No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)
NATIONAL RIVER CONSERVATION DIRECTORATE (NRCD)
MINISTRY OF ENVIRONMENT AND FORESTS

THE STUDY
ON
WATER QUALITY MANAGEMENT PLAN
FOR
GANGA RIVER
IN
THE REPUBLIC OF INDIA

FINAL REPORT

VOLUME IV FEASIBILITY STUDY FOR PROJECT CITIES

VOLUME IV-4 FEASIBILITY STUDY FOR VARANASI CITY
PART I SEWERAGE SCHEME

JULY 2005

TOKYO ENGINEERING CONSULTANTS CO., LTD.
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ABBREVIATIONS

AD/MM	Average Day / Max Month
ADF	Average Daily Flow
ADWF	Average Dry Weather Flow
AIWSP	Advanced Integrated Wastewater Stabilization Ponds
AL	Aerated Lagoon
AS	Activated Sludge
ASR	Aquifer Storage and Recovery System
Avg	Average
AWT	Advanced Wastewater Treatment
BOD	Biochemical Oxygen Demand
CI	Cast Iron
CMS	Cubic Meter per Second
CO_2	Carbon Dioxide
CPCB	Central Pollution Control Board
CWR	Clear Water Reservoir
DLW	Diesel Locomotive Work
DO	Dissolved Oxygen
DPR	Detailed Project Report
ES	Equalization/Storage
FAB	Fluidised Aerated Bioreactor
F/S	Feasibility Study
FSA	Future Service Area
GAP	Ganga/Gomti Action Plan
GoAP	Gomti Action Plan
GIS	Geographical Information System
gpd	Grams per day
GOI	Government of India
GOJ	Government of Japan
GWI	Ground Water Infiltration
HDR	High-Density Residential
HP	Horse Power
I/I	Infiltration/Inflow
ISC	Indian Standard Code
JICA	Japan International Cooperation Agency
JS	Jal Sansthan
KVA	Kilo Volt Ampere
LDR	Low-Density Residential
lpcd	Litres per capita per day
lpm	Litres per minute
lps	Litres per second
MC	Municipal Corporation
MDR	Medium-Density Residential
mg/l	Milligrams per Litre
ML	Million Litres
mld	Million Litres per Day
MLSS	Mixed Liquor Suspended Solids
M/P	Master Plan
MPN	Most Probable Number per 100 ml
MPS	Main Sewage Pumping Station
MPS	Meter per Second
MUD	Ministry of Urban Development
MoEF	Ministry of Environment and Forests
N/A	Not Available
NBC	National Building Code
NH_3-N	Ammonia-Nitrogen
NRCD	National River Conservation Directorate
NSA	Non Sewerage Area
O&M	Operations and Maintenance
PDWF	Peak Dry Weather Flow
PFR	Project Feasibility Report
PS	Pumping Station
PSC	Pre-Stressed Concrete
RAS	Return Activated Sludge
SMF	Sankat Mochan Foundation
SPS	Sewage Pumping Station
SS	Suspended Solids
SSO	Sanitary Sewer Overflow
STP	Sewage Treatment Plant
TDS	Total Dissolved Solids
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UASB	Up flow Anaerobic Sludge Blanket
UFW	Unaccounted for Water
UPJN	Uttar Pradesh Jal Nigam
UPPCB	Uttar Pradesh Pollution Control Board
USAID	United States Agency for International Development
UV	Ultra Violet
VCP	Vitrified Clay Pipe
WAS	Waste Activated Sludge
WRF	Water Reclamation Facility
WSP	Waste Stabilization Pond
WTP	Water Treatment Plant
YAP	Yamuna Action Plan

GLOSSARY OF TERMS

***Aerated Lagoons**:* Like WSPs but with mechanical aeration. Oxygen requirement mostly from aeration and hence more complicated and higher O&M costs requires less land than WSP.

Activated-Sludge Process: A biological wastewater treatment process in which a mixture of wastewater and biologically enriched sludge is aerated to facilitate aerobic decomposition by microbes.

Advance Wastewater Treatment: Treatment process designed to remove pollutants that are not adequately removed by conventional secondary treatment processes.

Aeration: The addition of air or oxygen to water or wastewater, usually by mechanical means, to increase dissolved oxygen levels and maintain aerobic conditions.

Anaerobic Digestion: Sludge stabilization process in which the organic material in biological sludge is converted to methane and carbon dioxide in an airtight reactor.

Assimilative Capacity: The ability of a water body to receive wastewater and toxic materials without deleterious effects on aquatic life or the humans who consume the water.

Average Daily Flow: The total flow past a physical point over a period of time divided by the number of days in that period.

Biochemical Oxygen Demand (BOD): A standard measure of wastewater strength that quantifies the oxygen consumed in a stated period of time, usually 5 days and at $20^{o}C$.

Biological Process: The process by which the metabolic activities of bacteria and other micro organisms break down complex organic materials to simple, more stable substances.

Bio solids: Solid organic matter recovered from municipal wastewater treatment that can be beneficially used, especially as a fertilizer. *Bio solids* are solids that have been stabilized within the treatment process, whereas sludge has not.

Chlorination: The addition of chlorine to water or wastewater, usually for the purpose of disinfection.

Coliform Bacteria: Rod shaped bacteria from intestinal track of man used as an indication that pathogenic organisms may also be present.

Collection System: In wastewater, a system of conduits, generally underground pipes, that receives and conveys sanitary wastewater and/or storm water. In water supply, a system of conduits or canals used to capture a water supply and convey it to a common point.

Composting: Stabilization process relying on the aerobic decomposition of organic matter in sludge by bacteria and fungi.

Dechlorination: The partial or complete reduction of residual chlorine by any chemical or physical process.

Design Storm: The magnitude of a storm on which the design of a system and/or facility is based; usually expressed in terms of the probability of an occurrence over a period of years.

Diffused-Air Aeration: The introduction of compressed air to water by means of submerged diffusers or nozzles.

***Digester**:* A tank or vessel used for sludge digestion.

Disinfection: The selective destruction of disease-causing microbes through the application of chemicals or energy.

Diurnal: A daily fluctuation in flow or composition that is of similar pattern from one 24-hour period to another.

Effluent: Partially or completely treated water or wastewater flowing out of a basin or treatment plant.

Fine-Bubble Aeration: Method of diffused aeration using fine bubbles to take advantage of their high surface areas to increase oxygen-transfer rate.

Fixed Film Process: Biological wastewater treatment process whereby the microbes responsible for conversion of the organic matter in wastewater are attached to an inert medium such as rock or plastic material. Also called *attached-growth process.*

Force Main: The pipeline through which flow is transported from a point of higher pressure to a point of lower pressure.

Friction Factor: A measure of the resistance to liquid flow that results from the wall roughness of a pipe or channel.

Gravity Thickening: A process that uses a sedimentation basin designed to operate at high solid loading rate, usually with vertical pickets mounted to revolving sludge scrapers to assist in releasing entrained water.

Grit Chamber: A settling chamber used to remove grit from organic solids through sedimentation or an air-induced spiral agitation.

Head Loss: The difference in water level between the upstream and downstream sides of a conduit or a treatment process attributed to friction losses.

Headworks: The initial structure and devices located at the receiving end of a water or wastewater treatment plant.

Infiltration: Water entering a sewer system through broken or defective sewer pipes, service connections, or manhole walls.

Influent: Water or wastewater flowing to a basin or treatment plant.

Invert: The lowest point of the internal surface of a drain, sewer, or channel at any cross section.

Land Application: The disposal of wastewater or municipal solids onto land under controlled conditions.

Lift Station: A chamber that contains pumps, valves, and electrical equipment necessary to pump water or wastewater.

Methane: A colourless, odourless combustible gas that is the principal by-product of anaerobic decomposition or organic matter in wastewater. Chemical formula is CH_4.

Mixed Liquid Suspended Solids (MLSS): Suspended solids in the mixture of wastewater and activated sludge undergoing aeration in the aeration basin.

Nitrification: Biological process in which ammonia is converted first to nitrite and then to nitrate.

Nutrient: Any substance that is assimilated by organisms to promote or facilitate their growth.

Pathogen: Highly infectious, disease-producing microbes commonly found in sanitary wastewater.

Peak Flow: Excessive flows experienced during hours of high demand; usually determined to be the highest 2-hour flow expected under any operational conditions.

Preliminary Treatment: Treatment steps including screening, grit removal, preparation, and/or flow equalization that prepare wastewater influent for further treatment.

Pump Station: (see lift station)

Primary Clarifier: Sedimentation basin that precedes secondary wastewater treatment.

Primary Treatment: Treatment steps including sedimentation and/or fine screening to produce an effluent suitable for biological treatment.

Rising Main : (see force main)

Reclaimed Wastewater: Wastewater treated to a level that allows its reuse for a beneficial purpose.

Return Activated Sludge (RAS): Settled activated sludge that is returned to mix with raw or primary settled wastewater.

Sanitary Sewer Overflow (SSO): Overloaded operating condition of a sanitary sewer that results from inflow/infiltration.

Screening: (1) A treatment process using a device with uniform openings to retain coarse solids. (2) A preliminary test method used to separate according to common characteristics.

Scum: Floatable materials found on the surface of primary and secondary clarifiers consisting of food wastes, grease, fats, paper, foam, and similar matter.

Secondary Clarifier: A clarifier following a secondary treatment process and designed for gravity removal of suspended matter.

Secondary Treatment: The treatment of wastewater through biological oxidation after primary treatment.

Sludge: Accumulated and concentrated solids generated within the wastewater treatment process that have not undergone a stabilization process.

Sludge Dewatering: The removal of a portion of the water contained in sludge by means of a filter press, centrifuge, or other mechanism.

Sludge Stabilization: A treatment process used to convert sludge to a stable product for ultimate disposal or use and to reduce pathogens to produce a less odorous product.

Suspended-Growth Process: Biological wastewater treatment process in which the microbes and substrate are maintained in suspension within the liquid.

Thickening: A procedure used to increase the solids content of sludge by removing a portion of the liquid.

Trickling Filters: Sewage passes down through a loose bed of stones, and the bacteria on the surface of the stones treats the sewage. An aerobic process in which bacteria take oxygen from the atmosphere (no external mechanical aeration). Has moving parts, which often break down.

Total Suspended Solids (TSS): The measure of particulate matter suspended in a sample of water or wastewater. After filtering a sample of a known volume, the filter is dried and weighed to determine the residue retained.

Waste Activated Sludge (WAS): Excess activated sludge that is discharged from an activated-sludge treatment process.

Wetlands Treatment: A wastewater treatment system using the aquatic root system of cattails, reeds, and similar plants to treat wastewater applied either above or below the soil surface.

Waste Stabilization Pond: Large surface area ponds that provide treatment essentially by action of sunlight, encouraging algal growth which provides the oxygen requirement for bacteria to oxidize the organic waste. Requires significant land area, but one of the few processes which is effective at treating pathogenic material. Natural process with no power/oxygen requirement. Often used to provide water of sufficient quality for irrigation, and very suited to hot, sunny climates.

UASB: Anaerobic process using blanket of bacteria to absorb polluting load. Suited to hot climates. Produces

little sludge, no oxygen requirement or power requirement, but produces a poorer quality effluent than processes such as ASP. (NOTE: other anaerobic processes exist, but UASB is the most common at present).

Collection System Terminology

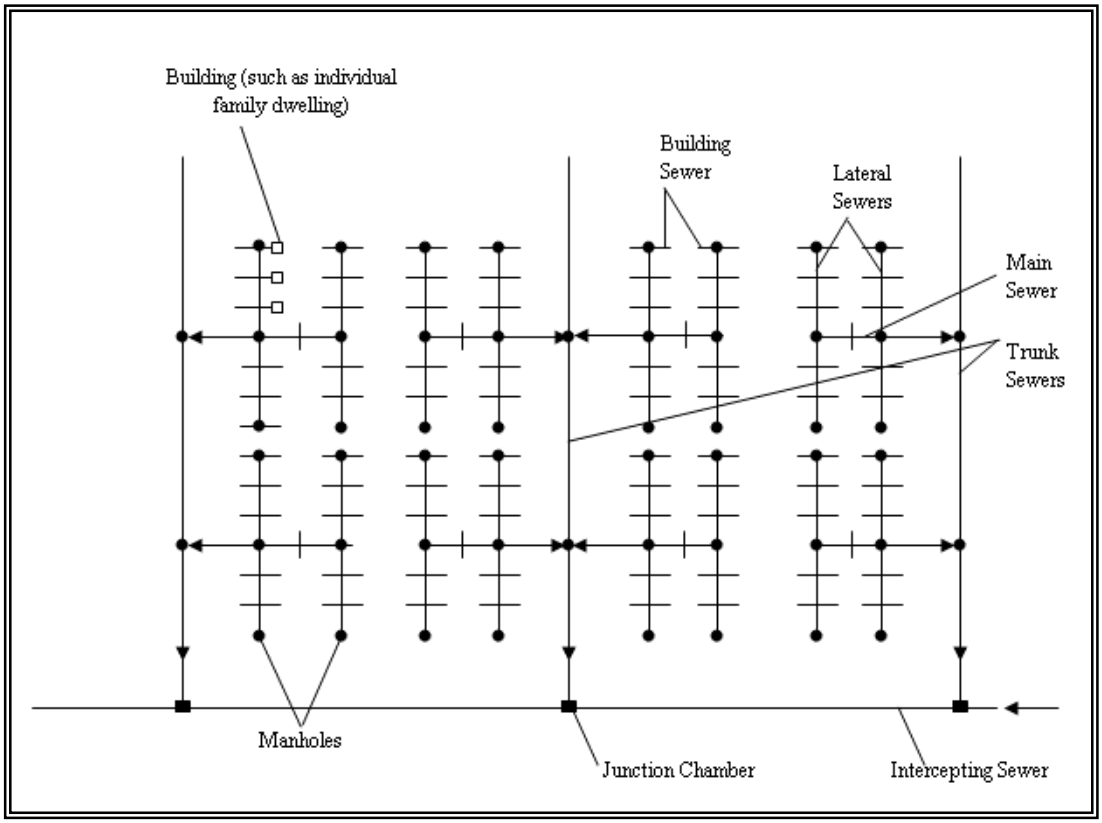
1. ***Interceptor Sewer:*** A sewer that receives flow from a number of other sewers or outlets for disposal or conveyance to a treatment plant.

2. ***Manhole:*** An opening in a vessel or sewer to permit human entry. Also called *manway.*

3. ***Trunk Sewer:*** Trunk sewers are large sewers that are used to convey wastewater from main sewers to treatment or other disposal facilities or to large intercepting sewers.

4. ***Main Sewer:*** Main sewers are used to convey wastewater from one or more lateral sewers to trunk sewers or to intercepting sewers.

5. ***Lateral Sewer:*** Lateral sewers form the first element of a wastewater collection system and are usually in streets or special easements. They are used to collect wastewater from one or more building sewers and convey it to a main sewers.



CHAPTER 1

INTRODUCTION

PART I SEWERAGE SCHEME

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

In response to a request from the Government of India, Japan International Cooperation Agency (JICA) has undertaken "The Study on Water Quality Management Plan for Ganga River in the Republic of India". The objectives of the Study are:

i. To formulate the Master Plan (M/P) for water quality management for Ganga River with the target year of 2030, focusing on Kanpur, Allahabad, Varanasi and Lucknow, and
ii. To carry out Feasibility Study (F/S) for the priority projects identified in the M/P.

To accelerate the implementation of projects and early realisation of M/P, the scope of work has provisions for selection of a city among the four cities as Priority City to carry out F/S.

The Study Team along with the Steering Committee, comprising Ministry of Environment and Forest, Department of Urban Development of Uttar Pradesh and other government agencies, has selected Varanasi as the Priority City. The selection was made comparing and evaluating several indicators, i.e. pollution impact on river, beneficiary, current sanitary conditions, cultural & religious importance of the River, etc.

The M/P for Varanasi has been formulated and the projects have been categorized into priority projects and urgent projects. The F/S for the identified priority and urgent projects has been carried out and the outcomes of the F/S are complied in this Report.

Major contents of the Sewerage M/P for Varanasi are as follows:

- Facility Plan including Cost Estimation and Implementation Plan
- Institutional Development Programme of Sewerage Sector
- Financial and Economic Evaluation of Proposed Projects
- Sanitary Education and Social Considerations (Public Participation / Awareness Programme)
- Initial Environmental Examination of Proposed Projects
- Selection of Priority Projects

1.2 PRIORITY SEWERAGE PROJECTS FOR FEASIBILITY STUDY

1.2.1 Selection of Sewerage Priority Projects

Sewerage priority projects are defined as projects that should be implemented as soon as possible to achieve pollution reduction targets. Projects that have already been sanctioned are not identified because funding is in place and it is assumed they will be fully implemented in the short term.

To select priority projects in M/P, following criteria were adopted.

- The projects selected are to contribute to significant improvement of water quality of rivers Ganga and Varuna
- Most of domestic wastewater discharging into the rivers are to be intercepted and treated by the year 2015
- Interceptor sewerage system is to be adopted as an immediate / intermediate measure and conventional sewerage system as a long term measure that requires considerable investment
- Internal or branch sewer is not to be included in priority projects
- Interceptor sewerage system is to be utilized in conventional sewerage system of future

development
- Upgrades and rehabilitation of existing major facilities are to be considered
- Required programmes to support and to properly operate & maintain the facilities constructed are to be considered.

1.2.2 Sewerage Priority Projects

The sewerage priority projects selected in M/P include:

- To Intercept wastewater in all major drains and sewer outfalls
- To convey collected wastewater to sewage treatment plant (STP)
- To treat wastewater at STP with appropriate technology and discharging effluent that comply with national effluent standards for STP

The following facilities have been identified in the Master Plan for the priority project and a further feasibility study, which should be implemented before 2015

(1) Ghat pumping station upgrades
- Review of sanctioned augmentation plan of Ghat Pumping Stations
- Determination of augmentation capacity for the F/S
- Planning of augmentation and rehabilitation

(2) Rehabilitation of STP at Dinapur and Sewage Pumping Station (SPS) at Konia

(3) Rehabilitation of STP at Bhagwanpur

(4) Operational plan for inspection and rehabilitation of main trunk sewer
- Preliminary inspection of existing main trunk sewer for cleaning and rehabilitation planning

(5) Relieving trunk sewer
- Extension of Relief Trunk Sewer from Sigra to Durgakund

(6) Chaukaghat main pumping station, and connection to Sathwa treatment plant
- Trunk main crossing under Varuna River
- Main Pumping Station
- Connection rising main
- Connection gravity trunk main

(7) Sathwa treatment plant
- Pumping facility
- Treatment plant
- Treated effluent drain to the local canal

(8) Varuna River interceptor sewer
- Left bank interceptor (up stream)
- Left bank interceptor (down stream)
- Right bank interceptor (up stream)
- Right bank interceptor (down stream)
- Interceptor for Samne Ghat and Nakkhi drains
- Secondary trunk sewers and connection facility to the interceptors

(9) Pump station at Narokhar drain and connection to Varuna River Interceptor
- Pumping Station at Narokhar drain

- Rising main

(10) Assi Nala Interceptor sewer
- Left bank interceptors
- Right bank interceptors
- Secondary trunk sewers and connection facility to the interceptors

(11) Secondary trunk sewers in all four sewerage districts
- Secondary trunk sewers under central sewage district & sub- central district

1.2.3 Scope of Works for Sewerage Feasibility Study

(1) Study Items

The scope of works for the F/S includes engineering services and to carry out required survey activities i.e. topographical survey and geo-technical survey. The following studies/ works have been carried out:

1) Review/ collection of existing documents,
2) Review of Master planning framework,
3) Assessing capacities of existing facilities,
4) Evaluation of design alternatives and determination of planning framework for F/S,
5) Detailed field survey for the F/S covering topographical survey and soil investigation,
6) Preliminary design and cost estimation for priority project of sewerage scheme,
7) Implementation planning
8) Organisation, operation & maintenance and human resource development plan,
9) Financial planning and evaluation, and
10) Formulation of work implementation plan

(2) Survey Works

Topographic and soil investigation surveys have to be conducted at designated locations in the proposed site. The results of this survey shall be used for obtaining topographic and geo-technical information, which is essential to design interceptor and trunk sewer, pumping station and treatment plant and to select the most appropriate construction technology respectively.

1) Preliminary Inspection of Existing Main Trunk Sewer

The existing main brick trunk sewer from Assi to Rajghat was constructed in 1917 and is the main lifeline of the sewerage system of Varanasi. The works of the GAP-I are dependent on functioning of the existing trunk sewer. Preliminary investigation of the trunk main is proposed under F/S to prepare a comprehensive cleaning, inspection and rehabilitation plan. Following activities are proposed under preliminary inspection of trunk sewer:

- Identification of sewer alignment and manholes
- Sewer alignment level survey.
- Manhole survey
- Preparation of drawings and manhole database

2) Topographical Survey

The objective of the investigation is to obtain topographic information, which is necessary to design interceptor and trunk sewer, pumping station and treatment plant. Following topographic survey shall be carried out at the designated locations in the Proposed Site.

- Levelling Survey on land, structure and water level of designated locations.
- Levelling Survey shall be carried out, by direct levelling at the proposed points, to show the ground level contour lines at one (1) meter intervals.
- Plane Survey on land of designated locations for the proposed sites of pumping stations and sewerage treatment plan.

The survey works are divided in the following two sub-schedules:

Sub-schedule (A): Plane and Longitudinal Survey of Proposed Pipeline Route
Sub-schedule (B): Levelling and Plane Survey of Propose Facility (PS and STP)

Sub schedule (A): Plane and Longitudinal Survey of Proposed Pipeline Route

- Assi Nala left and right bank interceptor sewer
- Pipeline crossing the Varuna River
- Varuna River left and right bank interceptor
- Connecting rising main between Narokhar Nala PS and Varuna River interceptor
- Secondary trunk sewers (only longitudinal survey shall be conducted)
- Rising main and gravity trunk sewer between Chaukaghat MPS and Sathwa STP
- Treated effluent drain between the Sathwa STP and the local canal near the STP

Sub schedule (B): Levelling and Plane Survey of Propose Facility (PS and STP)

- Site of Chaukaghat Main Pumping Station
- Site of Narokhar Nala Pumping Station
- Site of Sathwa STP
- Site of five (5) Ghat Pumping Stations including supplemental level survey of pumping station structure

3) Geo-technical Survey

Following geo-technical investigation shall be carried out at the designated locations along the sewer alignments and at pumping stations and sewage treatment plant site.

Sub-schedule (A): Boring
Sub-schedule (B) : Standard Penetration Test (SPT)
Sub-schedule (C) : Sampling and Laboratory Test

(3) Ghat Pumping Station Survey

The entire Ghat pumping stations constructed / refurbished under GAP-I are poorly maintained and need rehabilitation / capacity expansion. Following survey is proposed for data collection to facilitate the rehabilitation plan:

- Collection of available data
- Site survey for the preparation of layout plan, hydraulic flow diagram and general arrangement drawings
- Conditional assessment of mechanical and electrical equipment
- Assessment of present inflow condition.

CHAPTER 2

PRELIMINARY DESIGN AND COST ESTIMATION FOR SEWERAGE PRIORITY PROJECT

CHAPTER 2 PRELIMINARY DESIGN AND COST ESTIMATION FOR SEWERAGE PRIORITY PROJECT

2.1 PLANNING BASIS

2.1.1 Design Criteria

(1) Design Years

Master Plan (M/P) has identified a set of priority projects, which is proposed to be completed basically within five years after the adoption of M/P. Further, the capacity of Civil Works is sized for year 2030 and the capacity of mechanical and electrical works is planned for Year 2015 with provision for future expansion. Land requirements for sewage treatment works are based on year 2030. In Stage-I, STP capacity sufficient for Year 2015 will be implemented.

(2) Population Projections

Population projection forms the basis for estimation of capacity of the various engineering interventions. The ward wise population projected for Master Plan was reviewed and used in the feasibility study. The outcome of the review of the method adopted for population projection is as follows:

A detailed ward-wise population projection has been carried out in M/P. This has enabled to group the anticipated population into sewage zones, namely, FSA, NSA 1, NSA 2, Zone 1, Zone 2A, Zone 2B, Zone 2C and Zone 3.

It is clear that the ward wise growth rate has been used as a basis for population projection; however, it did not have the criteria or the assumption used for estimating the growth rates.

It is presumed that these growth rates are comparable with the growth rate of Varanasi Development Authority (VDA). This is because the growth rate depends on the anticipated development of a particular ward over the years and the prevailing development control regulations. VDA is the agency looking after the development activities and also responsible for formulation and implementation of development control regulations. The growth rate adopted can be reviewed further only if the criteria and/or assumptions used for projections are made available.

Population projections prepared in M/P are evaluated and agreed upon by UP Jal Nigam and NRCD. The details on the ward-wise population projections is included in the Annexure 2-1

(3) Wastewater Discharged

Wastewater discharged per capita is calculated using the proposed per capita water supply and is presented in Table 2.1.

Table 2.1 Per capita Sewage Generation

Particulars	Year 2003	Year 2015	Year 2030
Per capita water consumption (lpcd)	275	221	173
Return Factor	0.7	0.75	0.8
Per capita wastewater discharged (lpcd)	193	166	138
Including Infiltration allowance 10%	212 (215)	182 (185)	152 (155)

(4) Sewerage District

The sewerage system for Varanasi is planned in four different zones in the Master Plan. Table 2.2 presents the sewage zones proposed in Master Plan. A map of Zonal boundaries is presented in Figure 2.1.

Table 2.2 Sewage Zones Proposed in Master Plan

District I	Central Drainage Basin
District II	Covering Sub Central Drainage Basin (Zone IIA & IIB), Trans Varuna Drainage Basin (Zone IIC), FSA1, NSA1 and NSA2
District III	Covers Assi / BHU Drainage Basin and FSA4
District IV	Western Drainage Basin (FSA2 & FSA3)

These zones are planned to confirm to the topography and existing sewerage system in Varanasi. The characteristics of various sewerage zones are described below.

District I: Central City Sewerage District, the sewage generated from this area drains into Dinapur STP.

District II (Zone A+B): This district is further divided in to two zones namely Zone A, sub central district on the Cis-Varuna side west of the city centre and Zone B which is a slice of the Trans Varuna district along the Varuna river. Sewage generated in this area will be collected at the pumping stations proposed near Chaukaghat

District II (Zone C): This is the Trans Varuna district north of Jaunpur road. The sewage generated in this area to be collected and conveyed through the gravity line toward Sathwa STP and the Pumping Station proposed near Sathwa STP.

District III: It is BHU/Assi district south of the city. The sewage generated in this area follows the natural drains flowing into Nagwa Nala.

District IV: Covers service areas outside the current Municipal Corporation limits.

District wise population projection and wastewater discharged by 5 year-intervals is presented in Table 2.3.

Table 2.3 District Wise Population Projection and Wastewater Discharged

(mld)

	2003	**2015**	**2030**
Wastewater discharge rate	215 lpcd	185 lpcd	155 lpcd
Sewer service area			
District I	110.2	103.7	93.7
District II	115.0	148.3	174.1
District III	31.9	54.2	73.5
District IV	17.1	32.0	45.1
Sub-total	274.2	338.2	386.4
Non sewer areas			
NSA 1	9.3	17.2	33.4
NSA 2	5.1	10.6	17.8
Cantonment	3.8	3.2	2.7
Sub-total	18.2	31.0	53.9
Total	292.3	369.2	440.3

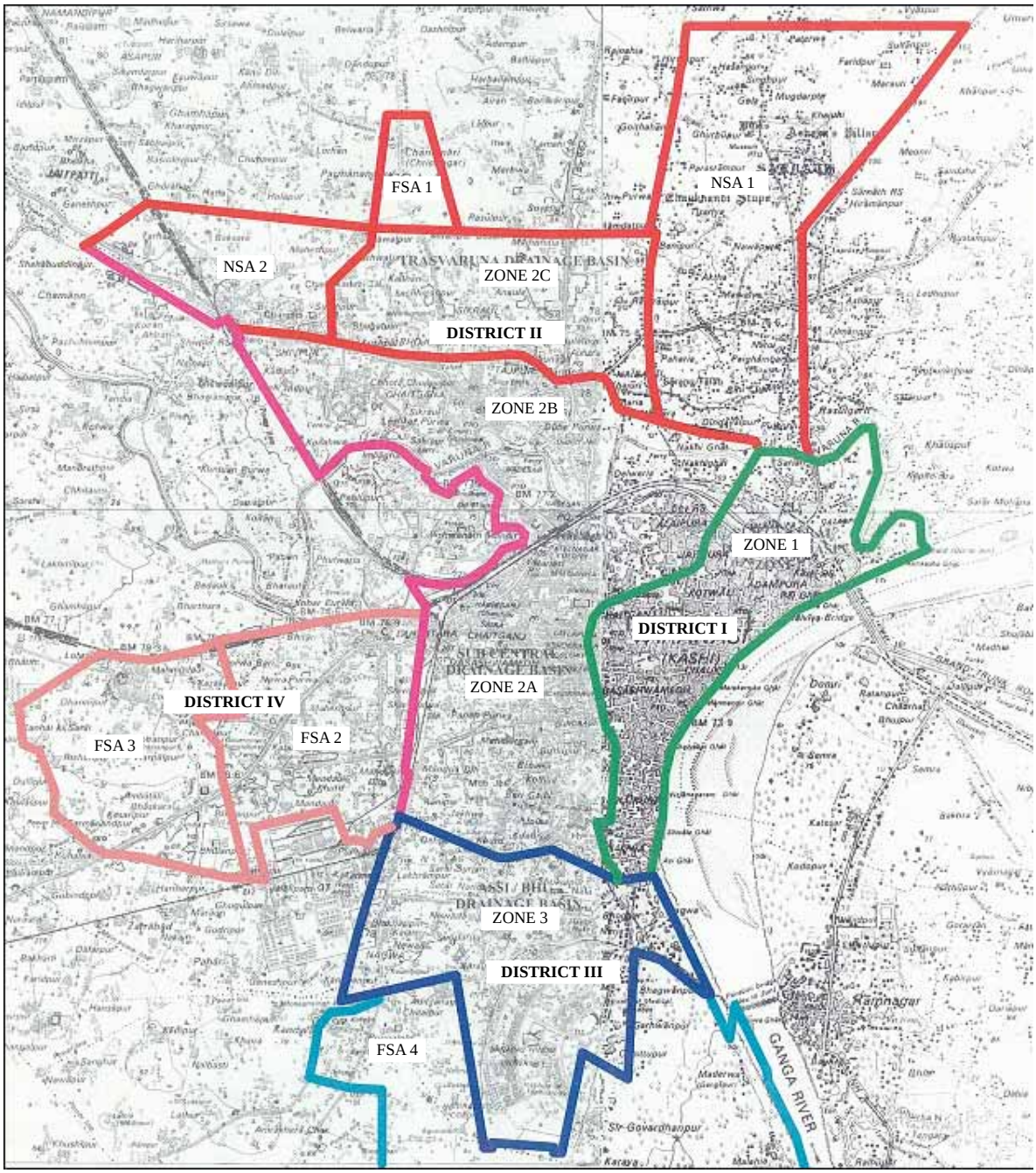


Figure 2.1 Sewerage District Boundary and Existing Facility

(5) Existing Sewerage System

1) Old Main Trunk Sewer (District I)

The sewerage system in Varanasi was commissioned in the Year 1917 (Old Main Trunk Sewer). This sewer begins at Assi and passes thorough thickly populated areas of the town viz. Central Drainage Zone and used to discharge untreated sewage into River Ganga, nearly 400 meters downstream of Malviya Bridge. It is a circular brick sewer in lime mortar of 7 km length. Its size varies from 750 mm to 2400 mm diameter.

