutrophic state and absence of oxygen in most of the river stretches.

8. **Bio-diversity**: The anthropogenic pressures in the catchment on the banks of river has resulted in degradation in bio-diversity and consequence erosion and increased silt flow in the river bed. Excessive growth of weeds in the river is resulting in breeding of vectors thereby causing disease in the area.

The alarming situation in river Ayad and the linked lakes, is leading to flooding, serious health hazards on account of contaminated surface and ground water, bio-diversity perils, unaesthetic environment to the city residents. Hence, immediate measures are required to restore quality water flow in the river and restore complete ecological balance of the system.

The Government of Rajasthan has already initiated measures for improvement of lake system in Udaipur. Two projects for conservation and management of Fatehsagar and Pichola Lakes, financed through National Lake Conservation Plan, Ministry of Environment and Forests, Government of India are under implementation. This includes desilting of lakes, purification of lake water, plantation in catchment area, development of green belts etc. Project for transfer of water from Sabarmati Basin is also under implementation.

1.3.2 Outline of Feasible Options

- Identification of river passage and removal of encroachment
- Dredging / desilting of river
- River channelization
- Collection and treatment of domestic waste water
- Treatment of industrial waste water
- Solid waste management
- Inter-basin water transfer
- River-front Beautification
- Hydrological Modeling for operation and management of water in various lakes
- Public awareness
- Creation of impounding reservoirs through rehabilitation of existing Anicuts and construction of new Anicuts

1.4 NECESSITY OF THE PROJECT

The necessity of the project arises because of the following:

i) The status of present situation of deteriorating condition of not only the lakes but Ayad River as well due to unabated pollution, degradation of watersheds and environmental & ecological in balances is well known to everybody. So much so, the pressure of increasing population in the city is getting reflected through encroachment on the banks of Ayad River. Therefore, unless the corrective measures are taken immediately, the situation may go beyond control and may rather become non- retrievable.

ii) The conceptual planning done by the Govt. of Rajasthan and local administration for the development of Ayad River needs to be implemented and given a particle shape on the ground.

iii) The prevailing maladies in the city are also already identified along with feasible solutions. So now only the socio-politico economical-political Will is required to implement the project before it is too late.

iv) The implementation of the project also entitles the state Govt. to avail of central funding under NRCP after obtaining requisite approval of the DPR from Ministry of Environment and Forests, Govt. of India, which otherwise remain allusive.

1.5 OUTLINE OF PROJECT OBJECTIVE AND SCOPE

1.5.1 Objective

The objective of the assignment is to prepare a comprehensive Detailed Project Report for Abatement of Pollution, River Flood Channelization and River Front Beautification of Ayad River in Udaipur for its long term conservation and sustainable management aimed at restoring the environmental and ecological balance of the river and surroundings.

1.5.2 Scope of Work

A detailed study is required to restore the environmental and ecological balance of Ayad River and its surrounding areas. The scope of study shall comprise of the following:

i) Study and review of all the available information / data / reports with various govt. department viz. UIT, PHED, WRD, Urban Town Planning department etc. relevant to the above mentioned aspects of the project.

ii) Review of the outcome of topographical survey of Ayad River (26 km stretch) for utilization in river channelization aspect

iii) Hydrological studies for assessment of water availability, design flood, releases from the lakes into Ayad River, and inter-lake transfers etc.

iv) Designing of river cross-section based on the hydrological studies to ensure proper river channelization

v) Identification of river passage based on the survey output and designed river section to enable authorities to demarcate river boundary and identify encroachments.

vi) Assessment of desiltation requirement of the river including rock outcrops in the river bed, if any

vii) Review and assessment of collection and treatment of domestic waste water

viii) Review and assessment of treatment of industrial waste water

ix) Study pertaining to solid waste management aspect

x) Studying the aspect of inter-basin waste transfer to augment the lean period flows in the river

xi) Hydrological modeling for operation and management of water in various lakes

xii) Studying River-Front Beautification aspect in the city river stretch and suggesting action plan.

xiii) Exploring feasibility of water impounding in the river through rehabilitation of existing anicuts and construction of new anicuts.

xiv) Ascertaining the present environmental and ecological conditions, Identify problem areas in terms of environmental conditions of the existing situation

xv) Designing Public Awareness Programme for Conservation and Management for water resources for maintaining environmental and ecological balance of the river, lakes and surrounding areas.

xvi) Preparation of Detailed Project Report including cost estimation

1.6 CONSULTANCY SERVICES BY WAPCOS

Keeping the conceptual planning in view, the Govt of Rajasthan Urban Development & Housing and Local self Government (UDH&LSG), Deptt considered the implementation of Ayad River Front Development Project in Udaipur and invited WAPCOS to make a field visit to the project area and submit an Approach Paper for the project. Accordingly, an interdisciplinary team of experts of WAPCOS comprising of water resources, hydrology, water supply & sewerage system, river front beautification and environment experts visited Udaipur on 24th & 25th September, 2012, held discussions with officials of Udaipur Improvement Trust (UIT) and other departments and submitted a detailed Approach Paper for "Ayad River Front Development Project" through river channelization, abatement of pollution and river front beautification 'for consideration of UDH&LSG Deptt, Jaipur.'

This was followed by a submission of Technical and Financial proposal by WAPCOS Limited to UDH & LSG, Jaipur for providing consultancy services for preparation of Detail Project Report for Ayad River Front Development Project, Udaipur during October, 2012

The technical and financial proposal for Consultancy Services for Preparation of DPR of Ayad River Front Development Project, Udaipur submitted by WAPCOS was vetted threadbare by UDH & LSG, Govt. of Rajasthan, Jaipur. After scrutiny, they have awarded the consultancy work to WAPCOS at a cost of Rs 70 Lakh wide their letter no. F(NRCP-04) / RUIFDCO / NRCP / 2012-13 / 18379 dt 06.12.2012.The agreement between RUIFDCO and WAPCOS has been signed on 6.3.2013. The completion time for preparation of DPR is six months from the date of agreement. A copy of Letter of Award is given in **Annex- 1.1.**

1.7 SUMMARY OF INCEPTION REPORT (MARCH, 2013)

The Inception report of the project was prepared by WAPCOS and submitted to RUIFDCO, UIT and all other concerned in March, 2003. The layout of the inception report was as under:

Chapter-I	:	Introduction
Chapter-II	:	Salient Characteristics of the Project Area
Chapter-III	:	Methodology
Chapter-IV	:	Appraisal and Feasibility
Chapter-V	:	Current Status of Activities and Studies

The Chapter on "Current Status of Activities and Studies" contained the review of various documents and initial findings. The documents/reports reviewed were as follows;

- Survey output of Ayad River
- Udaipur City Master Plan (year 2022)
- Water supply status
- Ground water status
- DPRs for Conservation and Sustainable Management of Pichola and Fatehsagar Lakes (May,2007)

After studying the documents/reports a brief summary on each of them was also provided in the inception report. The inception report was also provided with progress on various studies on hand viz Sewerage System and Sewage Treatment Plants, River Channelization and River Front Beautification aspects etc. However such studies were further continued to firm up the assessments made based on availability of additional data from local authorities and discussions with them by WAPCOS experts. The outcome of further studies on each component of the project forms the part of this report.

CHAPTER –
THE PROJEC

CHAPTER – II
THE PROJECT

2.1 GENERAL

The River Front Development Project comprises of the following three components:

i) River Channelization
ii) Abatement of Pollution
iii) Landscaping and River Front Beautification

All these components have been deliberated in details in various chapters of this report. A broad overview, however, is given below:

2.1.1 River Channelization

The river channelization aspect as per scope of work comprises of mainly two aspects. One is regarding the assessment of flood that can reasonably occur considering the rainfall, size and type of catchment area and other physical and climatological parameters. Having worked out the design flood for the river as per standard guidelines, it would be necessary to establish as to how the flood discharge would get channelized without causing damages to the adjoining area. This will entail further study to assess the existing carrying capacity of the river and if the existing capacity is not sufficient what should be the size of the channel, lined or unlined to ensure smooth exit of the flood discharge. The modified size of the channel would further depend on the availability of space on the banks and if the required space is not available it would need to be seen whether we can allow part of the flood discharge to spill beyond the banks and recommend to the city authorities accordingly to be ready with the remedial measures, if it so happens.

The second aspect to be studied is regarding the availability of water during the lean period from October to May when practically there is no rainfall and consequent runoff which can sustain the environmental and ecological balance of the river channel.

For lean period flow, it is considered that domestic waste water generated from the city can contribute substantially if the same is treated to a reasonably good level and made available in the river for reuse for various purposes. Secondly, the lean period flow can also be augmented with fresh water if there is any option for interbasin transfer of water from the adjoining basin having surplus water or the contribution from ground water if the prevailing ground water table is high in the city. All these aspects would need to be studied on case to case basis and give recommendations accordingly.

2.1.2 Abatement of Pollution

Pollution is taking place in the river from discharge of untreated domestic and industrial waste water. This has to be checked by providing a good network of sewerage system in the city which is linked with Sewage Treatment Plants (STPs) or Common Effluent Treatment Plants (CETPs) as the case may be before the waste water is let into the river. The level of treatment has also to be such that it can be reused for various designated purposes.

The scope of work envisages that the existing sewerage system of the city would be reviewed and suggestions made for its strengthening or enlargement if found inadequate or if all the areas are not covered. At the same time, assessment would also need to be made regarding collection and treatment of waste water by suggesting the installation of STPs and CETPs with regard to their capacity and location in the city area. This will be done so in consultation with officials of client and field inspections.

The solid waste management aspect shall also be looked into and suggestions would be made to adopt certain models like door-to-door collection etc. for disposal of solid waste which at present is also being dumped in the river.

2.1.3 Landscaping and River Front Beautification

As per scope of work, the studies regarding landscaping and river front beautification aspect of the project are to be carried out and conceptual plans are to be prepared considering vacant spaces on banks, width of the river etc.

The conceptual plan may include development of sites for recreational purposes, community centres, playground, pathway, sitting area, development of road with promenade, cycle track with cycle stand, walkway, lighting, Toilet Blocs, Food Kiosks, landscaping on the edges of the river bed, parking etc. The study will also include identified 3 to 4 typical sites for detailed design and costing etc.

2.2 COMPONENTWISE ACTIVITIES

2.2.1 River Channelization

2.2.1.1 Office Activities

a) Flood Studies

i) Identification of Sub- Catchments of River & computation of area, slope etc.

ii) Identification of relevant R.G stations

iii) Computation of 24 hr max. rainfall using frequency approach for required Return Period

iv) Splitting of 24 hr rainfall into hourly rainfall increments using sub-zonal Flood Estimation Reports (FER) of CWC

v) Computations of Unit Hydrographs (UGs) of each sub-catchment using FER of CWC

vi) Computation of Flood Hydrography of each sub-catchment using appropriate values of rainfall increments & above UGs

vii) Routing of Flood from each sub-catchment upto the identified nodal points using Muskingum Method of channel Routing

b) River Survey Output

Study of survey output and preparing statements for;

i) River x-sections at different chainages

ii) Encroachments with respect to revenue records

iii) Identification of vacant spaces villagewise and stretchwise

iv) Superimposition of design flood on river sections at all Nodal Points to ascertain the extent of flood accommodation in the river and/or the extent of spill beyond the banks in case of inadequate carrying capacity.

c) Water Level Profile Studies

Water level Profile studies both for existing condition and design conditions with the help of available software at different chainages using different combinations of width & depth, bed slope, side slope etc to provide adequate carrying capacity according to the design flood and local conditions for smooth channelization.

d) Water Availability Studies

Study of water availability during lean period (Oct-May) to establish;

i) the extent of river flow is availability in lean season

ii) to device ways to increase river flow to the extent feasible during lean season.

e) Impounding Reservoirs

i) To identify the locations of impounding reservoirs at site

ii) Finalizing the parameters of impounding reservoirs viz size, height, storage etc.

f) Lining of River Section

i) Review the necessity of lining especially in the city area for smooth channelization.

ii) Examine the extent of lining

g) River Siltation

i) Assessment of silt load/sqkm/year

ii) Status of silt accumulation in the river and assessment of quantity

iii) Cost of silt removal

2.2.1.2 Field Activities

i) Verification of survey.

ii) Field verification of river section at Nodal Points

iii) Site visit to existing check dams and collection of data

2.2.2 ABATEMENT OF POLLUTION

2.2.2.1 Office Activities

i) Review of Sewerage System Master Plan, if any

ii) Review and Assessment of existing arrangement for collection of domestic wastes water entering nallah/river for;
- Colonies/area covered by sewerage system
- Colonies/area not covered by sewerage system

iii) Review and Assessment of existing arrangement for treatment of domestic waste water for,
- Colonies covered by sewerage system
- Colonies covered by sewerage system but not treated

iv) Assessment of requirement of sewerage system and Sewage Treatment Plants (STPs) for;
- Present Scenario
- Future scenario

v) Review and assessment of treatment of Industrial waste water entering nallah considering following aspects;
- Existing quantity of industrial waste water entering nallah
- Extent of industrial waste being treated
- Quantity of untreated industrial waste
- Existing Capacity of CETPs and their locations
- Requirement of additional CETPs for
  - Present scenario
  - Future scenario

vi) Studying following aspects of solid waste management
- Extent of solid waste to be handled

- Present arrangements of solid waste disposal
- Review of solid waste management plan, if any
- Suggestions for solid waste management for;
  - Present Scenario
  - Future scenario

vii) Assessment of water quality for

- River water
- Ground water

viii) Assessment of water quality of domestic and industrial waste entering the river/nallah

2.2.2.2 Field Activities

i) Identification of untreated domestic waste water entry points into nallah/river

ii) Examining possibility of linking the above untreated waste water points with existing sewerage system or proposing new/ additional sewerage system for collection of such waste water.

iii) Identification of untreated industrial waste water entry points into nallah/river

iv) To identify the location of STPs and CETPs at site.

2.2.3 LANDSCAPING & RIVER FRONT BEAUTIFICATION

2.2.3.1 Office Activities

i) Review of the existing development along the river/ nallah to identify vacant space.

ii) Study of Master plan, Zonal plans, special area development plan and Heritage Laws to identify the river front development with the existing frame work.

iii) Identification of Heritage, Ecological or Historical sites and to suggest measures for its protection and development.

iv) Identification of spaces for the development of Parks, Gardens, nurseries, museums, trade grounds, tourists oriented activities etc.

v) Study of tourists characteristics of the city, their activities and revenue generating potential and to make provision for museums, craft centres etc.

vi) Examining the prevailing ecology, existing water systems/flora/vegetation and propose development systems/technologies.

2.2.3.2 Field Activities

i) To Visit vacant spaces on river banks as identified based on survey output
ii) Identification of sites for
- Landscaping
- Parks
- Heritage sites
- Walk ways, promenades
- Peripheral roads

iii) Identification of sites for impounding reservoirs

CHAPTER – II
PHYSIO-CLIMATOLOGICA
CHARACTERISTIC OF PROJECT AREA

CHAPTER – III

PHYSIO-CLIMATOLOGICAL CHARACTERISTICS OF PROJECT AREA

3.1 TOPOGRAPHY

The Udaipur City has a hilly terrain and undulating topography with lakes and tanks. The Elevated plateau within the town is occupied mainly under settlements and likewise other hilly towns. The plane areas are developed for housing. The Aravalli hills with the inter-mountain plateau, deeply dissected by streams and rivers. There are number of surface water streams like Ghmbiri, Sabarmati, Banas and its highly metamorphosed and so the depressions on the surface are filled with the rainwater in the form of natural tanks.

The area comprises of low Aravalli hills with intrusions of black lava rocks and metamorphic rocks. This is mostly a tribal area occupied by Bhils, Garasiyas and Damors. The area is rich in natural vegetation, which grows on the slopes of the Aravallis, and in the wetland areas but excessive felling of trees has degraded forests. Tank water irrigation is most common. The area produces maize as the chief food crop of the Kharif season but in irrigated areas, paddy is also grown. In the Rabi season, wheat, gram and oil seeds are the main crops. The non-irrigated land, crops are depending on the rain water where as part of the irrigated land is cultivated mainly for the water based crops. Yet the water scarcity at most of the places is the major constraint in agriculture practices.

3.2 GEOMORPHOLOGY & DRAINAGE

3.2.1 Geomorphology

The district is characterized by undulating topography. Towards the western part of district, series of Aravalli hills run along NE-SW direction. A typical plain of gneisses and granites without any alluvium cover is observed to the east of Aravalli ridges.

Geomorphologically the district is divided into following units:

Origin	Land Forms	Occurrence in the District
Fluvial	Valley Fill	Scattered in the entire district in between structural hill
Denudation	Pediment	Main concentration in north east and scattered in entire district
	Buried pediment	Main concentration in east and scattered in entire district
Hill	Structural hill	Covers entire district except north east

3.2.2 Drainage

The district has a well developed drainage system. The main rivers of the district are Jakham, Som, Wakal, Sei, Sabarmati, Gomti and Berach (Ayad river is a tributary of Berach). These are monsoon fed rivers and flow more rigorously in rainy season. Jakham, Gomti and Som drain the south eastern plains of the district. Wakal, Sabarmati and Sei rivers flow through the valley region of Aravalli ranges in the south west of the district. These rivers have been dammed at various sites and thus several artificial lakes have been created in the district. Important ones are Jaisamand, Udaisagar, Pichhola, Fatehsagar, Som Kagdar and Jakham. Drainage density in most part of the district varies from 0.5 to 0.7 km/km^2. Drainage density is from 0.7 to more than1km/km^2 in the south eastern and south western part of the district. In the north central part of the district its low and ranges between 0.3 to 0.5 km^2.

The drainage area of various Tehsils corresponding to different river basins is given below:

Sl. No	Name of Tehsil	Area in Sq. Km.			
		Sabarmati	West Banas	Mahi	East Banas
1	Dhariyawad			1322	
2	Girwa			1592.4	540.6
3	Jharol	793		597.9	82.2
4	Kherwara	179.4		673.9	

5	Mavli			621.4	179.6
6	Salumbar			805	
7	Sarara			775.6	
8	Bhinder (Vallabhnagar)			149.4	637.6
9	Kotra	2294	2.2		1.0
10	Gogunda	161.8			841

3.3 AYAD RIVER & UDAIPUR LAKE SYSTEM

The river Ayad (also called River Ahar) and other tributaries originate from western hills extending in North-South direction with average height varying between 650 to 900 m above MSL. The Central hills of the Berach Basins mainly extend from North-West to South-East direction in the central part of the region and forms inner Girwa plains, which has average height of 600 to 700 m above MSL. The inner Girwa plain is surrounded by western and central hills draining water into the River Ayad. Udaipur city and other settlements are situated in this plain. The drainage pattern of the area supports the water front, which is one of the important considerations for settlement. The important lakes of the Udaipur viz., Badi, Fateh Sagar, Pichola, Dudh Talai, Rang Sagar and Swaroop Sagar area are located in this plain. The original drainage pattern was very much intact with the lake system and support recharging and maintaining water level in the area. However, the changing land use pattern, human interventions and climatic variations affected the natural drainage pattern to an extent that recharging of Ayad river system is to be reassessed for the sustainable management.

The upper Berach Basin can be divided into four geomorphic sub-regions, which are as follows:

i) Western Hills

ii) Central Hills

iii) Inner Girwa Plain or Ahar Plain

iv) Outer Plain or Berach-Katara Plain

The lakes in Udaipur namely Fatehsagar, Pichhola, Rangswaroop and Swaroopsagar are interconnected. The overflow of these lakes goes into Ayad River which meets Berach River through Udaisagar reservoir. Ayad River ultimately goes into Ganga River through Banas River, Chambal River and Yamuna River.

The Udaipur lake system may be divided on the basis of surface water drainage as Pichola, Fatehsagar Lake, and Udaisagar lake systems that include the following water bodies:

1. **Pichola Lake System:** Pichola, the mother lake, Rang Sagar (water spread area 4.46 ha), Swaroop Sagar (water spread area 8.0 ha), Kumaria Talab (water spread area 2.2 ha), Dudh Talai (water spread area 0.7 ha)
2. **Fatehsagar Lake System:** Fatehsagar Lake, Badi Lake, and Bada Madar & Chhota Madar Lakes
3. **Udaisagar Lake System:** Udaisagar Lake, located at downstream of city and above lake systems

The management of these two lake systems is directly and indirectly related to each other. The water inflow and exchange in water bodies are being controlled through canals and is manually operated through gates. The recharging of Pichola and Fatehsagar depends upon the rainfall received in both the catchments, which is related to the intensity and duration of the rain. The surplus water in one of the water body is being released to other interconnected water body depending upon the water levels and requirement.

The combined flow from Pichola and Fatehsagar lakes ultimately goes into River Ganga through Ayad River, Udaisagar, Banas River, Chambal River and Yamuna River in that order.

River Ayad is non-perennial and receives water from its own catchment, Bada Madar, Chhota Madar, Badi Reservoir, Fatehsagar Lake and Pichola Lake. In addition entire untreated domestic as well as industrial waste water of Udaipur is discharged into the river. The river on downstream feeds the lake Udaisagar. Overflow from Bada Madar and Chhota Madar can be diverted to Fatehsagar Lake through Chikalwas feeder. Overflow from Badi Reservoir also feeds the Fatehsagar Lake. Fatehsagar Lake and

Pichola Lakes are linked through a canal via Swaroop Sagar and Rang Sagar Lakes. Overflow from Fatehsagar and Pichola Lakes enters river Ayad through nallah.

River Ayad in Udaipur is a life line river for the people of the city. Over the passage of time and expansion of the city, the environmental and ecological balance of the river has deteriorated considerably. This deterioration has taken place mainly due to the factors like uncontrolled and untreated inflow of sewage from the city, encroachments in the river bed and banks, inadequate river flows, dumping of solid waste in the river, siltation and uncontrolled weed growth etc. The Government of Rajasthan is very keen to carry out the remedial measures in order to correct the present situation and bring the River and Lakes to better shape.

Length of River Ayad from Thur Pick-up Weir below Madar to Udaisagar Lake is 26 km. Out of this 11 km is through populated city area. The length of River Ayad for the current study is also 26km. Index map showing Ayad River is given in **Plate-3.1.**

3.4 RAINFALL & CLIMATE

Average annual rainfall (1997-06) of the district is 657mm. However normal rainfall for the period 1901 to 1970 is 633.50mm. The southern part of the district receives slightly more rainfall. The mean annual rainfall is 854.4 mm at Dhariyawad and minimum average rainfall is 566.7 mm at Sarara.

The climate of the district is dry except S-W monsoon season. The cold season is from December to February and is followed by summer from March to June. From mid of September to end of November constitute post monsoon season.

The drought are in general of mild or normal type, however severe types of drought are recorded at Udaipur, Gogunda, Kherwara, Jharol, Kotra and Vallabhnagar. Very severe type of drought has been recorded in the year 1987 at Kotra. One day maximum rainfall distribution curve for Udaipur is given in **Plate-3.2.**

3.5 CATCHMENT AREA OF AYAD RIVER

The total catchment area of Ayad River from its origin i.e. upstream of Bada & Chhota Madar Reservoirs upto its confluence in Udaisagar Reservoir on Berach river is of the order of 563.2 sqkm.

The catchment of Ayad River is intercepted by a number of tanks / lakes constructed for domestic and industrial water supply to the city of Udaipur. The major ones are mentioned below:

i) Bada Madar Reservoir
ii) Chhota Madar Reservoir
iii) Badi Madar Reservior
iv) FatehSagar Lake & its system
v) Pichola Lake & its system
vi) Lakhawali Reservior

Fatehsagar Lake System comprises of the following:

- Fatehsagar Lake itself
- Badi Lake
- Bada Madar Reservoir
- Chhota Madar Reservoir

Badi Lake is situated upstream of Fatehsagar and its overflow enters Fatehsagar Lake. It is located in Girwa Tehsil of Udaipur District, 14 Km away from Udaipur City. The catchment area of Badi Lake is 15.54 sqkm (6sq miles) with gross and live storage capacities of 104.83M cum (370.15 Mcft) and 72.37M cum (255.55Mcft) respectively.

The salient features of Badi Lake are given in **Annex 3.1.**

The overflow of **Bada Madar** and **Chhota Madar** Reservoirs joins Ayad river near Thur village, where a Thur pick-up weir has been constructed to divert the overflow water of these reservoirs in Fatehsagar Lake through the Chikalwas Feeder channel. The catchment area of Ayad river intercepted by Bada Madar Reservoir is to the extent of 80.29 sqkm (31 sqmiles) and that of Chhota Madar Reservoir to the extent of 20.72sqkm (8 sqmiles). The grass and live storage capacities of Bada Madar are 23.79Mcum (84 Mcft) and 22.01 Mcum (78Mcft) respectively. Similarly, the gross and live storage capacities of Chhota Madar are 8.5 Mcum (30Mcft) and 7.65Mcum (27Mcft) respectively. Both Bada Madar and Chhota Madar Reservoirs are located in Girwa Tehsil of Udaipur District, 16 km Udaipur on Udaipur – Gogunda Road.

The salient features of Bada Madar and Chhota Madar Reservoirs are given in **Annex – 3.2** and **Annex – 3.3** respectively.

Fatehsagar Lake intercepts the catchment area of Ayad river to the extent of 20.72 sqkm (8 sq miles) over & above that of Badi Lake which is located in the catchment area of Fatehsagar Lake. The gross and live storage capacities of Fatehsagar are 120.92 Mcum (427 Mcft) and 69.95 Mcum (247 Mcft) respectively. This lake is being used predominantly for drinking water supply to Udaipur city.

The salient features of Fatehsagar lake is given in **Annex – 3.4.**

Pichola Lake System comprises of the following:

- Pichola lake, itself which is called the mother lake
- Rangsagar Reservoir
- Swaroopsagar reservoir
- Kumaria Talab
- Dudh Talai Reservoir
- Nandeshwar Reservoir

Nandeshwar Reservoir located in Girwa Tehsil of Udaipur District, intercepts the catchment area of Pichola Lake being on its upstream side. This dam was constructed as flood control scheme for Udaipur city and its overflow joins Pichola lake. The catchment area of Nandeshwar reservoir is 51.8 sqkm (20 sqmiles). The gross and live storage capacities are 39.65 Mcum (140 Mcft) and 35.25 Mcum (125 Mcft) respectively.

The salient features of Nandeshwar reservoir are given in **Annex – 3.5.**

Rang Sagar and Swaroop Sagar are parts of Pichola lake complex which are interconnected with each other as well as with Pichola lake. Pichola lake is also linked with Fatehsagar lake through Rang Sagar / Swaroop Sagar and a feeder channel. Thus both Pichola and Fatehsagar lakes are interconnected reservoirs which help in diverting the surplus water during monsoon period from one lake to another.

Dudh Talai reservoir is also a part of Pichola Lake.

Goverdhan Sagar Reservoir overflow joins Ayad River on the downstream of Sewa-Ashram Bridge in Udaipur city via Futa Talab. It is located in Girwa Tehsil of Udaipur District is 10km from Udaipur city. Goverdhan Sagar is also linked to Pichola Lake through a Pichola – Goverdhan Vilas link channel. The catchment area of Goverdhan sagar Reservoir is10sqkm (3.9sqmiles). The gross and live storage capacities of Goverdhan Sagar is 0.25Mcum (8.8Mcft).

The salient features of Goverdhan Sagar reservoir are given in **Annex – 3.6**

Pichola Lake, located in the heart of Udaipur city, is bigger lake as compared to FatehSagar lake having a catchment area of 142.45 sqkm (55 sqmiles) with gross and live storage capacities of 136.79 Mcum (483 Mcft) and 89.68Mcum (318 Mcft) respectively. The combined surplus flow of Fatehsagar and Pichola lakes joins Ayad River through Gumania wala Nallah. There is additional surplusing arrangement of Pichola Lake as well through Swaroopsagar reservoir which also meets Ayad River.

The salient features of Pichola Lakh are given in **Annex – 3.7**

Lakhawali Reservoir located north of Ayad river is another reservoir whose surplus flow meets Ayad River directly. It is located in Girwa Tehsil of Udaipur District, 10 km from Udaipur on Udaipur – Gogunda road. The catchment area of Lakhawali Reservoir is 15.54 sqkm (6 sqmiles). The gross and live storage capacities of this tank are of the order of 20.67 Mcum (73 Mcft) and 13.88 Mcum (49 Mcft) respectively.

The salient features of Lakhawali Reservoir are given in **Annex – 3.8**

Thus it may be stated that Ayad river which is a tributary of Berach river which in turn meets Banas Sub – basin receives water from a network of various lakes namely, Fateh Sagar and Pichola lake systems as well as directly from Lakhawali reservoir and Goverdhan Sagar reservoir. The river ultimately meets Udaisagar Reservoir being a terminal reservoir and receiving all the inflow from Ayad River.

Udaisagar is a medium irrigation scheme located near village Biohari in Girwa tehsil of Udaipur District, 3 km from Hindustan Zinc colony at Debari. The gross and net catchment area of this reservoir is 479 sqkm (185 sqmiles) and 196.84 sqkm (76 sqmiles) respectively. Its gross and live storage capacities are 311.52 Mcum (1100 Mcft) and 276.12 Mcum (975 Mcft) respectively. It is the largest reservoir in Udaipur in terms of its catchment area and capacity.

The salient features of Udaisagar Reservoir are given in **Annex-3.9.**

From the above, it would be noted that the catchment area of Ayad River which is 563.2 sqkm is intercepted to the extent of 357.06 sqkm i.e. 63% by various lakes/ reservoirs/ Talabs. The catchment area map of Ayad River is given in **Plate-3.3.**

3.6 SOILS

Most of the soil of Udaipur district has developed in situ. It varies from clay loam to heavy clay. The distribution of the soils in the district is as follows

Sl. No.	Type of soil	Total area in hectares	Tehsils
1	Clay loam	74477	Mavli, Girwa and Vallabhnagar
2	Red clay	147219	Salumbar, Kotra, Sarara, Kherwara and Dhariyawad
3	Heavy clay	322346	Gogunda, Jharol and Girwa

It would be noted from above that the soils of the area are medium to heavy textured having brown to grayish brown colour. The fertility of these soils is medium and soils have good retention capacity. In the foot hills, the soils are shallow to moderately deep. In the valley, the soils are deep to very deep. Based on soil characteristics, rainfall and percentage gross area irrigated, Rajasthan has been divided into 10 agro-climate zones. Udaipur District except Dhariyawad, Salumber and Sarara Tehsils fall under zone IV A-'Sub-humid Southern Plain & Aravali hills'. The remaining three Tehsils fall under zone IV B-'Humid Southern Zone'. Soil map of Rajasthan is given in **Plate-3.4**

3.7 GEOLOGY & PHYSIOGRAPHY

Aravali Super Group covers the major part of the district. The general stratigraphic sequence of the rock in the district is classified as under:

Post Delhi		**Erinpura Granite**
Post Super Group	Ajabgarh Group	Schist, Gneiss, Marble, Amphibolites
	Alwar Group	Quartzite
Aravali Super Group	Phyllites, Schist, Quartzite, Dolomite, Conglomerate Marble, Metavolconics	
Pre Aravali	Schist, Gneiss and Migmatites	

In Udaipur district, Aravali hills enter from Sirohi district in the southwest and extend in northeast direction. Towards southeast the hills loose their height and the topography becomes rolling and undulating. This region is extensively cultivated. The region has shallow valleys, low hills with pastures. The hilly portion is to +-1000 meters above MSL, lying between Kumbhalgarh and Gogunda is called 'Boharat' plateau. The longest hill of Udaipur district is of 25 Km long has the highest peak of +-1328 meters above MSL called 'Jarga'. From southwest to northeast there are numerous ridges. In the northeast, these ridges form a broad pene-plain with an elevation of +-450 to +-600 meters. The central and eastern portions f this plain is drained by the river Banas and its tributaries. Along these rivers is situated the main agricultural area because of its thick alluvium deposits. The southeastern portion of Udaipur division is considerably rugged and dissected by numerous nallahs and rivulets interspersed amongst undulating flat-topped hills. This region is known as 'Chappan'. The high hills and almost parallel ranges of west and northwest of Udaipur district are mainly of Aravali. The southwest and southern portions are of

Vindhyas and the admixture of Vindhyas and Aravali. 'Macchala Magra' hill in Udaipur city is a classical example of the admixture of Aravali and Vindhyas. The southeastern track of Udaipur district is comprised of Vindhyas, Deccan trap and their admixture.

Udaipur district is particularly rich in mineral resources, as a large variety of important metallic and non-metallic minerals found in the districts viz. ores of copper, lead, zinc, silver, rock phosphate, asbestos, calcite, lime stone, barites, emerald and marble etc are important. Geological map of Udaipur is given in **Plate-3.5.**

3.8 HYDRO-GEOLOGICAL ASPECTS OF UDAIPUR

The occurrence of ground water in the district is mainly controlled by the topographic and structural features present in the geological formations. Groundwater occurs mainly under unconfined condition to semi-confined in saturated zone of rock formation. Its occurrence is controlled by topography, physiography and structural features of the geological formations. The movement of the groundwater in hard rock areas is governed by size, openness, interconnection and continuity of structural weak planes while in unconsolidated rocks groundwater movement takes places through pore space between grains. Water bearing properties of different aquifers are described below:

Groundwater in Bhilwara Super Group

The eastern part of the district is underlain by rock belonging to Bhilwara super group. These aquifers occur predominantly in Bhinder (Vallabnagar), Salumbar, Sarada, Mavli Blocks. Few intrusive are also found which have low permeability. Groundwater in these rocks occurs under water table conditions in the zone of weathering and fracturing, joints and foliation planes. When schist's are inter mixed with gneisses it forms a better aquifer. The rate of recuperation is slow in gneisses and schist, it is comparatively faster in granites. The depth of dug wells ranges from 15 to 35metres and the Yield varies from 20m^3/day to 60 m^3/day. The depth to water level in the area tapping this aquifer ranges from 3m to 35m.

Groundwater in Aravalli

Aravalli Supergroup consisting of Phyllites, Quartzites and dolomite form important aquifer especially around Jharol, Udaipur and Barapal. Ground water occurs in weathered zones like schistosity, joint, fissures and bedding planes. Quartzites generally occur intercalated with phyllites and are well jointed. Ground water in phylites occurs mainly in fractured cleavages. Carbonate formation are cavernous, wherever calcium content is high, area around Jhamarkotra of Girwa block is potential and supplies water to Udaipur city. The depth to water level varies from 5 to 20 m below ground level where as depth of wells varies from 8 to 30 m below ground level. The average yield of wells is around 40 m^3/day. In carbonates the yield of wells varies from 20 to 200m^3/ day.

Groundwater in Delhi Super Group

The formations belonging to Delhi super group are exposed in the western part of the district. Ground water in Quartzite's occurs in the joints and fracture. Depth to water level is generally shallow. The yield of wells averages 50m^3/day. Ground water in biotite schist and hornblende schist occurs in joints and fractures. The depth to water level ranges from 5 to 20 m below ground level and yield of wells varies from 12 to 250 m^3/day. In calc schist and calc gneiss the yield of dug wells varies from 10 to 100 m^3/day. The yield is high when the lenticular cavities along calc bands are saturated and interconnected.

Groundwater in Alluvium

In the past Ground water occur under unconfined conditions in the unconsolidated formations consisting of sand, gravel, pebbles, cobles and boulders in areas close to river courses near Kanpur area. This aquifer has already dried out due to over exploitation.

CHAPTER – I

DATA COLLECTION AND SUMMARY O
PROJECT RELATED REPORTS
DOCUMENT

CHAPTER – IV

DATA COLLECTION AND SUMMARY OF PROJECT RELATED REPORTS & DOCUMENTS

4.1 DATA COLLECTION, REPORTS & DOCUMENTS

4.1.1 Data / Reports

The Data / Reports collected from various Departments related to the assignment are given below:

i) Survey output of 26 km length of Ayad River from Thur Pick-up weir to Udaisagar reservoir showing alignment in Plan, L-section and Cross-section (containing 26 sheets)

ii) Final DPR for Conservation and Sustainable Management of Pichola Lake (May 2007)

iii) Final DPR for Conservation and Sustainable Management of Fatehsagar Lake (May 2007)

iv) Udaipur City Master Plan (1997-2022)

v) Salient features of various Lakes/ Tanks in Udaipur city

vi) PHED Note regarding Water Supply to Udaipur city

vii) Data regarding Ground Water Levels in Badgaon and Girwa Blocks (for year 2012)

viii) Rajasthan State Pollution Control Board Report, dated: 22/01/2013 (containing data on ground water quality)

ix) Detail of Dewas Stage-II Project with Index map

x) PHED note regarding sewerage system

4.1.2 SOI Toposheets

The following SOI toposheets as relevant to project area have been obtained by WAPCOS:

S.No.	Toposheet No.
1	45H/9
2	45H/10
3	45H/11
4	45H/14
5	45H/15

4.2 SURVEY OUTPUT OF AYAD RIVER

The survey output of 26 km length of Ayad River comprising of Plan, L-sections and X-sections has been examined for utilizing the same for various studies in the project. The maps showing contours have also been provided.

The survey output is appended in volume II A of this Report.

4.3 CITY DEVELOPMENT MASTER PLAN (2022)

Master Plan has been prepared by the Udaipur Town Planning Department considering future scenario for the year 2022. The base year considered in the Master Plan was year 1997. An Advisory Committee headed by Minister for Urban Development and Housing Department was also constituted by Government of Rajasthan vide Government Notification dated 30.08.1989 to advise the Chief Town Planner, Rajasthan in the preparation of Master Plan for urban area of Udaipur City.

The relevant highlights of various aspects of Udaipur City Master Plan (1997-2022) are as under:

(i) Population : As per 1991 Census, Udaipur City population was 3.89 Lakh which was projected as 5.99 Lakh in 2011 and 8.3 Lakh in 2022. The increase between 2001 to 2011 was envisaged as 21,000 per year and that between 2011 to 2022 again as 21,000 per year. **(The modified population projections worked out by WAPCOS based on 2011 census are given in chapter – VI)**

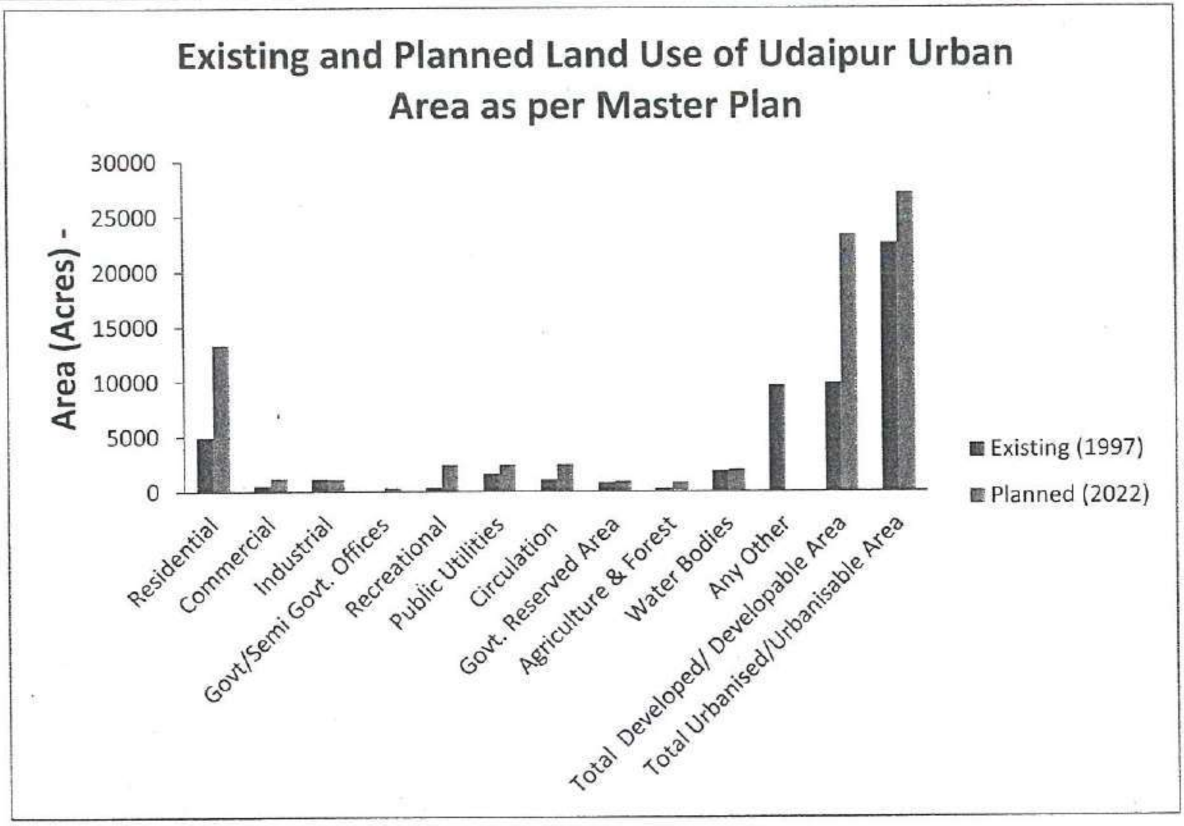
(ii) Land Use : In 1997, the urban area of Udaipur was 22601 acre in which 9879 acre was developed area i.e. 43.71%. Against this, it was envisaged that urban area in 2022 will increase to 27180 acre in which 23,380 acre will be the developed area i.e. 86.03%.

The following table shows the break-up of land use of different categories for base year 1997 and that projected for the year 2022:

Table - 4.1: Existing and Planned Land Use of Udaipur Urban Area as per Master Plan

(In Acres)

Sl. No .	**Land Use**	**Existing (1997)**			**Planned (2022)**		
		Urban Area	**% of**		**Urban Area**	**% of**	
			Developed Area	**Urbanised Area**		**Developable Area**	**Urbanisable Area**
1.	Residential	4988	50.50	22.07	13380	57.23	49.23
2.	Commercial	548	5.55	2.43	1220	5.22	4.49
3.	Industrial	1152	11.66	5.10	1110	4.75	4.08
4.	Govt/Semi Govt. Offices	96	0.97	0.42	340	1.45	1.25
5.	Recreational	358	3.62	1.58	2430	10.39	8.95
6.	Public Utilities	1632	16.52	7.22	2420	10.35	8.90
7.	Circulation (Roads, Rail etc)	1105	11.18	4.89	2480	10.61	9.12
Total of Developed/ Developable Area:		**9879**	**100**	**43.71**	**23380**	**100**	**86.02**
8.	Govt. Reserved Area	865	-	3.83	950	-	3.50
9.	Agriculture & Forest	285	-	1.26	850	-	3.12
10.	Water Bodies	1900	-	8.41	2000	-	7.36
11.	Any Other	9672	-	42.79	-	-	-
Total Urbanised/ Urbanisable Area		**22601**	-	**100**	**27180**	-	**100**



iii) Water Supply	:	The sources of water supply in the city are Pichola, Fatehsagar, Badi and Jaisamand lakes besides wells, tubewells, Baories and hand pumps. Against the present demand of 140 lpcd, the water supply demand envisaged in Master Plan by year 2022 is of the order of 170 lpcd.
iv) Sewerage & Drainage	:	There is no planned Sewerage and Drainage System existing in the city. In old city area, the dry latrines have though been converted into Flush-latrines but the waste is finding its way into open drains which are all discharging in Ayad River. New Colonies however have septic tanks along with flush latrines. Areas like Chandpol, Brahmpol, Jara Ganesh Ji, Jagdish Chowk etc have slope towards Pichola, Rangsagar & Swaroop Sagar lakes. The waste water from these areas flowing into open drains finds its way in above lakes ultimately. Similarly, the waste water of OTC scheme, Alkapuri, Ambhawgarh, Ambhamata Scheme, Malatalai, Haridas Magri etc let into open drains is also meeting Pichola and Fatehsagar lakes. There is thus urgent need to formulate properly planned schemes

for the disposal as well treatment of city waste water. The Master Plan however does not show any road map for the same.

However, two projects for Conservation and Sustainable Management of Pichola and Fatehsagar Lakes are under implementation with funding from GOI, Ministry of Environment and Forests under National Lake Conservation Plan (NLCP).

Map showing Urbanisable Area of Udaipur City for Year 2022 as per Master Plan is enclosed at **Plate 4.1**

4.4 CONSERVATION AND SUSTAINABLE MANAGEMENT OF PICHOLA LAKE, UDAIPUR (DPR, MAY 2007)

The water spread area of Pichola Lake is 696 ha and its maximum depth is 10.5m towards the west side where Kotra River meets the lake. The Catchment Area is 142.45 sqkm. Initially this lake was being used both for irrigation and water supply, but now it is reserved for supplying drinking water only to the city which is to the extent of 19.5MLD.

The lake is facing acute environment problems related to silting, degradation of water quality, reduction in water quantity, weed infestation, sewage, storm water and solid waste outfalling, lack of infrastructure for tourists etc.

Tetra Tech India Ltd, Delhi was assigned the job of preparation of DPR for "Conservation and Sustainable Management of Pichola Lake System, Udaipur" as per guidelines of National Lake Conservation Plan (NLCP) for seeking financial assistance from the Ministry of Environment and Forests (MOEF), Govt. of India. PDCOR Limited, Jaipur is the Coordinating Agency for the lake conservation and development projects. The DPR had been submitted by Tetra Tech in May, 2007. The project is being funded by MOEF, GOI under NLCP. The cost of the project is Rs.115 crore comprising 70% share of Govt. of India and 30% share of Govt. of Rajasthan. The implementation period is 3 years from the date of sanction of the project.

The reports have identified various problems affecting the environment & eco-system of the lake and have outlined the remedial measures for each one of them. These are;

- Desilting and dredging to restore the lake capacity
- De-weeding of lake for exposing the water surface to atmosphere for exchange of oxygen
- Biodiversity conservation zone to be part of the main lake
- Anaerobic conditions of lake to be changed to aerobic state by installing & ozoniser-cum-floating fountains.
- Medium and small islands to be protected by various conservation measures removal of encroachment and rehabilitation thereof with development of vacated area is necessary to maintain perimeter of the lake and to control pollution
- Shore line protection with strengthening of fence and boundary walls maintaining aquaculture for ecological balance by introducing fish seed of suitable variety
- Lake water quality not to be compromised at the cost of recreation and enjoyment while using motorized boats
- Idol immersion activity to be shifted to other alternate places which may be dealt sensibly after taking people in confidence
- Shifting of Dhobi Ghats at new site
- Sewage inflow taking place to the extent of 25.92 MLD in Pichola Lake, 8.05 MLD in Rangsagar Lake, 2.42 MLD in Swaroopsagar Lake besides contribution from non-point sources of pollution need to be intercepted, diverted and disposed in the sewer system. NLCP project includes the cost of this component to the extent of Rs. 25 cr for Pichola lake system.
- Storm water inflow to lake may be allowed after segregation of floating matter, debris and solid waste by constructing catch drains, silt arrestors, grit chambers, screen chambers, setting tanks, biological filters and sand beds for water filtration.
- Collection and disposal of solid waste by municipal council need to be strengthened in terms of equipment and infrastructure.

- Clearances/improvement of feeders/ inlets to the lake for better recharging of Pichola lake need to be done
- Removal of encroachments on the feeders
- Green belt in the fringe area needs to the developed
- Face lifting & Aesthetic improvement needs to be done by providing parking places, cafeteria, signage, greenery at available space, resting place, walker's path etc.
- Improvement of roads and pavements
- Control over the invading of cattle and stray animals
- Clearance of water ways and provision of culverts
- Providing wall and railing
- Control over mining and restoration of mined out area
- Construction of Gabion structures, dykes on irrigation schemes
- Afforestation and plantation to create vegetal cover.

Though the implementation period of the project was 3 years, it is understood that the same is still going on perhaps due to constraint of state share and lack of coordination among the implementing agencies.

4.5 CONSERVATION AND SUSTAINABLE MANAGEMENT OF FATEHSAGAR LAKE, UDAIPUR (DPR, MAY 2007)

Fatehsagar is another important and major lake forming part of the network of lakes in Udaipur City. The catchment area of the lakes is 20.72 sqkm. It is 2.4 km long, 1.6 km wide and 11.5m at its deepest point. Its water spread area is about 1 sqkm (100 ha) when full. Apart from its own catchment, it receives water from Pichola lake (being interconnected), Chhota and Bada Madar through Chikalwas feeder offtaking from Thur pick-up weir. The combined overflow of Fatehsagar and Pichola joins river Ayad through Gumaniawala Nallah passing through the city area. The lake was initially dug in year 1678 and then reconstructed in 1889. This is one of the major sources for drinking water supply to the city.

The lake is also suffering from various problems, similar to the one faced by Pichola Lake, which have made the water body highly polluted. The increasing human activity in the catchment area is leading to denudation, deforestation, mining and encroachment. The loss of vegetal cover and exposed land is causing soil erosion which is making the lake silted and reducing its live storage capacity.

Like Pichola, the Conservation and Sustainable Management of Fatehsagar Lake project is also being implemented under the National Lake Conservation Plan (NLCP) of the Ministry of Environment and Forests (MOEF), Govt. of India.

The DPR of the project was prepared by Tetra Tech limited of New Delhi and submitted its report in May 2007, with PDCOR, Jaipur being the coordinating Agency for preparation of DPRs of all the five priority lakes in Rajasthan for funding under NLCP. The total cost of the project is Rs 48.88 crore comprising of 70% share of Govt. of India i.e Rs.34.22 crore and 30% share of Rajasthan Govt. i.e. Rs 14.66 crore.

The DPR envisages all those remedial measures as suggested for Pichola Lake mentioned above. There is a provision in the project cost for interception and diversion of sewage in and around lake to the extent of Rs. 10 crore and storm water collection and screening before entry into lake to the extent of Rs. 5.0 crore.

There are seven different agencies which are responsible for implementation of the project in 3 years time after the sanction of the project, but it is understood to be still not completed due to reasons mentioned above for Pichola Lake.

4.6 CITY WATER SUPPLY

Udaipur is famous for lakes. The lakes are interconnected for purpose of replenishment of water levels in lakes and are used for recreational purpose and also for drinking water. The seepage and percolation of water improves ground water table and charge aquifer also.

There are two valuable lakes in Udaipur City. One is Pichola and another is Fatehsagar. Besides, Jaisamand being very important lake, situated 60 km from Udaipur city keeps key and plays an important role in Udaipur Water Supply System. Pichola lake has its own catchment and is fed by non-perennial river Sisarama. Dewas I dam is situated at upstream in the Arawali range and is connected to Kotra River in 1978, which connects to Pichola lake. The Fatehsagar has small catchment of its own. It is interconnected to Pichola Lake through Rang Sagar, Swaroop sagar and link canal. It is fed by Badi Lake and Chhota and Bada Madar. Further the overflow from Bada and Chota Madar joins to Ayad River and from Chikalwas Feeder Canal branches out and merges with Fateh Sagar. The overflow of Pichola and Fatehsagar lakes enter into Ayad River through Gumaniawala Nallah passing through the city. Udaisagar storage dam is on the downstream of the city on Ayad River.

4.6.1 Udaipur Water Supply from Lakes

For Udaipur city, initially the water supply schemes were commissioned from Pichola Lake as a source in 1968. The water supply scheme with Fatehsagar Lake as a source was subsequently commissioned in the year 1970. Accordingly, the water supply scheme with Pichola lake was again augmented in the year 1976. During the year 1987, Badi lake was considered for augmentation of water supply scheme for Udaipur city. Pichola and Fatehsagar lakes were only reserved for distribution as water supply for Udaipur since 1985.

During the year 1988, when there was drought, an emergency scheme for water supply was framed, viewing existing Jaisamand Dam as Source. This scheme was commissioned in the year 1995. This schemes is designed for 21 MLD (Million Litre per Day) supply. The water supply scheme from Pichola and Fatehsagar lakes were further augmented in the year 1996.

4.6.2 Other Sources

Another scheme was taken into consideration as a result from dewatering of Jhamerkotra mines in the year 1996. Thus the ground water of tubewells of

Jhamarkotra mines played considerable role in water supply in Udaipur city. Water of 8 tubewells of Kharbadiya mines were pumped to Purohito ki Madri. Besides this, department itself has 53 tubewells and 29 openwells/ Baories/ step wells which supplement water to the supply system. Total ground water production is estimated to be about 14 MLD approx.

About 108 Punghats are installed in various localities of Udaipur city. There are 2100 handpumps located at various parts of city. The water from handpumps and Punghats are used for other domestic purpose and free of cost to public.

4.6.3 Mansi Wakal (I) / (Dewas Stage I)

Mansi Wakal (I) Dam has been constructed across Mansi River, which is a tributary of Wakal River which inturn is a tributary of Sabarmati River Basin. This is an interbasin water transfer project from Wakal Sub-basin of Sabarmati Basin to Berach Sub-basin of Banas Basin. This project has been functional since 2000. The gross storage capacity of Mansi Wakal dam is 24.41 Mcum (862 mcft) with 50% dependability. The water supply of 23.25 MLD was commissioned in the year 2007-08 from this dam connecting with Pichola Lake through Dewas (I) Dam and a tunnel of 2.3 km length.

The Salient Features of Dewas Stage (I) are given in **Annex-4.1**

4.6.4 Project under Implementation

The state government has sanctioned Dewas Stage II project in the year 2005. It consists of construction of Akodara Dam on river Mansi River having net storage capacity of 8.52 Mcum (301 mcft), construction of Madri Dam also on Mansi River having net storage capacity of 2.42 Mcum (85.44 mcft), tunnel from Madri Dam 1.33 km and tunnel from Akodara dam 11.05 km. The net storage of both the dams with 90% dependability is 10.84 Mcum which will assure availability of water throughout the year. This is also an interbasin water transfer project from Sabarmati Basin to

Banas Basin, which will be linked to Pichola Lake to provide estimated water supply of 17.5 MLD.

4.6.5 Present Water Supply

As per latest information provided by PHED, Udaipur, the present maximum water supply to Udaipur City in a normal year is 102.44 MLD. Source wise Break-up is given in Table below:

Table-4.2: Details of Sources and Locations of Present Water Supply to Udaipur City

Sl. No.	Name of source	Gross Storage (Mcum)	Maximum Water Supply in a normal year in Million Litre/Day(MLD)	Remarks
1.	**Surface Source**			
	Pichola Lake	13.69	21.05	
	Fatehsagar Lake	12.1	18.35	
	Badi Lke	10.48		
	Jaisamand Lake	414.25	19.43	
	Mansi Wakai Dewas I	24.37	23.25	Diversion to Pichola Lake
	Dewas II (Akodara and Madri Dam)	10.94		It is under implementation. It will also be drained into Pichola Lake with estimated water availability of 17.5ML/Day for water supply.
2.	**Ground water Source**			
	Jhamarkotra, Kanpur and other local tubewells		14.36	
	Total (MLD)		**102.44**	

4.7 CITY SEWERAGE SYSTEM

The present municipal council limit of Udaipur covers an area of 64sqkm for Udaipur town and 20sqkm of adjoining seven villages, making the total area as 84sqkm.

Hitherto, two agencies namely Urban Improvement Trust (UIT), Udaipur and Public Health Engineering Department (PHED), Udaipur have been involved for planning, design and execution of sewerage system in Udaipur City.

Both the above agencies have been responsible for providing sewerage system in part areas of Udaipur City. The first sewerage scheme was implemented by PHED from 1976 to 1985 in which the sewerage system was provided in the walled city area from Hathi Pole to Suraj Pole with outfall sewer laid from Suraj Pole to Manwakheda ultimately discharging into Ayad River. The second sewerage scheme (prepared by NEERI, Nagpur) was executed by UIT from 2003 to 2007 covering the area around Pichola and Fatehsagar Lakes to prevent the entry of waste water into lakes. However, the walled city sewerage scheme has some operational problems especially the operation of Sewage Pumping Stations (SPS) and choking of sewers. Similarly, the sewerage scheme laid for Pichola Lake is having inadequacy for proper connections, operation of SPS and damaged manholes etc, as a result of which the sewage finds its way into the lakes and polluting Pichola, Rangsagar and Swarupsagar lakes. As far as Fatehsagar Lake is concerned, there are few pollution location points since the population density in the catchment of Fatehsagar Lake is very less and most of the property owners have provided septic tanks to treat the sewage.

The total length of sewer network laid in the city is about 45.5 Km comprising of 21.5 Km under first scheme for walled city executed by PHED and 24 Km under second scheme around the Pichola and Fatehsagar Lakes executed by UIT.

The size of pipeline for internal sewer network ranged between 150-300mm and those of trunk sewers between 400-800mm.

It is learnt that the sewerage coverage of population is to the extent of 15 to 20% of the present city population only.

However, the existing schemes have not been functioning properly because of the following reasons:

i) Schemes are not functioning properly due to O&M Problems.

ii) The capacity of existing internal sewers and main sewers is inadequate for designed stage master plan year (2022) or year 2041.

iii) Inadequate operation of the Sewage Pumping Stations (SPS) resulting in overflow of sewage into the lakes

iv) Sewers are choked with solid waste.

v) Manholes are broken

More details about Sewerage System of Udaipur City are given in the Chapter VI on 'Abatement of Pollution' of this report.

4.8 CITY DOMESTIC & INDUSTRIAL SEWAGE TREATMENT PLANTS

4.8.1 Domestic Sewage Treatment Plants (STPs)

In order to check the pollution of lakes and Ayad River, it is necessary to dispose-off the domestic waste water into these water bodies only after treatment. At present there is no STP existing in the city for treatment of domestic waste water. The master plan (2022) prepared by Udaipur Town Planning Department has also not outlined any such planning or proposal for the future. However, One STP of 20 MLD capacity is being constructed by M/S Hindustan Zinc Company near Manvakheda/Lakadwas outside the city, which is meant for their own use. The cost of land and the plant is also being borne by the company.

The requirement of STPs for treatment of domestic waste water and their locations & linkages with sewerage system based on latest population projections and sewerage system already provided etc are discussed in chapter VI on 'Abatement of Pollution' of this report.

4.8.2 Industrial Common Effluent Treatment Plant (CETP)

At present, there is no CETP for treatment of industrial waste water. It is proposed to provide separate CEPT to treat the industrial waste water. The requirement for CEPT may be of the order of about 20 MLD considering future scenario as well. There may be one or two CETPs totaling to 20 MLD capacity at appropriate locations near the industrial areas.

4.9 GROUND WATER STATUS AND QUALITY

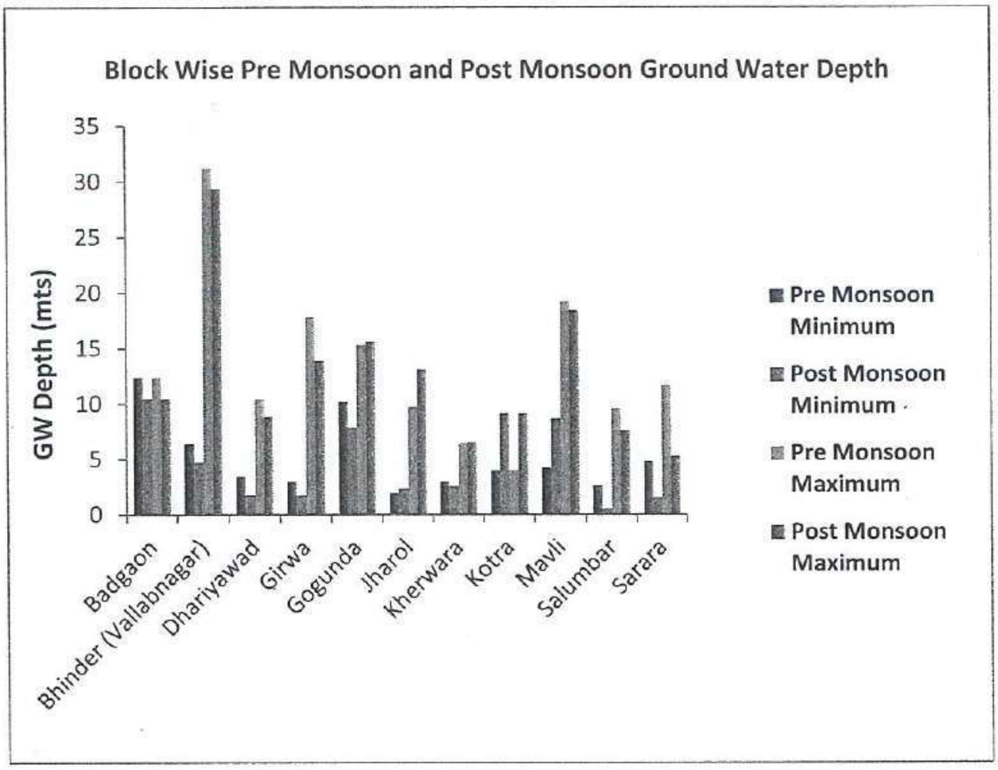
4.9.1 Ground Water Status

a) In Udaipur District

At district level the depth to water level (DTW) varies widely depending upon topography, drainage, bedrock geology etc. As per the report of Central Ground Water Board (CGWB), Year 2010, during Pre-monsoon DTW varies from 2 to 20m in greater part of the district. Deep water levels (>20m) are observed in parts of Bhinder (Vallabnagar) block. During post monsoon, water level ranges widely from less than 1m to more than 29m. Water level is shallower in western and southern part of the district. In general DTW varies from 2m to 15m in Jharol, Kherwara, Gogunda, Salumbar, Sarara & Girwa blocks and between 4m to 30m in Bhinder (Vallabnagar) block.

(in metre)

Block	**Pre Monsoon**		**Post Monsoon**	
	Min	**Max**	**Min**	**Max**
Badgaon	12.40	12.40	10.50	10.50
Bhinder (Vallabnagar)	6.42	31.23	4.75	29.40
Dhariyawad	3.48	10.46	1.80	8.86
Girwa	3.00	17.87	1.73	13.94
Gogunda	10.21	15.35	7.87	15.65
Jharol	1.98	9.76	2.40	13.15
Kherwara	3.00	6.45	2.59	6.56
Kotra	3.99	3.99	9.15	9.15
Mavli	4.24	19.23	8.70	18.45
Salumbar	2.67	9.62	0.55	7.60
Sarara	4.85	11.71	1.55	5.3



Maps showing ground water levels during pre-monsoon and post monsoon period are enclosed at **Plate 4.2 & 4.3** respectively.

b) In Badgaon and Girwa Blocks

Seasonal fluctuation in ground water level based on Pre and Post-monsoon 2012 indicate that there has been rise in water level in Badgaon and Girwa Blocks except few exceptions.

The area of study for Ayad River Front Development Project falls in Badgaon and Girwa Blocks of Udaipur District. As per status of ground water levels collected from ground water Dept. Udaipur, the water levels observed in the wells during pre & post monsoon period i.e. in May and Oct/Nov, 2012 in these two blocks indicate that in Badgaon Block during pre-monsoon the ground water level varies from 4m to 27m and during post-monsoon it varies from 2m to 17m. Similarly in Girwa Block, the same varies from 4m to 17m during pre-monsoon and from 3m to 9m during post-monsoon.

4.9.2 Groundwater Quality

4.9.2.1 Water Quality in Shallow Aquifer

a) In Udaipur District

In general the chemical quality of ground water is very good except for small pockets. The pH values of ground water vary from 7.11 to 9.20 indicating alkaline nature of ground water. The specific conductance in greater part of the district ranges from 680 to 2000 micromhos/cm at 25°C. In small belt extending in north east-south west part of the district covering part of Bhinder (Vallabnagar), Salumbar and Dhariyawad block the electrical conductivity of ground water is above 2000 micromhos/cm at 25°C. The fluoride in ground water generally falls within 1.5 mg/ lit. High fluoride is found in an elongated pockets located in the northern part of the district covering parts of Mavli, Bhinder (Vallabnagar) and Girwa blocks. In this pocket fluoride distribution is between 1.5 to 3.0 mg/lit.The concentration of chloride in major part of the district is within 500 ppm. In parts of Jharol and Kotra blocks the chloride concentration is between 500 to1000 ppm.The concentrations of Nitrate ranges from 2ppm to 120 ppm. Nitrate values in major part of the district are within 90ppm. Higher values of nitrate occur at Koorabar and Kholri. The groundwater is moderately hard to very hard in major part of the district.

The map showing ground water quality affected with Chloride and Fluoride in Udaipur District are given in **Plates 4.4 & 4.5** respectively.

b) In Udaipur City

The quality of ground water has been tested for chemical as well as bacteriological and biological analyses by taking water samples from hand pumps located in various colonies / areas of Udaipur City.

The test results of chemical analyses are given in **Annex – 4.2**. Few samples have shown higher values of Iron ranging from 1.73 to 2.35 mg/l against permissible limit of 0.1 mg/l.

Similarly the test results of bacteriological and biological analyses are given in **Annex – 4.3.** B.O.D. values are also found to be high in few samples i.e. 10.6 to 12.2 mg/l, which shows that the ground water is contaminated as a result of sewage flow in open drains or sewage flow in Ayad River.

CHAPTER – V
RIVER CHANNELIZATION

CHAPTER –V

RIVER CHANNELIZATION

5.1 GENERAL

The aspect of river channelization mainly involves study and assessment of following parameters:

i) Study of survey output of the river and assessment of existing river profile.
ii) Review and study of water availability, especially during the lean period of the year for maintaining environmental and ecological balance of the river and options to augment the same
iii) Computation of design flood so that adequate measures are adopted for its safe passage through the city.
iv) Hydrological modeling and design river section to work out required waterway for the computed flood for its smooth and unobstructed transportation.
v) Review of siltation aspect – a cause for hampering smooth flow of the river.

In this chapter, all these parameters have been deliberated threadbare and the outcome is discussed hereunder in the relevant paragraphs.

5.2 HYDROLOGICAL STUDIES

5.2.1 FLOOD STUDIES

5.2.1.1 General

Estimation of likely flood conditions in a river is a pre-requisite for carrying out river channelization studies for Ayad River.

Flood conditions however depend upon the severity of flood and therefore a judicious approach is made to select the flood magnitude vis-à-vis economy. This brings in to focus the selection of return period for which the flood is to be worked out. In the present studies, the flood of 50-year return period has been considered.

Following methodology has been adopted to work out 50-year return period flood.

1. Division of the river catchment into sub-catchments as per hydrological requirements

2. Computation of 50- year return period hyetograph
3. Development of unit hydrograph to convert hyetograph into direct surface runoff hydrograph
4. Convolution of rainfall hyetograph and unit hydrograph using appropriate values of base flow
5. Routing of flood from sub-catchments to downstream sections

5.2.1.2 Computation of Flood

I. Division of the river catchment into sub-catchments

For carrying flood studies, the river catchment from origin to Udaisagar Reservoir has been divided into four sub-catchments as per details given in **Table-5.1.**

Table-5.1 Division of River Catchment into Sub-Catchments

Sub-catchment	**Description**	**Chainage (km)**	**Physiographic Parameters**		
			Area (sq.km) – A	**Length of longest stream (km)- L**	**Slope (m/km) - S**
1	Origin to Thur Dam	0.00	139.73	22.45	8.41
2	Thur dam to GumaniaNallah	0.00 - 13.25	134.12	19.64	8.10
3	GumaniaNallah to GovardhanSagar	13.25 – 16.80	176.56	28.32	5.28
4	GovardahanSagarNallah to Udaipur Sagarreservoir	16.80 – 26.00	112.83	16.42	1.52
	Total		**563.24**		

*For computation of slope refer **Annex-5.1.**

The catchment area map showing sub-divisions is enclosed at **Plate-3.3.**

II. Computation of 50-year return period hyetograph

i) Topography

Udaipur has undulating and rocky topography with high and low hills. The city is surrounded by the hills of Aravalli ranges of various heights. The important hills within the area are:

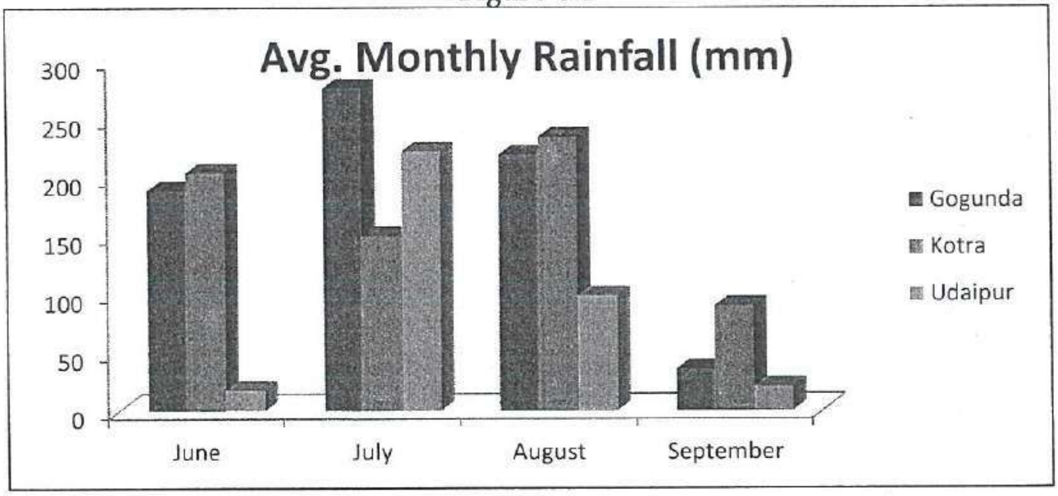
Northern hills:Nimach Mata Hill, Bhuwana Hill,
Southern hills:Balicha Hill, Odi Hill,
Eastern hills:Eklingpura Hill, Chorbavari Hill.
Western hills: Thoria Hill, MachhalaMagra, Sajjangarh Hill.

Besides these, the area also has depressions in form of lakes like Pichola, Fatehsagar, Rangsagar, Swaroopsagar and Goverdhanvilas-ka-Talab etc. The area has 234 water bodies. The River Ayad flows diagonally in the area from northwest to southeast direction.

ii) Computation of Return Period Hyetograph

For carrying out rainfall studies, 1-day maximum rainfall data of Udaipur, Gogunda and Kotra was available. In order to obtain the representative rain-gauge station, the monthly normal of these stations during monsoon season was compared. The plot of monthly rainfall of each station is given in **Figure-5.1.**

Figure-5.1



It is inferred from Figure-1 that Udaipur lies in the zone of comparatively low rainfall. In view of this, rainfall data of only Udaipur station was used to carry out rainfall studies.

The 1-day maximum point rainfall of Udaipur is given in **Table-5.2**.

Table-5.2
1-day Maximum Point Rainfall (mm)

Sl.No	Year	Udaipur
1	1957	105.7
2	1958	70.2
3	1959	49.2

4	1960	170
5	1961	65.5
6	1962	43.6
7	1963	94.2
8	1964	57.6
9	1965	133.5
10	1966	55.6
11	1967	84.8
12	1968	100.8
13	1969	45.1
14	1970	72.8
15	1971	41.2
16	1972	38
17	1973	91.5
18	1974	45
19	1975	45
20	1976	66
21	1977	71
22	1978	83.4
23	1979	36.3
24	1980	82
25	1981	47
26	1982	97
27	1983	170
28	1984	95.5
29	1985	148
30	1986	50
31	1987	23
32	1988	73
33	1989	102
34	1990	65
35	1991	64
36	1992	153
37	1993	73
38	1994	85
39	1995	43
40	1996	76
41	1997	64
42	1998	55
43	1999	49
44	2000	76
45	2001	76
46	2002	51
47	2003	79

48	2004	64
49	2005	104
50	2006	130
51	2007	47
52	2008	84
53	2009	63
54	2010	72
55	2011	127

The statistical parameters of the data given in **Table-5.3**:

Table-5.3 Statistical Parameters

Descriptor	lnx-stat	x-stat	lnx-stat
Mean	4.2724	75.1764	4.24
Var	0.2365	9.83E+02	0.1624
St.dev	0.4863	31.3511	0.403
Biasskew	0.5027	1.067	0.0136
Biaskurt	2.8638	3.8979	2.9924
Skew	0.5313	1.1278	0.0144
kurt	3.2015	4.3576	3.3453

The steps to obtain 50-year return period hyetograph are summarized below:

- Obtain 1-day annual maximum rainfall data-series.
- Arrange the data series in ascending order and rank it using the appropriate plotting position, such as Weibull's, Hazen's etc.
- Choose the Best-Fit Distribution.
- Obtain the 1-day-50 year return period point rainfall using the Best-Fit Distribution on the raked data
- Apply clock-hour correction on 1-day-50-year return period point rainfall to convert 1-day into 24-hour point rainfall.
- Convert 24-hour point rainfall into 24-hour areal rainfall using appropriate values of point to areal rainfall.
- Split 24-hour rainfall into hourly rainfall increments
- Obtain effective rainfall increments using appropriate value of loss rate.

iii) Ranking of Data

The annual rainfall data series has been ranked as per Weibull's ranking formula i.e., R = N/ (M+1), where N is the length of data series and M is the Rank. The ranked data series is given in **Table-5.4**.

Table-5.4 Ranked Data Series

Rank	Udaipur		
	X	ln(X)	Plotting Position
1	23	3.13549	1.7857
2	36.3	3.59182	3.5714
3	38	3.63759	5.3571
4	41.2	3.71844	7.1429
5	43	3.7612	8.9286
6	43.6	3.77506	10.7143
7	45	3.80666	12.5
8	45	3.80666	14.2857
9	45.1	3.80888	16.0714
10	47	3.85015	17.8571
11	47	3.85015	19.6429
12	49	3.89182	21.4286
13	49.2	3.89589	23.2143
14	49.2	3.89589	25
15	50	3.91202	26.7857
16	51	3.93183	28.5714
17	55	4.00733	30.3571
18	55.6	4.01818	32.1429
19	57.6	4.05352	33.9286
20	63	4.14313	35.7143
21	64	4.15888	37.5
22	64	4.15888	39.2857
23	64	4.15888	41.0714
24	65	4.17439	42.8571
25	65.5	4.18205	44.6429
26	66	4.18965	46.4286
27	70.2	4.25135	48.2143
28	71	4.26268	50
29	72	4.27667	51.7857
30	72.8	4.28772	53.5714
31	73	4.29046	55.3571
32	73	4.29046	57.1429
33	76	4.33073	58.9286
34	76	4.33073	60.7143
35	76	4.33073	62.5
36	79	4.36945	64.2857
37	82	4.40672	66.0714
38	83.4	4.42365	67.8571
39	84	4.43082	69.6429

40	84.8	4.4403	71.4286
41	85	4.44265	73.2143
42	91.5	4.51634	75
43	94.2	4.54542	76.7857
44	95.5	4.55913	78.5714
45	97	4.57471	80.3571
46	100.8	4.61314	82.1429
47	102	4.62497	83.9286
48	104	4.64439	85.7143
49	105.7	4.6606	87.5
50	127	4.84419	89.2857
51	130	4.86753	91.0714
52	135.5	4.90897	92.8571
53	148	4.99721	94.6429
54	153	5.03044	96.4286
55	170	5.1358	98.2143

iv) Selection of Best-Fit-Distribution

A number of distributions viz., Gumbel's, Normal, Pearson etc, have been recommended based on the statistical parameters of the data series. For Indian conditions, it is found that the Gumbel's distribution fits well in the rainfall series. Therefore, Gumbel's distribution has been used to compute the 50-year rainfall. A brief description of the Gumbel's distribution is given below:

➢ Gumbel's Distribution

According to Gumbel (1958), the cumulative probability that any extreme value will be less than the given quantity X approaches the double exponential expression:

$$\Phi(X) = \exp.(-e-\alpha(X-\mu))$$

$$= \exp.-e^{-Y}$$

Where,

$$Y = \alpha\,(X-\mu)$$

or

$$X = \mu + 1/\,\alpha \times Y \text{ -------------------------------- (A)}$$

Y is known as the reduced variate; μ is mode of extremes and 1/ α is equal to 0.7796968 times the standard deviation of the extremes X.

The return period (T) of an extreme value equal to or exceeding X, is given by:

$$T = \frac{1}{(1-\varphi(X))}$$

$$= \frac{1}{1-\exp.-e^{-Y}}$$

or

$$Y_t = -\log_e \log_e \left(\frac{T}{T-1}\right) \text{ -- (B)}$$

Where Yt is the reduced variate for return period T. According to Gumbel (1954), plotting position of the ordered series is defined as:

$$T = \frac{N+1}{m}$$

Where N is the total years of record and m is the rank of the ordered series.

Gumbel's equation is a straight line and can be easily solved

v) Computation of 50-year rainfall

For carrying out frequency studies, the ranked data given in Table-5.4 was fed in the software "Hydrological Frequency Analysis" (HYFA). This software computes rainfall of different return periods using different frequency distributions. The 50-year return period rainfall values obtained from the ranked data series are given in **Table-5.5.**

Table-5.5 50-year Return Period Rainfall (mm)

S.No.	Return Period (year)	Rainfall	
		Method of Moments	Method of Maximum Likelihood
1	1.0101	23.737	25.744
2	1.02564	29.161	30.912
3	1.05263	34.248	35.761
4	1.11111	40.681	41.892
5	1.25	49.436	50.236

6	2	70.028	69.861
7	5	97.734	96.267
8	10	116.077	113.75
9	20	133.673	130.52
10	25	139.255	135.839
11	50	156.449	152.227
12	100	173.516	168.493

The 50-year return period rainfall worked on the basis of Flood Estimation Report (FER) of Subzone 1(b), CWC Publication, is <220 mm. The computed values for 50-year return period given in Table 5.5 are consistent with these results.

The 50-year and 100-year return period isopluvial maps are enclosed at **Plates 5.1 & 5.2** for reference.

On the basis of above studies, the 50-year point rainfall has been considered to be 156mm.

vi) Clock-hour Correction

The clock-hour correction to convert 1-day rainfall into 24-hour rainfall has been considered to be 1.15 as per recommendations of IMD. Accordingly, the 24-hour 50-year return period rainfall works out to be 179.40 mm.

vii) Areal Rainfall

The areal reduction factors for different sub-catchments have been worked out on the basis of FER by appropriately centering the storm. The areal rainfall thus worked out is given in **Table-5.6.**

Table-5.6 Areal Rainfall (mm)

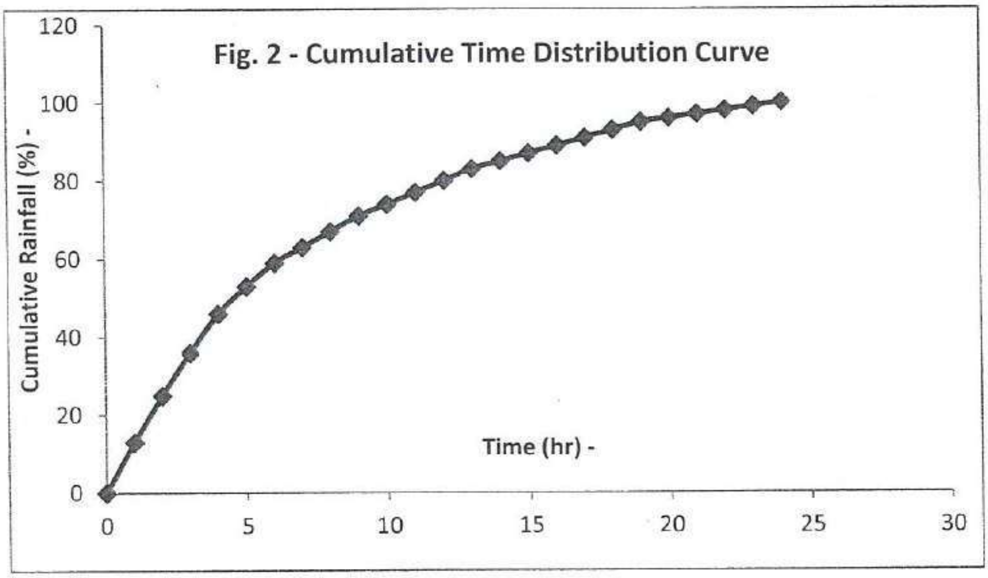
Sub-catchments	Areal Reduction Factor	Areal Rainfall (mm)
1	0.895	160.6
2	0.954	171.1
3	0.892	160.0
4	0.872	156.4

The areal reduction factors for different catchment areas, as recommended in the FER, are given in **Plate-5.3.**

viii) Computation of incremental hourly and effective rainfall

For splitting the 24-hourly rainfall into hourly rainfall, the Time-Distribution factors as recommended in the FER **(Refer Plate 5.4)** and loss rate (1.7 mm/hour, recommended in the FER)) was used. The time distribution curve is given in **Figure 5.2.**

Figure 5.2



Effective rainfall thus worked out for different sub-catchments is as given in **Table 5.7.**

Table 5.7 Effective Rainfall (mm)

Hour	TD (cum %)	SC1			SC2			SC3			SC4		
		Cum.	Hrly.	Eff.	Cum.	Hrly.	Eff.	Cum.	Hrly.	Eff.	Cum.	Hrly.	Eff.
0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	13	20.87	20.87	19.17	22.24	22.24	20.54	20.80	20.80	19.10	20.34	20.34	18.64
2	25	40.14	19.27	17.57	42.77	20.53	18.83	40.01	19.20	17.50	39.11	18.77	17.07
3	36	57.80	17.66	15.96	61.59	18.82	17.12	57.61	17.60	15.90	56.32	17.21	15.51
4	46	73.86	16.06	14.36	78.69	17.11	15.41	73.61	16.00	14.30	71.96	15.64	13.94
5	53	85.10	11.24	9.54	90.67	11.98	10.28	84.81	11.20	9.50	82.91	10.95	9.25
6	59	94.73	9.63	7.93	100.93	10.26	8.56	94.41	9.60	7.90	92.30	9.39	7.69
7	63	101.15	6.42	4.72	107.78	6.84	5.14	100.82	6.40	4.70	98.56	6.26	4.56
8	67	107.58	6.42	4.72	114.62	6.84	5.14	107.22	6.40	4.70	104.81	6.26	4.56
9	71	114.00	6.42	4.72	121.46	6.84	5.14	113.62	6.40	4.70	111.07	6.26	4.56
10	74	118.82	4.82	3.12	126.60	5.13	3.43	118.42	4.80	3.10	115.76	4.69	2.99
11	77	123.63	4.82	3.12	131.73	5.13	3.43	123.22	4.80	3.10	120.46	4.69	2.99
12	80	128.45	4.82	3.12	136.86	5.13	3.43	128.02	4.80	3.10	125.15	4.69	2.99
13	83	133.27	4.82	3.12	141.99	5.13	3.43	132.82	4.80	3.10	129.84	4.69	2.99
14	85	136.48	3.21	1.51	145.41	3.42	1.72	136.02	3.20	1.50	132.97	3.13	1.43
15	87	139.69	3.21	1.51	148.84	3.42	1.72	139.22	3.20	1.50	136.10	3.13	1.43
16	89	142.90	3.21	1.51	152.26	3.42	1.72	142.42	3.20	1.50	139.23	3.13	1.43
17	91	146.11	3.21	1.51	155.68	3.42	1.72	145.62	3.20	1.50	142.36	3.13	1.43
18	93	149.32	3.21	1.51	159.10	3.42	1.72	148.82	3.20	1.50	145.49	3.13	1.43
19	95	152.53	3.21	1.51	162.52	3.42	1.72	152.02	3.20	1.50	148.61	3.13	1.43
20	96	154.14	1.61	0.00	164.23	1.71	0.01	153.62	1.60	0.00	150.18	1.56	0.00
21	97	155.75	1.61	0.00	165.94	1.71	0.01	155.22	1.60	0.00	151.74	1.56	0.00
22	98	157.35	1.61	0.00	167.65	1.71	0.01	156.82	1.60	0.00	153.31	1.56	0.00
23	99	158.96	1.61	0.00	169.37	1.71	0.01	158.42	1.60	0.00	154.87	1.56	0.00
24	100	160.56	1.61	0.00	171.08	1.71	0.01	160.02	1.60	0.00	156.44	1.56	0.00

III. Development of Unit hydrograph

The following two methods are being used for estimating the design flood:

i) Flood frequency method
ii) Deterministic method

i) Flood frequency method

Flood frequency method interprets past record of flood events to predict the future probabilities of occurrence of extreme flood for a specific period. It involves following steps:

- Process the flow data for consistency by employing various consistency checks;
- Perform goodness of fit test to infer the best-fit distribution for the sample data.
- Estimate the T-year recurrence interval floods using the Best-fit-Distribution.
- The estimate for T-year flood, obtained from the best-fit distribution provides the design flood.

ii) Deterministic Method

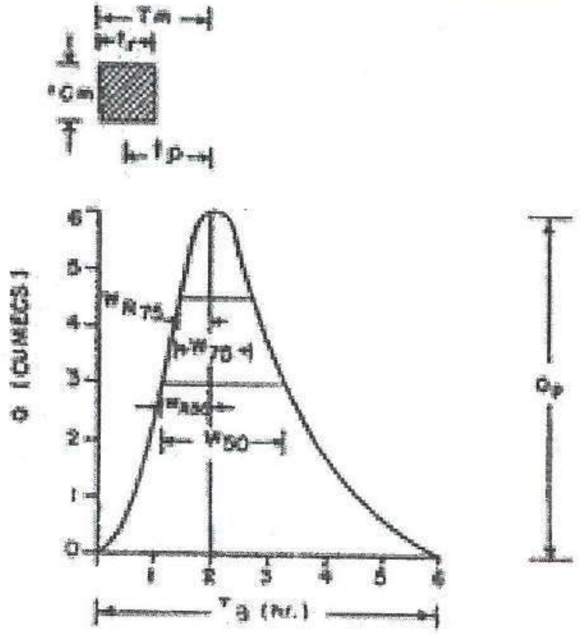
In the deterministic method, attempts are made to evaluate the causative factors responsible for production of severe floods. The design flood computation mainly involves the design storm hyetograph, and derivation of catchment response function (generally a unit hydrograph). The main advantage of the hydrometeorological approach is that, it gives a complete flood hydrograph and this allows in making a realistic determination of moderation effect while flood passes through a river reach.

➢ Development of unit hydrograph

As, site-specific short duration rainfall –runoff data is not available, synthetic unit graphs (SUG) based on topographical features of the river basins have been developed.

For developing SUG, CWC has developed a detailed methodology. It has divided the country in to various Hydrometeorological homogenous sub-zones and SUG equations for each of the sub-zone have been developed, wherein topographical features of the river basin such as basin area (A), river length (L) , basin equivalent slope (S) have been correlated with the UG parameters, t_p, q_p, W_{50}etc .A typical SUG is given in **Figure 5.3.**

Figure 5.3 Typical UG



U.G. = Unit Graph
t_r = Unit Rainfall Duration adopted in a specific study (hr.)
T_m = Time from the start of rise to the peak of the U.G (hr.)
Q_p = Peak Discharge of Unit Hydrograph (cumecs)
t_p = Time from the centre of effective rainfall duration to the U.G peak (hr.)
W_{50} = Width of the U.G. measured at 50% of peak discharge ordinate (hr.)
W_{75} = Width of the U.G measured at 75% of peak discharge ordinate (hr.)
W_{R50} = Width of the rising limb of U.G. measured at 50% of peak discharge ordinate (hr.)
W_{R75} = Width of the rising limb of U.G. measured at 75% of peak discharge ordinate (hr.)
T_B = Base width of Unit Hydrograph (hr.)
A = Catchment Area (Sq. km.)
$q_p = Q_p / A$ = Cumec per sq. km.

Based on the SUGequations given in the FER and physiographic parameters given in **Table-5.1**, UG parameters of each sub-catchment were worked out as given in **Table-5.8.**

Table-5.8 UG Parameters

S.No.	SUG equation	UG Parameter			
		SC1	SC2	SC3	SC4
	$t_p = 0.339\left(L/\sqrt{S} \right)^{0.826}$	1.50	1.50	2.50	2.50
	$q_p = 1.251/(t_p)^{0.61}$	0.98	0.98	0.72	0.72
	$W_{50} = 2.215/(q_p)^{1.034}$	2.27	2.27	3.13	3.13
	$W_{75} = 1.19/(q_p)^{1.057}$	1.22	1.22	1.70	1.70
	$W_{R50} = 0.834/(q_p)^{1.077}$	0.86	0.86	1.20	1.20
	$W_{R75} = 0.502/(q_p)^{1.065}$	0.51	0.51	0.72	0.72
	$T_B = 6.662(t_p)^{0.613}$	9.00	9.00	12.00	12.00
	$Q_p = q_p \times A$	136.50	131.02	126.30	80.71
	$T_m = t_p + t_r/2$	2.00	2.00	3.00	3.00

The respective unit hydrograph ordinates and their plots for each sub-catchment are given in **Table 5.9** and **Figures 5.4 to 5.7** respectively.

Table-5.9 Unit Hydrograph Ordinates

Time (hr)-	Discharge (cumec) -			
	SC-1	SC-2	SC-3	SC-4
0	0	0	0	0
1	56.40	54.14	26.37	16.86
2	136.50	131.02	75.95	48.53
3	85.61	82.17	126.30	80.71
4	50.01	47.88	93.85	59.97
5	29.16	27.88	61.61	39.37

6	16.76	15.87	40.82	26.10
7	9.49	9.30	27.02	17.29
8	4.20	4.30	17.73	11.35
9	0	0	11.32	7.25
10			6.70	4.29
11			2.78	2.00
12			0	0

Figure-5.4

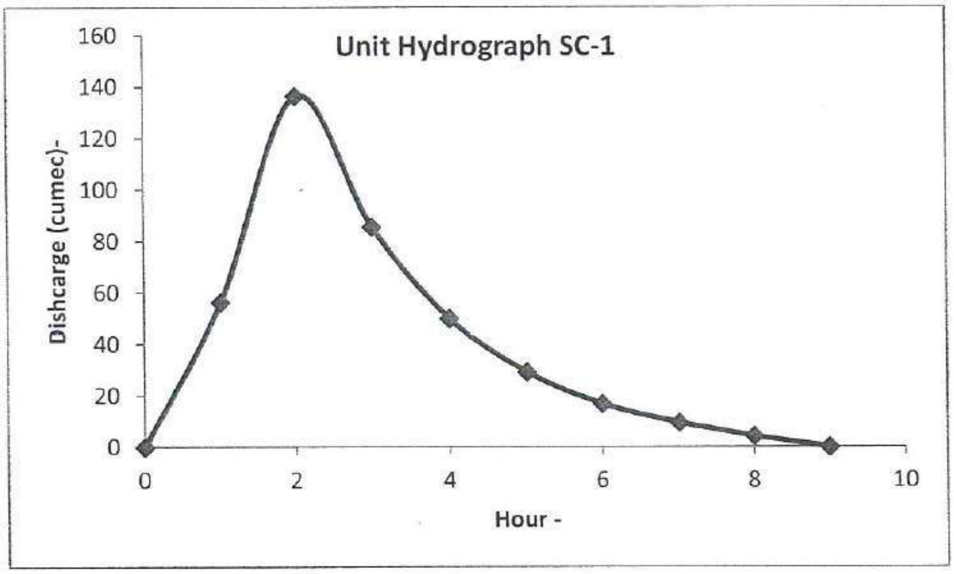


Figure-5.5

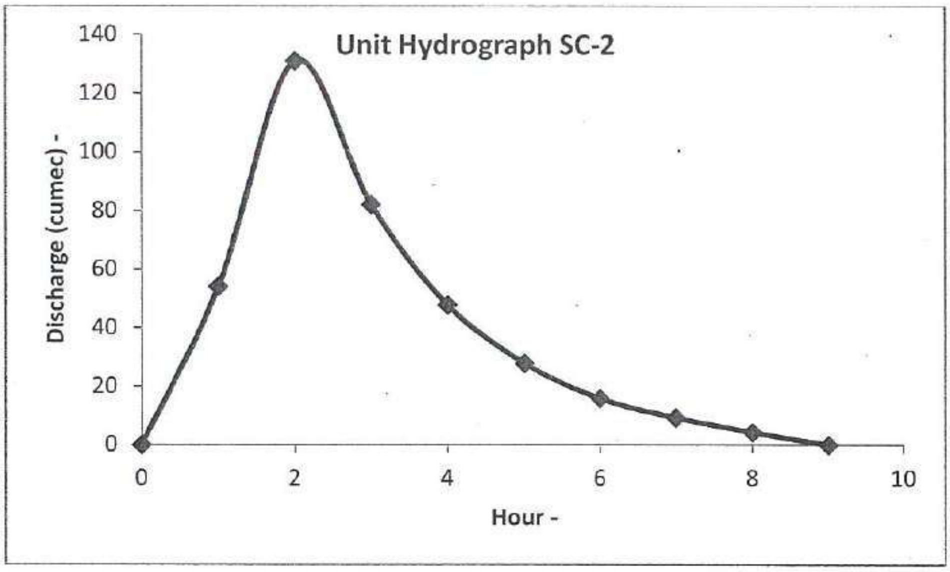


Figure-5.6

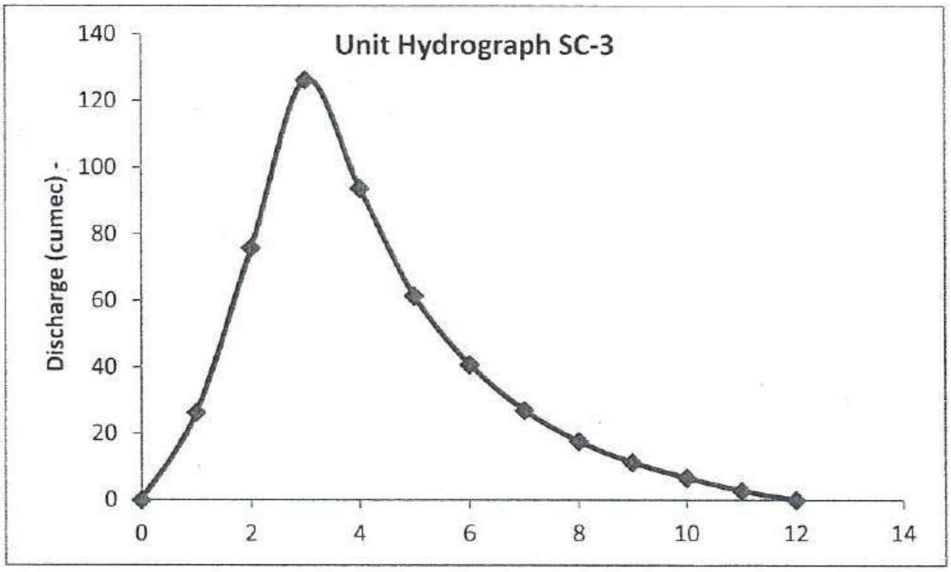
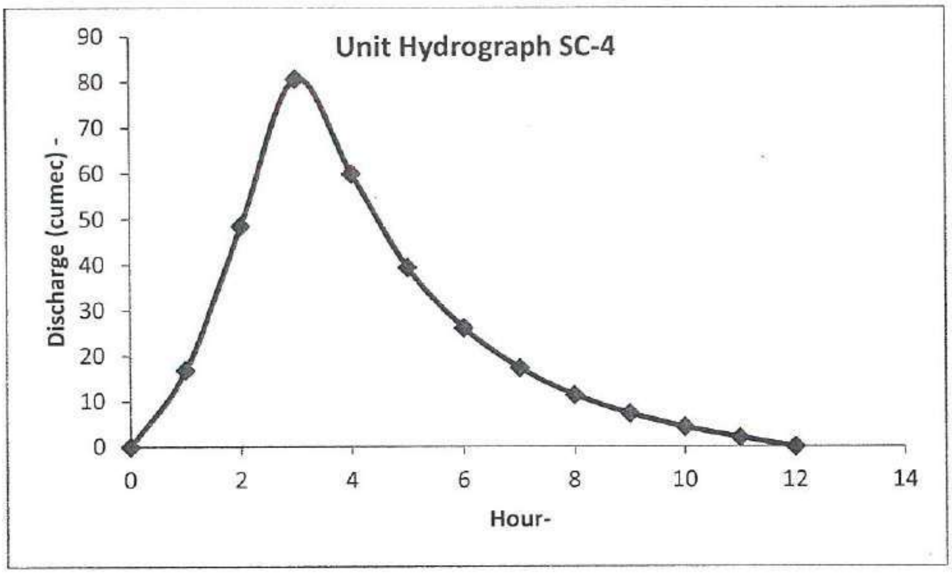


Figure-5.7



IV. Convolution of rainfall hyetograph and unit hydrograph using appropriate values of base flow

Flood for each sub-catchment has been obtained using the standard method of critical sequencing of hyetograph (**Table 5.7**) and unit hydrograph ordinates (**Table 5.9**), and base flow of the order of 0.06 cumec/sq. km. The computations are given in **Annex-5.2.** The flood hydrograph ordinates are given in **Table-5.10** and shown in **Figures 5.8 to 5.11**.

Table-5.10 Flood Hydrograph Ordinates

Time (hr)-	Discharge (cumec) -			
	SC-1	SC-2	SC-3	SC-4
0	0.06	0.06	0.06	0.06
1	26.70	27.90	0.21	0.20
2	91.16	95.29	8.73	5.57
3	149.70	156.07	36.60	22.83

4	226.21	234.78	87.87	54.53
5	316.56	327.44	145.52	90.29
6	438.14	451.81	208.02	129.14
7	554.15	570.58	295.72	183.82
8	**621.58**	**639.57**	**405.67**	252.43
9	537.31	552.72	539.39	335.93
10	320.27	329.26	657.80	409.86
11	182.86	187.93	702.84	**437.99**
12	101.43	104.53	631.12	393.29
13	52.39	54.43	466.70	290.82
14	23.26	24.81	310.13	193.35
15	6.76	7.42	201.33	125.69
16	0.06	0.06	128.13	80.13
17			78.29	49.17
18			44.07	27.89
19			21.35	13.75
20			7.63	5.11
21			1.37	0.97
22			0.06	0.06

Figure-5.8

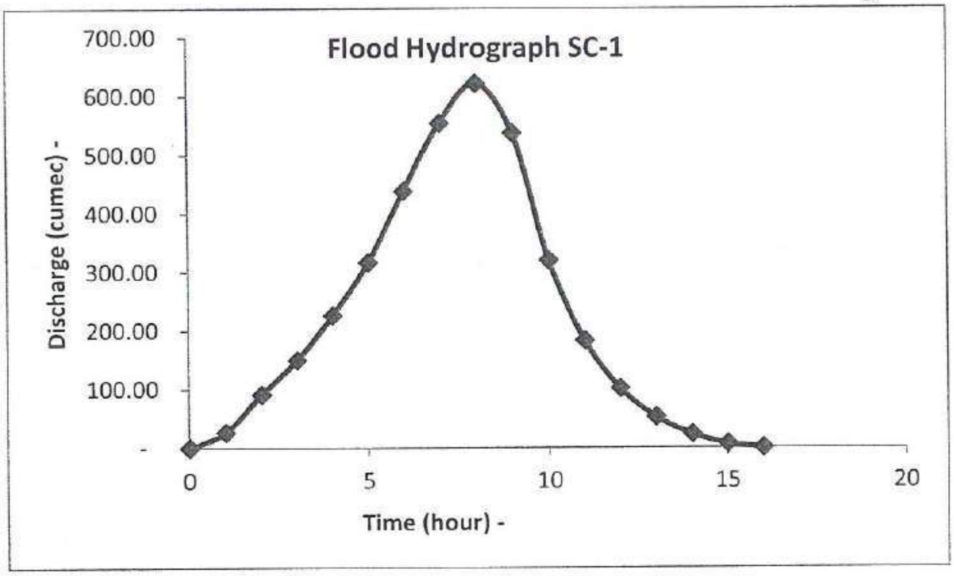


Figure-5.9

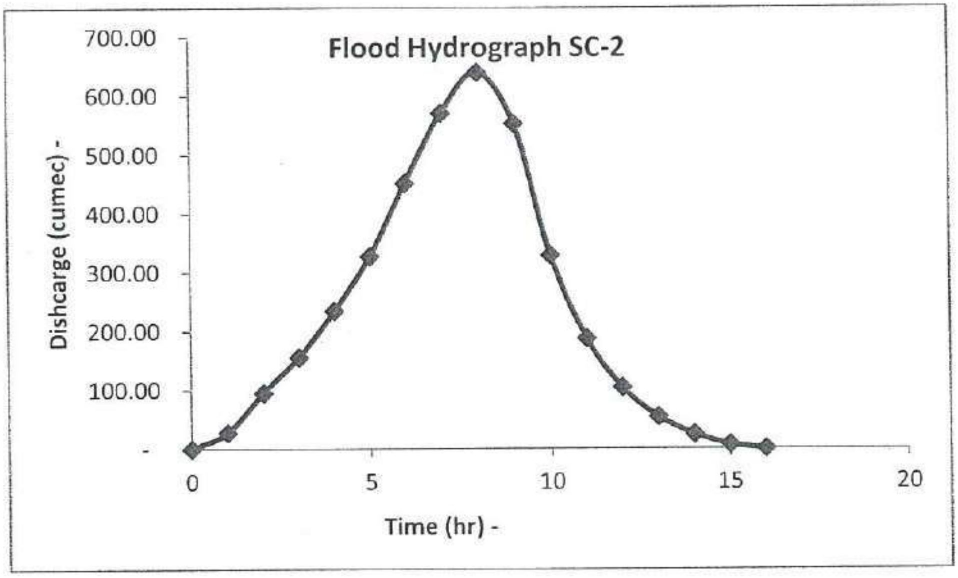


Figure-5.10

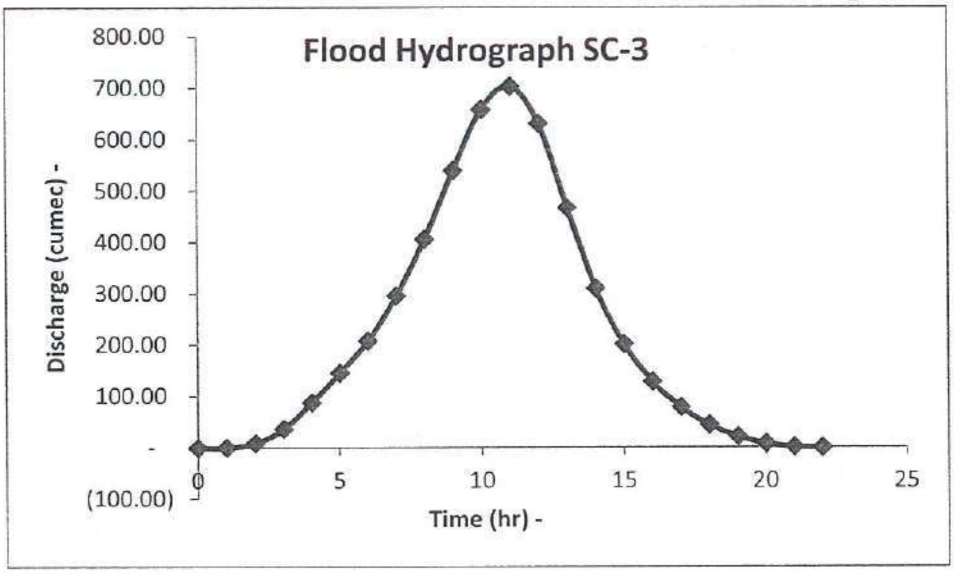
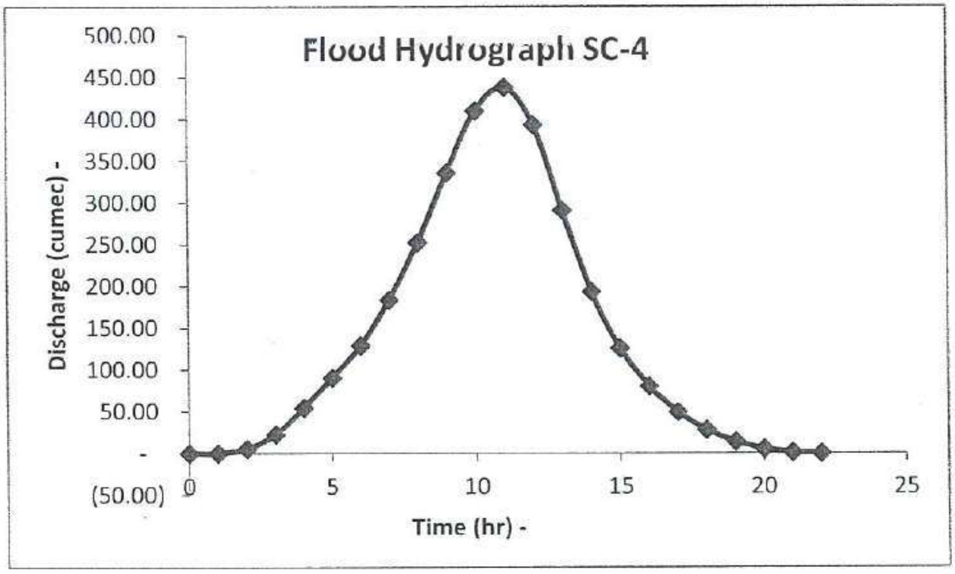


Figure-5.11



V. Routing of flood from sub-catchments to downstream sections

For routing the flood through successive reaches, Muskingum method of flood routing through river channel has been adopted. This method is briefly described below:

Muskingum method of channel storage involves the concept of prism and wedge storage in the channel. The prism storage is represented as kO, where k has the dimensions of time. The wedge storage is represented as k*x*(I-O), where 'x' is a parameter, which expresses the relative importance (weightage) of inflow and outflow in determining storage. The total storage is 's' given by:

$$S = k^*O + k^*x^*(I\text{-}O)$$

$$= k^*(x^*I + (1\text{-}x)^*O) \text{--}(1)$$

The storage constant k which expresses the ratio between storage and discharge, is a measure of the lag or travel time of the flood wave through the reach and is the slope of the storage-discharge curve. k may be determined by finding the lag time between the occurrences of the centre of mass of inflow and centre of mass of the outflow over the reach. It may also be approximated by determining the time of travel (t) of critical points on the hydrograph, such as the peak. 'k' can also be found out if velocity of flood wave (V) is known, using the relationship.

$$V = l/t, \text{ where l is the river length}$$

Equation (1) can be rewritten as,

$$S_2\text{-}S_1 = k^* [(I_2\text{-}I_1) + (1\text{-}x)^*(O_2\text{-}O_1)]$$

Where the subscripts 1, 2 indicate the routing periods and I, O and S are the instantaneous values of inflow, outflow and storage respectively.

The water balance equation for change in storage in a time interval (t) is

$$I - O = S$$

or

$[(I_1+ I_2)/2]*t - [(O_1 +O_2)/2)]*t = S_2-S_1$ --------------------------------------(2)

Combining equation (1) and (2) and simplifying we get

$O_2 = C_1I_2 + C_2I_1 + O_1$--(3)

Where:

$C_1 = t - 2kx/ (2k (1\text{-}x) + t)$

$C2 = t + 2kx/ (2k (1\text{-}x) + t)$

$C3 = (2k (1\text{-}x) -t)/ (2k (1\text{-}x) + t)$

And

$C 1+C2+C3 = 1$

In these equations, it is important that the routing period (t) is in the same time units as (k)

Equation (3) can be used to find out outflows through the river reach, provided (k) and (x) are known. The values of k and x can be computed from the observed inflow and outflow data. However, in majority of cases, site-specific inflow and outflow data is not available. In such cases, these parameters are obtained empirically as given below:

- **Determination of k**

(k) has the numerical value of the time lag of the flood wave (T). Its numerical value can be determined using the relation

$V = L/T;$

Where, V is the velocity of flood wave and L is the river length

- **Determination of (x)**

The constant (x) expresses the relative importance of inflow and outflow in determining storage. If storage is entirely a function of outflow (as in a reservoir), then (x) will be zero. But, if wedge storage is significant, then (x) will be > zero with a limiting value of

0.5 (when inflow and outflow have equal weights). For most streams, (x) lies between 0 and 0.3, with a mean near 0.2

Values of routing constants K & X for each sub-catchment are given in **Table-5.11.**

Table-5.11 Routing Constants

S.No.	**Sub-catchment**	**K**	**X**
1.	SC-2	2	0.2
2.	SC-3	1	0.2
3.	SC-4	2	0.1

The routed floods from each sub-catchment are given in **Tables-5.12 to 5.14** and shown if **Figures-5.12 to 5.14.**

Table-5.12 Flood Routing from Thur Dam upto Ghumania Nallah

Time (hour)	**Flood at Thur Dam (cumec)**	C_1I_{j+1}	C_2I_j	C_3Q_j	**Routed Flood of Thur Dam Upto Ghumania Nallah (cumec)**	**Flood from Thur Dam to Ghumania Nallah (cumec)**	**Total Flood at Ghumania Nallah (cumec)**
0	0.06					0.06	0.06
1	26.70	0	0	0	0.03	27.90	27.93
2	91.16	0	13	0	13.36	95.29	108.65
3	149.70	0	46	7	52.26	156.07	208.33
4	226.21	0	75	26	100.98	234.78	335.77
5	316.56	0	113	50	163.60	327.44	491.03
6	438.14	0	158	82	240.08	451.81	691.88
7	554.15	0	219	120	339.11	570.58	909.69
8	**621.58**	0	277	170	446.63	639.57	1086.20
9	537.31	0	311	223	534.11	552.72	**1086.82**
10	320.27	0	269	267	**535.71**	329.26	864.96
11	182.86	0	160	268	427.99	187.93	615.92
12	101.43	0	91	214	305.43	104.53	409.95
13	52.39	0	51	153	203.43	54.43	257.86

14	23.26	0	26	102	127.91	24.81	152.72
15	6.76	0	12	64	75.58	7.42	83.01
16	0.06	0	3	38	41.17	0.06	41.23
17	0.06	0	0	21	20.62	0.06	20.68
18	0.06	0	0	10	10.34	0.06	10.40
19	0.06	0	0	5	5.20	0.06	5.26
20	0.06	0	0	3	2.63	0.06	2.69
21	0.06	0	0	1	1.34	0.06	1.40
22	0.06	0	0	1	0.70	0.06	0.76
23	0.06	0	0	0	0.38	0.06	0.44
24	0.06	0	0	0	0.22	0.06	0.28
25	0.06	0	0	0	0.14	0.06	0.20
26	0.06	0	0	0	0.10	0.06	0.16
27	0.06	0	0	0	0.08	0.06	0.14
28	0.06	0	0	0	0.07	0.06	0.13
29	0.06	0	0	0	0.07	0.06	0.13
30	0.06	0	0	0	0.06	0.06	0.12
31	0.06					0.06	0.06

Figure-5.12

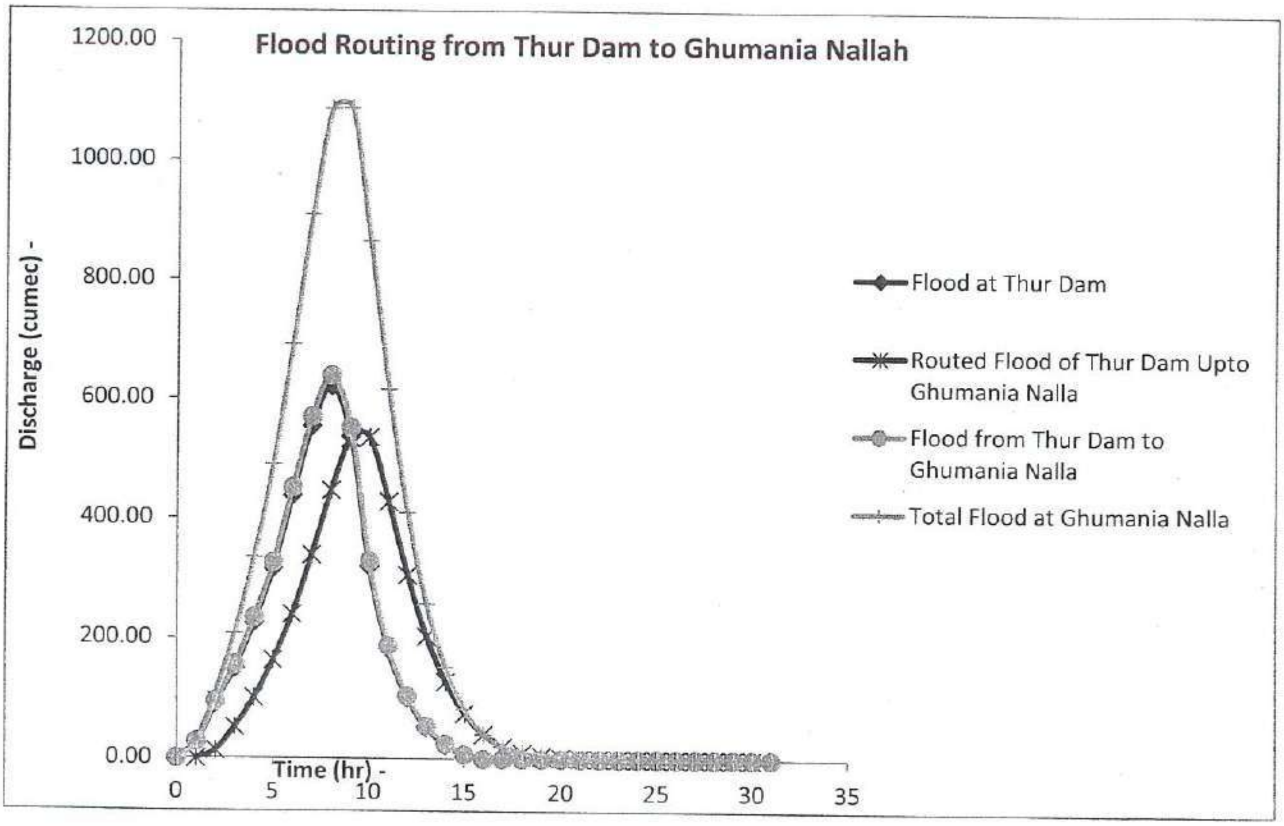


Table-5.13 Flood Routing from Ghumania Nallah upto Govardhan Sagar

Time (h)	Flood at Ghumania Nallah	C_1I_{j+1}	C_2I_j	C_3Q_j	Routed Flood from Ghumania Nallah to Govardhan Sagar	Flood from Ghumania Nallah to Govardhan Sagar	Total Flood at Govardhan Sagar
0	0.06					0.06	0.06
1	27.93	6	0	0	6.48	0.21	6.68
2	108.65	25	15	1	41.61	8.73	50.34
3	208.33	48	59	10	116.18	36.60	152.78
4	335.77	77	112	27	216.47	87.87	304.34

5	491.03	113	181	50	344.07	145.52	489.59
6	691.88	160	264	79	503.47	208.02	711.48
7	909.69	210	373	116	698.67	295.72	994.38
8	1086.20	251	490	161	901.73	405.67	1307.40
9	**1086.82**	251	585	208	**1043.77**	539.39	1583.16
10	864.96	200	585	241	1025.69	657.80	**1683.49**
11	615.92	142	466	237	844.58	702.84	1547.43
12	409.95	95	332	195	621.16	631.12	1252.27
13	257.86	60	221	143	423.59	466.70	890.29
14	152.72	35	139	98	271.84	310.13	581.97
15	83.01	19	82	63	164.12	201.33	365.45
16	41.23	10	45	38	92.08	128.13	220.21
17	20.68	5	22	21	48.22	78.29	126.51
18	10.40	2	11	11	24.66	44.07	68.73
19	5.26	1	6	6	12.50	21.35	33.85
20	2.69	1	3	3	6.34	7.63	13.97
21	1.40	0	1	1	3.24	1.37	4.60
22	0.76	0	1	1	1.68	0.06	1.74
23	0.44	0	0	0	0.90	0.06	0.96
24	0.28	0	0	0	0.51	0.06	0.57
25	0.20	0	0	0	0.32	0.06	0.38
26	0.16	0	0	0	0.22	0.06	0.28
27	0.14	0	0	0	0.17	0.06	0.23
28	0.13	0	0	0	0.14	0.06	0.20
29	0.13	0	0	0	0.13	0.06	0.19
30	0.12	0	0	0	0.13	0.06	0.19
31	0.06	0	0	0	0.11	0.06	0.17
32	0.06	0	0	0	0.07	0.06	0.13
33	0.06	0	0	0		0.06	0.06

Figure-5.13

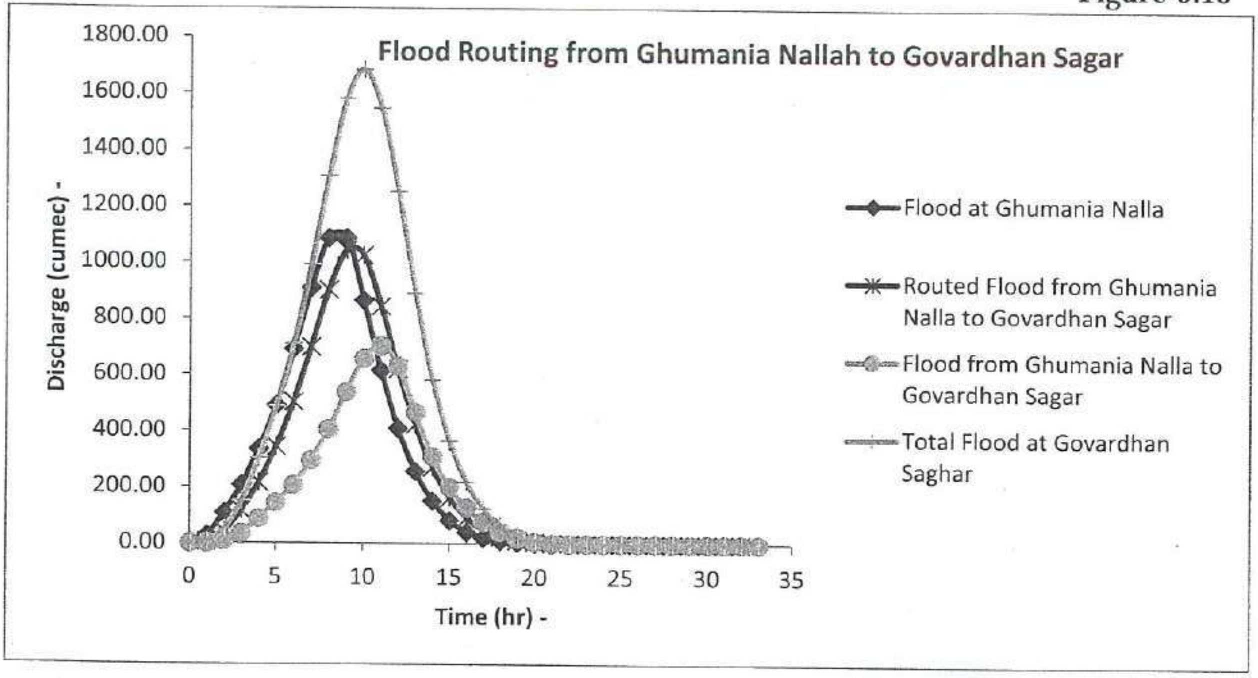
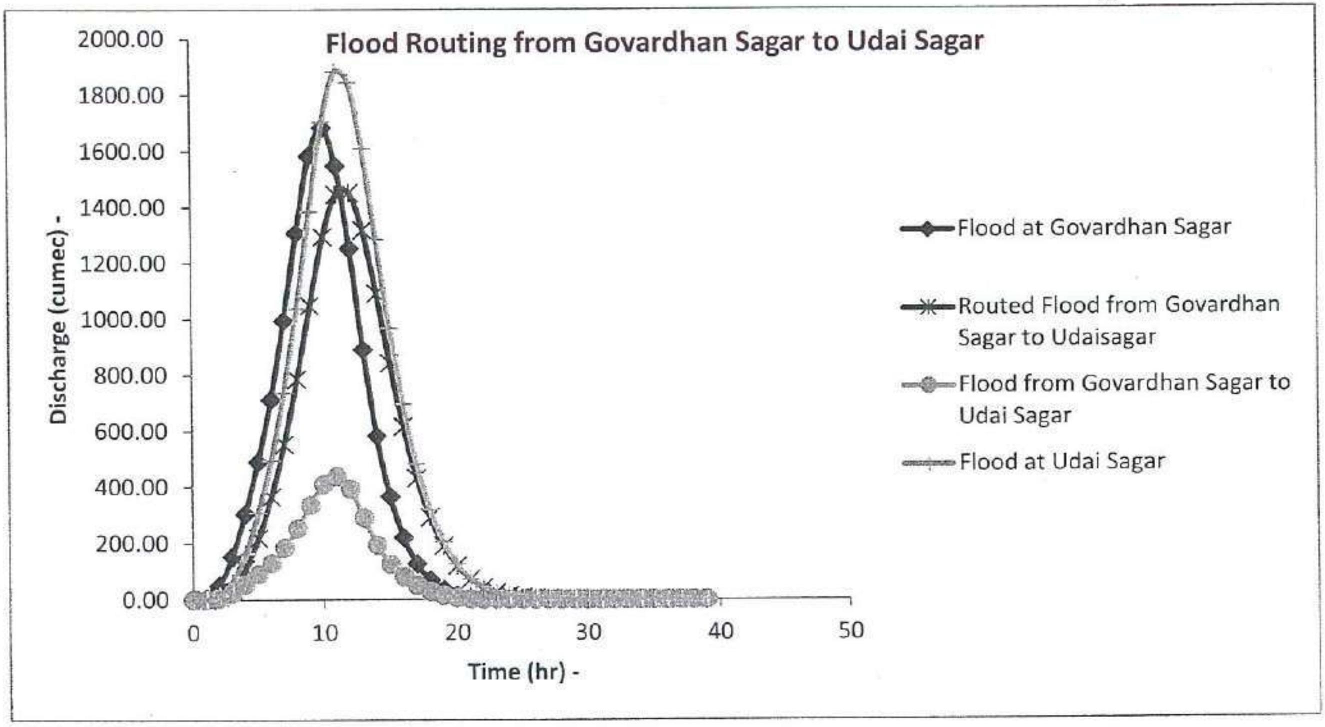


Table-5.14 Flood Routing from GovardhanSagaruptoUdaisagar

Time (h)	Flood at Govardhan Sagar	C_1I_{j+1}	C_2I_j	C_3Q_j	Routed Flood from Govardhan Sagar to Udaisagar	Flood from Govardhan Sagar to Udaisagar	Flood at Udaisagar
0	0.06					0.06	0.06
1	6.68	1	0	0	0.89	0.20	1.09
2	50.34	7	2	1	9.10	5.57	14.67
3	152.78	20	15	5	40.39	22.83	63.22
4	304.34	40	46	23	109.03	54.53	163.56
5	489.59	64	93	62	218.11	90.29	308.40
6	711.48	93	149	123	365.08	129.14	494.22
7	994.38	130	217	206	552.59	183.82	736.42
8	1307.40	171	303	312	785.50	252.43	1037.93
9	1583.16	206	398	444	1048.39	335.93	1384.31

10	**1683.49**	220	482	593	1293.98	409.86	1703.85
11	1547.43	202	512	731	**1445.59**	437.99	**1883.58**
12	1252.27	163	471	817	1451.37	393.29	1844.66
13	890.29	116	381	820	1317.59	290.82	1608.41
14	581.97	76	271	745	1091.59	193.35	1284.94
15	365.45	48	177	617	841.78	125.69	967.47
16	220.21	29	111	476	615.73	80.13	695.87
17	126.51	17	67	348	431.55	49.17	480.72
18	68.73	9	39	244	291.39	27.89	319.28
19	33.85	4	21	165	190.03	13.75	203.78
20	13.97	2	10	107	119.53	5.11	124.65
21	4.60	1	4	68	72.41	0.97	73.38
22	1.74	0	1	41	42.56	0.06	42.62
23	0.96	0	1	24	24.71	0.06	24.77
24	0.57	0	0	14	14.33	0.06	14.39
25	0.38	0	0	8	8.32	0.06	8.38
26	0.28	0	0	5	4.85	0.06	4.91
27	0.23	0	0	3	2.86	0.06	2.92
28	0.20	0	0	2	1.71	0.06	1.77
29	0.19	0	0	1	1.05	0.06	1.11
30	0.19	0	0	1	0.68	0.06	0.74
31	0.17	0	0	0	0.46	0.06	0.52
32	0.13	0	0	0	0.33	0.06	0.39
33	0.06	0	0	0	0.23	0.06	0.29
34	0.06	0	0	0	0.16	0.06	0.22
35	0.06	0	0	0	0.12	0.06	0.18
36	0.06	0	0	0	0.09	0.06	0.15
37	0.06	0	0	0	0.08	0.06	0.14
38	0.06	0	0	0	0.07	0.06	0.13
39	0.06	0	0	0		0.06	0.06

Figure-5.14



5.2.1.3 Recommendations

Based on the studies carried above, following flood values are recommended for use in the river channelization studies:

Table-5.15 Peak Flood Values (cumec)

S.No.	Location	Peak Flood (50-year return period)
1.	Thur Dam	621.58
2.	Ghumania Nallah	1086.82
3.	Govardhan Sagar	1683.49
4.	UdaiSagar	1883.58

5.5.4 WATER AVAILABLITY IN LEAN PERIOD

5.2.2.1 River Flow from Treated Waste Water

As per the modified population projections worked out in Chapter VI, the population for Master Plan Year 2022 works out to about 5.5 Lakh. Considering projected water supply demand per capita at the rate of 135 lpcd for domestic use and adding for domestic and industrial has been 15% losses, the projected water supply demand for domestic and industrial has been worked out to about 85 MLD and 20 MLD respectively for Year 2022. Accordingly, the generated waste water has been worked out to be about 85 MLD (65 + 20). It is assumed that by year 2022, the STPs/CETPs required to treat 85MLD of waste water will be in position in order to ensure that only treated waste water enters the river. Accordingly, the water availability from treated waste water during lean period (oct-may) will be to the extent of about 800million litres/km/year.

Considering average river section of50m x 3m, the requirement of filling the river section once would be 150 ml/km/year. Thus, with the waste water flow of 800 ml/km/year it would be possible to fill the above river section atleast 5 times during lean period of the year.

5.2.2.2 Interbasin Water Transfer – An Option for Maintaining Minimum River Flow

It is studied by eminent engineers of water resources department of Rajasthan Government that Wakal Sub-basin of Sabarmati basin, which is an adjoining basin to Berach Sub-basin of Banas Basin, is having surplus water to the extent of 396 Mcum which cannot be utilized within the basin due to non-availability of additional command and topography of the area. It has been proposed that about 62 Mcum out of total available surplus water can be transferred to Berach sub-basin to augment the inflow into Pichola Lake and in turn to Ayad River by implementing Dewas stage II, Dewas stage III and Dewas stage IV schemes. The scheme-wise break-up of transfer of surplus water corresponding to 50% dependable yield is as under:

Dewas stage – II = 20 Mcum
Dewas stage – III = 20 Mcum
Dewas stage – IV = 22 Mcum
Total = 62 Mcum approx.

A total of 4 dams will be constructed i.e. 2 dams on Wakal River (under Dewas Stage III and Dewas stage IV) and 2 dams on Mansi River, a tributary of Wakal River namely Akodara Dam and Madri Dam (Under Dewas stage II). Out of these, Dewas II scheme comprising of Akodara and Madri Dams is already under construction alongwith 2 tunnels one of 11.82 Km length from Akodara to Pichola and the second of 1 Km length from Madri dam to Akodara (to supplement the flow in Akodara dam). The salient features of proposed dams under Dewas stage – II, III & IV are given in **Annex – 5.3.**

The other two dams under Dewas III and Dewas IV on Wakal River are yet to be constructed. The survey work however has been initiated by water resources department. The surplus water from proposed dam at Dewas IV will be diverted to proposed Dewas stage III dam through 3.8 Km long tunnel. From Dewas III dam, the water will be diverted to Dewas II (Akodara dam) by means of another 10.38 Km long tunnel.