In GAP I, this untreated sewage was diverted to Konia MPS, from where it was pumped and treated at Dinapur STP. The capacity of Dinapur STP is 80 mld, however the Konia MPS receives around 130 MLD of sewage. Presently, this excess flow of sewage is diverted to River Ganga with a gate arrangement provided in a Special Manhole.

In the absence of any interceptor sewer, in Sub Central Drainage Basin (District II), the sewage flow of this area is not fully defined. A part of sewage from District II is discharged into Old Main Trunk Sewer and remaining flow is discharged into River Varuna through storm water drains.

2) Orderly Bazaar Sewer (District I and II)

Orderly Bazaar Sewer was commissioned in Year 1917 along with Old Main Trunk Sewer. This sewer was laid from Collectorate's office and, earlier, connected to old Main Trunk Sewer after crossing the Varuna River and railway line. In 1946, bridge supporting this line across Varuna River was washed away in the floods resulting in the discharge of untreated sewage into Varuna River.

3) Ghat Intercepting Sewer (District I)

The Ghat Intercepting sewers were constructed in 1971 for the purpose of sewage discharge to the River Ganga from a number of old drains between Meer Ghat and Trilochan Ghat. It consists of 300 mm dia CI pipe of 1184 m length and the outfall of this sewer was at Trilochan Ghat. The interceptor sewer serves the Ghat portion of the town on bank of river that cannot be drained into the Old Main Trunk Sewer.

Several branch sewers and laterals have been laid from time to time. It is assessed that the total length of sewer network in city is about 400 kms.

Under GAP I, interception and diversion works of following six major drains on western bank of River Ganga was carried out, through five Ghat pumping stations. These pumping stations lift sewage into Old Main Trunk Sewer.

- Shiwala Ghat Drain
- Harischandra Ghat Drain
- Mansarovar Drain
- Ghora Nala (Dr. R. P. Ghat Drains)
- Jalesan Drain
- Trilochan Drain

4) Existing Pumping Stations

<u>Ghat Pumping Stations (District I)</u>

Under GAP I, a new pumping station was added at Mansarovar Ghat and the other four existing pumping stations along the left bank of River Ganga were upgraded, by UP Jal Nigam.

Assi Main Pumping Station (District II)

Under GAP-I, a pumping station was installed for interception and diversion of sewage flowing through Assi Nala. The sewage is being lifted and pumped to Bhagwanpur STP from Assi Nala. The details of this pumping station are given in Table 2.4.

Table 2.4 Details of Assi SPS

Installed capacity	833 lps
Installed pumps	3 x 50 HP – 5,000 lpm @ 24 m head 1 x 22.5 HP – 3,000 lpm @ 15 m head
Diesel Generating Sets	1 x 70 kVA
Rising Main	400 mm dia PSC

Konia Main Pumping Station (District I)

100 MLD MPS was constructed under GAP-I at village Konia. This MPS was constructed to lift sewage from Old Main Trunk sewer to Dinapur STP. In this MPS, pumping is carried out in two stages, three screw pumps in first stage followed by a set of centrifugal pumps in second stage. The sewage lifted by screw pumps passes through screening and grit removal units. The existing facilities in Konia MPS are presented in Table 2.5.

Table 2.5 Existing Facilities in Konia MPS

Konia MPS First Stage	
Installed capacity	3 x 1,158 = 3474 lps
Installed pumps	3 x 215 HP – 1,158 lps @ 8.51 m head
Pre-treatment Units	
Screens	2 nos. mechanically operated – 50 MLD each
	1 no. manually operated – 50 MLD
Detritor	2 nos. of 100 MLD each
Konia MPS Second Stage	
Dimensions	32 m x 6 m
Installed capacity	3480 lps
Installed pumps	3 x 215 HP – 740 lps @ 8.51 m head 3 x 150 HP – 420 lps @ 8.51 m head
Diesel Generating Sets	4 x 500 kVA
Rising Main	1200 mm dia PSC (New) 900 mm dia Hume Steel (Old)

5) Existing Sewage Treatment Facilities

In total there are four STPs in Varanasi, to treat the sewage generated in the city. Among these four STPs, three are constructed under the GAP-I and are, presently, maintained by UPJN. The fourth STP of 1.8 MLD, Lalpur STP lies outside the project area, which serves the area covered under the Lalpur Town planning scheme Phase-I. This STP is maintained by VDA. Table 2.6 presents the source of sewage, design capacity of this STP.

Table 2.6 Existing STPs in Varanasi

(mld)

Sr.	Location	Source of sewage	Design capacity	Amount of sewage received	District
1	Dinapur	Konia MPS	80	100	Outside of the City limit
2	Bhagwanpur / BHU	Assi pumping station and BHU campus	8	12	District III
3	DLW	DLW campus	12	6	Outside of the City limit
4	Lalpur	Lalpur Town Planning Scheme Phase I	1.8	Nil*	Outside of the City limit

* The plant was not in operation during the site visit made by JICA Study Team.

2.1.2 Design Basis for Sewer Network

(1) Peak Factors

Based on the recommended values of peak factor as per CPHEEO's Manual on Sewerage and Sewage Treatment, the peak factors adopted for contributory populations of drainage area are given in Table 2.7. Depending on the contributory population, the peak factor changes - it being higher for less population and low for high population.

Table 2.7 Peak Factors Considered for Sewage Design

Contributory Population	Peak Factor as per CPHEEO Manual
Up to 20,000	3.00
20,000 - 50,000	2.50
50,000 - 7,50,000	2.25
Above 7,50,000	2.00

(2) Hydraulics of Sewers

For design purposes, the flow of sewage in pipes is presumed to be steady and uniform flow. The most popular equation for calculating the velocity and head loss for flow conditions in gravity sewers is Manning formula, which is used in this feasibility study for designs of gravity sewers.

1) Depth of Flow

The sewerage system for the ultimate design year has been designed to utilize 80% of the full bore of the pipe at peak flows.

2) Velocities

The sewerage system has been designed for a minimum velocity of 0.8 m/sec. for design flow i.e. peak flow at design horizon.

3) Sizing of Pipes and Slopes

The size of pipes and slope is calculated for contributory population based on the population density of the respective Administrative Wards forecasted for the design horizon of year 2030. The pipe diameter is selected by considering for full bore utilization. The corresponding flattest slope is provided so as to achieve the minimum required self-cleaning velocity with an aim to minimize sewer depth thus

ensuring reduced cost. In cases where (i) the topography does not permit to have the calculated gradient for full bore utilization and/or (ii) the proposed sewer is to be connected to an existing line, which is at a shallow depth, a higher size pipe is selected to match the crown of connecting sewers.

4) Minimum Pipe Size

The interceptor sewers have been designed considering the minimum size of sewer as 500 mm and secondary sewers as 300 mm.

5) Minimum Depth of Cover

The starting manhole depth of the proposed sewers ranges from 1.2 m to 2.5 m depending upon the topography and detail of road planning network available. The minimum depth of cover thus depends on the depth of starting manhole and the subsequent ground level of the road along the sewer. The actual depth of cover shall vary, as most of the sewers are planned on proposed roads.

6) Maximum Depth of Sewer

The sewerage system has been designed such that the maximum cover of sewer will be about 10 meters below ground level. In many areas construction of sewers below 10 meters becomes very difficult. This shall increase the cost of construction and maintenance. Hence as per the prevailing practice it is proposed to lift the sewage by the proposition of a Sewage Pumping Station once the sewer depth reaches @ 10 meters.

7) Sewer Appurtenances

Manholes
Standard circular manholes have been recommended for pipe diameter up to 1200-mm. However, rectangular manholes should be provided for shallow depths.

Scraper Manholes
For sewers of diameter 600 mm and above, scraper manholes shall be provided at major junctions and at an interval of every 150 m. Scraper manhole openings will be of minimum 900 to 1200 mm size to permit lowering of sewer cleaning equipment. It is very important to construct scraper manholes as the sewers are designed to serve for long term, which shall run with quite less flow during the initial years resulting into silting.

Drop Arrangement
The drop arrangement consists of a pipe that drops the invert of the incoming sewer to that of the main sewer in the manhole. The diameter of the drop pipe should be at least as large as the incoming pipe. Theoretically drop arrangements are provided where the drop of an incoming sewer in manhole exceeds 600 mm. Drop arrangements are provided in manhole for the following reasons:

- To convey the sewage to bottom of the manhole without splashing
- To minimize the scouring action of the sewage falling from a height on the cement concrete floor of the manhole
- For the safety of the personnel who enter the manhole

Receiving Manhole at Pressure line Discharge
A 2 m x 2 m receiving sump with the provision of PVC splash pad is proposed for chamber-type manhole into which pressure line is discharged prior to joining the gravity sewer.

Vent Shafts
Ventilation shafts will be provided at the head end of every sewer and along the sewers at about 150-m

interval as well as at junctions.

Pipe selection

The materials used extensively for sewerage in most Indian cities are glazed stoneware / vitrified clay and reinforced concrete pipes for gravity sewers whereas cast iron / ductile iron pipes are employed for rising / force mains of pumping stations. Concrete pipes conforming to IS: 458 of appropriate strength with proper anti-corrosive lining may even last for about 50-60 years. Considering the capital cost, durability and availability of the pipes, RCC pipes, preferably NP3/NP4 class as per IS: 458-1988, have been proposed. Concrete pipes are usually laid and jointed by collar joints.

The class of concrete pipes is decided on the basis of analysis of design loads likely to be imposed upon on the sewer depending upon its depth.

Structural Design of Buried Sewers

Any sewer line buried into the ground should have adequate strength to withstand the stresses imposed not only by the internal pressure but also more importantly, by the stresses induced by external loads. There are two types of external loads, one is due to the backfill material known as backfill load and other is due to superimposed loads. Besides these external loads, the sewer line is also subjected to the load of water in the pipeline, especially during surcharge conditions.

Load on Conduit due to Backfill

The load on a buried conduit is equal to the weight of the prism of earth directly over the conduit plus the frictional shearing forces transferred to the prism by the adjacent prism of earth. The most widely used method for determining the vertical load due to backfill on buried conduit is Martson's Formula, the general form of which is

$W = C.w.B^2$

where,

W	= Vertical load in kg per meter length acting on the conduit due to gravity loads
w	= Unit weight of earth, kg/m^3
B	= Width of trench or conduit depending upon type of installation condition, m
C	= Dimensionless coefficient that measures the effect of ratio of height of fill to width of trench or conduit

The value of C for various types of installation and depending on the height / width ratio is given in the Manual of Sewerage and Sewage Treatment (CPHEEO) published by the Ministry of Housing and Urban Affairs, New Delhi. The C-value for 'Ordinary maximum for clay' has been considered for design purposes.

The unit weight of earth varies from 1600 kg / m^3 for dry sand to 2100 kg/ m^3 for saturated clay.

Load on Conduit due to Superimposed load

Superimposed loads may be either concentrated or distributed loads. The formula for load due to *concentrated* load such as truck wheel is given by Boussinesq's formula

$W_{sc} = C_s(PF/L)$

where,

Wsc	= load on the conduit, kg/m
P	= concentrated load acting on the surface, kg
F	= impact factor (1.0 for air field runways, 1.5 for highway traffic and air taxi ways, 1.75 for railway traffic) and
Cs	= load coefficient which is a function of Bc/2H and L/2H, where

H	=	the height of the top of conduit to ground surface, m
Bc	=	the outside width of conduit, m and
L	=	effective length of the conduit to which the load is transmitted, m.

For distributed superimposed loads, the formula for the conduit is given by

Wsd = Cs.p.F.Bc
where,

Wsd	=	load on conduit, kg/m
p	=	intensity of distributed load, kg/m2
F	=	impact factor
Bc	=	width of conduit, m
Cs	=	load coefficient, a function of D/2H and L/2H
H	=	height of the top of conduit to the ground surface, m and D and L are width and length respectively of the area over which the distributed load acts, in meters.

For class AA IRC loading in the critical case of 6.25 tones wheel load, the intensity of distributed load with wheel area 300mm x 150mm is given by P = 6.25/(0.3x0.15) T/m2.

Supporting Strength of Rigid Conduit
The ability of a conduit to resist safely the earth load depends on its inherent strength as well as the distribution of vertical load and bedding reaction and on the lateral pressure acting against the sides of the conduit. The inherent strength of a rigid conduit is usually expressed in terms of the three edge bearing test results, the condition of which are however different from the field load conditions. For strength calculations of NP class precast RCC pipes, IS: 458 (1988) is used.

Field Supporting Strength
The field supporting strength of a rigid conduit is the maximum load per unit length, which the pipe will support while retaining complete serviceability when installed under specified conditions of bedding and backfilling. The field supporting strength however does not include any factor of safety. The ratio of the strength of a pipe under any stated condition of loading and bedding to its strength measured by the three edge-bearing test is called the load factor. The load factor does not contain a factor of safety. Load factors have been determined experimentally and analytically for the commonly used construction condition for both trench and embankment conduits.

The basic design relationships between the different design elements are:

Safe supporting strength,

W	=	Field supporting strength/Factor of Safety
	=	(Load factor x three edge bearing Strength)/Factor of safety

A factor of safety of at least 1.5 should be applied to the specified minimum three edge bearing strength to determine the working strength for all the rigid conduits. The class of bedding considered is B type, whose load factor as per the CPHEEO Manual is 1.9.

Based on the above consideration, a general guide for selecting the class of pipe from 200 to 600-mm diameter is given in Table 2.8. However, in our case we have carried out the structural designs for all pipes above 300mm.

Table 2.8 Guideline for Selection of Pipe Class for Sewers with B-class Bedding

Diameter	NP2	NP3	NP4
200	1.2 to 7.0 m		
250	1.2 to 7.0 m		
300	1.2 to 4.2 m	4.2 to 6.0 m	6.0 to 10.0 m
350	1.2 to 2.7 m	2.7 to 3.5 m	3.5 to 10.0 m
400	1.2 to 2.7 m	2.7 to 3.5 m	3.5 to 10.0 m
450	1.2 to 2.7 m	2.7 to 3.5 m	3.5 to 9.5 m
500		1.5 to 3.5 m	3.5 to 8.5 m
600		1.5 to 3.5 m	3.5 to 7.5 m

Note: For larger diameters of 700-mm and above, pipe class cannot be generalized and has to be calculated on a case-to-case basis.

Type of Bedding
The type of bedding provided for pipes will be selected from granular bedding, concrete (M20) cradle bedding or concrete encasement (M20) and the choice will depend on the depth at which the sewer is laid, three edge bearing strength of pipes used, load due to backfill and superimposed vehicular traffic loads. Technical suitability of such bedding, as per the guidelines of CPHEEO, is studied and adopted as found acceptable.

Force Main
Sewage may have to be carried to higher elevations through force main. The size of the main should be determined by taking into account the initial cost of pipeline and cost of operation of pumping for different sizes. The size of pressure main has been calculated for velocity of 1.1 to 1.5 m/sec for design peak flows with a maximum velocity up to 2.0 m/sec.

Losses in valves, fittings, etc. are dependent upon the velocity head $V^2/2g$. Loss in bends, elbows depend upon the ratio of absolute friction factor to pipe diameter, besides the velocity head. Loss due to sudden enlargement depends upon the ratio of diameters.

Each individual case needs to be studied from various aspects such as operation of pumps, the specified limits, availability of land required for duplicating the main in future, etc.

CI pipes conforming to IS: 1536 (1989) and DI pipes as per IS: 8329 (1994) are corrosion resistant with an expected life of about 100 years. CI pipes will be jointed either by rubber gaskets suitable tyton joints or by lead joint.

2.1.3 Design Basis for Sewage Treatment Plants

(1) Concept of Decentralized Sewage Treatment Plant

One of the basic design concepts required to be studied for the design of sewerage system for a city is whether centralized or de-centralized sewage treatment plants are suitable. The main criteria governing the choice of the scheme are:

- Topography of the contributing area
- Usage of existing sewerage system
- Proximity to the discharge point for the treated sewage
- Location of discharge of the treated sewage from intake of water works
- Availability and accessibility of site for the STP
- Location of the selected site for STP vis-à-vis the City
- Availability of other utilities such as power, roads, communications etc.

- Capitalized Operation and Maintenance costs

1) Topography of the contributing area (sewerage zone)

The Varanasi City is divided into various sewerage districts considering topography and natural drainage system. Considering these facts of natural topography, which conveys sewage in different directions, will make it economically a non-viable solution to bring the sewage generated in different areas to a common point.

2) Usage of existing sewerage system

The existing sewerage system consists of the main trunk sewer line viz. existing Old Trunk Sewer and Relief Trunk sewer. The Old Trunk Main sewer is discharging at the Konia Pumping station and the Relief Trunk Sewer, which is under construction, discharging the sewage to Chaukaghat Pumping Station. In addition to these trunk mains, there are over 400 kms lengths of sewers existing in Varanasi. The intricate existing sewerage system and non-availability of the land, which will be required for large capacity, STP makes it non-conducive for planning of centralized STP.

3) Proximity to the discharge point for the treated sewage

It is necessary to locate the proposed plant at a suitable site from where the treated sewage can be safely discharged. The treated sewage from the Sathwa STP is proposed to be used for irrigation application and can be discharged into the irrigation canal located about a one km from the proposed STP site.

4) Location of discharge of the treated sewage from intake of water works

It is very essential that the location of discharge point of treated sewage into receiving body is on the downstream side of the water intake points for water supply system. The discharge point envisaged for the proposed STP is far away from the raw water intake points.

5) Availability and accessibility of site for the STP

It is essential to have proper access roads to the STP location. The site identified for the proposed Sathwa STP is adjacent to the Azamgarh road, which is easily accessible from Varanasi. The land earmarked for construction of this STP is found to be adequate for the recommended treatment scheme. The existing land use of the city makes it necessary to locate the proposed STP at the outskirts.

6) Location of the selected site for STP vis-à-vis the City

The location of the proposed Sathwa STP site is about 7 kms from Pandeypur junction, which is one of the most important road connections of traffic in Varanasi City. It is a vast distance from the human settlements and is not envisaged to have any detrimental effect on the City's population.

7) Availability of other utilities like power supply, roads, communications etc.

The STP site proposed under the master plan is easily approachable being on the Azamgarh road. The site is location being located on a proper road network ensures that other utilities such as power supply, communication facilities can be made available.

8) Capitalized Operation and Maintenance costs

Looking at the existing sewerage facilities and all above factors which have influence on the selection of STP locations have any adverse impact on the Capital Costs as well as on the Operation &

Maintenance costs and the existing facilities will be utilized to fullest possible extent.

9) Conclusion

After studying the Centralized v/s Decentralized System proposed in the Master plan, it is evident that the proposed decentralized system for constructing the sewage treatment plant is appropriate.

(2) Raw Sewage Characteristics Considered for Design Purpose

The wastewater characteristics used for design of the proposed sewage treatment plant at Sathwa are based on the projected wastewater characteristics presented in the Table 2.9.

Table 2.9 Raw Sewage Characteristics considered for Design Purpose

Sr.	Parameter	Average Value
1	Minimum Temperature, ^{o}C	20
2	pH	6.0 - 8.5
3	Biochemical Oxygen Demand (BOD5), mg/l	300
4	Total Suspended Solids, mg/l	600
5	Faecal Coliform Count, MPN/100 ml	2 x 10^{7}

(3) Discharge Standards

NRCD have conveyed the recommendations of the Expert Committee through their letter no DO. No. A-33013/1/99-NRCD dated 5th October 1999, suggesting that the maximum permissible value for Faecal Coliform in treated water should not exceed 10,000 MPN per 100 ml sample irrespective of its mode of disposal in river or its use for irrigation to grow either restricted or unrestricted crops. It is also mentioned in NRCD guidelines that BOD and TSS concentration less than 30 mg/l and 50 mg/l respectively.

The sewage treatment plant has been therefore designed so as to achieve treated wastewater of equal or better quality as mention in the Table 2.10 hereunder.

Table 2.10 Treated Wastewater Quality

Sr.	Parameter	Value (Irrigation Field/River)
1	pH	5.5 – 9.0
2	Biochemical Oxygen Demand, mg/l	$\leq$ 30
3	Total Suspended Solids, mg/l	$\leq$ 50
4	Faecal Coliform Count, MPN/100 ml	$\leq$10,000

(4) Selection of Sewage Treatments Scheme for Sathwa

The requirement of a feasible sewage treatment system are as following:

- Simple to construct and operate,
- Ability to handle strong sewage within short detention time,
- Minimum capital and operation cost,
- Possibility of cost recovery,
- Minimum land requirement,
- Ability to treat unto the prescribed discharge standards,
- Minimum odour, flies and other nuisance, and

- General acceptance to the people in the vicinity of the STP.

(5) Treatment Options for Varanasi City for Use of Treated Water for Irrigation Purpose

The techno-economic treatment option should take into consideration the site-specific constraints and the inlet characteristics of the sewage. Further, for a city of Varanasi that is fast growing and with huge quantum of sewage being generated every day with high organic load, the treatment option should not be separately looked into without considering the land costs.

The four treatment options for the prescribed standards under consideration for getting through the best feasible option for the sewage treatment plant at Sathwa are as following:

Alternative 1: Waste Stabilisation Pond System consisting of Anaerobic Pond followed by Facultative pond followed by Maturation pond,
Alternative 2: Activated Sludge Process with Chlorination System,
Alternative 3: UASB Process followed by Facultative Aerated Lagoon with Chlorination System,
Alternative 4: Facultative Aerated Lagoon followed by Maturation Ponds with Chlorination System,

Alternative 1: Waste Stabilisation Pond System of Anaerobic Pond + Facultative + Maturation Pond

Stabilisation ponds are open, flow through earthen basins specially designed and constructed to treat sewage and biodegradable industrial wastewater. Stabilisation ponds provide long detention periods extending to several days. In ponds the organic waste is stabilized through symbiotic relationship between the algae and bacteria. Oxygen is provided by photosynthesis of algae or by mechanical aeration in some cases.

The treatment process will consist of inlet chamber, screen channel, and an anaerobic pond having hydraulic retention time of 2.0 days. The Facultative pond having a detention time of 21 days will follow the anaerobic pond. Subsequent to the Facultative pond, there shall be Maturation ponds having detention time of 5 days. The waste stabilisation ponds are designed for ambient temperature of 16 deg cel.

The schematic flow diagram of this Alternative is presented in the Figure 2.2.

Table 2.11 Area Statement for Waste Stabilisation Pond System

Unit	Detention time (day)	Depth (m)
Anaerobic Lagoon	2	3.0
Facultative Pond	21	2.0
Maturation Pond	5	1.2

Alternative 2: Activated Sludge Process with Chlorination System

An Activated Sludge Process (ASP) is a type of Aerobic Suspended Growth system. The ASP plant essentially consist of the following:

- Aeration Tank containing micro organisms in suspension in which biological degradation of organic matter takes place aerobically,
- Activated Sludge Recirculation System to maintain the sufficient micro organisms in Aeration Tank,
- Excess Sludge wasting and disposal facilities,

- Aeration system to transfer oxygen,
- Secondary Settling tank to settle the suspended solids,
- Thickener to thicken activated sludge,
- Digester for sludge digestion,
- Gasholder for gas storage resulting from sludge digestion, and
- Chlorination system for disinfecting treated sewage.

This Alternative consists of the following treatment units-

- Inlet Chamber,
- Fine Screen Channel,
- Detritor Tank,
- Primary Clarifier,
- Aeration Tank,
- Secondary Clarifier,
- Chlorination System,
- Sludge Pumping Station,
- Filtrate Pumping Station,
- Sludge Thickener,
- Sludge Digester,
- Gasholder and
- Sludge Drying Beds.

Raw sewage will be received in the inlet chamber and then passed to the screen channel and subsequently to the Detritor tank. In screen channel floating matters are trapped and removed whereas in Detritor tank, grit is removed. After screening and grit removal the wastewater is taken into a primary Clarifier. This is provided for the removal of suspended matter before taking wastewater for further biological treatment. The sludge generated as a result of primary settling is taken for thickening and subsequently for digestion. A sludge digester and pumps are provided for this purpose.

After primary settlement of the suspended matter, the wastewater is taken to aeration tank containing microorganisms in suspension in which the biological degradation takes place. Further, a secondary Clarifier is provided to separate the activated sludge. A part of the incoming flow is re-circulated upstream of the aeration tank. A tapping is provided on this line to lead the excess sludge to the sludge sump.

A two-stage digestion system is provided for sludge digestion. The detention time in the digester is about 20 days. Mixers are provided to operate in a completely mixed regime in the digester. It is proposed to use sludge-drying beds for sludge dewatering prior to sludge disposal.

The schematic flow diagram of this Alternative is presented in the Figure 2.3.

Alternative 3: UASB Process followed by Facultative Aerated Lagoon with Chlorination

The UASB process followed by Facultative Aerated Lagoon with chlorination essentially consist of the following:

- Primary treatment consisting of screening and degritting,
- UASB reactor for anaerobic degradation of sewage,
- Facultative Aerated Lagoon having aeration system to transfer oxygen,
- Chlorination system for further reduction of faecal coliform and disinfecting treated sewage
- Gasholder for gas storage and Gas utilisation system, and
- UASB Sludge wasting and dewatering facilities

The treatment process will consist of the following treatment units:

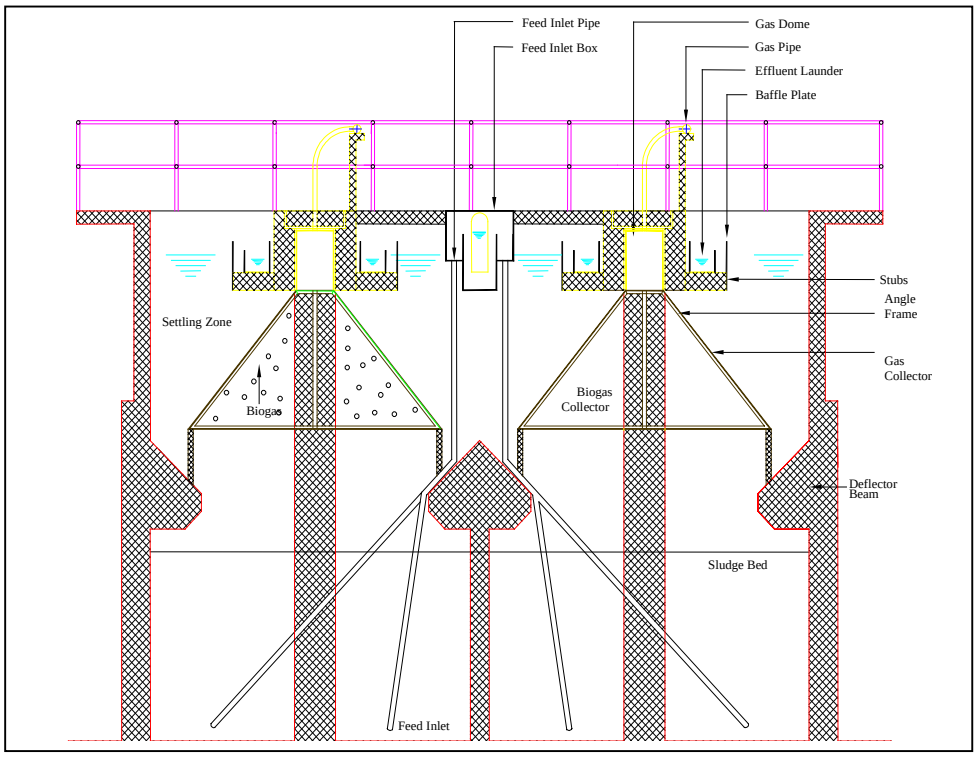
- Inlet Chamber,
- Fine Screen Channel,
- Detritor Tank,
- UASB Reactors
- Facultative Aerated Lagoon,
- Chlorination System,
- Sludge Pumping Station,
- Filtrate Pumping Station,
- Gas Utilisation System, and
- Sludge Drying Beds.