Thus, the transfer of 62 Mcum of surplus water to Pichola Lake would mean augmentation in water availability to the extent of about 150-170 MLD, part of which can be utilized for ensuring minimum flow for maintaining environmental and ecological balance of Ayad River.

The schematic diagram showing the layout of the above three schemes namely Dewas II, III & IV are shown in Plate 5.5.

It may be mentioned that Dewas stage I has been already commissioned by Water Resources Department in 2007-08 with Mansi Wakal Dam (I) across river Mansi which is transferring domestic water supply to the extent of 23.25 MLD to Pichola Lake through a tunnel of 2.3km length.

5.3 STUDY OF EXISTING LONGITUDINAL & X-SECTIONAL PROFILE OF RIVER

The existing river profile in terms of longitudinal and cross-sectional in various reaches all along the river length is required to be established and used as an input for planning of river channelization and also for planning of various riverfront development works.

To study the existing details of L and X –sections, following data from survey output is used:

- Plan and L-sections of the river from Thur dam (0 m) upto the outfall point in Udaisagarlake (26077 m).
- X-sections at an interval of 50 m.

From detailed studies carried out on the basis of available data, the following broadinferencesare drawn:

- The river reach from RD 9.5 km to 20.5 km (11 km) is located within the city area.
- At some locations flat banks are encountered and river depth is very less
- At some locations, river section is not defined
- At some locations within the city, the river section becomes narrow, due to which flow is not smooth
- In certain stretches, there is scope of changing the course of the river to protect inhabited areas from flood

The details of existing river profile at every 500m interval have been tabulated and are given in **Annex-5.4.**It covers lowest bed level, left and right bank levels, top width of river and depth of river bed w.r.t. average bed level and lower bank level. The salient features of the existing river profile are as under:

Table 5.16: Salient Features of Existing River Profile

Average top width of river	70m (varying between 27m to 145m)
Average depth of river bed	1m (varying between 0.2 m to 2.5 m)
Left bank level	Between 624m to 542m
Right bank level	Between 616m to 542m
Average bed level	Between 616 to 541.5m
Lowest bed level	Between 610m to 539m

5.4 RIVER CHANNELIZATION

5.4.1 Necessity

From river channelization angle, the condition of Ayad River is very precarious. Following peculiarities further complicate the river channelization.

i) No defined river section
ii) Encroachment on river banks
iii) Flat banks in many reaches
iv) Narrow section in city area
v) No maintenance of river banks
vi) No greenery on the river banks
vii) High siltation of river bed
viii) Excessive weed growth in the river bed
ix) In the absence of proper banks , the river depth is very less

Unless in-depth studies are made and consequent appropriate measures taken to remove the above said bottlenecks, the river channelization scenario will remain a distant reality.

5.4.2 Hydrological Modeling

The hydrological modeling studies for the river have been carried out using HEC-RAS Software developed by US Army corps of Engineers for River Analysis System. The software is designed to perform one-dimensional hydraulic calculations for a full network of natural and constructed channels. HEC-RAS system contains four one-dimensional river analysis components for:

- Steady flow water surface profile computations,

- Unsteady flow simulation
- Movable boundary sediment transport computations
- Water quality analysis.

In addition to the four river analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed.

In this project, this software has been used to study steady flow water surface profiles. This component of the modeling is intended for calculating water surface profiles for steady gradually varying flow. The system can handle a single river reach or a full network of channels. The steady flow component is capable of modeling subcritical, supercritical, and mixed flow regime water surface profiles. The mixed flow regime calculations include the effect of various obstructions such as bridges, culverts, weirs and other structures in the flood plain where the water surface profile is rapidly varied. The steady flow system is designed for application in flood plain management studies to evaluate flood way encroachments. Also, capabilities are available for assessing the change in water surface profiles due to channel improvements and levees.

Special features of the steady flow component of the software include: multiple plan analyses, multiple profile computations, multiple bridge/culvert opening analysis and split flow optimization at stream junctions and lateral weirs, anicuts etc.

5.4.3 Water Level Profile Studies

5.4.3.1 Under Existing Scenario

Water level profile studies have been carried out on river Ayad using **HEC-RAS software** for a design flood of 50-year return period using digitized cross section survey data. As an example, the existing river cross section as plotted in HEC-RAS at Ch-22500 is given in **Figure 5.15.**

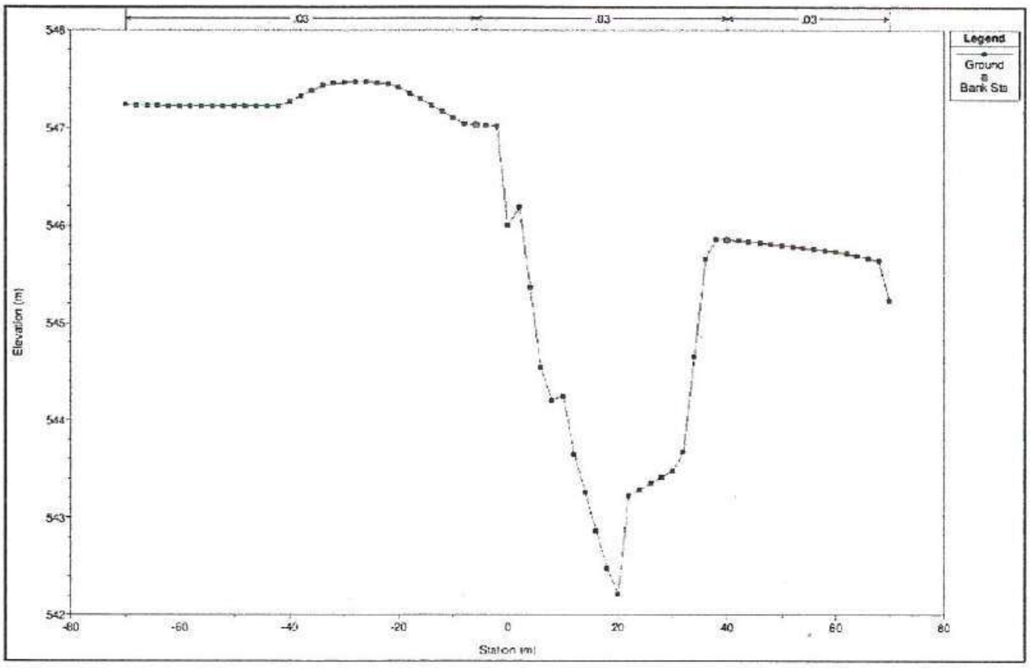


Figure-5.15 Cross Section at Chainage 22500 m

The peak flow values used for simulating design flood conditions in different reaches are given in **Table-5.15.** The resulting water levels in existing river cross sections at 500 m intervals are given in **Table-5.17.** HEC-RAS output of water level profile at a few existing cross sections are given in **Figures 5.16 to 5.19.**

Table-5.17 Water Levels in Existing Cross Sections

Chainage (km)	Minimum Channel Elevation (m)	Water Surface Elevation (m)
0	615.69	618.72
500	607.8	610.21
1000	605.1	610.32
1500	603.01	608.49
2000	602.39	606.81
2500	600.03	604.79
3000	597.07	603.68
3500	596.54	601.15
4000	593.92	598.21

4500	593.14	597.22
5000	591.16	594.98
5500	588.21	593.44
6000	586.63	592.87
6500	586.22	590.84
7000	585.1	590.21
7500	582.74	588.41
8000	582.26	587.68
8500	580.46	585.92
9000	578.99	583.92
9500	578.28	581.79
10000	575.63	581.09
10500	575.63	580.34
11000	573.24	579.37
11500	573.3	578.52
12000	572.49	576.65
12500	570.17	574.46
13000	565.58	574.31
13250	567.08	573.92
13500	567.67	572.71
14000	565.29	571.79
14500	564.14	570.16
15000	561.97	568.41
15500	560.52	565.29
16000	558.38	563.04
16500	556.12	562.95
16800	555.54	562.53
17000	555.03	562.36
17500	556.2	560.88
18000	552.56	560.2
18500	552.91	558.5
19000	551.18	557.36
19500	549.55	555.07
20000	547.35	554.8
20500	546.2	552.61
21000	545.6	551.81
21500	545.41	551.26
22000	543.75	550.62
22500	542.22	549.41

23000	541.77	548.88
23500	541.1	548.51
24000	540.89	548.11
24500	540.98	547.76
25000	539.1	546.95
25500	538.31	546.34
26000	539.24	545.77
26077	539.95	545.49

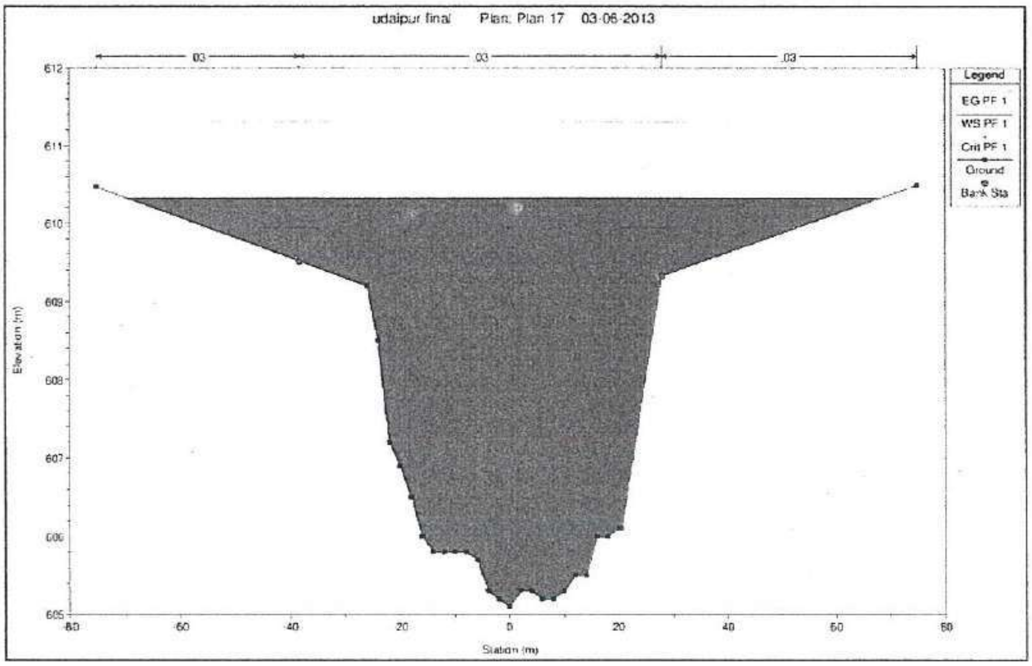


Figure 5.16 - Water Level Profile at Ch-1000 m

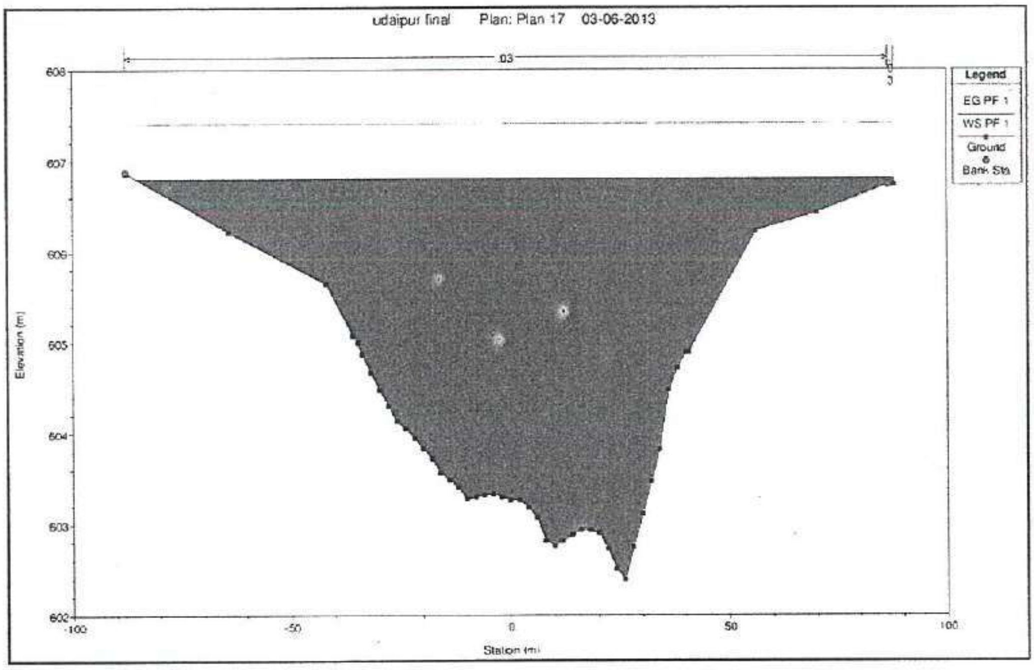


Figure 5.17 - Water Level Profile at Ch-2000 m

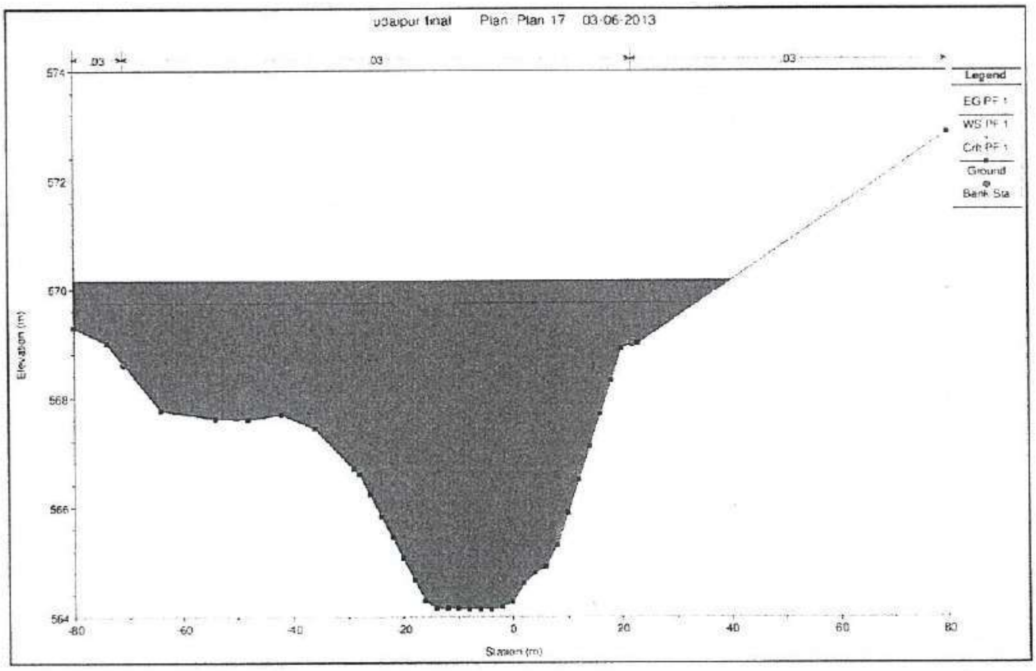


Figure 5.18 - Water Level Profile at Ch-14500 m

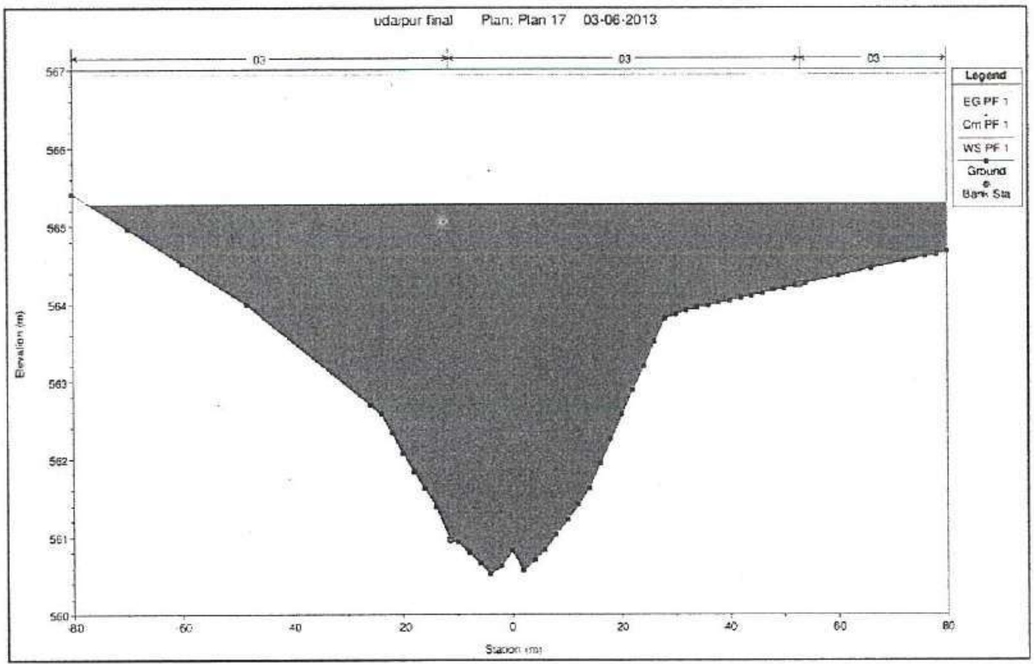


Figure 5.19 - Water Level Profile at Ch-15500 m

The plot of water surface profile for 50-year return period flood impinged on existing river sections along the entire length of the river is given in **Figure 5.20**.

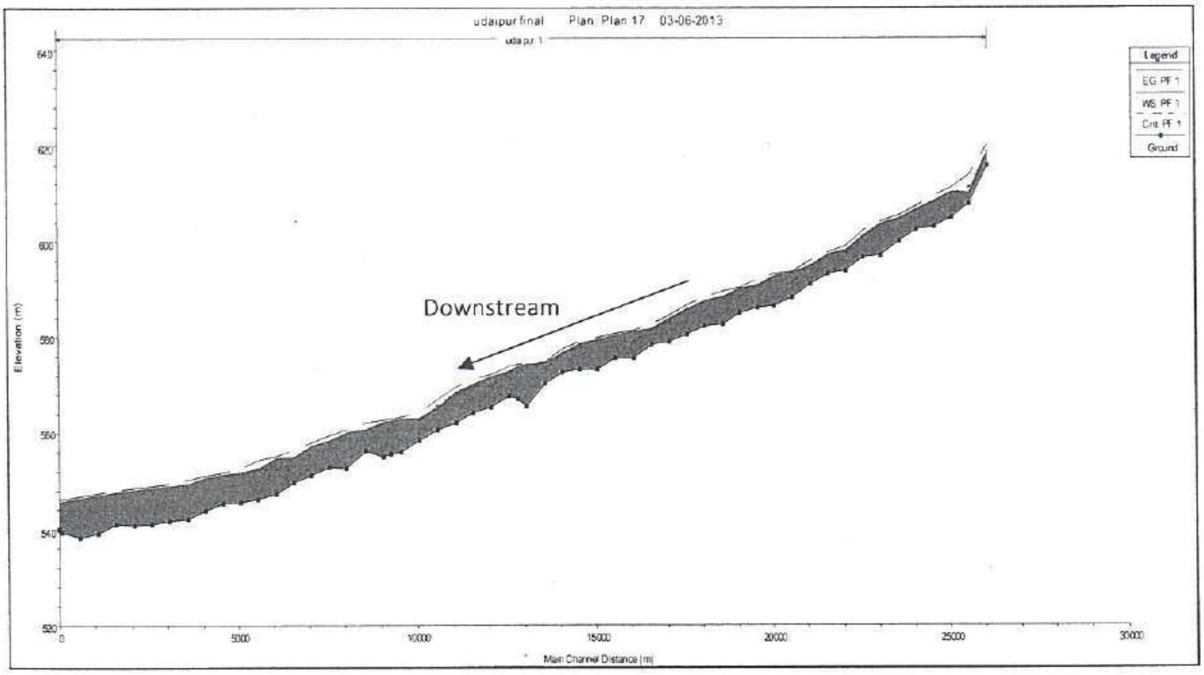


Figure-5.20 Water Surface Profile

5.4.3.2 Efficacy of Flooding in Existing River Channel

In order to ascertain the efficacy of flooding in the river channel, it is necessary to determine in which reaches/points the flood water level is exceeding the natural river bank level. The Flood Water Levels (F.W.L.) of 50-year computed flood compared to the right bank levels (R.B.L.) and left bank levels (L.B.L.) at different points of the river under the existing scenario are given in **Table-5.18**. A graphical plot showing the relative magnitude of these three parameters is given in **Figure-5.21.**

Table-5.18 50-year Flood Level and Bank Levels

Unit: m

Chainage	L.B.L	R.B.L	F.W.L.	Result
0	624.00	616.00	618.72	B
500	609.00	609.80	610.21	C
1000	609.20	606.10	610.32	
1500	608.92	603.95	608.49	B
2000	605.00	604.90	606.81	C
2500	602.62	602.05	604.79	
3000	601.00	600.95	603.68	
3500	599.40	598.99	601.15	
4000	595.59	596.25	598.21	
4500	595.50	594.96	597.22	
5000	595.56	593.98	594.98	B
5500	592.75	590.89	593.44	C
6000	590.71	591.41	592.87	
6500	588.56	590.52	590.84	
7000	585.18	589.63	590.21	
7500	587.21	586.12	588.41	
8000	584.72	585.12	587.68	
8500	585.00	585.61	585.92	
9000	582.58	584.01	583.92	A
9500	580.82	580.70	581.79	C
10000	581.00	578.76	581.09	
10500	579.55	576.84	580.34	
11000	575.00	577.23	579.37	
11500	574.50	576.97	578.52	

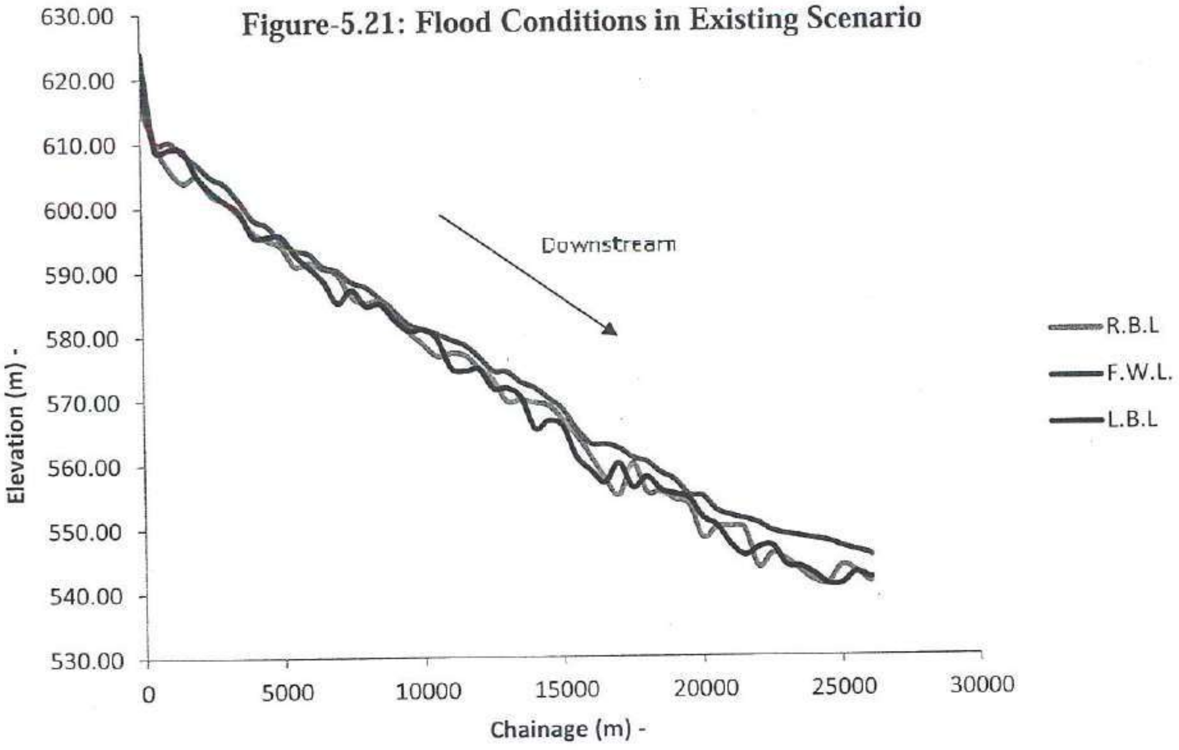
12000	574.78	574.94	576.65	C
12500	571.76	573.06	574.46	
13000	571.80	569.68	574.31	
13500	570.31	570.01	572.71	
14000	565.45	569.50	571.79	
14500	566.70	569.00	570.16	
15000	565.79	566.73	568.41	
15500	560.96	564.25	565.29	
16000	558.83	561.00	563.04	
16500	557.00	557.60	562.95	
17000	560.00	555.03	562.36	
17500	556.20	559.92	560.88	
18000	557.85	555.50	560.2	
18500	555.80	555.48	558.5	
19000	555.20	554.32	557.36	
19500	554.50	553.50	555.07	
20000	551.50	548.45	554.8	
20500	550.21	550.07	552.61	
21000	547.31	550.06	551.81	
21500	545.62	549.66	551.26	
22000	546.78	543.84	550.62	
22500	547.03	545.85	549.41	
23000	544.06	544.91	548.88	
23500	543.78	543.16	548.51	
24000	542.64	541.61	548.11	
24500	541.07	541.26	547.76	
25000	541.13	543.95	546.95	
25500	542.83	543.11	546.34	
26000	542.04	541.39	545.77	
26077	542.05	541.92	545.49	

A- Flood spilling on Left Bank

B- Flood Spilling on Right Bank

C- Flood Spilling on both Banks

Figure-5.21: Flood Conditions in Existing Scenario



It is seen from the above **Table-5.18** and **Figure-5.21** that the flood water level is higher than the banks practically in the entire river stretch except at 4 points, thereby necessitating the requirement of river channelization with proper designed sections with or without lining so that water level may remain contained within the banks.

A plan showing the water spread in case of 50-year return period flood in Ayad River is given in **Plate-5.6.**

5.4.3.3UnderDesign Scenario

Keeping the existing scenario in view, the river sections have been designed considering lined sections in 11 km reach from Ch. 9.5 km to 20.5 km and remaining portion as unlined sections also properly designed.

The bed level, bottom width and embankment level (including freeboard) of the designed sections at every 500 m interval is given in **Table-5.19**.

Table: 5.19 Details of Designed Sections

Reach	River Station	Chainage	Discharge	Bed Level	Bottom Width	Embankment Level
		(m)	(m3/s)	(m)	(m)	(m)
1	55	500	1086.82	607.93	35	611.42
1	54	1000	1086.82	605.19	35	610.85
1	53	1500	1086.82	603.18	35	609.94
1	52	2000	1086.82	602.47	35	608.02
1	51	2500	1086.82	600.12	35	605.00
1	50	3000	1086.82	597.17	35	603.30
1	49	3500	1086.82	596.62	35	601.72
1	48	4000	1086.82	594.00	60	599.00
1	47	4500	1086.82	593.23	60	597.75
1	46	5000	1086.82	591.25	60	595.80
1	45	5500	1086.82	588.30	60	594.40
1	44	6000	1086.82	586.87	60	593.40
1	43	6500	1086.82	585.51	35	593.30
1	42	7000	1086.82	584.16	35	590.80
1	41	7500	1086.82	582.80	35	589.70
1	40	8000	1086.82	581.12	35	589.90
1	39	8500	1086.82	579.31	20	586.50
1	38	9000	1086.82	577.50	35	586.50
1	37	9500	1086.82	576.00	43	584.20
1	36	10000	1086.82	574.80	43	584.20
1	35	10500	1086.82	573.58	30	582.70
1	34	11000	1086.82	572.50	23	582.00
1	33	11250	1086.82	572.00	23	579.80
1	32	11500	1086.82	571.50	40	578.50
1	31	12000	1086.82	568.50	30	576.00
1	30	12500	1086.82	567.50	30	575.50
1	29	13000	1086.82	565.50	40	574.40
1	28	13250	1683.49	564.80	40	573.00
1	27	13500	1683.49	564.20	40	572.90
1	26	14000	1683.49	562.56	30	571.84

1	25	14500	1683.49	561.10	30	570.90
1	24	15000	1683.49	559.73	40	570.49
1	23	15500	1683.49	558.00	52	568.50
1	22	16000	1683.49	557.00	23	567.80
1	21	16500	1683.49	556.00	23	567.50
1	20	16800	1883.58	555.00	23	567.20
1	19	17000	1883.58	554.69	23	565.80
1	18	17500	1883.58	553.62	23	564.20
1	17	18000	1883.58	553.00	23	562.40
1	16	18500	1883.58	552.60	28	559.00
1	15	19000	1883.58	550.00	38	557.40
1	14	19500	1883.58	547.85	38	555.10
1	13	20000	1883.58	547.29	38	554.50
1	12	20500	1883.58	546.66	38	553.50
1	11	21000	1883.58	546.14	60	553.60
1	10	21500	1883.58	545.46	60	552.90
1	9	22000	1883.58	543.90	60	551.30
1	8	22500	1883.58	543.25	60	550.70
1	7	23000	1883.58	542.63	60	550.10
1	6	23500	1883.58	542.04	60	550.20
1	5	24000	1883.58	541.73	60	549.90
1	4	24500	1883.58	541.13	60	549.30
1	3	25000	1883.58	540.65	60	547.40
1	2	25500	1883.58	540.04	60	547.20
1	1	26000	1883.58	539.29	60	545.70
1	0	26077	1883.58	539.20	60	545.50

A freeboard of atleast 0.5 m shall be provided in the designed river sections. In the unlined sections, i.e. the region outside the city area, a side slope of 2:1 has been provided. In the city portion, keeping in mind the space limitations, it is proposed to provide retaining walls to prevent the flood from affecting the surrounding regions.

The designed river sections in different river reaches superimposed on the existing river x-sections are given **Plates-5.7**.

Water profile studies were conducted on the above designed sections to ascertain the 50-year flood profile using HEC-RAS. The corresponding water surface elevations and Energy Gradient (EG) elevations are given in **Table-5.20**.

Table-5.20 50-Year Flood Levels in Designed Sections

Chainage (m)	Water Level (m)	EG Elevation (m)
500	610.68	614.19
1000	609.73	610.76
1500	608.86	609.44
2000	606.76	608.05
2500	603.94	605.23
3000	602.75	603.25
3500	600.51	601.85
4000	598.37	598.92
4500	597.00	597.75
5000	594.29	595.56
5500	592.72	593.20
6000	592.28	592.55
6500	591.15	591.88
7000	589.06	590.30
7500	588.54	589.05
8000	588.29	588.59
8500	586.00	587.82
9000	583.01	585.04
9500	582.6	583.34
10000	582.47	583.01
10500	581.65	582.67
11000	579.82	581.91
11250	578.08	581.11
11500	575.55	579.73
12000	575.22	576.06
12500	573.13	575.29
13000	573.84	574.39
13250	572.63	574.12

13500	572.47	573.80
14000	570.04	572.89
14500	567.94	571.35
15000	567.69	569.11
15500	568.06	568.59
16000	567.14	568.30
16500	566.89	567.91
16800	566.46	567.68
17000	564.99	567.35
17500	564.15	566.49
18000	562.00	565.31
18500	556.51	562.55
19000	555.10	558.45
19500	554.68	556.13
20000	553.97	555.51
20500	552.54	554.65
21000	552.43	553.30
21500	550.73	552.06
22000	550.43	550.92
22500	549.91	550.38
23000	549.42	549.87
23500	548.78	549.36
24000	548.13	548.78
24500	547.58	548.13
25000	546.86	547.47
25500	546.06	546.72
26000	545.19	545.89
26077	545.03	545.75

Water profile on a few designed sections is given in **Figures-5.22 to 5.24**. The designed longitudinal 50-year flood profile is given in **Figure-5.25**.

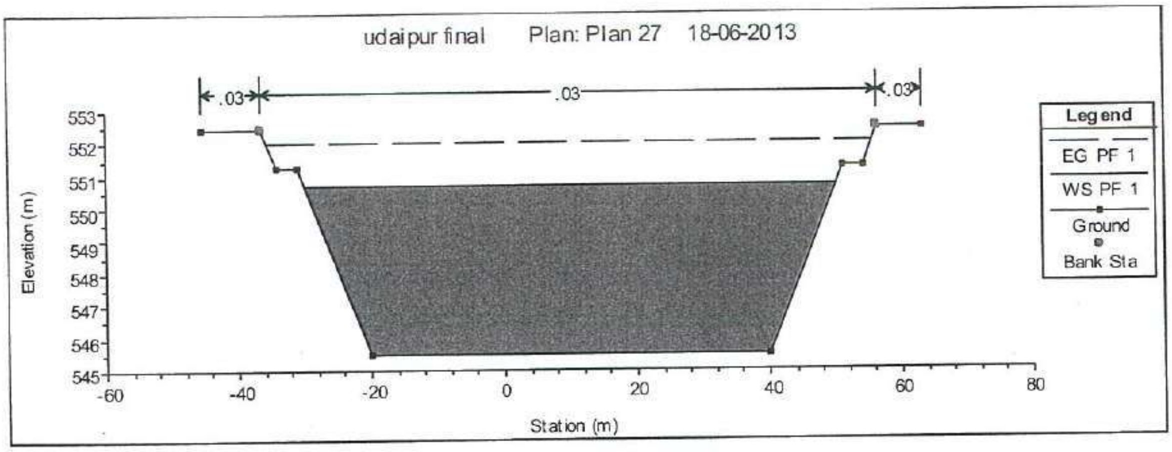


Figure-5.22 Flood Profile at Chainage-21500 m

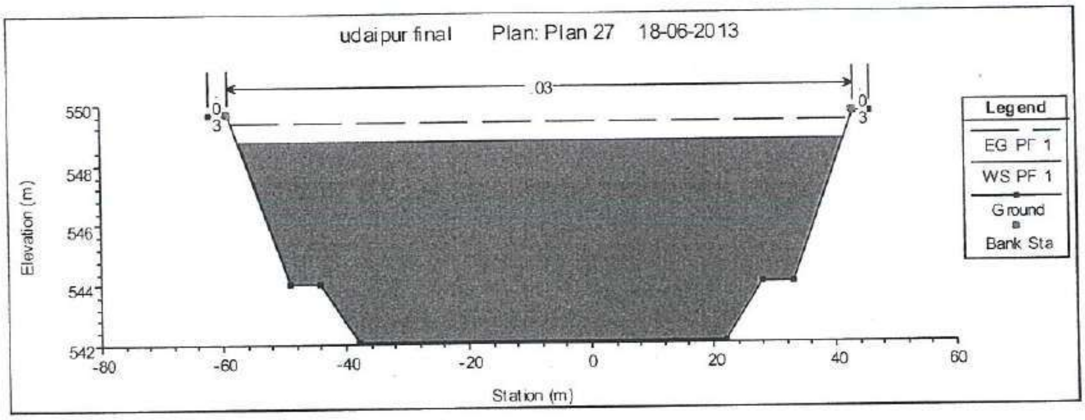


Figure-5.23 Flood Profile at Chainage-23500 m

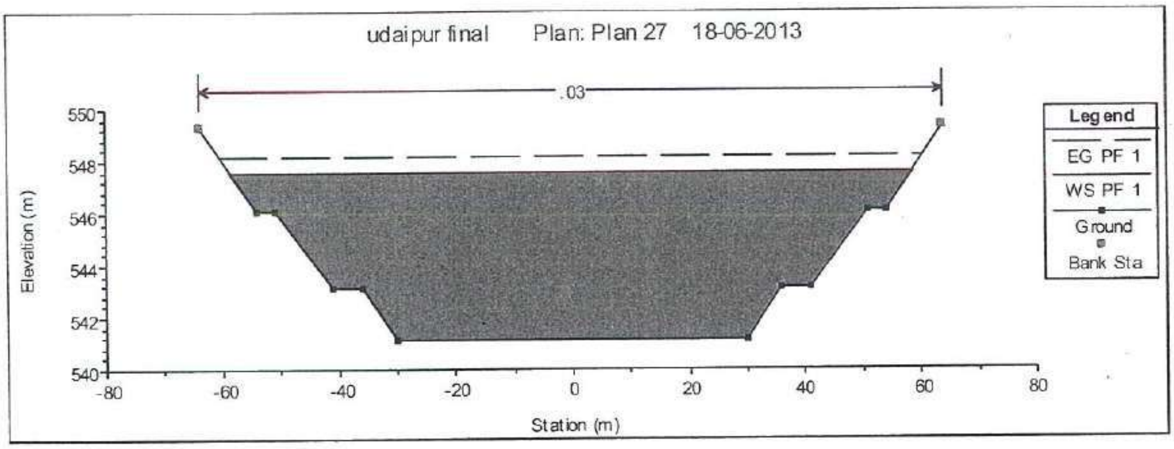


Figure-5.24 Flood Profile at Chainage-24500 m

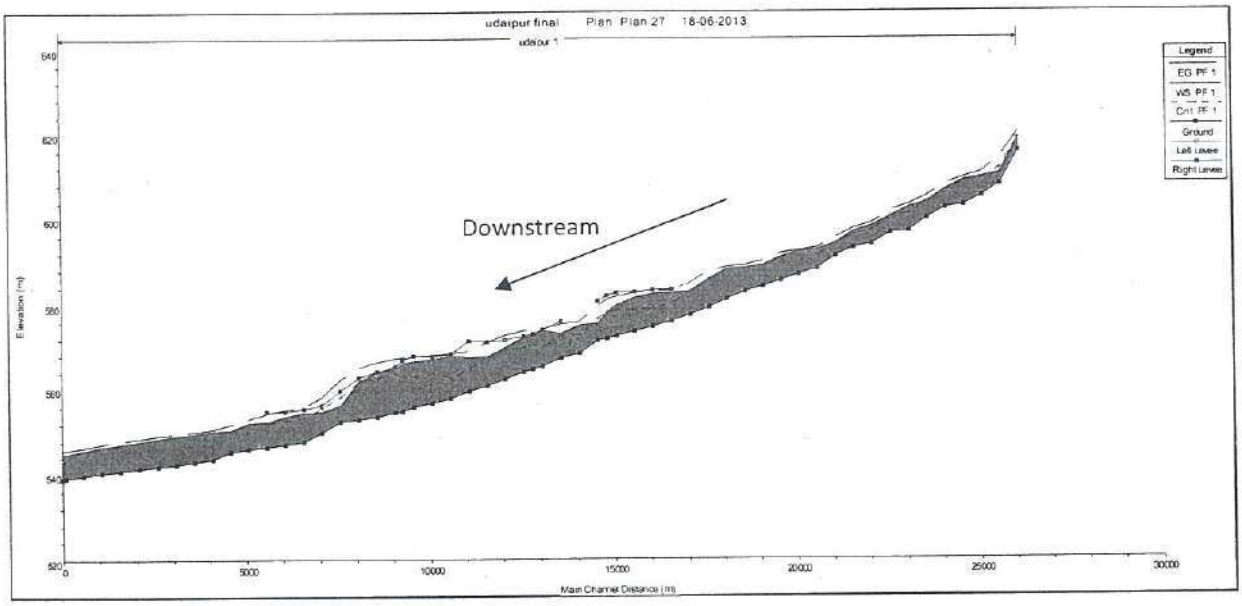


Figure-5.25 Designed Channel Longitudinal 50-Year Flood Profile

It can be observed from the longitudinal water profile that the 50-year flood depths in the portion of the river outside the city are less compared to the depths within the city region, as sufficient width is available outside the city.

The plot of Bed Level (B.L.), Water Level (W.L.) and Embankment Level (E.L.) for the channelized river sections is given in **Figure-5.26.**

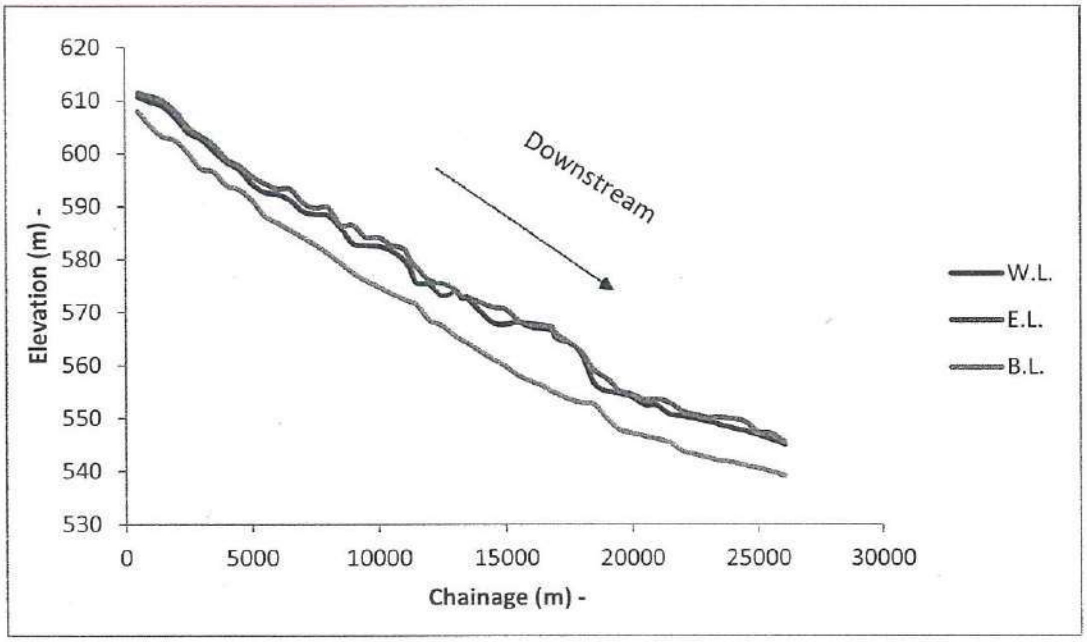


Figure-5.26 Details of Channelized River Section

5.4.4 Requirement and Extent of River Lining

As already mentioned, river portion lying in the city area is 11 km i.e. from Ch 9.5km to Ch 20.5km. The river boundary in the city portion is narrow and therefore in order to pass the computed flood, it is necessary to increase the carrying capacity of the river channel by lining. The details of proposed lining in 11 km length of the river after channelization are under:

i. Length of lining : 11 km
ii. Chainage : 9.5 to 20.5 km
iii. Computed flood in lined portion : 621 to 1883 cumec
iv. Type of lining : Stone Masonry Lining

v. Lining of river section :
- Sides-Lined with Stone Toe Wall at Bed Level
- River Bed-Unlined

The river bed, which has been kept unlined to economize cost, will be properly dressed by removing the silt and finishing properly for smooth flow of water.

The quantity of lining and the requirement of desiltation& dressing of the river bed in lined portion work out as under:

i) Quantity of Desiltation& Dressing of river bed in 11 km length of lined portion = 1121545Cum
ii) Quantity of Stone Masonry Lining = Being worked out

5.4.5 Requirement of Dressing and Re-Sectioning of Unlined River Portion

Against the total length of 26 m, 11m is proposed as lined and the remaining 15 Km as unlined. But for passing of the requisite flood, it is necessary to prepare the river section as per design by removing the deposited silt & weed growth from bed and re-sectioning the sides and banks as per required slope.

The details of the unlined portion of the river after channelization are as under:

i. Length of unlined portion : 15 km

ii. Chainage : 0 to 9.5 km = 9.5 km
20.5 to 26 km = 5.5 km
----
15 km

iii.	Computed Flood in unlined portion	:	Between 621 to 1086 cumec (0 to 9.5 km) 1883 cumec (20.5 to 26 km)
iv.	Side Slope	:	2:1 (H:V)
v.	Water Depth in unlined portion	:	6.8 to 7.3 m (0 to 9.5 km) 6.0 to 8.0 m (20.5 to 26 km)

The quantity involved in re-sectioning of sides and dressing of river bed in unlined portion shall be as under:

i)	Quantity of Desiltation and Dressing of bed in 15 km length of unlined portion	:	513350Cum (0-9.5 km) 464810Cum (20.5-26 km)
ii)	Quantity of Re-sectioning of sides and banks in unlined portion	:	Being worked out

5.5 RIVER SILTATION

5.5.1 General

Siltation in the river is caused by soil erosion from the catchment area. Soil erosion is one form of soil degradation alongwith soil compaction, low organic matter, and poor internal drainage, salinization, and soil acidity problems. These other forms of soil degradation, serious in themselves, usually contribute to accelerated soil erosion.

Soil erosion is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year.

The rate and magnitude of soil erosion is controlled by accompanying water, wind and stream and ditch bank erosion parameters. A brief description of these parameters is given below:

➢ **Erosion by Water**

Erosion by water is influenced by following factors:

- Rainfall Intensity and Runoff

- Soil Erodibility
- Slope Gradient and Length
- Vegetation

➢ Rainfall Intensity and Runoff

The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter can be easily removed by the raindrop splash and runoff water; greater rain drop energy or runoff amounts might be required to move the larger sand and gravel particles.

➢ Soil Erodibility

Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils.

➢ Slope Gradient and Length

Naturally the steeper the slope of a field, the greater the amount of soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential, due to increased velocity of water which permits a greater degree of scouring (carrying capacity for sediment).

➢ Vegetation

Soil erosion potential is increased if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate.

The erosion-reducing effectiveness of plant and/or residue covers depends on the type, extent and quantity of cover. Vegetation and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface and the most efficient in controlling soil (e.g. forests, permanent grasses).

➢ Erosion by wind

Erosion by wind is influenced by the following factors:

- Erodibility of soil
- Soil Surface Roughness
- Climate
- Unsheltered Distance
- Vegetative Cover

➢ Erodibility of Soil

Very fine particles can be suspended by the wind and then transported to great distances. Fine and medium size particles can be lifted and deposited, while coarse particles can be blown along the surface (commonly known as the siltation effect). The abrasion that results can reduce soil particle size and further increase the soil erodibility.

➢ Soil Surface Roughness

Soil surfaces that are not rough or ridged offer little resistance to the wind. However, over time, ridges can be filled in and the roughness broken down by abrasion to produce a smoother surface susceptible to the wind. Excess tillage can contribute to soil structure breakdown and increased erosion.

➢ Climate

The speed and duration of the wind have a direct relationship to the extent of soil erosion. Soil moisture levels can be very low at the surface of excessively drained soils or during periods of drought, thus releasing the particles for transport by wind.

➢ Unsheltered Distance

The lack of windbreaks (trees, shrubs, residue, etc.) allows the wind to put soil particles into motion for greater distances thus increasing the abrasion and soil erosion. Knolls are usually exposed and suffer the most.

➢ Vegetative Cover

The lack of permanent vegetation cover in certain locations has resulted in extensive erosion by wind. Loose, dry, bare soil is the most susceptible; however, crops that produce low levels of residue also may not provide enough resistance. As well, crops that produce a lot of residue also may not protect the soil in severe cases.

The most effective vegetative cover for protection should include an adequate network of living wind breaks combined with good tillage, residue management, and crop selection.

Wind erosion may create adverse operating conditions in the field. Crops can be totally ruined so that costly delay and reseeding is necessary - or the plants maybe sandblasted and set back with a resulting decrease in yield, loss of quality, and market value. The removal of wind-blown soils from fence rows, ditches, roads and from around buildings is a costly process.

- **Stream and Bank Erosion**

Poor construction, or inadequate maintenance, of surface drainage systems, uncontrolled livestock access, and cropping too close to both stream banks leads to bank erosion problems.

The direct damages from bank erosion include:

- The loss of productive farmland.
- The undermining of structures such as bridges.
- The washing out of lanes, roads and fence rows.

Sediment which reaches streams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels.

5.5.2 Project Specific

The type of soil in the catchment area of Ayad River is low dunes with Indus alluvial soil. The dominant soils of the alluvial plain are light brownish grey to brown and loamy to very fine sandy loam.

During the spells of rain and consequent runoff, silt gets transported to the river. So far, no desiltation measures have been taken as a result of which lot of silt has got accumulated in the river bed. After designing of the river section in various reaches for channelization of the flood discharge, it is estimated that the requirement of desiltation and dressing would be in the range 75,000 to 80,000 cum/km.

5.6 IMPOUNDING RESERVOIRS IN RIVER SECTION

5.6.1 Need:

The objective of providing impounding reservoirs within the river section is to charge the river with surface water and surrounding areas with ground water. These will be provided at intermittent points along the river depending upon the suitability of river bed strata. Clayey bed or rocky bed could be most suitable. Since the river bed is fairly silted up with silt material containing both sand and fine clay, there should not be any problem to provide such impounding reservoirs. The bed of Ayad river is also found to be having rock outcrops at numerous places.

The structure for impounding reservoir would be Anicuts or check dams (without gates) made of cement concrete or stone blocks provided with concrete capping. The height of Anicuts or check dam would be kept small say between 1.5 to 2.0m above the river bed so that series of such Anicuts/check dams constructed could get filled up simultaneously. The water impoundment behind such structures would also take place during the lean period depending upon the availability of flow which may be either rain water runoff, the treated or untreated waste water being discharged into the river.

5.6.2 Existing Anicuts

The State Govt. has already constructed Anicuts at four locations in the initial 7 km reach of Ayad River starting from Thur Dam with the objective to keep the water impounded in the river during the lean period from October to May. The location and other details of the existing Anicuts are as under:

Table 5.21: Details of Existing Anicuts on River Ayad

S.No	Chainage (m)	Top level (m)	Village	Approximate Depth (m)
1	Ch. 450 m	608.873	Thur	1 m
2	Ch. 3850 m	599.442	Loyra	2 m
3	Ch. 6600 m	585.949	Bedla	1.5 m
4	Ch.7150 m	585.806	Bedla	2 m

The location of the Anicuts has been kept in such a manner that the available depression in the river bed on upstream is exploited for impounding water. The storage created by these are estimated to be in the range of 15 to 20 million litres of water in one filling.

5.6.3 Additional Proposed Anicuts

The total length of the river to be tackled for River Front Development Project is 26 km. it is seen that the existing Anicuts are provided only in the initial 7 km length, the remaining length of 19 km is without any anicut.

Since enhancement of water availability during the lean period is one of the objectives of this project, it is proposed to provide additional Anicuts at suitable locations in the uncovered stretch of the river.

The locations of the additional Anicuts or check dams has been decided after examining the survey output, bed profile of river, scope for ponding upstream etc. Since river section in the city area is narrow, no anicut is proposed in such portions of the city as it might hinder the smooth transportation of flood discharge. The details of proposed Anicuts are given below:

Table 5.22: Details of Proposed Anicuts on River Ayad

Sl.No.	Chainage (m)	Top Level (m)	Village
1	8410	584.237	Bedla
2	11640	575.971	Devali
3	19410	552.072	Manvakheda
4	24890	543.851	Kharbaria

The average impoundment u/s of these Anicuts may be of the order of 10 to 15 Million Litres depending upon the size of local depression in the river bed.

The existing and proposed Anicuts totaling to 8 Nos, would provide the intermittent balancing storage to the tune of 80 to 120 Million Litres along the river. This can be used to withdraw water for maintenance of green patches, parks etc proposed on the river banks under the landscaping and beautification plan of the project.

CHAPTER – V

ABATEMENT OF POLLUTIOI

CHAPTER - VI

ABATEMENT OF POLLUTION

6.1 GENERAL

Human civilization and settlements flourished around available water sources. Human consume the water for daily needs and livelihood. After consumption and use the spent water is discharged on land. With the rapid growth in industrialization and population, increase in water demand and spent water has tremendously increased which finds its way in low lying areas and ultimately in water bodies to pollute these natural water bodies which are considered sacred from ancient times and linked with religious beliefs. To keep these water bodies free from any pollution, remedial measure are required to be taken to abate the pollution from point and non point sources.

The pollution from point sources can be easily identified, measured and tackled as compared to non point sources. During survey along the Ayad River, locations have been identified where the sullage water after use by the city residents is being discharged into river. Pollution from point source is quantified in subsequent paras which is based on expected population and rate of water supply to city residents.

6.2 DEMOGRAPHY

6.2.1 Census population

Census population of Udaipur municipal corporation as per census is available in master plan since 1901.To forecast the expected future population it will be fairly good to take the census data after independence. Population data as per census since 1951 to 2011 is tabulated below:-

Table 6.1: Population as per Census

Year	Population
1951	89621
1961	111139
1971	161278
1981	232588

1991	308571
2001	389317
2011	451735

6.2.2 Population Projection by different methods as per CPHEEO Manual

Population projection has been done by different methods as prescribed in manual issued by CPHEEO Government of India. **Projected population in different years as per arithmetical progression, geometrical progression, and incremental increase methods is tabulated in the Annex - 6.1.**

6.2.3 Final Adopted Population

As per master plan the population for Udaipur town is expected to be 830000 in 2022. Detailed Project report of sewerage scheme Udaipur prepared by M/s Voyant Solutions indicate projected population as 532602, 763833, and 1111227 in the year 2011, 2026 and 2041 respectively. This is much on the higher side if compared with the actual population of 451735 in 2011 as per census.

Census data 1971 onwards shows decreasing trend in decadal population growth. Decadal growth was 45.11% in 1961-1971, 44.22% in 1971 1981, 32.67% in 1981 1991, 26.18% in 1991-2001 and 16.03% in 2001-2011. **In view of decreasing trend it is fairly good to assume average population as calculated above by different methods.**

Table 6.2: Population Forecast by Different Methods

Year	Population			
	Arithmetic Progression	Geometric Progression	Incremental Increase	Average
2011	451735	451735	451735	451735
2016	481911	514026	484979	493639
2021	512087	584907	520267	539087
2026	**542263**	**665561**	**557601**	**588475**
2031	572439	757338	596979	642252
2036	602615	861769	638403	700929
2041	**632791**	**980601**	**681871**	**765088**
2046	662967	1115819	727385	835390

6.3 EXISTING WATER SUPPLY AND SEWERAGE SYSTEM

For any sewerage system to work properly and efficiently it is of utmost importance that water for daily use is available to the public in adequate quantity and with sufficient pressure in the city.

6.3.1 Water Supply System

Urban Water Supply Scheme Udaipur includes Udaipur town and seven peripheral villages. The population of Udaipur town is 451735 as per 2011 census. The population of these villages is around 30000.

6.3.1.1 Source of Water Supply

There are two types of sources for meeting water supply demand of city:

- **Surface source**

  There are many lakes in the city which are the major source of water supply

- **Ground water source**

  There are number of tubewells and punghatas which are source of water supply in some localities of city.

6.3.1.1.1 Surface source

Udaipur has numerous lakes in its vicinity, the important ones being Pichola, Fatehsagar, Jaisamand, etc. These lakes, along with Mansi Wakal Stg I Dam, local bowries and borewells, have been Udaipur's major sources of drinking water in the past. Capacity of the Pichola Lake is 13,700 million litres, whilst at its minimum drawable level its corresponding capacity is 2,250 million litres. Capacity of Fateh Sagar Lake is 12,100 million litres and at its minimum drawable level its corresponding capacity is 2,300 million litres. Jaisamand lake is much larger than Pichola and Fatehsagar lakes and has gross storage of 415000 million litres and live storage of 300000 million litres. The storage capacity Mansi Wakal Stage I dam is 24.41 MCum (862 Mcft). Project is designed to produce 36 MLD water (13.14 Mcum - 464 Mcft annually). Hindustan Zinc Limited Udaipur is 30 percent share holder as this project has been executed with concept of Public Private Partnership. Water is also drawn from Badi Lake which is located on the outskirts of the city during emergency. Maximum drawl is about 3 MLD.

6.3.1.1.2 Ground Water Source

Ground water is drawn from the wells at Sahelion ki bari & Gulab Bag within the city of Udaipur and Jhamar Kotra mines located at outskirts of Udaipur.

The present ground sources include production from 89 Nos. of tube wells and 30 Nos. of open wells. Besides this, water supply is also supplemented through 150 Panghats. There are 2129 No. of hand pumps working in the town.

6.3.1.2 Availability of Water from Different Sources

The installed water capacity of different sources vis a vis production in lean years is as mentioned below. The inflows into the lakes have been poor since the year 1999 except 3 years. The available water sources for Udaipur water supply are given in the Table below:

Table 6.3: Available water sources for Udaipur urban water supply scheme

SURFACE SOURCES			
S.No	**Name of Source**	**Water production in MLD**	
		Maximum in normal years	**In lean years**
1	Pichola	21.05	10.0
2	Fatehsagar	18.35	2.00
3	Jaisamand	19.43	19.43
4	Mansi Wakal Stage I	23.25	20.00
	SUB TOTAL	**82.08**	**51.43**
GROUND WATER SOURCES			
5.	Jhamar Kotra Tubewells	4.11	1.00
6.	Local Wells And Tubewells	10.25	2.00
	SUB TOTAL	**14.36**	**3.00**
	GRAND TOTAL	**96.44**	**54.43**

6.3.1.3 Existing Storage Reservoirs and Filtration Capacity

There are 30 Over Head Service Reservoirs (OHSR), 20 Ground Level Service Reservoirs (GLSR) and 25 numbers of Clear Water Reservoirs (CWR). The total storage capacity is 48.50 ML, which includes 21 ML capacity OHSRs, 20 ML capacity GLSRs and 7.5 ML capacity CWRs.

Udaipur has eleven Water Treatment Plants (WTP) having total capacity of about 84. 42 MLD. Out of these two Pressure filters, two old Rapid Gravity Filters (RGFs) and Ambavgarh filter plant with 12.16 MLD capacity have outlived their lives. Being old, filtration capacity of three other Water Treatment Plants is also reduced and thus available capacity of filtration is around 60 MLD.

6.3.1.4 Present Demand, Production & Supply per capita

Total water requirement for domestic and industrial use is 90 MLD. The present average water production for the town is around 70 MLD. The per capita supply is around 110-120 lpcd.

The alternate day water supply is being maintained in the town since Dec.'1996. The duration of supply is about 1.5 to 2.5 hours. The details of present production of water for domestic use are given in Table below:

Table 6.4: Present Production from different sources

SURFACE SOURCES			
S.No	Name of Source	Average Water production (MLD)	
		Sept 2009	Oct 2009
1	Pichola	7.54	13.48
2	Fatehsagar	9.72	10.89
3	Jaisamand	10.20	9.50
4	Mansi Wakal Stage I	28.92	20.60
5	Bari Lake	3.48	3.00
	SUB TOTAL	59.86	57.47

	GROUND WATER SOURCES		
6.	Local Wells and Tubewells	10.51	11.17
	GRAND TOTAL	**70.37**	**68.64**

6.3.1.5 Projected Water Demand

Rate of per capita supply of water considered is 135 lpcd for domestic use. 15% losses are taken into account as per manual of water supply issued by CPHEEO New Delhi. Bulk & Industrial Demands of 20 MLD is considered. The details of Projected Water Demand for domestic and industrial are given in Table below:

Table 6.5: Projected Water Demand for Udaipur City

S. No.	Year	Projected Water demand in MLD			
		Population	Domestic	Industrial	Total
1	2011	**451735**	70.01	20.00	90.01
2	2016	493639	76.51	20.00	100.33
3	2021	539087	83.55	20.00	103.55
4	2026	588475	91.21	20.00	111.21
5	2031	642252	99.54	20.00	119.54
6	2036	700929	108.64	20.00	128.64
7	2041	765088	118.58	20.00	138.58
8	2046	835390	129.48	20.00	149.48

6.3.1.6 Plan for Augmentation

With the increase in city population and industrialisation, the increase in water demand has compelled the authorities to think about the additional source. For further augmenting the source of water supply Dewas stage II project was sanctioned by state government in 2005. This is an inter basin water transfer from Sabarmati Basin to Banas Basin. It envisaged construction of Akodra Dam with net storage of 8.52 Mcum (301 mcft) and

Madri Dam having net storage of 2.42 Mcum (85.44 mcft) , both on Mansi River including tunnel length of 1.03km and 11.82 km. from Madri and Akodra dams respectively. The net storage of both the dams with 90% dependability is 10.84 Mcum with assured availability throughout the year. This will augment Pichola lake to provide estimated water supply of 17.5MLD.

6.3.2 Sewerage System

Wastewater is essentially the water supply of the community after it has been fouled by a variety of uses. The water supplied to a community receives a range of chemical substances and microbial flora during its use such that the wastewater acquires a polluting potential and becomes a health and environmental hazard. Communicable diseases of the intestinal tract such as cholera, typhoid, dysenteries and water borne diseases like infectious hepatitis etc., can be spread from uncontrolled disposal of waste water, and therefore prevention of communicable diseases and protecting public health attracts the primary objective is of sanitary waste water disposal·

6.3.2.1 Present Coverage

About 15-20 % area of city is covered with sewerage system. PHED constructed about 21.5 km. of sewerage network of different sizes ranging from 150mm to 800mm diameter. Areas covered were Chand Pole Area, Shivaji Nagar, Ganesh Ghati, Bhupalwadi, Delhi Gate, Hathi Pol, Shakti Nagar, Ashok Nagar, Subash Nagar and Hiran Magri Sector -3.

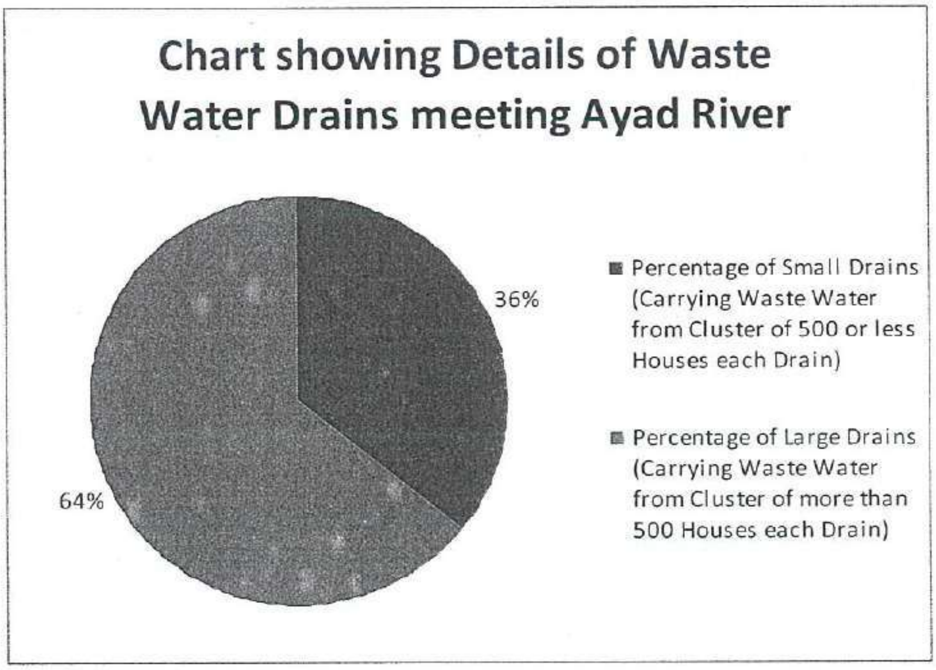
Udaipur Improvement trust in 2005 covered areas of Hari Dass ji Ki Margi, Amber Garh, Malla Talai, Left side area of Rang Sagar Lake, Brahm Pol Area, Guni Dyal Marg, Amber Mata, Brahm Pol Margi and Naga Margi. The sewerage network was laid in the areas to avoid waste water flow in the lakes. Length of network was about 24 km.

6.3.2.2 Present System of Disposal of Domestic Waste

The city does not have proper sewerage system and is mainly using septic tanks at domestic levels. The overflow from the septic tanks through various open drains finds its way into storm water drains or other water bodies which ultimately join Ayad River. Some of the populated areas on the banks of river are discharging waste water directly into the river.

6.3.2.3 Identification of Location of Pollution Points

Detailed survey has been carried out along the river alignment and it is found that at 28 locations the wastewater is meeting the river (refer **plate 6.1**). Out of 28 locations, 18 locations are such that each of these drain carry the wastewater from cluster of more than 500 houses, some of clusters are having number of houses as high as 20000 houses. At 10 locations each drain carries the waste from cluster of houses less than 500 number. Details of locations with RD, number of houses from which wastewater is carried are at **Annex – 6.2.** Pie chart below represents the comparison of large and small drains meeting the Ayad River.



Present estimated about 55 (Million litres per day) untreated domestic waste water is being discharged into this river. In addition, 20 MLD of untreated / partially treated waste water from industries is also entering the river.

6.3.2.4 Assessment of Pollution in River by Laboratory Tests of Sewage Samples

For assessment of pollution contribution by sewage in Ayad River, sewage samples were collected from different RDs and got analyzed for BOD and other parameters. Analysis reports of sample are tabulated in **Annex – 6.3**. Analysis of samples indicate that BOD is 235 mg/l,673mg/l, 561mg/l, 565 mg/l and 838 at RD 0.00 km, 8.50 km, 14.40 km, 15.30 km and 25.25 km respectively. The high BOD of 673, 565 and 838 is due to discharge of untreated sewage and effluent from industries. Low pH value of 6.75 is also an indication of industrial discharge in Ayad River.

0Km. $\frac{235\ mg}{l}$

8.50Km $\frac{673\ mg}{l}$ ✓

14Km. $\frac{561\ mg}{l}$

15.30 Km $\frac{565\ mg}{)}$

25.25 Km. $\underline{838}$

6.3.2.5 Plan for Prevention of Pollution in Pichola and Fatehsagar Lakes

6.3.2.5.1 Pichola Lake

Tetra Tech India Ltd, Delhi was assigned the job of preparation of DPR for "Conservation and Sustainable Management of Pichola Lake System, Udaipur" as per guidelines of National Lake Conservation Plan (NLCP) for seeking financial assistance from the Ministry of Environment and Forests (MOEF), Govt. of India. PDCOR Limited, Jaipur is the Coordinating Agency for the lake conservation and development projects. The DPR had been submitted by Tetra Tech in May, 2007. The project is being funded by MOEF, GOI under NLCP. The cost of the project is Rs.115 crore comprising 70% share of Govt. of India and 30% share of Govt. of Rajasthan. The implementation period is 3 years from the date of sanction of the project. The reports have identified various problems affecting the environment & eco-system of the lake and have outlined the remedial measures for each one of them. One of the measures outlined was regarding sewage inflow taking place to the extent of 25.92 MLD in Pichola Lake, 8.05 MLD in Rangsagar Lake, 2.42 MLD in Swaroopsagar Lake besides contribution from non-point sources of pollution which needed to be intercepted, diverted and disposed in the sewer system. NLCP project includes the cost of this component to the extent of Rs. 25 cr for Pichola lake system.

Though the implementation period of the project was 3 years, the project is still going on. The present status is not available.

6.5.2.5.2Fatehsagar Lake

The DPR of the project was prepared by Tetra Tech limited of New Delhi and submitted its report in May 2007, with PDCOR, Jaipur being the coordinating Agency for preparation of DPRs of all the five priority lakes in Rajasthan for funding under NLCP. The total cost of the project is Rs 48.88 crore comprising of 70% share of Govt. of India i.e Rs.34.22 crore and 30% share of Rajasthan Govt. i.e. Rs 14.66 crore. The DPR envisages all those remedial measures as suggested for Pichola Lake mentioned above. There is a provision in the project cost for interception and diversion of sewage in and around lake to the extent of Rs. 10 crore and storm water collection and screening before entry into lake to the extent of Rs. 5.0 crore.

Though the implementation period of the project was 3 years, the project is still going on. The present status is not available.

6.3.2.6 Zoning of Town for Sewerage Network Design

M/s Voyants Solution was entrusted the consultancy job to develop sewerage network for collection, interception and diversion of sewage from catchments of Pichola and Fatehsagar Lakes to Hathi Pole and ultimately divert the sewage to proposed Sewage Treatment Plant at Manwakheda. It covers mainly the old city area between Pichola and Fatehsagar Lakes. Areas or settlements covered are Charag Marg, Officers Training Colony, Mahakaleshwar Road, Ambargarh, PP Singh Marg, Billurana Colony, Gas

Godown Colony, Ambabadhi, Ekalavya Colony, Champa Colony, Hari-ji-ki-Magri, Sajjan Nagar, Rathahet, Duhiya Ganesh, Mallaitali area, New Rampura Colony, Alkapuri Colony, Mastan Baba Darga area and the area around hotel Radisson etc.

In addition to sewerage system in the above colonies, a trunk main sewer from Hathi Pol to Manwakheda is designed to transfer wastewater / sewage from the city. The proposed route of alignment of trunk main was finalized after discussion with Secretary and concerned official of UIT as well as Additional Project Director and Deputy Project Officer of RUIDP in August 2011. The trunk main is proposed to be laid along Ashwani Road, Delhi Gate, Panchsheel Marg, Suraj Pol, Chittore Road, Seva Ashram, Hiran Margi Sector -3, and the pipe line will follow the route / alignment of the old existing 800mm diameter trunk main trunk main in front of the VSNL office at Hiran Margi Sector- 3.

As per report of M/s Voyant Solution, the city has been divided into three sewerage zones for network design. The major development is in zone I of the city around the lakes and the old city as explained in above paras. Independent sewerage system can be provided for the surrounding areas which form a part of Udaipur Urban Agglomeration.

6.3.2.7 Expected Sewage Generation

Interception factor for calculation of sewage flow is considered as 80% of water supplied per capita per day. Infiltration at the rate of 5% is also considered. Sewage generated in different years is tabulated below:

Table 6.5: Details of Domestic Sewage Generated

Year	Population	Domestic sewage generated (80+5)% of 135lpcd	Floating Population	Sewage Generated by Floating Population	Total sewage generated
	No.	MLD	No.	MLD	MLD
2011	451735	51.84	30000	1.15	52.99

2016	493639	56.65	30000	1.15	57.79
2021	539087	61.86	30000	1.15	63.01
2026	**588475**	**67.53**	**30000**	**1.15**	**68.68**
2031	642252	73.70	30000	1.15	74.85
2036	700929	80.43	30000	1.15	81.58
2041	**765088**	**87.79**	**30000**	**1.15**	**88.94**
2046	835390	95.86	30000	1.15	97.01

M/s Voyants Solution has estimated the sewage generation of 121.08 MLD in the year 2041 for the population forecast of 1111227. As per WAPCOS estimate the population in 2041 shall be around 765088. WAPCOS has projected population on the census data of independent India since 1951 to 2011which seems appropriate in place of data since 1901 as considered by M/s Voyants Solution. As such the expected domestic sewage generation will be around 88.94 MLD by year 2041. Since detailed design is beyond the scope of consultant the expected sewage generation in three zones is reduced proportionately as calculated by M/s Voyants Solution. The sewage generation in three zones in 2041 is given in table below:

Table 6.6: Zone-wise Expected Domestic Sewage Generation

S. NO.	ZONE	Expected Domestic Sewage Generation(MLD)	
		Year 2026	Year 2041
1	ZONE I	50	65
2	ZONE II	10	12
3	ZONE III	10	12
TOTAL		**70**	**89**

One STP of 20 MLD capacity is being constructed in Zone 1 of sewerage. Another module of 30 MLD can be added to augment its capacity for the expected flow in the year 2026.

6.3.2.8 TREATMENT OF DOMESTIC WASTE WATER

The adverse environmental impact of allowing untreated wastewater to be discharged in groundwater or surface water bodies and/ or lands are as follows:

i) The decomposition of the organic materials contained in wastewater can lead to the production of large quantities of mal-odorous gases.

ii) Untreated wastewater (sewage) containing a large amount of organic matter, if discharged into a river / stream, will consume the dissolved oxygen for satisfying the Biochemical Oxygen Demand (BOD) of wastewater and thus deplete the dissolved oxygen of the stream, thereby causing fish kills and other undesirable effects.

iii) Wastewater may also contain nutrients, which can stimulate the growth of aquatic plants and algal blooms, thus leading to eutrophication of the lakes and streams.

iv) Untreated wastewater usually contains numerous pathogenic, or disease causing micro-organisms and toxic compounds, that dwell in the human intestinal tract or may be present in certain industrial waste. These may contaminate the land or the water body, where such sewage is disposed. For the above-mentioned reasons the treatment and disposal of wastewater, is not only desirable but also necessary. Some of the organics in wastewater are not biologically degradable and thus do not impart the BOD. Some of these non-degradable organics such as pesticides can have adverse long-term effects and can contribute to taste, odour and colour problems in downstream water supplies. The term chemical oxygen demand (COD) is used to measure the quantities of these materials present. The COD value also reflects biologically degradable materials: therefore, the COD is higher than the BOD because more compounds can be oxidized chemically than biologically. Some of the COD causing materials are organics that are very resistant to breakdown in the environment: they are of particular concern where water is used for a municipal water supply downstream.

Given the characteristics of raw wastewater and the requirements of disposal or reuse, the wastewater usually requires some type of preparation or treatment before it is rendered fit for disposal or reuse. Generally, in many situations involving domestic wastewater, the treatment consists of removal of suspended solids and 5-day, 20°C BOD, which are the two usual parameters of prime interest. The purpose of waste water treatment plant is to separate inorganic particulates and to stabilize the decomposable organic matter present in waste water so as to produce an effluent and sullage which can be disposed of in the environment without causing health hazards or nuisance. The complete treatment of wastewater is brought by a sequential combination of various physical unit operations, and chemical and biological unit processes.

6.3.2.9 Location of Sewage Treatment Plants

At present untreated sewage and sullage of the city from areas having sewerage network or not having sewerage network is discharged either into nearby storm drains which ultimately meet Ayad River or directly into river. In Zone I, one STP of 20 MLD capacity is being constructed at Manwakheda by Hindustan Zinc Ltd for treatment of domestic sewage of the city. The plant is based on MBBR technology. The STP is designed to treat the sewage to the level to produce effluent of the quality that it is fit for reuse. The treated effluent will be reused by Hindustan Zinc Ltd in its plant 600mm internal diameter steel pipe is also being laid by it for carrying treated sewage to the plant.

The capacity of STP can be augmented in stages by adding more modules and by laying sewerage network in uncovered areas side by side to intercept and carry the untreated sewage to plant site.

At present there is nominal development in Zone II and Zone III. Independent separate STP for Zone II and Zone III are proposed at locations marked on the plan (refer **plate 6.2**). Site is to be arranged by the authorities. Independent STP for each zone is proposed to avoid crossing of River Ayad. Independent treatment of sewage can be proposed for surrounding area which forms a part of Udaipur Urban Agglomeration.

6.3.2.10 Technologies for Sewage Treatment

Different technologies are available for treatment of domestic liquid waste.

Type	**Common Name**	**Purpose**
Aerobic Process:		
Suspended growth	Activated sullage process Conventional (plug flow) Continuous- flow stirred-tank Step aeration Contact stabilization Sequential Batch Reactor Extended aeration Oxidation ditch	Carbonaceous BOD removal (nitrification)
	Suspended growth nitrification Aerated lagoons	Carbonaceous BOD removal (nitrification)
Attached growth:	Trickling filters Low- rate High-rate	carbonaceous BOD removal (nitrification)
Aerobic / anoxic or Suspended growth	Rotating biological Contractor	BOD removal (nitrification)
	Single stage de nitrification	Carbonaceous BOD Removal (nitrification)
Attached growth Combined processes	Nitrification De nitrification	Nitrification De nitrification
Anaerobic processes	Facultative lagoons (ponds) Maturation or tertiary ponds Anaerobic-facultative lagoons Anaerobic-facultative aerobic Lagoons	Carbonaceous BOD removal Nitrification

Following technologies for sewage treatment are commonly being used in India:

i) Waste Stabilization Ponds (WSP)

ii) Up flow Anaerobic Sullage Blanket (UASB) followed by final polishing ponds

iii) Activated Sullage Process (ASP) in its conventional form and derivatives like Extended Aeration, Aerated Lagoon, and Oxidation Ditch etc.

iv) Moving Bed Bio film Reactor (MBBR)

v) Sequential Batch Reactor (SBR)

6.3.2.11 Choice of Suitable Technology for Town

Standards with respect to main parameters for discharge of treated effluent into surface waters, as prescribed by Central Pollution Control Board are as under: -

Sr.No.	Parameter	Standard (Maximum value)
1.	Total suspended solids	100 mg/l
2.	Bio Chemical Oxygen Demand (5 days at 20^0C)	30 mg/l
3.	Chemical Oxygen Demand	250 mg/l
4.	pH value	5.5 – 9.0

However, in view of the:

i) Present worsening pollution scenario of the drains/rivers and underground waters

ii) Limited or no dilution water available in the water bodies

It is recommended to adopt the treatment technology which gives BOD less than 10 mg/l as the treated water is to be utilized for landscaping/agriculture.

➢ **Criteria for selection of Technology**

The treatment technology is selected based on compliance with applicable pollution norms. While numerical evaluation based on Life Cycle Cost is important, other factors i.e. power requirement, effluent quality, treatment technology reliability, environmental issues, and land requirements are also given due consideration in the selection of treatment technology.

The parameters of treated effluent achievable through above treatment technologies are given in Table below:

Table 6.6: Achievable Parameter of Treated Effluent

Sr.No.	Parameter/Treatment technology	WSP	UASB	ASP	MBBR	SBR
1	Total suspended solids (mg/l)	100	50	50	30	20
2	Bio Chemical Oxygen Demand (5 days at 20^0C) (mg/l)	30	30	20	20	10

Sewage Treatment Technology Selection Considerations

Sr.No	Consideration	Goal
1.	Land required	Minimize land requirement
2.	Power requirement	The treatment technology choice should consider minimizing power requirements
3.	Capital Cost of Plant	Treatment technology should allow optimum utilization of capital
4.	Operation & Maintenance	Treatment technology design should be conducive to attain lower running cost
5.	Maintenance	Simplicity and reliability
6.	Treated wastewater	The technology must consistently meet the standards as required.
7.	Load Fluctuations	Plant is able to withstand organic and hydraulic load fluctuations
8.	Resource Recovery	Ability to minimize operational costs.
9.	Sustainability	Treatment technology should be ultimately sustainable technically, financially, socially, environmentally.
10.	Reuse/recycle	Treated effluent should be reusable for irrigation/any other purposes.

➢ Decision Matrix

The selection of a treatment technology requires analysis of all factors, not just life-cycle costs. In order to provide additional factors for the final considerations, key parameters are evaluated and weighed as shown in the Table below to reach a final recommendation. The matrix attributes are ranked as Excellent, Very Good, Good, Average, or Poor recognizing that differences between treatment technologies are relative, and often, the result of commonly accepted observations.

Table 6.7: Decision Matrix for selection of Technology for STP

Parameter/Treatment technology	**Activated Sullage Process (ASP)**	**Moving Bed Biofilm Reactor (MBBR)**	**Sequencing Batch Reactor (SBR)**	**UASB + FPP**	**Waste Stabilization Pond (WSP)**
Land use	Very Good	Excellent	Excellent	Good	Poor
Power requirement	Average	Average	Average	Very Good	Very Good
Capital Cost of Plant (without land cost)	Good	Good	Good	Very Good	Excellent
Operation & Maintenance costs	Average	Average	Good	Very Good	Excellent
Ease of Operation & Maintenance	Good	Good	Good	Good	Excellent
Treated wastewater quality	Good	Very Good	Excellent	Good	Average
Resource Recovery	Good	Good	Good	Very Good	Poor
Sustainability	Average	Average	Average	Good	Very Good
Reuse/recycle	Very Good	Very Good	Excellent	Good	Good

➢ Selection Criteria

Three stage selection criteria for final choice of treatment is recommended.

Stage 1

To reject the treatment technology options

i) Which need land and power beyond decided/available limits and

ii) Which has high environmental risk associated with it

iii) Which has high social negative impact

Stage 2

After screening through stage 1, for the remaining treatment technology options, the life cycle cost is estimated based on following parameters:

- Cost of land
- Capital cost of STP
- Annual Operation & Maintenance cost for the STP
- Net present value of the Operation & Maintenance cost over a life period of the STP discounted at a rate of return on the capital investment.

The values (on all India bases) of above parameters contributing to life cycle cost are given in Table below:

Table 6.8: Life Cycle Cost of Various Technologies for STP

Parameter/ Treatment technology	**WSP**	**UASB + FPU**	**ASP**	**MBBR**	**SBR**
Land requirement (Acre/MLD)	3	0.70-1.0	0.30-0.40	0.10-0.15	0.10-0.20
Capital cost (Rs. lac/MLD)	25-35	50-60	70-100	65-90	80-110
Installed Power requirement (Kilo Watt/ MLD)	Nil	2-3	10-15	20-30	20-30
Power consumption (Kilo Watt/MLD/day)	Nil	25	180	180	160
Annual power cost (Rs. lac/MLD) (Assuming power rate of Rs. 4.5 per KW)	Nil	0.40	3.00	3.00	2.60
Other (excluding power) annual operation &	1.0	1.0-1.5	1.50-2.00	1.50-2.00	1.50-2.00

maintenance charges (Rs. lac/MLD)					
Total Annual Operation & Maintenance charges (Rs. lac/MLD)	1.0	1.40-1.90	4.50-5.00	4.50-5.00	4.10-4.60

The technology with least life cycle cost and other technologies whose life cycle costs are 10% higher are selected for stage 3.

Stage 3

Out of the treatment technology options selected at stage 2, the option which is suitable w.r.t other parameters i.e. effluent quality, treatment technology reliability, sustainability and reuse/recycle of effluent quality, are finally adopted.

Life cycle cost of three different sewage treatment plants proposed for three zones is calculated and attached at **Annex - 6.4, 6.5 & 6.6.**

Life cycle cost is minimum in case of SBR technology amongst all the treatment technological options. Moreover the quality of treated effluent by SBR technology is best of all the effluents produced by different treatment technologies.

The abstract of Life Cycle Cost of STPs required to be installed with SBR Technologies for year 2026 in Udaipur City is given in Table below:

Table 6.9: Life Cycle Cost of Zone-wise STPs with SBR Technology for year 2026

S.No.	Zone	Life Cycle Cost (Rs Lac)	
		Capacity (MLD)	Cost
1	Zone I	50	5377
2	Zone II	10	1072
3	Zone III	10	1072
	Total	70	7521

6.3.3 Industrial Waste Water

At present there is no Common Effluent Treatment Plant (CETP) existing in Udaipur town, as such untreated waste water by the industries is being discharged in the Ayad River. Discharge of untreated effluent by industries is adding toxic pollution to Ayad River which not only cause environmental hazard but is risk for human health. In this context it becomes more important to treat the industrial effluent to make it harmless by treating to bring parameters within prescribed limits before its final disposal.

A 20 MLD CETP is proposed for treatment of industrial waste water.

➢ **Proposal for Industrial Waste Water**

- The large and medium industries should install their own treatment plant and treat the effluent to bring the parameters within prescribed standards.
- All the industrial units should reuse the waste water after treatment to minimize the waste water disposal.
- The small scale industries can be grouped together to be served with Common Effluent Treatment Plant.

6.3.4 Solid Waste

The city lacks scientific solid waste management system and significant part of the solid waste is dumped into the river which is further aggravating the river water quality situation and obstruction in smooth flow of river water.

Solid Waste Management is an essential urban service provided to achieve following objectives;

- Protection of public health
- Promotion of hygiene
- Recycling of materials
- Avoidance of waste

- Reduction of waste quantities, and
- Reduction of emission and residuals

Programme for effective collection, handling and disposal of Solid Waste to create a safe and pleasant environment as per Solid Waste Management Rules 2000 needs to be planned. Presently about 200 MT of solid waste is produced daily by the city considering generation of solid waste @ 400 gm per capita per day.

6.3.5 Ground Water Contamination

As a consequence of waste water and solid waste disposal into the river, the ground water has become highly contaminated. Water from hand pumps and tube wells is used for domestic purposes in some localities of city. To judge the quality of ground water for domestic data has been collected and is tabulated in **Annex – 4.2 & 4.3**. Available data reveals that in case of ground water samples water is polluted and is not potable to be used for domestic purpose.

6.3.6 Reuse of Treated Waste Water

Treated waste water can be utilized for various purposes as under;

- Irrigation purposes in the fields,
- For industrial use by industries,
- For horticulture purpose,
- For river front development,
- Creating artificial lakes for boating
- For ground water recharge
- For irrigation purposes in municipal parks

6.3.7 Project Proposal/Solution/Action Plan w.r.t. River

Ayad River passing through Udaipur town is non perennial and does not have flow throughout the year. Untreated wastewater from private and government properties is finding its way in the river and polluting the river. To make the river pollution free, it is important to provide;

i) Sewerage network to intercept the sewage entering the river and treat it to prescribed standards.

ii) Modular approach can be adopted for construction of STPs. Presently STPs with capacity to treat expected waste water flow in 2026 can be set up and and thereafter modules of STPs can be added as per requirement.

iii) Three STPs with treatment capacity of 50MLD, 10MLD and 10MLD based on SBR technology are proposed for the year 2026 for zone I, II and III respectively.

iv) The treated effluent quality will be having BOD and SS less than 10 mg/l and 20 mg /l respectively.

v) At present 20MLD STP is being constructed by Hindustan Zinc Ltd. The treated waste water shall be reused by Hindustan Zinc Ltd in their industry.

vi) Industrial units should be responsible to treat the effluent of their units at their own cost.

vii) Alternatively CETP can be constructed for treatment of industrial discharge at the cost of industries.

viii) Reuse of treated waste water should be encouraged. Treated waste water can be used by industrial units and also for landscaping / agriculture purposes.

ix) Proper scientific Solid Waste Management plan has to be put in place to reduce pollution and health hazard.

CHAPTER – VI

ENVIORNMENTAL AND ECOLOGICA
ASPECT

CHAPTER – VII

ENVIRONMENTAL AND ECOLOGICAL ASPECTS

7.1 General

As name of the Project is Ayad River Front Development Project, Udaipur, it clearly indicates that one of the important aspects of the Project is to improve the environmental & ecological conditions of the Udaipur city along the river bank. It is, therefore, essential to have Pre- Project input on various environmental and ecological parameters so that the parameters which are not up to the mark/ not within permissible limit can be improved by bringing them within the standard limit. Another major objective of the project is to improve cross-section of the river at suitable locations so that river can discharge flood water during monsoon smoothly without spilling over the banks, without causing submergence in the local area and without causing erosion.

7.2 Proposed Structures

i) Enhanced cross section of the river/Nallah, wherever feasible.

ii) Lining of proposed channel to improve carrying capacity, especially in the city area.

iii) Construction of series of anicuts / check dams to check high velocity of water & create pondage.

iv) Parks & Recreational Centers near the location of anicuts / check dam, if possible.

7.3 Environmental Impact

7.3.1 Impact on Land

(a) Unauthorized Encroachment in river banks

Due to rapid urbanization and increase in population of Udaipur city, the land along river banks of 13 km stretch of river has been badly encroached by the neighbouring inhabitants. Further, in a stretch where encroachment is not there, nallah/river bed is used for open defecation leading to air pollution. This has mainly happened due to the fact that river is seasonal and remains dry for over eight months. Even chance of flooding during monsoon is also not every year. So, large scale encroachment has removed the bank line of the river. So under pre project condition, environmental impact due to aforesaid reasons is negative.

Since it is proposed to increase the existing cross sectional area of the nallah/river and do its lining in city area to pass design flood, unauthorized encroachment will automatically be removed in this process. Further it is proposed to construct walkway/cycle track/park in near vicinity of proposed check dams/existing anicuts. It would, therefore further improve the environment. As such due to construction of proposed project, environmental impact on the land will be highly positive.

(b) Erosion of banks

As stated earlier, Ayad river has a steep slope in the initial 10 km length (against total length of 26 km) covering the reach below Chota Madar and Bada Madar reservoirs. The bed slope in the initial 10 km reach ranges between 1:200 to 1:400. The slope of the river in the next 10 km reach is also steep i.e. 1:400. Later on, the slope of the river flattens out fairly i.e. with 1:1000 slope. There are few existing anicuts constructed across the river in the initial reach to retain storm water on their upstream and reduce the velocity but their condition is also much depilated. So in pre project condition, loss of land is taking place in vulnerable reaches during high flood, causing negative impact.

Since it is proposed to construct series of new anicuts and to improve the condition of existing anicuts, it would reduce the velocity of flood water during monsoon, leading to checking of erosion. Further it is also proposed that measures for catchment area treatment plan for upper catchment will be implemented. It would help in checking erosion of land in upper catchment as well as in lower catchment. Thus, the proposed project, in post project condition, would reduce erosion to a great extent and positive environmental impact.

(c) Creation of Park and Beautification Plan

Creation of Park and Beautification Plan along bank of the nallah/river will attract visiting tourists of Udaipur to this particular area and provide opportunity of employment and business to the local people. However this positive impact cannot be quantified at this stage.

7.3.2 Impact on Air

(a) Air Pollution

Due to discharge of untreated industrial waste as well as domestic waste into Ayad river and use of Nallah/River bed & banks for open defecation, air of the area gets highly polluted during dry weather when nallah does not have its own flow. Thus environmental impact in pre project condition is highly negative.

Due to re-sectioning of nallah/river for passing deign flood, discharge of treated industrial effluents and domestic in post project scenario will reduce air pollution to a great extent and improve the aerial environment. Thus the proposed project will have high positive impact on the aerial environment.

(b) Noise Pollution

Though part of the stretch of nallah/river is in the city, but as the nallah/river is not parallel to any highway or main road, noise pollution is not significant and having adverse or negative impact on the environment in this case in pre project condition.

Further proposed re-sectioning of nallah/river and its lining is not going to involve very heavy machinery or equipment which will create noise pollution. As such no problem is foreseen on this account during construction of the project. Even if there is any extra noise, that would be within permissible limits.

7.3.3 Impact on Water

(a) Water Pollution

Increasing human activities in the absence of stringent environmental pollution control law and discharge of domestic and industrial effluent without treatment are contributing to the deterioration of water quality in this natural stream.

There is proposal in the present scheme to discharge only treated industrial and domestic effluents into the natural stream and till such time arrangement of treatment of these effluents is not done by the respective administrative bodies, these effluents will be discharged somewhere else through pipes somewhere for below the city area. Water pollution due to open defecation will also be eliminated due to re-sectioning of channel and proposed Solid Waste Management Plan. Thus all the factors leading to water pollution will fully be brought under control in the post project scenario and project would have very positive impact on the environment on this account.

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(b) Sediment load

During monsoon, flood water erodes the banks in upper reaches and transports these sediments in the lower reaches where it gets deposited. This problem is not very serious as flood of high magnitude does not come every year. However measures for Catchment Area Treatment Plan, if implemented, would take care of this problem. Thus project will have positive impact on this account.

Proposed anicuts will also trap these sediments. It would therefore be advisable to inspect such anicuts every year after monsoon and if necessary, removal of deposited sediment should be done manually or mechanically.

(c) Ground water

Quality of ground water is poor in the pre project condition and it has been depleted also. Due to construction of anicuts and proposal to discharge only treated effluents in this project, the quality and quantity of ground water will improve considerably, having very high positive impact from the project.

7.4 Environment Management Plan

(a) Detailed water quality monitoring programme should be drawn up by the local authorities. Standard methods of sampling and testing of physical and chemical parameters (IS: 1620:1961 and IS: 3025:1964) should be used. The Physical, Chemical, Bacteriological & Biological Parameters should be analyzed.

(b) Sediment load

Monitoring of Sediment trapped at selected locations may be done every year after monsoon to assess the status of sediment load and if necessary, remedial measures of removal of sediment manually or by machine should be taken.

(c) Catchment Area Treatment Plan

A Catchment Area Treatment (CAT) Plan for the catchment area for upper catchment needs to be prepared after studying the land use pattern from satellite data, delineating water sheds in the catchment, mapping of critically degraded areas based on integration of Remote Sensing technique, GIS methodology and silt yield index (SYI) method coupled with ground survey. This plan will help in soil conservation and reduce the sediment load in downstream stretch of the stream/nallah, if implemented.

(d) Public Participation

Public Participation is an effective management method for doing such type of work and is becoming increasingly popular in conserving water body environments in urban areas.

Non-Governmental Organizations (NGOs) have acted as catalysts to people's participation for the management of water bodies. In major urban centers people have organized themselves and have moved the Judiciary (the Supreme and the High Courts) through Public Interest Litigations (PILs) seeking directives of the courts to restore water bodies. Information Centers - cum - Watch Towers for mass awareness and promoting public participation in the conservation programme has been suggested. Formation of a Group on the pattern of WUA (Water Uses Association) would help in conservation of better environment along the Ayad River on long term basis, created through this project.

7.5 Environment and Ecology

The anthropogenic pressures in the catchment itself has resulted in degradation of the catchment area due to deforestation, extensive agricultural use and consequent erosion and increased silt flows, which have vitiated the quality of water. Infrastructure development, housing pressure and encroachments have resulted in converting into hyper eutrophic state.

A preliminary examination or "reconnaissance" of the river and catchment is made to get a overall assessment of the landscape and its vegetation. In the reconnaissance survey, information on following features is collected:

- Major vegetative patterns and plant communities, their physiognomy (plant growth) and dominant species.
- Presence of rare and endangered, economically important species, medicinal and other ecologically sensitive species, etc.

ANNEXURE

Annex – 1.1

Government of Rajasthan
Local Self Department of Rajasthan

Ref. No. F(NRCP-04)/RUIFDCO/NRCD/2012-13/18379 Jaipur, Dated: 6-12-12

Sh. O. P. Mathur,
Development Adviser,
WAPCOS limited,
Chaman Villa,
29, Hathroi fort, Jaipur- 302006

Subject:- Preparation of DPRS for the River Front Development Projects for River Jajori in Jodhpur & river Ayad at Udaipur and Amanishah ka nallah in Jaipur.

Refrence : Your letter No. WAP/JPR/12-13/791 dated 05.11.12

Sir,

Technical and financial proposal for Ayad River front development project at Udaipur, Jojari River front development Project at Jodhpur & Amanishah ka Nallah front development project at Jaipur was submitted by you on dt. 11-10-2012. Subsequent discussions on these proposals were held with your officials on 30.10.2012. keeping in view revised offer for JoJari River amounting to Rs. 1.10cr., Ayad River amounting to Rs. 0.70 Cr. and Amanishah ka Nalleh for amounting to Rs 0.65 Cr. Total Rs. 2.45 cr. It has been decided to approve this inclusive of Service Tax was submitted vide your letter no. 791 dated 05.11.2012

The revised offer as submitted by you is here by approved . Term & Conditions for payment would be sent to you subsequently after further discussion. You are required to immediately depute your teams to the three towns and start the assigned works.

RUIFDCO will be nodal agency which will monitor the progress of the work and will make all due payments. Please complete the assigned work within Six month. For any assistance you can contact Sh. V.K.Garg, Team Leader, RUIFDCO.

(Tara Chand Meena)
Deputy Secretary LSG

Annex – 3.1

Salient Features of Badi Lake

1	Tehsil	Girwa		
2	Location			
	(i) Longitude	73^{0}-36 -0" E		
	(ii) Latitude	24^{0}-37.5 -0" N		
	(iii) Accesses	14 Km. away from Udaipur		
	(iv) Nearby village	Badi		
3	Name of the River/Nalla	Berach		
4	Year of completion	N.A. (STATE TIME)		
5	Capital cost	N.A.		
6	Catchment area			
	(i) Gross Area	6.0 Sq.miles		
	(ii) Intercepted area	Nil		
	(iii)Net catchment area	6.0 Sq.miles		
	(iv)Type	Average		
7	Average monsoon rainfall in inches.	25"		
8	Name of the rainguage station	Udaipur		
9	Average annual yield	53.84 Mc ft.		
10	Capacity: Gross/Live	370.15/255.55 Mc ft.		
11	Type of Dam	Both side face wall with earth filling.		
12	F.R.L.	490 Ft.		
13	M.W.L.	492 Ft.		
14	T.B.L.	497 Ft.		
15	SILL Level	458 Ft.		
16	Whether levels are GTS/arbitrary.	Arbitrary		
17	Surplusing arrangements:			
	(i) Designed Maximum discharge	3834 Cusec		
	(ii) Value of 'C' in Dicken's formula	1000		
	(iii)Type of weir & length	27 Ft. Waste weir.		
18.	Canals/command	Lt.	Rt. --	Total
	(i) Length of canals	10.0	100	110.0 Ch.
	(ii) Head outlet discharge in cusecs.	-	-	8.12
	(iii)G.C.A. in acres.	-	-	738
	(iv)C.C.A. in acres.	-	-	620
	(v) I.C.A. in acres	-	-	400
19	Bed cultivation	12 Acres		
20	Full tank gauge (Depth)	32 Ft.		

Annex – 3.2

Salient Features of Bada Madar Reservoir

1	Tehsil	Girwa
2	Location	
	(i) Longitude	73^0-36 -0" E
	(ii) Latitude	24^0-41.5 -0" N
	(iii) Accesses	16 Km. from Udaipur on Udaipur-Gogunda Road.
	(iv) Nearby village	Madar
3	Name of the River/Nalla	Berach River
4	Year of completion	N.A.
5	Capital cost	5.0 Lacs
6	Catchment area	
	(i) Gross Area	31.0 Sq.miles
	(ii) Intercepted area	Nil.
	(iii) Net catchment area	31.0 Sq.miles
	(iv) Type	Good
7	Average monsoon rainfall in inches.	25"
8	Name of the rainguage station	Udaipur.
9	Average annual yield	245 Mc ft.
10	Capacity: Gross/Live	84.0/78.0 Mc ft.
11	Type of Dam	Masonry dam.
12	F.R.L.	100 Ft.
13	M.W.L.	108 Ft.
14	T.B.L.	110 Ft.
15	SILL Level	76 Ft.
16	Whether levels are GTS/arbitrary.	Arbitrary
17	Surplusing arrangements:	
	(i) Designed Maximum discharge in cusecs	13187
	(ii) Value of 'C' in Dicken's formula	1000
	(iii) Type of weir & length	355 Ft , Waste weir.
18.	Canals/command	Lt. Rt. -- Total
	(i) Length of canals	300 100 400 Ch.
	(ii) Head outlet discharge in cusecs.	8.00
	(iii) G.C.A. in acres.	755
	(iv) C.C.A. in acres.	693
	(v) I.C.A. in acres	650
19	Bed cultivation	3 Acres
20	Full tank gauge (Depth)	24 Ft

Annex – 3.3

Salient Features of Chhota Madar Reservoir

1	Tehsil		Girwa			
2	Location					
	(i)	Longitude	73^{0}-36'-0" E			
	(ii)	Latitude	24^{0}-38'-0" N			
	(iii)	Accesses	16 Km. from Udaipur on Udaipur-Gogunda Road.			
	(iv)	Nearby village	Madar			
3	Name of the River/Nalla		Berach River			
4	Year of completion		N.A.			
5	Capital cost		3.50 Lacs			
6	Catchment area					
	(i)	Gross Area	8.0 Sq.miles			
	(ii)	Intercepted area	Nil.			
	(iii)	Net catchment area	8.0 Sq.miles			
	(iv)	Type	Average			
7	Average monsoon rainfall in inches.		25"			
8	Name of the rainguage station		Udaipur			
9	Average annual yield		71.78 Mc ft.			
10	Capacity: Gross/Live		30.0/27.0 Mc ft.			
11	Type of Dam		Masonry dam.			
12	F.R.L.		100 Ft.			
13	M.W.L.		105 Ft.			
14	T.B.L.		107 Ft.			
15	SILL Level		79 Ft.			
16	Whether levels are GTS/arbitrary.		Arbitrary			
17	Surplusing arrangements:					
	(i)	Designed Maximum discharge in cusecs	4757			
	(ii)	Value of 'C' in Dicken's formula	1000			
	(iii)	Type of weir & length	329 Ft. Waste weir Broad crested.			
18.	Canals/command		Lt.	Rt.	--	Total
	(i)	Length of canals		30		30 Ch.
	(ii)	Head outlet discharge in cusecs.		2		
	(iii)	G.C.A. in acres.		191		191
	(iv)	C.C.A. in acres.		108		108
	(v)	I.C.A. in acres		88		88
19	Bed cultivation		3 Acres			
20	Full tank gauge (Depth)		21 Ft.			

Annex – 3.4

Salient Features of Fatehsagar Lake

1	Tehsil	Girwa		
2	Location			
	(i) Longitude	73^0-37'-0" E		
	(ii) Latitude	24^0-35^1-0" N		
	(iii) Accesses	Udaipur City		
	(iv) Nearby village	Udaipur City		
3	Name of the River/Nalla	Berach River/ State tank		
4	Year of completion	1889 Year		
5	Capital cost	11.0 Lacs		
6	Catchment area			
	(i) Gross Area	8.0 Sq.miles		
	(ii) Intercepted area	Nil.		
	(iii) Net catchment area	8.0 Sq.miles		
	(iv) Type	Average		
7	Average monsoon rainfall in inches.	25"		
8	Name of the rainguage station	Swaroopsagar (Udaipur).		
9	Average annual yield	71.87 Mc ft.		
10	Capacity: Gross/Live	427/247 Mc ft.		
11	Type of Dam	Masonry dam.		
12	F.R.L.	95 Ft.		
13	M.W.L.	97 Ft.		
14	T.B.L.	100 Ft.		
15	SILL Level	82 Ft.		
16	Whether levels are GTS/arbitrary.	Arbitrary		
17	Surplusing arrangements:			
	(i) Designed Maximum discharge in cusecs	4757		
	(ii) Value of 'C' in Dicken's formula	1000		
	(iii) Type of weir & length	80 Ft, Waste weir.		
18.	Canals/command	Lt.	Rt. --	Total
	(i) Length of canals	300	100	400 Ch.
	(ii) Head outlet discharge in cusecs.			7.2
	(iii) G.C.A. in acres.	1684	300	1984
	(iv) C.C.A. in acres.	1485	162	1647
	(v) I.C.A. in acres			1000
19	Bed cultivation	14 Acres		
20	Full tank gauge (Depth)	13 Ft.		

Annex – 3.5

Salient Features of Nandeshwar Reservoir Flood Control Scheme, Udaipur

1	Tehsil	Girwa
2	Longitude	73^0-38'-00" E
3	Latitude	24^0-31'-30" N
4	Catchment area in Sq. mile.	20
5	Designed storage Capacity	140 mcft.
6	Live Capacity	125 mcft
7	Irrigation	-NIL-
8	T.B.L.	151.80 M
9	M.W.L./ F.R.L.	150.30 M
10	Sill RL.	143.30 M
11	Flood lift	----
12	Designed flood Discharge in cusecs	3400
13	Total Length of Bund	255M
14	Length of earthen Dam	255M
15	Main canal	NIL
16	Nearest village	Nai
17	Name of River	Kotra River
18	Basin	Banas
19	Sub basin	Berach
20	Cost of project	13.57 Lacs
21	Year of completion	1981 - 82

Annex – 3.6

Salient Features of Goverdhan Sagar Reservoir

1	Location	
	(a) Longitude	73^0-42'-0" E
	(b) Latitude	24^0-34'-0" N
2	Near by Village	Goverdhanvilas
3	Access	10 km. from Udaipur on Udaipur-Dungarpur Road
4	Name of River/Nallah	Berach River
5	Year of Completion	N.A.
6	Captial Cost	Rs.3.00 Lacs
7	Catchment Area	
	(a) Gross	10 Sq. km
	(b) Intercepted	Nil
	(c) Net	10 Sq. km
8	Type of Catchment	Average
9	Average Monsoon Rainfall	590 mm
10	Name of Raingauge Station	Udaipur
11	Average Annual Yield	0.40 M. Cum
12	Capacity	
	(a) Gross	0.25 MCum
	(b) Live	0.25 MCum
13	Type of Dam	Masonry Dam
14	F.R.L.	EL 102.75 m
15	M.W.L.	EL 103.20 m
16	T.B.L.	EL 103.80 m
17	Sill Level	EL 100.00 m
18	Surplusing arrangements	
	(a) Designed maximum discharge in Cusecs	2000 Cusec
	(b) Type of Weir and length	23.00 m Byewash with masonry bed bar
19	Length of Canal	
	Left Main Canal	25.00 Chainage
	Right Main Canal	100.00 Chainage
	TOTAL	125.00 Chainage
	Head outlet discharge	1.50 Cusec
	G.C.A.	250 Acre
	C.C.A.	190 Acre
	I.C.A.	80 Acre

Annex – 3.7

Salient Features of Pichola Lake

1		Tehsil	Girwa			
2		Location				
	(i)	Longitude	73^{0}-40 -0" E			
	(ii)	Latitude	24^{0}-34 -0" N			
	(iii)	Accesses	Udaipur City			
	(iv)	Nearby village	Udaipur			
3		Name of the River/Nalla	Berach River			
4		Year of completion	1560			
5		Capital cost	N.A.			
6		Catchment area				
	(i)	Gross Area	55.0 Sq.miles			
	(ii)	Intercepted area	Nil.			
	(iii)	Net catchment area	55.0 Sq. miles			
	(iv)	Type	Average			
7		Average monsoon rainfall in inches.	25"			
8		Name of the rainguage station	Udaipur.			
9		Average annual yield	493.51 Mc ft.			
10		Capacity: Gross/Live	483/318 Mc ft.			
11		Type of Dam	Masonry dam.			
12		F.R.L.	95.0 Ft.			
13		M.W.L.	98.0 Ft.			
14		T.B.L.	105.0 Ft.			
15		SILL Level	84.00 Ft.			
16		Whether levels are GTS/arbitrary.	Arbitrary			
17		Surplusing arrangements:				
	(i)	Designed Maximum discharge	19923 cusecs			
	(ii)	Value of 'C' in Dicken's formula	1000			
	(iii)	Type of weir & length	225' waste weir.			
18.		Canals/command	Lt.	Rt.	--	Total
	(i)	Length of canals	-	200		200 Ch.
	(ii)	Head outlet discharge in cusecs.				4.50
	(iii)	G.C.A. in acres.				639.0
	(iv)	C.C.A. in acres.				597.0
	(v)	I.C.A. in acres				500.0
19		Bed cultivation	20 Acres			
20		Full tank gauge (Depth)	11 Ft			

Annex – 3.8

Salient Features of Lakhawali Reservoir

1	Tehsil	Girwa
2	Location	
	(i) Longitude	73^{0}-41 -0” E
	(ii) Latitude	24^{0}-40 -0” N
	(iii)Accesses	10 Km. from Udaipur on Udaipur Gogunda road.
	(iv)Nearby village	Lakhawali
3	Name of the River/Nalla	Berach
4	Year of completion	1968 - 69
5	Capital cost	1.50 lacs
6	Catchment area	
	(i) Gross Area	6.0 Sq.miles
	(ii) Intercepted area	Nil
	(iii)Net catchment area	6.0 Sq.miles
	(iv)Type	Average
7	Average monsoon rainfall in inches.	25”
8	Name of the rainguage station	Udaipur
9	Average annual yield	54.0 Mc ft.
10	Capacity: Gross/Live	73.0/49.0 Mc ft.
11	Type of Dam	Face wall with earth backing.
12	F.R.L.	100.0 Ft.
13	M.W.L.	102.0 Ft.
14	T.B.L.	103.0 Ft.
15	SILL Level	81.0 Ft.
16	Whether levels are GTS/arbitrary.	Arbitrary
17	Surplusing arrangements:	
	(i) Designed Maximum discharge in cusecs	3834
	(ii) Value of ‘C’ in Dicken’s formula	1290
	(iii)Type of weir & length	130 Ft. Waste weir.
18.	Canals/command	Lt. Rt. -- Total
	(i) Length of canals	150 100 250 Ch.
	(ii) Head outlet discharge in cusecs	- - 5 Ch.
	(iii)G.C.A. in acres.	- - 477
	(iv)C.C.A. in acres.	- - 435
	(v) I.C.A. in acres	- - 250
19	Bed cultivation	1 Acres
20	Full tank gauge (Depth)	19 Ft.

Annex – 3.9

Salient Features of Udaisagar Reservoir

1	Tehsil	Girwa
2	Location	
	(i) Longitude	73^0-47 -0" E
	(ii) Latitude	24^0-33 -0" N
	(iii) Accesses	3 Km. from Hindustan Zinc Colony, Debari.
	(iv) Nearby village	Biohari
3	Name of the River/Nalla	Berach
4	Year of completion	400 years old
5	Capital cost	N.A.
6	Catchment area	
	(i) Gross Area	185.0 Sq.miles
	(ii) Intercepted area	109.0 Sq.miles
	(iii) Net catchment area	76.0 Sq.miles
	(iv) Type	Average
7	Average monsoon rainfall in inches.	25"
8	Name of the rainguage station	Udaipur
9	Average annual yield	783.0 Mc ft.
10	Capacity: Gross/Live	1100/975.0 Mc ft.
11	Type of Dam	Both side face wall with Earthen Dam.
12	F.R.L.	528.0 Ft.
13	M.W.L.	536.0 Ft.
14	T.B.L.	554.0 Ft.
15	SILL Level	504.0 Ft.
16	Whether levels are GTS/arbitrary.	Arbitrary
17	Surplusing arrangements:	
	(i) Designed Maximum discharge in cusecs	50160
	(ii) Value of 'C' in Dicken's formula	1000
	(iii) Type of weir & length	Gated – spillway – 32.00'
18.	Canals/command	Lt. Rt. -- Total
	(i) Length of canals	950 350 1300 Ch.
	(ii) Head outlet discharge in cusecs.	75 22.5 97.50 Ch.
	(iii) G.C.A. in acres.	12583
	(iv) C.C.A. in acres.	11498
	(v) I.C.A. in acres	4800
19	Bed cultivation	290 Acres
20	Full tank gauge (Depth)	24 Ft.

Annex – 4.1

Salient Features of Dewas Stage (I)

1	Tehsil	Girwa
2	Location	
	(i) Longitude	73^{0}-33 -0” E
	(ii) Latitude	24^{0}-28 -0” N
	(iii) Accesses	27 Kms. From Udaipur on Udaipur-Jhadol road.
	(iv) Nearby village	Alsigarh.
3	Name of the River/Nalla	Tributary of River Wakal
4	Year of completion	1974-75
5	Capital cost	103.85 Lacs.
6	Catchment area	
	(i) Gross Area	11.0 Sq. miles
	(ii) Intercepted area	Nil.
	(iii) Net catchment area	11.0 Sq. miles
	(iv) Type	Good
7	Average monsoon rainfall in inches.	28”
8	Name of the rainguage station	Jhodol-Gorana
9	Average annual yield	172 Mc ft.
10	Capacity: Gross/Live	126/121 Mc ft.
11	Type of Dam	Masonry dam.
12	F.R.L.	2467 Ft.
13	M.W.L.	2476.8 Ft.
14	T.B.L.	2482.0 Ft.
15	SILL Level	2433.0 Ft.
16	Whether levels are GTS/arbitrary.	G.T.S. B.M.
17	Surplusing arrangements:	
	(i) Designed Maximum discharge	11,000 cusecs
	(ii) Value of ‘C’ in Dicken’s formula	1800
	(iii) Type of weir & length	Ogee created waste weir, 104 Ft. length
18.	Canals/command	
	(i) Length of canals	It is a water diversion
	(ii) Head outlet discharge in cusecs.	scheme to augment water supply to Pichhola Lake of Udaipur City.
	(iii) G.C.A. in acres.	-
	(iv) C.C.A. in acres.	-
	(v) I.C.A. in acres	-
19	Bed cultivation	N.A.
20	Full tank gauge (Depth)	34 Ft.

ANNEX-4.2

Chemical Analyses of Ground Water Quality, Udaipur City
(Source: Rajasthan State Pollution Central Board)

S.No.	Parameters	Location of Samples									
		1		2		3		4		5	
		Date	Value	Date	Value	Date	Value	Date	Value	Date	Value
1	Copper as Cu mg/l	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT
		19/04/2011	NT	19/04/2011	0.07	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT
		21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT
2	Zinc as Zn mg/l	12/04/2012	0.1	12/04/2012	NT	12/04/2012	0.06	12/04/2012	NT	12/04/2012	NT
		19/04/2011	0.74	19/04/2011	4.97	19/04/2011	0.71	19/04/2011	3.47	19/04/2011	0.09
		21/04/2010	0.6	21/04/2010	0.3	21/04/2010	0.8	21/04/2010	2.5	21/04/2010	NT
3	Nickel as Ni mg/l	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT
		19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT
		21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT
4	Lead as Pb mg/l	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT
		19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT
		21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT
5	Total Chromium as Cr mg/l	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT
		19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT
		21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT	21/04/2010	NT
6	Iron as Fe mg/l	12/04/2012	2.30	12/04/2012	2.33	12/04/2012	0.09	12/04/2012	0.47	12/04/2012	0.11
		19/04/2011	1.73	19/04/2011	2.35	19/04/2011	0.48	19/04/2011	0.35	19/04/2011	0.007
		21/04/2010	0.484	21/04/2010	0.074	21/04/2010	0.423	21/04/2010	0.535	21/04/2010	NT
7	Cadmium as Cd mg/l	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT	12/04/2012	NT
		19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT	19/04/2011	NT
		21/04/2010	0.003	21/04/2010	NT	21/04/2010	0.002	21/04/2010	NT	21/04/2010	NT

Note: NT – Not Traceable

Locations:

1. Hand Pump near UIT bridge, Udaipur
2. Hand Pump near Fatehpura 200ft
3. Hand Pump near the house of Shri Mohan Nagda S/o Tulsi Ram Nagda, Sardarpura, Udaipur
4. Hand Pump near Rana Pratap Nagar, Railway Station, Udaipur
5. Open Well, Hotel Oriental Palace, Subhash Nagar, Udaipur

ANNEX - 4.3

Bacteriological and Biological Analyses of Ground Water Quality, Udaipur City

(Source: Rajasthan State Pollution Control Board)

S.No.	Determinand	Location of Samples									
		1		2		3		4		5	
		Date	Value	Date	Value	Date	Value	Date	Value	Date	Value
1	Total Alkalinity mg/l	18.10.2012	232	18.10.2012	516	18.10.2012	432	18.10.2012	348	18.10.2012	316
		12.04.2012	320	12.04.2012	336	12.04.2012	412	12.04.2012	336	12.04.2013	272
		10.10.2011	460	10.10.2011	452	10.10.2011	472	10.10.2011	328	10.10.2011	348
		19.04.2011	324	19.04.2011	48	19.04.2011	336	19.04.2011	364	19.04.2011	264
2	B.O.D. mg/l	18.10.2012	1.36	18.10.2012	0.99	18.10.2012	1.55	18.10.2012	1.36	18.10.2012	1.16
		12.04.2012	1.09	12.04.2012	1.83	12.04.2012	1.68	12.04.2012	1.58	12.04.2013	0.69
		10.10.2011	0.24	10.10.2011	0.09	10.10.2011	0.7	10.10.2011	1.52	10.10.2011	0.33
		19.04.2011	7.2	19.04.2011	10.6	19.04.2011	12.2	19.04.2011	2.1	19.04.2011	0.8
3	C.O.D. mg/l	18.10.2012	9.62	18.10.2012	9.25	18.10.2012	11.84	18.10.2012	8.14	18.10.2012	8.14
		12.04.2012	28	12.04.2012	26	12.04.2012	20	12.04.2012	20	12.04.2013	12
		10.10.2011	13.10	10.10.2011	30.17	10.10.2011	34.94	10.10.2011	10.32	10.10.2011	17.47
		19.04.2011	24.13	19.04.2011	30.78	19.04.2011	29.95	19.04.2011	9.98	19.04.2011	5.82
4	Calcium as Ca mg/l	18.10.2012	72	18.10.2012	112	18.10.2012	72	18.10.2012	184	18.10.2012	112
		12.04.2012	65.6	12.04.2012	132.8	12.04.2012	102.4	12.04.2012	232	12.04.2013	94.4
		10.10.2011	57.6	10.10.2011	137.6	10.10.2011	30.4	10.10.2011	118.4	10.10.2011	81.6
		19.04.2011	120	19.04.2011	137.6	19.04.2011	100.8	19.04.2011	123.2	19.04.2011	89.6
5	Chloride mg/l	18.10.2012	128	18.10.2012	352	18.10.2012	368	18.10.2012	300	18.10.2012	256
		12.04.2012	76	12.04.2012	280	12.04.2012	400	12.04.2012	260	12.04.2013	220
		10.10.2011	380	10.10.2011	372	10.10.2011	608	10.10.2011	308	10.10.2011	344
		19.04.2011	292	19.04.2011	420	19.04.2011	264	19.04.2011	420	19.04.2011	328
6	Conductivity µmho/cm	18.10.2012	730	18.10.2012	1870	18.10.2012	2100	18.10.2012	2000	18.10.2012	1530
		12.04.2012	1050	12.04.2012	2200	12.04.2012	1900	12.04.2012	2300	12.04.2013	1690
		10.10.2011	2000	10.10.2011	2200	10.10.2011	3100	10.10.2011	2400	10.10.2011	2200
		19.04.2011	1710	19.04.2011	2400	19.04.2011	1610	19.04.2011	2300	19.04.2011	1900

7	Dissolved Oxygen mg/l	18.10.2012	4.2	18.10.2012	4	18.10.2012	3.8	18.10.2012	4.1	18.10.2012	4.3
		12.04.2012	3.9	12.04.2012	3.8	12.04.2012	3.4	12.04.2012	4	12.04.2013	4.1
		10.10.2011	4.42	10.10.2011	4.70	10.10.2011	4.88	10.10.2011	4.45	10.10.2011	4.28
		19.04.2011	3.32	19.04.2011	3.36	19.04.2011	2.94	19.04.2011	3.22	19.04.2011	3.51
8	Fecal Coliform MPN/100ml	18.10.2012	4	18.10.2012	<3	18.10.2012	<3	18.10.2012	4	18.10.2012	<3
		12.04.2012	4	12.04.2012	<3	12.04.2012	<3	12.04.2012	4	12.04.2013	<3
		10.10.2011	<3	10.10.2011	<3	10.10.2011	<3	10.10.2011	<3	10.10.2011	<3
		19.04.2011	4	19.04.2011	<3	19.04.2011	4	19.04.2011	7	19.04.2011	<3
9	Magnesium as mg/l	18.10.2012	22.448	18.10.2012	55.632	18.10.2012	112.24	18.10.2012	65.392	18.10.2012	52.704
		12.04.2012	8.784	12.04.2012	34.16	12.04.2012	35.136	12.04.2012	46.848	12.04.2013	25.376
		10.10.2011	99.55	10.10.2011	25.38	10.10.2011	141.52	10.10.2011	107.36	10.10.2011	74.176
		19.04.2011	49.776	19.04.2011	81.008	19.04.2011	54.656	19.04.2011	66.368	19.04.2011	57.584
10	pH	18.10.2012	7.17	18.10.2012	7.04	18.10.2012	6.88	18.10.2012	7.01	18.10.2012	6.92
		12.04.2012	7.93	12.04.2012	7.89	12.04.2012	7.82	12.04.2012	7.85	12.04.2013	7.92
		10.10.2011	7.88	10.10.2011	8.41	10.10.2011	7.84	10.10.2011	7.64	10.10.2011	7.38
		19.04.2011	7.2	19.04.2011	7.1	19.04.2011	7.37	19.04.2011	7.21	19.04.2011	7.57
11	Phenolphthalein Alkalinity	18.10.2012	NIL	18.10.2012	NIL	18.10.2012	NIL	18.10.2012	NIL	18.10.2012	NIL
		12.04.2012	NIL	12.04.2012	NIL	12.04.2012	NIL	12.04.2012	NIL	12.04.2013	NIL
		10.10.2011	NIL	10.10.2011	4	10.10.2011	NIL	10.10.2011	NIL	10.10.2011	NIL
		19.04.2011	NIL	19.04.2011	0	19.04.2011	NIL	19.04.2011	NIL	19.04.2011	NIL
12	Sodium mg/l	18.10.2012	53	18.10.2012	195	18.10.2012	152	18.10.2012	145	18.10.2012	126
		12.04.2012	104	12.04.2012	104	12.04.2012	265	12.04.2012	150	12.04.2013	156
		10.10.2011	390	10.10.2011	400	10.10.2011	609	10.10.2011	210	10.10.2011	273
		19.04.2011	184	19.04.2011	236	19.04.2011	159	19.04.2011	252	19.04.2011	276
13	Sulphate mg/l	18.10.2012	43	18.10.2012	117.5	18.10.2012	150	18.10.2012	215	18.10.2012	137.5
		12.04.2012	49	12.04.2012	168	12.04.2012	148	12.04.2012	352	12.04.2013	200
		10.10.2011	43	10.10.2011	100	10.10.2011	84	10.10.2011	12.5	10.10.2011	27
		19.04.2011	70	19.04.2011	55	19.04.2011	70	19.04.2011	31.5	19.04.2011	25
14	Temperature °C	18.10.2012	24	18.10.2012	24	18.10.2012	24	18.10.2012	23	18.10.2012	24
		12.04.2012	24	12.04.2012	24	12.04.2012	24	12.04.2012	24	12.04.2013	24
		10.10.2011	24	10.10.2011	24	10.10.2011	24	10.10.2011	24	10.10.2011	23

		19.04.2011	22	19.04.2011	22	19.04.2011	20	19.04.2011	22	19.04.2011	21
15	Ammonia Nitrogen mg/l	18.10.2012	0.36	18.10.2012	1.18	18.10.2012	1.18	18.10.2012	1.26	18.10.2012	0.52
		12.04.2012	0.12	12.04.2012	0.08	12.04.2012	0.58	12.04.2012	0.08	12.04.2013	0.14
		10.10.2011	0.3	10.10.2011	0.38	10.10.2011	0.52	10.10.2011	0.48	10.10.2011	0.44
		19.04.2011	2.6	19.04.2011	0.9	19.04.2011	0.28	19.04.2011	1.44	19.04.2011	0.54
16	Boron Dissolved mg/l	18.10.2012	0.31	18.10.2012	0.62	18.10.2012	0.54	18.10.2012	0.58	18.10.2012	0.54
		12.04.2012	0.44	12.04.2012	0.46	12.04.2012	0.16	12.04.2012	0.25	12.04.2013	0.23
		10.10.2011	0.31	10.10.2011	0.65	10.10.2011	0.58	10.10.2011	0.13	10.10.2011	0.46
		19.04.2011	0.7	19.04.2011	1	19.04.2011	0.75	19.04.2011	0.9	19.04.2011	0.08
17	Fixed Dissolved Solids mg/l	18.10.2012	264	18.10.2012	644	18.10.2012	656	18.10.2012	724	18.10.2012	564
		12.04.2012	240	12.04.2012	544	12.04.2012	816	12.04.2012	804	12.04.2013	560
		10.10.2011	796	10.10.2011	884	10.10.2011	1260	10.10.2011	572	10.10.2011	720
		19.04.2011	652	19.04.2011	860	19.04.2011	580	19.04.2011	808	19.04.2011	680
18	Fluoride as F mg/l	18.10.2012	1.14	18.10.2012	1.52	18.10.2012	1.28	18.10.2012	1.6	18.10.2012	1.28
		12.04.2012	1.18	12.04.2012	1.32	12.04.2012	0.82	12.04.2012	1.18	12.04.2013	0.86
		10.10.2011	0.28	10.10.2011	0.56	10.10.2011	0.82	10.10.2011	0.86	10.10.2011	0.54
		19.04.2011	0.52	19.04.2011	0.38	19.04.2011	0.36	19.04.2011	1.14	19.04.2011	0.4
19	Total Hardness as $CaCO_3$ mg/l	18.10.2012	272	18.10.2012	508	18.10.2012	640	18.10.2012	728	18.10.2012	496
		12.04.2012	200	12.04.2012	472	12.04.2012	400	12.04.2012	772	12.04.2013	340
		10.10.2011	552	10.10.2011	448	10.10.2011	656	10.10.2011	736	10.10.2011	508
		19.04.2011	504	19.04.2011	676	19.04.2011	476	19.04.2011	580	19.04.2011	460
20	Nitrate as N mg/l	18.10.2012	0.58	18.10.2012	1.1	18.10.2012	0.92	18.10.2012	1.24	18.10.2012	3.04
		12.04.2012	1.1	12.04.2012	0.38	12.04.2012	0.74	12.04.2012	3.64	12.04.2013	3.15
		10.10.2011	1.66	10.10.2011	6.24	10.10.2011	11.2	10.10.2011	6	10.10.2011	5.48
		19.04.2011	0.92	19.04.2011	1.14	19.04.2011	0.58	19.04.2011	0.72	19.04.2011	0.32
21	Phosphate as Po_4 mg/l	18.10.2012	0.1	18.10.2012	0.1	18.10.2012	0.1	18.10.2012	0.1	18.10.2012	0.2
		12.04.2012	0.1	12.04.2012	0.1	12.04.2012	0.1	12.04.2012	0.1	12.04.2013	0.1
		10.10.2011	0.3	10.10.2011	0.4	10.10.2011	0.7	10.10.2011	0.4	10.10.2011	0.5
		19.04.2011	NIL	19.04.2011	0.005	19.04.2011	NIL	19.04.2011	NIL	19.04.2011	0.005
22	Potassium as K mg/l	18.10.2012	0.6	18.10.2012	1.0	18.10.2012	0.6	18.10.2012	1.5	18.10.2012	1.3
		12.04.2012	0.5	12.04.2012	0.7	12.04.2012	0.9	12.04.2012	1.2	12.04.2013	0.9

		10.10.2011	1.1	10.10.2011	1.7	10.10.2011	1.6	10.10.2011	1.2	10.10.2011	0.4
		19.04.2011	1.4	19.04.2011	1	19.04.2011	1	19.04.2011	1.7	19.04.2011	1.4
23	Total Coliform MPN/100ml	18.10.2012	9	18.10.2012	4	18.10.2012	4	18.10.2012	9	18.10.2012	4
		12.04.2012	14	12.04.2012	4	12.04.2012	7	12.04.2012	14	12.04.2013	7
		10.10.2011	4	10.10.2011	7	10.10.2011	4	10.10.2011	7	10.10.2011	7
		19.04.2011	28	19.04.2011	7	19.04.2011	20	19.04.2011	460	19.04.2011	7
24	Total Dissolved Solids mg/l	18.10.2012	424	18.10.2012	858	18.10.2012	1168	18.10.2012	1148	18.10.2012	802
		12.04.2012	610	12.04.2012	1550	12.04.2012	1270	12.04.2012	1660	12.04.2013	1160
		10.10.2011	1432	10.10.2011	1406	10.10.2011	2014	10.10.2011	1680	10.10.2011	1468
		19.04.2011	800	19.04.2011	1130	19.04.2011	750	19.04.2011	940	19.04.2011	830
25	Total KJELDAHL Nitrogen mg/l	18.10.2012	6.72	18.10.2012	7.28	18.10.2012	5.04	18.10.2012	8.96	18.10.2012	4.48
		12.04.2012	5.6	12.04.2012	8.96	12.04.2012	2.24	12.04.2012	9.52	12.04.2013	5.04
		10.10.2011	2.24	10.10.2011	7.28	10.10.2011	11.76	10.10.2011	7.28	10.10.2011	6.16
		19.04.2011	5.04	19.04.2011	24.64	19.04.2011	19.6	19.04.2011	22.4	19.04.2011	1.12
26	Total Suspended Solids mg/l	18.10.2012	8	18.10.2012	22	18.10.2012	34	18.10.2012	24	18.10.2012	26
		12.04.2012	19	12.04.2012	20	12.04.2012	83	12.04.2012	25	12.04.2013	16
		10.10.2011	30	10.10.2011	12	10.10.2011	13	10.10.2011	17	10.10.2011	6
		19.04.2011	18	19.04.201	24	19.04.2011	5	19.04.2011	3	19.04.2011	7
27	Turbidity JTU/NTU	18.10.2012	1.0	18.10.2012	0.8	18.10.2012	0.6	18.10.2012	0.7	18.10.2012	0.5
		12.04.2012	0.9	12.04.2012	1.3	12.04.2012	3.4	12.04.2012	3.6	12.04.2013	1.5
		10.10.2011	2.7	10.10.201	0.9	10.10.2011	2	10.10.2011	1.1	10.10.2011	0.8
		19.04.2011	30.7	19.04.201	29.3	19.04.2011	9.4	19.04.2011	1.6	19.04.2011	0.4