UASB Technology

The development of the Upflow Anaerobic Sludge Blanket (UASB) reactor dates back from early 1970's. Pre-sedimentation, anaerobic wastewater treatment and final sedimentation including sludge stabilisation are essentially combined in one reactor making it most attractive high-rate wastewater treatment Alternative. It produces high value by-products viz.

- Treated wastewater usable for gardening purpose or for pisciculture after a simple post treatment,
- Methane enriched biogas having high calorific value is converted into a usable energy resource like heat energy, electricity etc., and
- Mineralised excess sludge produced in UASB reactor for its usage as manure for agricultural purpose.

UASB initially was developed for the anaerobic treatment of Industrial wastewater with a moderate to high COD and BOD concentrations. The basic idea is flocculent or granular sludge developed in the reactor depending on the wastewater characteristics and operational parameters will tend to settle under gravity when applying moderate upward velocities in the reactor. In this way no separate sedimentation basin is necessary. Anaerobic bacteria are developed in the reactor and are kept in the biological reaction compartment for sufficient time. Organic compounds present in the wastewater are absorbed or adsorbed on the sludge particles in the reaction zone during its passage through the sludge bed. Organic compounds there after get anaerobically biodegraded converting it into methane-enriched biogas and a small part into the new bacterial mass. Biogas consists of Methane CH_4, Carbon dioxide CO_2, Hydrogen H, Hydrogen Sulfide H_2S and traces of Ammonia NH_3 and Nitrogen N_2. This biogas can be used as energy source and for this reason is collected in gas collectors.



A Gas, Liquid and Solids Separator (GLSS) is provided below the gas collectors in order to provide an opportunity to the sludge particles to which Biogas bubbles are attached to lose biogas and settle back into the reaction compartment. In between two gas collectors a settling zone is provided where virtually no gas bubbles are present in the liquid. The sludge particles carried with the wastewater flow are settled in the settling zone and slide down into the biological reaction zone. Wastewater enters the UASB reactor from the bottom and travels through the reactor in the upward direction. In order to ensure sufficient contact between the incoming wastewater and the anaerobic bacterial mass present in the reactor, the wastewater is fed uniformly all over the bottom of the reactor. Further mixing in the reaction zone is achieved by the production of the biogas travelling in the upward direction, settling velocity of the sludge particles and the density currents in the sludge mass.

With proper seed material available at the time of Start-Up of the UASB reactor, the microbial population is developed within three months period. Proper care is taken while designing the UASB reactor to absorb estimated shock loads in terms of hydraulic and organic contents in the wastewater. The reactor is having the following zones:

- Gas collection zone
- Clarification zone
- Sludge blanket zone

The schematic flow diagram of this Alternative is presented in the Figure 2.4.

Alternative 4: Facultative Aerated Lagoon followed by Maturation Pond with Chlorination System

Facultative Aerated Lagoons are generally provided in the form of simple earthen basins with inlet at one end and outlet at the other to enable the wastewater to flow through while aeration is usually provided by mechanical means to stabilise the organic matter. The major difference between activated sludge systems and aerated lagoons is that in the latter, settling tanks and sludge recirculation is absent.

Aerated lagoons are of two principal types depending on how the microbial mass of solids in the system is handled. Facultative Aerated Lagoons are those in which some solids may leave with the effluent stream and some settle down in the lagoon since aeration power input is just enough for oxygenation and not for keeping all solids in suspension. As the lower part of such lagoons may be anoxic and anaerobic while the upper layers are aerobic, the term facultative is used.

Aerobic Lagoons, on the other hand, are fully aerobic from top to bottom as the aeration power input is sufficiently high to keep all the solids in suspension besides meeting the oxygenation needs of the system. No settlement occurs in such lagoons and under equilibrium conditions the new (microbial) solids produced in the system equal the solids leaving the system. Thus, the solids concentration in the effluent is relatively high and some further treatment is generally provided after such lagoons. If the effluent is settled and the sludge recycled, the aerobic lagoon, in fact, becomes an activated sludge or extended aeration type lagoon.

Facultative type aerated lagoons have been more commonly used the world over because of their simplicity in operation and minimum need of machinery. They are often referred to simply as 'aerated lagoons'. Their original use came as a means of upgrading overloaded oxidation ponds in some countries without adding to the land requirement. In fact, much less land is required compared to oxidation ponds.

Aerated lagoons are generally provided in the form of simple earthen basins with inlet at one end and outlet at the other to enable the wastewater to flow through while aeration is usually provided by mechanical means to stabilise the organic matter. The major difference between activated sludge systems and aerated lagoons is that in the latter settling tanks and sludge recirculation is absent.

Depending on how the microbial mass of solids in the system is handled, Aerated lagoons are of two principal types viz.;

- Facultative Aerated Lagoons are those in which some solids may leave with the effluent stream and some settle down in the lagoon since aeration power input is just enough for oxygenation and not for keeping all solids in suspension. As the lower part of such lagoons may be anoxic and anaerobic while the upper layers are aerobic, the term facultative is used. Facultative type aerated lagoons have been more commonly used the world over because of their simplicity in operation and minimum need of machinery.
- Aerobic Lagoons are fully aerobic from top to bottom as the aeration power input is sufficiently high to keep all the solids in suspension besides meeting the oxygenation needs of the system. No settlement occurs in such lagoons and under equilibrium conditions the new (microbial) solids produced in the system equal the solids leaving the system. Thus, the solids concentration in the effluent is relatively high and some further treatment is generally provided after such lagoons.

The schematic flow diagram of this Alternative is presented in the Figure 2.5.

(6) Existing STP at Lalpur

Discussion with the VDA officials revealed that they have constructed a STP near Lalpur to treat the sewage generated by the residents residing within limits of Lalpur Town Planning Scheme Phase I. The outcome of the survey is as follows:

- The STP is located out side the boundary of the present study
- The STP is 1.8 MLD capacity of Facultative Aerated Lagoon with Polishing Pond
- At present there is no flow from the STP
- The treated effluent is discharged into the irrigation canal located at around 800 m distance

from the STP site

- The irrigation canal merges with River Varuna near Panchkoshi Road
- In this 800 m length, VDA has laid sewer for around 300m and for rest of the distance the VDA has to acquire land.

As this STP is located outside the boundaries of this study it is decided not to integrate this STP with the proposed scheme.

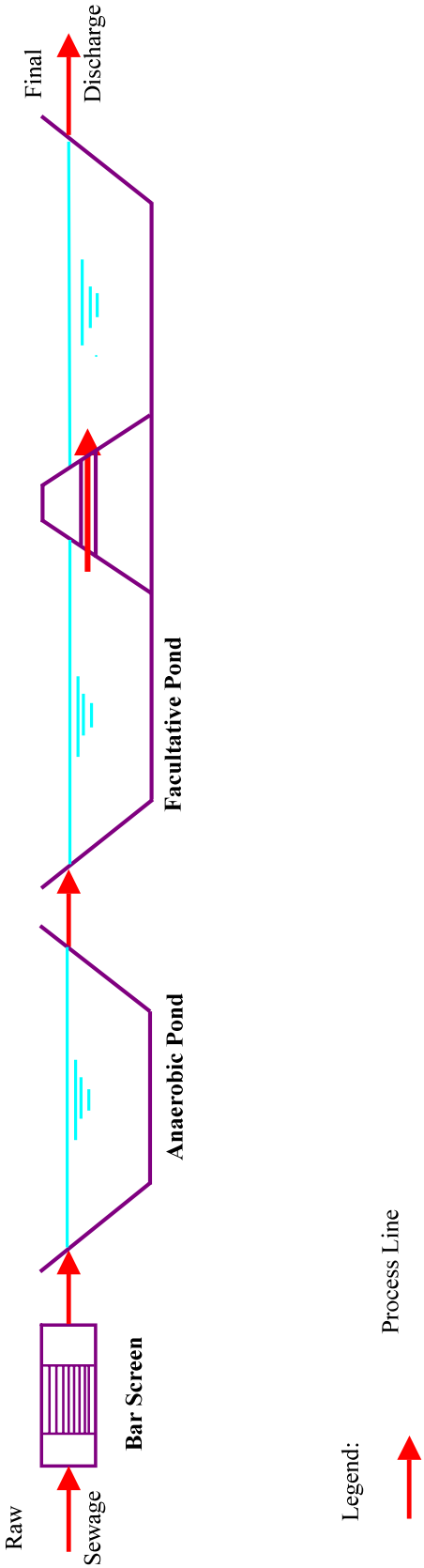


Figure 2.2 Schematic Flow Diagram of Waste Stabilisation Pond System

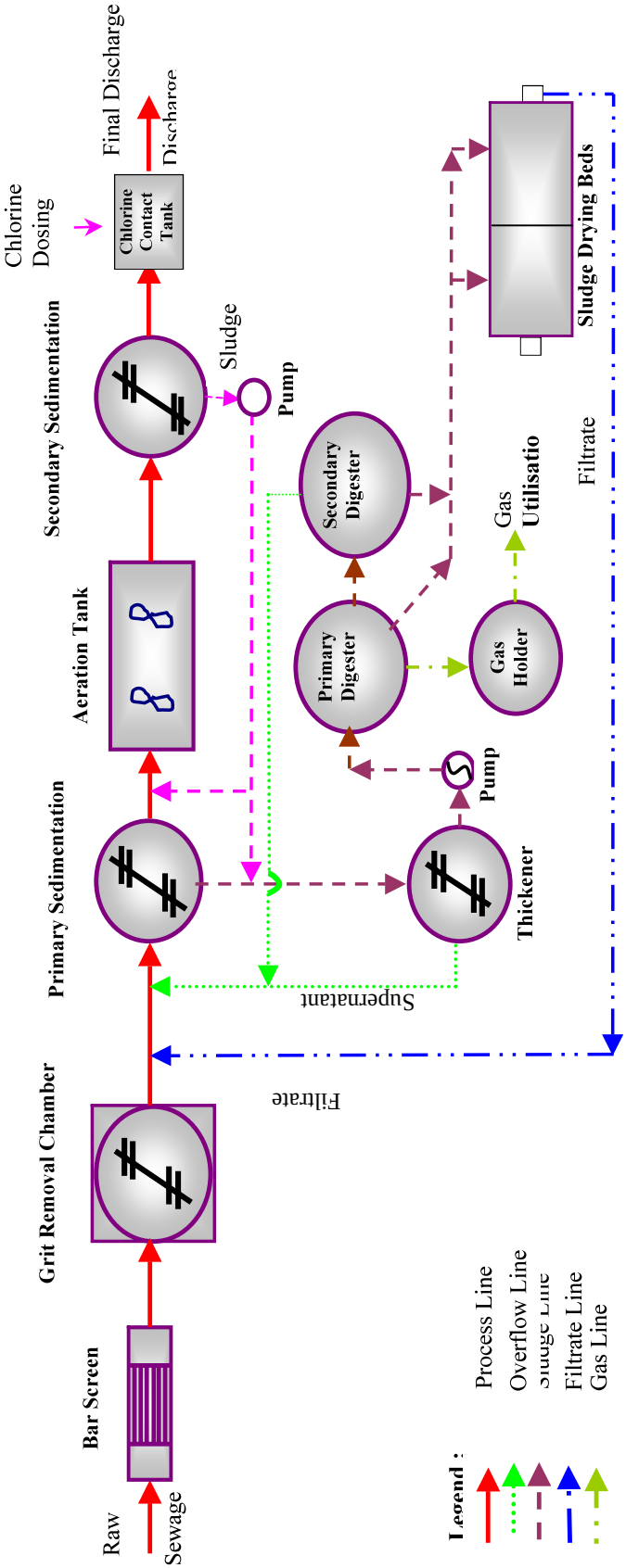


Figure 2.3 Schematic Flow diagram of Activated Sludge Process

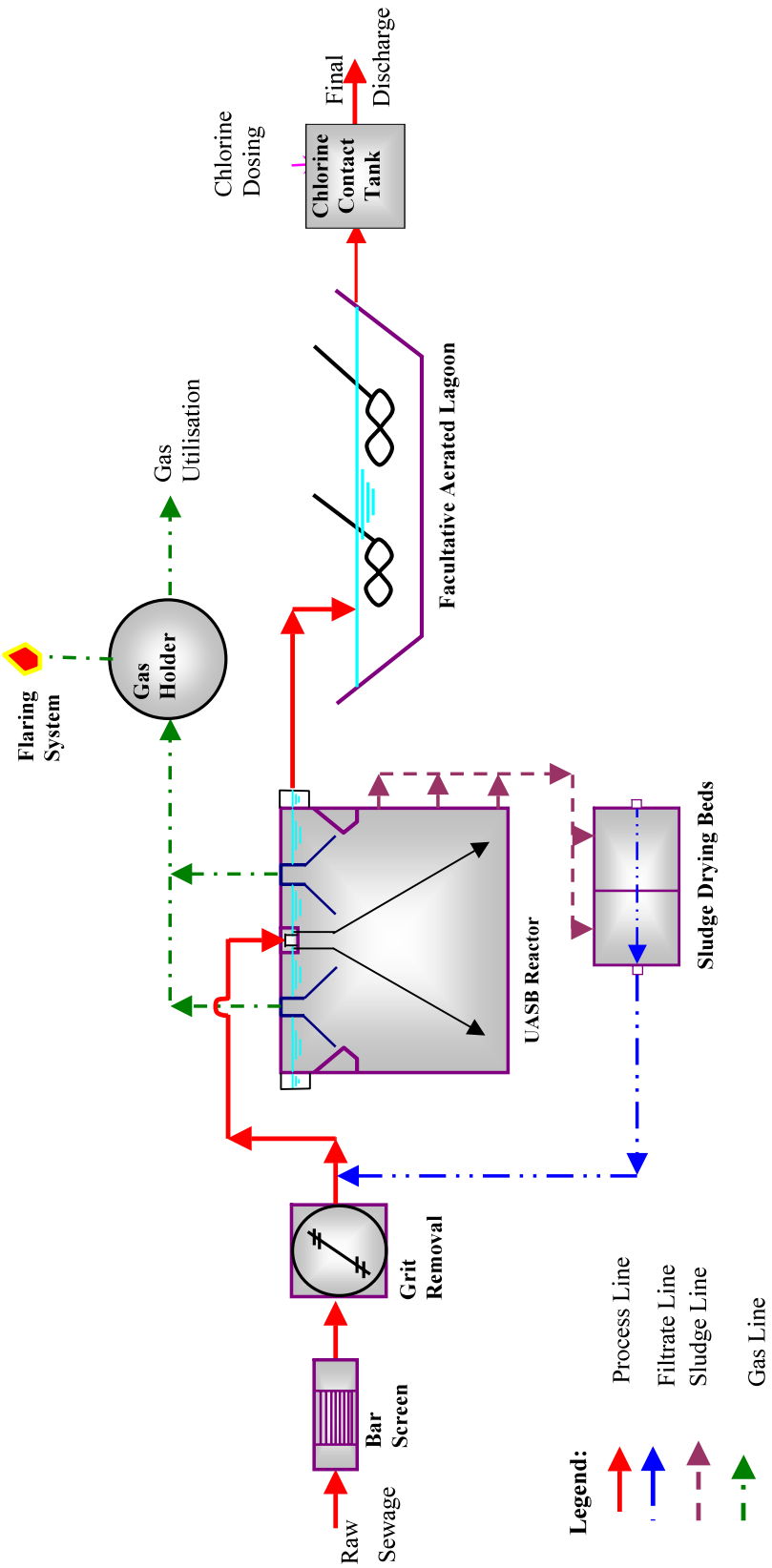


Figure 2.4 Schematic Flow diagram of UASB Process + Facultative Aerated Lagoon

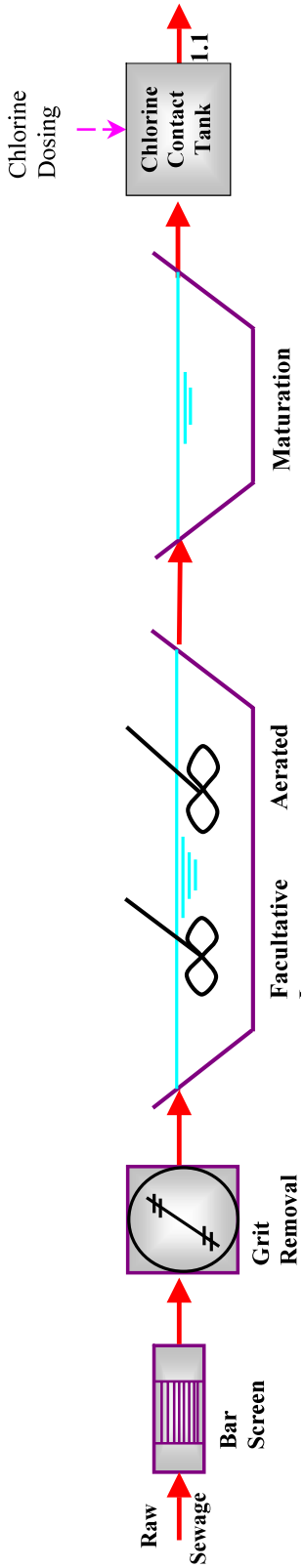


Figure 2.5 Schematic Flow diagram of Facultative Aerated Lagoon + Maturation Ponds

2.1.4 Design Basis of Sewage Pumping Station

(1) Design Approach

1) General Design Principle

The design and selection of pumps for a sewage pumping station involves a multi-disciplinary team of experts who have to work out every detail of the Civil, Electrical and Mechanical aspects in order to obtain a satisfactory design and operation of the pumping station. Different types of pumps have their own purposes and characteristics. There are a series of decisions that have to be taken while selecting and designing the pumps. The design of pumps broadly follows the following lines:

- Determine location and purpose
- Determine the required discharge (average and peak flows)
- Determine the required lift or pressure increase, including the variations therein, as well as the transport distance
- Determine the type of liquid
- Determine in and outflow conditions, etc.

The outline of design procedure can be best laid out in the following flow diagram.

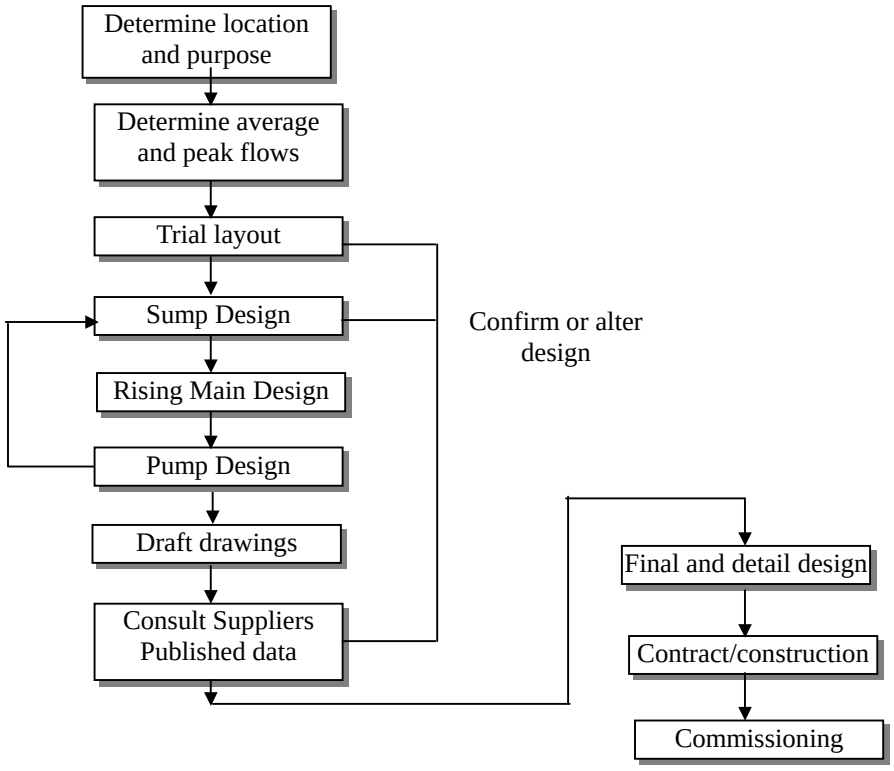


Figure 2.6 Pumping Station Design Procedure

2) Location and Purpose

Pumping Stations are normally located at the lowest point of the area they are intended to serve. They will frequently, therefore be found alongside the watercourses that drain the area as they are at the natural lowest level.

Proper location of the pumping station requires a comprehensive study of the area to be served to ensure that the entire area can be adequately drained. Special considerations have to be given in

undeveloped or developing areas to the probable future growth, as the location of the pumping station will, in many cases, be determined by the future overall development of the area. The site should also be aesthetically satisfactory. The pumping station shall be located and constructed in such a manner that it will not be flooded at any time. The station should be easily accessible under all weather conditions.

In deciding the purpose, one must have first priority for pumping domestic sewage which is the prime purpose of most pumping stations. The pumping station is thus to pump only foul flows, including commercial and trade effluents, from a designated area. "Purpose" would also include a decision, in principal, on screening and grit removal at the pumping station.

3) Determination of Flows

Having decided on the location of the pumping station, its purpose and the contributory area, the next stage is to calculate average and peak flows for the present day and a point in the future at a set "design horizon'. Whilst in the structural sense, concrete structures are designed to last for 30-50 years; they are normally sized to deal with the peak flow at a 30-year horizon.

The basic step of the existing procedure is therefore to:

- Determine existing population
- Extrapolate for development and growth
- Derive per capita consumption
- Estimate trade flows
- Allow for other losses and gains
- Estimate peak factor
- Produce maximum and minimum design flows

4) Layout

For the layout of pumping stations no overall criteria can be formulated, as local conditions will be of great influence. Generally the layout is the result of a design process in which all the design factors will be taken into account. In general, it can be said that the layout of a pumping station is a logic fit of all functions of the station, with sufficient room to move between machinery for erection and maintenance purposes, but without unnecessary empty spaces neither in a horizontal plane not in vertical direction.

In principle, flow lines shall be as short as possible and no unnecessary bends shall be present in the piping.

Spaces that may be required are for the following units.

- Inlet chamber
- Screen chamber
- Main Collection Sump
- Valve chamber/ Dry well
- Transformer station
- Electrical panel room
- DG set room
- Operations Office

Two type of pump house layout is considered based on type of pumps:

- Dry well and wet well for horizontal centrifugal pumps

- Wet well and valve chamber for submersible pumps

All spaces should be well lighted. Also, outside lighting may be required. Proper railings are required along stairs or on platforms. Sufficient space shall be available for future extension of the station.

5) Pump Sizing

Pump sizing is carried out with reference to manufacturer's catalogues, as these are the most reliable guides. Having determined the HP (or kW), the pipe work, solids handling capacity and basic dimensions will be known.

Sump Design

a) Wet Well

Capacity of wet well sump is taken considering CPHEEO Manual and NRCD guidelines for submersible and horizontal centrifugal type of pumps. A maximum of 5 minutes detention time at peak flow condition has been considered to size the sump well.

There are two basic criteria to be incorporated.

- Free fall into the well: governed by the level of the impeller and the invert of the sewer.
- Sufficient space to enable pumps within the well to be removed for maintenance (submersibles only).

In addition to these sizing criteria, the well must be self-cleansing and hence have a shaped base (benching)

b) Dry Well/ valve Chamber

Sizing of Dry well (for horizontal centrifugal pumps) or Valve chamber (for submergible pumps) has been taken considering common header diameter, fittings, valves, working space and operating space.

6) Rising main Design

The concept of rising main design is to meet following criteria:

- The main must be self cleaning with minimum flows
- Velocities shall not be excessive with design peak flows
- Techno-economic diameter of rising main is calculated considering capitalised cost of pumps and rising main for 15 years

(2) Technical Evaluation for Selection of Pumps

1) General

Sewage pumps are used to lift liquid wastes from one level of the Collection System to another (as in the case of Intermediate Pumping Stations) or to the treatment plant for treatment (as in the case of Main Pumping Stations).
Even though the sewage is normally screened at larger installations before entering the suction wet well, it still contains a large quantity of problem materials, such as rags, jute bags, fiber and plastic pouches, which find their way through the coarse screens. This is typical for Indian Conditions. A

sewage pump shall be reliable, unchokable and accessible for quick maintenance, be robust and wear resisting. Some measure of overall efficiency may have to be sacrificed to secure these properties and safety features. The type of pump to be installed at each pumping station shall be judged on its technical merits in relation to the rate of pumping, the total head, the physical composition of the sewage, septicity and preliminary treatment before pumping.

Pumps may be classified on the basis of the purpose or the application they serve, the material of construction, the liquids they handle, and even their orientation in the space. A more basic system of classification is to categorize the pumps on the principle by which the energy is supplied to the pump. Under this system, all pumps may be divided into two major categories.

Dynamic, in which energy is continuously added to increase the fluid velocities within the machine to values in excess of those occurring at the discharge such that subsequent velocity reduction within or beyond the pump produces a pressure increase.

Displacement, in which energy is periodically added by application of force to one or more movable boundaries of any desired number of enclosed, fluid containing volumes, resulting in a direct increase in pressure upto the value required to move the fluid through valves or ports into the discharge line.

Dynamic pumps may be further sub-divided into several varieties of Centrifugal Pumps and other special-effect pumps, like Jet Pumps and Hydraulic Ram Pumps etc. Displacement Pumps are essentially divided into Reciprocating Pumps and Rotary pumps.

Reciprocating Pumps are suitable for applications where the required capacity is expected to be virtually constant over a wide range of system head variations. Another factor that has to be taken into consideration is that the output from the reciprocating pumps is pulsating. Where this is objectionable, Rotary pumps are preferred over the Reciprocating Pumps. However the application of Rotary Pumps is limited to low to medium pressure ranges.

In India, for sewage pumping application Centrifugal Pumps are in use. A centrifugal pump consists of a set of rotating vanes, enclosed within a housing or casing and used to impart energy to a fluid through centrifugal force. Thus, stripped of all the refinements, a centrifugal pump has two main parts.

- A rotating element, including an impeller and a shaft
- A stationary element made up of a casing, stuffing box, and bearings.

In this type of pump, atmospheric pressure or other pressure, into a set of rotating vanes, forces the liquid. These vanes constitute an impeller, which discharges the liquid at its periphery at a higher velocity. This velocity is converted into pressure energy by means of a volute or by a set of stationary diffusion vanes surrounding the impeller periphery. Pumps with volute casings are called Volute Pumps, while those with diffusion vanes are called Diffuser Pumps.

Depending on the location of motor with respect to the pump, Centrifugal Pumps can be divided into two types, namely the Conventional Centrifugal Pumps and the Submersible Centrifugal Pumps. The broad classification of the commonly used pumps is shown in the following chart.

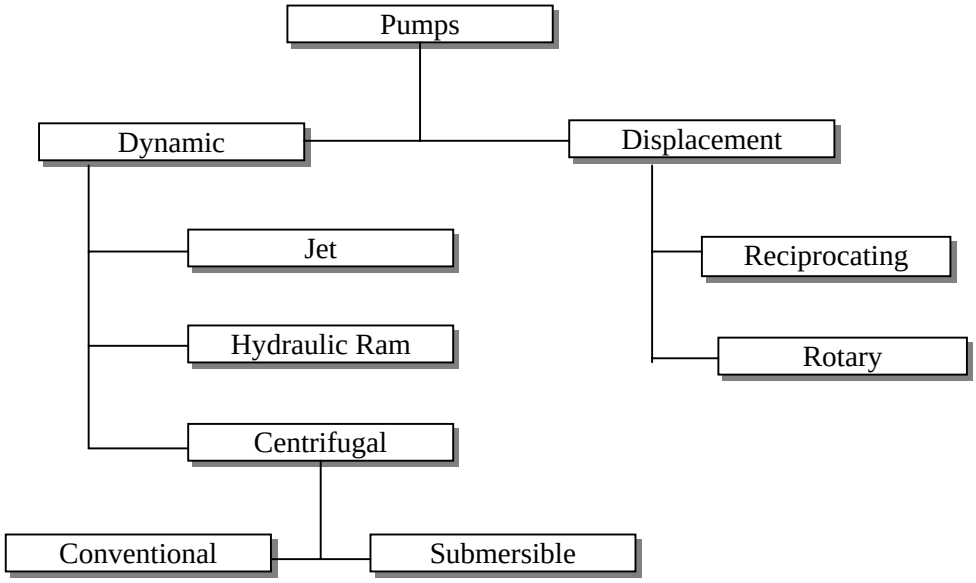


Figure 2.7 Pump Classification

2) Conventional Centrifugal Pumps

A Conventional Centrifugal Pump is more specifically described as an end-suction, volute-type, with an overhung impeller of either the Non-clog or the Radial Flow Type or the Mixed Flow Type Pump.