Locations:

1. Hand Pump near UIT bridge, Udaipur
2. Hand Pump, 200ft from Panchwati Nallah, New Fatehpura, Udaipur
3. Hand Pump near the house of Shri Mohan Nagda S/o Tulsi Ram Nagda, Sardarpura, Udaipur
4. Hand Pump near Rana Pratap Nagar, Railway Station, Udaipur
5. Open Well, Hotel Oriental Palace, Subhash Nagar, Udaipur

Annex-5.1

SLOPE CALCULATIONS FOR SUB-CATCHMENTS OF AYAD RIVER

i) LONGEST STREAM IN SC-1

R.D. (km)	R.L. (m)	Li (km)	Di	Di + Di-1	li * (Di + Di-1)
0	614	0	0	0	0
0.64	620	0.64	6	6	3.84
4.18	640	3.54	26	32	113.28
9.26	660	5.08	46	72	365.76
10.49	680	1.23	66	112	137.76
12.19	700	1.7	86	152	258.4
13.93	720	1.74	106	192	334.08
15.61	740	1.68	126	232	389.76
16.33	760	0.72	146	272	195.84
16.83	780	0.5	166	312	156
18.59	800	1.76	186	352	619.52
20.33	820	1.74	206	392	682.08
21.27	840	0.94	226	432	406.08
21.67	860	0.4	246	472	188.8
22.45	866.4	0.78	252.4	498.4	388.752
				Total	**4239.95**

Slope = li * (Di + Di-1)/L^2 = 8.41 m/km

ii) LONGEST STREAM IN SC-2

R.D. (km)	R.L. (m)	Li (km)	Di	Di + Di-1	li * (Di + Di-1)
0	567	0	0	0	0
3.28	600	3.28	33	33	108.24
6.22	620	2.94	53	86	252.84
7.43	640	1.21	73	126	152.46
10.54	660	3.11	93	166	516.26
12.41	680	1.87	113	206	385.22
14.2	700	1.79	133	246	440.34
15.6	720	1.4	153	286	400.4
16.75	740	1.15	173	326	374.9
17.61	760	0.86	193	366	314.76
17.82	780	0.21	213	406	85.26
18.03	800	0.21	233	446	93.66

18.09	820	0.06	253	486	29.16
18.14	840	0.05	273	526	26.3
18.19	860	0.05	293	566	28.3
18.23	880	0.04	313	606	24.24
19.64	893	1.41	326	639	901
				Total	**3124.10**

Slope = li * (Di + Di-1)/L^2 = 8.10 m/km

iii) LONGEST STREAM IN SC-3

R.D. (km)	R.L. (m)	Li (km)	Di	Di + Di-1	li * (Di + Di-1)
0	556	0	0	0	0
9.8	600	9.8	44.28	44.28	433.944
15.21	620	5.41	64.28	108.56	587.3096
18.88	640	3.67	84.28	148.56	545.2152
20.7	660	1.82	104.28	188.56	343.1792
22.79	680	2.09	124.28	228.56	477.6904
24.7	700	1.91	144.28	268.56	512.9496
25.82	720	1.12	164.28	308.56	345.5872
26.92	740	1.1	184.28	348.56	383.416
27.17	760	0.25	204.28	388.56	97.14
28.11	780	0.94	224.28	428.56	402.8464
28.18	800	0.07	244.28	468.56	32.7992
28.32	820	0.14	264.28	508.56	71.1984
				Total	**4233.28**

Slope = li * (Di + Di-1)/L^2 = 5.28 m/km

IV) LONGEST STREAM IN SC-4

R.D. (km)	R.L. (m)	Li (km)	Di	Di + Di-1	li * (Di + Di-1)
0	553	0	0	0	0
9.92	560	9.92	7	7	69.44
13.7	580	3.78	27	34	128.52
15.87	600	2.17	47	74	160.58
16.42	601.1	0.55	48.1	95.1	52.305
				Total	**410.845**

Slope = li * (Di + Di-1)/L^2 = 1.52 m/km

Annex-5.2

Calculation of Flood Hydrograph Ordinates (SC-1)

Time (hr)	Unit Hydrograph (cumec)	Critically Sequenced Effective Rainfall Ordinates (mm)								Direct Runoff Hydrograph (cumec)	Base Flow (cumec)	Flood Hydrograph (cumec)
		0.47	0.47	0.79	0.95	1.44	1.76	1.92	1.60			
0	0										0.06	0.06
1	56.40	26.64								26.64	0.06	26.70
2	136.50	64.46	26.64							91.10	0.06	91.16
3	85.61	40.43	64.46	44.75						149.64	0.06	149.70
4	50.01	23.62	40.43	108.30	53.81					226.15	0.06	226.21
5	29.16	13.77	23.62	67.92	130.21	80.97				316.50	0.06	316.56
6	16.76	7.91	13.77	39.68	81.67	195.96	99.09			438.08	0.06	438.14
7	9.49	4.48	7.91	23.13	47.71	122.91	239.80	108.14		554.09	0.06	554.15
8	4.20	1.98	4.48	13.30	27.81	71.80	150.40	261.71	90.03	621.52	0.06	**621.58**
9	0		1.98	7.53	15.99	41.86	87.86	164.15	217.88	537.25	0.06	537.31
10				3.33	9.05	24.06	51.22	95.89	136.66	320.21	0.06	320.27
11					4.01	13.62	29.44	55.90	79.83	182.80	0.06	182.86
12						6.03	16.67	32.13	46.54	101.37	0.06	101.43
13							7.38	18.20	26.75	52.33	0.06	52.39
14								8.05	15.15	23.20	0.06	23.26
15									6.70	6.70	0.06	6.76
16											0.06	0.06

Calculation of Flood Hydrograph Ordinates (SC-2)

Time (hr)	Unit Hydrograph (cumec)	Critically Sequenced Effective Rainfall Ordinates (mm)								Direct Runoff Hydrograph (cumec)	Base Flow (cumec)-	Flood Hydrograph (cumec)
		0.51	0.51	0.86	1.03	1.54	1.88	2.05	1.71			
0	0										0.06	0.06
1	54.14	27.84								27.84	0.06	27.90
2	131.02	67.38	27.84							95.23	0.06	95.29
3	82.17	42.26	67.38	46.37						156.01	0.06	156.07
4	47.88	24.63	42.26	112.21	55.63					234.72	0.06	234.78
5	27.88	14.34	24.63	70.37	134.63	83.41				327.38	0.06	327.44
6	15.87	8.16	14.34	41.01	84.43	201.87	101.94			451.75	0.06	451.81
7	9.30	4.78	8.16	23.88	49.20	126.60	246.70	111.20		570.52	0.06	570.58
8	4.30	2.21	4.78	13.59	28.65	73.77	154.71	269.11	92.67	639.51	0.06	**639.57**
9	0		2.21	7.97	16.31	42.96	90.16	168.77	224.28	552.66	0.06	552.72
10				3.68	9.56	24.45	52.50	98.35	140.66	329.20	0.06	329.26
11					4.42	14.33	29.88	57.27	81.96	187.87	0.06	187.93
12						6.63	17.51	32.60	47.73	104.47	0.06	104.53
13							8.10	19.10	27.17	54.37	0.06	54.43
14								8.83	15.92	24.75	0.06	24.81
15									7.36	7.36	0.06	7.42
16											0.06	0.06

Calculation of Flood Hydrograph Ordinates (SC-3)

Time (hr)	Unit Hydrograph (cumec)	Critically Sequenced Effective Rainfall Ordinates (mm)											Direct Runoff Hydrograph (cumec)	Base Flow (cumec)	Flood Hydrograph (cumec)
		0.31	0.31	0.47	0.47	0.79	0.95	1.43	1.75	1.91	1.59	0.47			
0	0													0.06	0.06
1	26.37	0.15											0.15	0.06	0.21
2	75.95	0.49	8.18										8.67	0.06	8.73
3	126.30	0.59	23.55	12.40									36.54	0.06	36.60
4	93.85	0.54	39.16	35.70	12.40								87.81	0.06	87.87
5	61.61	0.44	29.10	59.37	35.70	20.84							145.46	0.06	145.52
6	40.82	0.29	19.10	44.12	59.37	60.01	25.06						207.96	0.06	208.02
7	27.02	0.25	12.66	28.96	44.12	99.80	72.16	37.72					295.66	0.06	295.72
8	17.73	0.15	8.38	19.19	28.96	74.15	120.01	108.63	46.16				405.61	0.06	405.67
9	11.32	0.15	5.50	12.70	19.19	48.68	89.17	180.64	132.93	50.38			539.33	0.06	539.39
10	6.70	0.10	3.51	8.33	12.70	32.25	58.54	134.22	221.06	145.09	41.94		657.74	0.06	657.80
11	2.78	0.10	2.08	5.32	8.33	21.35	38.78	88.11	164.26	241.27	120.78	12.40	702.78	0.06	**702.84**
12	0		0.86	3.15	5.32	14.01	25.67	58.38	107.83	179.28	200.85	35.70	631.06	0.06	631.12
13				1.31	3.15	8.95	16.85	38.64	71.44	117.69	149.24	59.37	466.64	0.06	466.70
14					1.31	5.29	10.76	25.36	47.29	77.97	97.97	44.12	310.07	0.06	310.13
15						2.20	6.37	16.19	31.03	51.61	64.91	28.96	201.27	0.06	201.33
16							2.64	9.58	19.82	33.87	42.97	19.19	128.07	0.06	128.13
17								3.98	11.73	21.63	28.20	12.70	78.23	0.06	78.29
18									4.87	12.80	18.00	8.33	44.01	0.06	44.07
19										5.31	10.66	5.32	21.29	0.06	21.35

20											4.42	3.15	7.57	0.06	7.63
21												1.31	1.31	0.06	1.37
22														0.06	0.06

Calculation of Flood Hydrograph Ordinates (SC-4)

Time (hr)	Unit Hydrograph (cumec)	Critically Sequenced Effective Rainfall Ordinates (mm)											Direct Runoff Hydrograph (cumec)	Base Flow (cumec)	Flood Hydrograph (cumec)
		0.30	0.30	0.46	0.46	0.77	0.93	1.39	1.71	1.86	1.55	0.46			
0	0													0.06	0.06
1	16.86	0.14											0.14	0.06	0.20
2	48.53	0.46	5.05										5.51	0.06	5.57
3	80.71	0.56	14.53	7.69									22.77	0.06	22.83
4	59.97	0.51	24.16	22.12	7.69								54.47	0.06	54.53
5	39.37	0.42	17.95	36.78	22.12	12.96							90.23	0.06	90.29
6	26.10	0.28	11.79	27.33	36.78	37.30	15.60						129.08	0.06	129.14
7	17.29	0.23	7.81	17.94	27.33	62.04	44.90	23.51					183.76	0.06	183.82
8	11.35	0.14	5.17	11.90	17.94	46.09	74.66	67.67	28.79				252.37	0.06	252.43
9	7.25	0.14	3.40	7.88	11.90	30.26	55.47	112.54	82.86	31.43			335.87	0.06	335.93
10	4.29	0.09	2.17	5.17	7.88	20.06	36.42	83.61	137.79	90.45	26.15		409.80	0.06	409.86
11	2.00	0.09	1.29	3.31	5.17	13.29	24.14	54.90	102.38	150.42	75.27	7.69	437.93	0.06	**437.99**
12	0		0.60	1.96	3.31	8.72	15.99	36.39	67.22	111.76	125.17	22.12	393.23	0.06	393.29
13				0.91	1.96	5.57	10.50	24.10	44.56	73.38	92.99	36.78	290.76	0.06	290.82
14					0.91	3.30	6.71	15.83	29.51	48.64	61.06	27.33	193.29	0.06	193.35
15						1.53	3.97	10.11	19.38	32.22	40.48	17.94	125.63	0.06	125.69

16							1.85	5.99	12.38	21.15	26.81	11.90	80.07	0.06	80.13
17								2.78	7.33	13.52	17.60	7.88	49.11	0.06	49.17
18									3.41	8.00	11.25	5.17	27.83	0.06	27.89
19										3.72	6.66	3.31	13.69	0.06	13.75
20											3.10	1.96	5.05	0.06	5.11
21												0.91	0.91	0.06	0.97
22														0.06	0.06

Annex – 5.3

Salient features of Proposed dams under Dewas stage II, III and IV

		Dewas Stage II			
S.no.	**Description**	**Madri dam**	**Akodara Dam**	**Dewas Stage III**	**Dewas Stage IV**
	Location				
	State	Rajasthan	Rajasthan	Rajasthan	Rajasthan
1	District	Udaipur	Udaipur	Udaipur	Udaipur
	Tehsil	Jhadol	Jhadol	Jhadol	Kotra
	Latitude	24^{0}32’23” N	24^{0}32’45” N	24^{0}35’00” N	24^{0}29’11” N
	Longitude	73^{0}31’26” E	73^{0}30’11”E	73^{0}25’15” E	73^{0}13’40”E
2	Total Catchment Area in Km^2	22	90	86	90
3	Name of River	Dewas	Dewas	Wakal	Wakal
4	75% Dependable Rainfall (mm)	698.50	698.5	635	635
5	50% Dependable yield (MCM)	5.01	14.77	20.54	21.50
6	Gross Storage Capacity (MCM)	3.00	11.00	14.20	14.18
7	Dead Storage Capacity (MCM)	0.30	1.00	2.20	1.416
8	Live Storage Capacity (MCM)	2.70	10.00	12.00	12.74
9	M.W.L.	654.30	647.40	643.20	657.50
10	F.T.L.	652.50	645.40	641.20	655.00
11	Diversion from the dam (MCM)	5.01	61.82	42.04	21.50
12	Type of Non-overflow	Masonry Dam	Masonry Dam	Masonry Dam	Masonry Dam
13	Type of Overflow	Masonry Dam-Ungated	Masonry Dam-Ungated	Masonry Dam-Ungated	Masonry Dam-Ungated
14	Length of Non-overflow at Top				
15	Left Bank (m)	62	76	70	200
16	Right Bank (m)	190	64	140	60
17	Length of Overflow (m)	80	180	120	100
18	Top Width of Non-overflow (m)	1.50	1.50	1.50	1.50
19	Free Board (m)	0.60	0.60	0.60	0.60
20	Length of Tunnel (Km)	1	11.82	10.38	3.80

21	Bed slope of the tunnel	1 in 2000	1 in 2000	1 in 4000	1 in 4000
22	Tunnel section width (m) Depth (m)	 4.16 1.02	 3.65 1.82	 3.65 1.82	 3.65 1.524
23	Capacity of Tunnel (Cumec)	4.50	4.50	4.33	4.33
24	Proposed section of open cut Width (m) FSD (m)	 5.18 1.20	 5.20 1.20	 3.66 1.525	 3.66 1.525
25	Bed slope of open cut	1 in 2000	1 in 2000	1in 2000	1 in 2000

ANNEX-5.4

AYAD RIVER FRONT DEVELOPMENT PROJECT (UDAIPUR)

Details of Existing River Cross-Sections as per Survey Output

Chainage (m)	Lowest Bed Level (m)	Left Bank Level (m)	Right Bank Level (m)	Average Bed Level (m)	Top River Width (m)	Depth of river bed with respect to average bed level & lower bank level (M)
0.00	610.09	624.00	616.00	616.14	128.40	0.14
500.00	607.80	609.00	609.80	608.22	59.65	0.79
1000.00	605.10	609.20	606.10	606.13	46.69	0.03
1500.00	603.01	608.92	603.95	604.94	45.73	0.99
2000.00	602.39	605.00	604.90	603.56	75.72	1.33
2500.00	600.03	602.62	602.05	601.80	71.14	0.25
3000.00	597.07	601.00	600.95	598.61	41.61	2.34
3500.00	596.54	599.40	598.99	597.95	54.32	1.03
4000.00	593.92	595.59	596.25	594.85	76.65	0.73
4500.00	593.14	595.50	594.96	594.07	91.69	0.90
5000.00	591.16	595.56	593.98	592.67	92.90	1.31
5500.00	588.38	592.75	590.89	590.06	140.77	0.84
6000.00	586.63	590.71	591.41	589.15	109.34	1.56
6500.00	586.22	588.56	590.52	587.93	65.84	0.62
7000.00	585.17	585.18	589.63	586.72	91.16	1.55
7500.00	582.74	587.21	586.12	584.39	54.72	1.73
8000.00	582.26	584.72	585.12	583.36	56.23	1.36
8500.00	580.46	585.00	585.61	583.37	92.96	1.63
9000.00	578.99	582.58	584.01	580.91	87.30	1.67
9500.00	578.29	580.82	580.70	579.57	103.42	1.13
10000.00	576.79	581.00	578.76	577.64	81.38	1.12
10500.00	575.63	579.55	576.84	576.52	60.55	0.32
11000.00	573.24	575.00	577.23	575.17	48.37	0.17
11500.00	573.30	574.50	576.97	574.89	46.47	0.39
12000.00	572.49	574.78	574.94	573.77	50.94	1.02
12500.00	570.17	571.76	573.06	571.04	101.88	0.72
13000.00	565.58	571.80	569.68	568.71	64.62	0.97
13500.00	567.67	570.31	570.01	569.14	61.06	0.87
14000.00	565.30	565.45	569.50	566.84	43.69	1.38
14500.00	564.10	566.70	569.00	565.72	52.01	0.98
15000.00	562.00	565.79	566.73	563.93	55.05	1.86
15500.00	560.52	560.96	564.25	562.53	63.95	1.57
16000.00	558.38	558.83	561.00	559.07	57.51	0.23
16500.00	556.12	557.00	557.60	556.81	44.63	0.19
17000.00	555.03	560.00	555.03	555.96	70.82	0.93
17500.00	556.20	556.20	559.92	558.25	36.96	2.05
18000.00	552.56	557.85	555.50	554.57	50.00	0.94
18500.00	552.91	555.80	555.48	554.46	65.92	1.02
19000.00	551.18	555.20	554.32	553.40	113.99	0.92
19500.00	549.04	554.50	553.50	551.64	95.00	1.86
20000.00	547.35	551.50	548.45	548.54	65.20	0.10
20500.00	546.20	550.21	550.07	547.57	56.68	2.50
21000.00	545.60	547.31	550.06	546.87	88.00	0.45
21500.00	545.40	545.62	549.66	547.10	97.66	1.49

22000.00	543.75	546.78	543.84	544.72	65.67	0.88
22500.00	542.00	547.03	545.85	544.36	45.80	1.50
23000.00	541.80	544.06	544.91	544.48	59.90	0.42
23500.00	541.10	543.78	543.16	543.03	49.74	0.13
24000.00	540.89	542.64	541.61	541.64	30.00	0.03
24500.00	540.98	541.07	541.26	541.22	31.18	0.16
25000.00	539.10	541.13	543.95	541.93	27.82	0.80
25500.00	542.83	542.83	543.11	542.98	26.79	0.15
26000.00	539.24	542.04	541.39	541.03	117.74	0.36
26077.00	539.95	542.05	541.92	541.55	144.82	0.37
				Average =	**69.59**	**0.94**

ANNEX - 6.1

Population forecast by different methods

YEAR	Arithmetical Progression	Geometrical Progression	Incremental Increase	AVERAGE
2011	451735	451735	451735	451735
2012	457770	463558	458220	459849
2013	463805	475690	464787	468094
2014	469841	488140	471436	476472
2015	475876	500916	478166	484986
2016	481911	514026	484979	493639
2017	487946	527479	491873	502433
2018	493981	541285	498849	511372
2019	500017	555451	505906	520458
2020	506052	569989	513046	529696
2021	512087	584907	520267	539087
2022	518122	600215	527570	548636
2023	524157	615924	534955	558345
2024	530193	632044	542422	568220
2025	536228	648586	549970	578261
2026	542263	665561	557601	588475
2027	548298	682981	565313	598864
2028	554333	700856	573107	609432
2029	560369	719199	580982	620183
2030	566404	738022	588940	631122
2031	572439	757338	596979	642252
2032	578474	777159	605100	653578
2033	584509	797499	613303	665104
2034	590545	818371	621588	676835

2035	596580	839790	629954	688775
2036	602615	861769	638403	700929
2037	608650	884324	646933	713302
2038	614685	907468	655545	725899
2039	620721	931219	664238	738726
2040	626756	955591	673014	751787
2041	632791	980601	681871	765088
2042	638826	1006266	690810	778634
2043	644861	1032602	699831	792431
2044	650897	1059628	708934	806486
2045	656932	1087361	718118	820804
2046	662967	1115819	727385	835390

ANNEX-6.2

Location of Pollution Points along Ayad River , Udaipur

S.No.	Chainage	Waste Water inflow into the river				Remarks
		Left Bank		Right Bank		
		Outlet Size	No. of House	Outlet Size	No. of Houses	
1	8550	0.6x0.6	200-300			At Bardgaon-Bedla Link Road
2	9100	0.6x0.3	2000	0.6x0.3	500-700	Bedla Village (Left Bank) & BadgaonVillage (Right Bank)
3	9250			0.6x0.3	200	Badgaon Village
4	9400	0.6x0.3	2000			Bedla Village
5	9850			0.6x0.3	1500	Badgaon Village
6	10250			0.6x0.6	1000	Devali Village
7	10650	0.6x0.3	100			Bhuwana Village
8	10700			0.6x0.6	200	Devali Village
9	10750	0.6x0.3	200			Bhuwana Village
10	10800			0.6x0.6	200	Devali Village
11	10850	0.6x0.3	600			Bhuwana Village
12	10950	0.6x0.3	300			Bhuwana Village
13	11750			Nallah	500-700	Devali Village
14	12150	0.6x0.3	200-300			Bhuwana Village
15	13350			Big Nallah	5000	Gumainawala Nallah meets
16	13450	0.6x0.6	200-300			Sobhagpura Village
17	14050			0.6x0.6	5000	Bhopalpura Bridge, Udaipur City
18	14400	0.60 Dia.	10000			C.P.S.School Bridge, Ayed Village
19	14800			0.60x0.60	2000	Udaipur City
20	15300	Open Nallah	500	3.0x3.0	7000	Near City Center (Ayed Village on Left Bank & Udaipur City on Right Bank)
21	15700	0.6x0.6	1000			Ayed Village
22	15950	0.6x0.6	500-700			Ayed Village
23	16250	0.6x0.30	300-400			Parda Village
24	16500			0.60x0.30	1500	Udaipur City
25	17250			Big Nallah	10000	Manwa Kheda Village
26	19200			Nallah	20000	Old Proposed STP By HZL, Manwa Kheda Village

ANNEX – 6.3

S.No.	Location	EC (Micro-Siemens/Cm)	TDS (mg/l)	Upper values in meq/l and lower values in mg/l from 6 to 14											TH $CaCO_3$ (mg/l)	Na %	RSC (Meq/l)	Remarks BOD (PPM)
				pH	Na^{+}	K^{+}	Ca^{+2}	Mg^{+2}	Cl^{-1}	So_4^{-2}	Co_3^{-2}	HCO_3^{-1}	No_3^{-1}	F^{-1} (mg/l)				
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Chainage – 00 km	690	414	8.15	-	-	2.60	1.20	2.60	1.25	-	5.40	-	-	190	-	1.60	235
							52	17	92	60	-	330	-					
2	Chainage – 8.50 km	2250	1350	7.60	-	-	6.80	0.80	14.00	8.74	-	7.60	-	-	380	-	-	673
							136	11	496	420	-	464	-					
3	Chainage – 14.40 km	1680	1008	7.75	-	-	5.00	1.10	6.60	4.16	-	11.00	-	-	305	-	4.90	561
							100	16	234	200	-	671	-					
4	Chainage – 15.30 km	1680	1008	7.97	-	-	4.30	1.20	6.80	5.83	-	11.60	-	-	275	-	6.10	565
							86	17	241	280	-	708	-					
5	Chainage – 25.25 km	2560	1536	6.75	-	-	8.50	5.00	18.00	4.79	-	5.40	-	-	675	-	-	838
							170	71	630	230	-	330	-					

ANNEX - 6.4

Life Cycle Cost for setting up of STP at Udaipur (Zone I)

Estimated flow (year 2026) for STP construction (Mld)	:	50
Estimated flow (year 2041) for land acquisition (Mld)	:	65
STP life	:	20 years
Rate of return on investment	:	10%
Capitalisation factor	:	8.51
Land Cost(lacs/acre)	:	27

S.no.	Description	ASP	SBR	MBBR	WSP
1	Land requirement in acres per Mld	0.30	0.10	0.10	3
2	Total Land required in acres	19.50	6.50	6.50	195.00
3	Total cost of the land (Rs. lac)	526.50	175.50	175.50	5265.00
4	Unit cost for STP construction(Rs. lac per Mld)	70.00	70.00	65.00	25
5	Cost of STP construction (Rs. lac)	3500.00	3500.00	3250.00	1250.00
6	Annual maintenance cost (Rs. lac/Mld)	4.50	4.00	4.60	1
7	Total Annual maintenance cost (Rs.lac)	225.00	200.00	230.00	50.00
8	Net present worth of STP maintenance @8.51	1915.00	1702.00	1957.00	426.00
	Life Cycle Cost (3+5+8)	**5941.50**	**5377.50**	**5382.50**	**6941.00**

Keeping in view the high treatment efficiency, least cost and less land requirement, it is proposed to construct Sewage Treatment Plant based on SBR technology.

ANNEX - 6.5

Life Cycle Cost for setting up of STP at Udaipur (Zone II)

Estimated flow (year 2026) for STP construction (Mld)	:	10
Estimated flow (year 2041) for land acquisition (Mld)	:	12
STP life	:	20 years
Rate of return on investment	:	10%
Capitalisation factor	:	8.51
Land Cost(lacs/acre)	:	27

S.no.	Description	ASP	SBR	MBBR	WSP
1	Land requirement in acres per Mld	0.30	0.10	0.10	3
2	Total Land required in acres	3.60	1.20	1.20	36.00
3	Total cost of the land (Rs. lac)	97.20	32.40	32.40	972.00
4	Unit cost for STP construction(Rs.lac per Mld)	70.00	70.00	65.00	25
5	Cost of STP construction(Rs. lac)	700.00	700.00	650.00	250.00
6	Annual maintenance cost (Rs. lac/Mld)	4.50	4.00	4.60	1
7	Total Annual maintenance cost (Rs. ac)	45.00	40.00	46.00	10.00
8	Net present worth of STP maintenance @8.51	383.00	340.00	391.00	85.00
	Life Cycle Cost (3+5+8)	**1180.20**	**1072.40**	**1073.40**	**1307.00**

Keeping in view the high treatment efficiency, least cost and less land requirement, it is proposed to construct Sewage Treatment Plant based on SBR technology.

ANNEX - 6.6

Life Cycle Cost for setting up of STP at Udaipur (Zone III)

Estimated flow (year 2026) for STP construction (Mld)	:	10
Estimated flow (year 2041) for land acquisition (Mld)	:	12
STP life	:	20 years
Rate of return on investment	:	10%
Capitalisation factor	:	8.51
Land Cost(lacs/acre)	:	27

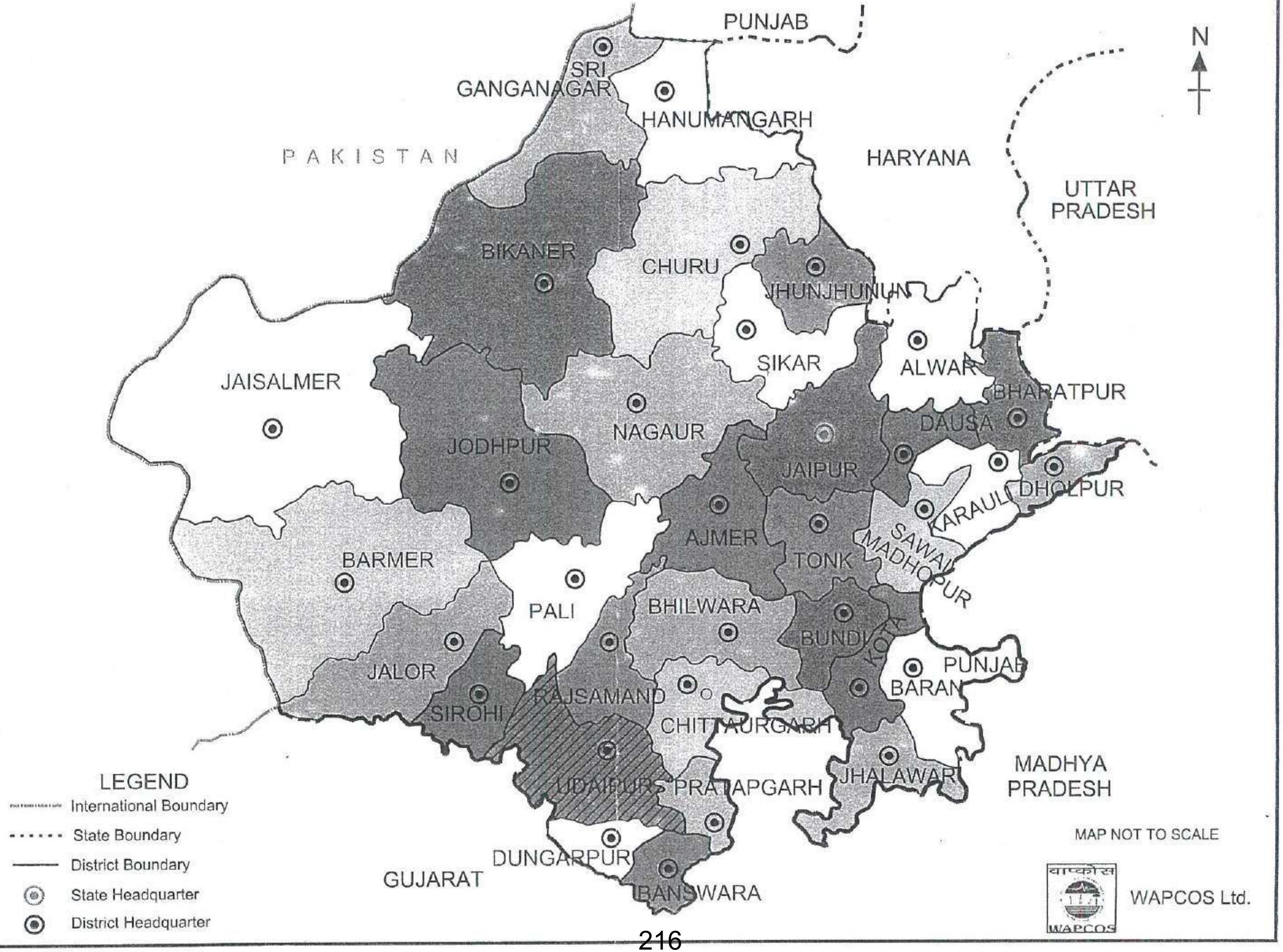
S.no.	Description	ASP	SBR	MBBR	WSP
1	Land requirement in acres per Mld	0.30	0.10	0.10	3
2	Total Land required in acres	3.60	1.20	1.20	36.00
3	Total cost of the land (Rs. lac)	97.20	32.40	32.40	972.00
4	Unit cost for STP construction(Rs.lac per Mld)	70.00	70.00	65.00	25
5	Cost of STP construction(Rs. lac)	700.00	700.00	650.00	250.00
6	Annual maintenance cost (Rs. lac/Mld)	4.50	4.00	4.60	1
7	Total Annual maintenance cost (Rs. lac)	45.00	40.00	46.00	10.00
8	Net present worth of STP maintenance @8.51	383.00	340.00	391.00	85.00
	Life Cycle Cost (3+5+8)	**1180.20**	**1072.40**	**1073.40**	**1307.00**

Keeping in view the high treatment efficiency, least cost and less land requirement, it is proposed to construct Sewage Treatment Plant based on SBR technology.

PLATE

PLATE N 11

RAJASTHAN STATE MAP SHOWING UDAIPUR DISTRICT



INDEX MAP OF AYAD RIVER

PLATE No.- 3.1

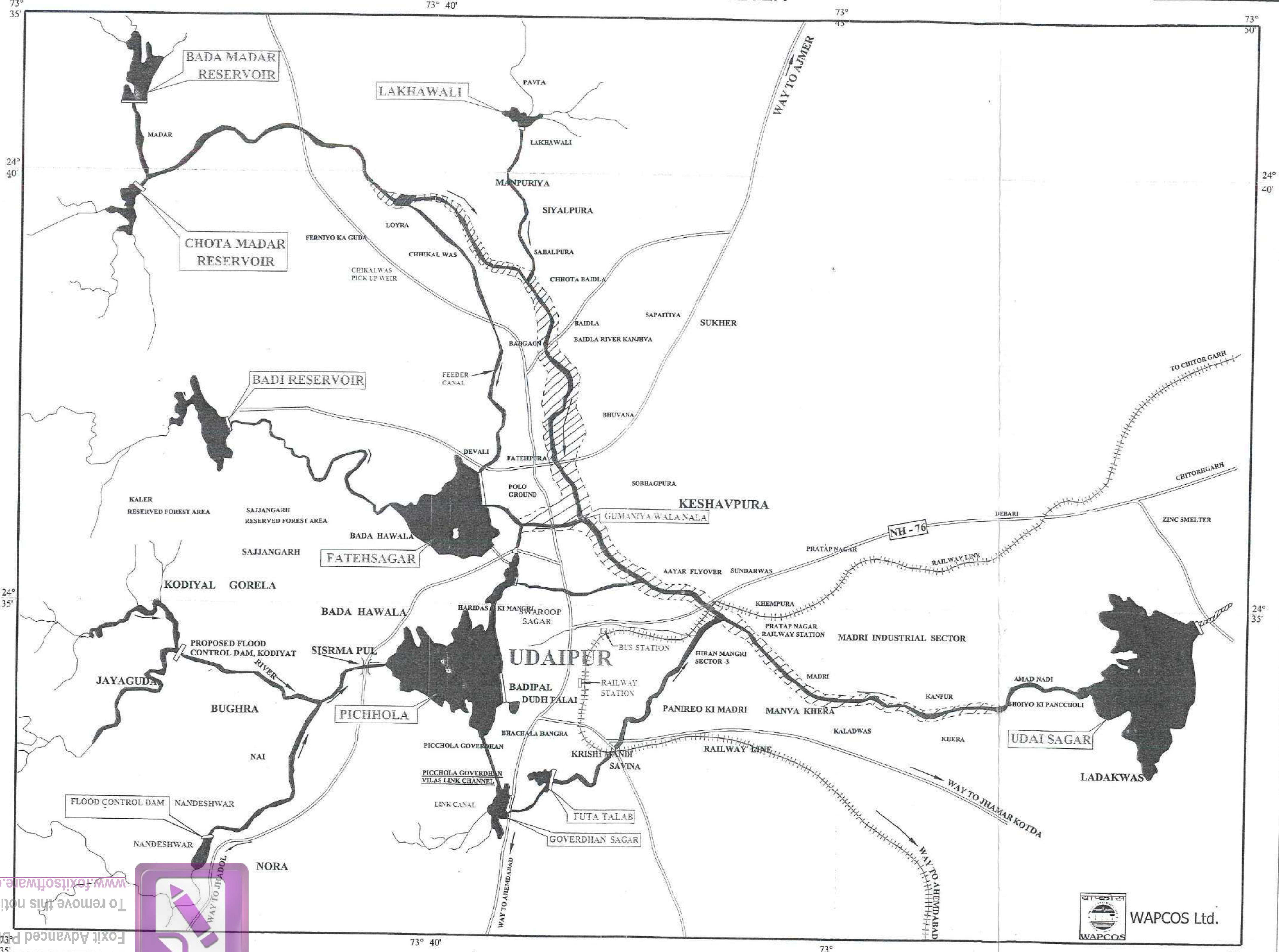
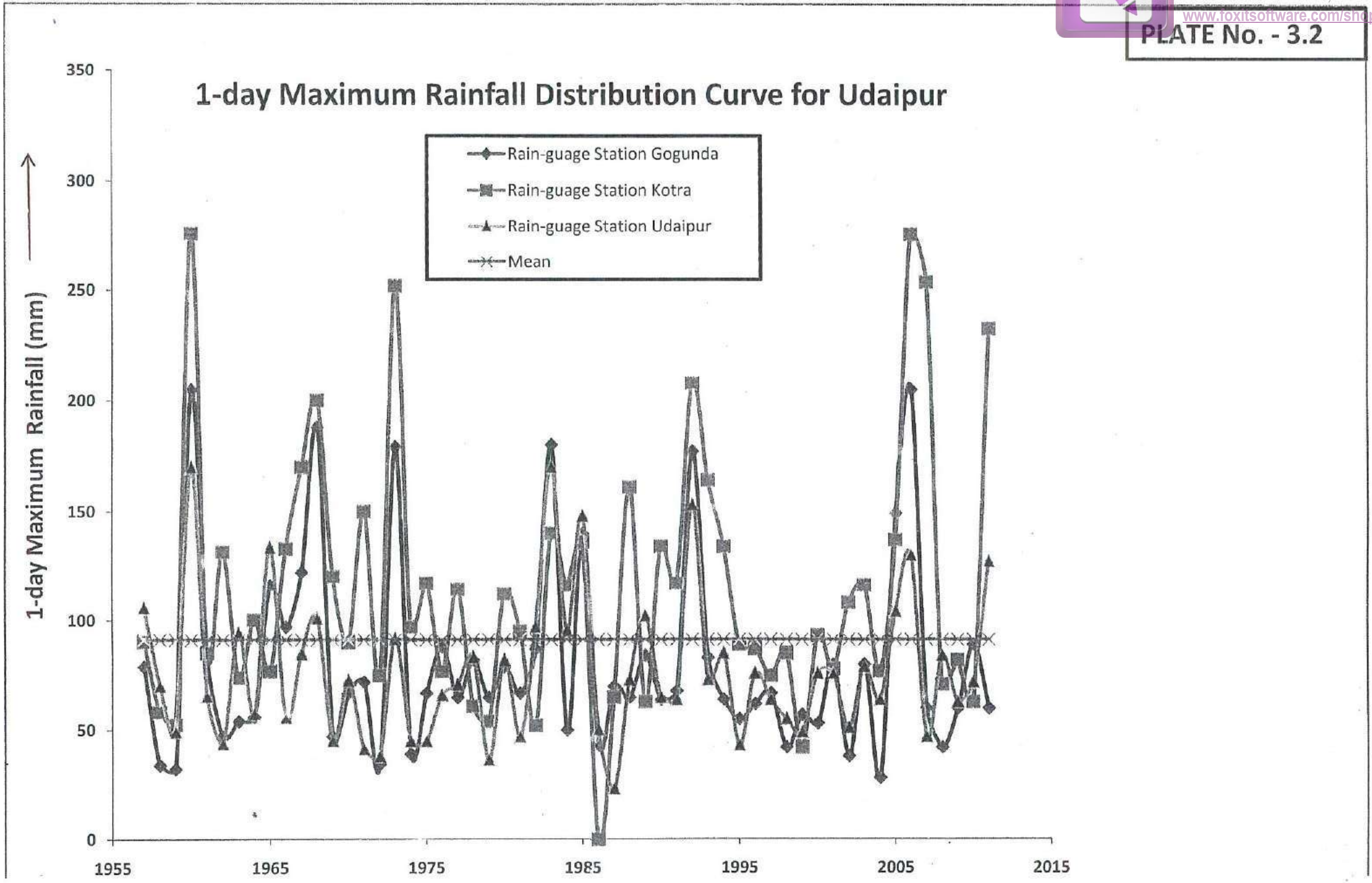
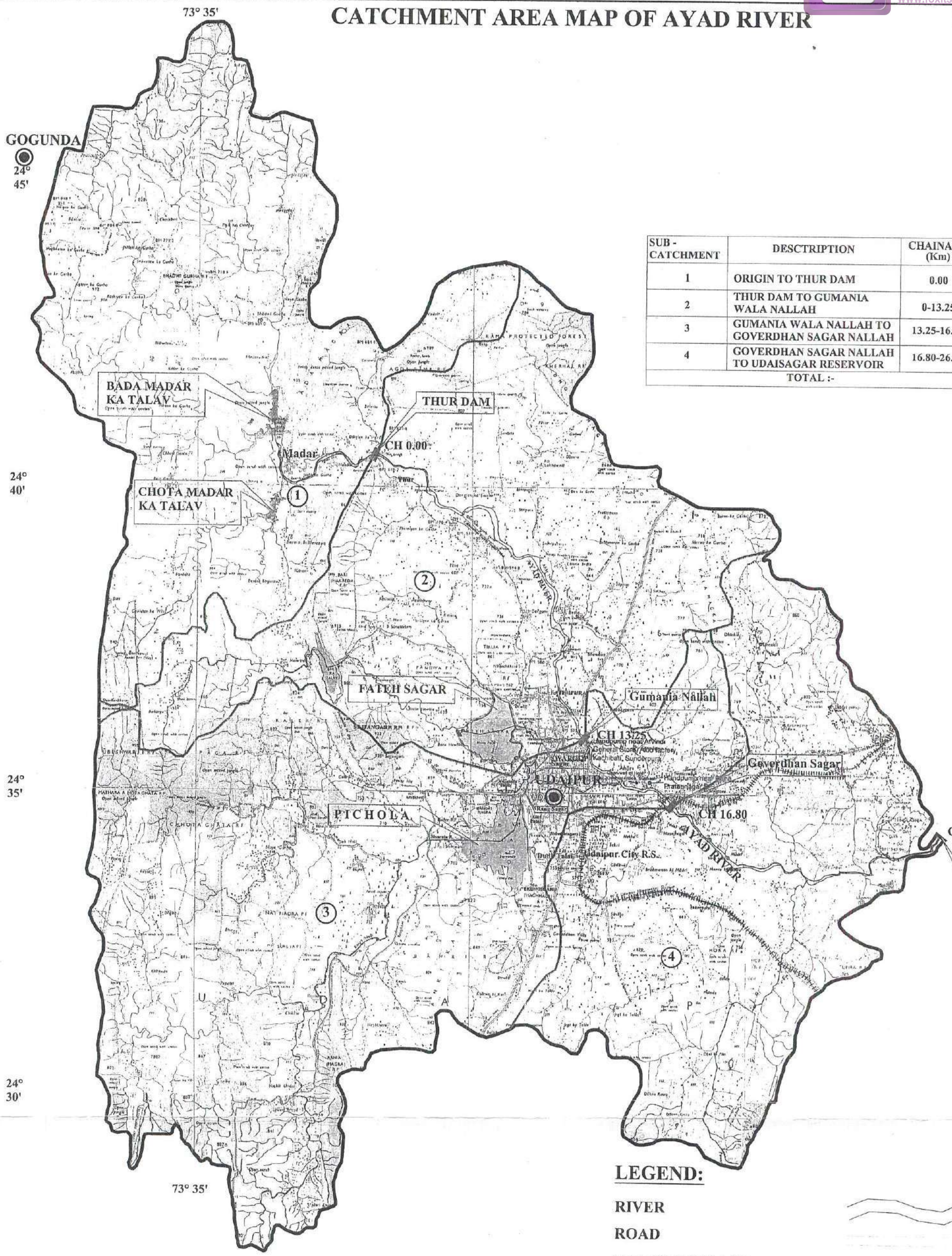


PLATE No. - 3.2


1-day Maximum Rainfall Distribution Curve for Udaipur
Rain-guage Station Gogunda
Rain-guage Station Kotra
Rain-guage Station Udaipur
Mean
1-day Maximum Rainfall (mm)
350
300
250
200
150
100
50
0
1955
1965
1975
1985
1995
2005
2015

CATCHMENT AREA MAP OF AYAD RIVER

PLATE No. 3.



SUB - CATCHMENT	DESCRIPTION	CHAINAGE (Km)	Sq. Km
1	ORIGIN TO THUR DAM	0.00	139.73
2	THUR DAM TO GUMANIA WALA NALLAH	0-13.25	134.12
3	GUMANIA WALA NALLAH TO GOVERDHAN SAGAR NALLAH	13.25-16.80	176.56
4	GOVERDHAN SAGAR NALLAH TO UDAISAGAR RESERVOIR	16.80-26.00	112.83
	TOTAL :-		563.24

LEGEND:

RIVER

ROAD

RAILWAY TRACK

CATCHMENT BOUNDARY

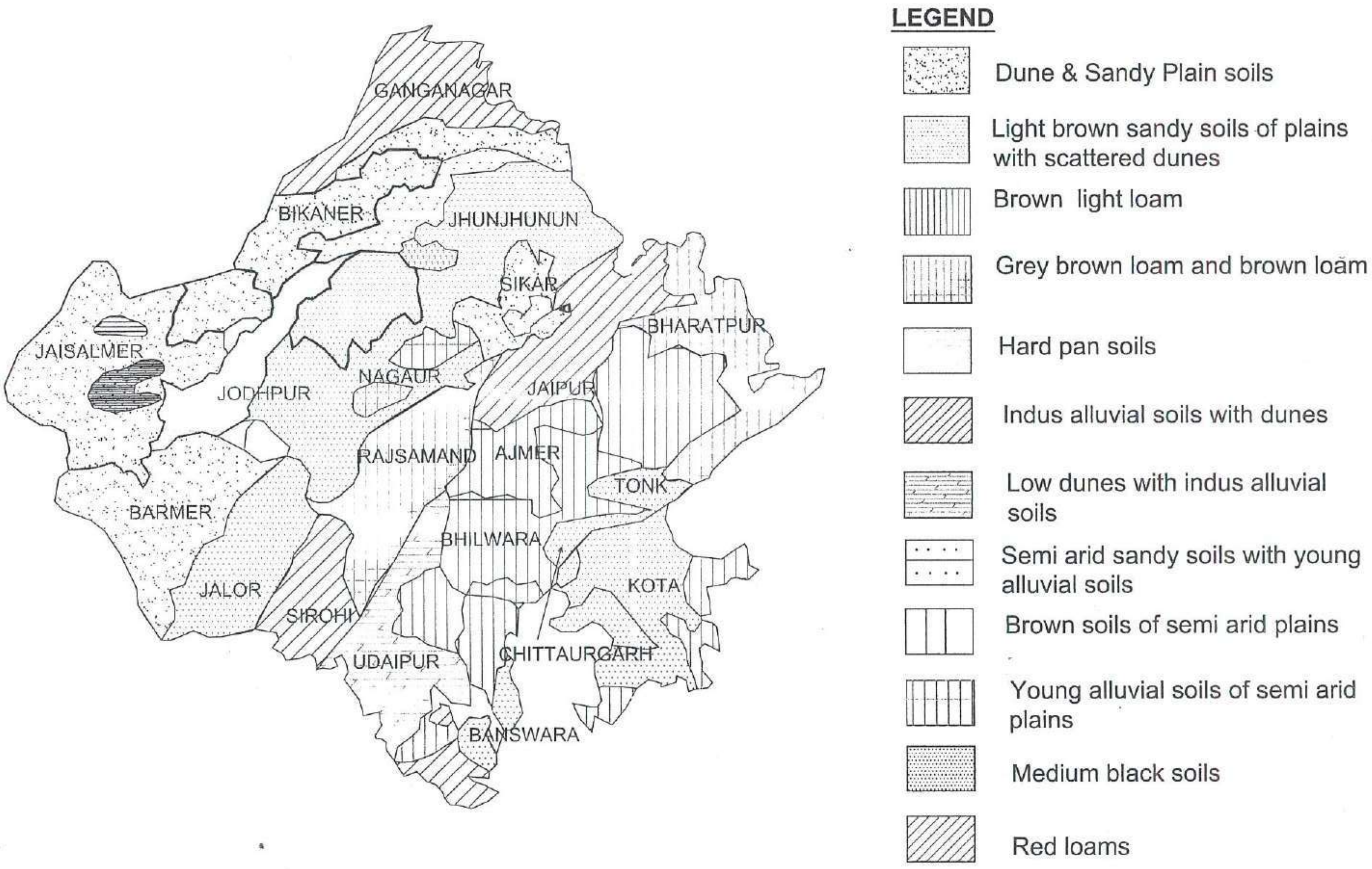
SUB-CATCHMENT BOUNDARY

RAINFALL STATION ◉

WAPCOS Ltd.

PLATE 3.4

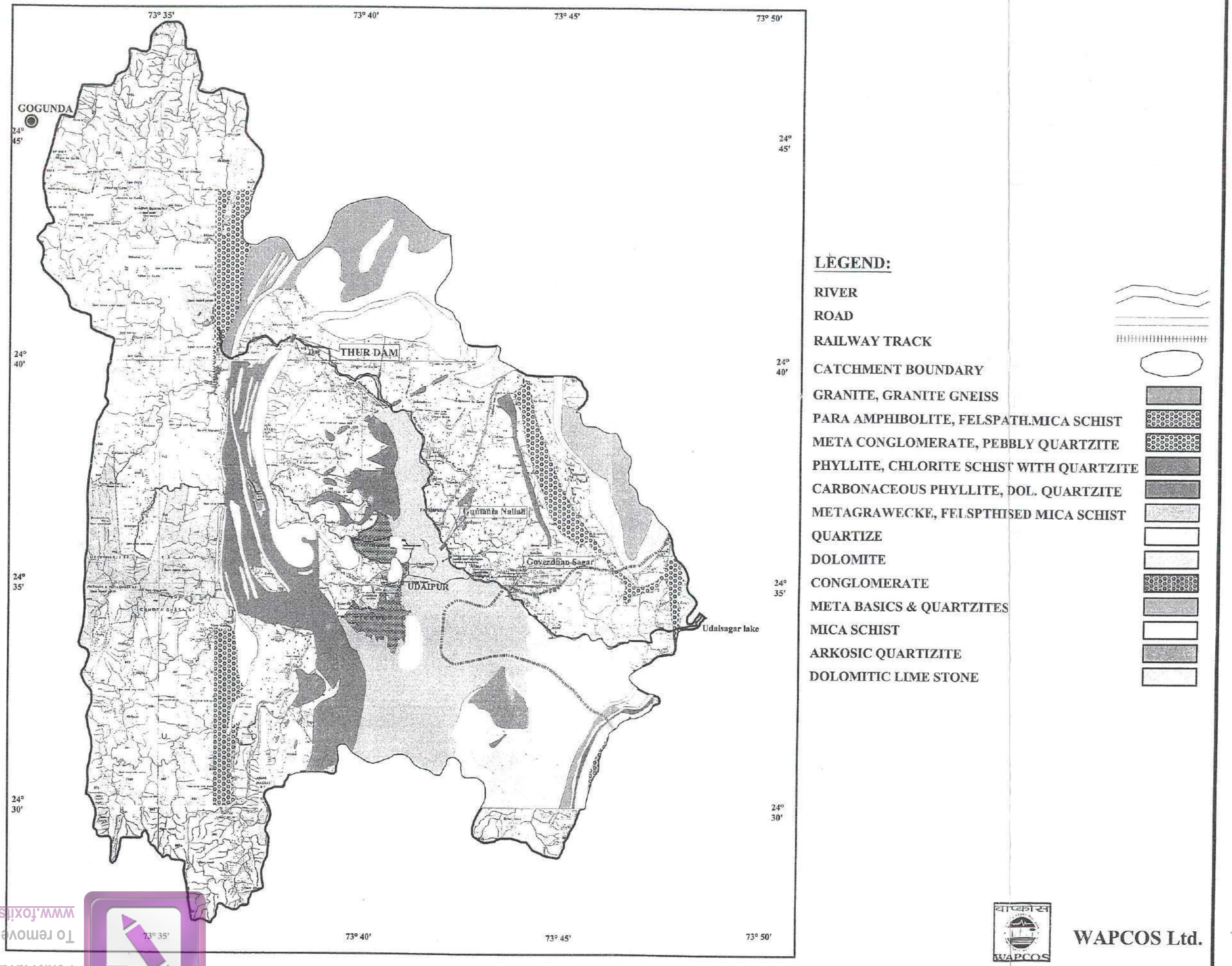
SOIL MAP OF RAJASTHAN



WAPCOS Ltd

GEOLOGICAL MAP OF UDAIPUR

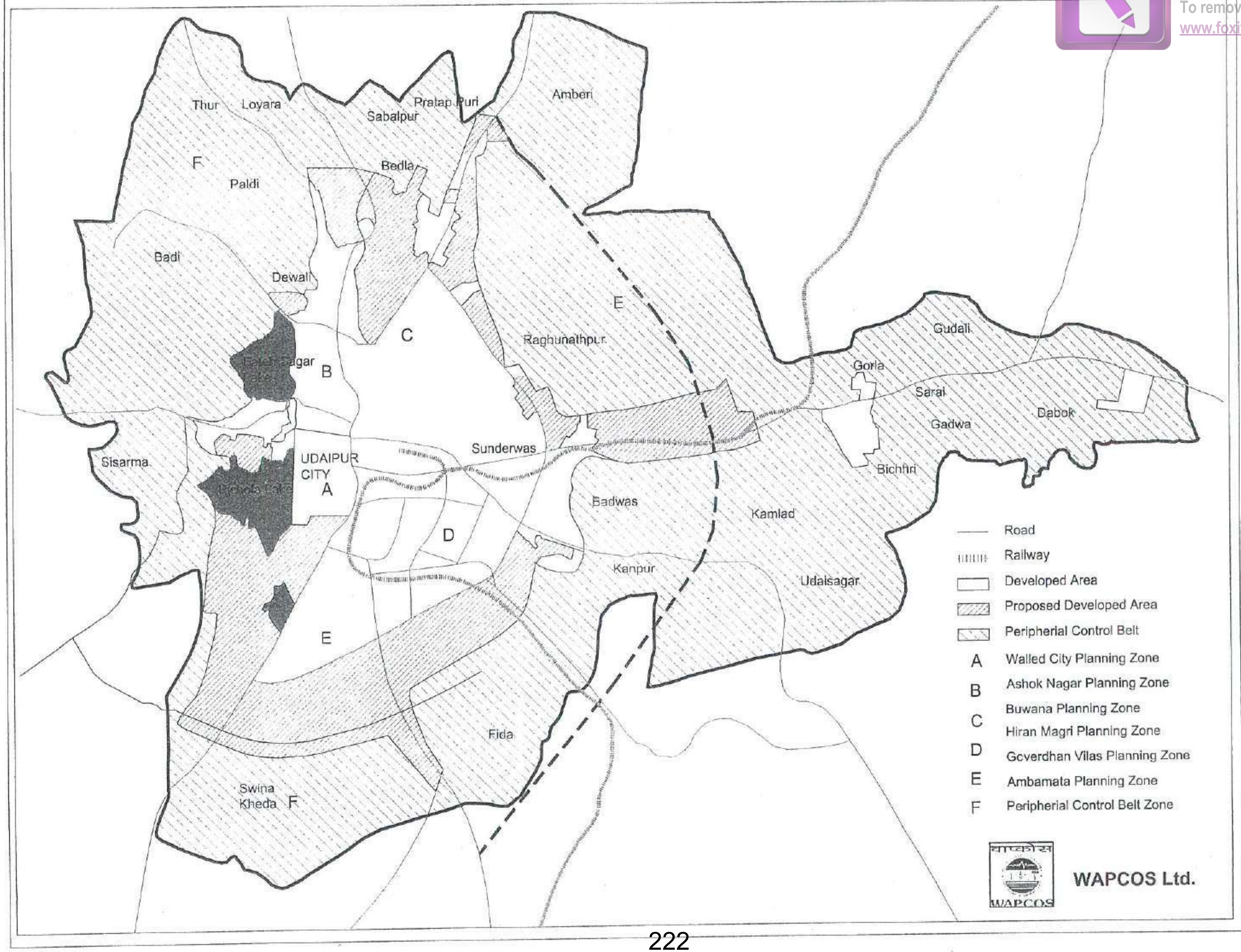
PLATE No.- 3.5



WAPCOS Ltd.