The installation of Conventional Centrifugal Pump requires considerable length of drive shafting. The addition of this shafting, of the many line bearings, and of an external lubrication system represents a major portion of the total installed cost. Furthermore, power losses increase rapidly due to elongation of shafts.

Conventional Centrifugal Pumps operate within a dry well adjacent to the wet well. The pumps are connected with the wet well through a suction line (Figure 2.8). One of the major drawbacks with these pumps is that they generally do not work with any suction lift. Instead they need a suction head or minimum submergence for trouble free pumping. Therefore, it is always advisable to install these pumps at such a level that the impeller or the volute of the pump is positioned below the low water level of the wet well to ensure a positive suction or prime.

3) Submersible Centrifugal Pumps

Submersible Centrifugal Pumps are based on Modern developments and have integral motors with special seals suitable for operation below liquid level. The pump, along with the motor, is submerged into the wet well and does not need a dry well for installation (Figure 2.9). The pumps are fitted with Semi-open type of Impellers Cutting and Tearing Contra-Block System, which efficiently handles jute bag pieces, long fibers, plastic bags & pouches, cigarette buts, solid admixes etc. present in the typical Indian Sewage.

Submersible Centrifugal Pumps eliminate the need for extended shafting, shaft couplings, a stuffing box, a sub-surface motor stand, and an expensive dry well.

Submersible Centrifugal Pumps are available with closed coupled submersible motors. The pumps are supported by guide rails, which make it possible to lower and lift the pumps by means of a chain hoist. During this operation, the discharge is connected and disconnected without dewatering the wet well.

Motors for this type of pump are hermetically sealed, employing a double mechanically sealed oil

chamber with moisture sensing probe to detect any influx or conductive liquid past the outer seal.

Due to their inherent advantages over Conventional Centrifugal Pumps, Submersible Centrifugal Pumps have been popular all over the world, for pumping municipal wastewater. Over the past 10 years, the application of Submersible Centrifugal Pumps has become very popular in India, for pumping municipal wastewater and is replacing Conventional Centrifugal Pumps.

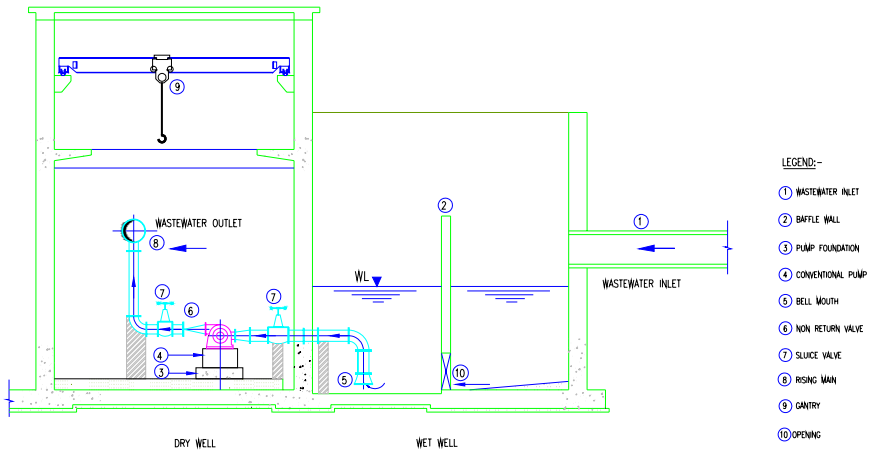


Figure 2.8 Schematic of Conventional Centrifugal Pump

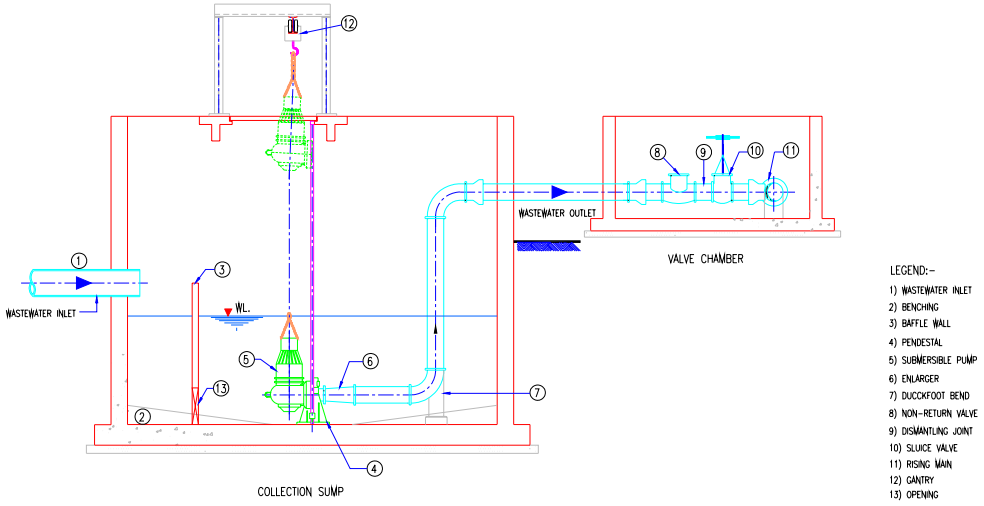


Figure 2.9 Schematic of Submersible Centrifugal pump

A Technical Evaluation has been carried out for selection of pumps. For this purpose, Conventional Centrifugal Pumps and Submersible Centrifugal Pumps have been compared.

4) General Comparison of Conventional Centrifugal Pumps and Submersible Centrifugal Pumps

The Conventional Centrifugal Pumps and Submersible Centrifugal Pumps have their own advantages and disadvantages. The merits and demerits of both types can be summarized as given below in Table 2.12.

Table 2.12 Comparison between Conventional Centrifugal Pump vs. Submersible Pumps

Sr.	Parameter	Conventional Centrifugal Pumps	Submersible Centrifugal Pumps
1	Civil Structure to house the pumps	Superstructure is needed for protection of motors and therefore these pumps require a dry well in conjunction with a wet well (sump). Sectional view of a Pumping Station with Conventional Centrifugal Pumps has been given in Figure 2.8	Both pump and motor are installed in the wet well. This saves substantial space and brings about significant saving in the civil engineering costs. Sectional View of a Pumping Station with Submersible Centrifugal Pumps has been given in Figure 2.9
2	Land Requirements	Require more space	Require very little space
3	Piping	Extended	Shorter
4	Column Pipes	Required	Not required
5	Suction Pipes	Required	Not required
6	Discharge Pipes	Required	Required
7	Delivery Piping and Common Header	The Conventional Centrifugal Pumps require column assembly	In case of Submersible Centrifugal Pumps, the discharge pipes of all pumps can be terminated at the common header, which is installed in a shallow valve chamber just adjacent to the Collection Sump
8	Solid Handling Capacity	Lower (80 mm)	Higher (100 mm and above)
9	Weight of Pumps	Heavy	Relatively much lighter
10	Lubrication	Special attention is required for lubricating lines of intermediate bearing support and further design is required to check intermediate floor for bearing supports, etc.	No such attention required. Further, the supports required for the intermediate bush bearings is also not applicable
11	Vibrations and Noise	Large column lengths always cause vibrations and motor mounted on top causes noise pollution. The vibrations are also due to their heavy weight	Submersible Centrifugal Pump being a mechanically robust mono-block unit where impeller is mounted on the motor shaft which is supported by two sturdy bearing, ensures a mechanically robust design which in turn results in vibration free performance of the pump and further whatever vibrations that still remain, are damped because the pump is submerged in sewage
12	Starts and Stops	Capable of less stops and starts per hour (4 to 5) and hence requires more hydraulic retention time (5 minutes at peak flow) for wet well	Capable of relatively more starts and stops per hour (8 to 10). This results in reducing the hydraulic retention time (3.75 minutes at peak flow) of the sump, ensuring the compactness of wet sump itself.
13	Impeller	The Conventional Centrifugal Pumps are normally offered with closed impeller having both front and back shrouds. This type of impeller is not suitable for Indian sewage, which has solids like plastic bags & pouches and jute fibre. Choking and clogging of impeller is quite frequent	Submersible Centrifugal Pumps are fitted with specially designed and specially shaped single/double vane impeller of open type with Contra-Block Cutting system. These two combined features make this pump truly non-clogging and therefore substantially more reliable under Indian conditions
14	Motor	In a Conventional Centrifugal Pump, the Squirrel Cage Induction Motor is the Prime Mover, which is coupled	In a Submersible Centrifugal Pump, the Squirrel Cage Motor is an integral part of the pump and fitted with a

Sr.	Parameter	Conventional Centrifugal Pumps	Submersible Centrifugal Pumps
		with the pump by means of a Rigid or Flexible Coupling	Aluminum Die Cast Rotor. This totally enclosed motor is equipped with sealing features to permit operation while submerged in a specified medium at a specified depth.
15	Electrical Cabling and Control Panels	Since Conventional Centrifugal Pumps offer substantially reduced kilowatt consumption, the ampere consumption also reduces, resulting in reduction in size of motor cabling, length of cabling, reduction in capacity of transformer & generator set.	Cabling and Control Cabling is extended.
16	Installation and Removal	Installation and removal is cumbersome since the assembly is on a foundation and each pump has to be specially removed and then lifted	The pump installation and removal are automatic, without having to enter into the sewage pit. Guide Rail System and guide pipe are provided to facilitate the Automatic Coupling of the pump

5) Operation and Maintenance Aspects

Operation and Maintenance is an important aspect to be considered while selecting the type of pumps. It is therefore, necessary to consider ease of installation and removal, materials of construction, safety features and frequency of lubrication etc. as important parameters.

In case of Conventional Centrifugal Pumps, the changes of frequent clogging of impeller are more due to its Closed Type Design and Lower Solid Handling Capacity. Also, due to presence of Line Shaft Bearings, there is a need of frequent lubrication. There is more wear and tear of glands and other parts due to extended shafts. It is not easy to install and remove these pumps because of their heavy weight and manual fixing onto the foundation.

In case of Submersible Centrifugal Pumps, due to their Semi-Open Type Impeller, clogging is less frequent. Furthermore, the special **Contra-Block Cutting and Tearing System** provides on the suction side of the pump facilitates disposing off soft materials like plastic pouches, small jute pieces, which is very typical of Indian sewage. Pump bearings are of Anti-Friction Type and are maintenance free and are grease lubricated for long life. The bearings are capable of taking normal thrust loads due to unbalanced hydraulic loads on the impellers.

The maintenance of Submersible Centrifugal Pumps is comparatively less because there are no line shaft bearings, which need reliable lubrication and periodic replacement. Only mechanical seal of this type of pump may need replacement after certain working hours, thereby reducing the maintenance cost substantially.

Selecting a pump with less moving parts and low RPM reduces wear and tear of parts and ensures trouble and maintenance free operations. Submersible pumps offer state of the art technology in pump protection ensuring trouble free operation in toughest applications.

The salient operation and maintenance features of Conventional Centrifugal Pumps and Submersible Centrifugal Pumps are given in Table 2.13.

Table 2.13 Salient Operation and Maintenance Aspects of Conventional Centrifugal Pumps and Submersible Centrifugal Pumps

Sr.	Conventional Centrifugal pumps	Submersible Centrifugal Pumps
1	None	Thermostat sensors for motor protection
2	None	Bearing monitors for trouble free and smooth operation
3	None	Mechanical seal health monitors for ensuring an enhanced pump life
4	Periodic greasing required	Lubricated for life bearings
5	Absence of warning system results in abrupt failure giving no time for planning not allows selective maintenance	Early warning system allows ample planning time & selective maintenance
6	More moving parts	Less moving parts
7	Design incorporating multiple shafts, resulting in frequent alignment problems.	Compact design on single shaft.

6) Conclusions and Recommendations

With reference to the Technical Comparison between Conventional Centrifugal Pumps and Submersible Centrifugal Pumps it can be concluded that the Submersible Centrifugal Pumps is based on modern developments in the technology of centrifugal pumps for Sewage pumping applications. Development in impeller design like Semi-Open Type with Contra-Block System, Steel Material of Construction, better Solid Handling Capacity, better design due to direct mounting of motor shaft on impeller, better design of Motor Stator Rotor (Aluminum Die Cast) makes the Submersible Centrifugal Pumps technically more superior. The facility of Guides Rail System and Automatic Coupling facilitate better Operation and Maintenance. Also the Submersible Centrifugal Pumps offering better safety and construction features ensures reliability and trouble free operation. However availability of submersible pumps are limited to a specified capacity (usually a maximum of 300 HP) in India.

Based on the above Technical Evaluation, considering merits, advantages, disadvantages, and also the past experiences of UP Jal Nigam officials on existing installations, it was decided and recommended that for the various sewage pumping stations in Varanasi, Submersible Pumps are proposed upto 150 HP capacity and Horizontal Centrifugal Pumps are selected for higher (>150 HP) capacities.

However, the selection of pumps for rehabilitation of Ghat Pumping Stations has been restricted to Conventional Centrifugal Pumps as the area available for installation of pumps is very limited which can result in overlapping of zone of influence in case of submersible pumps resulting in reduced efficiency. Also, the present structure of wet well and drywell is more appropriate for installation of conventional centrifugal pumps.

(3) Design Criteria for Sewage Pumping Stations

1) Design Year

For the design of civil structures 2030
For the design of mechanical and electrical items 2015
For the design of rising main 2030
Rising main is usually designed for year 2030; however, final decision is considered case specific considering economy while selecting the diameter for year 2015 and 2030.

2) Wet well Capacity

Design year 2030

Detention time of wet well at peak flow	5 minutes for horizontal centrifugal pumps 3.75 minutes for submersible pumps

3) Dry Well/ Valve Chamber Size

Based on number of pumps and clear spacing requirement for pumps, pumps dimension, valves, fittings and working space requirement.

4) Rising Main

The pump capacity together with rising main diameter should be calculated considering pump cost, rising main cost and annual operation & maintenance cost. Lesser diameter rising main may be cheaper in initial cost but the operation cost may be more due to increased pump head.

The most economical size of the pumping main should be selected after analysing following factors:

- The different diameter of pipes for different head losses, which can be considered for the quantity of sewage, intended to be transported.
- The design period and the quantum of flow to be carried out for design period.
- The pipe and its relative cost including cost of laying and jointing.
- The cost of pump and its installation against the various diameters of pipes.
- The annual and capitalised cost of electric charges.
- Minimum required velocity (scouring) in pipeline (should be 0.6 m/sec) during non-peak condition.
- Maximum allowable velocity in pipe line (should not more than 2.0 m/sec)

5) Pumps

Design year:	2015
Number of pumps:	
A) For small capacity plant	
i) When rising main is long	a) 3 nos. pumps of Half Peak Flow b) 2 nos. pumps of Non Peak Flow
ii) When rising main is short	a) 5 nos. pumps of One fourth Peak flow
B) For large capacity plant	equal capacity pumps (6 to 8) + 50% standby on peak flow

Above criteria for selection of pumps is basic guideline. Final decision on pump configuration is taken based on availability of pump capacity in market.

Pump capacity in kW	9.81 * H * Q/ (Ep * Em)
Where	H = working pressure, m Q = pump discharge, m3/sec Ep = Pump efficiency Em = Motor efficiency
Electric charges	Rs. 3.25 per unit
Capitalised energy charges	CC = CR *{ [1 – (1+r) ^ (-n)]/ r }
Where	CR = annual energy charges n = period in years = 15 r = rate of interest = 10% For n=15 & r=10%; CC=7.61 CR

6) Screens & Screen Channel

Screening of incoming wastewater is required for the removal of large floating materials, which can damage the pumps. This will be carried out in two stages, viz. 40 mm opening manually cleaned bar screen followed by a 20 mm opening mechanically cleaned bar screen.

Design year	2030
Standby Units	50 % (normally)
Stage - I	
Clear spacing between screen bar	40 mm
Thickness of screen bar	10 mm
Type of working screens	Manual screen
Stage - II	
Clear spacing between screen bar	20 mm
Thickness of screen bar	10 mm
Type of working screens	Mechanical screen
Type of standby screen	Manual screen
Minimum Approach velocity @ avg. flow	0.3 m/sec
Minimum velocity through screens	0.6 m/sec
Maximum velocity through screens	1.2 m/sec

7) Electrical Load capacity

Main Transformer and other electrical equipments are designed for peak flow electrical load requirement.

8) Standby Power Supply Source

In case of electrical power failure, Diesel Generator set of peak flow load capacity is proposed for sewage pumping station with auto exchanger arrangement from grid power to DG power.

2.2 PROVISIONS FOR DISTRICT I

2.2.1 Planning Scheme

The following Table summaries the existing, sanctioned and proposed priority facilities in District I.

1)	Existing Major Sewage Facility
	a) Old trunk sewer b) Five Ghat pumping stations: located along the left bank of the Ganga River c) Konia Main pumping station and rising main to Dinapur STP d) Dinapur STP (80 mld)
2)	Sanctioned Facility
	a) Increase pumping capacity at Harishchandra and Trilochan SPS b) Provide new Ghat interceptor sewers to Trilochan SPS
3)	Proposed Facility for Priority Project
	a) Rehabilitation of old trunk sewer b) Ghat pumping stations upgrades c) Renovation and rehabilitation of Dinapur STP d) Renovation and rehabilitation of Konia MPS

2.2.2 Inspection, Cleaning and Rehabilitation of Old Trunk Sewer

(1) Background

Sewer systems are an important part of infrastructure and play an essential part of maintaining public health. Yet they are largely out of sight and in the past this has often been a cause of neglect, leading to sewer flooding, pollution, collapse and blockage. A sewer normally fails to receive attention till it starts giving serious trouble.

First sewerage system for Varanasi city was commissioned in 1917 which was designed for a population of 0.20 millions. The works included laying of a main brick sewer from Assi to Rajghat, which comes under Central city sewerage zone. It starts from Assi area and runs parallel to the bank of River Ganga, passing through heavily built up area to Church crossing and onwards along Nai Sadak to Benia, Kabir Chauraha, Maidagin and Rajghat, after which it discharges into the river Ganga at about 0.50 km down stream of rail cum- road bridge, now known as Malviya bridge. Sewer alignment of this existing trunk sewer passes through the built-up areas at certain places

Various measures were taken under Ganga Action Plan (Phase 1) for the pollution abatement of holy river Ganga in which old trunk sewer plays an important part. Following major schemes which involves old trunk sewer as an integral part were executed under GAP-1:

a) Out of the 12 nala/ drains along the Ganga River, 8 nala/ drains namely, Shiwala Drain, Harishchandra Ghat Drain, Mansarovar Drain, Dr. R.P. Ghat Nala, Jalesan Drain, Sankatha Ghat, Trilochan Ghat Drain and Telia Nala were intercepted at their tail ends and diverted to the Old Trunk sewer by pumping the sewage water flowing into the drains.
b) The main trunk sewer was intercepted near Rajghat by providing a special manhole with diversion gates to divert the sewage flow (maximum 130 mld) to Konia pumping station. Out of the 130 mld flow, 80 to 100 mld is pumped to Dinapur Sewage Treatment Plant and the remaining 30 to 50 mld is discharged into Varuna river after pre-treatment.

The Old Trunk Sewer is the main lifeline of the sewerage system of the Varanasi and it cannot be dispensed with or abandoned. Maximum carrying capacity of the trunk sewer is around 130 mld and is presently running with overloaded capacity resulting in surcharge/ overflow conditions during peak hours. Trunk relief sewer was planned and is under execution (GAP-II) in the central sewerage zone to relieve the flow in main trunk sewer as well as to carry the flow of sub central sewerage zone. There has been subsidence in the past on the trunk sewer, which is a warning that due to the aging effect the sewer may collapse anywhere any time, which may dislocate the city life with a total chaos.

Considering the importance of existing Old Trunk Sewer as a part of overall sewerage system of Varanasi, the woks of inspection, cleaning and rehabilitation of the Old Trunk Sewer an urgent should be proposed as one of urgent components Feasibility Study.

(2) Basics of Sewer Rehabilitation Plan

Sewers are one infrastructure investment that most communities would like to install and forget. And with good reason, with good design and installation many sewers are trouble free for many years.

Sewers are constructed of many different materials. These, typically, included brick, precast or cast in place concrete, vitrified clay, plastic. Sewers are not however indestructible. Over time heavy earth and traffic loads, corrosion from chemicals and sewer gasses, and loss of supporting soil weaken the pipe. The traditional method for repairing a failed sewer is excavation and replacement. This may be done at a single point of failure (point repair) or long lengths of failed sewer may be replaced. Excavation is often expensive and can be extremely disruptive to traffic and pedestrians. Excavation

can also be dangerous, and worker safety is always an issue. Excavation can become impossible due to unplanned development of the town and congestion and inaccessibility of the sites as a result of this. In such situation trench less rehabilitation becomes the only viable option.

Some communities are rehabilitating their sewers because of continued maintenance problems. An ongoing rehabilitation programme helps minimize catastrophic failures by identifying and systematically rehabilitating at risk sewers. This controlled rehabilitation reduces disruption of the services and inconvenience to citizen through planning, preparation, scheduling, advanced funding, and design.

The procedure followed for any rehabilitation plan is divided into three main stages as described below:

Stage 1: Initial Planning

This is an initial (preliminary) investigation to collect the preliminary data and to establish the extent and type of problems in the drainage area (trunk sewer) and to plan the approach for the diagnostic study.

Stage 2: Diagnostic Study (Inspection Programme)

This is the detailed investigation stage, which is further subdivided into a number of diagnostic studies, the details of each study will therefore depend on the nature of the problems identified during the initial planning (preliminary investigation) stage. There are many methods and procedures, and it is necessary to consider their limitations in selecting among them. The combination of two or more methods usually provides sufficient information for making a cost effective evaluation. The investigation methods are decided on the basis of the initial study (planning).

a) Closed Circuit Television (CCTV) Inspection

CCTV or man entry inspection is required for thorough internal pipe and appurtenant inspection. The pipe size or internal dimensions that permit in –pipe observation are as follows:

Upto 900 mm diameter	CCTV inspection
Above 900 mm diameter	Man entry inspection and CCTV

The CCTV inspection technique has been further enhanced in to techniques like Sewer Evaluation Technique (SET) with the help of modern electronics and computers. This helps in categorizing the sewers through a grading plan outlined in the WRc's Sewer Rehabilitation Manual, which forms the basis for systematic rehabilitation of sewers. The sewers are graded in to five distinct categories with Grade 1 as satisfactory and Grade 5 as collapsed or imminent collapse with other stages in between.

b) Ground Water Monitoring

Groundwater depths and normal fluctuations shall be identified along pipeline alignments. This information is necessary for determining groundwater infiltration and its impact on field investigations and any subsequent rehabilitation/ replacement project activity.

c) Flow Measurement

The objective of a flow-monitoring programme is to quantify the magnitudes of flow occurring in the pipeline. Quantification of dry and wet weather flow along the sewer

length could be important in making flow diversion plan and in identifying the major problem of concern.

d) Soil investigation

Soil investigation along the sewer alignment could be important in deciding the rehabilitation methods and material.

e) Ground surface condition

Driving and/or walking the pipeline route provide the above ground information for determining certain geological or surface conditions. Features above ground, which may affect the sewer system, include swales, surface drainage, types and volume of traffic etc.

f) Waste water analysis

Sampling and analysis of wastewater flowing through the sewer line may provide important information about corrosiveness, gas contents (methane, hydrogen sulphides) and other factors important in selecting the rehabilitation material.

g) Structural Assessment

This is carried out through Non-destructive techniques (NDT) like SONAR, rebound hammer, geo-physical imaging etc.
These investigations and grading/ evaluation assist in selection of rehabilitation philosophy based on WRc Manual. The Philosophies for trenchless rehabilitation are divided in to Type I- Composite, Type- Standalone, Type III- Non-structural liners.

Stage 3: Implementation (Rehabilitation)

The final stage of the procedure involves the implementation of the rehabilitation plan, operation of the system in accordance with the operation and maintenance plan, and the long term monitoring of the system.

Trenchless Rehabilitation has following advantages:

- Non-disruptive
- Fast
- Environment/ Eco- friendly
- Use of advanced materials resulting in increased service life
- Improved hydraulic efficiency if used in proper manner
- Does not need additional space for laying of additional utility (especially significant in congested cities)

Limitations:

- Costly if only direct costs are accounted for
- Reduction in CSA/ Carrying capacity if not used properly
- Dependant on foreign technology/ manpower/ inputs

Each stage is further divided into phases and steps. The interrelation of each phase and individual step is shown in the detailed flow diagram below (Figure 2.10).

Rehabilitation Methods and Material

The selection of rehabilitation methods and materials depends on an understanding of the specific

problems to be corrected. It is also important to evaluate external as well as internal factors before a decision can be made on the methods and materials that will most effectively solve the problem.

The effects of the pipe zone soil structure and groundwater conditions are essential considerations in the analysis of pipeline rehabilitation. Groundwater can rise and fall, creating a soil pumping action adjacent to the leaking or failing pipe. The movement of groundwater can affect the soil around the pipeline. The soil type and grain size can impact the rate of this soil pumping action and its effects on the pipeline. Soil structure and groundwater conditions also greatly influence the feasibility of certain methods or materials.

Other factors, which significantly influence the choice of methods and materials, are:

- Accessibility
- Magnitude of flows
- Available bypassing or rerouting flows
- Mechanism of failure or problem
- Type and magnitude of problem
- Rights-of-way
- Lateral connections
- Length and size of pipe(line).
- Need for up-sizing

The best rehabilitation procedure chosen for a pipeline repair is the one that taken into account all of these conditions, and meets the parameters for solving the entire problem.

1) Methods and Materials for sewer rehabilitation

The various available internal and external rehabilitation options are tabulated below.

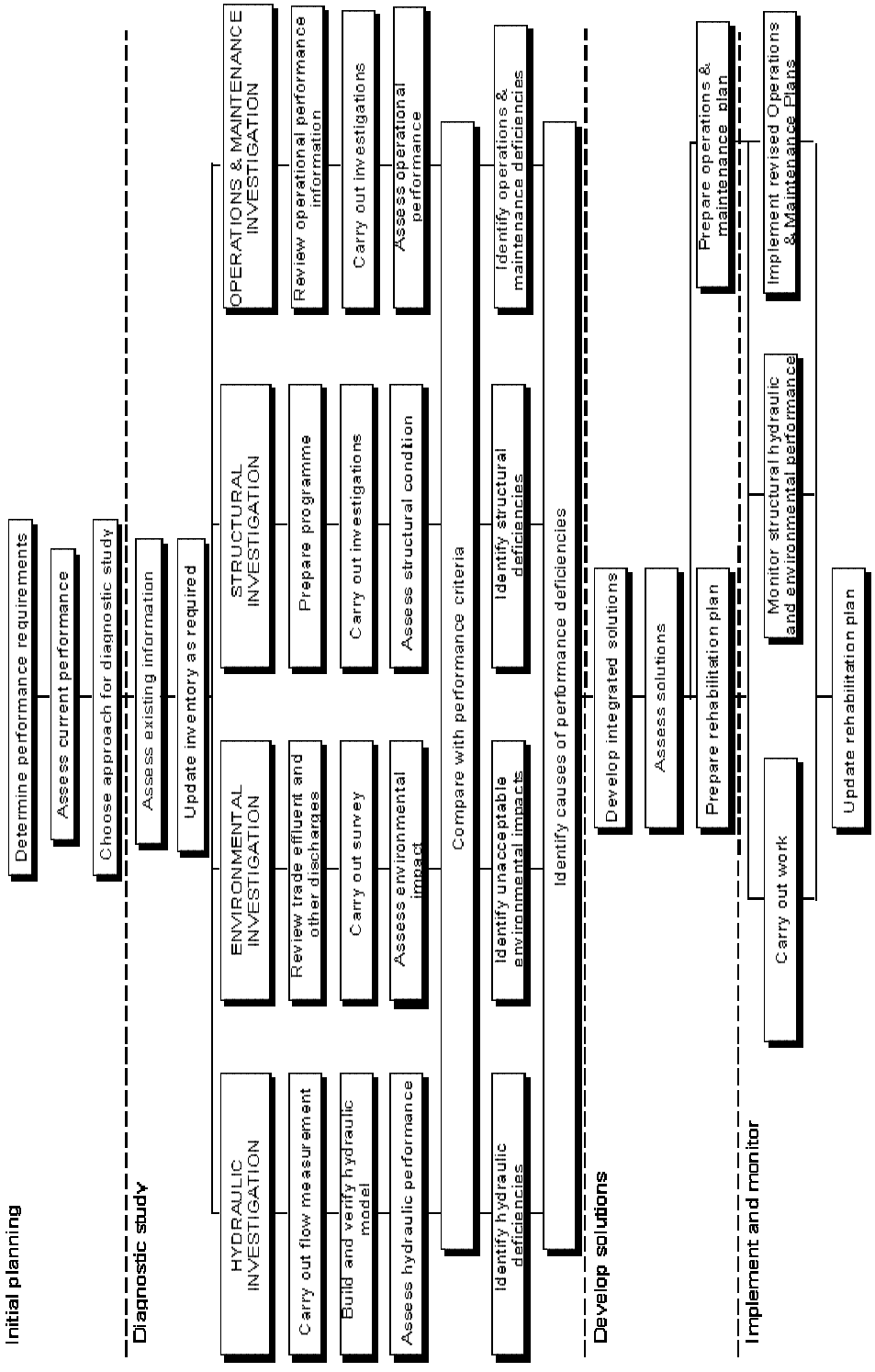


Figure 2.10 Interrelation of Each Phase and Individual Step

Table 2.14 Sewer Rehabilitation Options

Rehabilitation Option	Principal Advantages	Principal Disadvantages	Diameter Range
A. Pipeline Preparation			
Cleaning	Increases effective capacity May resolve localized problems	May cause damage. May become a routine requirement and add enormously to the O&M cost	All
Root Removal	May increase effective capacity May resolve localize problems	Problem likely to recur Does not address the cause of the problem and may be unable to ensure structural repairs	All
B. External			
External Grouting	Improves soil conditions surrounding	Difficult to assess effectiveness Can be costly	All
C. Internal			
Internal Grouting	Seals leaking joints and minor cracks Prevents soil loss Moderate cost and causes minimal disruption Can reduce infiltration Can include root inhibitor	Infiltration may find other routes of entry Existing sewer must be structurally sound	All
Short Pipe (PSE, PB, PVC, RPM, FRL, DI, Steel)	High strength-to-weight ratio Variety of cross section can be manufactured Minimal disruption	Some materials easily damaged during installation Larger pipes may require stage grouting. External lateral connection	150mm to 3000mm
Cured-in-place pipe	Rapid installation No excavation Accommodates bends and minor deformation Maximizes capacity Grouting not required Internal lateral connection	Full bypass pumping necessary High set-up costs on small projects Chemical process can be severely affected by tropical and hot climate hence not recommended for large diameter and longer length than those could be handled within the setting time	150mm to 1000mm (in general)
Deformed Pipe			
a) U-Liner/Nu-Pipe	Rapid installation Continuous pipes Maximizes capacity No excavation Grouting not required Internal lateral connection	Relies on existing pipe for installation support	150mm to 600mm
b) Swage Lining /Roll Down	Rapid installation Maximizes capacity Minimal excavation Grouting not required Internal lateral connection	Relies on existing pipe for installation support	150mm to 600mm
Spiral Wound Pipe			
a) Danby/ Rib-Loc	Tailor-made inside the conduit. No excavation required External lateral connection Maximizes capacity Non-circular available	Joints rely on sealants Relies on existing pipe for Support Required careful grouting of annulus Large diameter requires person entry	300mm to 3000mm
b) Coatings	Connections easily accommodate Zero/minimal excavation Variety of cross sections possible	Difficult to supervise May be labor intensive Control of infiltration required	150mm to 800mm
c) Mechanical Sealing	Seals leaking joints and minor cracks Prevents soil loss Low cost and causes minimal disruption	Infiltration may find other routes of entry Existing sewer must be structurally	Person- entry only

Rehabilitation Option	Principal Advantages	Principal Disadvantages	Diameter Range
	Can reduce infiltration	sound Suitable for person entry sewers only	
d) Spot (Point) Repairs	Deals with isolated problems	Requires excavation for small conduits May require extensive work on brick sewers	All
Pipe Linings			
a) Reinforced Shotcrete Placement	Variety of cross section possible	Requires person entry – may be labor intensive Lacks corrosion resistance	1000mm and larger
b) Segmented Linings	High strength-to-weight ratio Variety of cross section can be manufactured Minimal disruption	Some materials easily damaged during installation May require temporary support during routing Labor intensive Requires person entry	36" and larger
c) Continuous Pipe (Fusion-welded Polyethylene / Polybutyline / Polypropylene)	Quick insertion Large-radius bends accommodated	Circular cross section only Insertion trench disruptive High loss of area in smaller sizes Less cost effective where deep External lateral connection	150mm to 600mm due to availability of the pipes only in this range in India
Trenchless Replacement			
a) Pipe Bursting	Can replace a variety of materials Not dependent on condition of existing conduit Size for size or size increase	Potential damage to adjacent laterals Full bypass pumping required Only suitable for brittle pipes Body connections to existing pipes are difficult to handle requiring robotic cutting	100mm to 600mm existing pipe
Conventional Replacement			
a) Open Cut	Removes all problems in length Traditional designs	Expensive, particularly if deep Disruptive	All

2) Manhole Rehabilitation

Manholes are rehabilitated to correct structural deficiencies, to address maintenance concerns, and to eliminate extraneous flows. Manhole rehabilitation may also minimize or prevent corrosion of the internal surface caused by sulfuric acid formed when hydrogen sulfide gas is released from the sewerage into the sewer environment.

Many methods to rehabilitate Manhole are currently available. New products and application technologies are continually being developed. The evaluation of each method should consider:

- The type or types of problem
- The physical characteristics of the structure such as the construction material
- The condition and age
- The location of the manhole with respect to traffic and accessibility
- The risk of damage or injury associated with the current condition of the structure
- The cost/value in terms of rehabilitation performance

The rehabilitation of Manholes can be divided into the following methods.

- Chemical grouting
- Coating systems

- Structural linings
- Corrosion protection
- Manhole components

Table 2.15 Sewer Manhole Rehabilitation Options

Rehabilitation Options	Principal Advantages	Principal Disadvantages
Rehabilitation of manhole structure by plugging, patching, and coating and sealant (Both non-cementitious & cementitious, with or without plastic lining)	Improve structural condition, eliminate leakage and provide corrosion protection. Little disruption	Will not rehabilitate badly deteriorated or structurally unsound Manholes
Repair or rebuilding of manhole chimney and cone section when excavation is required	Rehabilitate badly deteriorated or structurally unsound chimney and cone section	Excavation required
Step removal and / or replacement	Improve access and safety and eliminate leakage	Installation difficulty
Replacement of manhole frame and cover	Improve service life and alignment, adjust grade, and eliminate leakage	Excavation required
Structural relining	Renew structural integrity	Reduction of dimension, cost
Seal or replace cover, or install insert	Eliminates inflow and stop rattle	Raises cover slightly
Chemical grouting of manhole structure	Eliminates infiltration and fills voids in surrounding soil	Does not improve or rehabilitate interior or manhole
Total replacement	New manhole	Cost

3) Pipeline Preparation

Prior to initiating any rehabilitation work, it is necessary to prepare the pipeline, inspection and cleaning.

The purpose of cleaning is to remove foreign materials from the sewer in advance of CCTV monitoring work. The degree of cleaning depends on the type(s) of rehabilitation work planned. However, there are times when CCTV work may be done in advance of cleaning.

Cleaning equipment used may include a hydraulically propelled, high-velocity jet (hydrocleaner) or mechanically powered equipment. The proper equipment is usually determined in advance and normally depends on pipe type and condition.

After cleaning is completed, CCTV visually inspects the pipeline sections. The television camera shall be one specifically designed for pipeline work. The lighting for the camera must be suitable to allow a clear picture of the entire periphery of the pipe. The lighting should be preferably provided with Xenon bulbs. The lens head shall have facilities for tilt/ pan and 360 degrees fish eye view of the internal surface of the pipe. The CCTV may be mounted on articulated crawlers or floats so as to provide easy maneuverability.

Roots removal from the pipeline is necessary for maintaining proper flow conditions and for reducing infiltration and/or structural damage to the pipeline. Special attention should be given during the cleaning operation to ensure complete removal. Removal procedures usually require the use of mechanical equipment, such as rodding machines, bucket machines, winches using root cutters, porcupines and high velocity jet cleaners.

(3) Varanasi Project - Collection of Data and Manhole Survey

Data Collection

a) Flow Measurement

Flow measurements were carried out on the old trunk sewer outfall at Rajghat as well as on Nala/ drains, which were intercepted and diverted to old trunk main sewer via Ghat pumping stations.

Table 2.16 Flow Measurement Details under Old Trunk Main

Sr.	Name of Nala & Drains	Measured Discharge, mld		Type	Remark
		1986	2000		
1	Old Trunk Sewer outfall at Rajghat	**100**	**130**	Circular pipe	Main trunk sewer catchment flow + intercepted nala flow
2	Shiwala Drain	1.00	5.50	Circular pipe	Intercepted into main trunk sewer
3	Harishchandra Ghat Drain	1.50	2.50	Rectangular	Intercepted into main trunk sewer
4	Mansarovar Drain	2.50	2.50	Circular pipe	Intercepted into main trunk sewer under GAP-1
5	Dr. R.P. Ghat Nala	20.00	25.00	Rectangular	Intercepted into main trunk sewer
6	Jalesan Drain	2.75	3.75	Rectangular	Intercepted into main trunk sewer
7	Sankatha Ghat		0.30	Rectangular	Intercepted into main trunk sewer
8	Trilochan Ghat Drain	2.00	3.50	Rectangular	Intercepted into main trunk sewer
9	Telia Nala	1.00	3.00		Intercepted into main trunk sewer under GAP-1
	Total (2 to 9)	**30.75**	**46.05**		

b) Trunk Sewer Inventory

At present around 130 MLD of sewage flows out of the Old Trunk sewer at special manhole near railway bridge. Available collected data from UP Jal Nigam on old trunk sewer were examined to ascertain the maximum carrying capacity of trunk sewer and is tabulated below. Earlier manhole survey carried out by UP Jal Nigam shows heavy silting conditions especially in the upstream reach. It may also be possible that due to inadequate flows- especially in upstream stretches; self-cleansing velocity may not be achievable due to larger than necessary size. Large size hydraulically is not necessarily the efficient option. It would be essential to evaluate the water supplied and water returned in to sewers before concluding anything.

Table 2.17 Old trunk Sewer Inventory

Case 1: Considering brick sewer internal surface in rough condition (n = 0.017)

Sr.	Location	Dia (inches)	Slope	Length (meter)	Max flow (80% flow) lpm	Max flow (Full bore) lpm
1	Assi to Shiwala	30	1:600	924	320.0	363.70
2	Shiwala to Gudaulia	48	1:1100	1,740	830.0	940.39
3	Gudaulia to Benia Park	72	1:1600	697	2,000.0	2,298.27
4	Benia Park to Hirapur	78	1:1600	595	2,500.0	2,844.97
5	Hirapur to Baraganesh	84	1:1300	250	3,350.0	3,845.65
6	Baraganesh to Hansapur	90	1:1800	1,511	3,450.0	3,928.14
7	Hansapur to Konia SMH	96	1:2450	1,175	3,490.0	3,999.13
8	Konia SMH to Rajghat outfall	96		280		

Case 2: Considering brick sewer internal surface in bad condition (n = 0.02)

Sr.	Location	Dia (inches)	Slope	Length (meter)	Max flow (80% flow) lpm	Max flow (Full bore) lpm
1	Assi to Shiwala	30	1:600	924	270.0	309.14
2	Shiwala to Gudaulia	48	1:1100	1,740	700.0	799.33
3	Gudaulia to Benia Park	72	1:1600	697	1,700.0	1,953.53
4	Benia Park to Hirapur	78	1:1600	595	2,100.0	2,418.22
5	Hirapur to Baraganesh	84	1:1300	250	2,850.0	3,268.80
6	Baraganesh to Hansapur	90	1:1800	1,511	2,900.0	3,338.92
7	Hansapur to Konia SMH	96	1:2450	1,175	2,950.0	3,399.26
8	Konia SMH to Rajghat outfall	96		280		

Roughly present flow condition represents more than 50% silting in sewers and corresponding loss in carrying capacity and internal brick surface of sewer from rough to bad condition.

c) Proposed Relief Trunk Sewer (Under Construction)

At present U.P. Jal Nigam is constructing a trunk relief sewer of maximum 225 mld capacity for sub-central and part central district sewerage zone. Provision has been given to connect this relief sewer to existing Old Trunk Sewer near Beniya Park so that excess wastewater can be diverted to this relief trunk sewer.

Considering the existing ground situation (heavy traffic, narrow roads) along the alignment of old trunk sewer, the under execution trunk relief sewer will play a vital role during rehabilitation of old trunk sewer by facilitating flow diversion.

Manhole Survey

Due to heavy traffic congestion on the route of trunk sewer, manholes could only be opened for inspection during midnight to early morning hours.

Out of 83 manholes identified during survey, 70 manholes could be surveyed for assessments of condition. Remaining 13 identified manholes could not be surveyed despite best effort. Remaining manholes of the possible 200 manholes could not be located due to its buried positions, construction over manholes, and presence of manholes within private/ inaccessible boundaries.

(4) Inferences based on the available information

Manhole survey was carried out at night during lean flow conditions. A number of manholes were found under surcharged condition during lean flow periods also, which is due to heavy silting condition or probable damage to sewer section. Important outcome of manhole survey are:

- Manholes were found heavily surcharged in the downstream section of Old Trunk Sewer between Vishewarganj and Rajghat passing through Maidagin, Mokimganj and Prahlad Ghat. This might lead to caving in of the old brick sewer.
- Moderate to heavy silting was found in most of the manholes.
- Internal plaster of most of the manholes was corroded resulting in further deterioration of structural integrity of manholes. Probable reason of deterioration of manhole plaster could be presence of hydrogen sulphide gases resulting in formation of sulphuric acid.
- Cast Iron steps were missing in most of the manholes.
- Cast iron square and circular manhole covers in fairly good condition were found on most of the manholes.
- Mechanical bucket machines were used for the desilting of sewers.
- The external surface of the bucket is glittery mainly due to the abrasion, which indicate the presence of hardened silt deposition
- The use of buckets for desilting might erode the pointing as well as the bricks, which might reduce the structural stability, and cause increased silt deposition.
- Manhole cleaning is required to get further useful data.

Manhole survey shows major problem of silting, surcharge, unsatisfactory internal manhole plaster and possible structural deterioration (plaster). It gives very limited information about the internal condition of sewers, however it can be presumed that severe conditions can be expected on some of the sewer sections. A detailed investigation (diagnostic study) in accordance with the guidelines of the Sewer Rehabilitation Manual of WRc, UK is further required as a first step of proposed rehabilitation plan to gather more information about the internal condition of sewers which will help in evaluating its performance in terms of hydraulic, environmental, structural integrity and operational performance indicators.

(5) Proposed Rehabilitation Programme

After evaluating the preliminary investigation outcome following line of action is proposed under three steps.

Step 1: Database Generation

Detailed information of old trunk sewer is required before planning any rehabilitation and maintenance plan. After reviewing the initial investigation following survey is required to generate more database.

<u>Manhole cleaning and inspection</u>

During preliminary investigation only 70 manholes could be surveyed against an expected 200 numbers. Most of the manholes are buried under structures or under road surface, which need to be located. Manhole survey of surveyed manholes shows heavy silting and surcharges conditions resulting in inability to gather key information at this stage. Hence, it would be imperative to carry out a detailed manhole inspection after desilting/ cleaning the manholes, which would be done in next stage for enabling preparation of DPR. So, the proposed manhole cleaning and inspection programme needs following activities:

- Identification and opening of all buried manholes
- Manual or mechanical (super suction machine) cleaning of manholes
- Detailed inspection of manholes

Conditional Assessment of Sewer

Internal inspection of sewer is required to understand the present condition of sewer. Inspection survey can be carried out either by high-resolution colour CCTV camera or by man entry survey depending upon the sizes of the sewers. Man entry survey requires special safety equipments and flow diversion.

CCTV inspection survey can be carried out along with sewer cleaning, however, considering the age of the Old Trunk Sewer and the amount of silting, CCTV survey prior to any cleaning programme is recommended in stretches where essential and possible to prevent any major damage during cleaning. CCTV survey should be carried out during lean flow conditions and under general circumstance 40% of pipe bore should be empty during inspection.

Two options are available for condition assessment of sewer:

Option 1: CCTV inspection of sewer
Option 2: CCTV inspection along with sonar equipment for continuous liquid depth & clear opening depth recording.

Option 2 will give more details of sewer in terms of silt depth, hydraulic line, pipe sagging details and is recommended.

Some new structural assessment techniques like geophysical sounding may be used in combination of the inspection to provide more information.

The information gathered shall be recorded preferably on digital media and shall be used for grading of the sewer condition as per the WRc Sewer Rehabilitation Manual (SRM).
This shall be recorded in a database for further use of the client.

Step 2: Pipe Preparation

Based on the CCTV survey outcome, sewer sections shall be graded in to the five grades defined under the SRM and a detailed desilting plan will be formulated. Desilting of sewers can be carried out by high pressure jetting cum suction machines (upto 1000 mm diameter), mechanical bucket machines or manually paying careful attention to the likely state of the sewer. Flow bypassing or over-pumping may be required at various sections for effective cleaning of pipeline. CCTV survey after desilting shall be required to check the effectiveness of cleaning.

Step 3: Sewer Rehabilitation

Stabilisation (local repairs): Sealing of joints and openings.

Stabilisation is only appropriate if it can be assumed that the original sewer is structurally sound. A structural design check on the renovation is therefore unnecessary.

Lining

The structural linings can be considered as either "Type I" or "Type II", depending on how they interact with the existing pipe:

Type I - The lining, grout (where present) and existing sewer act as a rigid composite section. A bond

is required between the lining and existing sewer (and grout where present).

Type II - The lining is designed as a flexible pipe and it does not require a bond between the lining, and grout (where present) or the existing sewer.

The third type, **Type III** is only non-structural lining for improvement of hydraulic condition.

After taking into account various technologies adopted in Indian scenario pertaining to the ongoing/ completed sewer rehabilitation projects in India, following sewer rehabilitation methods are considered for this project

Slip Lining

The insertion of smaller diameter pipe, usually plastic (like HDPE) or glass reinforced plastic (GRP) into deteriorated pipe to retain the function of the 'the hole in the ground' is widely practiced. The liner pipe is usually selected to withstand all soil and traffic loads and the annular space between the liner pipe and the existing pipe is filled with a grout compound to secure the line and level of the liner and transfer structural loading from the existing pipe. There is usually a significant loss (may be up to 20%) of cross sectional area and flow capacity. But to keep the loss of cross sectional area to an acceptable level, proprietary techniques like reaming would be required case by case.
There is a number of pipe pushing and pulling devices available and the method is widely practiced for short crossings and other applications where capacity is not a major issue. Slip lining can be used to achieve both Type I and Type II rehabilitation and is especially suitable for man-entry sizes and works out to be economical over other methods like CIPP under such circumstances.

Lining with cured in place liners (CIPP)

First developed in 1971 by Insituform Technologies Inc. cured in place liners are applicable to pipe in the size range 100-2700 mm.

Cured in place liners can be installed in non-circular pipe, can accommodate bends and changes of pipe diameter, can incorporate fibre optics and other communications media. The process is generally applied to lengths between manholes but may run through several manholes if a long length is required. Most liners are 70 – 200 m, but longer lengths up to 900m can be attempted. Short lengths patch repairs can also be installed using a packer arrangement.

The majority of cured in place pipe installed are small and middle sized pipe, liners up to 1000 mm are commonplace, larger liners up to 2750mm have been successfully installed, but experienced crews, special equipment and extreme planning are required
Catalyzed resins are extremely light and temperature sensitive and require shade and refrigerated storage for transportation to site.
The design methods are used to determine the thickness of cured in place pipe required to accommodate the external loads.

Lining with Spirally Wound Pipe

Originally developed in Australia as Ribloc, this process was first used to make formwork for cast in place pipe with the outback. It was first implemented for sewer renovation about 1987. The profiled PVC strip incorporates a male and female joint form and ribs to provide stiffness. Fed through a winding machine usually located in a manhole the strip can be rapidly formed into pipe and introduced into the pipe line with some loss of cross sectional area. The annular space is filled with a cement grout to secure the pipe in place and bond to the existing structure.

Spiral wound pipes should be designed as WRc Type II liners; Type 1 designs are inapplicable due to

the profound strain incompatibility between the plastic strip and the brick or concrete pipe structure.

Lining with Segments

The use of precast sections to restore the fabric of deteriorated sewer is probably one of the earliest methods known, the development in the late 1970s of glass reinforced cement and glass reinforced plastic technology made possible the construction of relatively light weight repair sections more readily manhandled in to confined spaces.

Good quality polyester resins and glass fibre materials are locally available in India and segment manufacture requires manufacturing skill easily assimilated. Circular, semicircular and non-circular section can be readily made using hand lay up, mechanized and closed mould processes of varying qualities. Segments are usually made with a sandwich structure for stiffness and economy and with glass rich layers concentrated in zones where higher tensile stresses can be expected. A resin rich skin usually protects the glass rich zones. Where joints are incorporated, gaskets or solvent bonds are used to ensure strength and water tightness. Segments can be installed by manual intervention in conditions of modest flow, but flow should be suspended for grouting operations.

Lining with sprayed coating

Gunite or Shotcrete is used to repair large structures such as tunnels and can be employed in sewers. Shotcrete is a pneumatically applied mortar or concrete in which the cementitious mix is projected at high speed to impact on the wall of the existing structure with such force that it compacts and can support itself without sagging or sloughing.

Gunite is the 'dry mix' process in which cement and damp aggregate are fed into a stream of compressed air in a hose and carried to a delivery nozzle where water is introduced under pressure and intimately mixed, the dry mix can include flash set accelerators. Gunite with accelerators can be applied to surfaces covered by running water, though severe infiltration must be controlled. If applied slowly and with care it forms a good bond with finely distributed reinforcement and its high cement – low w/c ratio mixture makes for a strong and durable concrete.

Use in combination with reinforcing mesh to control crack propagation and increase strength Shotcrete or Gunite forms a ferro-cement Type 1 liner. The Shotcrete/Gunte process can be used to produce pre-fabricated sections in a factory condition; such units are almost always used for the invert of the lining system so that flow can be accommodated with a minimum of over-pumping or diversion. In situ Gunite can be used to complete the liner or seal over joints. This form of construction requires cleaning and preparation of the surface of the sewer often with a primer such as PVA to enhance the bond.

However, considering the life cycle analysis of the systems, it would be preferable to adopt non-cementatious materials like GRP or Polymers so as to ensure cost effectiveness in long term.

Safety and safe working practices are also critical elements in the application of trenchless technologies. Due attention must be mandated for these works and all obligations concerning the safety of client, contractor and consultant personnel must be properly documented and promulgated in all required languages to promote safe working practices. Particular attention must be given to underground and confined spaces working.

<u>Manhole Rehabilitation</u>

Manhole rehabilitation should also be considered with any pipe rehabilitation project. Old Trunk Sewer manholes are constructed of brick. Manholes are complicated structures and all individual components need consideration. Various parts of manhole rehabilitation covers:

- Plastering, grouting
- Fixing of steps
- Repair/ replacement of manhole cover and frame
- Raising of manholes (presently buried)
- Restoration of benching
- On spot repair

Flow Diversion

For most trenchless technology work, it is necessary to bypass flow around the sewer that is being rehabilitated. Trunk relief sewer presently under execution will play an important part in the rehabilitation of old trunk sewer by diverting majority flow. Further segmental flow diversion can be achieved by providing portable pumps and temporary on ground rising main from upstream manhole of the sewer section under rehabilitation to the downstream manhole. Another important aspect of rehabilitation programme is traffic diversion planning during rehabilitation.

It must be borne in mind that flow diversion is the crucial process and may be deciding factor about success of a particular method of rehabilitation rather than the method itself.

(6) Cost Estimates

Budgetary cost estimation of sewer inspection, cleaning and rehabilitation plan for the Old Trunk Sewer has been calculated based on certain assumptions and feedback from ongoing/ completed similar type of projects under Delhi Jal Board and Municipal Corporation of Greater Mumbai.

Following details were considered while estimating the sewer inspection and rehabilitation cost:

- Total Length of sewer line is considered as 7500 m.
- Diameter wise breakup of sewer length is taken based on data from UPJN as accurate diameter wise breakup of length could not be possible from manhole survey due to submerged manhole condition.

Diameter, mm	Sewer Length (m)
750	815
1200	815
1800	970
2100	840
2250	1,290
2400	2,770

- Maximum expected manholes on sewer line = 200

Cost estimation for the rehabilitation project is divided into two broad categories:

a) Cost estimation for detailed investigation (Diagnostic study)

Table 2.18 Cost Estimate for Detailed Investigation of Old Trunk Sewer

Sr.	Particular	Cost (Rs.)
1	Identification, cleaning and inspection of manholes	440,000
2	CCTV inspection of sewers along with sonar continuous depth measurement equipment	3,375,000
3	Ground water monitoring, soil investigation and NDT structural assessment along the sewer alignment	500,000
4	**Total (1 to 3)**	**4,315,000**

b) Cost estimation for Sewer Rehabilitation
Assumption1: 80% of the sewer length of 750 - 1200 mm diameter needs rehabilitation
Assumption2: 60% of the sewer length of 1800 – 2400 mm diameter needs rehabilitation
Assumption3: 750 mm diameter sewer shall be rehabilitated by CIPP
Assumption3: 1200 to 2400 mm diameter shall be rehabilitated by GRP lining

Table 2.19 Cost Estimate of Old Trunk Sewer Rehabilitation

Sr.	Particular	Cost (Rs.)
1	Sewer Desilting including flow diversion arrangement and cleaned pipe CCTV inspection	59,586,000
2	Rehabilitation of 750 mm diameter, 652 m sewer length by CIPP technology	45,640,000
3	Rehabilitation of 1200 mm – 2400 mm diameter sewer line by GRP lining technology	502,920,000
4	**Total (1to 3)**	**608,146,000**

2.2.3 Rehabilitation of Ghat Pumping Stations

(1) Background

Under GAP-I, a new pumping station was added at Mansarovar Ghat and the other four existing pumping stations along the left bank of River Ganga were upgraded, by UP Jal Nigam. The specifications of the existing Ghat pumping stations are given in the following table.

Table 2.20 Specifications of the Existing Ghat Pumping Stations

1. Harischandra Ghat SPS	
Dimensions	6m dia circular sump cum pump house Sump floor is 6.5 m below the operating platform
Installed capacity	146 lps
Installed pumps	1 x 50 HP – 5,000 lpm @ 24 m head 1 x 25 HP – 2,600 lpm @ 13.5 m head 1 x 10 HP – 1,150 lpm @ 9.5 m head
Diesel Generating Sets	1 x 70 kVA
Rising Main	200 mm dia CI
2. Mansarovar Ghat SPS	
Dimensions	9m dia circular sump cum pump house Sump floor is 11m below the operating platform
Installed capacity	173 lps
Installed pumps	2 x 10 HP – 1,300 lpm @ 15 m head 3 x 25 HP – 2,600 lpm @ 21 m head
Diesel Generating Sets	1 x 100 kVA
Rising Main	400 mm dia CI
3. Dr. R.P. Ghat SPS	
Dimensions	6.1m dia circular sump cum pump house Sump floor is 18.3 m below the operating platform
Installed capacity	793 lps
Installed pumps	2 x 125 HP – 15,000 lpm @ 23 m head 2 x 75 HP – 8,800 lpm @ 22 m head
Diesel Generating Sets	3 x 160 kVA
Rising Main	600 mm dia CI
4. Jalesan Ghat SPS	
Dimensions	6.1m dia circular sump cum pump house sump floor is 16.3 m below the operating platform
Installed capacity	160 lps
Installed pumps	2 x 30 HP – 3,600 lpm @ 20 m head 2 x 15 HP – 1,200 lpm @ 15 m head
Diesel Generating Sets	1 x 70 kVA
Rising Main	250 mm dia CI
5. Trilochan Ghat SPS	
Dimensions	6.1m dia circular sump cum pump house Sump floor is 18.3 m below the operating platform
Installed capacity	182 lps
Installed pumps	2 x 35 HP – 4,100 lpm @ 20.5m head 2 x 12 HP – 1,365 lpm @ 18 m head
Diesel Generating Sets	1 x 160 kVA
Rising Main	300 mm dia CI

The monthly average quantum of sewage pumped from these pumping station during the period April 2002 to August 2003 are presented in Figure 2.11 to Figure 2.15.