URBANIZABLE AREA OF UDAIPUR CITY AS PER MASTER PLAN (2022)

Plate No. 1



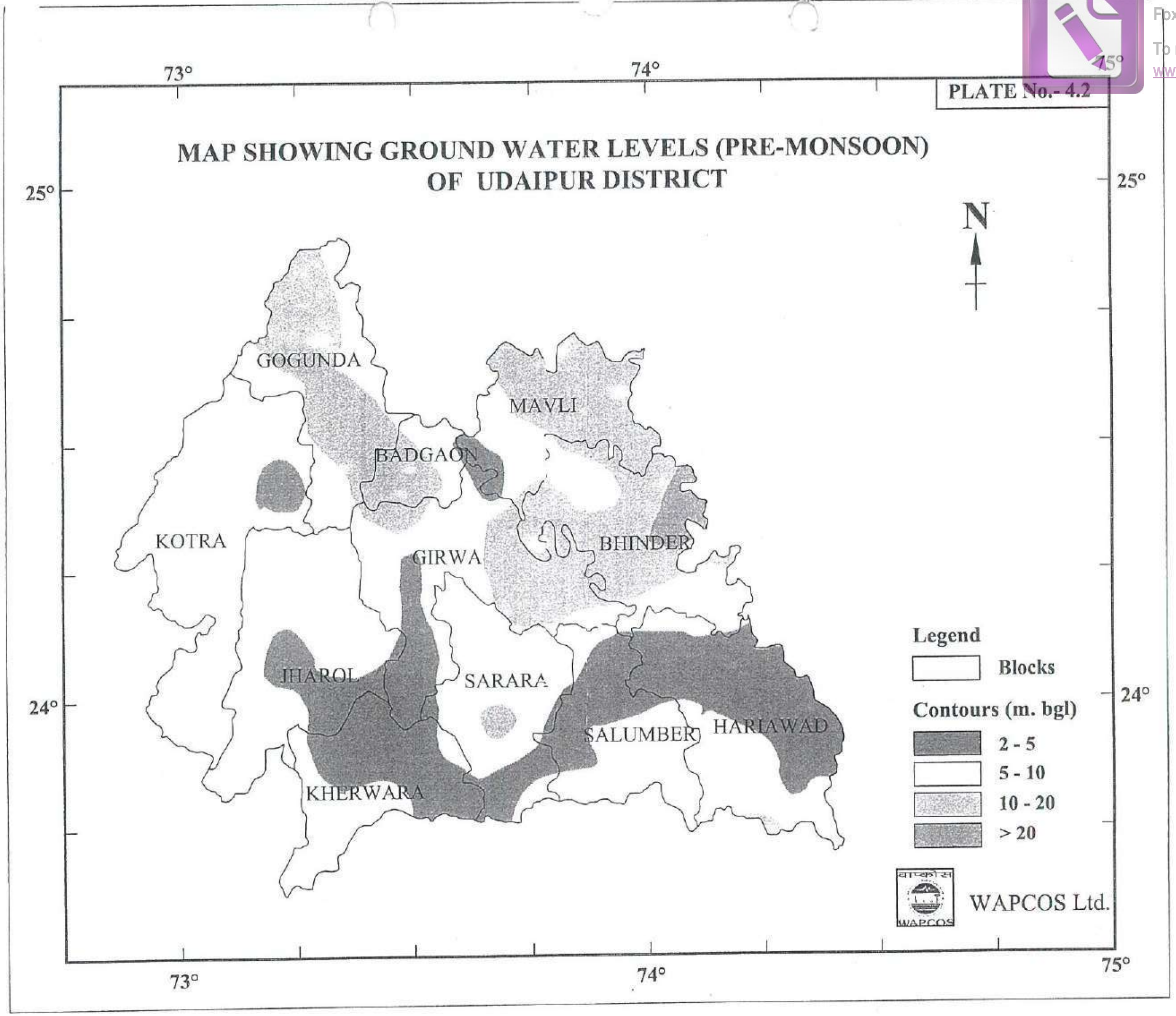


PLATE No.- 4.2

MAP SHOWING GROUND WATER LEVELS (PRE-MONSOON) OF UDAIPUR DISTRICT

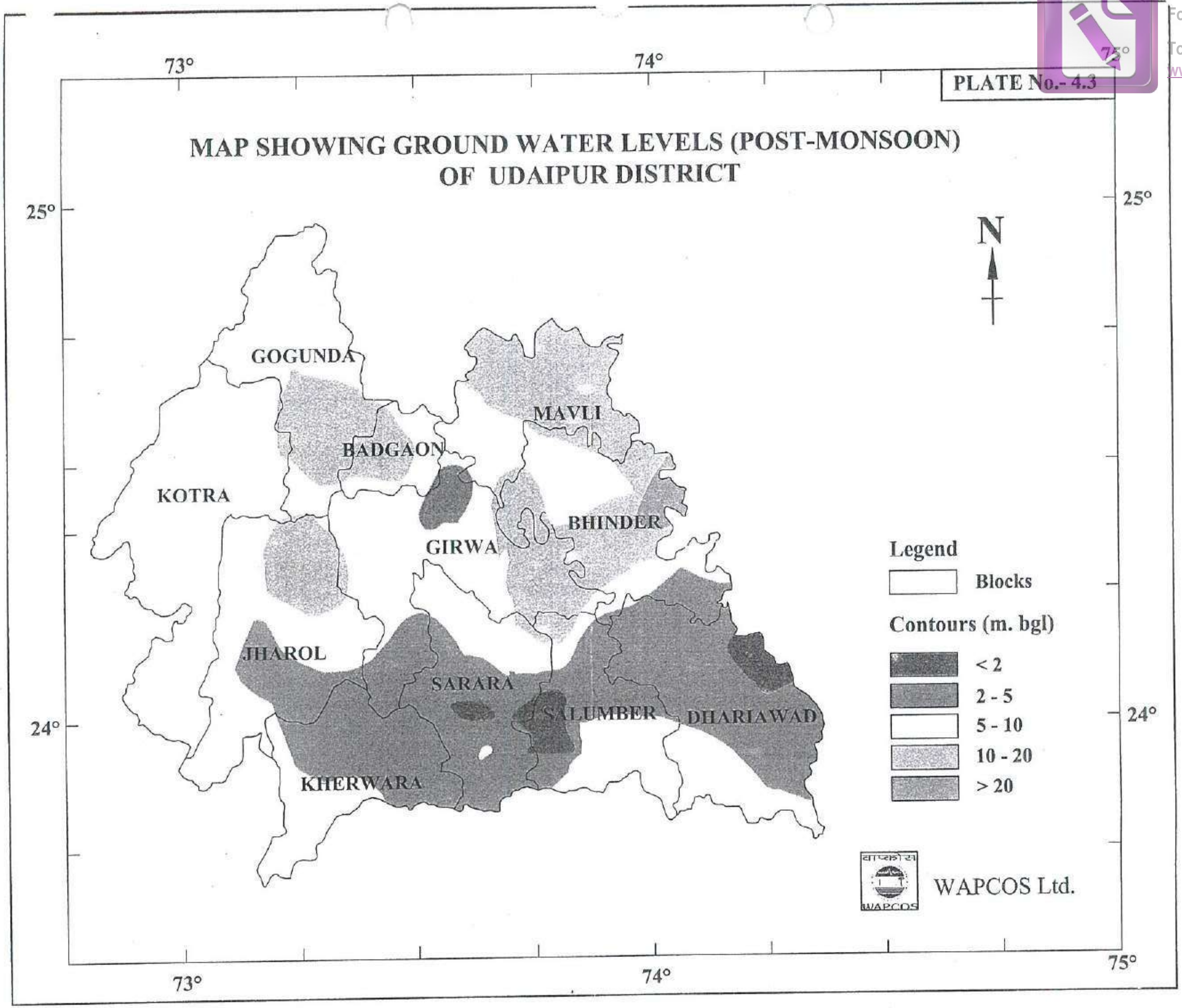


PLATE No.- 4.3

MAP SHOWING GROUND WATER LEVELS (POST-MONSOON) OF UDAIPUR DISTRICT

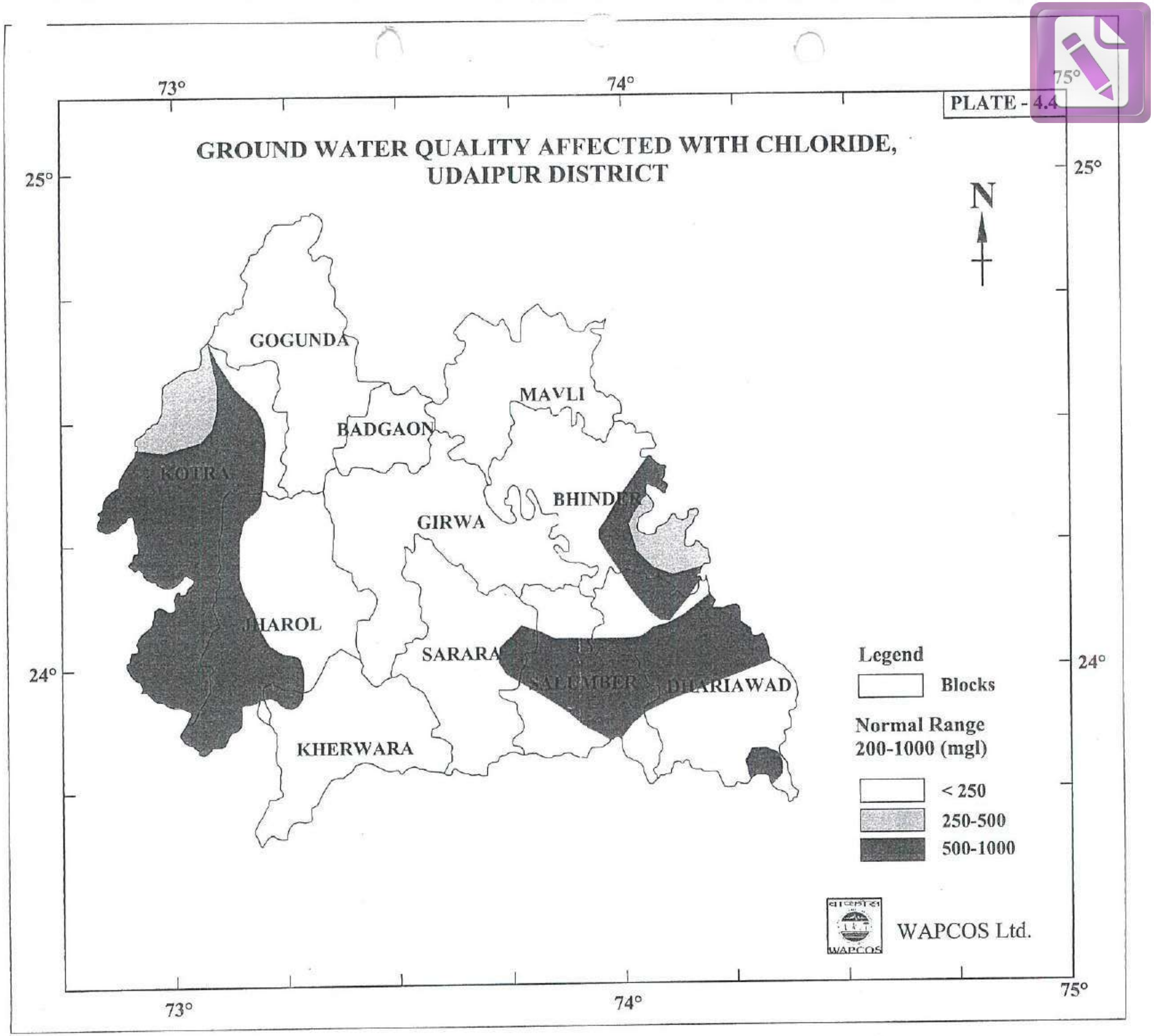


PLATE - 4.4

GROUND WATER QUALITY AFFECTED WITH CHLORIDE, UDAIPUR DISTRICT

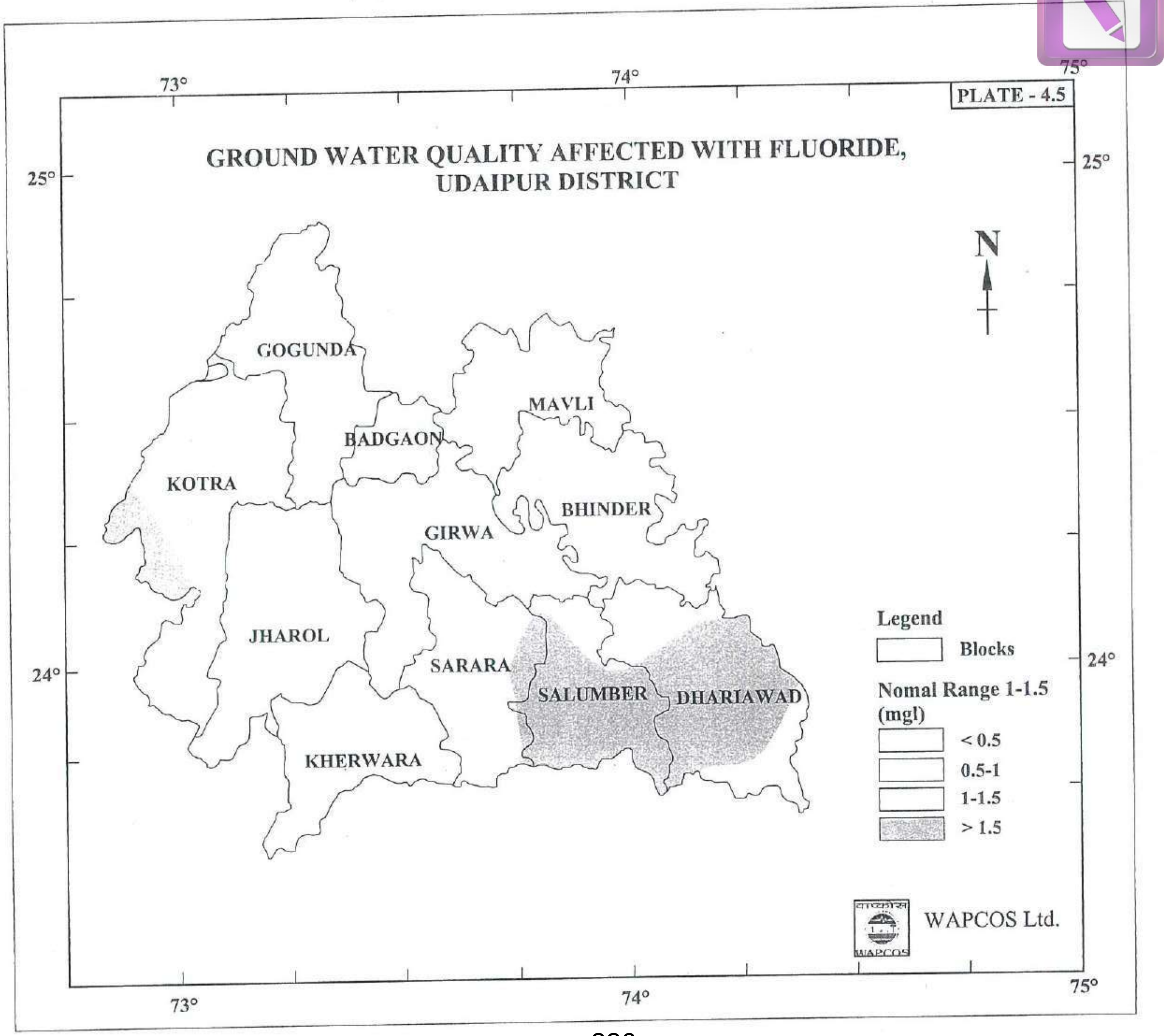


PLATE - 4.5

GROUND WATER QUALITY AFFECTED WITH FLUORIDE, UDAIPUR DISTRICT

Plate-5.1

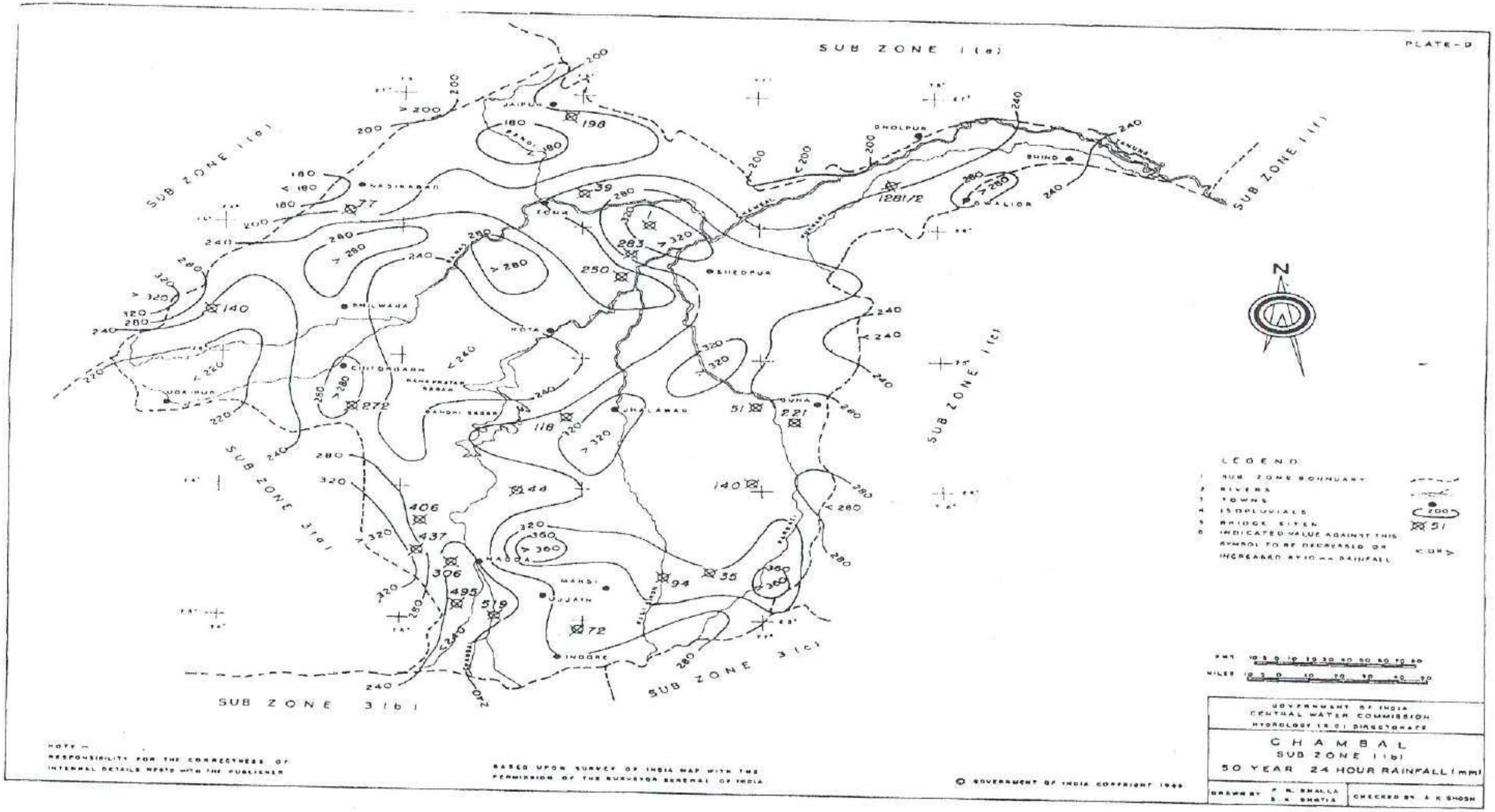


PLATE-D
SUB ZONE I (a)
SUB ZONE I (c)
SUB ZONE I (f)
SUB ZONE 3 (a)
SUB ZONE 3 (b)
SUB ZONE 3 (c)
JAIPUR
DHOLPUR
BHIND
GWALIOR
NASIRABAD
TONK
SHEOPUR
BHILWARA
KOTA
CHITORGARH
RANAPRATAP SAGAR
GANDHI SAGAR
JHALAWAR
GUNA
UDAIPUR
NAGDA
MAKSI
UJJAIN
INDORE
N
LEGEND
1 SUB ZONE BOUNDARY
2 RIVERS
3 TOWNS
4 ISOPLUVIALS
5 BRIDGE SITES
6 INDICATED VALUE AGAINST THIS SYMBOL TO BE DECREASED OR INCREASED BY 10 — RAINFALL
200
51
< OR >
KMS 10 5 0 10 20 30 40 50 60 70 80
MILES 10 5 0 10 20 30 40 50
GOVERNMENT OF INDIA
CENTRAL WATER COMMISSION
HYDROLOGY (S.C.) DIRECTORATE
CHAMBAL
SUB ZONE 1(b)
50 YEAR 24 HOUR RAINFALL (mm)
DRAWN BY P. R. BHALLA
S. K. BHATIA
CHECKED BY A K GHOSH
NOTE —
RESPONSIBILITY FOR THE CORRECTNESS OF INTERNAL DETAILS RESTS WITH THE PUBLISHER
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Plate-5.2

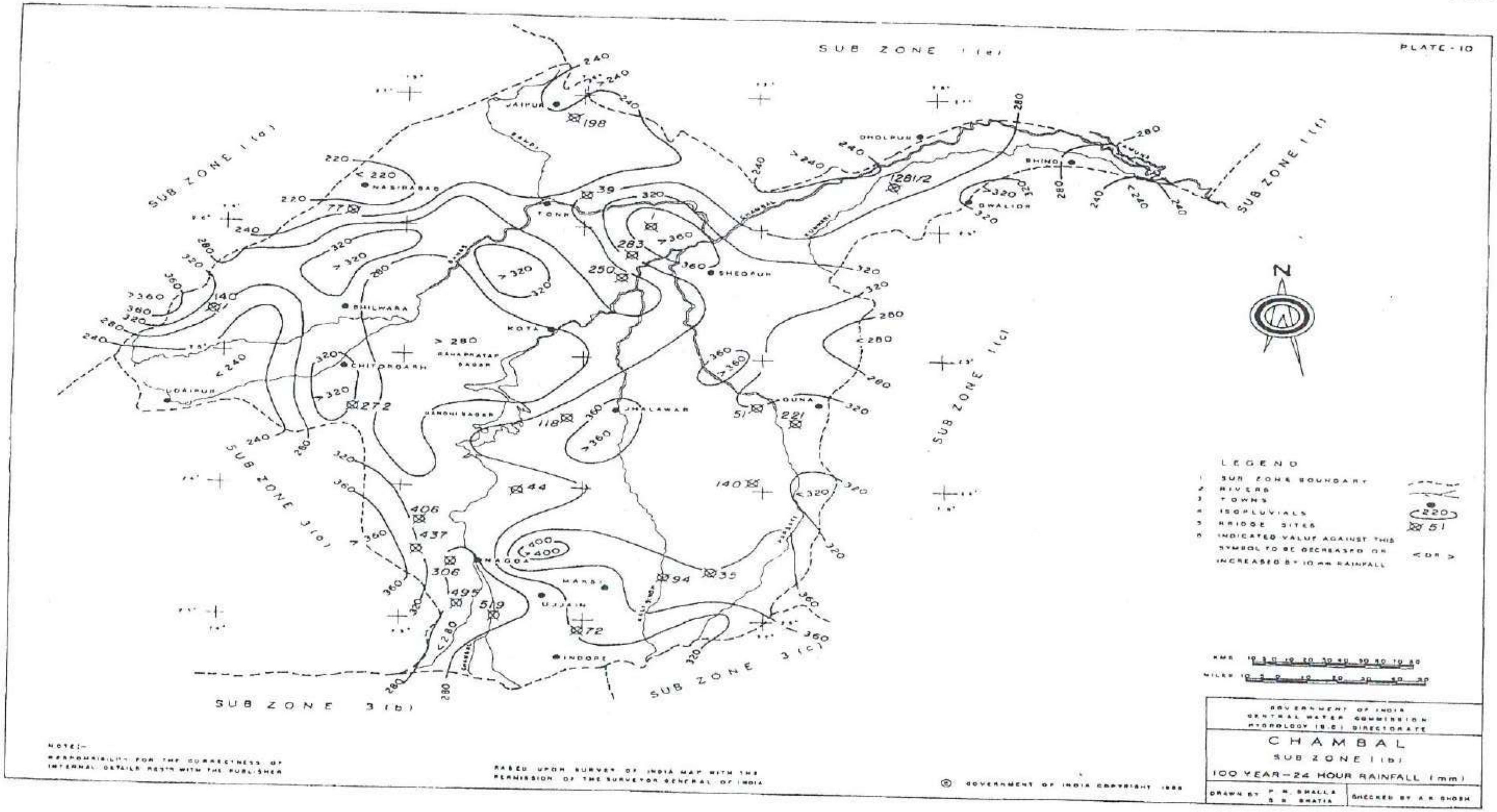
PLATE - 10
SUB ZONE 1(e)
SUB ZONE 1(a)
SUB ZONE 1(f)
SUB ZONE 1(c)
SUB ZONE 3(a)
SUB ZONE 3(b)
SUB ZONE 3(c)
JAIPUR
TONK
NASIRABAD
BHILWARA
CHITORGARH
UDAIPUR
KOTA
RANAPRATAP SAGAR
GANDHI SAGAR
JHALAWAR
SHEOPUR
DHOLPUR
BHIND
GWALIOR
GUNA
NAGDA
UJJAIN
MAKSI
INDORE
CHAMBAL
YAMUNA
KUNWARI
PARBATI
KALI SINDH
BANAS
N
LEGEND
1 SUB ZONE BOUNDARY
2 RIVERS
3 TOWNS
4 ISOPLUVIALS
5 BRIDGE SITES
6 INDICATED VALUE AGAINST THIS SYMBOL TO BE DECREASED OR INCREASED BY 10 mm RAINFALL
220
51
< OR >
KMS 10 5 0 10 20 30 40 50 60 70 80
MILES 10 5 0 10 20 30 40 50
GOVERNMENT OF INDIA
CENTRAL WATER COMMISSION
HYDROLOGY (S.C.) DIRECTORATE
CHAMBAL
SUB ZONE 1(b)
100 YEAR-24 HOUR RAINFALL (mm)
DRAWN BY P. R. BHALLA
S. R. BHATIA
CHECKED BY A. K. GHOSH
NOTE:-
RESPONSIBILITY FOR THE CORRECTNESS OF INTERNAL DETAILS RESTS WITH THE PUBLISHER
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Plate – 5.3

POINT TO AREAL RAINFALL RATIO'S (PERCENTAGE)

Area in sq. km.	1-hr	2-hr	3-hr	4-hr	5-hr	6-hr	7-hr	8-hr	9-hr	10-hr	11-hr	12-hr	13-hr	14-hr	15-hr	16-hr	17-hr	18-hr	19-hr	20-hr	21-hr	22-hr	23-hr	24-hr	Area in sq. km
0	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	0
50	87.00	89.00	91.00	91.67	92.33	93.00	93.17	93.33	93.50	93.67	93.83	94.00	94.25	94.50	94.75	95.00	95.25	95.50	95.75	96.00	96.25	96.50	96.75	97.00	50
100	78.00	81.00	84.00	85.67	87.33	89.00	89.33	89.67	90.00	90.33	90.67	91.00	91.33	91.67	92.00	92.33	92.67	93.00	93.33	93.67	94.00	94.33	94.67	95.00	100
150	71.00	75.00	79.00	80.67	82.33	84.00	84.67	85.33	86.00	86.67	87.33	88.00	88.33	88.67	89.00	89.33	89.67	90.00	90.33	90.67	91.00	91.33	91.67	92.00	150
200	66.00	70.50	75.00	77.00	79.00	81.00	82.00	83.00	84.00	85.00	86.00	87.00	87.33	87.67	88.00	88.33	88.67	89.00	89.33	89.67	90.00	90.33	90.67	91.00	200
250	63.00	67.50	72.00	74.00	76.00	78.00	79.17	80.33	81.50	82.67	83.83	85.00	85.42	85.83	86.25	86.67	87.08	87.50	87.92	88.33	88.75	89.17	89.58	90.00	250
300	60.00	64.50	59.00	71.33	73.67	76.00	77.33	78.67	80.00	81.33	82.67	84.00	84.42	84.83	85.25	85.67	86.08	86.50	86.92	87.33	87.75	88.17	88.58	89.00	300
350			68.00	70.33	72.67	75.00	76.33	77.67	79.00	80.33	81.67	83.00	83.42	83.83	84.25	84.67	85.08	85.50	85.92	86.33	86.75	87.17	87.58	88.00	350
400			67.00	69.33	71.67	74.00	75.33	76.67	78.00	79.33	80.67	82.00	82.42	82.83	83.25	83.67	84.08	84.50	84.92	85.33	85.75	86.17	86.58	87.00	400
450			66.00	68.33	70.67	73.00	74.33	75.67	77.00	78.33	79.67	81.00	81.50	82.00	82.50	83.00	83.50	84.00	84.50	85.00	85.50	86.00	86.50	87.00	450
500			55.00	67.33	69.67	72.00	73.50	75.00	76.50	78.00	79.50	81.00	81.42	81.83	82.25	82.67	83.08	83.50	83.92	84.33	84.75	85.17	85.58	86.00	500
600												79.00	79.50	80.00	80.50	81.00	81.50	82.00	82.50	83.00	83.50	84.00	84.50	85.00	600
700												78.00	78.50	79.00	79.50	80.00	80.50	81.00	81.50	82.00	82.50	83.00	83.50	84.00	700
800												77.00	77.50	78.00	78.50	79.00	79.50	80.00	80.50	81.00	81.50	82.00	82.50	83.00	800
900												77.00	77.42	77.83	78.25	78.67	79.08	79.50	79.92	80.33	80.75	81.17	81.58	82.00	900
1000												76.00	76.50	77.00	77.50	78.00	78.50	79.00	79.50	80.00	80.50	81.00	81.50	82.00	1000
1500																								80.00	1500
2000																								79.00	2000
2500																								78.00	2500

Note : 1) The lowest areal to point rainfall ratios (precentages) against the catchment areas for various durations in the above table are also applicable to all the catchment areas exceeding the catchment area for which the lowest ratios are given for specific durations.

2) For catchment areas from 2,500 to 5,000 sq km the lowest ratios for various durations in the above table are applicable.

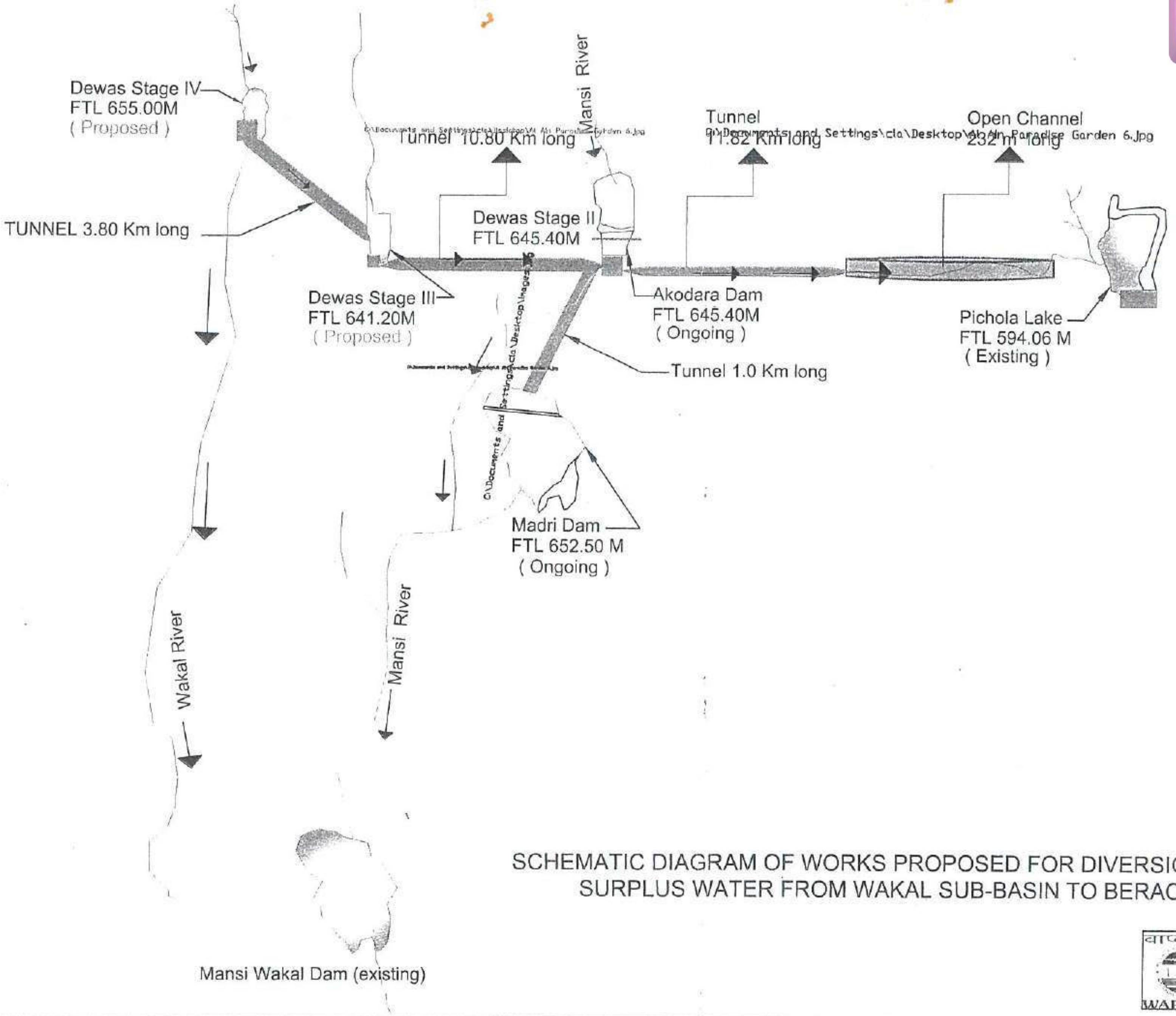
Plate-5.4

TIME DISTRIBUTION CO-EFFECIENTS OF AREAL RAINFALL
SUB-ZONE 1(b)

TIME	DISTRIBUTION CO-EFFECIENTS FOR DESIGN STORM DURATION OF 2 -24 HOURS																							TIME
HOURS	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	HOURS
24																							1.00	24
23																						1.00	0.99	23
22																					1.00	0.99	0.98	22
21																				1.00	0.99	0.98	0.97	21
20																			1.00	0.99	0.98	0.97	0.96	20
19																		1.00	0.99	0.98	0.97	0.95	0.94	19
18																	1.00	0.99	0.98	0.96	0.95	0.94	0.93	18
17																1.00	0.99	0.98	0.97	0.95	0.93	0.92	0.90	17
16															1.00	0.99	0.98	0.96	0.95	0.94	0.92	0.90	0.88	16
15														1.00	0.99	0.98	0.96	0.94	0.93	0.90	0.88	0.87	0.85	15
14													1.00	0.99	0.97	0.96	0.93	0.92	0.90	0.88	0.87	0.85	0.83	14
13												1.00	0.99	0.97	0.96	0.94	0.93	0.90	0.87	0.85	0.84	0.83	0.81	13
12											1.00	0.99	0.97	0.96	0.94	0.92	0.91	0.86	0.84	0.82	0.81	0.80	0.79	12
11										1.00	0.98	0.96	0.95	0.93	0.92	0.91	0.89	0.83	0.82	0.80	0.79	0.78	0.76	11
10									1.00	0.99	0.97	0.94	0.92	0.91	0.89	0.88	0.86	0.80	0.78	0.77	0.76	0.75	0.73	10
9								1.00	0.98	0.97	0.96	0.92	0.90	0.88	0.86	0.85	0.84	0.76	0.75	0.73	0.71	0.70	0.68	9
8							1.00	0.98	0.97	0.96	0.94	0.90	0.87	0.85	0.84	0.82	0.80	0.73	0.71	0.67	0.69	0.66	0.64	8
7						1.00	0.98	0.96	0.95	0.93	0.92	0.85	0.83	0.82	0.80	0.78	0.76	0.68	0.66	0.65	0.64	0.62	0.60	7
6					1.00	0.98	0.96	0.94	0.92	0.90	0.88	0.82	0.79	0.78	0.75	0.74	0.72	0.63	0.61	0.60	0.59	0.58	0.56	6
5				1.00	0.98	0.95	0.93	0.91	0.88	0.86	0.84	0.77	0.74	0.72	0.70	0.69	0.67	0.57	0.55	0.54	0.53	0.52	0.50	5
4			1.00	0.98	0.96	0.92	0.89	0.84	0.82	0.80	0.76	0.70	0.68	0.66	0.64	0.63	0.61	0.50	0.49	0.48	0.47	0.45	0.43	4
3		1.00	0.97	0.92	0.88	0.86	0.80	0.76	0.73	0.70	0.67	0.62	0.59	0.58	0.54	0.53	0.52	0.41	0.40	0.39	0.38	0.37	0.36	3
2	1.00	0.91	0.88	0.82	0.78	0.72	0.68	0.64	0.61	0.58	0.54	0.50	0.48	0.45	0.44	0.42	0.40	0.31	0.30	0.29	0.27	0.25	0.24	2
1	0.86	0.77	0.70	0.63	0.59	0.52	0.48	0.44	0.41	0.38	0.37	0.32	0.30	0.29	0.28	0.27	0.25	0.20	0.17	0.16	0.15	0.14	0.13	1

Note : Hourly rainfall distribution co-effecients are given in the vertical columns for various design storm durations from 2 - 24 hours.

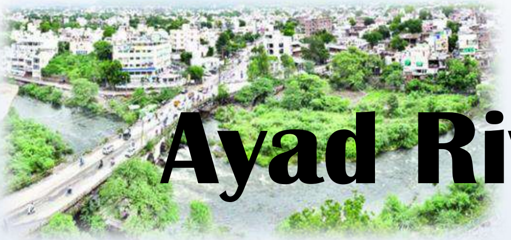
PLATE 5.5



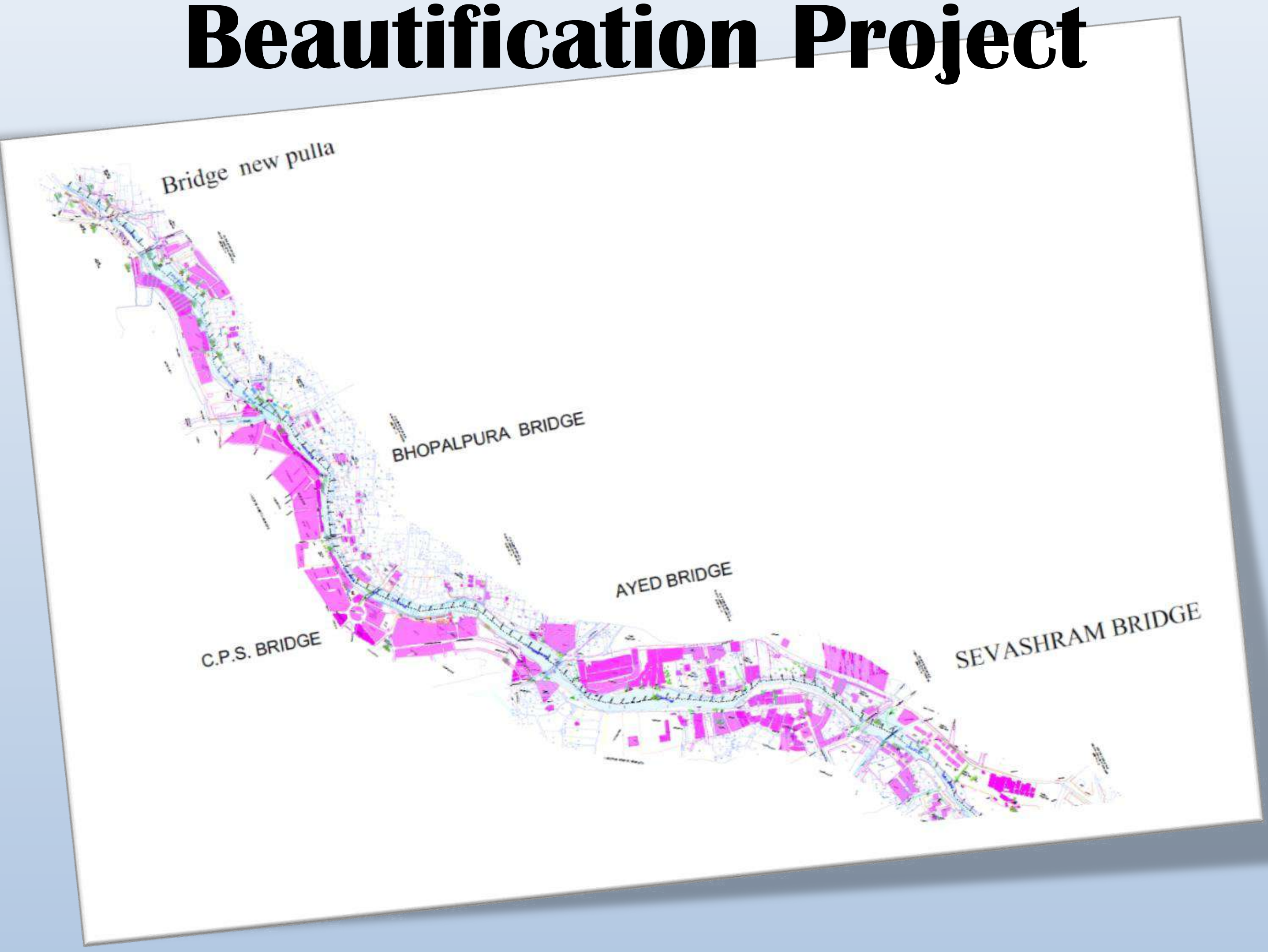
SCHEMATIC DIAGRAM OF WORKS PROPOSED FOR DIVERSION OF 62.00 MCM OF SURPLUS WATER FROM WAKAL SUB-BASIN TO BERACH SUB-BASIN

WAPCOS Ltd.

Annexure-5



Ayad River Smart Front Development and Beautification Project



PROJECT COST: ₹ 75 Cr.

UDAIPUR SMART CITY LIMITED

CHAPTER -1
INTRODUCTION

1.1 BACKGROUND

The **AYAD River** is a tributary of the **Berach River** (itself a tributary of **Banas River**, which in turn is a tributary of Chambal River, itself a tributary of Yamuna River, which in turn is the most important tributary of Ganges River).

The river flows through the **Udaipur city** and is its larger drainage body. The spill water of the famous **Lake Pichola** and **Fateh Sagar Lake** of Udaipur district gets into the Ayad River. *This historically important river is at present functioning as the drainage body of the Udaipur city filled with sewage and garbage. This forgotten river* flowing through Udaipur **is connected to almost every lake and river of Udaipur** including Bada Madar, Chhota Madar, Bedla River, Govardhan Sagar, Nela Taalab, Roopsagar, Fateh Sagar and Swaroop Sagar.

All along the stretch, the river is victim of pollution, either by littering or by sewage water flowing into the river. Access to the river is made difficult by the absence of a continuous path along the river. Agricultural fields block the access to the river in upstream areas, and further downstream constructions encroach on the space reserved for the riverbed.

Earlier WAPCOS (I) Ltd prepared the detailed project report for the Berech (Ayad) River Front Development Project which envisages overall development of the river surrounding Udaipur City as it has been suffering for want of proper flow, pollution due to discharge of waste water and no proper river front development in the form of landscape and beautification etc. in its entire stretch of 26 km up to terminal reservoir of Udaisagar. The objective of the project was to correct these anomalies to the extent feasible to create proper environment for the city people as well as make the river eco-friendly free of pollution.

Development of a river is never complete without making it pollution free. Therefore, priority needs to be given to undertake measures to conserve the river stretch around Udaipur City so that polluted water does not enter the river. The abatement of pollution is thus another component which needs to be tackled and RUIDP took the project of “Abatement of Ayad River” with laying trunk line on both the sides of the the river and trapping all the 139 drains/nallahs falling into the river.

Accordingly, three pronged strategy need to be evolved to deliberate the outcome of Ayad River Front Development Project i.e. first of all identifying the problems faced by Ayad River, evolving appropriate and feasible solutions and then implementing the solutions in order to remedy the situation.

The situation in Udaipur is no different from other cities of India. With rapid growth of Population, the cities are bursting out of their municipal limits with the result the municipalities and other local administrations are finding it too difficult to cope up with alarming situation because of lack of infrastructure with them and also shortage of funds.

Ayad River Smart Front Development is the **topmost priority** for the District Administration, UIT, UMC and every citizen of Udaipur. In order to achieve **Sustainable Beautification** with respect to the Riverfront Project of River Ayad with the effective Technical Support and Aspirations of Local Senior Retired Engineers and Government Officials from UIT, WRD, UMC and USCL, Hon’ble District Collector has formulated a Technical Team. A stretch of Ayad of 5 Km length has been selected from New Pula bridge to Sevashram bridge, which is

- Located in the dense habitation of the city,
- Most exposed to tourist and public, and
- Most vulnerable with respect to the pollution.

1.2 ABOUT UDAIPUR CITY

Udaipur, known to be city of lakes, attract lot of national and international tourists due to the presence of such lakes and other water bodies but the development scenario of the city continue to be far from satisfactory.

The human activities has not only resulted in over exploitation of lakes but has made them highly polluted due to disposal of waste water thereby leading to their overall degradation in terms of quantity and quality of water.

The Ayad River which flows on the north-east side of Udaipur City and receives polluted overflow not only from city lakes (mainly Pichola and Fatehsagar) but solid & liquid wastes directly as well. As on date, Ayad River is also rated to be more polluted than the city lakes.

Udaipur district is located between 23° 46' & 25° 05' North latitude and 73°09'& 74°35' East longitude covering an area of 11630.66 sq. km. The district is bounded by Sirohi, Pali and Bhilwara Districts on the north, Chittaurgarh District on the east, Banswara and Dungarpur on the south and state of Gujarat on the west. The city of Udaipur is located in the northern part of Udaipur District and is approx. 420 km from Jaipur and 692 km from Delhi by road. The district of Udaipur is divided into seven sub-divisions namely Girwa, Dhariyawad, Mavali, Vallabhnagar, Kotra, Jharol and Salumbar.Administratively the district is divided into 10 Tehsils and 11 Development blocks. The names of the 10 Tehsils are; Girwa, Dhariyawad, Mavali, Bhinder (Vallabnagar), Kotra, Jharol, Salumber, Kherwara, Sarara and Gogunda. The names of 11 Development blocks are same as those of Tehsils with one additional name i.e. Badgaon. Total number of villages in the district is 2406 and 9 urban towns. Urban and rural population of the district is 4.9 lakh and 21.4 lakh respectively.

Rajasthan State Mapshowing UdaipurDistrictis giveninPlate– 1.1

1.3 AYAD RIVER AND ITS SURROUNDINGS

The Present Scenario of Udaipur City is as under:

- The less rainfall that occurred during the last few years has significantly affected the socio-economic profile of the area. Due to failure of monsoons, the water level in the lakes has receded considerably and ground water table also fallen.
- Shortage of water had multifaceted effects on the economy of the area.
- Udaipur is on the world tourist Map, but its drying lakes, inadequate inflow in Ayad River and no proper management of disposal of waste water has reduced the influx of tourists in the city.
- The over exploitation of groundwater for the purpose of irrigation has costed quantity and quality of groundwater. The problem of fluorides and salinity has developed in the area.

- Industrial development has also been affected due to non-availability of adequate quantity of water.
- Fulfilling the requirement of drinking water has become a herculean task. It requires steps to be taken for augmentation of water supply.
- Service sector has been significantly affected due to migration of tribal population to adjoining Gujarat State for better employment opportunities.

In view of the above, the Govt. of Rajasthan in their Master Plan for Udaipur City conceptualized certain planning policies which are highlighted below:

(i) While maintaining the importance of historical & religions places and tourists spots in the walled city, there is need to make adequate transportation arrangements in the narrow lanes of the city and the narrow roads widened, where feasible along with parking lots.

(ii) All the city lakes like Pichhola, Fatehsagar, Rangsagar and Swaroopsagar located on the west side which have special importance from the environmental angle need to the protected by proper land use planning of the surrounding areas.

(iii) Keeping the importance of tourism in view, there is need to provide better tourist facilities in the city like hotels, transportation, parks, tourist complexes etc.

(iv) Industries causing pollution need not be allowed to the set up near the city from tourism angle.

(v) The development and location of commercial centres need to be planned and provided in such a way that the local area demands could be met without commuting long distances.

(vi) In order to reduce the influx of heavy vehicles in the narrow roads of the city, land outside the city needs to the reserved for major establishments like Whole Sale Trade, Transport Nagar, Godowns & Storages etc which encourage deployment of heavy transport vehicles

(vii) Ayad River which is passing through the city area need to be protected from environmental angle. Both the banks of the river should be developed with tree plantation and greenery. RUIDP project is under progress for laying of trunk on both sides and trapping of all the 139 drains falling in to the Ayad river for Abatement of Ayad.

(viii) Afforestation needs to be done in the entire Udaipur Valley and surrounding bald hills in order to check the inflow of sediment into Ayad River as well as the city lakes.

1.4 IDENTIFIED PROBLEMS

The major problems identified are:

1. **Insufficient Flow**: The water flow in the river is insufficient due to limited catchment area, lower average rainfall, degradation of the catchment area and increasing water demand for domestic purposes.
2. **Degradation of Catchment Area**: Due to increased human interference in the catchment area, forest is getting depleted. This has resulted in reduced vegetative cover, reduction in subsurface water flows- essential for flow maintenance during lean period. This is also causing excessive soil erosion and thus siltation of lakes and river.
3. **Encroachment:** The river bed and banks have been encroached by the people over the passage of time because there was no firm demarcation of river boundary. In some of the stretches multi storied buildings have come up right over the side wall of the river. This has resulted in reduction of the river cross section considerably thereby affecting the smooth flow of water in the river and also leading to flood like situations during the period of high rainfall.
4. **Waste Water Discharge:** The city does not have proper sewerage system and is mainly using septic tanks at domestic levels. The overflow from the septic tanks through various open drains finds its way into the river. Some of the populated areas on the banks of river are discharging waste water directly into the river.
5. **Solid Waste:** The city lacks scientific solid waste management system and significant part of the solid waste is dumped into the river which is further aggravating the river water quality situation and obstruction in smooth flow of river water.
6. **Ground Water Contamination:** As a consequence of waste water and solid waste disposal into the river, the ground water has become highly

contaminated. Use of contaminated water ground water has led to reduction in agriculture productivity, contamination of vegetables, etc.

7. **Siltation and Weed Growth:** Most of the river stretches specially in the city area is experiencing siltation and deposit of organic solids causing heavy growth of aquatic weed. This has led to hyper eutrophic state and absence of oxygen in most of the river stretches.
8. **Bio-diversity**: The anthropogenic pressures in the catchment and on the banks of river has resulted in degradation in bio-diversity and consequence erosion and increased silt flow in the river bed. Excessive growth of weeds in the river is resulting in breeding of vectors thereby causing disease in the area.

The alarming situation in river Ayad and the linked lakes, is leading to flooding, serious health hazards on account of contaminated surface and ground water, bio-diversity perils, unaesthetic environment to the city residents. Hence, immediate measures are required to restore quality water flow in the river and restore complete ecological balance of the system.

To some extent, the Government of Rajasthan has already initiated measures for improvement of lake system in Udaipur. Two projects for conservation and management of Fatehsagar and Pichola Lakes, financed through National Lake Conservation Plan, Ministry of Environment and Forests, Government of India have been implemented. This includes desilting of lakes, purification of lake water, plantation in catchment area, development of green belts etc.

One project of “Abatement of Ayad River” is under implementation by RUIDP.

Demarcation of River Boundary and Removal of Encroachments under implementation by Urban Improvement Trust and Municipal Corporation Udaipur.

“Ayad Cleaning Drive” has been carried out with the support of Industrial houses and Institutions by District Administration, UIT and UMC.

Installation of Fencing at salient locations by UIT and UMC *to check littering*.

Udaipur Municipal Corporation and Udaipur Smart City Limited are also implementing the sewerage projects under AMRUT mission and Installation of 3 Decentralized STPs at following location under HAM (Hybrid Annuity Model) and 40% contribution will be under convergence to Smart City Mission-

1. 25 MLD at Eklingpura

2. 10 MLD at FCI Godown
3. 5 MLD at Karjali Complex

1.5 OUTLINE OF FEASIBLE OPTIONS

- Identification of river passage based on survey output
- Channelization to maintain perennial flow in between
- Protection of banks
- Walkway on both the sides
- Water Availability during lean period from treatment of domestic waste water,
- River-front Landscape and Beautification plans
- Tree plantation
- Public awareness

1.6 THE PROJECT

Promote the Ecology

New development along the river should preserve and restore the ecology and sustainability of the Ayad River System. This goal recognizes the **regional** and **local ecological significance** of the river and its importance as a defining feature for Udaipur. This goal comprises of the following principles:

- Protect and restore riparian habitat through preservation and enhancement of the ecological function of the river

- Respect flood control efforts along the river with an eye on sustenance

Pathways

Create a connected pathway along the river to enhance ***'eco – mobility'***

Promenades

Creation of promenades at certain locations available above HFL for leisure activities and enjoying the river.

Public Access

Increase public access to the river through the creation of access roads and public parks.

Recreation & Tourism

Develop the River as a recreational and an amenity unit, attracting tourists and enhancing UDAIPUR'S image as a desirable place to live, work and visit.

Demarcation and Protection of Banks

UIT and UMC demarcated the river boundary and removed encroachments. For sustainability, both the River Banks shall be properly developed with eco-friendly materials such as coir-mat with a mix of gabion structure properly designed.

Perennial flow in the River

After commissioning of 5 and 10 MLD STPs', **the treated water will be flowed through the River**. So to make the water column visible, a channel shall be constructed in the middle of the River.

Post detailed deliberations and Site visit conducted, Proposal has been prepared based on the following considerations:

1. A typical section of **50 meters** has been selected.

2. Both the Sides/Banks have been proposed to be protected by **Coir Mat with Grass and Gabion wall** in the ratio of **80%** and **20%** area respectively for beautification keeping in mind the economic aspects.

3. A channel of **width 5 meters** has been proposed in between to carry the treated water from STP ensuring a perennial flow in the River Ayad.

4. A **walkway of width 2.4 meters** has been proposed on both the sides using the encasing of existing sewer trunk line laid along the River Ayad.

5. **Conocarpus tree plantation** has been proposed along the upper edges of the Bank on both the sides

6. Plantation within the River bed has also been proposed with the support of RCC pipe embedded in the ground.

Running meter cost of Proposed Ayad River Front Development - Rs. 1.50 Lacs. Length of River Ayad from Annicut (near Pulla Bridge) to Sevashram Bridge - 5.0 Km has been decided in the proposed projects which Cost as Rs. 74.50 Cr.

Rejuvenation of River Ayad is amongst one of the most aspired project of the citizen feedback collected for preparation of SCP. The Project has been taken under convergence and the Estimated Project Cost of **Rs. 75 Crores** has been decided to be shared by USCL, UIT and Nagar Nigam as Rs. 35 Cr., Rs. 35 Cr. and Rs. 5 Cr. respectively. Nagar Nigam will do maintenance and the cost of the same will be shared equally between UIT and Nagar Nigam Udaipur. After completion of this project, it will act as a major lifeline for rejuvenation of local economy and will work as an improved ecosystem. It will be a blessing for the residential colonies alongside the river and with walking trails coming up, it will act as a boon for morning walkers.

CHAPTER – 2
NECESSITY OF THE PROJECT

A river attracts people; hence riverfronts have emerged as lively Urban Cores of cities - their sociocultural, intellectual and economic centers. The Riverfront Development Plan defines that vision, provides a framework that allows us to capitalize on the energy, interest and goodwill that has coalesced around our rivers. Adding to its value with greenways and other amenities and attracting public attention. Today, everyone recognizes the value of public access to the waterfronts. A renewed waterfront offers investors a promising return on capital. Cities enjoy increased tourism, employment and growth. Resident gain new recreation opportunities and an expanded awareness of the natural aspects of river life. Most importantly, a vital and vibrant waterfront serves to unite residents and visitors in a shared experience of the city, just as the city public places and streets. It is in that daily exchange of ideas and points of view that a city finds the energy and desire to continually improve and remake itself.

Once the river has got channelization, the banks can be developed to provide spaces for social infrastructure. Public promenades, religious facilities and other activities can be drawn close to the river, making it the vibrant heart of the urban fabric. Along with this, it is essential to integrate the environment and provide for a sustainable riverfront. By redensifiying the designated greens, treating the sewage that flows into the river and attempting to provide a holistic system.

The River Front Development Project comprises of the following three components:

i) Channelization to maintain perennial flow in between

ii) Protection of banks and Walkways on both sides

iii) River Front Landscaping and Beautification

All these components are very essential in any smart riverfront development project. They have been deliberated in details in various chapters of this report.

2.1 CHANNELIZATION –A BASIC NECESSITY IN RIVER FRONT DEVELOPMENT PROJECTS

The river channelization aspect comprises of availability of water during the lean period from October to May when practically there is no rainfall and consequent runoff which can sustain the environmental and ecological balance of the river channel.

For lean period flow, it is considered that domestic waste water generated from the city can contribute substantially if the same is treated to a reasonably good level and made available in the river for reuse for various purposes.

Two STP's of capacity 5 and 10 MLD are under construction, along the River bank in Hybrid Annuity Model by Udaipur Smart City Limited and as per HAM the treated effluent of both the STP's will be left in the Ayad. So to make use of this water effectively a central channel has been proposed. The treated waste water when available in the river all through the year can be utilized for other purposes.

2.2 PROTECTION OF BANKS AND WALKWAYS ON BOTH SIDES

The protection of the banks of the river are essential to ensure the two aspects. The first aspect is to keep the river boundary intact and safe from encroachments and slope protection. The second aspect is of beautification.

The walkways on both the sides will provide a safe and BLUE/GREEN space for the local residents and tourist also which is a measure issue in the dense habitation.

2.3 LANDSCAPING AND RIVER FRONT BEAUTIFICATION

The studies regarding landscaping and river front beautification aspect of the project are carried out and conceptual plans prepared considering vacant spaces on banks, width of the river etc.

The conceptual plan would include development of sites for recreational purposes, pathway, sitting area, development of road with promenade, cycle track with cycle stand, walkway, lighting, landscaping on the edges of the river bed, parking etc.

The necessity of landscaping and river front beautification arises due to the following:

i) The fundamental component of the river front development projects is landscaping and beautification of the river stretches passing through the city area by way of developing parks, green spaces etc. which provides opportunity to local people to enjoy the river front for recreation.

ii) With rapid urbanization, private properties and colonies have come up very close to the river banks amounting to encroachment of the river boundary at many places. However, the situation can be improved for future if the river front development project is followed which envisages provision of a buffer zone on the banks where vacant land is available. Accordingly steps can be taken by local administration to protect the buffer area on the river banks from getting encroached by the people.

CHAPTER – 3
CHARACTERISTICS OF PROJECT AREA

3.1 TOPOGRAPHY

The Udaipur City has a hilly terrain and undulating topography with lakes and tanks. The Elevated plateau within the town is occupied mainly under settlements and likewise other hilly towns. The plane areas are developed for housing. The Aravalli hills with the inter-mountain plateau, deeply dissected by streams and rivers. There are number of surface water streams like Ghambiri, Sabarmati, Banas and its highly metamorphosed state and so the depressions on the surface are filled with the rainwater in the form of natural tanks.

The area comprises of low Aravalli hills with intrusions of black lava rocks and metamorphic rocks. This is mostly a tribal area occupied by Bhils, Garasiyas and Damors. The area is rich in natural vegetation, which grows on the slopes of the Aravallis, and in the wetland areas but excessive felling of trees has degraded forests. Tank water irrigation is most common. The area produces maize as the chief food crop of the Kharif season but in irrigated areas, paddy is also grown. In the Rabi season, wheat, gram and oil seeds are the main crops. The non-irrigated land, crops are depending on the rain water whereas part of the irrigated land is cultivated mainly for the water based crops. Yet the water scarcity at most of the places is the major constraint in agriculture practices.

3.2 GEOMORPHOLOGY & DRAINAGE

3.2.1 Geomorphology

The district is characterized by undulating topography. Towards the western part of district, series of Aravalli hills run along NE-SW direction. A typical plain of gneisses and granites without any alluvium cover is observed to the east of Aravalli ridges.

Geomorphologically the district is divided into following units:

Origin	Land Forms	Occurrence in the District
Fluvial	Valley Fill	Scattered in the entire district in between structural hill
Denudation	Pediment	Main concentration in north east and scattered in entire district
	Buried pediment	Main concentration in east and scattered in entire district
Hill	Structural hill	Covers entire district except north east

3.2.2 Drainage

The district has a well developed drainage system. The main rivers of the district are Jakham, Som, Wakal, Sei, Sabarmati, Gomti and Berach (Berech (Ayad) river is a tributary of Berach). These are monsoon fed rivers and flow more rigorously in rainy season. Jakham, Gomti and Som drain the south eastern plains of the district. Wakal, Sabarmati and Sei rivers flow through the valley region of Aravalli ranges in the south west of the district. These rivers have been dammed at various sites and thus several artificial lakes have been created in the district. Important ones are Jaisamand, Udaisagar, Pichhola, Fatehsagar, Som Kagdar and Jakham. Drainage density in most part of the district varies from 0.5 to 0.7 km/km^2. Drainage density is from 0.7 to more than1km/km^2 in the south eastern and south western part of the district. In the north central part of the district its low and ranges between 0.3 to 0.5 km/km^2.

The drainage area of various Tehsils corresponding to different river basins is given below:

Sl. No	Name of Tehsil	Area in Sq. Km.			
		Sabarmati	West Banas	Mahi	East Banas
1	Dhariyawad			1322	
2	Girwa			1592.4	540.6
3	Jharol	793		597.9	82.2
4	Kherwara	179.4		673.9	
5	Mavli			621.4	179.6
6	Salumbar			805	
7	Sarara			775.6	
8	Bhinder (Vallabhnagar)			149.4	637.6
9	Kotra	2294	2.2		1.0
10	Gogunda	161.8			841

3.3 AYAD RIVER & UDAIPUR LAKE SYSTEM

The river Ayad (also called River Ahar) and other tributaries originate from western hills extending in North-South direction with average height varying between 650 to 900 m above MSL. The Central hills of the Berach Basins mainly extend from North-West to South-East direction in the central part of the region and forms inner Girwa plains, which has average height of 600 to 700 m above MSL. The inner Girwa plain is surrounded by western and central hills draining water into the River Berech (Ayad). Udaipur city and other settlements are situated in this plain. The drainage pattern of the area supports the water front, which is one of the important considerations for settlement. The important lakes of the Udaipur viz., Badi, Fateh Sagar, Pichola, Dudh Talai, Rang Sagar and Swaroop Sagar area are located in this plain. The original drainage pattern was very much intact with the lake system and support recharging and maintaining water level in the area. However, the changing land use pattern, human interventions and climatic variations affected the natural drainage pattern to an extent that recharging of Berech (Ayad) river system is to be reassessed for the sustainable management.

The upper Berach Basin can be divided into four geomorphic sub-regions, which are as follows:

i) Western Hills
ii) Central Hills
iii) Inner Girwa Plain or Ahar Plain
iv) Outer Plain or Berach-Katara Plain

The lakes in Udaipur namely Fatehsagar, Pichhola, Rang Sagar and Swaroop Sagar are interconnected. The overflow of these lakes goes into Berech (Ayad) River which meets Berach River through Udaisagar reservoir. Berech (Ayad) River ultimately goes into Ganga River through Banas River, Chambal River and Yamuna River.

The Udaipur lake system may be divided on the basis of surface water drainage as Pichola, Fatehsagar Lake, and Udaisagar lake systems that include the following water bodies:

1. **Pichola Lake System:** Pichola, the mother lake, Rang Sagar (water spread area 4.46 ha), Swaroop Sagar (water spread area 8.0 ha), Kumaria Talab (water spread area 2.2 ha), Dudh Talai (water spread area 0.7 ha)
2. **Fatehsagar Lake System:** Fatehsagar Lake, Badi Lake, and Bada Madar & Chhota Madar Lakes
3. **Udaisagar Lake System:** Udaisagar Lake, located at downstream of city and above mentioned lake systems

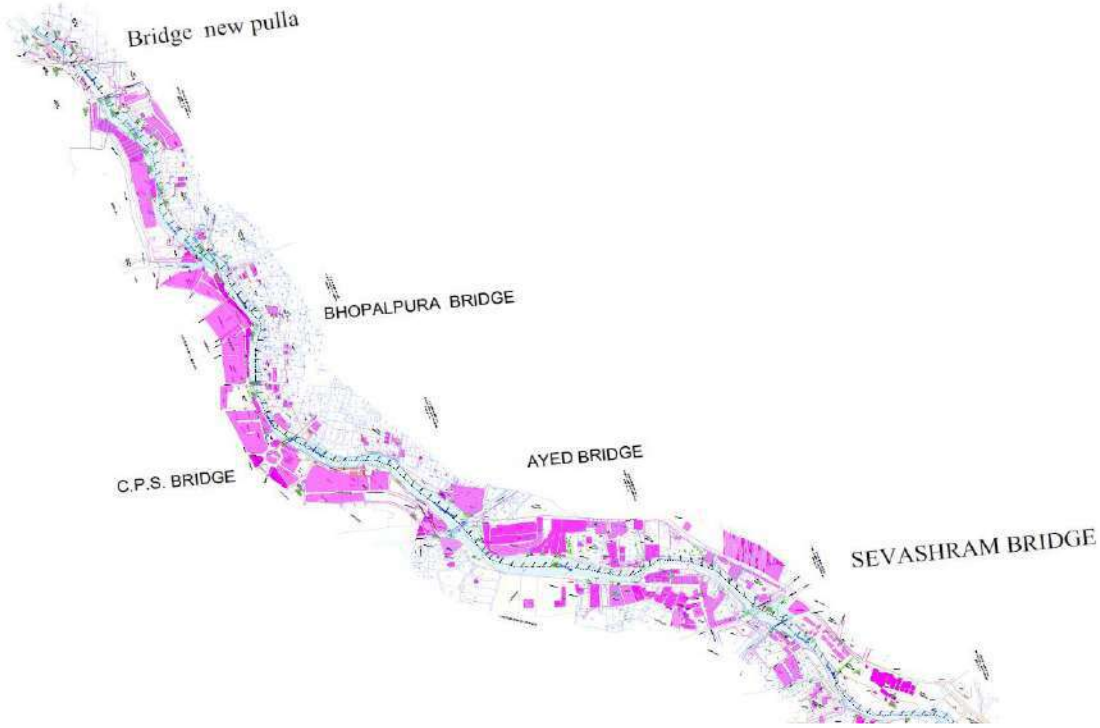
The management of these two lake systems is directly and indirectly related to each other. The water inflow and exchange in water bodies are being controlled through canals and is manually operated through gates. The recharging of Pichola and Fatehsagar depends upon the rainfall received in both the catchments, which is related to the intensity and duration of the rain. The surplus water in one of the water body is being released to other interconnected water body depending upon the water levels and requirement.

The combined flow from Pichola and Fatehsagar lakes ultimately goes into River Ganga through Berech (Ayad) River, Udaisagar, Banas River, Chambal River and Yamuna River in that order.

River Berech (Ayad) is non-perennial and receives water from its own catchment, Bada Madar, Chhota Madar, Badi Reservoir, Fatehsagar Lake and Pichola Lake. In addition entire untreated domestic as well as industrial waste water of Udaipur is discharged into the river. The river on downstream feeds the lake Udaisagar. Overflow from Bada Madar and Chhota Madar can be diverted to Fatehsagar Lake through Chikalwas feeder. Overflow from Badi Reservoir also feeds the Fatehsagar Lake. Fatehsagar Lake and Pichola Lakes are linked through a canal via Swaroop Sagar and Rang Sagar Lakes. Overflow from Fatehsagar and Pichola Lakes enters river Berech (Ayad) through nallah.

River Berech (Ayad) in Udaipur is a life line river for the people of the city. Over the passage of time and expansion of the city, the environmental and ecological balance of the river has deteriorated considerably. This deterioration has taken place mainly due to the factors like uncontrolled and untreated inflow of sewage from the city, encroachments in the river bed and banks, inadequate river flows, dumping of solid waste in the river, siltation and uncontrolled weed growth etc. The Government of Rajasthan is very keen to carry out the remedial measures in order to correct the present situation and bring the River and Lakes to better shape.

Length of River Berech (Ayad) from Thur Pick-up Weir below Madar to Udaisagar Lake is 26 km. Out of this 11 km is through populated city area. The length of River Ayad for the current study is also 5 km.



Index map showing Berech (Ayad) River

3.4 RAINFALL & CLIMATE

Average annual rainfall (1997-06) of the district is 657mm. However, normal rainfall for the period 1901 to 1970 is 633.50mm. The southern part of the district receives slightly more rainfall. The mean annual rainfall is 854.4 mm at Dhariyawad and minimum average rainfall is 566.7 mm at Sarara.

The climate of the district is dry except S-W monsoon season. The cold season is from December to February and is followed by summer from March to June. From mid of September to end of November constitute post monsoon season.

The drought are in general of mild or normal type, however severe types of drought are recorded at Udaipur, Gogunda, Kherwara, Jharol, Kotra and Vallabhnagar. Very severe type of drought has been recorded in the year 1987 at Kotra.

3.5 CATCHMENT AREA OF BERECH (AYAD) RIVER

The total catchment area of Berech (Ayad) River from its origin i.e. upstream of Bada & Chhota Madar Reservoirs upto its confluence in Udaisagar Reservoir on Berach river is of the order of 563.2 sqkm.

The catchment of Berech (Ayad) River is intercepted by a number of tanks / lakes constructed for domestic and industrial water supply to the city of Udaipur. The major ones are mentioned below:

i) Bada Madar Reservoir
ii) Chhota Madar Reservoir
iii) Badi Madar Reservior
iv) FatehSagar Lake & its system
v) Pichola Lake & its system
vi) Lakhawali Reservior

Fatehsagar Lake System comprises of the following:

- Fatehsagar Lake itself
- Badi Lake
- Bada Madar Reservoir
- Chhota Madar Reservoir

Badi Lake is situated upstream of Fatehsagar and its overflow enters Fatehsagar Lake. It is located in Girwa Tehsil of Udaipur District, 14 Km away from Udaipur City. The catchment area of Badi Lake is 15.54 sqkm (6sq miles) with gross and live storage capacities of 104.83M cum (370.15 Mcft) and 72.37M cum (255.55Mcft) respectively.

The overflow of **Bada Madar** and **Chhota Madar** Reservoirs joins Berech (Ayad) river near Thur village, where a Thur pick-up weir has been constructed to divert the overflow water of these reservoirs in Fatehsagar Lake through the Chikalwas Feeder channel. The catchment area of Berech (Ayad) river intercepted by Bada Madar Reservoir is to the extent of 80.29 sqkm (31 sqmiles) and that of Chhota Madar Reservoir to the extent of 20.72sqkm (8 sqmiles). The gross and live storage capacities of Bada Madar are 23.79Mcum (84 Mcft) and 22.01 Mcum (78Mcft) respectively. Similarly, the gross and live storage capacities of Chhota Madar are 8.5 Mcum (30Mcft) and 7.65Mcum (27Mcft) respectively. Both Bada Madar and Chhota Madar Reservoirs are located in Girwa Tehsil of Udaipur District, 16 km Udaipur on Udaipur – Gogunda Road.

Fatehsagar Lake intercepts the catchment area of Berech (Ayad) river to the extent of 20.72 sqkm (8 sq miles) over & above that of Badi Lake which is located in the catchment area of Fatehsagar Lake. The gross and live storage capacities of Fatehsagar are 120.92 Mcum (427 Mcft) and 69.95 Mcum (247 Mcft) respectively. This lake is being used predominantly for drinking water supply to Udaipur city.