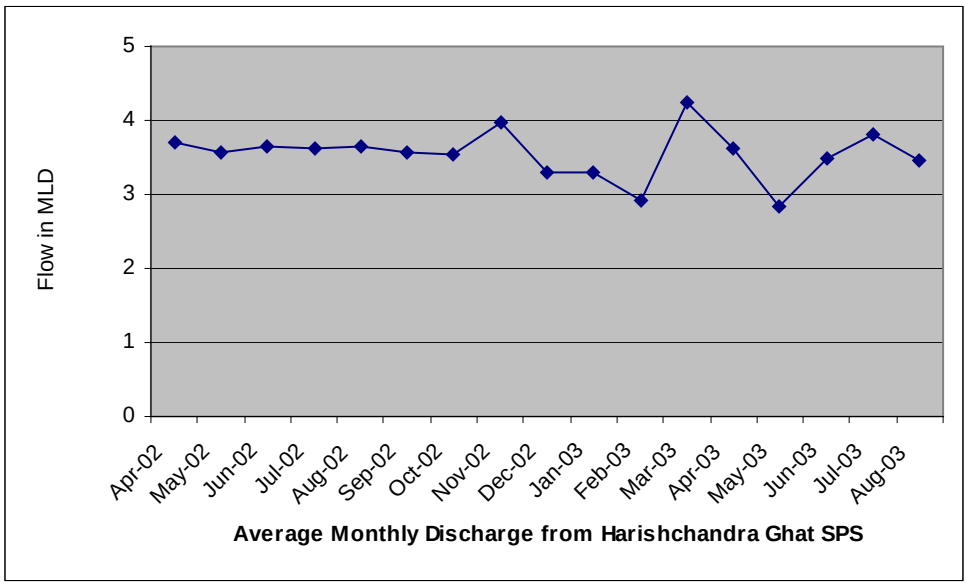


Figure 2.11 Average Monthly Discharge from Harishchandra Ghat SPS

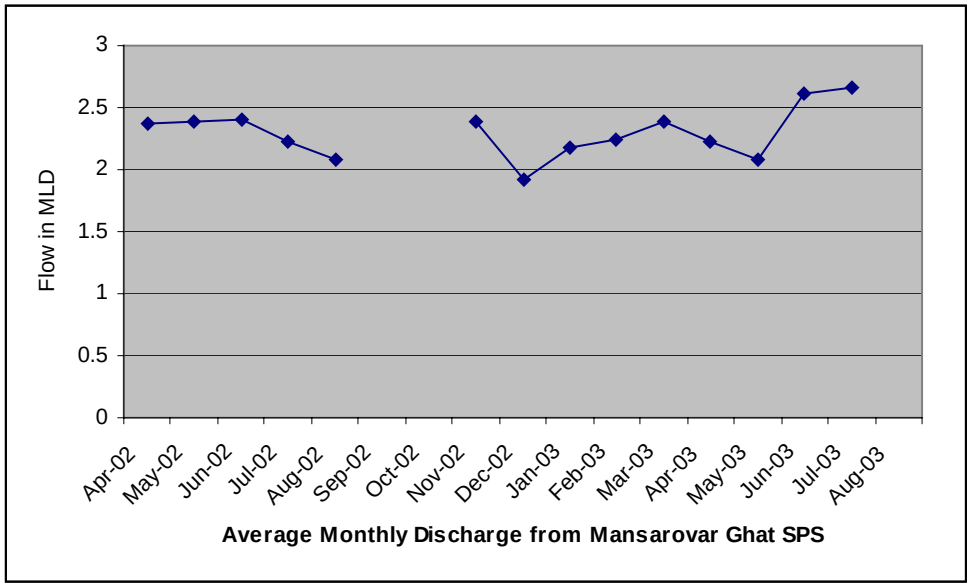


Figure 2.12 Average Monthly Discharge from Mansarovar Ghat SPS

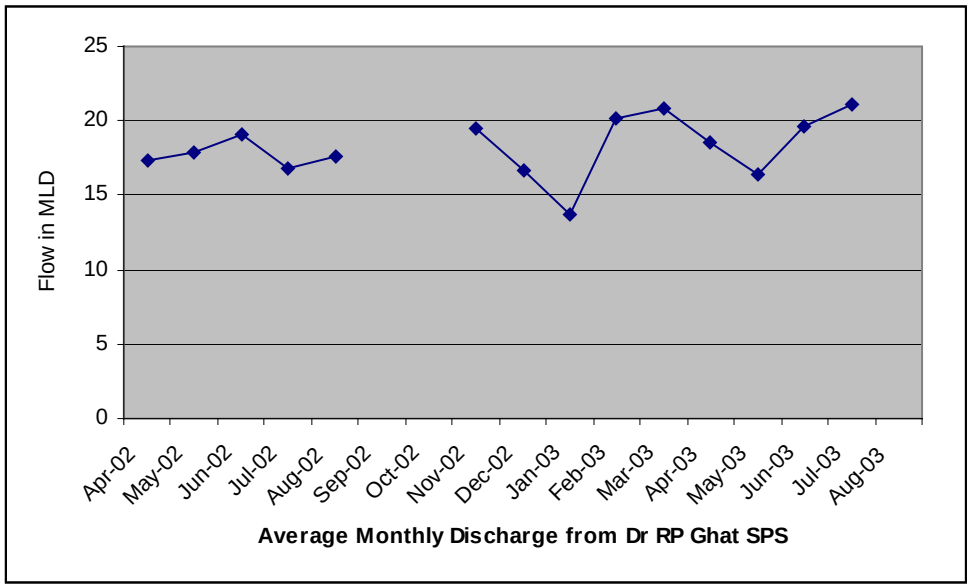


Figure 2.13 Average Monthly Discharge from Dr R P Ghat SPS

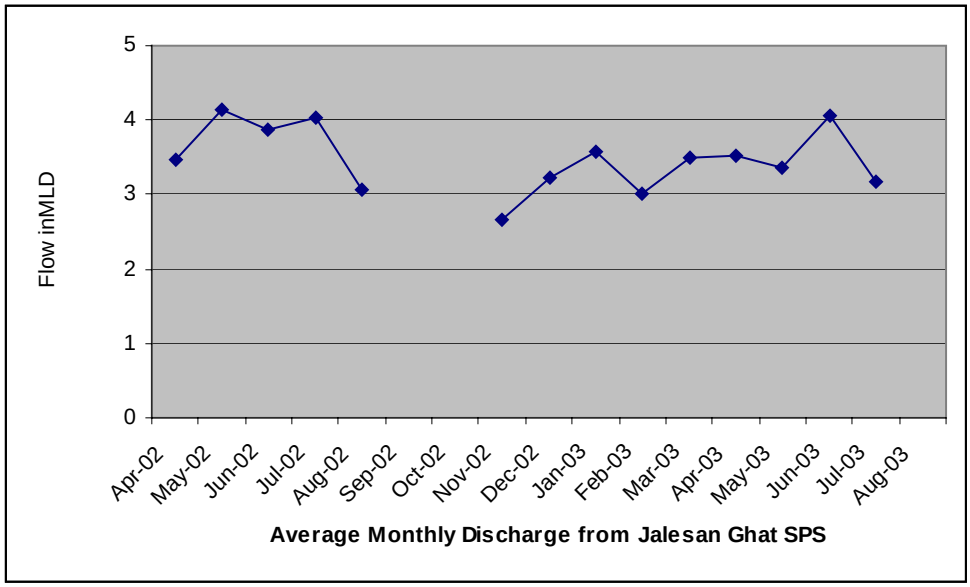


Figure 2.14 Average Monthly Discharge from Jalesan Ghat SPS

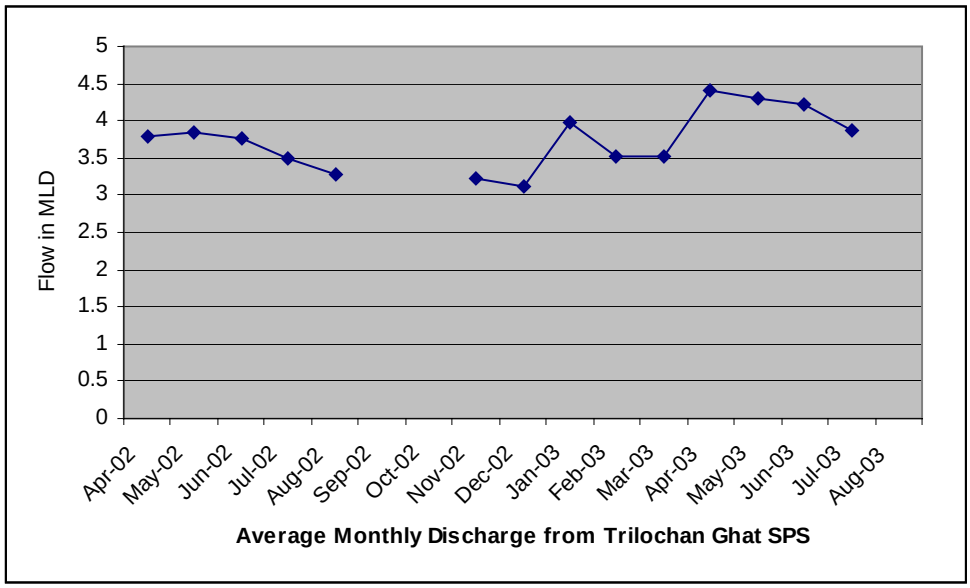


Figure 2.15 Average Monthly Discharge from Trilochan Ghat SPS

(2) Preliminary Inspection of Pumping Stations

All the five ghat pumping stations, located along the banks of the River Ganga were visited to understand the existing situation of these pumping stations.

The observations made during the survey of these pumping stations are as follows:

- During peak hours all pumps are running including standby pumps and some amount of over flow also observed during the visit
- There is no capacitor panel provided in these pumping stations
- There is no spare feeder in L.T. Panel
- Indication lamps on panels are either missing or not working
- The appearance of the Civil structure is poor
- Earthing system at all the IPS is improper and requires urgent attention and improvements
- Alternative power supply (DG Generator) is available at all IPS. However, there is no standby generator, except at R.P.Ghat
- There is not a single instrument to measure level, flow, pressure, temperature etc for proper operation at all IPS
- There is no mechanized screen (only wire mesh) available to screen the sewage water
- There is no telecommunication facility provided at any of the IPS
- Skilled operation and maintenance staff is unavailable

(3) Inferences based on the available information

Based on the reviewing the data collected, from the various organisations and the observations made during the site visits to these pumping stations following inferences are made.

Wastewater flowing through the branch sewers are intercepted and diverted to the pumping stations. The proposals, of UPJN, for increasing the pumping capacity in these pumping stations have been sanctioned.

From the observation, overflow of sewage in the pumping stations, it can be concluded that the incoming raw sewage volume is more than the capacity of the pumping stations. The pumping

capacities in all these pumping stations are increased as and when it is required considering only the present needs. Thus, strategies for further enhancement, in the capacity, of these pumping stations has to be developed with a space constraint.

As the present flow observed in the pumping stations is more than the existing capacity of these pumping stations, the stand by pumps are also in operation during the normal days. This shall lead to a sudden breakdown of the pump equipment due to excess wear and tear.

The life of the pump installed in these pumping station has expired, which leads to the temporary breakdowns. These temporary breakdowns, especially during the peak hours shall lead to a considerable amount of pollution to the River Ganga.

To overcome the electricity breakdowns and facilitate continuous operation all these Ghat pumping stations are equipped with a diesel generator. However, due to the limited resource these generators are not fully utilized in all the pumping stations.
It is confirmed that there is an immediate need to rehabilitate these pumping stations to achieve the over all objective of reducing the pollution level in River Ganga.

(4) Evaluation of Alternatives

As mentioned above, the life of the pumping equipment has expired thus the existing pump equipment has to be replaced and there is a need to enhance the pumping capacity. With the available data and time, it can be said that mechanical engineering interventions are to be undertaken immediately. The various possible rehabilitation and augmentation alternatives for these pumping stations are:

1. Replacement of the existing pump equipment by new centrifugal pumps with vertical motor
2. Convert the existing dry well to wet well and provide new submersible pumps

It is obvious, that any equipment requires proper and timely maintenance. Especially in the case of sewage pumps it is very necessary to adhere to a strict maintenance schedule to avoid breakdowns. It is therefore, necessary to select an alternative, which can be maintained with ease.

Alternative 1:
Replacement of the existing pump equipment by new centrifugal pumps with vertical motor.

The main advantage of this strategy is that the total augmentation time taken will be very minimized. The other advantage of this system is that the existing operation and maintenance schedule can be used.

Centrifugal Pumps also offer substantial reduction in the energy consumption, resulting in reduction in size of motor cabling, length of cabling, reduction in capacity of transformer & generator set.

Alternative 2:
Convert the existing dry well to wet well and provide new submersible pumps
The main constraint in space, for augmentation and rehabilitation, in the existing pumping station can be overcome, however the structural stability, water tightness, of the dry well has to be further investigated.

(5) Proposed Rehabilitation Programme

Based on the comparison of the various technical and commercial aspects it is apparent that the Alternative Replacement of the existing pumping equipment by new centrifugal pumps with vertical motor is more attractive and it is also the least cost alternative. Thus, the Feasibility Study proposes

that this alternative for Rehabilitation of the Ghat Pumping station shall be adopted.

New provisions are made to cater to the demand in the year 2003. Pumps have been provided in order to get the flexibility in operation and maintenance.

Trilochan Ghat SPS

- Required pumping capacity is 262 lps including 25 % stand by capacity
- All the pumps are replaced as the existing pumps are more than 15 years old
- Two pumps, one of 5,300 lpm @ 26 m head and another of 2,600 lpm @ 26 m head, have already been acquired by UP Jal Nigam and same are to be installed
- In addition, three pumps, two of 5,300 lpm @ 26 m head and another of 2,600 lpm @ 26 m head, are proposed to take care of the ultimate flow
- Altogether five are required, where 2 pumps of 5,300 lpm and one of 2,600 lpm will be working to handle the peak flow with one of 5,300 lpm as stand by
- One pump of 2,600 lpm is provided as spare for the same capacity pump and has to be kept in the store
- Therefore, the total capacity provided is 308 lps
- All the above pumps will be connected to the two rising mains viz. 300 mm dia existing and 350 mm dia under execution

Jalesan Ghat SPS

- Required pumping capacity is 136 lps including 25 % stand by capacity
- All the pumps are replaced as the existing pumps are more than 15 years old
- Four pumps, each of 2,176 lpm @ 27 m head, are proposed to take care of the ultimate flow
- At peak, three pumps of 2,176 lpm will be working with one as stand by
- Therefore, the total capacity provided is 145 lps
- All the above pumps will be connected to the existing rising main of 250 mm dia that is connected, to 350 mm dia rising main originating from Dr. R.P. Ghat pumping station. This 350 mm dia rising main finally connects to a 600 mm dia rising main.

Dr. R.P. Ghat SPS

- Required pumping capacity is 904 lps including 25 % stand by capacity
- All the pumps are replaced as the existing pumps are more than 15 years old
- Three pumps, each of 21,696 lpm @ 23 m head, are proposed to take care of the ultimate flow
- At peak, two pumps of 21,696 lpm will be working with one as stand by
- Therefore, the total capacity provided is 1084.8 lps
- All the above pumps will be connected to a common header that will be connected to two existing rising mains of 350 mm dia and 450 mm dia. Both rising mains are connected to two rising mains of 600 mm dia separately. Also, a 250 mm dia rising main from Jalesan Ghat SPS is connected to the above 350 mm dia rising main.

Mansarovar Ghat SPS

- Required pumping capacity is 90 lps including 25 % stand by capacity
- All the pumps are replaced as the existing pumps are more than 15 years old
- Three pumps, each of 2,160 lpm @ 20 m head, are proposed to take care of the ultimate flow
- At peak, two pumps of 2,160 lpm will be working with one as stand by
- Therefore, the total capacity provided is 108 lps
- All the above pumps will be connected to the existing rising main of 400 mm dia

Harischandra Ghat SPS

- Required pumping capacity is 290 lps including 25 % stand by capacity
- All the pumps are replaced as the existing pumps are more than 15 years old
- Two pumps, each of 6,800 lpm @ 15 m head, have already been acquired by UP Jal Nigam and same are to be installed
- In addition, one more pump of 6,800 lpm @ 15 m head, is proposed to take care of the ultimate flow
- Altogether three pumps are required, where 2 pumps of 6,800 lpm will be working to handle the peak flow with one as stand by
- Therefore, the total capacity provided is 339 lps
- All the above pumps will be connected to a new 400 mm dia rising main, which is under execution and the existing rising main of 150 mm dia may be discarded.

There is need to complement the mechanical intervention with the electrical and instrumentation interventions at each Ghat pumping station. The electrical interventions for the entire Ghat pumping stations are described below.

Electrical Interventions: Variable Frequency Drive

A Variable Frequency Drive (VFD) has been proposed in the entire Ghat pumping stations; the principle of the VFD is illustrated in Figure 2.16.

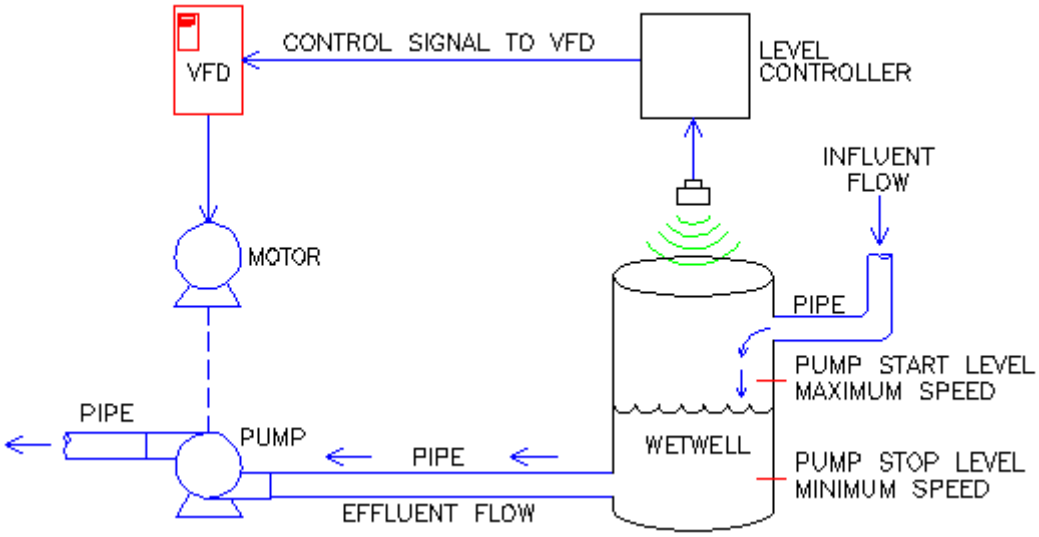


Figure 2.16 Application of Variable Frequency Drives in Wastewater Pumping Station

a) The objective is to pump the wet-well down when it is full (similar to a sump pump in a house). The control scheme consists of an ultrasonic level controller, which will monitor the level in the wet-well and send this information to the VFD. The controller will start, stop, and vary the speed of the pump based on set fonts in the wet-well.
b) As influent wastewater fills the-wet well, the level controller starts the VFD: the VFD will turn the pump on at zero speed, and ramp the pump at a smooth acceleration rate to maximum speed.
c) With the pump operating at maximum speed, it starts drawing the level in the wet-well down. As the wet well level decreases, so does the speed of the VFD. The VFD will operate at maximum operating speed at the start level and the minimum operating speed at the stop level.
d) While the VFD is operating the pump, one of two scenarios will take place:

- The pump will overcome the influent into the wet-well. As the level decreases, so does the VFD (pump) speed. The level becomes low enough to shut down the VFD that causes the pump to stop.
- The pump will reach a speed at which the influent and effluent are equal. When the amount of liquid entering the wet-well and the amount of liquid being pumped out of the wet-well become equal, the control system has achieved flow matching.

e) The advantage of the above two scenarios are:

- Soft start and stop reduces mechanical wear.
- Acceleration and deceleration is controllable.
- Speed is controllable.
- Motor current limiting.
- Power savings.

The advantages of the VFD drive are:

Starting current kicks are eliminated

With conventional starting methods or star delta starting, the motor draws 5 to 6 times the rated current at start. The AC drive controls both the voltage and frequency at any given time. Hence, the starting current kick is eliminated. This reduces the maximum demand of the plant and electrical stresses on the upstream equipment e.g. cable breakers and transformers. Lower starting current also means that the plant DG set can be of a lower rating.

Better Input Power factor

With conventional control methods, if the motor runs on part load, it operates at a very poor efficiency and power factor. Since a majority of the motors usually operate at lower than rated load continuously, this leads to power wastage. Modern generation of AC drives have an in-built flux optimisation feature that allows defluxion of the motor at light loads. This allows the motor to run at its best efficiency point even at light load. Also, the AC drive presents a near unity power factor to the mains. These factors lead to savings of energy that would otherwise have been wasted.

Longer Equipment life

With conventional methods there is a big jerk at starting due to sudden surge of starting current. Inbuilt soft start feature of the ac drive provides smooth acceleration and limits sudden jerks. This leads to longer mechanical life of equipment e.g. fan blades; pump impellers, gearbox, belts, pulleys etc.

Complete Motor protection

Conventional methods of motor protection e.g. fuse and overload relays offer limited motor protection. Moreover, these devices are prone to drift due to aging and hence need frequent recalibration. Modern AC drives offer comprehensive motor protection against faults like over-current, overload, short circuit, ground fault, over-voltage and under-voltage. Since, all settings are digital in nature, they do not change with age and do not need recalibration.

Interface with Higher-level Systems

Modern AC drives have in built communication ports for communication to high level systems e.g. DCS, PLC's and plant computers. This allows for extensive data logging, fault monitoring and operation from a centralised location.

Depreciation Benefits

AC drives are classified as energy saving devices under the Income Tax rules of Govt. of India. Hence, the amount invested in ac drives can be deducted from the taxable income in the very first year of investment. This reduces the payback period further.

Energy saving by reduction in pump loading

Variable frequency drive reduces the pump loading proportionately with the flow of incoming sewage. The pump running at 100% load at peak flow will run at 75% load at average flow. The same pump

will run at 50% load at lean flow. Thus reducing the input power consumption proportionately based on the flow.

DG Sets

There is a frequent electricity breakdown in the city of Varanasi. Thus for proper operation of the pump equipment in these Ghat pumping stations there is a need to provide alternate power source (DG Sets). All the five Ghat pumping stations have DG Sets, however, some of them are of lesser capacity than required to meet the augmented pumping capacity. Thus the following strategy is developed for provision of DG sets. While proposing the strategy the existing assets are also considered.

- Each Pumping station shall have proper DG Set
- All the Pumping station shall have DG sets to meet the power requirement at peak flow as well as average/lean flow
- The use of VFD with this strategy will further save the fuel cost.
- At Trilochan Ghat SPS, a new DG set of 200 KVA is proposed to handle the revised pump capacity.
- At HarishchandraGhat SPS, the existing DG sets, 2 nos. of 70 kVA, are adequate to take care of new pumping capacity. However, provision has been made for an auto synchronisation system for these DG sets.
- At Jalesan Ghat SPS, the existing DG set of 70 kVA is to be replaced with a 100 kVA DG set from Mansarovar Ghat SPS.
- At Dr. R.P. Ghat SPS, the existing DG sets, 3 nos. of 160 kVA, are adequate to take care of new pumping capacity. However, provision has been made for an auto synchronisation system for these DG sets.
- At, Mansarovar Ghat SPS, the existing DG set of 100 kVA is to be replaced with a 70 kVA DG set from Jalesan Ghat SPS.
- It is proposed to have an Auto Mains Failure (AMF) panel for DG sets at each Ghat SPS
- A level sensor has been proposed at diesel storage tank of the DG set.

Capacitor Panel
It is observed during the field visits, that none of the SPS has power factor correction capacitor panel. As per the existing regulations formulated by the Electricity Authority, it is required to maintain a power factor equivalent to 0.95 and if it is maintained at more than 0.95, the facilities are eligible for the rebate in the energy bill. If the facility has a poor power factor then a penalty can be levied on that facility. Considering the global concern of reducing the energy losses it is proposed to have a capacitor control panel at each Ghat SPS to maintain a power factor equivalent to 0.98.

Earthing System
It is proposed to have an earthing system at each Ghat SPS as per the IS: 3043 to maintain earth resistance to less than 1 ohm.

Instrumentation Interventions

Ultrasonic Level Controller
It is proposed to install an ultrasonic level controller at all the five Ghat SPS to regulate the switching of the pumps automatically based on the sewage level in wet well.

PLC Control Panel
To facilitate the automatic operation of the pumps it is proposed to install a PLC control panel at each Ghat SPS.

Pressure Gauge
It is necessary to maintain the pressure at the inlet to carry necessary precautionary measures at the inlet so as to avoid the damages to the suction pipe due to abnormal pressure at the inlet. Thus a

pressure gauge is proposed at all the Ghat SPS.

(6) Cost Estimates

The augmentation / rehabilitation cost for the selected alternative and complementing interventions are estimated and presented in Table 2.21.

Table 2.21 Break up of Costs for Rehabilitation of Ghat Pumping Station

(Rs.)

Sr.	Location	Mechanical Cost	Electrical Cost	Total Capital Cost	O & M Cost @ 3%
1	Trilochan Ghat	1,585,000	6,467,000	8,052,000	241,560
2	Harsichandra Ghat	719,000	4,240,000	4,959,000	148,770
3	Jalesan Ghat	1,077,000	4,076,000	5,153,000	154,590
4	Dr. RP Ghat	5,975,000	13,531,000	19,506,000	585,180
5	Mansarovar Ghat	622,000	3,452,000	4,074,000	122,220
	Grand total			41,744,000	1,252,320

2.2.4 Renovation / Rehabilitation of Existing Konia Pumping Station

(1) Existing Scheme

Main Pumping Station (MPS) was constructed under GAP-I at village Konia. This pumping station is located near Rajghat for conveyance of sewage from old trunk main sewer to the treatment works at Dinapur. The pumping station has a capacity of 100 mld.

In this MPS, pumping is carried out in two stages, three screw pumps in first stage followed by a set of centrifugal pumps in second stage. The sewage lifted by screw pumps passes through screening and grit removal units. The existing facilities in Konia MPS are presented in Table 2.22.

A special manhole has been provided near Rajghat for diversion of sewage to this pumping station through a 305 m long and 2,286 mm dia brick sewer. A sluice gate has been provided in this manhole to prevent flow of sewage into the outfall sewer and also to control the amount of sewage flowing to Konia MPS.

Power requirement at Konia pumping station is around 1600 kVA. A switchyard is provided to accommodate 3 nos., 1000 kVA transformers with other accessories. A Metering Room is provided adjacent to the switchyard. It is further supplied to the individual equipment panels through the air circuit breaker, bus duct and a bus bar. Stand by power arrangement is provided by 4 nos.-generating sets. A heat exchanger is provided for cooling of these engines.

Table 2.22 Existing Facilities in Konia MPS

Konia MPS First Stage	
Installed capacity	3 x 1,158 = 3,474 lps
Installed pumps	3 x 215 HP – 1,158 lps @ 8.51 m head
Pre-treatment Units	
Screens	2 nos. mechanically operated – 50 mld each
	1 no. Manually operated – 50 mld
Detritor	2 nos. of 100 mld each
Konia MPS Second Stage	
Dimensions	32 m x 6 m
Installed capacity	3480 lps
Installed pumps	3 x 215 HP – 740 lps @ 8.51 m head 3 x 150 HP – 420 lps @ 8.51 m head
Diesel Generating Sets	5 x 500 kVA
Rising Main	1200 mm dia PSC (New) 900 mm dia Hume Steel (Old)

(2) Provisions for Upgradation

Following table presents unit wise provisions made for upgradation Konia Pumping Station

Table 2.23 Provisions for Upgradation of Konia Pumping Station

Sr.	Unit	Civil	Mechanical
1	Diversion works at Rajghat	Repair of existing manhole chamber	Sluice gate
2	Pumps - Ist stage		1 nos. Screw Type, 215 HP, 1,158 lpm @ 8.51 m head, 29 RPM
3	Screen - IInd Stage		1 no. Mechanical type screen with 6mm spacing
4	Detritor - IInd Stage		Replacement of 1 no. gear box for a 100 MLD capacity with 20% overloading
5	Pumps - IInd stage		1 pump 740 lps and 1 of 420 lps at 18.5m head, 590 rpm
6	Miscellenous	Painting of entire plant	

(3) Cost Estimation

The rehabilitation cost for interventions for Konia PS is estimated to be Rs. 9,870,000.

Table 2.24 Rehabilitation Cost of Konia SPS

Sr.	Works	Cost (Rs.)
1	Civil Works	300,000
2	Mechanical Works	9,570,000
3	**Total capital cost**	**9,870,000**

2.2.5 Renovation / Rehabilitation of Existing STP at Dinapur

(1) Existing Scheme

One 80 mld STP was constructed under GAP-I at Dinapur. This STP receives sewage from Konia pumping station. This plant is designed and constructed in three streams, each of 26.67 mld capacity.

This plant is based on activated sludge process with an extra provision of trickling filter to care of high loads of BOD in the raw wastewater and thereby reducing the overall operation and maintenance cost of plant.

The plant consists of inlet chamber, parshall flume, primary settling tank, roughening filter, aeration tank, secondary settling tank, sludge digester, gas holder, power generation system, gas burner, raw sludge pump house, filtrate pump house, treated effluent pump house and sludge drying beds.

Settled sludge from primary settling tank is pumped to digester where anaerobic digestion takes place resulting in production of biogas. Dual fuel engines, of 400 kVA capacity each, have been provided for generating electricity, using biogas produced from the plant. 2 nos. transformers, each of 1,000 kVA capacity, are provided for power supply to the plant.

An effluent channel of 4 km length is provided for conveyance of treated wastewater for irrigation purpose. In case of reduction in demand of treated wastewater, for irrigation, it is discharged into River Ganga near Sehbar village.

Table 2.25 Characteristics of Raw Wastewater Considered for Design Purpose

Sr.	Parameter	Average Value
1	Minimum Temperature, ^{o}C	20
2	pH	7.0 – 8.0
3	Biochemical Oxygen Demand (BOD_5), mg/l	300
4	Total Solids, mg/l	1,500
5	Suspended Solids, mg/l	600
6	Volatile Suspended Solids, mg/l	420

Table 2.26 Characteristics of Treated Wastewater Considered for Design Purpose

Sr.	Parameter	Average Value
1	pH	7.0 – 8.0
2	Biochemical Oxygen Demand (BOD_5), mg/l	< 20
3	Suspended Solids, mg/l	< 30

(2) Provisions for Upgradation

The observations during site inspection are presented in Table 2.27 with its required upgradation.