Pichola Lake System comprises of the following:

- Pichola lake, itself which is called the mother lake
- Rang Sagar Reservoir
- Swaroop Sagar reservoir
- Kumaria Talab
- Dudh Talai Reservoir
- Nandeshwar Reservoir

Nandeshwar Reservoir located in Girwa Tehsil of Udaipur District, intercepts the catchment area of Pichola Lake being on its upstream side. This dam was constructed as flood control scheme for Udaipur city and its overflow joins Pichola lake. The catchment area of Nandeshwar reservoir is 51.8 sqkm (20 sqmiles). The gross and live storage capacities are 39.65 Mcum (140 Mcft) and 35.25 Mcum (125 Mcft) respectively.

Rang Sagar and Swaroop Sagar are parts of Pichola lake complex which are interconnected with each other as well as with Pichola lake. Pichola lake is also linked with Fatehsagar lake through Rang Sagar / Swaroop Sagar and a feeder channel. Thus both Pichola and Fatehsagar lakes are interconnected reservoirs which help in diverting the surplus water during monsoon period from one lake to another.

Dudh Talai reservoir is also a part of Pichola Lake.

Goverdhan Sagar Reservoir overflow joins Berech (Ayad) River on the downstream of Sewa-Ashram Bridge in Udaipur city via Futa Talab. It is located in Girwa Tehsil of Udaipur District, 10km from Udaipur city. Goverdhan Sagar is also linked to Pichola Lake through a Pichola – Goverdhan Vilas link channel. The catchment area of Goverdhan Sagar Reservoir is 10sqkm (3.9sqmiles). The gross and live storage capacities of Goverdhan Sagar is 0.25Mcum (8.8Mcft).

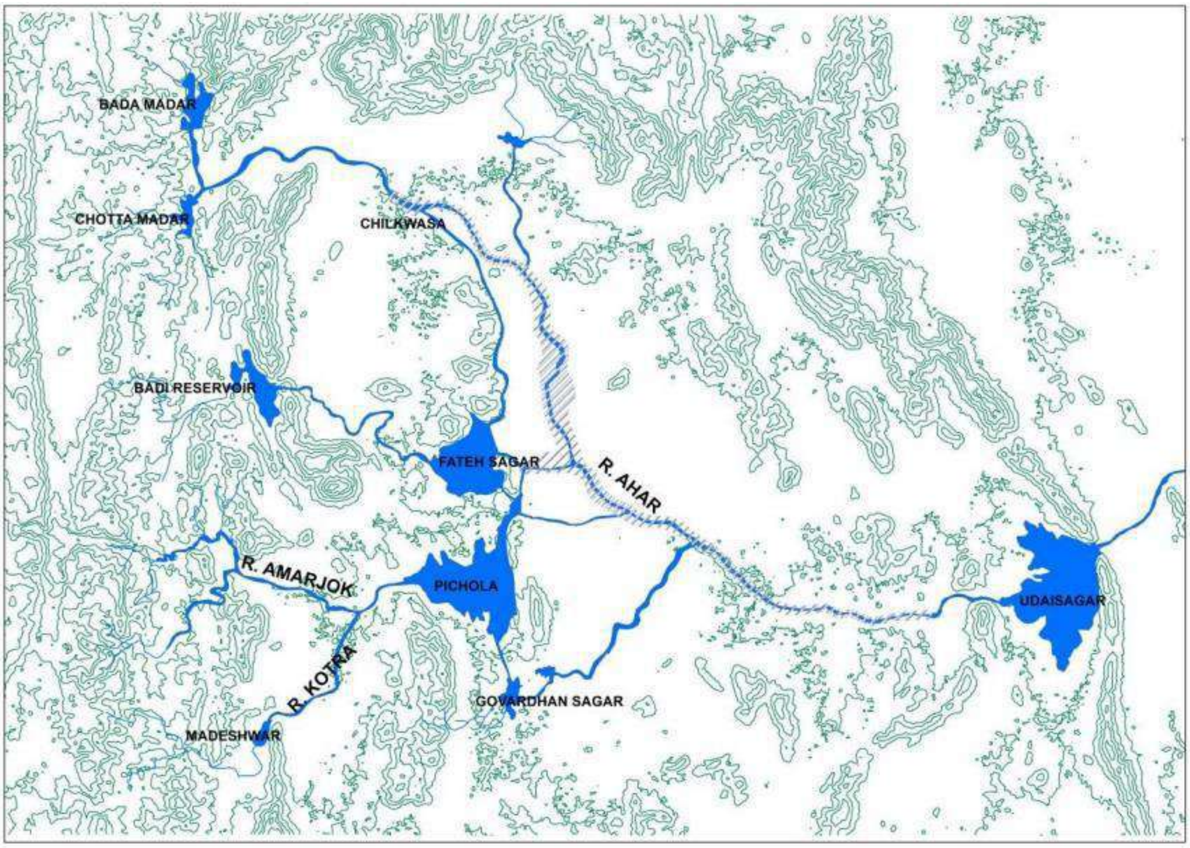
Pichola Lake, located in the heart of Udaipur city, is a bigger lake as compared to FatehSagar lake having a catchment area of 142.45 sqkm (55 sqmiles) with gross and live storage capacities of 136.79 Mcum (483 Mcft) and 89.68Mcum (318 Mcft) respectively. The combined surplus flow of Fatehsagar and Pichola lakes joins Berech (Ayad) River through Gumania wala Nallah. There is additional surplusing arrangement of Pichola Lake as well through Swaroopsagar reservoir which also meets Berech (Ayad) River.

Lakhawali Reservoir located north of Berech (Ayad) river is another reservoir whose surplus flow meets Berech (Ayad) River directly. It is located in Girwa Tehsil of Udaipur District, 10 km from Udaipur on Udaipur – Gogunda road. The catchment area of Lakhawali Reservoir is 15.54 sqkm (6 sqmiles). The gross and live storage capacities of this tank are of the order of 20.67 Mcum (73 Mcft) and 13.88 Mcum (49 Mcft) respectively.

Thus it may be stated that Berech (Ayad) river which is a tributary of Berach river which in turn meets Banas Sub – basin receives water from a network of various lakes namely, Fateh Sagar and Pichola lake systems as well as directly from Lakhawali reservoir and Goverdhan Sagar reservoir. The river ultimately meets Udaisagar Reservoir being a terminal reservoir and receiving all the inflow from Berech (Ayad) River.

Udaisagar is a medium irrigation scheme located near village Biohari in Girwa tehsil of Udaipur District, 3 km from Hindustan Zinc Colony at Debari. The gross and net catchment area of this reservoir is 479 sqkm (185 sqmiles) and 196.84 sqkm (76 sqmiles) respectively. Its gross and live storage capacities are 311.52 Mcum (1100 Mcft) and 276.12 Mcum (975 Mcft) respectively. It is the largest reservoir in Udaipur in terms of its catchment area and capacity.

From the above, it would be noted that the catchment area of Berech (Ayad) River which is 563.2 sqkm is intercepted to the extent of 357.06 sqkm i.e. 63% by various lakes/ reservoirs/ Talabs.



3.6 SOILS

Most of the soil of Udaipur district has developed in situ. It varies from clay loam to heavy clay. The distribution of the soils in the district is as follows:

Sl. No.	Type of soil	Total area in hectares	Tehsils
1	Clay loam	74477	Mavli, Girwa and Vallabhnagar
2	Red clay	147219	Salumbar, Kotra, Sarara, Kherwara and Dhariyawad
3	Heavy clay	322346	Gogunda, Jharol and Girwa

It would be noted from above that the soils of the area are medium to heavy textured having brown to grayish brown colour. The fertility of these soils is medium and soils have good retention capacity. In the foot hills, the soils are shallow to moderately deep. In the valley, the soils are deep to very deep.

Based on soil characteristics, rainfall and percentage gross area irrigated, Rajasthan has been divided into 10 agro-climate zones. Udaipur District except Dhariyawad, Salumber and Sarara Tehsils fall under zone IV A-‘Sub-humid Southern Plain & Aravali hills’. The remaining three Tehsils fall under zone IV B-‘Humid Southern Zone’.

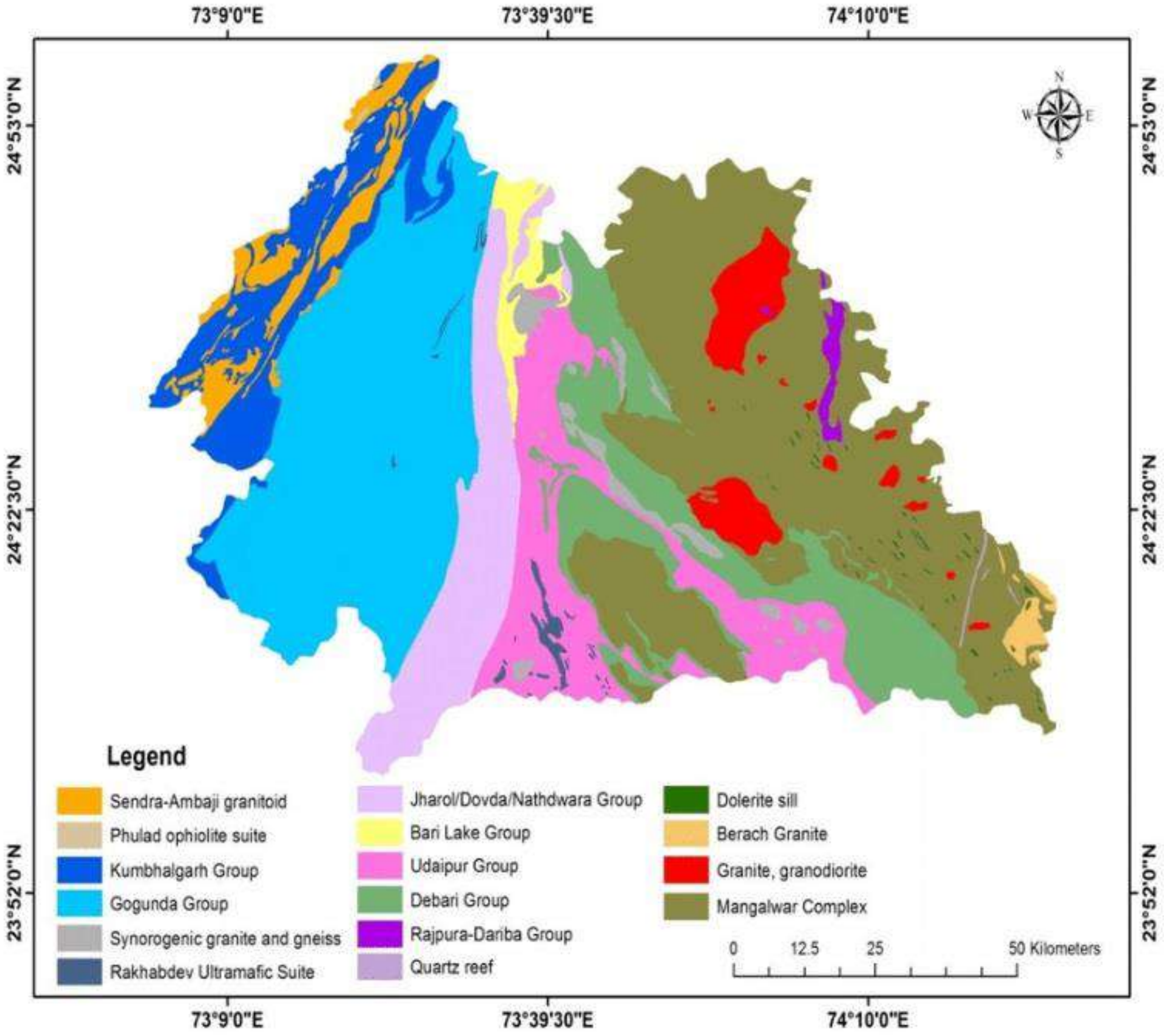
3.7 GEOLOGY & PHYSIOGRAPHY

Aravali Super Group covers the major part of the district. The general stratigraphic sequence of the rock in the district is classified as under:

Post Delhi		**Erinpura Granite**
Post Super Group	Ajabgarh Group	Schist, Gneiss, Marble, Amphibolites
	Alwar Group	Quartzite
Aravali Super Group	Phyllites, Schist, Quartzite, Dolomite, Conglomerate Marble, Metavolconics	
Pre Aravali	Schist, Gneiss and Migmatites	

In Udaipur district, Aravali hills enter from Sirohi district in the southwest and extend in northeast direction. Towards southeast the hills loose their height and the topography becomes rolling and undulating. This region is extensively cultivated. The region has shallow valleys, low hills with pastures. The hilly portion is to +-1000 meters above MSL, lying between Kumbhalgarh and Gogunda is called ‘Boharat’ plateau. The longest hill of Udaipur district is of 25 Km long which has the highest peak of +-1328 meters above MSL called ‘Jarga’. From southwest to northeast there are numerous ridges. In the northeast, these ridges form a broad pene-plain with an elevation of +-450 to +-600 meters. The central and eastern portions of this plain is drained by the river Banas and its tributaries. Along these rivers is situated the main agricultural area because of its thick alluvium deposits. The southeastern portion of Udaipur division is considerably rugged and dissected by numerous nallahs and rivulets interspersed amongst undulating flat-topped hills. This region is known as ‘Chappan’. The high hills and almost parallel ranges of west and northwest of Udaipur district are mainly of Aravali. The southwest and southern portions are of Vindhyas and the admixture of Vindhyas and Aravali. ‘Macchala Magra’ hill in Udaipur city is a classical example of the admixture of Aravali and Vindhyas. The southeastern track of Udaipur district is comprised of Vindhyas, Deccan trap and their admixture.

Udaipur district is particularly rich in mineral resources, as a large variety of important metallic and non-metallic minerals found in the districts viz. ores of copper, lead, zinc, silver, rock phosphate, asbestos, calcite, lime stone, barites, emerald and marble etc are important. Geological map of Udaipur is as below-



Geological map of the Udaipur District

3.8 HYDRO-GEOLOGICAL ASPECTS OF UDAIPUR

The occurrence of ground water in the district is mainly controlled by the topographic and structural features present in the geological formations. Groundwater occurs mainly under unconfined condition to semi-confined in saturated zone of rock formation. Its occurrence is controlled by topography, physiography and structural features of the geological formations. The movement of the groundwater in hard rock areas is governed by size, openness, interconnection and continuity of structural weak planes while in unconsolidated rocks groundwater movement takes places through pore space between grains. Water bearing properties of different aquifers are described below:

Groundwater in Bhilwara Super Group: The eastern part of the district is underlain by rock belonging to Bhilwara super group. These aquifers occur predominantly in Bhinder (Vallabnagar), Salumbar, Sarada, Mavli Blocks. Few intrusive are also found which have low permeability. Groundwater in these rocks occurs under water table conditions in the zone of weathering and fracturing, joints and foliation planes. When schist's are inter mixed with gneisses it forms a better aquifer. The rate of recuperation is slow in gneisses and schist, it is comparatively faster in granites. The depth of dug wells ranges from 15 to 35metres and the Yield varies from 20m^3/day to 60 m^3/day. The depth to water level in the area tapping this aquifer ranges from 3m to 35m.

Groundwater in Aravalli : Aravalli Supergroup consisting of Phyllites, Quartzites and dolomite form important aquifer especially around Jharol, Udaipur and Barapal. Ground water occurs in weathered zones like schistosity, joint, fissures and bedding planes. Quartzites generally occur intercalated with phyllites and are well jointed. Ground water in phylites occurs mainly in fractured cleavages. Carbonate formation are cavernous, wherever calcium content is high, area around Jhamarkotra of Girwa block is potential and supplies water to Udaipur city. The depth to water level varies from 5 to 20 m below ground level where as depth of wells varies from 8 to 30 m below ground level. The average yield of wells is around 40 m^3/day. In carbonate formation, the yield of wells varies from 20 to 200m^3/ day.

Groundwater in Delhi Super Group: The formations belonging to Delhi super group are exposed in the western part of the district. Ground water in Quartzite's occurs in the joints and fracture. Depth to water level is generally shallow. The yield of wells averages 50m^3/day. Ground water in biotite schist and hornblende schist occurs in joints and fractures. The depth to water level ranges from 5 to 20 m below ground level and yield of wells varies from 12 to 250 m^3/day. In calc schist and calc gneiss the yield of dug wells varies from 10 to 100 m^3/day. The yield is high when the lenticular cavities along calc bands are saturated and interconnected.

Groundwater in Alluvium: In the past Ground water occur under unconfined conditions in the unconsolidated formations consisting of sand, gravel, pebbles, cobles and boulders in areas close to river courses near Kanpur area. This aquifer has already dried out due to over exploitation.

CHAPTER – 4
DATA COLLECTION AND REVIEW

4.1 DATA COLLECTION, REPORTS & DOCUMENTS

4.1 Data / Reports

The Data / Reports collected from various Departments related to the assignment are given below:

i) Udaipur City Master Plan (1997-2022)

ii) Salient features of various Lakes/ Tanks in Udaipur city

iii) PHED Note regarding Water Supply to Udaipur city

iv) Integrated Sewerage DPR of Udaipur by UMC regarding sewerage system

v) WAPCOS - Detailed Project Report on Berech (Ayad) River Front Development Project

4.2 CITY DEVELOPMENT MASTER PLAN (2022)

Master Plan has been prepared by the Udaipur Town Planning Department considering future scenario for the year 2022. The base year considered in the Master Plan was year 1997. An Advisory Committee headed by Minister for Urban Development and Housing Department was also constituted by Government of Rajasthan vide Government Notification dated 30.08.1989 to advise the Chief Town Planner, Rajasthan in the preparation of Master Plan for urban area of Udaipur City.
The relevant highlights of various aspects of Udaipur City Master Plan (1997-2022) are as under:

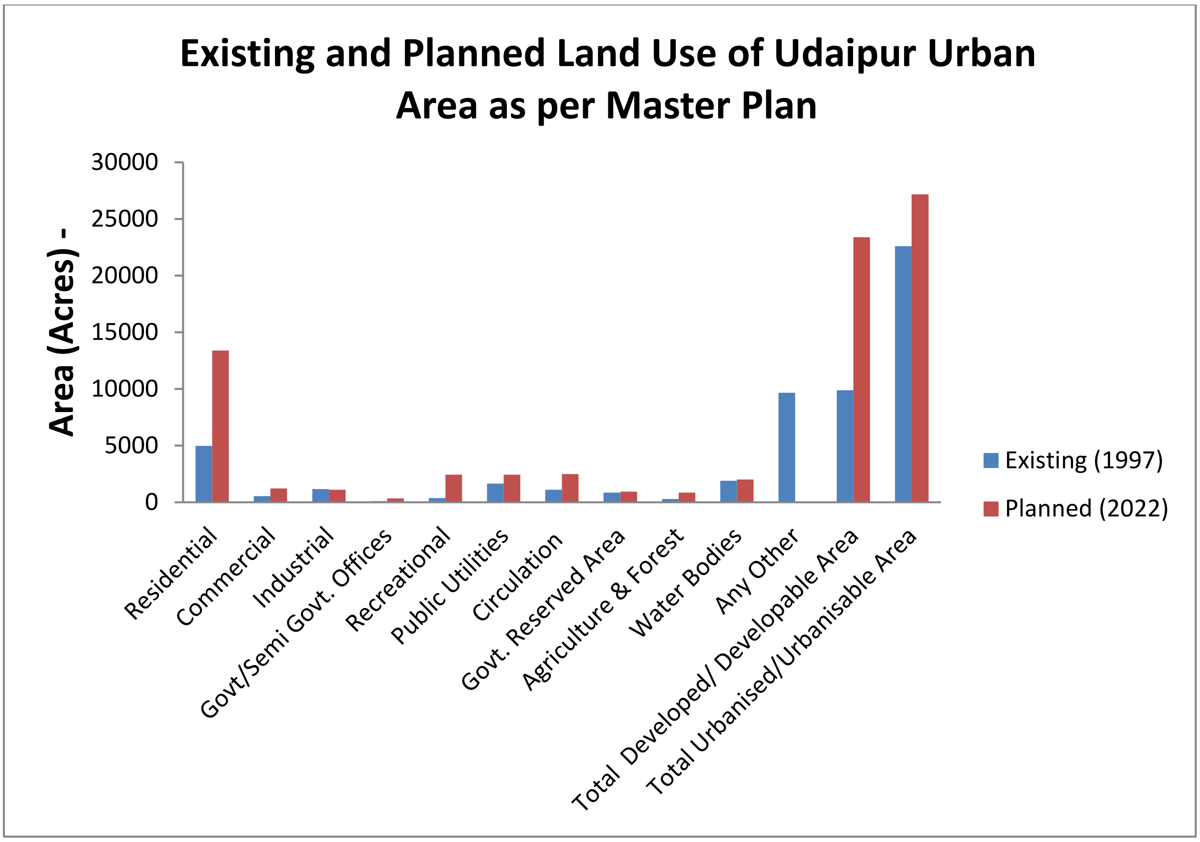
(i)	**Population**	:	As per 1991 Census, Udaipur City population was 3.89 Lakh which was projected as 5.99 Lakh in 2011 and 8.3 Lakh in 2022. The increase between 2001 to 2011 was envisaged as 21,000 per year and that between 2011 to 2022 again as 21,000 per year.
(ii)	**Land Use**	:	In 1997, the urban area of Udaipur was 22601 acre in which 9879 acre was developed area i.e. 43.71%. Against this, it was envisaged that urban area in 2022 will increase to 27180 acre in which 23,380 acre will be the developed

			area i.e. 86.03%. The following table shows the break-up of land use of different categories for base year 1997 and that projected for the year 2022:

Table - 4.1: Existing and Planned Land Use of Udaipur Urban Area as per Master Plan

(In Acres)

Sl. No.	**Land Use**	**Existing (1997)**			**Planned (2022)**		
		Urban Area	**% of**		**Urban Area**	**% of**	
			Developed Area	**Urbanised Area**		**Developable Area**	**Urbanisable Area**
1.	Residential	4988	50.50	22.07	13380	57.23	49.23
2.	Commercial	548	5.55	2.43	1220	5.22	4.49
3.	Industrial	1152	11.66	5.10	1110	4.75	4.08
4.	Govt/Semi Govt. Offices	96	0.97	0.42	340	1.45	1.25
5.	Recreational	358	3.62	1.58	2430	10.39	8.95
6.	Public Utilities	1632	16.52	7.22	2420	10.35	8.90
7.	Circulation (Roads, Rail etc)	1105	11.18	4.89	2480	10.61	9.12
Total of Developed/ Developable Area:		**9879**	**100**	**43.71**	**23380**	**100**	**86.02**
8.	Govt. Reserved Area	865	-	3.83	950	-	3.50
9.	Agriculture & Forest	285	-	1.26	850	-	3.12
10.	Water Bodies	1900	-	8.41	2000	-	7.36
11.	Any Other	9672	-	42.79	-	-	-
Total Urbanised/ Urbanisable Area		**22601**	**-**	**100**	**27180**	**-**	**100**



iii)	**Water Supply**	**:**	The sources of water supply in the city are Pichola, Fatehsagar, Badi and Jaisamand lakes besides wells, tubewells, Baories and hand pumps. The present demand is reported as 140 lpcd. The water supply demand envisaged in Master Plan by year 2022 was of the order of 170 lpcd.
iv)	**Sewerage & Drainage**	**:**	There is no planned Sewerage and Drainage System existing in the city. In old city area, the dry latrines have though been converted into Flush-latrines but the waste is finding its way into open drains which are all discharging in Berech (Ayad) River. New Colonies however have septic tanks along with flush latrines. Areas like Chandpol, Brahmpol, Jara Ganesh Ji, Jagdish Chowk etc have slope towards Pichola, Rang Sagar & Swaroop Sagar lakes. The waste water from these areas flowing into open drains finds its way in above lakes ultimately. Similarly, the waste water of OTC scheme, Alkapuri, Ambhawgarh, Ambhamata Scheme, Malatalai, Haridas Magri etc let into open drains is also meeting Pichola and Fatehsagar lakes. There is thus urgent need to formulate properly planned schemes for the disposal as well treatment of city waste water. The Master Plan however did not show any road

			map for the development of sewerage system in the city. However, two projects for Conservation and Sustainable Management of Pichola and Fatehsagar Lakes are under implementation with funding from GOI, Ministry of Environment and Forests under National Lake Conservation Plan (NLCP), which has components of sewerage system to be developed around these lakes.

4.3 CONSERVATION AND SUSTAINABLE MANAGEMENT OF PICHOLA LAKE, UDAIPUR (DPR, MAY 2007)

The water spread area of Pichola Lake is 696 ha and its maximum depth is 10.5m towards the west side where Kotra River meets the lake. The Catchment Area is 142.45 sqkm. Initially this lake was being used both for irrigation and water supply, but now it is reserved for supplying drinking water only to the city to the extent of 19.5MLD.

The lake is facing acute environment problems related to silting, degradation of water quality, reduction in water quantity, weed infestation, sewage, storm water and solid waste outfalling, lack of infrastructure for tourists etc.

Tetra Tech India Ltd, Delhi was assigned the job of preparation of DPR for "Conservation and Sustainable Management of Pichola Lake System, Udaipur" as per guidelines of National Lake Conservation Plan (NLCP) for seeking financial assistance from the Ministry of Environment and Forests (MOEF), Govt. of India. PDCOR Limited, Jaipur is the Coordinating Agency for the lake conservation and development projects. The DPR had been submitted by Tetra Tech in May, 2007. The project is being funded by MOEF, GOI under NLCP. The cost of the project is Rs.115 crore comprising 70% share of Govt. of India and 30% share of Govt. of Rajasthan. The implementation period is 3 years from the date of sanction of the project.

The report has identified various problems affecting the environment & eco-system of the lake and have outlined the remedial measures for each one of them. These are:

- Desilting and dredging to restore the lake capacity
- De-weeding of lake for exposing the water surface to atmosphere for exchange of oxygen
- Biodiversity conservation zone to be part of the main lake

- Anaerobic conditions of lake to be changed to aerobic state by installing & ozoniser-cum-floating fountains.

- Medium and small islands to be protected by various conservation measures removal of encroachment and rehabilitation thereof with development of vacated area is necessary to maintain perimeter of the lake and to control pollution

- Shore line protection with strengthening of fence and boundary walls maintaining aquaculture for ecological balance by introducing fish seed of suitable variety

- Lake water quality not to be compromised at the cost of recreation and enjoyment while using motorized boats

- Idol immersion activity to be shifted to other alternate places which may be dealt sensibly after taking people in confidence

- Shifting of Dhobi Ghats at new site

- Sewage inflow taking place to the extent of 25.92 MLD in Pichola Lake, 8.05 MLD in Rang Sagar Lake, 2.42 MLD in Swaroop Sagar Lake besides contribution from non-point sources of pollution need to be intercepted, diverted and disposed in the sewer system. NLCP project includes the cost of this component to the extent of Rs. 25 cr for Pichola lake system.

- Storm water inflow to lake may be allowed after segregation of floating matter, debris and solid waste by constructing catch drains, silt arrestors, grit chambers, screen chambers, setting tanks, biological filters and sand beds for water filtration.

- Collection and disposal of solid waste by municipal council need to be strengthened in terms of equipment and infrastructure.

- Clearances/improvement of feeders/ inlets to the lake for better recharging of Pichola lake need to be done

- Removal of encroachments on the feeders

- Green belt in the fringe area needs to the developed

- Face lifting & Aesthetic improvement needs to be done by providing parking places, cafeteria, signage, greenery at available space, resting place, walker's path etc.
- Improvement of roads and pavements
- Control over the invading of cattle and stray animals
- Clearance of water ways and provision of culverts
- Providing wall and railing
- Control over mining and restoration of mined out area
- Construction of Gabion structures, dykes on irrigation schemes
- Afforestation and plantation to create vegetal cover.

The project implemented up to year 2015.

For rehabilitation of old sewerage network in the walled city area, project has been taken up under AMRUT and SMART CITY Mission, 7 Lifting stations has been commissioned under AMRUT and rehabilitation of sewerage network is progress under Smart City Mission.

4.4 CONSERVATION AND SUSTAINABLE MANAGEMENT OF FATEHSAGAR LAKE, UDAIPUR (DPR, MAY 2007)

Fatehsagar is another important and major lake forming part of the network of lakes in Udaipur City. The catchment area of the lakes is 20.72 sqkm. It is 2.4 km long, 1.6 km wide and 11.5m at its deepest point. Its water spread area is about 1 sqkm (100 ha) when full. Apart from its own catchment, it receives water from Pichola lake (being interconnected), Chhota and Bada Madar through Chikalwas feeder offtaking from Thur pick-up weir. The combined overflow of Fatehsagar and Pichola joins river Berech (Ayad) through Gumaniawala Nallah passing through the city area. The lake was initially dug in year 1678 and then reconstructed in 1889. This is one of the major sources for drinking water supply to the city.

The lake is also suffering from various problems, similar to the one faced by Pichola Lake, which have made the water body highly polluted. The increasing human activity in the catchment area is leading to denudation, deforestation, mining and encroachment. The loss of vegetal cover and exposed land is causing soil erosion which is making the lake silted and reducing its live storage capacity.

Like Pichola, the Conservation and Sustainable Management of Fatehsagar Lake project is also being implemented under the National Lake Conservation Plan (NLCP) of the Ministry of Environment and Forests (MOEF), Govt. of India.

The DPR of the project was prepared by Tetra Tech limited of New Delhi and submitted its report in May 2007, with PDCOR, Jaipur being the coordinating Agency for preparation of DPRs of all the five priority lakes in Rajasthan for funding under NLCP. The total cost of the project is Rs 48.88 crore comprising of 70% share of Govt. of India i.e Rs.34.22 crore and 30% share of Rajasthan Govt. i.e. Rs 14.66 crore.

The DPR envisages all those remedial measures as suggested for Pichola Lake mentioned above. There is a provision in the project cost for interception and diversion of sewage in and around lake to the extent of Rs. 10 crore and storm water collection and screening before entry into lake to the extent of Rs. 5.0 crore.

There are seven different agencies which are responsible for implementation of the project in 3 years time after the sanction of the project, project implemented.

4.5 CITY WATER SUPPLY

Udaipur is famous for lakes. The lakes are interconnected for purpose of replenishment of water levels in lakes and are used for recreational purpose and also for drinking water. The seepage and percolation of water improves ground water table and charge aquifer also.

There are two valuable lakes in Udaipur City. One is Pichola and another is Fatehsagar. Besides, Jaisamand being very important lake, situated 60 km from Udaipur city keeps key and plays an important role in Udaipur Water Supply System. Pichola lake has its own catchment and is fed by non-perennial river Sisarama. Dewas I dam is situated at upstream in the Arawali range and is connected to Kotra River in 1978, which connects to Pichola lake. The Fatehsagar has small catchment of its own. It is interconnected to Pichola Lake through Rang Sagar, Swaroop Sagar and link canal. It is fed by Badi Lake and Chhota and Bada Madar. Further the overflow from Bada and Chota Madar joins to Berech (Ayad) River and from Chikalwas Feeder Canal branches out and merges with Fateh Sagar. The overflow of Pichola and Fatehsagar lakes enter into Berech (Ayad) River through Gumania wala Nallah passing through the city. Udaisagar storage dam is on the downstream of the city on Berech (Ayad) River.

4.5.1 Udaipur Water Supply from Lakes

For Udaipur city, initially the water supply schemes were commissioned from Pichola Lake as a source in 1968. The water supply scheme with Fatehsagar Lake as a source was subsequently commissioned in the year 1970. Accordingly, the water supply scheme with Pichola lake was again augmented in the year 1976. During the year 1987, Badi lake was considered for augmentation of water supply scheme for Udaipur city. Pichola and Fatehsagar lakes were only reserved for distribution as water supply for Udaipur since 1985.

During the year 1988, when there was drought, an emergency scheme for water supply was framed, viewing existing Jaisamand Dam as Source. This scheme was commissioned in the year 1995. This schemes is designed for 21 MLD (Million Litre per Day) supply. The water supply scheme from Pichola and Fatehsagar lakes were further augmented in the year 1996.

4.5.2 Other Sources

Another scheme was taken into consideration as a result from dewatering of Jhamerkotra mines in the year 1996. Thus the ground water of tubewells of Jhamarkotra mines played considerable role in water supply in Udaipur city. Water of 8 tubewells of Kharbadiya mines were pumped to Purohito ki Madri. Besides this, department itself has 53 tubewells and 29 openwells/ Baories/ step wells which supplement water to the supply system. Total ground water production is estimated to be about 14 MLD approx.

About 108 Punghats are installed in various localities of Udaipur city. There are 2100 handpumps located at various parts of city. The water from handpumps and Punghats are used for other domestic purpose and free of cost to public.

4.5.3 Mansi Wakal (I) / (Dewas Stage I)

Mansi Wakal (I) Dam has been constructed across Mansi River, which is a tributary of Wakal River which inturn is a tributary of Sabarmati River Basin. This is an interbasin water transfer project from Wakal Sub-basin of Sabarmati Basin to Berach Sub-basin of Banas Basin. This project has been functional since 2000. The gross storage capacity of Mansi Wakal dam is 24.41 Mcum (862 mcft) with 50% dependability. The water supply of 23.25 MLD was commissioned in the year 2007-08 from this dam connecting with Pichola Lake through Dewas (I) Dam and a tunnel of 2.3 km length.

4.5.4 Project under Implementation

The state government has sanctioned Dewas Stage II project in the year 2005. It consists of construction of Akodara Dam on river Mansi River having net storage capacity of 8.52 Mcum (301 mcft), construction of Madri Dam also on Mansi River having net storage capacity of 2.42 Mcum (85.44 mcft), tunnel from Madri Dam 1.33 km and tunnel from Akodara dam 11.05 km. The net storage of both the dams with 90% dependability is 10.84 Mcum which will assure availability of water throughout the year. This is also an interbasin water transfer project from Sabarmati Basin to Banas Basin, which will be linked to Pichola Lake to provide estimated water supply of 17.5 MLD.

4.6 CITY SEWERAGE SYSTEM

Existing Sewerage System (coverage 20.3%)

Udaipur city is not fully covered by an integrated underground sewerage system. What ever the old system, is in the worn out condition due to completion of its design life insufficient design capacity. Only the area covered by UIT has workable the sewer system which is new. At present, the city has a skeleton existing sewerage system, which covers the high density populated areas of the walled city. Very sparse old sewerage system in the catchment areas of the lakes in Ambamata, Brahmapuri, Lalghat, Navghat, and Chandpole area. The sewage from these sewers used to flow by reaping up to Jhatwadi by a pump-house located at Chandpole (ridgeline) from where it was gravitating to Hathipole through 400 mm diameter gravity sewers.

Besides this, UIT Udiapur took the execution of sewerage project to protect lake Pichola from pollution. Sewage generated from the area Mallatalai, Haridasji Ki Magri, Ambamata Scheme, Raja Colony, Yadav Kachi Basti, Bagore Ki Haveli, Purohit Ji Ki Haveli, Brampole, Gangor Ghat, Lalghat, Gadia Deora etc. gravitate to Hathipole through 800mm dia sewer line from where it is carried by existing sewer line already functional from Hathipole to Manwa Kheda. There is one pumping station near Hanuman Temple in Ambamataa area because of some low lying areas such as Yadav Kachi Basti, Ambavgarh, part of Ambamata scheme etc. Part of this sewer line has been laid in the bed of Lake Pichola. The ductile Iron (800mm) pipe line has been laid in the lake bed.

Sewerage System constructed by PHED

Initially PHED introduced the sewerage system in the city and they constructed sewerage network for 84.2 Ha area in the walled city. The total length of the network is 24 km. The Operation and Maintenance (O&M) of the sewerage system is being looked after by the Udaipur Municipal Council (UMC). The colonies or areas served by the PHED scheme are listed below:

“Chand Pol Area ,Shivaji Nagar, Ganesh Ghati, Shakti nagar, Bhupal Wadi, Ashok Nagar, Delhi Gate, Subhash Nagar, Hathi Pol,Hiran Magri Sector-3 ”

The trunk sewer of the above sewerage system starts at Suraj Pol and drains into River Ahar at Manwakheda. The size of pipes in the sewerage system ranges from 150 mm to 300 mm and the size of the trunk main ranges from 400 mm to 800 mm.This system is in highly degraded condition.

PHED (Year 1976-78)

- 21.5 km Sewer line in Walled city and adjoining area
- House sewer connections: 5000 nos

Sewerage System Constructed by UIT

The Udaipur Improvement Trust (UIT) built sewerage system for the following areas around the lakes in the year 2005, to avoid untreated sewage being discharged in to the lakes. The sewerage network built under this scheme is primarily along the internal roads in older parts of the City. Main areas covered by the above scheme are as follows. Hari Das Ji Ki Magri Ambamata Malla Tallai Brahm Pol Area Amber Mata Brahm Pol Magri Amber Garh Left side area of Rang Sagar lake Guni Dayal Marg Naga Magri.

UIT constructed the sewerage system in two phases. In first phase, it covered an area of 144 Ha around the lakes, which includes the colonies like Ambamataa, Chandpole, city palace area, fateh palace area etc. In the second phase UIT covered an area of 212 Ha which includes the colonies like malla thalai, ekalavya colony, Raza colony, Amar Nagar, Kaimi Ekta Nagar, Pragati Nagar etc. There are total 17 Sewage Pumping and Lifting Stations and the length of the pumping mains is 6.9 km. The existing trunk line from Hathipole to Manwa Khera is not sufficient to bear the heavy load of sewage from these areas. Hence UIT, laid a parallel trunk line of 8 km length from Hathipole to Manwa khera treatment plant site. In Manwa Khera , there is a sewage treatment plant of 20 MLD capacity.

1. **UIT (year 2002-04)**
   - 24 km sewer line
   - House sewer connections: 6000 nos.
   - Area covered: Lake periphery area of Pichola Lake, Chandpole area, Shivaji Nagar, Ganesh Ghati, Shakti Nagar, Bhupal Wadi, Ashok Nagar, Delhi Gate, Subhash Nagar, Hathi Pol, Hiran Magri Sector-3
   - UIT with assistance of funds from Hindustan Zinc Ltd (Year 2013-16)
     - 7.78 km trunk line of dia 800 mm to 1400 mm.
     - Sewage Treatment Plant: 20 MLD at Eklingpura based on MBBR technology.
     - Area covered: Ambamataa, Chandpole, city palace area, fateh palace, malla thalai, ekalavya colony, Raza colony, Amar Nagar, Kaimi Ekta Nagar, Pragati Nagar etc
2. **NLCP (year 2013-16)**
   - Sanctioned amount: Rs.52 cr.
   - Total scope: 54 km laterals; 95% work is completed

- House sewer connections: 5000 nos out of which 4400 nos has been done till date.
- Area Covered: Fatehsagar and Pichola lake periphery

DISPOSAL OF SEWAGE

The entire sewage generated in the city finds its way to Ayar River through 800mm diameter outfall sewer at Manwa Kheda village. Congested parts of the city areas have extensive network of surface water drains, to which wastewater from houses (including water closets) is directly connected. The surface water drains ultimately discharge into lakes causing lake pollution. There has been an arrangement to collect and convey sewage from community septic tanks at various locations up to nearest natural or constructed drains.

Existing Trunk Line

The existing trunk sewer starts at Mallatallai with 500mm diameter. The alignment of the trunk sewer passes through Brahmpole Marg, Swaroop Sager Lake and Hathi Pol. The diameter of the trunk sewer increases from 500mm to 700mm at Jethion-Ki-Bari and continues with the same diameter up to Brahmpole Gate where, the size of the trunk increases to 800mm and continues up to Hathi Pol. The above trunk line joins another trunk line laid in 1971 by PHED, which goes all the way up to Manwa Kheda.

PRESENT STATUS

Integrated Detailed Project Report prepared by Municipal Corporation Udaipur with detailed survey in 2016. The design based on the following sewage generation-

Sewage Generation

Year	**2011**	**2016**	**2031**	**2048**
Population	451100	489185	640354	863930
Water Supply lpcd	135	135	135	135
Water Flow MLD	60.90	66.04	86.45	116.63
Average Sewage Flow without Infiltration MLD	48.72	52.83	69.16	93.30
Infiltration @ 5% MLD	2.44	2.64	3.46	4.67
Total Sewage Flow	51.16	55.47	72.62	97.97
Peak Flow MLD	112.06	121.51	159.07	191.27
Peak Flow = (Av. Flow X Peak Factor) +(0.05 X Av. Flow)	112 MLD	122 MLD	159 MLD	191 MLD

The DPR submitted to RUDSICO, the state nodal agency. Following projects sanctioned under AMRUT and SMART city mission-

1. AMRUT Phase – I
2. AMRUT Phase – II

3. 40 MLD Decentralized STP
4. ABD area sewerage work
5. Other than above RUIDP sanctioned project “Design and Construction of intercepting Sewer on both banks of Ayad River and Lateral Sewer Network in Ward No. 34, 35 & 38 along with Allied Works”

SANCTIONED & RUNNING PROJECTS

1. **AMRUT Phase I (18% population coverage)**
    - Sanctioned amount : Rs. 85 cr
    - 84.70 km sewer line
    - House sewer connections: 15102 nos,
    - Laterals shall be integrated with existing 20 MLD STP of Hindustan Zinc Ltd.
    - Area covered: Fatehpura circle to sukhadia Circle and nearby area, Pachwati Circle to Chetak circle nearby area, area between Chetak circle to Hathipol, Chetak circle to shashtri circle and upto ayad river and Shastri circle to Surajpole.
    - Municipal Corporation is the executive agency.

2. **AMRUT Phase II (7.5% population coverage)**
    - Sanctioned amount : Rs. 75 cr
    - 77.72 km sewer line
    - House sewer connections: 5271 nos,
    - Laterals shall be integrated with existing trunk.
    - Area covered: Hiranmagri area of ward No. 26, 27, 28, 29 and 30.
    - Udaipur Smart City Limited is the executive agency

3. **Under Integrated Infrastructure of ABD area (12% population coverage)**
    - Sanctioned amount : Rs. 179 cr
    - 84 km sewer line out of which 39 km will be new line and 45 km rehabilitation work using CIPP and Pipe bursting technology
    - House sewer connections: 19303 nos,
    - Laterals shall be integrated with existing trunk.
    - Area covered: Old walled city area.
    - Udaipur Smart City Limited is the executive agency

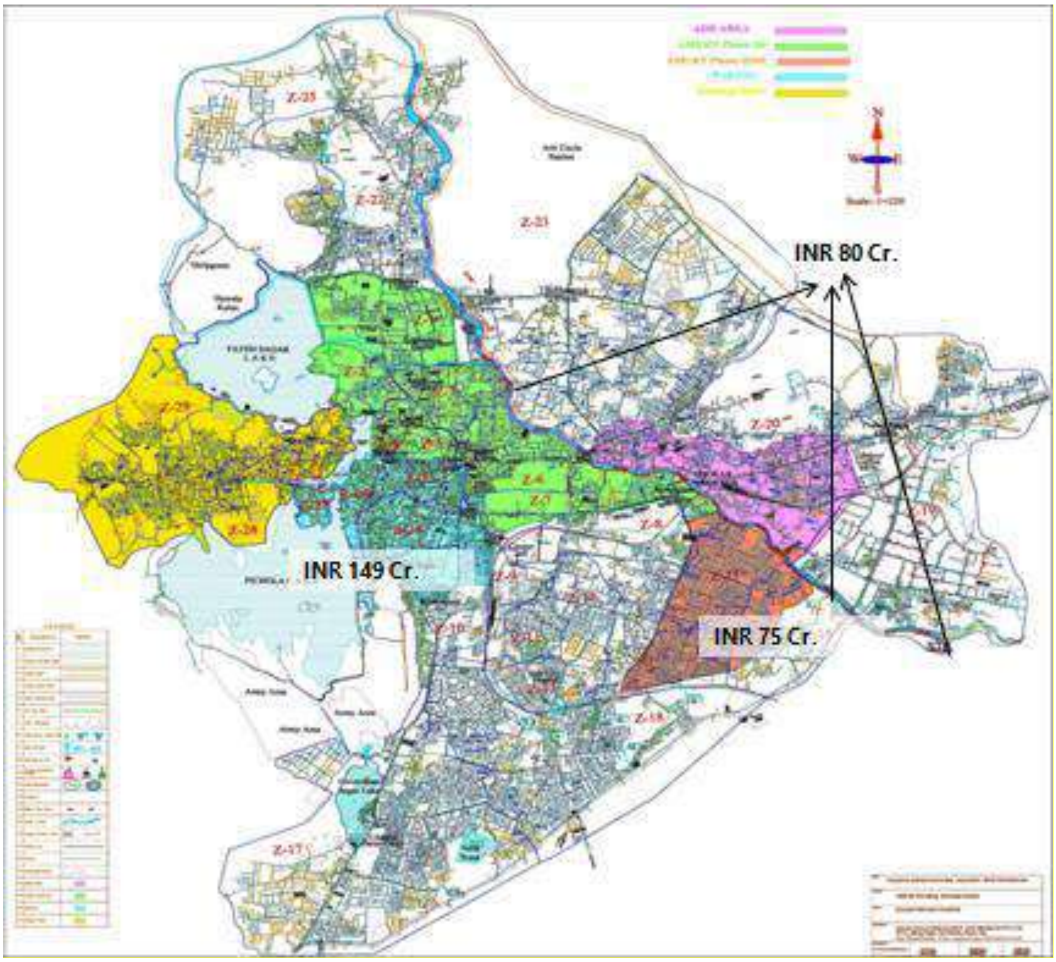
4. **Abatement of Ayad river (4.97% population coverage)**
    - Sanctioned amount : Rs. 126 cr
    - 52 km sewer line

- House sewer connections: 3600 nos,
- Laterals shall be integrated with existing trunk.
- Area covered: ward 34, 35 & 38.
- RUIDP is the executive agency

4.7 CITY DOMESTIC & INDUSTRIAL SEWAGE TREATMENT PLANTS

4.7.1 Domestic Sewage Treatment Plants (STPs)

In order to check the pollution of lakes and Berech (Ayad) River, it is necessary to dispose-off the domestic waste water into these water bodies only after treatment. At present there are two STP existing in the city for treatment of domestic waste water. The master plan (2022) prepared by Udaipur Town Planning Department has also not outlined any such planning or proposal for the future. One STP of 20 MLD capacity constructed by M/S Hindustan Zinc Company near Manvakheda outside the city. The cost of land, the plant and O&M is also being borne by the company.



Construction of three Decentralized 40 MLD STP has been taken up under Smart City Mission on HAM (a type of PPP model)

- Sanctioned amount : Rs. 80 cr
- 3 Decentralized STP -
    1. 5 MLD near Karzali house
    2. 10 MLD near FCI Godown
    3. 25 MLD at Eklingpura
- Udaipur Smart City Limited is the executive agency

4.7.2 Industrial Common Effluent Treatment Plant (CETP)

At present, there is no CETP for treatment of industrial waste water. It is proposed to provide separate CEPT to treat the industrial waste water. The requirement for CEPT may be of the order of about 20 MLD considering future scenario as well. There may be one or two CETPs totaling to 20 MLD capacity at appropriate locations near the industrial areas.

4.8 GROUND WATER STATUS AND QUALITY

4.9.1 Ground Water Status

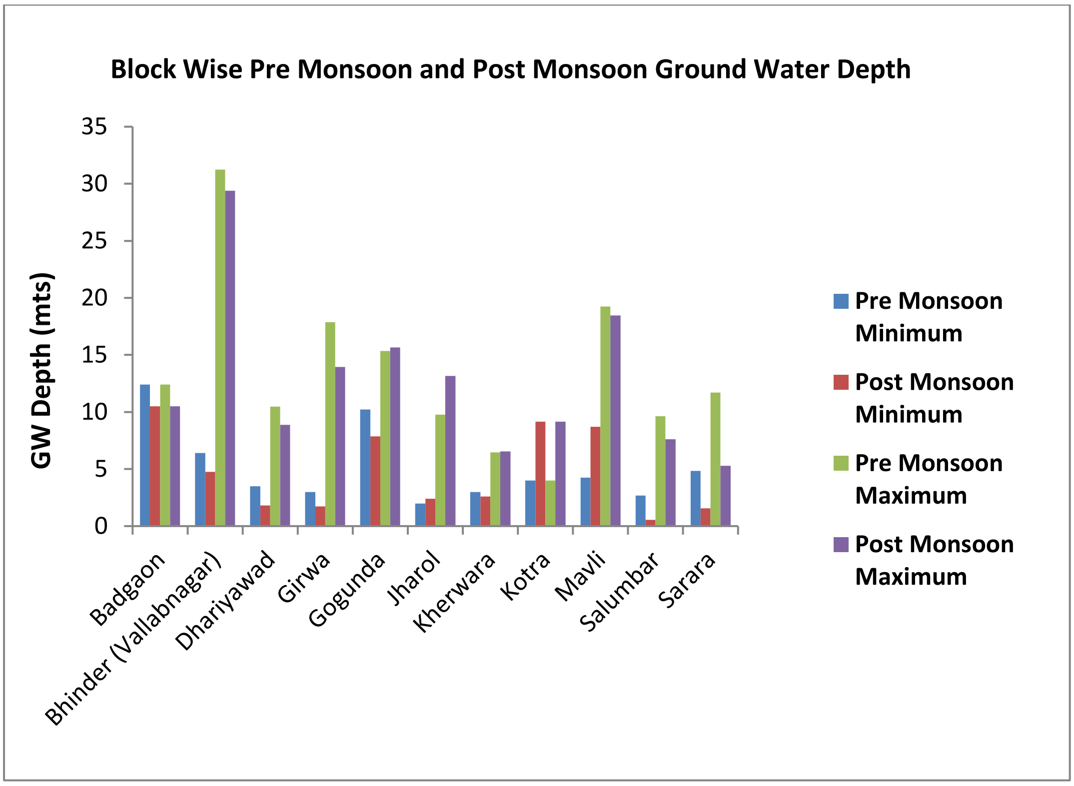
a) In Udaipur District

At district level the depth to water level (DTW) varies widely depending upon topography, drainage, bedrock geology etc. As per the report of Central Ground Water Board (CGWB), Year 2010, during Pre-monsoon DTW varies from 2 to 20m in greater part of the district. Deep water levels (>20m) are observed in parts of Bhinder (Vallabnagar) block. During post monsoon, water level ranges widely from less than 1m to more than 29m. Water level is shallower in western and southern part of the district. In general DTW varies from 2m to 15m in Jharol, Kherwara, Gogunda, Salumbar, Sarara & Girwa blocks and between 4m to 30m in Bhinder (Vallabnagar) block.

(in metre)

Block	Pre Monsoon		Post Monsoon	
	Min	Max	Min	Max
Badgaon	12.40	12.40	10.50	10.50
Bhinder (Vallabnagar)	6.42	31.23	4.75	29.40
Dhariyawad	3.48	10.46	1.80	8.86
Girwa	3.00	17.87	1.73	13.94
Gogunda	10.21	15.35	7.87	15.65
Jharol	1.98	9.76	2.40	13.15
Kherwara	3.00	6.45	2.59	6.56
Kotra	3.99	3.99	9.15	9.15

Mavli	4.24	19.23	8.70	18.45
Salumbar	2.67	9.62	0.55	7.60
Sarara	4.85	11.71	1.55	5.3



b) **In Badgaon and Girwa Blocks**

Seasonal fluctuation in ground water level based on Pre and Post-monsoon 2012 indicate that there has been rise in water level in Badgaon and Girwa Blocks except few exceptions.

The area of study for Berech (Ayad) River Front Development Project falls in Badgaon and Girwa Blocks of Udaipur District. As per status of ground water levels collected from ground water Dept. Udaipur, the water levels observed in the wells during pre & post monsoon period in these two blocks indicate that in Badgaon Block during pre-monsoon the ground water level varies from 4m to 27m and during post-monsoon it varies from 2m to 17m. Similarly, in Girwa Block, the same varies from 4m to 17m during pre-monsoon and from 3m to 9m during post-monsoon.

4.9.2 Groundwater Quality

4.9.2.1 Water Quality in Shallow Aquifer

a) **In Udaipur District**

In general, the chemical quality of ground water is very good except for small pockets. The pH values of ground water vary from 7.11 to 9.20 indicating alkaline nature of ground water. The specific conductance in greater part of the district ranges from 680 to 2000 micromhos/cm at 25^{o}C. In small belt extending in north east-south west part of the district covering part of Bhinder (Vallabnagar), Salumbar and Dhariyawad block the electrical conductivity of ground water is above 2000 micromhos/cm at 25^{o}C. The fluoride in ground water generally falls within 1.5 mg/ lit. High fluoride is found in an elongated pockets located in the northern part of the district covering parts of Mavli, Bhinder (Vallabnagar) and Girwa blocks. In this pocket fluoride distribution is between 1.5 to 3.0 mg/lit.The concentration of chloride in major part of the district is within 500 ppm. In parts of Jharol and Kotra blocks the chloride concentration is between 500 to1000 ppm.The concentrations of Nitrate ranges from 2ppm to 120 ppm. Nitrate values in major part of the district are within 90ppm. Higher values of nitrate occur at Koorabar and Kholri. The groundwater is moderately hard to very hard in major part of the district.

b) In Udaipur City

The quality of ground water has been tested for chemical as well as bacteriological and biological analyses by taking water samples from hand pumps located in various colonies / areas of Udaipur City.

Few samples have shown higher values of Iron ranging from 1.73 to 2.35 mg/l against permissible limit of 0.1 mg/l.

B.O.D. values are also found to be high in few samples i.e. 10.6 to 12.2 mg/l, which shows that the ground water is contaminated as a result of sewage flow in open drains or sewage flow in Berech (Ayad) River.

CHAPTER –5
DETAILS OF RIVER CHANNELIZATION COMPONENT

5.1 GENERAL

The aspect of river channelization mainly involves study and assessment of following parameters:

i) Study of survey output of the river and assessment of existing river profile.
ii) Review and study of water availability, especially during the lean period of the year for maintaining environmental and ecological balance of the river and options to augment the same
iii) Review of siltation aspect – a cause for hampering smooth flow of the river.

In this chapter, all these parameters have been deliberated threadbare and the outcome is discussed hereunder in the relevant paragraphs.

5.2 Water Availability during Lean Period in Ayad River

Ayad River is not perennial. In river front development project, the focus along with other issues is therefore to find out ways and means to keep the flow generated during lean period to the extent feasible.

Accordingly, various options for the same are; provision of anicuts, flow from treated waste water, water availability through regulated releases from upstream dams etc. The details are given below:

5.2.1 Impounding Reservoirs in River Section through Anicuts

5.2.1.1 Need

The objective of providing impounding reservoirs within the river section is to charge the river with surface water and surrounding areas with ground water. These will be provided at intermittent points along the river depending upon the suitability of river bed strata. Clayey bed or rocky bed could be most suitable. As the river bed is fairly silted up with silt material containing both sand and fine clay, it will serve as a positive feature to provide such impounding reservoirs. The bed of Berech (Ayad) river is also found to be having rock outcrops at numerous places.

The structure for impounding reservoir would be Anicuts (with removable gates) made of Reinforced Cement Concrete (RCC). Water Resources Department constructed low height Anicuts less than 2.0m above the river bed so that series of such Anicuts/check dams constructed could get filled up simultaneously. During construction of Anicuts, the presence of rock outcrops in the river bed had also been exploited favourably to dovetail them in the structure.

During rainy season, the anicut gates would be removed and kept on the banks so that flood discharge can pass smoothly through the river. However, after the rainy season is over, the gates will be put in position so that impoundment of water behind the anicuts could take place thereby providing small storages at the locations of such anicuts all through the river length which will be available for various uses during the lean period.
Anicuts have been constructed at the following places-

Near Shamshan New Pula Bridge

Near Ashok nagar Shamshan

Near Subhash Nagar

5.2.4 Reservation of releases from Upstream Storage Dams during Lean Period

The following storage dams exist in the catchment area of Ayad River. The overflow from these dams invariably comes to Ayad river during monsoon period.

i) Bada Madar Reservoir
ii) Chhota Madar Reservoir
iii) Lakhawali Reservoir
iv) Badi Reservoir and Fatehsagar
v) Pichola Reservoir

In order to keep the storage behind the existing and proposed anicuts live and make the flow perennial, it is necessary to release water from the above reservoirs at periodical intervals, for which it is recommended that:

a) At present, releases from Bada & Chhota Madar are being diverted from Thur Dam via Chikalwas feeder channel to Fatehsagar Lake. At times, Chikalwas feeder can be closed and release from U/s reservoir could be made to flow in the river.
b) The storage of Lakhawali Dam can be reserved during monsoon period and released into the river only during lean period.
c) The storages of Bada, Chhota and Fatehsagar Dams are being kept reserved for domestic water supply. But the surplus as and when arises in case of rains could be let into the river.

5.3 STUDY OF EXISTING LONGITUDINAL & X-SECTIONAL PROFILE OF RIVER

The existing river profile in terms of longitudinal and cross-sectional in various reaches all along the river length is required to be established and used as an input for planning of river channelization and also for planning of various riverfront development works.

To study the existing details of L and X –sections, data from WAPCOS report has been used with physical checking.

From detailed studies carried out on the basis of available data, the following broad inferences are drawn:

- The river reach from New Pula bridge to Sevashram bridge 5 km has been selected in this project as this stretch is within the city area.
- At some locations flat banks are encountered and river depth is very less
- At some locations, river section is not defined
- At some locations within the city, the river section becomes narrow
- No maintenance of river banks
- No greenery on the river banks
- High siltation of river bed
- Excessive weed growth in the river bed

5.4 RIVER CHANNELIZATION

5.4.1 General

In view of the varying river profile in terms of its width and depth at various points along its length, it is important to make the river channelizable during reason by providing lining.

The existing boundary wall on the edges of the river, however, is in poor condition at certain places, and discontinuities and gaps are also present at various locations. Therefore,it is proposed to provide Geo-grid with Gabion wall.

A Geogrid is geosynthetic material used to reinforce soils and similar materials. Geogrids are commonly used to reinforce retaining walls, as well as sub-bases or sub-soils below roads or structures. Soils pull apart under tension. Compared to soil, geogrids are strong in tension. This fact allows them to transfer forces to a larger area of soil than would otherwise be the case.

Geogrid would also allow vegetation to grow in the compacted soil adding to the beauty of the river.

In addition to the above, it is proposed to provide fencing along the river revenue boundary on both sides of the river throughout its length.

The drawings of designed sections in city portion of river Ayad have been prepared.

5.4.4 River Bed Slope

While carrying out the re-sectioning and de-siltation of the river, care has to be taken to provide a smooth bed slope to the river removing pockets of negative slope to ensure smooth flow of water.

5.5 RIVER SILTATION

5.5.1 General

Siltation in the river is caused by soil erosion from the catchment area. Soil erosion is one form of soil degradation along with soil compaction, low organic matter, and poor internal drainage, salinization, and soil acidity problems. These other forms of soil degradation, serious in themselves, usually contribute to accelerated soil erosion.

Soil erosion is a naturally occurring process on all land. The agents of soil erosion are water and wind, each contributing a significant amount of soil loss each year.
The rate and magnitude of soil erosion is controlled by accompanying water, wind and stream and ditch bank erosion parameters. A brief description of these parameters is given below:

➢ **Erosion by Water**

Erosion by water is influenced by following factors:

- Rainfall Intensity and Runoff
- Soil Erodibility
- Slope Gradient and Length
- Vegetation

➢ **Rainfall Intensity and Runoff**

The impact of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material. Lighter aggregate materials such as very fine sand, silt, clay and organic matter can be easily removed by the raindrop splash and runoff water; greater rain drop energy or runoff amounts might be required to move the larger sand and gravel particles.

- **Soil Erodibility**

  Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical characteristics of each soil. Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils.

- **Slope Gradient and Length**

  Naturally the steeper the slope of a field, the greater the amount of soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often results in longer slope lengths with increased erosion potential, due to increased velocity of water which permits a greater degree of scouring (carrying capacity for sediment).

- **Vegetation**

  Soil erosion potential is increased if the soil has no or very little vegetative cover of plants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate.

  The erosion-reducing effectiveness of plant and/or residue covers depends on the type, extent and quantity of cover. Vegetation and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface and the most efficient in controlling soil (e.g. forests, permanent grasses).

- **Erosion by wind**

  Erosion by wind is influenced by the following factors:

  - Erodibility of soil
  - Soil Surface Roughness
  - Climate
  - Unsheltered Distance
  - Vegetative Cover

- **Erodibility of Soil**

Very fine particles can be suspended by the wind and then transported to great distances. Fine and medium size particles can be lifted and deposited, while coarse particles can be blown along the surface (commonly known as the siltation effect). The abrasion that results can reduce soil particle size and further increase the soil erodibility.

- **Soil Surface Roughness**

  Soil surfaces that are not rough or ridged offer little resistance to the wind. However, over time, ridges can be filled in and the roughness broken down by abrasion to produce a smoother surfaces susceptible to the wind. Excess tillage can contribute to soil structure breakdown and increased erosion.

- **Climate**

  The speed and duration of the wind have a direct relationship to the extent of soil erosion. Soil moisture levels can be very low at the surface of excessively drained soils or during periods of drought, thus releasing the particles for transport by wind.

- **Unsheltered Distance**

  The lack of windbreaks (trees, shrubs, residue, etc.) allows the wind to put soil particles into motion for greater distances thus increasing the abrasion and soil erosion. Knolls are usually exposed and suffer the most.

- **Vegetative Cover**

  The lack of permanent vegetation cover in certain locations has resulted in extensive erosion by wind. Loose, dry, bare soil is the most susceptible; however, crops that produce low levels of residue also may not provide enough resistance. As well, crops that produce a lot of residue also may not protect the soil in severe cases.

  The most effective vegetative cover for protection should include an adequate network of living windbreaks combined with good tillage, residue management, and crop selection.

  Wind erosion may create adverse operating conditions in the field. Crops can be totally ruined so that costly delay and reseeding is necessary - or the plants maybe sandblasted and set back with a resulting decrease in yield, loss of quality, and market value. The removal of wind-blown soils from fence rows, ditches, roads and from around buildings is a costly process.

- **Stream and Bank Erosion**

Poor construction, or inadequate maintenance, of surface drainage systems, uncontrolled livestock access, and cropping too close to both stream banks leads to bank erosion problems.

The direct damages from bank erosion include:

- The loss of productive farmland.
- The undermining of structures such as bridges.
- The washing out of lanes, roads and fence rows.

Sediment which reaches streams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels.

5.5.2 Project Specific

The type of soil in the catchment area of Berech (Ayad) River is low dunes with Indus alluvial soil. The dominant soils of the alluvial plain are light brownish grey to brown and loamy to very fine sandy loam.

During the spells of rain and consequent runoff, silt gets transported to the river. So far, no de-siltation measures have been taken as a result of which lot of silt has got accumulated in the river bed.