Table 2.27 Provisions for Upgradation of Dinapur STP

Sr.	Unit	Civil	Mechanical	Electrical	Instrumentation
1	Inlet Chamber	-	-	-	-
2	Parshall Flume	-	1 nos. flow meter for throat width 450 mm, range of flume - 40 to 180 MLD to be provided	-	1 no. Flow Transmitter to be replaced
3	Primary Clarifier	-	1 no. 2 HP motor and complete gear box assembly as spare	-	-
			1 no. Scum Box	-	-
			1 no. overflow weir to be replaced	-	-
4	Distribution Chamber for Trickling Filter	-	-	-	-
5	Roughening Trickling filter	-	3 nos. Trickling filter central drum to be replaced	-	-
6	Aeration Tank	-	1 no. Standby gear box required	-	-
7	Secondary Clarifier	-	1 no. 2 HP motor and complete gear box assembly as spare	-	-
			1 no. Scum Box	-	-
			1 no. Overflow weir to be replaced	-	-
8	Treated Effluent Pump House	-	-	-	1 no. Level switch with cables
9	Primary Sludge Pump House	2 nos. of 80 m long pipe lines for carrying the primary sludge from clarifier to pumping station	1 no. Standby pump needs to be provided	-	1 no. Level switch with cables
10	Return Sludge Pump House	1 nos. 200 m long pipe line for carrying excess return sludge to digester	3 sets of impeller of return sludge pumps (2 W + 1 S) to be replaced	-	1 no. Level switch with cables
11	Sludge Digester	Repairs and lining in 2 digesters	1 nos. mixer and 20 HP motor required as standby	-	-
12	Sludge Drying Beds	New sand layer to be provided on all the beds	-	-	-
13	Filtrate Pump House	-	4 nos. pumps to be replaced by non clog semi open impeller type submersible pumps (2+2 nos. of 35 cum/hr@ 14 m)	-	1 no. Level switch with cables
14	Gas Holder	Leakage to be trapped and lining to be provided	-	-	1 no. Gas flow meter
15	Power Generator Room	-	1 nos. Cooling tower as stand by, 2 nos. of Turbo start Engine Air starter of DFG to be replaced	Relay, PF meter, Capacitor Bank to be changed in 1-of-2 APFC Panel	-
16	Gas Burner	-	-	AVR for 500 kVA DFG set	Required automation for flair
17	Miscellaneous	Repairs, painting and roads	2 nos. 1.5 tonne capacity Air Conditioners for lab	-	-
18	Effluent channel (5000m)	Repair	1 no. 3 tonne capacity Air Conditioners for Electrical Panel Room	Lightening Arrester for gas digester and gas holder	-
19	Chlorination room, chlorine contact tank, inter connecting piping and dechlorination by aeration	Provision of chlorination for removal of coliform as per revised NRCD Guidelines. Additional provision of dechlorination is made as the treated water is proposed to be used for irrigation.	-	-	-
20	Miscellaneous	-	1 no. Microscope, 1 nos. water cooler	-	-

(3) Cost Estimation

The rehabilitation cost for interventions for Dinapur STP is estimated to be Rs. 29,765,333.

Table 2.28 Rehabilitation Cost of Dinapur STP

Sr.	Items	Cost (Rs.)
1	Civil Works	21,218,333
2	Mechanical Works	6,547,000
3	Electrical Works	1,385,000
4	Instrumentation Works	615,000
	Total capital cost	29,765,333

2.3 PROVISIONS FOR DISTRICT II AND IV

2.3.1 Planning Scheme

The following Table summaries the existing, sanctioned and proposed priority facilities in District II and IV.

1) Existing Major Sewage Facility
a) Orderly Bazaar trunk sewer
2) Sanctioned Facility
a) Reliving trunk sewer
3) Proposed Facility for Priority Project
a) Varuna River interceptor sewer and extension of relieving trunk sewer b) Sewage pumping stations (Sathwa at STP site and interceptor pumping stations) c) Sathwa sewage treatment plant

2.3.2 Varuna River Interceptor Sewer

(1) Master Plan Provisions

The Master Plan strategies are categorized in to two components, Varuna Left Bank Interceptor and Varuna right Bank Interceptor, based on natural drainage.

The Varuna left bank interceptor is further divided into two interceptors, namely left bank upstream (u/s) and downstream (d/s) interceptor and these interceptors meet at the proposed Pumping Station at Chaukaghat.

The interceptor proposed on the upstream of Varuna left bank upto Chaukaghat diverts the flow from the Central Jail Nala, Rajghat Nala, Chamrautia Nala, and Nala of Khajuri Colony. This interceptor will also cater to the sewage generated from the sub districts. Similarly, the interceptor proposed on the down stream of the left bank Varuna River will cater to the settlements located in the sub district while diverting the flow from Nala of Basti, Hukulganj Nala, Banaras Nala and Narokhar Nala.

The Varuna right bank interceptor is also divided into two interceptors, viz. right bank (u/s) and right bank (d/s) sections. The up stream section of the interceptor diverts flow from the Phulwaria Nala, Sadar Bazar Nala, Drain of Hotels Nala, Raja Bazar Nala and Telia Bagh Nala. The down stream section of this interceptor will divert the flow from the nala near Nakkhi Ghat. This interceptor is also planned to convey the sewage generated in the respective sewage sub districts.

As per Master Plan, Varuna River left and right bank interceptor sewers (upstream and downstream) shall intercept the sewage water of area and will transfer it to intermediate pumping station at

Chaukaghat (left bank). Sewage flow of sub-central drainage basin (District II, Zone A) conveyed by Trunk relief sewer (presently under construction) shall also be transferred to the Chaukaghat intermediate pumping station. Varuna River crossing below bed level is proposed under the Master Plan for transfer of flow of trunk relief sewer and right bank interceptor sewer to left bank Chaukaghat pumping station. From Chaukaghat pumping station sewage will be pumped and transferred to Pandeypur Crossing by a rising main. From Pandeypur Crossing to proposed Sathwa Sewage Treatment Plant, sewage flows by gravity trunk sewer (Sathwa Trunk Sewer). Sewage from District II, Zone C and Future Service Area (FSA 1) will be also intercepted by the same Sathwa trunk sewer.

(2) Evaluation of Alternatives on Planning

While planning the Varuna River interceptor sewerage system following important points were considered:

Interception of Phulwaria Nala

Phulwaria nala meets Varuna River near cantonment boundary. Catchment of Phulwaria falls in District IV under FSA 2 (Future Service Area). This area comes under Stage II phase in Master Plan for which a sewage treatment plant is proposed at Lohta. However, census data and visual interpretation of land use indicates that density in this area is already greater than 120 persons per hectare. Present measured flow of Phulwaria Nala is around 7.60 mld. This nala can be intercepted near Varuna River confluence point and can be conveyed to Chaukaghat pumping station or can be intercepted near railway line for its conveyance to proposed Lohta STP.

It is proposed to intercept and divert the Phulwaria Nala flow to the Varuna river right bank interceptor sewer (u/s) until Lohta STP scheme is commissioned. I & D works for Phulwaria Nala is thus designed for present flow only.

Single pumping station vs two pumping station at Chaukaghat

As per Master Plan, Varuna river, left and right bank, interceptor sewer (u/s and d/s) shall carry the sewage to Chaukaghat. Two options are available for the conveyance of sewage from Chaukaghat to Pandeypur Crossing:

Option 1: Under this option a single pumping station can be constructed for both side interceptor sewers at left or right bank of river Varuna at Chaukaghat. This requires river under bed sewer crossing from left bank to right bank or right bank to left bank. Sewer crossing through river bed from right bank to left bank requires special measures as the diameter of sewer shall be more that 2200 mm (will include trunk relief sewer flow). Similarly left bank sewer flow to right bank pumping station requires two-time river crossing (one for gravity sewer and second for rising main).

Option 2: Under this option two separate pumping stations can be constructed on both the banks of Varuna River to cater both bank interceptor flows.

Considering the site conditions, area availability, amount of flow and flexibility in operation and maintenance, two separate sewage pumping stations are proposed to cater the left bank and right bank interceptor sewer flow separately.

Narokhar Nala flow diversion

Narokhar nala catchment covers areas of ward No. 7 (Pahadiya), 25 (Mavaiya) and 27 (Sarnath) which falls under Non Sewered Area (NSA1). It is proposed to intercept this nala at the downstream end near Varuna River. Narokhar Nala flow can be diverted to a) Dinapur STP, or b) Left bank interceptor sewer (d/s) on Panchkoshi road. Anticipated flow in year 2015 and 2030 at Narokhar Nala is 14 mld

and 18 mld respectively.

A rising main of 2760 m long is required for conveyance of sewage from identified location for I&D works for Narokhar Nala, which is only 1880 m in case the sewage is to be conveyed to left bank interceptor on Panchkoshi Road. Static head requirement for both the cases is same. So the option of transfer of Narokhar Nala flow to Dinapur STP shall require high capital cost for rising main and higher operation and maintenance cost due to high head pumps, as the head loss will be more in longer rising main. Further, construction cost for providing an additional 18 MLD capacity sewage treatment plant at Dinapur plant shall be more than the cost of same capacity plant in Sathwa STP as the overall effective increase in plant capacity at Sathwa would be lesser.

Considering the above factors, it is decided to divert the Narokhar Nala flow to Varuna River Left Bank Interceptor Sewer (d/s).

(3) Proposed Scheme

Based on survey results and preliminary design of Varuna river interceptor sewerage system following scheme is proposed for the collection and transportation of wastewater (Figure2.17):

Right Bank

- Phulwaria Nala shall be intercepted and diverted to right bank interceptor sewer (u/s) by 1620 m long rising main. Interception and diversion work shall be designed for present flow (7.60 mld) as the catchment flow of this nala will ultimately go to Lohta STP.
- Right bank Interceptor Sewer (u/s) from Varanasi Cantonment Board to proposed Chaukaghat pumping station (R/B) through Kennedy Road and Raja Bazar Road (3150 m).
- Right bank interceptor sewer (d/s) on GT Road starting near City Railway Station from Nakkhi drain to Chaukaghat pumping station (right bank) of 750 m length.
- An interception and diversion works with a pumping station to intercept Saraiya Nala near Puranapul which will be connected to Varuna Right Bank (d/s) interceptor sewer.
- Chaukaghat pumping station (right bank) and rising main (1200 m) up to Pandeypur Crossing including river crossing on Varuna. Capacity of Chaukaghat pumping station shall also include the trunk relief sewer flow.

Left Bank

- Left bank interceptor sewer (u/s) from Sun Beam School to Chaukaghat pumping station (left bank) through Central Jail Road, State Bank of India and on Makbul Alam Marg (2100 m).
- Left bank interceptor sewer (d/s) from Panchkoshi road to Pandeypur crossing (1035 m).
- Interception and diversion (including pumping) of Narokhar nala, at the junction of railway line and Narokhar nala, and its disposal into left bank interceptor sewer (d/s) on Panchkoshi road through a 1880 m rising main.
- Chaukaghat pumping station (left bank) and rising main (1000 m) up to Pandeypur Crossing.
- A trunk sewer (3870 m) from Pandeypur Crossing to Sathwa Main Pumping Station at STP site.
- Sathwa Sewage Treatment Plant.

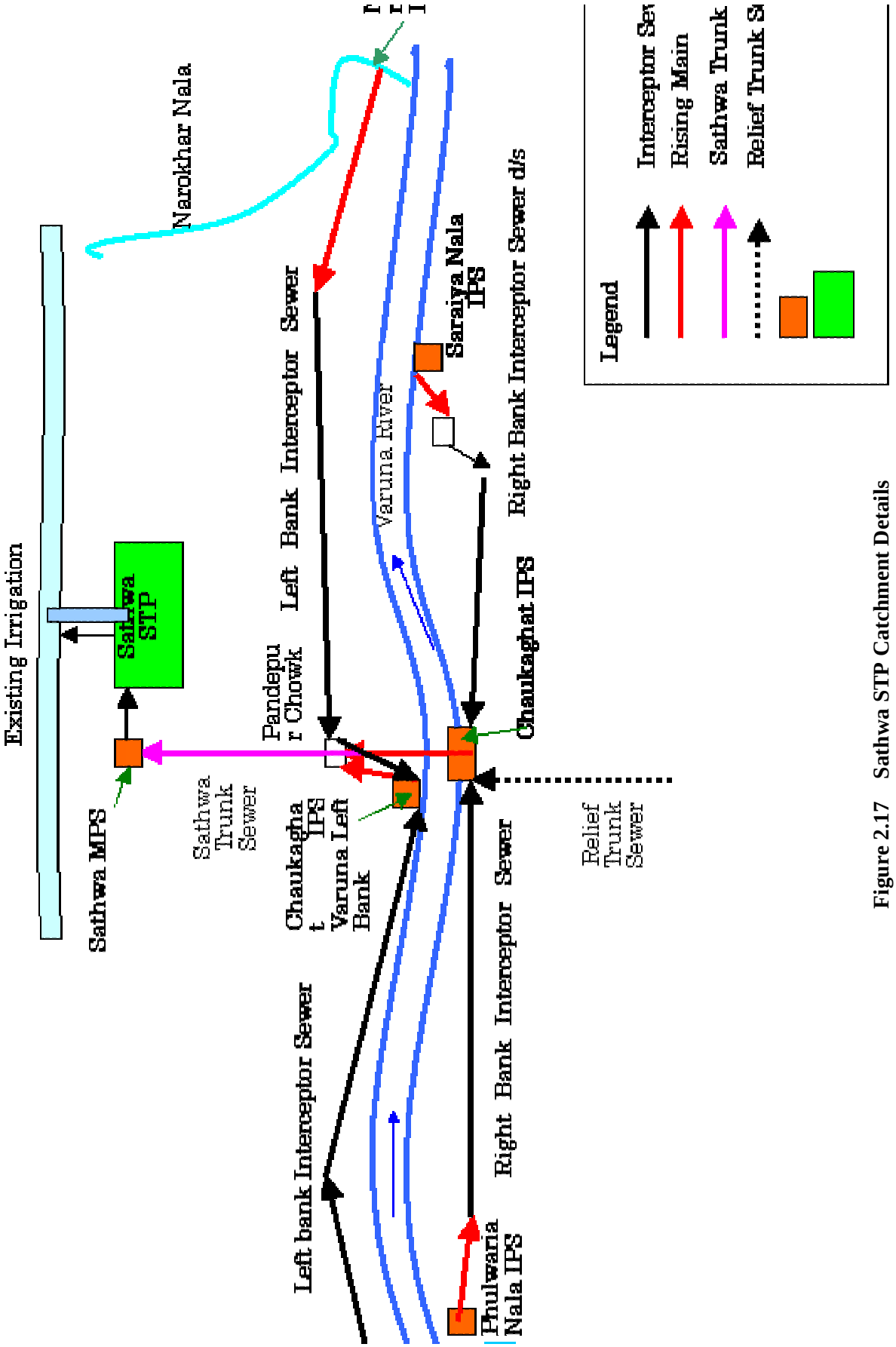


Figure 2.17 Sathwa STP Catchment Details

(4) Design Engineering Works

Design Population

Catchment boundary was marked for different interceptor sewers and contributing population and sewage flow for various years were calculated.

Table 2.29 Projected Population of Sathwa STP Catchment

Sr.	Catchment	Contributing Ward	Contributing Population			
			2008	2015	2023	2030
1	Varuna river right bank (u/s)	6, 19, 33, 51	75,448	85,223	99,067	110,494
2	Varuna river right bank (d/s)	8,9,14,19, 36	64,854	72,246	79,707	85,612
3	Varuna river left bank (u/s)	2, 21, 38, 82	52,733	75,672	97,583	121,770
4	Varuna river left bank (d/s)	7, 25, 27, 20, 23, 82	68,896	92,885	123,353	148,898
5	Sathwa Trunk sewer (Pandeypur to Sathwa STP)	2,4,5,7,20,21,23, 38, 73, 82	99,019	140,576	198,955	239,960
6	Relief Trunk Sewer (including diverted old trunk flow area)	Sub Central District Zone		572,973		632,258

Design Flow

Wastewater generation for various areas under different catchment is tabulated below:

Table 2.30 Design Flow of Sathwa STP Catchment

(mld)

Sr.	Catchment	Contributing Flow			
		2008	2015	2023	2030
1	Varuna river right bank (u/s)[1]	14.09	15.77	16.50	17.13
2	Varuna river right bank (d/s)	12.97	13.37	13.15	13.27
3	Relief Trunk Sewer (including diverted old trunk flow area)	93.00	106.00	97.00	98.00
A	**Total Flow to Chaukaghat Right Bank Pumping Stations**	**120.06**	**135.14**	**126.65**	**128.40**
3	Varuna river left bank (u/s)	10.55	14.00	16.10	18.88
B	**Total Flow to Chaukaghat Left Bank Pumping Stations**	**10.55**	**14.00**	**16.10**	**18.88**
4	Varuna river left bank (d/s)[2]	13.78	17.19	20.35	23.08
5	Sathwa Trunk sewer (Pandeypur to Sathwa STP)	19.80	26.01	32.83	37.19
C	**Total Flow of Sathwa MPS (A+B+4+5)**	**164.19**	**192.34**	**195.93**	**207.55**

Note: 1. Sewage flow includes 7.60 mld of Phulwaria nala flow.
2. Sewage flow includes 10.83 mld (2008), 13.24 mld (2015), 15.32 mld (2023) & 17.21 mld (2030) of Narokhar Nala flow

Design of Interceptor Sewer

Detailed design of interceptor sewer is given in Annexure 4-1 and is summarised below:

Table 2.31 Pipe Length Details of Varuna River Interceptor Sewer

(m)

Sr.	Diameter, (mm)	Sewer Length				
		Varuna river right bank (u/s)	Varuna river right bank (d/s)	Varuna river left bank (u/s)	Varuna river left bank (d/s)	Sathwa Trunk Sewer
1	500		180			
2	700	2,070	300			
3	800	570				
4	900		270	390		
5	1000	510		1,020	240	
6	1100			690	510	
7	1200				285	
8	2400					3,870
	Total, Rmt	**3,150**	**750**	**2,100**	**1,035**	**3,870**

Secondary Sewer

Secondary sewer is proposed in the Trans Varuna catchment region in addition to main interceptor sewers (Left bank u/s, d/s and Sathwa Trunk Sewer). Design of secondary sewer is given in Annexure 4-2 and is summarised below.

Table 2.32 Pipe Length Details of Varuna River Secondary Sewer

(m)

Sr.	Diameter (mm)	Length
1	300	2,160
2	400	2,660
3	500	1,760
4	600	4,480
5	700	1,310
	Total length	**12,370**

(5) Extension of Trunk Relief Sewer

In year 2000-2001, U. P. Jal Nigam had prepared a Detailed Project Report on Laying of Relieving Trunk Sewer from Chuakhaghat to Durgakund. This total scheme is technically approved by NRCD. A part of this scheme from Chaukhaghat to Sigra is financially sanctioned and is currently under execution. Trunk Relief Sewer from Sigra to Durgakund though is technically sanctioned, financial sanction was not given due to lack of funds.

Under this feasibility report it is recommended that the extension of the Trunk Relief Sewer, which is under execution, may be considered as a priority project as it will reduce considerable sewage load on the Old Trunk Sewer preventing pollution of Ganga River. The route of this proposed sewer is from Sigra-Rathyatra Marg-Gurubag Crossing-UPPC Office-Vinaika-Khojwan police Chowki-Vijaya Cinema-Gurudham upto Durgakund. The details of this project can be seen in the DPR prepared by UPJN and submitted to NRCD for approval on “Laying of Relieving Trunk Sewer in Varanasi” Estimated cost of the project is 2,500 Million Indian Rupees

(6) Cost Estimates

Budgetary cost estimation of the interceptor sewers and secondary sewer was carried out based on schedule of rates and prevailing market rates and is tabulated below.

Table 2.33 Cost Estimation of Varuna River Catchment Sewers

Sr.	Components	Project Execution Cost, Rs.	
		Interceptor Sewer	Secondary Sewer
A	**Capital Cost**		
1	Excavation for sewers and manholes	39,179,247	6,400,746
2	RCC pipes (supply, laying and jointing)	124,535,908	19,217,733
3	Bedding for sewer lines	147,745,463	4,772,087
4	Ancillaries: Manholes and Ventshafts	35,500,878	17,063,984
5	Miscellaneous (road restoration, temporary water connections, shifting of cables)	148,509,438	30,667,388
6	Extension of Relief Trunk Sewer	250,000,000	
7	**Grand Total (1 to 5)**	**745,470,933**	**78,121,938**
B	Operation & Maintenance cost		
	Yearly O&M Cost (@0.5%)	**3,727,355**	**390,610**

2.3.3 Proposed Sewage Pumping Stations (Under Sathwa Catchment)

(1) Master Plan Provisions

Sewage pumping stations (terminal and main) are integral part of any sewerage system and is mainly required:

a) to reduce the depth of sewer
b) to maintain the required hydraulics of plant
c) as per site conditions

Following sewage pumping stations are considered in Master Plan under Sathwa Sewage Treatment Plant catchment basin:

a) Intermediate Pumping Station at Chaukaghat to pump the sewage flow of Varuna river right and left bank interceptor sewer and trunk relief sewer.
b) Intermediate Pumping Station at Narokhar Nala to pump the nala flow to Varuna River left bank (d/s) interceptor sewer.
c) Main Pumping Station at Sathwa STP to maintain the hydraulics of the plant.

(2) Proposed Scheme

Sathwa Main Pumping Station (MPS)

A pumping station is proposed at Sathwa STP site to maintain the hydraulics of the treatment plant. Various components of MPS will include:

a) Main pumping Station screen channel, wet well and valve chamber,
b) MEP and DG room, and
c) Twin Rising main of 40 m length.

Chaukaghat Right Bank Sewage Pumping Station

Chaukaghat right bank sewage pumping station is proposed to pump the sewage flow of right

bank interceptor sewers and, presently, relief trunk sewer (under construction) upto Pandeypur Crossing. Various component of pumping station include:

a) Sewage pumping station screen channel, wet well and valve chamber,
b) MEP and DG Room,
c) Rising main of 1200 m length from pumping station to Pandeypur Crossing, and
d) River crossing structure on Varuna river for rising main

Chaukaghat Left Bank Sewage Pumping Station

Chaukaghat left bank sewage pumping station will receive the sewage flow of left bank u/s interceptor sewer and this flow will be pumped to Pandeypur Crossing. Various component of pumping station includes:

a) Sewage pumping station, screen channel, wet well and valve chamber,
b) MEP and DG Room,
c) Rising main for 1000 m length from pumping station to Pandeypur Crossing.

Narokhar Nala Sewage Pumping Station

It is proposed to intercept and divert (I&D) the flow of Narokhar Nala near the junction of Railway line with Narokhar Nala. Flow of this nala shall be pumped to the Left bank interceptor sewer (d/s) on Panchkoshi Road. Proposed scheme for Narokhar Nala includes:

a) Construction of Intake weir and training of Nala,
b) Diversion of flow to Grit channels,
c) Intermediate Sewage Pumping station screen channel, wet well and valve chamber,
d) Main Electrical Panel (MEP) and Diesel Genset (DG) Room, and
e) Rising main of 1830 m length from pumping station to left bank interceptor sewer (d/s) on Panchkoshi road.

Phulwaria Nala Pumping Station

It is proposed to intercept and divert (I&D) the flow of Phulwaria nala, near Cantonment into right bank interceptor sewer. Phulwaria nala catchment falls under District IV, FSA 2, which comes under Lohta STP catchment in Phase II. Therefore, Interception and Diversion work is proposed for the present flow only and this facility will be dismantled in the future. Proposed scheme for Phulwaria Nala includes:

a) Construction of Intake weir and training of Nala,
b) Diversion of flow to Grit channels,
c) Intermediate Sewage Pumping station of 7.60 MLD average flow capacity including screen channel, wet well and valve chamber,
d) Main Electrical Panel (MEP) and Diesel Genset (DG) Room, and
e) Rising main of 1620 m length from pumping station to right bank interceptor sewer

Saraiya Nala Pumping Station

It is proposed to intercept and divert (I&D) the flow of Nala running in Saraiya near the barrage on River Varuna. Flow of this nala shall be pumped to the Right bank interceptor sewer (d/s) on Mugalsarai Road near Nakkhi Nala. Proposed scheme for Saraiya Nala includes:

a) Construction of Intake weir and training of Nala,
b) Diversion of flow to screen channels,
c) Intermediate Sewage Pumping station wet well and valve chamber,
d) Main Electrical Panel (MEP) and Diesel Genset (DG) Room, and
e) Rising main of 1100 m length from pumping station to right bank interceptor sewer (d/s) on Mugalsarai Road near Nakkhi Nala.

(3) Design Engineering Works

Pumping Capacity

Projected sewage flow at various pumping stations are tabulated below:

Table 2.34 Design Flow of Sewage Pumping Station

(mld)

Sr.	Pumping Station	Sewage Flow	
		2015	2030
1	Sathwa main pumping Station[1]	192.34	207.55
2	Chaukaghat Right Bank Pumping Station	135.14	128.40
3	Chaukaghat Left Bank Pumping Station	14.00	18.88
4	Phulwaria Nala Pumping Station[2]	7.60	7.60
5	Narokhar Nala Pumping Station	13.24	17.21
6	Saraiya Nala Pumping Station	3.70	3.10

Note: 1. As per actual alignment of right bank interceptor sewer, a part of contributing area of relief trunk sewer is transferred to interceptor sewer. So, the net flow in trunk relief sewer will reduce by 7 to 10 mld. Considering this, it is expected to receive around 200 mld of sewage at Sathwa MPS.
2. Phulwaria sewage pumping station is designed for present flow of 7.60 mld only.

All the sewage pumping stations are designed for following capacity:

a) Civil structure shall be designed for year 2030
b) Rising main shall be designed for year 2030 or 2015 based on economy of option
c) All mechanical and electrical equipment shall be designed for year 2015.
d) Provision of extra space for pumps after year 2015 shall be made in the civil structure

Detailed designs of pumping stations were carried out to calculate the most techno- economical diameter in combination to various options of pumping. Summaries of designed pumping stations are given in Table 2.35 and 2.37.

Table 2.35 Sewage Pumping Stations Detail

Sr.	Pumping Station	Flow (mld)		Rising Main Details			Pump details			
		2030	2015	MOC	Dia (mm)	Length (m)	Type	Pump combination	2015	2030
1	Sathwa MPS	200	185	PSC	2 x 1400	40	HC	12 nos. x 50 mld x 21.5 m (270 HP each)	7w+4s	8w+4s
2	Chaukaghat Right Bank PS	140	130	PSC MS	1 x 1800 1 x 1800	1000 200	HC	12 nos. x 37.5 mld x 24 m (240 HP each)	7w+4s	8w+4s
3	Chaukaghat Left Bank PS	19	14	CI	1 x 600	1000	SC	3 nos. x 15.75 mld x 21.5 m (100 HP each), 2 nos. x 7.0 mld x 21.5 m (50 HP each)	2w+3s at peak	+ 2 pump of 11.25 mld cap each
4	Narokhar Nala	18	14	CI	1 x 600	1600	SC	3 nos. x 15.75 mld x 22.5 m (100 HP each), 2 nos. x 7.0 mld x 22.5 m (50 HP each)	2w+3s at peak	+ 2 pump of 10.5 mld cap each
5	Phulwaria Nala		7.6	CI	1 x 400	1620	SC	3 nos. x 8.55 mld x 29 m (100 HP each), 2 nos. x 3.8 mld x 29 m (50 HP each)	2w+3s at peak	
6	Saraiya Nala	3.7	3.1	CI	1 x 350	1100	SC	3 nos. x 4.65 mld x 15.5 m (25 HP each), 2 nos. x 1.55 mld x 15.5 m (10 HP each)	2w+3s at peak	

HC: Horizontal centrifugal, SC: Submersible centrifugal.

Table 2.36 Unit Details of Sewage Pumping Stations

Sr	Pumping Station	Screen Channel				Wet Well					Dry Well / Valve Chamber*			
		No.	L (m)	W(m)	A (sqm)	DT (min)	No.	L (m)	W (m)	A (sqm)	No.	L (m)	W (m)	A (sqm)
1	Sathwa MPS	6	6	2.4	86.4	5.00	2	20.0	14.0	560.0	1	20.0	16.0	320.0
2	Chaukaghat Right Bank PS	4	6	2.4	57.6	5.00	1	38.0	11.6	440.8	1	38.0	10.0	216.0
3	Chaukaghat Left Bank PS	2	6	1.2	14.4	3.75	1	12.0	6.2	74.4	1	12.0	3.5	42.0
4	Narokhar Nala PS	2	6	1.2	14.4	3.75	1	12.0	5.9	70.8	1	12.0	3.5	42.0
5	Phulwaria Nala PS	2	6	1.0	12.0	3.75	1	8.0	3.8	30.4	1	8.0	3.0	24.0
6	Saraiya Nala PS	2	6	0.5	6.0	3.75	1	9.0	2.4	21.6	1	9.0	3.0	27.0

Note: L = Length, W = Width, A = Area, DT = Detention time at peak flow, MEP = Main Electrical Panel, DG = Diesel Genset, PS= Pumping Station
* Dry well in Case of 1 & 2; Valve chamber in case of 3, 4, 5 & 6

Table 2.37 Unit Details of Allied Buildings of Sewage Pumping Stations

Sr.	Pumping Station	HT / Metering Room	MEP Building	DG Room + Control Room	Transformer Yard
1	Sathwa MPS	21.0 x 6.5	26.0 x 6.5	33.5 x 10.0	15.0 x 9.0
2	Chaukaghat Right Bank PS	14.0 x 6.5	26.0 x 6.5	33.5 x 10.0	15.0 x 8.5
3	Chaukaghat Left Bank PS	14.0 x 6.0	16.0 x 6.0	14.0 x 7.5	13.0 x 7.5
4	Narokhar Nala PS	14.0 x 6.0	16.0 x 6.0	14.0 x 7.5	13.0 x 7.5
5	Phulwaria Nala PS	14.0 x 6.0	16.0 x 6.0	14.0 x 7.5	13.0 x 7.5
6	Saraiya Nala PS	7.0 x 6.0	8.0 x 6.0	8.0 x 6.0	8.0 x 6.0

All the dimensions are in meters.