CHAPTER -6
COST ESTIMATE

6.1 GENERAL

Cost estimate has been prepared for all the components of the project based on ISOR 2017 of RUIDP. The abstract of cost of the project is as under:

Ayad River Smart Front Development and Beautification Project		
S.No.	**Description of Work**	**Amount in Rs.**
1	Hard Core Work	719594838
2	Soft Core Work	25261875
	Total Amount in Rs.	**744856713**

Say Rs. 74.50 Crore

Part "A" Hard Core Work

S. No.	RUIDP SOR-2017	DESCRIPTION OF ITEMS	UNIT	QTY	RATE	AMOUNT
1	4.2	Earth work in excavation for roadway, including trimming bottom and side slopes in accordance with requirement of line, grades and cross sections, including disposal of surplus material with all lift and lead upto 1000 metre as per MoRT&H specification clause 301.				
	4.2.1	In all type of soil	Cum	73500	145	10657500
2	4.2.2	In ordinary rock	Cum	73500	220	16170000
3	4.3.2	In Hard Rocks - Blasting prohibited (considering serviceable material)	Cum	24500	637	15606500

4	4.10	Earth work in excavation in foundation, trenches etc. including dressing of sides and ramming of bottoms, including getting out the excavated material, refilling after laying pipe/ foundation and disposal of surplus excavated material at a lead upto 50m suitable site as per direction of Engineer for following depths, below natural ground / Road top level.				
	4.10.1	In all types soils/ saturated soil such as moorum, sand, sandy silt, clay, black cotton soil, kankar, etc.				
	4.10.1.1	Depth upto 1.5 m				
			Cum	22500		
			Cum	5625		
		Toe wall on both side	Cum	6750		
		Total	**Cum**	**34875**	175	6103125
5	4.10.2	In ordinary rock.				
	4.10.2.1	Depth upto 1.5 m				
			Cum	18000		
		Toe wall on both side	Cum	2250		
				20250	712	14418000
6	4.10.4	In hard rock (Blasting prohibited)				
	4.10.4.1	Depth upto 1.5 m				
			Cum	13500	2315	31252500
7		Add extra over item no 4.10.1, 4.10.2, 4.10.3 and 4.10.4 in RUIDP SOR for excavation in saturated soil, silt and sludge where pumping or bailing out of water is required including shoring strutting where required and dewatering, where width is upto 6 metre				
			cum	108375	33	3576375
8	21.1	Providing and laying in **position cement concrete** of specified grade excluding the cost of centring and shuttering - All work upto plinth level :				
	21.1.6	1:2:4 (1 Cement : 2 coarse sand : 4 graded stone aggregate 40 mm nominal size).				
			Cum	5400		

			Cum	15000		
			Cum	540		
		Toe wall on both side	Cum	900		
		Total	**Cum**	**21840**	3670	80152800
9	14.7	Providing and laying structural plain/ **reinforced cement concrete** (design mix) of specified grade in substructure at all levels using batching plant, transit mixer, concrete pump and vibrater including cost of form work complete as per drawing and clause 1500, 1700 and 2200 of MoRT&H specification including all scaffolding, material, labour, machinery etc.				
	14.7.3	RCC Grade M -30				
			Cum	6750		
		Anchoring Wall at 30m interval	Cum	720		
		Check wall at 10 m interval	Cum	1250		
			Cum	7969		
		Total	**Cum**	**16689**	5580	93123225
10	23.19	Reinforcement for R.C.C. work at all levels including straightening, cutting, bending, placing in position and binding all complete.				
	23.19.6	Thermo-Mechanically Treated bars.	Kg	1668875	51.50	85947062.5
11	7.1	Providing, laying, spreading and compacting of **granular sub- ase** by providing close graded Material, mixing in a mechanical mix plant at OMC, carriage of mixed Material to work site, spreading in uniform layers with motor grader on prepared surface and compacting with vibratory power roller to achieve the desired density, complete as per MoRT&H specification clause - 401 including all material, labour, machinery, lighting, guarding and maintenance of diversion.				
	7.1.1	Grading - I Material	Cum	10500		
			Cum	60000		
		Total	**Cum**	**70500**	1070	75435000

12	25.1	**Random rubble** masonry with hard stone in foundation and plinth :				
	25.1.2	Cement mortar 1:4 (1 cement : 4 coarse sand)				
			Cum	5500		
		channel wall	Cum	14500		
		Total	**Cum**	**20000**	3450	69000000
13	14.8	Providing **weep holes** in brick/ stone masonry/ Plain/ Reinforced concrete abutment, wing wall/ return wall with following dia AC pipe, extending through the full width of the structure with slope of 1V : 20H towards drawing face complete as per drawing, technical specifications and clause 2205 of MoRT&H Specification including all scaffolding, material, labour, machinery etc.				
	14.8.2	150 mm dia	Metre	2500	117	292500
14	13.32	**Making holes** in all types of rock for anchorage etc.for any depth below foundation level 30/40 mm dia. including fixing charges for providing of inserts like anchor bars along the grouting, anchoring etc. true in line & plumb as per approved detailed working drawing including cost of cement grout etc. complete in all respect.(Cement grout 1:1 as per clause no. 2800 & 2806 of MoRTH Specification)(excluding cost of steel) and as per the directed of the Engineer.				
		At 5 m interval	Metre	6000	131	786000
15	17.20	Providing at site, lowering of **RCC pipes NP2 class** (with s/s ends IS: 458 - 1988 (amended up to date) marked at all levels as per drawing, etc., complete as directed by Engineer in length of 0.75 mtr with perforation of dia 150/100 mm hole				
	17.20.9	600 mm internal diameter	Rmt	1275	1870	2384250

16	19.4	Providing, lowering, laying, aligning, fixing in position at and jointing at all level/ depths ISI marked **HDPE pipes** of PE-100 grade & PN-6 for potable water as per IS 4984 (amended upto date) in trenches complete with all accessories like Bend, Tee, Reducer, Stub end, End cap etc including all material, labour, testing and commissioning as per Technical Specifications and as per direction of Engineer. Note : E/w to be measured and paid separately.				
	19.4.1	75 mm dia	Metre	10000	212	2120000
17	15.2	Providing and laying **Pitching** on slopes laid over prepared filter media including boulder apron laid dry in front of toe of embankment complete as per drawing and Technical specifications and as per clause 2504 of MoRT&H Specification.				
	15.2.1	With R.R. Stone/ bolder, weighing not less than 40 kg, thickness not less than 150mm, Specific gravity not less than 2.65.				
			Cum	7500		
		Total	**Cum**	**7500**	1100	8250000
18	15.8	Supplying & Laying of a **geotextile filter** between pitching and embankment slopes on which pitching is laid to prevent escape of the embankment material through the voids of the stone pitching/ cement concrete blocks as well as to allow free movement of water without creating any uplift head on the pitching.	Sqm	12500	103	1287500
19	32.41	Finishing with **Epoxy paint** (two or more coats) at all locations prepared and applied as per manufacturer's specifications including appropriate priming coat, preparation of surface, etc. complete.				
	32.41.2	On concrete work	Sqm	45000	117	5265000

20	Non SOR	Providing and fixing **Bijoliya stone flooring Blue and Red color** with thickness 100 mm as per approved pattern including fixing in cement mortar 1:4 as per the direction of Engineer in charge.	Sqm	100000	1100	110000000
21	Non SOR	Providing and laying **Non woven Coir Mat** 600 GSM minimum including levelling, terracing & preparation for coir mat, including removal of unwanted material at site, and plantation of Vetiver grass tiliers on it, 15 numbers per sqm of area including cost of all men and materials, cost of hire charges of all machineries required for the execution of work and maintenance of Non woven-Coir matting including sourcing and transporting of water from nearby area, watering for a initial period of 3 months from the date of seedling, with all lead and lift, cost and conveyance of all men and machineries including cost of all required materials, labour charges, loading and unloading etc. complete as per Technical specifications. **600 GSM both sides netting**	Sqm	80000	250	20000000
22	Non SOR	**Supply and Installatiom of Gabion Mattress** units of 0.3 m height made of mechanically woven, double twisted, hexagonal shaped wire mesh, Mesh type 10 x 12, having D=60 mm with tolerance of +/-2%, Mesh wire dia 2.2/3.2mm(ID/OD), Galmac+PVC coated ,with partition at 1 m interval as per direction of Enginer in charge-complete in all respect	Sqm	12500	1800	22500000

24	Non SOR	Supply of stones for filling in mattress units in range of 150mm-250mm, strong, hard, durable having good crushing strength and preferably having density not less than 22kN/m3 and having flat face including 15% kapachi of appropriate size for levelling the top of filled Gabion units and filling the voids. Miminum 30% wastage shall be considered. Including Stone breaking & segregation into required sizes for Gabion wall as per the instructions of engineer incharge.	Cum	1250		
			Cum	2500		
			Cum	3750		
			Cum	5000		
			Cum	6250		
				18750	1250	23437500
25	10.16	Supplying and fixing of GI chain link fencing of required width in mesh including strengthening with 2 mm dia GI wire/ G.I. staples/ G.I.U-nails/ nuts bolts with 2.4 m angle iron posts 50 mm x 50 mm x 6 mm placed every 3 metres center to center founded in M15 grade cement concrete 30cmx30cmx60cm, 0.6 metre below ground level, every 15th post, last but one end post and corner post shall be strutted on both sides and end post on one side only etc complete as required and as per direction of Engineer-in-charge.				
	10.16.3	Mesh size 100mm x 100mm made of GI wire 3.15mm dia	Sqm	20000	514	10280000

26	19.1	Providing, lowering, laying in trenches, aligning, fixing in position and double flanged (welded) centrifugally (spun) Ductile iron ISI marked K-9 grade pipes as per IS:8329-2000 (amended upto date), (including jointing and jointing material) complete including all material, labour, hydraulic testing and commissioning as per Technical Specifications and as per direction of Engineer. 100 mm dia	mtr	5000	2310	11550000
		Total Amount in Rs.				**719594838**

Part "B" Soft Core Work

S. No.	RUIDP SOR - 2017	DESCRIPTION OF ITEMS	UNIT	QTY	RATE	AMOUNT
1	39.3	Supplying and stacking **good earth** at site of work. Note: 1) Loading, unloading and carriage to be paid extra as per actual lead. 2) Earth measured in stacks will be reduced by 20% for payment	Cum	15000		
				7500		
				22500	206	4635000
2	39.4	Supply at site of work **well decayed farm yard manure,** from any available source, approved by the engineer in charge including screening and stacking.	Cum	11250	605	6806250
3	39.11	**Spreading of sludge farm yard manure** or/ and good earth in required thickness (cost of sludge, farm- yard manure or/and good earth to be paid for separately).	Cum	33750	30	995625
		Tree				
4		Conocarpus - 6 to 8 ft height	Each	1500	200	300000

		10feet height tree - …….	Each	2500	4000	10000000
5		**Shrub**	Each	100000	25	2500000
		Lily grass				25000
		Total Amount in Rs				**25261875**

CHAPTER -7
DRAWINGS

Report on Construction Activities in Ayad River

Under

Ayad Smart Front Development and Rejuvenation Project

By

Udaipur Smart City Ltd

By:
Dr. S.K. Singh BE (Civil), ME (Env Engg), PGD (Fin Mgt), Ph.D.
Professor & Head
Civil Engineering Department
MBM University Jodhpur (Raj)
(A Government of Rajasthan State Funded University)
Ph:+91- 8209036225

17/4/2023

Dr. Suresh Kumar Singh
Professor & Head
Department of Civil Engineering
MBM University Jodhpur (Rajasthan)

April - 2023

1. Introduction :

Udaipur also called "Lake City" is situated in the southern part of the state of Rajasthan in the Aravalli Hills and Ayad river is flowing through the city and dividing the city of Udaipur in two parts. Ayad river is a non-perennial river and water flows only in rainy season for few days only as it receive overflow water of upstream lakes (Pichola, Fateh Sagar & Swaroop Sagar Lakes) and this river meets ultimately in Udai Sagar Lake which is outside Udaipur city. Few years back waste water of the city was continuously discharging into the various lakes and Ayad river. Ayad river was practically a waste water drain in non-rainy season.

A Study indicates that Ayad River catchment is located in Udaipur district and for mean annual rainfall is 620.89 mm in catchment area and annual run off is 118.53 mm, which means runoff to rainfall ratio is only 0.17, (Study titled "Estimation of Runoff for Ayad River Catchment in Udaipur District Integrated Remote Sensing and Geographical Information System by Pratibha Katara*, Deepesh Machiwal**, H.K. Mittal*, Yogita Dashora*and Arun D. Bhagat* of College of Technology and Engineering, MPUAT, Udaipur (Rajasthan) and Central Arid Zone Research Institute, Regional Research Station, Bhuj (Gujarat) was carried out from rainfall data of ten years (i.e. 2001-2010)). Considering total mean annual rainfall as 620.89 mm and assuming upstream contributing catchment as 348.23 Km^2 and 0.17 ratio of runoff to rain fall, the total mean annual run off will be 36.7 million cubic meters.

Fateh Sagar Lake system mainly comprises of :

a. Fateh Sagar Lake
b. Badi Lake
c. Bada Madar Reservoir
d. Chhota Madar Reservoir

Badi Lake is situated upstream of Fateh Sagar and its overflow enters in the Fateh Sagar Lake.

Similarly Pichola Lake System comprises of :

a. Rangsagar Reservoir
b. Swaroop Sagar Reservoir
c. Kumaria Talab
d. Dudh Talai Reservoir
e. Nandeswar Reservoir
f. Pichola Lake

Nandeshwer Reservoir is situated in the upstream of Pichola Lake and its overflow enters in the Pichola Lake.

It is important to note that the Capacity of Pichola lake is about 13.08 million cubic meter and Fateh Sagar lake is 2.1 millions cubic meters and are storing about 41.4 % total runoff. Because of the reduced contributing runoff (Change of land use pattern, change in drainage pattern etc may be the causes) Lakes of Udaipur are having shortage of water.

The length of the Ayad river is about 26 km and out of which 11 km is through populated city area. Most of the runoff of the area is not directly joining the Ayad River. Initially runoff goes to lakes and spill water of lakes/reservoirs situated upstream of Ayad river

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Dr. Suresh Kumar Singh
Professor & Head
Department of Civil Engineering
MBM University Jodhpur (Rajasthan)

or excess released water in case of heavy rains from lakes/reservoirs situated upstream of Ayad river is major source of discharge in Ayad river.

Local authorities (i.e., UIT Udaipur, RUIDP and Nagar Nigam, Udaipur) jointly worked and laid sewer line in most of the areas of Udaipur to stop the disposal of untreated sewage in to lakes and river. Various Sewage Treatment Plants were constructed by Hindustan Zinc Ltd in joint collaboration with Udaipur Smart city to treat the sewage within prescribed norms.

Ayad Smart Front Development and Rejuvenation Project was prepared and being undertaken by Udaipur Smart City Ltd by considering the recommendations of a technical committee of experts and following guidelines issued by "Town and Country Planning Organisation, Government of India, to ensure sustainability of rivers passing through cities and town".

The project report indicates that the rejuvenation project is conceived with the following main objectives.

a. Protection of Slope Stability.
b. Protection of river bank erosion.
c. Safety of structures situated on the river banks.
d. Reducing chances of flash flooding.
e. Increase of ground water recharge.
f. Improvement of aesthetic appearance of riverfront within the city.

by considering:

i. Assessment of existing profile
ii. Water availability during lean period
iii. Likely flood conditions in river and safe passage through the city (flood of 50 year return period considered)
iv. Siltation Aspect
v. Environmental and ecological balance

2. Hydrological Studies:

By analysing the data available for hydrological studies , following conclusions may be drawn:

a. **50 year return period point rainfall:** Hydrological frequency Analysis (by methods of moments) gives 50 year return period point rainfall value as 156 mm and applying clock-hour correction the values of 50 year return period point rainfall will be 179.40 mm.
b. **Flood Routing :** After analysis it was calculated that the flood values based on peak flood (50 years return period) for various locations which majorly contribute flooding in city area, are from :Routed Flood from Thur Dam and routed flood from Ghumania Nallah . The flood will be only because of spill discharge from Thur Dam and upstream side lakes.
c. **Existing profile of river:**

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Dr. Suresh Kumar Singh
Professor & Head
Department of Civil Engineering
MBM University Jodhpur (Rajasthan)

S.N.	Chainage	Lowest bed level (m)	Left Bank Level (m)	Right Bank Level (m)	Top width of river (m)	Remarks
1	0.0 km	610.09	624.00	616.00	128.40	The top width of river is varying from about 144.0 m to about 30.0 m throughout the reach
2	2.0 km	602.39	605.00	604.90	75.72	
3	4.0 km	593.92	595.40	596.25	76.65	
4	6.0 km	586.63	590.71	591.41	109.34	
5	8.0 km	582.26	584.72	585.12	56.23	
6	10.0 km	576.79	581.00	578.76	81.38	
7	12.0 km	572.49	574.78	574.94	50.94	
8	15.0 km	562.0	565.79	566.73	55.05	
9	18.0 km	552.56	557.85	555.50	50.0	
10	21.0 km	545.6	547.31	550.06	88.0	
11	24.0 km	540.89	542.64	541.61	30.00	
12	26.07 km	539.95	542.05	541.92	144.82	

d. **Efficacy of Flooding in existing river in city area:** Based on peak flood (50 years return period): The analysis was done to estimate the flooding of water which indicates that within the city flood water may spill on both river bank in case of 50 year return period. The top width of the river in the city area varies from about 50 m to 81m and general lowest bed level varies from 1 in 280 m to 1 in 465 m with an average bed slope of 1 in 350. The general minimum lowest bed slope is flatter where width is more which reflects that the within the city reach discharge carrying capacity is almost same. Hence increase of cross-sectional of river / increase of river capacity is required.

3. The major activities:

The major activities in this river rejuvenation project includes:

a. Cleaning of river Ayad: by removing the deposited waste material
b. Construction of a channel of 10.0 m outer width and 0.7 to 1.0 m clear water depth in the central portion of the river. This channel is having cement concrete side wall and dry-stone pitching in the middle part.
c. Slope Stabilization by Gabion pitching, protection walls, coir mats and grassing.
d. Walkway/service road
e. Stone pitching (30 m wide) and development of grass area (15 m wide) alternatively along the river Ayad as river is non- perennial river.

4. Impact of activities:

All the activities are proposed in the river are of non- permanent nature except side wall of channel and toe walls. These activities are not affecting the Catchment drainage pattern and not obstructing any inflow of storm water from river catchment.

a. Cleaning of river will increase the cross-sectional area of the river which will increase the carrying capacity of the river and this will reduce the chances of spilling of water from both bank in rainy season.
b. Construction of proposed channel bed mostly below natural bed of river will increase the cross-sectional area of the river which will increase the carrying capacity of the river

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and this will reduce the chances of spilling of water from both bank in rainy season as analysis indicates that flood water level will come down for 50 year return period.

c. The average 15 MLD treated waste water of less than 10 BOD after disinfection, will flow throughout the year except in case of flood period and as bottom of the channel is of dry stone pitching which will increase ground water recharge.

d. Gabion pitching/protection walls/dry stone pitching/coir matting will protect side slope and will provide protection against erosion of river bank. As the surface will become smooth and which will decrease friction losses so that the velocity of flow will increase. As velocity is increasing the discharging capacity will increase and will reduce the chances of flash flooding.

e. Stone pitching (30 m wide) and development of grass area (15 m wide) along the river Ayad will slightly decrease the ground water recharge due to increase of velocity in rainy season but at the same time increase of discharging capacity will reduce the probable chances of flash flooding (if any). As the requirement of ground water table recharging is mainly in lean period, the slight decrease due to stone pitching will not affect much in recharge process.

5. Recommendations & Suggestions:

The Ayad river is flowing through the Udaipur city and about 11 km reach is within the city. The river has varying section and the top width of river is varying from about 141.0 m to about 27.0 m throughout the reach. Analysis for Efficacy of Flooding in existing river in city area [Based on peak flood (50 years return period)] indicates flooding spilling on both banks . Hence to protect the city, it is necessary to increase the carrying capacity of river by increasing the depth of the river as width of the river cannot be increased. It is important here to clarify that increase of depth in total width of the river is to be avoided as it may lead to failure of foundation of buildings situated on the river banks.

Hence construction of a channel in the central portion of the river below natural bed where ever required as the level permits, in the river is a practical solution. The same channel will be used for disposal of treated sewage of the city of less than 10 BOD after disinfection. The activities proposed are with the aim to provide long term conservation and sustainable management solution for restoring the environmental and ecological balance of the river along with slope stability, prevention of erosion. increasing ground water recharge, safety against flooding of areas adjacent to river banks and ensure safety of human life and properties.

Followings are some suggestion and specific recommendations on ongoing project:

a. In project, Reinforcement cement concrete (RCC) shall not be allowed except vertical walls of channel/toe walls along the direction of flow. As at some places RCC construction is proposed (where the soil is loose and the bearing capacity is low) to support stone pitching etc, this should be avoided and stabilization (increase of strength) is to done by providing dry stone boulders or other techniques etc. instead of providing RCC Slabs etc.

b. Chlorination process is used for the disinfection of treated waste water of STP before discharging it to river, it is important here to point out that practically it is very difficult to control dose of chlorine for complete disinfection and the excess residual chlorine in

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Dr. Suresh Kumar Singh
Professor & Head
Department of Civil Engineering
MBM University Jodhpur (Rajasthan)

water may cause adverse effect to river ecology. Hence it is recommended to change the process of chlorination to ozonisation which is a very effective process of disinfection and same time it will increase dissolve oxygen in the treated waste water.

c. Provision of gates is to be included in proposed anicuts and existing anicuts.
d. Plantation on both side of river banks area (i.e., between sewer line and Bank boundary)
e. If local bye laws permits then restriction of multistorey building adjacent to river banks.
f. Construction of central channel in the whole city reach of river (i.e., about 11.0 km length).
g. The increase of depth near river banks is to be avoided as it may lead to failure of foundation of buildings situated on the river banks.

6. Opinion on the court cases referred in the Writ Petition filed in the Hon'able NGT:

As I have been involved directly/indirectly in various cases related to environmental issues and also referring the decisions of Hon'able Courts / Hon'able NGT in the process of granting Environmental Clearance as expert member in SEAC Committee. My personal opinion on various legal issues are:

a. Violation of section 24 (1) (b) of the water act 1974: As construction activities in the river is to protect side slope, minimise erosion etc. without reducing the discharge carrying capacity, and not only in India but all over the world such activities are carried out by the administration in the river flowing within the city, and these activities are not creating any obstruction to flow and no work is proposed out side the river (i.e. in the flood plain/catchment of river), hence there is no violation of section 24 (1) (b) of the water act 1974.

b. (i) Abdual Rahman v/s State of Rajasthan :
   (ii) Prof K.P. Sharma v/s State of Rajasthan :
   (iii) Akash Vashishtha & Anr. V/s Union of India & Ors.
   (iv) Manoj Misra v/s : Delhi Development Authority & Ors.:
   (v) Manoj Misra v/s Union of India & Ors.

As authorities are not giving any right to anyone for permanent/ temporary construction for any specific use and with or without change of land use. Here construction activities are related to rehabilitation of river to protect the slope, minimise the erosion, increase the underground recharge etc. for sustainable management of river within the city reach. Similarly no construction is proposed in flood plain/ catchment of river.

Hence all above mentioned decision are not applicable in this matter and there is no violation of any decision regarding construction activities related to the rehabilitation and sustainable river management of river flowing within the city. Even such wok has been done in various perennial river such as in Sabarmati river (Ahmedabad), Narmada (Ujjain), Ganga (Varanasi), Gomati (Lucknow) etc.

17/4/2023

(Dr. Suresh Kumar Singh)
Professor & Head
Department of Civil Engineering
M.B.M. University Jodhpur (Raj)
(A Government of Rajasthan State Funded University)

Dr. Suresh Kumar Singh
Professor & Head
Department of Civil Engineering
MBM University Jodhpur (Rajasthan)

Annexure-7

CIN: U75144RJ2016SGC049591

UDAIPUR SMART CITY LIMITED

Abhay Command and Control Centre Building
Nagar Nigam, Town Hall, Udaipur (Rajasthan) 313001
Tel: 0294-2425325
Website: www.udaipursmartcity.in, E-mail: uscl2016@gmail.com

Letter No.: USCL/2023-24/Ayad/ 531 Date: 17/08/23

To,

Central Pollution Control Board,
Regional Directorate (Central),
Parivesh Bhawan, Paryavaran Parisar,
E-5, Arera Colony, Bhopal - 462016

Subject:- NGT application no. 14/2023 "Rahabilitation of Ayad River"

Sir,

As per the directions/discussions, the short note of the project "Rehabilitation of Ayad River" are as under-

- First of all, a study was conducted by WEPCOS [Water and Power Consultancy Services (India) Ltd.]. They studied the rainfall data of the catchment area, cross section, profile, levels of the river, ground water status, quality etc. The total length of the River is approx. 26 Kms and it terminates in the Udaisagar Lake.
- The project for Rehabilitation of the Ayad River in a stretch of 5 Kms. in the city area was chosen. The Collector of Udaipur, who is also the Vice chairperson of the Udaipur Smart City, formed a committee of 10 members comprising of 3 officials from USCL/UMC & UIT, 1 Executive Engineer from Water resource department (Irrigation), 3 Retired Chief Engineers from CPWD/Irrigation, 3 Professors from College of Technology and Engineering (A govt. of Rajasthan engineering college at Udaipur) vide order no. 579 Dated 10/07/19. The committee hold site visits & meetings and finalized the proposal and prepared DPR. The cost of the DPR for 5 Kms stretch was Rs. 75 Crores. The USCL Board of Directors granted its consent in 14th meeting dated 21/11/19.
- The main provisions of the project were as per the details:-
    1. 5 Mt. wide impermeable RCC channel at the center of the River. Both side banks to be protected by Gabion wall and grass. A walkway on both sides.
    2. Tree plantation on both sides & within the river bed.
    3. Pumping and rising main of pipe for taking the treated water from the STP's to increase the water column.
    4. Grassing & Stone flooring (alternate panels) on both sides of the RCC channel.
- The tenders were floated and the work started. At the time of beginning of the work, it was suggested / found suitable to change the 5 Mt. RCC channel into a 9 Mt. permeable channel with RCC walls on both sides and dry stone pitching inside the channel, so that maximum water may percolate to recharge the ground water table.
- The contractor was directed to work in a sample part of around 220 Mts. The contractor delayed the work and penalty was imposed on him and the contract was terminated.
- Due to the time constrained and to finish the work as soon as possible, the civil works were splitted into 8 Parts, one electrical and one pipe & pumping part. The revised estimates were

prepared and the revised cost of the all 10 works comes out to be Rs.72.39 Crores (excluding O&M).

- The main provisions of the revised project are:
    1. 9 Mt. permeable channel with RCC walls on both sides and dry stone pitching inside the channel to allow maximum water to recharge the ground water table.
    2. The current bed of the river was very uneven with many depressions of upto 4-5 Mts. in which the water was stagnated and causing severe health hazards, pollution, bed smell etc. The proposed level of the bed of the channel has been kept in such a way that no water will be stagnated. The bed level of the river has been kept to match the invert levels of all the structures resulting in no stagnation of the water and the water may smoothly flow by gravity.
    3. Side protection walls with Gabion / stone masonry to protect banks of the river, habitation, cremation places etc.
    4. The top level of the channel walls are well below the HFL. In case of the flood, the water will flow over the channel and the stone flooring resulting in no obstruction to the flowing water.
    5. Grassing & Stone flooring / pitching (alternate panels) on both side in between the channel walls and service road / walkway.
    6. Pumping and pipe arrangements for taking the treated water from the STP to increase the water column.
    7. Low height M.S. gates on Anicuts / Bridges openings to increase the water column on upstream sides during the lean period. This will be regulated for cleaning and maintenance purposes.
- In this river during the rainy season, the overflow water of the three main lakes of Udaipur (Pichhola, Swaroop Sagar & Fatehsagar) comes in the Ayad River. Due to the unprecedented heavy rains in July month, the water in the river has risen and so, all the works have been stopped from 5th July 2023 onwards and still the site is not reachable/workable.
- At present only the works of central channel walls, side protection works, earthwork etc. are in progress and are about 80% complete. No work of stone pitching / flooring has been started so far.
- Overall, the present progress is approx. 30%.

As per discussions, the proposed revised drawings with the provisions of dry sand stone over compacted earth in place of earlier provision of stone pitching/flooring from USCL side are attached as annexure-1.

Annexure:- As above 1 No.

Dpachol

(Dinesh Pacholi)
Executive Engineer

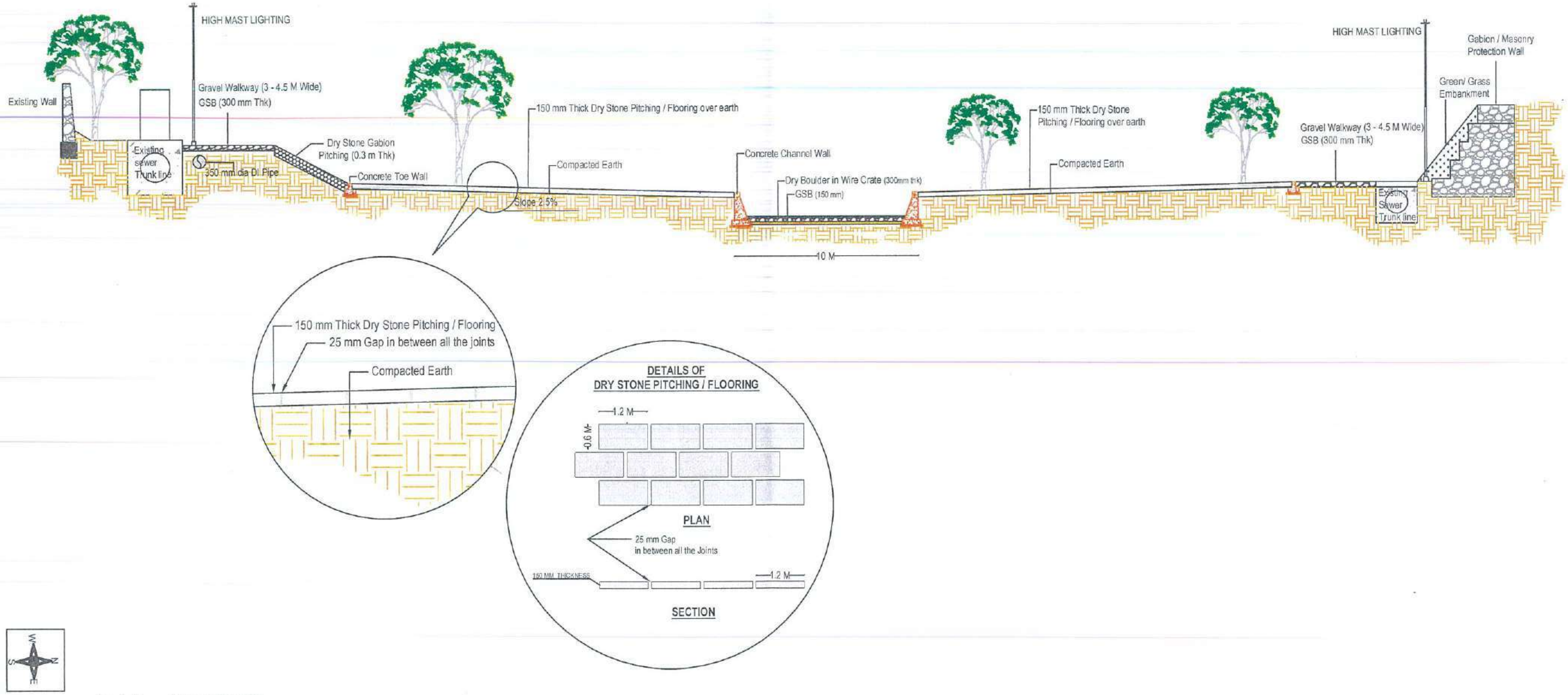
Copy To:

1. Chief Executive Officer, USCL
2. ACEO, USCL
3. ACE, UIT
4. PMC
5. Guard File

Executive Engineer

REHABILITATION OF AYAD RIVER,UDAIPUR

TYPICAL CROSS SECTION



Note : Section may differ as per site condition

LEGEND

Dinesh

DINESH PACHOLI
Executive Engineer
USCL, Udaipur

DATE	REV. NO.	DISCRIPTIONS	BY

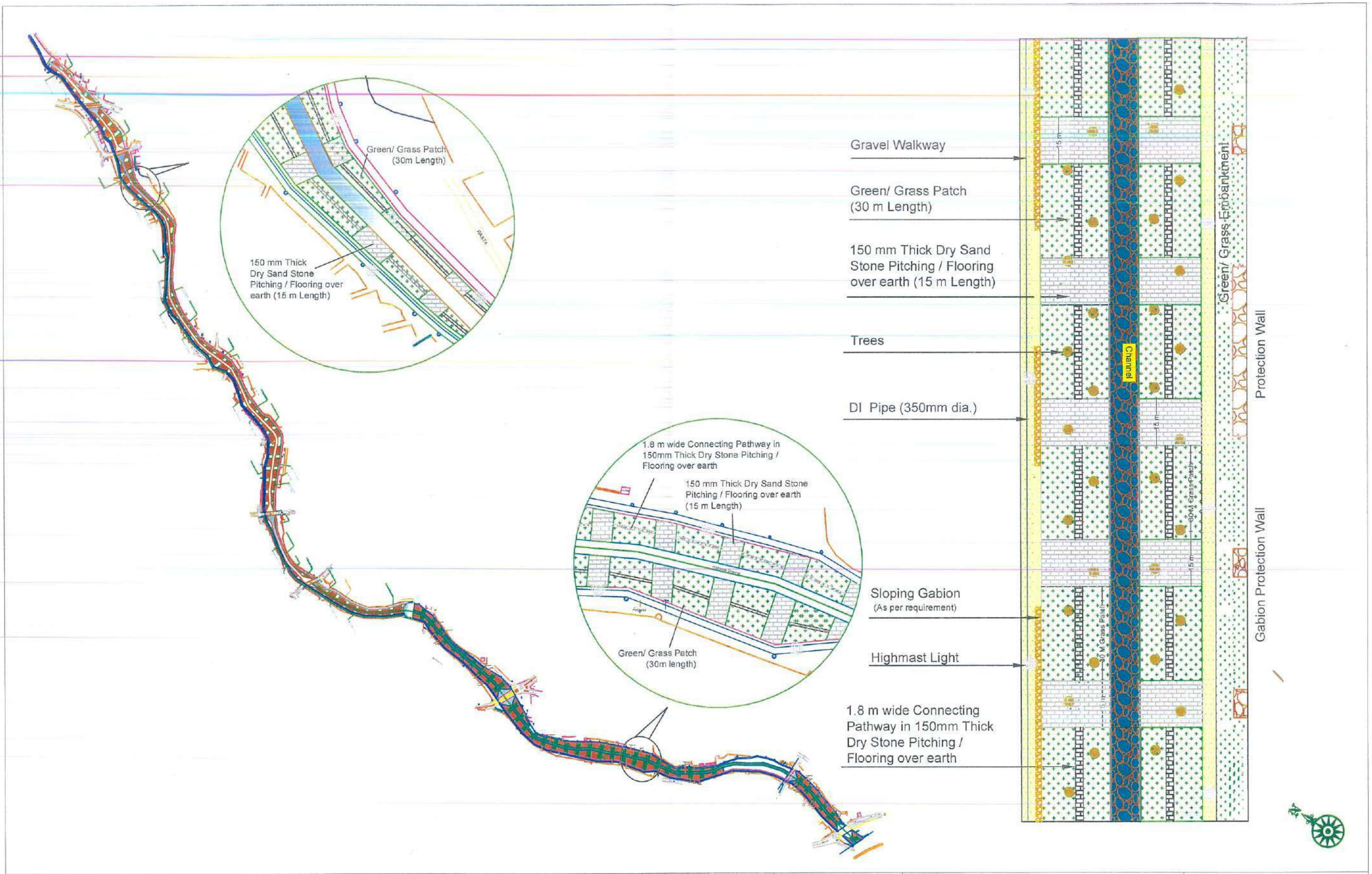
REVISIONS

CLIENT:
UDAIPUR
SMART CITY LTD.

CONSULTANTS:
GROWEVER INFRA P. LTD.

PROJECT:
REHABILITATION OF AYAD RIVER,UDAIPUR

DRAWING NO. USCL/Ayad/2023-24/02
REVISED:
DATE: 16.08.2023
DESIGNED:
CHECKED:
APPROVED:



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DATE	REV. NO.	DESCRIPTIONS	BY

REVISIONS

CLIENT:

UDAIPUR
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GROWEVER
INFRA PVT. LTD

PROJECT:

REHABILITATION OF AYAD RIVER, UDAIPUR

DRAWING NO: USCL/Ayad/ 2023-24/01

REVISED:

DATE: 16.08.2023

DESIGNED: CHECKED: APPROVED:

Annexure-8

REHABILITATION WORK OF AYAD RIVER, UDAIPUR

Work Progress Detail as on 31.07.2023

S.NO.	NAME OF WORK	TENDER AMOUNT (Cr.)	REVISED TENDER COST (Cr.)	PHYSICAL PROGRESS	Physical Work Done	FINANCIAL PROGRESS (Cr.)	REMARKS
1	PULA ANICUT TO 5 MLD STP	10.33	9.39	20%	• Side Protection / Gabion Wall Structure. • Concrete Channel Wall/ Toe Wall • Earthwork Excavation work	1.43	Work stopped due to heavy flood flow in river due to incoming overflow of Lake Pichhola, Fateh Sagar, Swaroop Sagar and nearby Lakes.
2	5 MLD STP TO KRISHNAPURA CAUSEWAY	7.19	8.99	30%	• Side Protection Wall • Concrete Channel Wall / Toe Wall • Earthwork Excavation work	3.78	
3	KRISHNAPURA CAUSEWAY TO NEW BHOPALPURA BRIDGE	8.20	7.97	35%	• Side Protection Wall • Concrete Channel Wall / Toe Wall • Earthwork Excavation work	2.36	
4	NEW BHOPALPURA BRIDGE TO ASHOK NAGAR ANICUT	8.45	8.39	20%	• Side Protection Wall • Concrete Channel Wall / Toe Wall • Earthwork Excavation work	3.40	
5	ASHOK NAGAR ANICUT TO LAKE CITY MALL	7.44	7.62	25%	• Side Protection Wall • Concrete Channel Wall / Toe Wall • Earthwork Excavation work	1.80	
6	LAKE CITY MALL BRIDGE TO CHAMPA BAUGH ANICUT	7.78	7.71	20%	• Side Protection Wall • Concrete Channel Wall / Toe Wall • Earthwork Excavation work	1.33	
7	CHAMPA BAUGH ANICUT TO SUBHASH NAGAR ANICUT	11.23	10.26	25%	• Side Protection / Gabion Wall Structure. • Concrete Channel Wall/ Toe Wall • Earthwork Excavation work	1.81	
8	SUBHASH NAGAR ANICUT TO THOKAR BRIDGE	6.20	7.58	35%	• Side Protection Wall • Concrete Channel Wall / Toe Wall • Earthwork Excavation work	0.92	
9	PUMPING ARRANGEMENTS	5.29	5.34	90%	• 6.3 Km DI Pipe Laying work done	3.80	
10	24 No. High Mast	1.52	1.52	0%	Work to be started	-	
	TOTAL (Rs.)	**73.63**	**74.77**			**20.63**	

DINESH PACHOLI
Executive Engineer
USCL, Udaipur

Central Pollution Control Board
Regional Directorate (Central)
"Parivesh Bhawan"
Paryavaran Parisar, E-5, Arera Colony, Bhopal
EPA Recognised Lab
Test Report:Fresh Water (PhysicoChemical Parameter)

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F/LAB/06/TR-01

Project Name	NGT Case Aayard River, Udaipur, Rajasthan	Test Report No.	FW/23-24/27
Sample Description	Aayard River U/S New Pula, Udaipur, Rajasthan	Requisition No.	67
Date of sample collection	12.08.2023	**Date**	18.08.2023
Date of sample receipt	14.08.2023	**Type of sample**	Grab
Date of analysis	14.08.2023 to 18.08.2023	**Sample collected by**	Dr. Anoop Chaturvedi (Sci. B) & Sunil Kolhatkar (SLA)

S.No.	Parameters	Unit	Result	Method
1	**Temperature**	°C	27	-
2	Odour	-	-	-
3	Appearance	-	-	-
4	**Colour**	**Pt-Co Scale**	**Clear**	**APHA, 2120-B**
5	Residual Chlorine	mg/L	-	APHA 4500-Cl-B
6	**Dissolved Oxygen**	**mg/L**	**8.04**	**APHA 4500-O-C**
7	**pH**	**pH unit**	**7.57**	**APHA, 4500H+B**
8	**Specific Conductivity**	**µmho/cm**	**1124**	**APHA 2510 B**
9	**Suspended Solids**	**mg/L**	**16**	**APHA 2540 D**
10	**Total Dissolved Solids**	**mg/L**	**580**	**APHA 2540 C**
11	**Total Solids**	**mg/L**	**596**	**APHA 2540 B**
12	Fixed Dissolved Solid	mg/L	-	APHA 2540 E
13	**COD**	**mg/L**	**16**	**APHA, 5220 B**
14	**BOD (3 days, 27°C)**	**mg/L**	**1.4**	**IS 3025, 1993**
15	**Chloride**	**mg/L**	**193**	**APHA, 4500-CL-B**
16	**Total Alkalinity**	**mg/L**	**71**	**APHA 2320-B**
17	T. Hardness (as $CaCO_3$)	mg/L	-	APHA 2340-C
18	Ca Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Ca-B
19	Mg Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Mg-B
20	Oil & Grease	mg/L	-	APHA 5520-D
21	Total Kjehdal Nitrogen	mg/L	-	APHA 4500-Norg-C
22	Turbidity	N.T.U.	-	APHA, 2130-B
23	**Phosphate (as P)**	**mg/L**	**0.14**	**APHA 4500-P-D**
24	**Sulphate (as SO_4)**	**mg/L**	**62**	**APHA 4500-SO_4-E**
25	Ammo. Nitrogen (as NH_3)	mg/L	-	APHA 4500-NH_3-F
26	**Nitrite Nitrogen (as NO_2)**	**mg/L**	**0.07**	**APHA 4500-NO_2-B**
27	**Nitrate Nitrogen (as NO_3)**	**mg/L**	**0.27**	**APHA 4500-NO_3B**
28	Fluoride (as F)	mg/L	-	APHA 4500-F-D
29	Sodium (as Na)	mg/L	-	APHA 3500-Na-B
30	Potassium (as K)	mg/L	-	APHA 3500-K-B
31	Chromium (as Cr^{+6})	mg/L	-	APHA 3500-Cr B
32	Boron (as B)	mg/L	-	APHA 4500-B-C
33	**Faecal Coliform**	**MPN/100ml**	**94**	**APHA 9221-E**
34	**Total Coliform**	**MPN/100ml**	**350**	**APHA 9221-B**
35	Bioassay Test	% Survival	-	APHA 8910 A-C
36				
37				

Prepared by:

Laboratory Head

Milind Kumar Nimje
Laboratory Head

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F/LAB/06/TR-01

Central Pollution Control Board
Regional Directorate (Central)
"Parivesh Bhawan"
Paryavaran Parisar, E-5, Arera Colony, Bhopal
EPA Recognised Lab
Test Report:Fresh Water (PhysicoChemical Parameter)

Project Name	NGT Case Aayard River, Udaipur, Rajasthan	Test Report No.	FW/23-24/28
Sample Description	Aayard River KrishnaPura Gaon, Udaipur, Rajasthan	Requisition No.	67
Date of sample collection	12.08.2023	**Date**	18.08.2023
Date of sample receipt	14.08.2023	**Type of sample**	Grab
Date of analysis	14.08.2023 to 18.08.2023	**Sample collected by**	Dr. Anoop Chaturvedi (Sci. B) & Sunil Kolhatkar (SLA)

S.No.	Parameters	Unit	Result	Method
1	**Temperature**	°C	28	-
2	Odour	-	-	-
3	Appearance	-	-	-
4	**Colour**	**Pt-Co Scale**	**Clear**	**APHA, 2120-B**
5	Residual Chlorine	mg/L	-	APHA 4500-Cl-B
6	**Dissolved Oxygen**	**mg/L**	**8.13**	**APHA 4500-O-C**
7	**pH**	**pH unit**	7.77	**APHA, 4500H+B**
8	**Specific Conductivity**	**µmho/cm**	**1183**	**APHA 2510 B**
9	**Suspended Solids**	**mg/L**	**19**	**APHA 2540 D**
10	**Total Dissolved Solids**	**mg/L**	**595**	**APHA 2540 C**
11	**Total Solids**	**mg/L**	**614**	**APHA 2540 B**
12	Fixed Dissolved Solid	mg/L	-	APHA 2540 E
13	**COD**	**mg/L**	**12**	**APHA, 5220 B**
14	**BOD (3 days, 27°C)**	**mg/L**	**2.7**	**IS 3025, 1993**
15	**Chloride**	**mg/L**	**194**	**APHA, 4500-CL-B**
16	**Total Alkalinity**	**mg/L**	**83**	**APHA 2320-B**
17	T. Hardness (as $CaCO_3$)	mg/L	-	APHA 2340-C
18	Ca Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Ca-B
19	Mg Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Mg-B
20	Oil & Grease	mg/L	-	APHA 5520-D
21	Total Kjehdal Nitrogen	mg/L	-	APHA 4500-Norg-C
22	Turbidity	N.T.U.	-	APHA, 2130-B
23	**Phosphate (as P)**	**mg/L**	**0.15**	**APHA 4500-P-D**
24	**Sulphate (as SO_4)**	**mg/L**	**72**	**APHA 4500-SO_4-E**
25	Ammo. Nitrogen (as NH_3)	mg/L	-	APHA 4500-NH_3-F
26	**Nitrite Nitrogen (as NO_2)**	**mg/L**	**0.07**	**APHA 4500-NO_2-B**
27	**Nitrate Nitrogen (as NO_3)**	**mg/L**	**0.26**	**APHA 4500-NO_3B**
28	Fluoride (as F)	mg/L	-	APHA 4500-F-D
29	Sodium (as Na)	mg/L	-	APHA 3500-Na-B
30	Potassium (as K)	mg/L	-	APHA 3500-K-B
31	Chromium (as Cr^{+6})	mg/L	-	APHA 3500-Cr B
32	Boron (as B)	mg/L	-	APHA 4500-B-C
33	**Faecal Coliform**	**MPN/100ml**	**120**	**APHA 9221-E**
34	**Total Coliform**	**MPN/100ml**	**430**	**APHA 9221-B**
35	Bioassay Test	% Survival	-	APHA 8910 A-C
36			-	
37			-	

Prepared by सुनील -

Laboratory Head

Milind Kumar Nimje
Laboratory Head

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Central Pollution Control Board
Regional Directorate (Central)
"Parivesh Bhawan"
Paryavaran Parisar, E-5, Arera Colony, Bhopal
EPA Recognised Lab
Test Report:Fresh Water (PhysicoChemical Parameter)

Project Name	NGT Case Aayard River, Udaipur, Rajasthan	Test Report No.	FW/23-24/29
Sample Description	Gumaniya Nallha at Krishnapura Gaon, Udaipur, Rajasthan	Requisition No.	67
Date of sample collection	12.08.2023	**Date**	18.08.2023
Date of sample receipt	14.08.2023	**Type of sample**	Grab
Date of analysis	14.08.2023 to 18.08.2023	**Sample collected by**	Dr. Anoop Chaturvedi (Sci. B) & Sunil Kolhatkar (SLA)

S.No.	Parameters	Unit	Result	Method
1	**Temperature**	°C	27	-
2	Odour	-	-	-
3	Appearance	-	-	-
4	**Colour**	**Pt-Co Scale**	**Clear**	**APHA, 2120-B**
5	Residual Chlorine	mg/L	-	APHA 4500-Cl-B
6	**Dissolved Oxygen**	**mg/L**	**8.01**	**APHA 4500-O-C**
7	**pH**	**pH unit**	7.71	**APHA, 4500H+B**
8	**Specific Conductivity**	**µmho/cm**	587	**APHA 2510 B**
9	**Suspended Solids**	**mg/L**	**14**	**APHA 2540 D**
10	**Total Dissolved Solids**	**mg/L**	**298**	**APHA 2540 C**
11	**Total Solids**	**mg/L**	**312**	**APHA 2540 B**
12	Fixed Dissolved Solid	mg/L	-	APHA 2540 E
13	**COD**	**mg/L**	16	**APHA, 5220 B**
14	**BOD (3 days, 27°C)**	**mg/L**	3.3	**IS 3025, 1993**
15	**Chloride**	**mg/L**	85	**APHA, 4500-CL-B**
16	**Total Alkalinity**	**mg/L**	53	**APHA 2320-B**
17	T. Hardness (as $CaCO_3$)	mg/L	-	APHA 2340-C
18	Ca Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Ca-B
19	Mg Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Mg-B
20	Oil & Grease	mg/L	-	APHA 5520-D
21	Total Kjehdal Nitrogen	mg/L	-	APHA 4500-Norg-C
22	Turbidity	N.T.U.	-	APHA, 2130-B
23	**Phosphate (as P)**	**mg/L**	**0.15**	**APHA 4500-P-D**
24	**Sulphate (as SO_4)**	**mg/L**	**31**	**APHA 4500-SO_4-E**
25	Ammo. Nitrogen (as NH_3)	mg/L	-	APHA 4500-NH_3-F
26	**Nitrite Nitrogen (as NO_2)**	**mg/L**	**0.05**	**APHA 4500-NO_2-B**
27	**Nitrate Nitrogen (as NO_3)**	**mg/L**	**0.21**	**APHA 4500-NO_3B**
28	Fluoride (as F)	mg/L	-	APHA 4500-F-D
29	Sodium (as Na)	mg/L	-	APHA 3500-Na-B
30	Potassium (as K)	mg/L	-	APHA 3500-K-B
31	Chromium (as Cr^{+6})	mg/L	-	APHA 3500-Cr B
32	Boron (as B)	mg/L	-	APHA 4500-B-C
33	**Faecal Coliform**	**MPN/100ml**	**150**	**APHA 9221-E**
34	**Total Coliform**	**MPN/100ml**	**540**	**APHA 9221-B**
35	Bioassay Test	% Survival	-	APHA 8910 A-C
36				
37				

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Laboratory Head

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Regional Directorate (Central)
"Parivesh Bhawan"
Paryavaran Parisar, E-5, Arera Colony, Bhopal
EPA Recognised Lab

Test Report:Fresh Water (PhysicoChemical Parameter)

F/LAB/06/TR-01

Project Name	NGT Case Aayard River, Udaipur, Rajasthan	Test Report No.	FW/23-24/30
Sample Description	Aayard River D/S Near Central Public school , Road Bridge, Udaipur, Rajasthan	Requisition No.	67
Date of sample collection	12.08.2023	**Date**	18.08.2023
Date of sample receipt	14.08.2023	**Type of sample**	Grab
Date of analysis	14.08.2023 to 18.08.2023	**Sample collected by**	Dr. Anoop Chaturvedi (Sci. B) & Sunil Kolhatkar (SLA)

S.No.	Parameters	Unit	Result	Method
1	**Temperature**	^0C	**28**	-
2	Odour	-	-	-
3	Appearance	-	-	-
4	**Colour**	**Pt-Co Scale**	**clear**	**APHA, 2120-B**
5	Residual Chlorine	mg/L	-	APHA 4500-Cl-B
6	**Dissolved Oxygen**	**mg/L**	**8.14**	**APHA 4500-O-C**
7	**pH**	**pH unit**	**8.01**	**APHA, 4500H+B**
8	**Specific Conductivity**	**µmho/cm**	**1149**	**APHA 2510 B**
9	**Suspended Solids**	**mg/L**	**18**	**APHA 2540 D**
10	**Total Dissolved Solids**	**mg/L**	**571**	**APHA 2540 C**
11	**Total Solids**	**mg/L**	**571**	**APHA 2540 B**
12	Fixed Dissolved Solid	mg/L	-	APHA 2540 E
13	**COD**	**mg/L**	**12**	**APHA, 5220 B**
14	**BOD (3 days, 27°C)**	**mg/L**	**3.7**	**IS 3025, 1993**
15	**Chloride**	**mg/L**	**189**	**APHA, 4500-CL-B**
16	**Total Alkalinity**	**mg/L**	**82**	**APHA 2320-B**
17	T. Hardness (as $CaCO_3$)	mg/L	-	APHA 2340-C
18	Ca Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Ca-B
19	Mg Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Mg-B
20	Oil & Grease	mg/L	-	APHA 5520-D
21	Total Kjehdal Nitrogen	mg/L	-	APHA 4500-Norg-C
22	Turbidity	N.T.U.	-	APHA, 2130-B
23	**Phosphate (as P)**	**mg/L**	**0.16**	**APHA 4500-P-D**
24	**Sulphate (as SO_4)**	**mg/L**	**94**	**APHA 4500-SO_4-E**
25	Ammo. Nitrogen (as NH_3)	mg/L	-	APHA 4500-NH_3-F
26	**Nitrite Nitrogen (as NO_2)**	**mg/L**	**0.07**	**APHA 4500-NO_2-B**
27	**Nitrate Nitrogen (as NO_3)**	**mg/L**	**0.25**	**APHA 4500-NO_3B**
28	Fluoride (as F)	mg/L	-	APHA 4500-F-D
29	Sodium (as Na)	mg/L	-	APHA 3500-Na-B
30	Potassium (as K)	mg/L	-	APHA 3500-K-B
31	Chromium (as Cr^{+6})	mg/L	-	APHA 3500-Cr B
32	Boron (as B)	mg/L	-	APHA 4500-B-C
33	**Faecal Coliform**	**MPN/100ml**	**120**	**APHA 9221-E**
34	**Total Coliform**	**MPN/100ml**	**540**	**APHA 9221-B**
35	Bioassay Test	% Survival	-	APHA 8910 A-C
36			-	
37			-	

Prepared by:

Laboratory Head

Milind Kumar Nimje
Laboratory Head

Central Pollution Control Board
Regional Directorate (Central)
"Parivesh Bhawan"
Paryavaran Parisar, E-5, Arera Colony, Bhopal
EPA Recognised Lab
Test Report: Waste Water (PhysicoChemical Parameter)

Project Name	NGT Case Aayard River, Udaipur, Rajasthan	**Test Report No.**	FW/23-24/62
Sample Description	M/s 5 MLD, STP, Karzali, Udaipur, Rajasthan	**Requisition No.**	90
Date of sample collection	12.08.2023	**Date**	18.08.2023
Date of sample receipt	14.08.2023	**Type of sample**	Grab
Date of analysis	14.08.2023 to 18.08.2023	**Sample collected by**	Dr. Anoop Chaturvedi (Sci. B) & Sunil Kolhatkar (SLA)

S.No.	Parameters	Unit	Result	Method	
1	Temperature	°C	-	-	
2	Odour	-	-	-	
3	Appearance	-	-	-	
4	Colour	Pt-Co Scale	-	APHA, 2120-B	
5	Residual Chlorine	mg/L	-	APHA 4500-Cl-B	
6	Dissolved Oxygen	mg/L	-	APHA 4500-O-C	
7	**pH**	**pH unit**	7.59	**APHA, 4500H+B**	
8	Specific Conductivity	µmho/cm	-	APHA 2510 B	
9	**Suspended Solids**	**mg/L**	12	**APHA 2540 D**	
10	Total Dissolved Solids	mg/L	-	APHA 2540 C	
11	Total Solids	mg/L	-	APHA 2540 B	
12	Fixed Dissolved Solid	mg/L	-	APHA 2540 E	
13	**COD**	**mg/L**	14	**APHA, 5220 B**	
14	**BOD (3 days, 27°C)**	**mg/L**	2.3	**IS 3025, 1993**	
15	Chloride	mg/L	-	APHA, 4500-CL-B	
16	Total Alkalinity	mg/L	-	APHA 2320-B	
17	T. Hardness (as $CaCO_3$)	mg/L	-	APHA 2340-C	
18	Ca Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Ca-B	
19	Mg Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Mg-B	
20	Oil & Grease	mg/L	-	APHA 5520-D	
21	Total Kjehdal Nitrogen	mg/L	-	APHA 4500-Norg-C	
22	Turbidity	N.T.U.	-	APHA, 2130-B	
23	Phosphate (as P)	mg/L	-	APHA 4500-P-D	
24	Sulphate (as SO_4)	mg/L	-	APHA 4500-SO_4-E	
25	Ammo. Nitrogen (as NH_3)	mg/L	-	APHA 4500-NH_3-F	
26	Nitrite Nitrogen (as NO_2)	mg/L	-	APHA 4500-NO_2-B	
27	Nitrate Nitrogen (as NO_3)	mg/L	-	APHA 4500-NO_3B	
28	Fluoride (as F)	mg/L	-	APHA 4500-F-D	
29	Sodium (as Na)	mg/L	-	APHA 3500-Na-B	
30	Potassium (as K)	mg/L	-	APHA 3500-K-B	
31	Chromium (as Cr^{+6})	mg/L	-	APHA 3500-Cr B	
32	Boron (as B)	mg/L	-	APHA 4500-B-C	
33	**Faecal Coliform**	**MPN/100ml**	12	**APHA 9221-E**	
34	**Total Coliform**	**MPN/100ml**	94	**APHA 9221-B**	
35	Bioassay Test	% Survival	-	APHA 8910 A-C	
36			-		
37			-		

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Laboratory Head

Milind Kumar Nimj
Laboratory Head

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Paryavaran Parisar, E-5, Arera Colony, Bhopal
EPA Recognised Lab

F/LAB/06/TR-01

Test Report:Fresh Water (PhysicoChemical Parameter)

Project Name	NGT Case Aayard River, Udaipur, Rajasthan	**Test Report No.**	FW/23-24/31
Sample Description	Handpump of Near CP school, Sandeshwar Mahadev Temple, Udaipur, Rajasthan	**Requisition No.**	67
Date of sample collection	12.08.2023	**Date**	18.08.2023
Date of sample receipt	14.08.2023	**Type of sample**	Grab
Date of analysis	14.08.2023 to 18.08.2023	**Sample collected by**	Dr. Anoop Chaturvedi (Sci. B) & Sunil Kolhatkar (SLA)

S.No.	Parameters	Unit	Result	Method
1	**Temperature**	^{o}C	**28**	-
2	Odour	-	-	-
3	Appearance	-	-	-
4	**Colour**	**Pt-Co Scale**	**less Turbidit**	**APHA, 2120-B**
5	Residual Chlorine	mg/L	-	APHA 4500-Cl-B
6	Dissolved Oxygen	mg/L	-	APHA 4500-O-C
7	**pH**	**pH unit**	**7.05**	**APHA, 4500H+B**
8	**Specific Conductivity**	**µmho/cm**	**938**	**APHA 2510 B**
9	**Suspended Solids**	**mg/L**	**18**	**APHA 2540 D**
10	**Total Dissolved Solids**	**mg/L**	**474**	**APHA 2540 C**
11	**Total Solids**	**mg/L**	**492**	**APHA 2540 B**
12	Fixed Dissolved Solid	mg/L	-	APHA 2540 E
13	**COD**	**mg/L**	**4**	**APHA, 5220 B**
14	BOD (3 days, $27^{o}C$)	mg/L	-	IS 3025, 1993
15	**Chloride**	**mg/L**	**97**	**APHA, 4500-CL-B**
16	**Total Alkalinity**	**mg/L**	**89**	**APHA 2320-B**
17	T. Hardness (as $CaCO_3$)	mg/L	-	APHA 2340-C
18	Ca Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Ca-B
19	Mg Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Mg-B
20	Oil & Grease	mg/L	-	APHA 5520-D
21	Total Kjehdal Nitrogen	mg/L	-	APHA 4500-Norg-C
22	Turbidity	N.T.U.	-	APHA, 2130-B
23	**Phosphate (as P)**	**mg/L**	**0.11**	**APHA 4500-P-D**
24	**Sulphate (as SO_4)**	**mg/L**	**67**	**APHA 4500-SO_4-E**
25	Ammo. Nitrogen (as NH_3)	mg/L	-	APHA 4500-NH_3-F
26	**Nitrite Nitrogen (as NO_2)**	**mg/L**	**0.06**	**APHA 4500-NO_2-B**
27	**Nitrate Nitrogen (as NO_3)**	**mg/L**	**0.14**	**APHA 4500-NO_3B**
28	Fluoride (as F)	mg/L	-	APHA 4500-F-D
29	Sodium (as Na)	mg/L	-	APHA 3500-Na-B
30	Potassium (as K)	mg/L	-	APHA 3500-K-B
31	Chromium (as Cr^{+6})	mg/L	-	APHA 3500-Cr B
32	Boron (as B)	mg/L	-	APHA 4500-B-C
33	**Faecal Coliform**	**MPN/100ml**	**<1.8**	**APHA 9221-E**
34	**Total Coliform**	**MPN/100ml**	**17**	**APHA 9221-B**
35	Bioassay Test	% Survival	-	APHA 8910 A-C
36				
37				

Prepared by:

Laboratory Head

Milind Kumar Nimje
Laboratory Head

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F/LAB/06/TR-01

Central Pollution Control Board
Regional Directorate (Central)
"Parivesh Bhawan"
Paryavaran Parisar, E-5, Arera Colony, Bhopal
EPA Recognised Lab

Test Report:Fresh Water (PhysicoChemical Parameter)

Project Name	NGT Case Aayard River, Udaipur, Rajasthan	Test Report No.	FW/23-24/32
Sample Description	Borewell of Near Girls Hostel, Patori Marg Seva Aashram Circle, Udaipur, Rajasthan	Requisition No.	67
Date of sample collection	12.08.2023	Date	18.08.2023
Date of sample receipt	14.08.2023	Type of sample	Grab
Date of analysis	14.08.2023 to 18.08.2023	Sample collected by	Dr. Anoop Chaturvedi (Sci. B) & Sunil Kolhatkar (SLA)

S.No.	Parameters	Unit	Result	Method
1	**Temperature**	°C	27	-
2	Odour	-	-	-
3	Appearance	-	-	-
4	**Colour**	**Pt-Co Scale**	**Clear**	**APHA, 2120-B**
5	Residual Chlorine	mg/L	-	APHA 4500-Cl-B
6	Dissolved Oxygen	mg/L	-	APHA 4500-O-C
7	**pH**	**pH unit**	**7.07**	**APHA, 4500H+B**
8	**Specific Conductivity**	**µmho/cm**	**1286**	**APHA 2510 B**
9	**Suspended Solids**	**mg/L**	**14**	**APHA 2540 D**
10	**Total Dissolved Solids**	**mg/L**	**642**	**APHA 2540 C**
11	**Total Solids**	**mg/L**	**656**	**APHA 2540 B**
12	Fixed Dissolved Solid	mg/L	-	APHA 2540 E
13	**COD**	**mg/L**	**4**	**APHA, 5220 B**
14	BOD (3 days, 27°C)	mg/L	-	IS 3025, 1993
15	**Chloride**	**mg/L**	**203**	**APHA, 4500-CL-B**
16	**Total Alkalinity**	**mg/L**	**92**	**APHA 2320-B**
17	T. Hardness (as $CaCO_3$)	mg/L	-	APHA 2340-C
18	Ca Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Ca-B
19	Mg Hardness (as $CaCO_3$)	mg/L	-	APHA 3500-Mg-B
20	Oil & Grease	mg/L	-	APHA 5520-D
21	Total Kjehdal Nitrogen	mg/L	-	APHA 4500-Norg-C
22	Turbidity	N.T.U.	-	APHA, 2130-B
23	**Phosphate (as P)**	**mg/L**	**0.13**	**APHA 4500-P-D**
24	**Sulphate (as SO_4)**	**mg/L**	**107**	**APHA 4500-SO_4-E**
25	Ammo. Nitrogen (as NH_3)	mg/L	-	APHA 4500-NH_3-F
26	**Nitrite Nitrogen (as NO_2)**	**mg/L**	**0.01**	**APHA 4500-NO_2-B**
27	**Nitrate Nitrogen (as NO_3)**	**mg/L**	**0.04**	**APHA 4500-NO_3B**
28	Fluoride (as F)	mg/L	-	APHA 4500-F-D
29	Sodium (as Na)	mg/L	-	APHA 3500-Na-B
30	Potassium (as K)	mg/L	-	APHA 3500-K-B
31	Chromium (as Cr^{+6})	mg/L	-	APHA 3500-Cr B
32	Boron (as B)	mg/L	-	APHA 4500-B-C
33	**Faecal Coliform**	**MPN/100ml**	<1.8	**APHA 9221-E**
34	**Total Coliform**	**MPN/100ml**	17	**APHA 9221-B**
35	Bioassay Test	% Survival	-	APHA 8910 A-C
36			-	
37			-	

Prepared by:

Laboratory Head

Milind Kumar Nimje
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