(4) Cost Estimates

Budgetary cost estimation of sewage pumping stations was carried out considering prevailing market rates and applicable schedule of rates. Estimated Capital cost and Operation & Maintenance cost of the pumping station is given below.

Land Acquisition Cost

Table 2.38 Land Acquisition Cost for Pumping Stations

Sr.	Pumping Station	Cost (Rs.)
1	Sathwa MPS	Considered in STP
2	Chaukaghat Right Bank PS	12,551,000
3	Chaukaghat Left Bank PS	4,967,000
4	Narokhar Nala PS	3,372,000
5	Phulwaria Nala PS	3,620,000
6	Saraiya Nala	1,592,000
	Total Cost (1 to 5)	**26,102,000**

Sathwa Main Pumping Station Cost

Table 2.39 Capital and O&M Cost of Sathwa MPS

Sr.	Item	Cost (Rs.)
A	**Capital Cost**	
1	Civil Cost	60,113,700
2	Mechanical Cost	33,310,000
3	Electrical & Instrumentation Cost	126,714,138
4	Rising main cost	1,059,808
5	**Grand Total (1 to 4)**	**221,197,646**
B	**Yearly Operation & Maintenance Cost**	
1	Manpower Cost	198,000
2	Power consumption cost (20 hr @ Rs. 3.25/ kWh)	19,114,758
3	Diesel consumption cost (4 hr @ Rs. 20/ ltr)	16,611,556
4	Maintenance of civil work @ 1.5%	901,705
5	Maintenance of rising main @ 0.25%	2,650
6	Maintenance of E&M work @ 3%	4,800,724
	Total O & M Cost (Yearly)	**41,629,393**

Power consumption cost depends on peak flow

Chaukaghat Right Bank Sewage Pumping Station Cost

Table 2.40 Capital and O&M Cost of Chaukaghat Right bank SPS

Sr.	Item	Cost (Rs.)
A	**Capital Cost**	
1	Civil Cost	68,623,450
2	Mechanical Cost	34,510,000
3	Electrical & Instrumentation Cost	102,875,882
4	Rising main cost	30,771,740
5	**Grand Total (1 to 4)**	**236,781,072**
B	**Yearly Operation & Maintenance Cost**	
1	Manpower Cost	944,000
2	Power consumption cost (20 hr @ Rs.3.25/ kWh)	16,990,896
3	Diesel consumption cost (4 hr @ Rs. 20/ ltr)	16,611,556
4	Maintenance of civil work @ 1.5%	461,576
5	Maintenance of rising main @ 0.25%	76,929
6	Maintenance of E&M work @ 3%	4,121,576
	Total O & M Cost (Yearly)	**39,206,533**

Power consumption cost depends on peak flow

Chaukaghat Left Bank Sewage Pumping Station Cost

Table 2.41 Capital and O&M Cost of Chaukaghat Left Bank SPS

Sr.	Item	Cost (Rs.)
A	**Capital Cost**	
1	Civil Cost	13,835,050
2	Mechanical Cost	4,650,000
3	Electrical & Instrumentation Cost	18,735,479
4	Rising main cost	7,794,700
5	**Grand Total (1 to 4)**	**45,015,229**
B	**Yearly Operation & Maintenance Cost**	
1	Manpower Cost	587,000
2	Power consumption cost (20 hr @ Rs. 3.25/ kWh)	1,769,885
3	Diesel consumption cost (4 hr @ Rs. 20/ ltr)	1,297,778
4	Maintenance of civil work @ 1.5%	116,921
5	Maintenance of rising main @ 0.25%	19,487
6	Maintenance of E&M work @ 3%	701,564
	Total O & M Cost (Yearly)	**4,492,635**

Power consumption cost depends on peak flow

Narokhar Nala Sewage Pumping Station

Table 2.42 Capital and O&M Cost of Narokhar Nala SPS

Sr.	Item	Cost (Rs.)
A	**Capital Cost**	
1	Civil Cost	12,810,050
2	Mechanical Cost	4,650,000
3	Electrical & Instrumentation Cost	21,368,709
4	Rising main cost	12,427,520
5	**Grand Total (1 to 4)**	**51,256,279**
B	**Yearly Operation & Maintenance Cost**	
1	Manpower Cost	570,240
2	Power consumption cost (20 hr @ Rs. 3.25/ kWh)	1,769,885
3	Diesel consumption cost (4 hr @ Rs. 20/ ltr)	1,297,778
4	Maintenance of civil work @ 1.5%	186,413
5	Maintenance of rising main @ 0.25%	31,069
6	Maintenance of E&M work @ 3%	780,561
	Total O & M Cost (Yearly)	**4,635,946**

Power consumption cost depends on peak flow

Phulwaria Nala Sewage Pumping Station

Table 2.43 Capital and O&M Cost of Phulwaria Nala SPS

Sr.	Item	Cost (Rs.)
A	**Capital Cost**	
1	Civil Cost	6,256,250
2	Mechanical Cost	4,155,000
3	Electrical & Instrumentation Cost	12,858,650
4	Rising main cost	6,633,725
5	**Grand Total (1 to 4)**	**29,903,625**
B	**Yearly Operation & Maintenance Cost**	
1	Manpower Cost	537,000
2	Power consumption cost (20 hr @ Rs. 3.25/ kWh)	1,769,885
3	Diesel consumption cost (4 hr @ Rs. 20/ ltr)	830,578
4	Maintenance of civil work @ 1.5%	99,506
5	Maintenance of rising main @ 0.25%	16,584
6	Maintenance of E&M work @ 3%	510,410
	Total O & M Cost (Yearly)	**3,763,963**

Power consumption cost depends on peak flow

bank interceptor sewers and, presently, relief trunk sewer (under construction) upto Pandeypur Crossing. Various component of pumping station include:

a) Sewage pumping station screen channel, wet well and valve chamber,
b) MEP and DG Room,
c) Rising main of 1200 m length from pumping station to Pandeypur Crossing, and
d) River crossing structure on Varuna river for rising main

Chaukaghat Left Bank Sewage Pumping Station

Chaukaghat left bank sewage pumping station will receive the sewage flow of left bank u/s interceptor sewer and this flow will be pumped to Pandeypur Crossing. Various component of pumping station includes:

a) Sewage pumping station, screen channel, wet well and valve chamber,
b) MEP and DG Room,
c) Rising main for 1000 m length from pumping station to Pandeypur Crossing.

Narokhar Nala Sewage Pumping Station

It is proposed to intercept and divert (I&D) the flow of Narokhar Nala near the junction of Railway line with Narokhar Nala. Flow of this nala shall be pumped to the Left bank interceptor sewer (d/s) on Panchkoshi Road. Proposed scheme for Narokhar Nala includes:

a) Construction of Intake weir and training of Nala,
b) Diversion of flow to Grit channels,
c) Intermediate Sewage Pumping station screen channel, wet well and valve chamber,
d) Main Electrical Panel (MEP) and Diesel Genset (DG) Room, and
e) Rising main of 1830 m length from pumping station to left bank interceptor sewer (d/s) on Panchkoshi road.

Phulwaria Nala Pumping Station

It is proposed to intercept and divert (I&D) the flow of Phulwaria nala, near Cantonment into right bank interceptor sewer. Phulwaria nala catchment falls under District IV, FSA 2, which comes under Lohta STP catchment in Phase II. Therefore, Interception and Diversion work is proposed for the present flow only and this facility will be dismantled in the future. Proposed scheme for Phulwaria Nala includes:

a) Construction of Intake weir and training of Nala,
b) Diversion of flow to Grit channels,
c) Intermediate Sewage Pumping station of 7.60 MLD average flow capacity including screen channel, wet well and valve chamber,
d) Main Electrical Panel (MEP) and Diesel Genset (DG) Room, and
e) Rising main of 1620 m length from pumping station to right bank interceptor sewer

Saraiya Nala Pumping Station

It is proposed to intercept and divert (I&D) the flow of Nala running in Saraiya near the barrage on River Varuna. Flow of this nala shall be pumped to the Right bank interceptor sewer (d/s) on Mugalsarai Road near Nakkhi Nala. Proposed scheme for Saraiya Nala includes:

Saraiya Nala Sewage Pumping Station

Table 2.44 Capital and O&M Cost of Saraiya Nala SPS

Sr.	Item	Cost (Rs.)
A	**Capital Cost**	
1	Civil Cost	6,075,000
2	Mechanical Cost	1,980,000
3	Electrical & Instrumentation Cost	9,883,678
4	Rising main cost	4,539,875
5	**Grand Total (1 to 4)**	**22,478,553**
B	**Yearly Operation & Maintenance Cost**	
1	Manpower Cost	422,000
2	Power consumption cost (20 hr @ Rs. 3.25/ kWh)	707,954
3	Diesel consumption cost (4 hr @ Rs. 20/ ltr)	1,297,778
4	Maintenance of civil work @ 1.5%	68,098
5	Maintenance of rising main @ 0.25%	11,350
6	Maintenance of E&M work @ 3%	355,910
	Total O & M Cost (Yearly)	**2,863,090**

Power consumption cost depends on peak flow

Total Cost of Pumping Stations

Table 2.45 Total Cost of Pumping Stations

Sr.	Location	Total Capital Cost	O&M cost	Land Cost
1	Sathwa main pumping station	221,197,646	**41,629,393**	Included in cost of STP
2	Chaukaghat right bank pumping station	236,781,072	**39,206,533**	12,551,000
3	Chaukaghat left bank pumping station	45,015,229	**4,492,635**	4,967,000
4	Narokhar Nala pumping station	51,256,279	**4,635,946**	3,372,000
5	Phulwaria Nala pumping station	29,903,625	**3,763,963**	3,620,000
6	Saraiya Nala pumping station	22,478,553	**2,863,090**	1,592,000
	Grand total	**606,632,404**	**96,591,560**	**26,102,000**

2.3.4 Sathwa Sewage Treatment Plant

(1) Evaluation of the Site Selection

This STP is one of the important components of the entire sewage scheme proposed under GAP, Phase II. The sewage diverted form the Cis Varuna and Trans Varuna areas of Varanasi city is to be treated to avoid the further pollution of the River Ganga.
This STP will treat the sewage and the treated effluent shall be discharged into irrigation canal located near this site. This treated effluent shall also be used for irrigating the crops cultivated on the downstream of this canal. This will also reduce, to a minor extent, further exploitation of the ground water in the vicinity.

During the survey it was observed that the depth of this canal is about 2 m, whereas the width at top is about 12 m and at the bottom is 7.5 m. Further observations made during the visit are:

- The lands adjacent to this canal are productive land and currently agriculture has been

practiced through out the stretch
- The farmers use ground water for irrigating these lands as there is very little quantity of water in the tail stretch of this irrigation canal
- The farmers spend around Rs 500 every month for the electricity bill, which can be reduced.
- At present the down stream section of irrigation canal is completely dry

Based on the above observations it was concluded that the treated water can be used for irrigation purposes and this will certainly benefit the local farmers.

As discussed above, a 200 mld capacity sewage treatment plant is proposed at Sathwa to cater the demand for year 2030.

(2) Selection of Scheme for Sathwa STP

As discussed in the previous section, following four treatment alternatives have been considered for the proposed 200 mld capacity sewage treatment plant at Sathwa. The cost comparison for the treatment alternatives is presented in Table 2.46.

Alternative 1: Waste Stabilisation Ponds
Alternative 2: Activated Sludge Process + Chlorination
Alternative 3: UASB + Facultative. Aerated Lagoon + Chlorination
Alternative 4: Facultative. Aerated Lagoon + Maturation Pond + Chlorination

300 ha land at Sathwa STP site is not sufficient for Alternative 1. Due to intensive agricultural area at Sathwa it will be impossible to acquire sufficient land for STP with Stabilisation Ponds.

Table 2.46 Cost Comparison of Treatment Alternatives for Sathwa STP

Sr.	Units	Alternative 1	Alternative 2	Alternative 3	Alternative 4
I	**Qualitative Factors**				
a.	Location of land	At Sathwa, North of Varanasi	At Sathwa, North of Varanasi	At Sathwa, North of Varanasi	At Sathwa, North of Varanasi
b.	Is land available at existing site?	No	Yes	Yes	Yes
c.	Ease of Operation	Comparatively easy	Moderate	Moderate	Moderate
d.	Possibility of Biogas Production?	No	Yes	Yes	No
e.	Possibility of Sludge Production?	No	Yes	Yes	No
f.	Treated Sewage Characteristics: BOD, mg/l TSS, mg/l Faecal coliform, MPN/100 ml	 <30 <50 <10,000	 <30 <50 <10,000	 <30 <50 <10,000	 <30 <50 <10,000
g.	Likely problem areas Odor Seasonal variability Ground water pollution Mosquito nuisance potential	 High Maximum High High	 Moderate Minimum Minimum Moderate	 Localized Minimum Moderate Minimal	 High Maximum High High
h.	Potential for meeting WHO Bacteriological	Suitable for unrestricted	Suitable for unrestricted	Suitable for unrestricted	Suitable for unrestricted

Sr.	Units	Alternative 1	Alternative 2	Alternative 3	Alternative 4
	guidelines for irrigation	irrigation	irrigation	irrigation	irrigation
II	**Quantitative Factors**				
A.	**Cost (Rs.)**				
1	Capital Cost				
	Civil cost	402,767,654	666,687,915	587,167,044	448,339,415
	Mechanical cost	9,050,000	67,949,763	29,370,505	73,100,000
	Electrical & Instrumentation cost	3,008,000	221,623,000	25,810,000	17,318,500
	Total Civil, E & M Cost	414,825,654	956,260,678	642,347,549	538,757,915
2	STP Utilities	17,357,923	17,357,923	15,857,923	17,357,923
3	**Total Capital Cost**	**432,183,577**	**973,618,601**	**658,205,472**	**556,115,838**
B.	**Land Requirement**				
	As per Design				
	Area required for 200 mld, ha	370.00	28.00	41.00	94.00
	Land Cost[+]				
	Land rate (Rs/hectare)	4,199,000	4,199,000	4,199,000	4,199,000
	Land Cost (Rs.)	**1,553,630,000**	**117,572,000**	**172,159,000**	**394,706,000**
C.	**O & M Cost per annum**				
1	Operation Cost				
a	Manpower	3,247,200	7,611,600	7,611,600	4,570,800
b	Power	921,258	47,524,584	17,922,216	51,134,748
c	Chemicals	-	2,976,000	2,976,000	2,976,000
2	Maintenance Cost				
a	Civil	8,632,521	13,333,759	11,743,341	8,966,789
b	Mechanical and Electrical & Instrumentation	361,740	2,122,156	930,471	2,712,555
3	**Total O & M Cost**	**8,994,261**	**80,133,126**	**41,908,573**	**70,360,892**
D.	**Cost Analysis**				
	Land Cost	1,553,630,000	117,572,000	172,159,000	394,706,000
	Total Capital Cost	432,183,577	973,618,601	658,205,472	556,115,838
	Total Cost	1,985,813,577	1,091,190,601	830,364,472	950,821,838
	O & M Cost per year	13,162,725	80,133,126	41,908,573	70,360,892
	Resource Recovery*	-	12,760,000	12,760,000	-
	Capitalized Cost [(1)]	2,188,156,922	2,126,880,681	1,278,449,483	2,032,441,204
	Ranking	IV	III	I	II
	Capitalized Cost [(2)]	2,085,930,310	1,603,635,954	1,052,070,836	1,485,992,377
	Ranking	**IV**	**III**	**I**	**II**

Note :
+ Source : Finance & Revenue Dept., Govt. of Uttar Pradesh
(1) : Capitalised Cost calculated for 30 years at interest rate of 5%
(2) : Capitalised Cost calculated for 15 years at interest rate of 10%
** : Cost recovered through Resource Recovery is not considered while working out the Capitalised Cost.*

(3) Evaluation of Treatment Scheme Alternatives

Each treatment Alternative has some positive and some negative aspects to it. These are discussed below with reference to certain key factors.

Process Performance

The treatment schemes proposed under the four alternatives are suitable and technically viable to meet

the NRCD guidelines for treated sewage discharge. All the treatment schemes are time tested proven treatment schemes.

Inference

All four treatment processes satisfy the Process Performance criteria as these will meet the discharge standards as stipulated by NRCD for land irrigation as well as for river discharge.

Seasonal Variability

As regards coliform removal, the performance of the ponds considered in the Alternatives 1 & 4 will be reduced substantially in the winter months due to low temperatures. While in summer months, coliform removal will improve but effluent BOD will increase owing to algae in the effluent. This effect will not be so pronounced in the alternative of UASB followed by Aerated Lagoon owing to the dampening effect of the UASB. Alternative 3 will be least affected by seasonal variations.

Inference

Alternative 3 namely, UASB followed by Aerated Lagoon with chlorination, is the most suitable treatment process from the Seasonal Variability aspect as it is least affected by the temperature variations.

Environmental Impact (Preliminary Evaluation)

Ground Water

There is a possibility of ground water contamination in case of first and Alternative 4 due to seepage from the holding area of the ponds although as a precaution all the ponds are proposed to be lined at considerable cost. This possibility is minimum in case of Alternative 2 as well as Alternative 3. Since, the aerated lagoon has the least detention time and therefore, least contact surface with the soil. The aerated lagoon will also be lined

Mosquito

Mosquito breeding in the pond is generally caused due to weed growth and marginal vegetation in badly maintained ponds. Fly breeding may be another problem in badly maintained ponds. Hence this problem can occur only in badly a maintained pond, which is more likely in case of large size ponds as in Alternative 1 & 4.

Odour

In summer months, blue green algae may grow vigorously in the pond, giving rise to floating mats of algae. The algae in the mats may then die and give rise to odours. Some odorous sulphides may also be generated in warmer months. Due to mechanical aeration in the second and Alternative 3, odour problem is not foreseen, which could occur in the other alternatives nos. 1 and 4. The UASB may at worst give a slight localised odour problem

Inference

Alternative 3 of UASB followed by Aerated Lagoon with Chlorination is the most suitable treatment process as it has minimal adverse environmental impact on the population. No odour and mosquito problem is envisaged due to aeration. In comparison to the other alternatives, the holding area of the aerated lagoon, which will also be lined, is very small and there is a minimal possibility of ground water contamination due to seepage.

Land Availability

The available land of 300 hectares is adequate for the Alternatives 2, 3 & 4. The land requirement for the Alternative 1 is lager and found substantially more than the available land.

Inference

The Alternative 2, 3 & 4 are feasible treatment process from the Land Availability viewpoint as the existing land for the proposed plant at Sathwa is sufficient for this alternative only. However, Alternative 2 & 3 have the least quantum of land requirement.

Resource Recovery

The treatment Alternative 2 & 3 only offer the avenue for resource recovery from the treatment scheme. The by-products of ASP and UASB system are biogas and excess sludge. The biogas formed can be utilized as an energy source and the sludge as manure. The Operation & Maintenance cost can be partly recovered from the sale of these products. This benefit is available with both Alternative 2 and 3. There is neither possibility of resource recovery from Alternative 1 nor 4.

Inference

Alternative 2 & 3 are equally beneficial from the Resource Recovery viewpoint as both generate biogas and sludge, which can partly reduce the operating costs.

Capitalised Costs

The Capitalized Cost of the treatment alternatives is based on Capital Cost, O&M Cost as well as Resource Recovery. The costs are annualised for 15 years at an interest rate of 10%. The Alternative 3 of UASB followed by Aerated Lagoon is the lowest as shown in the Table 2.46. The land cost is included since it will be a revenue asset.

Inference

Alternative 3 is the least from the Capitalised Cost viewpoint as it has the lowest Present Worth in comparison to the other three treatment alternatives.

(4) Recommendation

It can finally be concluded that "***Alternative 3: UASB followed by Facultative Aerated Lagoon with Chlorination System***" is best suited for the proposed 200 MLD capacity sewage treatment plant at Sathwa. The process will comply with the all the relevant discharge standards as well as being the most economically viable.

(5) Sewage Quantity

The design year for the sewage treatment plant is 2030. Forecasting the population for the design year meets at the sewage quantity for design of treatment plant. A STP of 200 mld capacity is proposed based on the sewage generation.

The Manual on Sewerage and Sewage Treatment prepared by CPHEEO prescribes the guidelines for peak factor for the design of sewerage and sewage treatment plant. The same is reproduced below hereunder.

Table 2.47 Recommended Peak Factors for Design of Treatment Plants

Sr.	Contributory Population	Peak Factors
1	Upto 20,000	3.0
2	20,000 to 50,000	2.5
3	50,000 to 7,50,000	2.25
4	Above 7,50,000	2.0

The design population for the proposed treatment plant is above 750,000 and accordingly a peak factor of 2.0 is assumed for the design of proposed sewage treatment at Sathwa.

(6) Raw Sewage Characteristics

The wastewater characteristics for the proposed sewage treatment plant at Sathwa are based on the projected wastewater characteristics presented in Master Plan.

The following wastewater characteristics are used for design of sewage treatment plant.

Table 2.48 Raw Sewage Characteristics

Sr.	Parameter	Average Value
1	Average Wastewater Flow, cu.m/day	200,000
2	Minimum Temperature, Degree-Celsius	20
3	pH	6.0 - 8.5
4	Biochemical Oxygen Demand (BOD_5), mg/l	300
5	Total Suspended Solids, mg/l	600
6	Faecal Coliform Count, MPN/100 ml	10.0×10^6

(7) Treated Sewage Discharge Standards

NRCD have conveyed the recommendations of the Expert Committee through their letter no DO. No. A-33013/1/99-NRCD, suggesting that the maximum permissible value for Faecal Coliform in treated water should not exceed 10,000 MPN per 100 ml sample irrespective of its mode of disposal in river or its use for irrigation to grow either restricted or unrestricted crops. It is also mentioned in NRCD guidelines that BOD and TSS concentration less than 30 mg/l and 50 mg/l respectively.

The sewage treatment plant has been therefore designed so as to achieve treated wastewater of equal or better quality as mentioned in the table below.

Table 2.49 Desired Treated Wastewater Quality

Sr.	Parameter	Value(Irrigation Field/River)
1	pH	5.5 – 9.0
2	Biochemical Oxygen Demand, mg/l	< 30
3	Total Suspended Solids, mg/l	< 50
4	Faecal Coliform Count, MPN/100 ml	<10,000

Design Basis of STP

The design basis for the treatment scheme "UASB Process followed by Facultative Aerated Lagoon with Chlorination System" is presented below:

Table 2.50 Design Basis of STP

Sr.	Component	Value	Unit
	Data		
	Average flow	200	mld
	(Average flow)	2.315	cu.m/sec
	Peak factor	2	times
	Peak flow	4.630	cu.m/sec
1.0	**Inlet Chamber**		
	Detention period	30	sec
	Number of units	1	nos.
2.0	**Screen Channel**		
	Minimum Approach velocity at average flow	0.3	m/sec
	Minimum Velocity through screens	0.6	m/sec
	Maximum Velocity through screens	1.2	m/sec
	Width of screen bars	4.00	mm
	Clear Spacing between screen bars (Matt type screen)	6.00	mm
	Maximum headloss across the screen	0.3	m
3.0	**Grit Chamber**		
	Velocity	0.3	m/sec
	Particle size	0.15	mm
	Specific gravity	2.65	
	Temperature	20	Deg. C.
	Settling velocity of particles V	0.0168	m/sec
	Settling velocity of particles V	1451.52	cu.m/sq.m/day
	Efficiency	75	%
	n	1/8 or 0.125	
	Surface loading	958.95	cu.m/sq.m/day
4.0	**UASB Reactor**		
	Solids Retention Time	38	days
	Sludge Bed Concentration	65	kg TSS/cum
	Maximum Sludge Bed Height	80	% of hgt. to Gas Collector
	Average Upflow velocity	0.5	m/h
	Maximum Upflow velocity	1.5	m/h
	Average aperture velocity	0.22	m/h
	Maximum aperture velocity	5	m/h
	Average Biogas loading	1	m/h
	Angle of gas collector	50	Degrees to horizontal
	Hood width	0.44	m
	Settling zone surface %	75	%

Sr.	Component	Value	Unit
	Feed inlet point distance	2	m
	Overlap	0.015	m
	Clear distance between the gas domes	3.0	m
	C/C distance between gas domes	4.0	m
5.0	**Facultative Aerated Lagoon**		
	Temperature	16.0	Deg. Cel.
	Overall BOD removal rate, K, at 20 Deg. Cel.	0.75	
	K at 16 Deg. Cel.	0.65	per day
	Total Hydraulic Retention Time in Pond, ^{o}C	1.50	days
	Stage-I : Aeration Zone		
	HRT	0.5	day
	Depth	3.50	m
	Stage-II : Quiescent Zone		
	HRT	1.00	day
	Depth	1.50	m
	Kb(20) for Faecal Coliform Reduction formula	2.60	
	K x θ	1.00	
	D/UL	1.000	
	Oxygen efficiency of aerator	2.0	kg/kWh
	Factor of standard to field	0.75	
	Reduction gear/motor efficiency	0.9	
	Minimum Power required	0.75	W/cum
	Sludge accumulation (for only lagoon)	0.04	cum/person-year
	Cleaning interval	5.00	years
6.0	**Chlorination System**		
6.1	**Chlorine Mixing Tank**		
	Detention time provided	2	min
6.2	**Chlorine Contact Tank**		
	Detention time provided	30	min
6.3	**Chlorine Dosage**		
	Residual Chlorine	0.50	mg/l
	Chlorine Dosing	5.00	mg/l
7.0	**Sludge Drying Beds**		
	Sludge depth	0.2	m
8.0	**Gas Holder**		
	Detention time	6	hrs
9.0	**Sludge Pumping Station**		
	Detention period of sump	15	min
	No. of working Pumps	1	nos.
	No. of standby Pumps	1	nos.
10.0	**Filtrate Pumping Station**		
	Solids conc. in the excess sludge produced in UASB, P1	6	%
	Solids conc. in the dried sludge produced on SDB, P2	40	%
	Detention period of sump	15	min
	No. of working Pumps	1	nos.
	No. of standby Pumps	1	nos.

Unit Sizing

The sizing of various treatment units for the treatment scheme "UASB Process followed by Facultative Aerated Lagoon with Chlorination System" is presented below:

Table 2.51 Unit Sizing

Sr.	Units	Quantity (nos.)	Length/ Dia, (m)	Width (m)	Side Water Depth (m)	Freeboard (m)
1	Inlet Chamber	1	2.0	14.2	5.0	0.5
2	Screen Channel	6	5.0	2.2	1.0	0.5
3	Grit Chamber	4	11.6	11.6	0.7	0.6
4	UASB Reactor	20	26.0	32.0	5.7	0.6
5	Facultative Aerated Lagoon					
	a) Stage I : Aeration Zone	2	84.6	168.9	3.5	0.6
	b) Stage II : Quiescent Zone	2	394.8	168.9	1.5	0.5
6	Chlorine Mixing Tank	1	10.6	10.6	2.5	0.5
7	Chlorine Contact Tank	1	57.7	28.9	2.5	0.5
8	Treated Water Disposal Channel	1	1,800.0	3.4	1.5	0.5
9	Sludge Drying Beds	74	31.5	18.5	0.2	
10	Gas Holder	2	19.2		6.0	0.4
11	Sludge Pumping Station	2	1.9	1.9	2.5	5.0
12	Filtrate Pumping Station	1	2.5	2.5	2.0	5.0
13	Transformer Yard for MPS	1	15.0	9.0		
14	Generator Room for MPS	1	33.5	10.0		
15	MEP Room for MPS	1	26.0	6.5		
16	HT / Metering Room	1	21.0	6.5		
17	Transformer Yard for STP	1	8.0	10.0		
18	Generator Room for STP	1	20.0	10.0		
19	MEP Room for STP	1	18.0	6.5		
20	DG cum Control Room	1	20.0	10.0		
21	Administration Block cum lab	1	12.0	20.0		

The layout showing the proposed Sathwa STP based on the UASB process followed by Facultative Aerated Lagoon with Chlorination system is presented in Figure 2.18.

(8) Cost Estimation of Sathwa STP

The cost estimation of Sathwa STP is summaries in the following table and total cost is 522,405,000 Rs.

Table 2.52 Capital Cost of Sathwa STP

Sr.	Particulars	Costs (Rs.)
1	Civil	451,367,044
2	Mechanical	29,370,505
3	Electrical & Instrumentation	25,810,000
4	STP Utilities	15,857,923
	Total Cost	522,405,472
	round	**522,405,000**

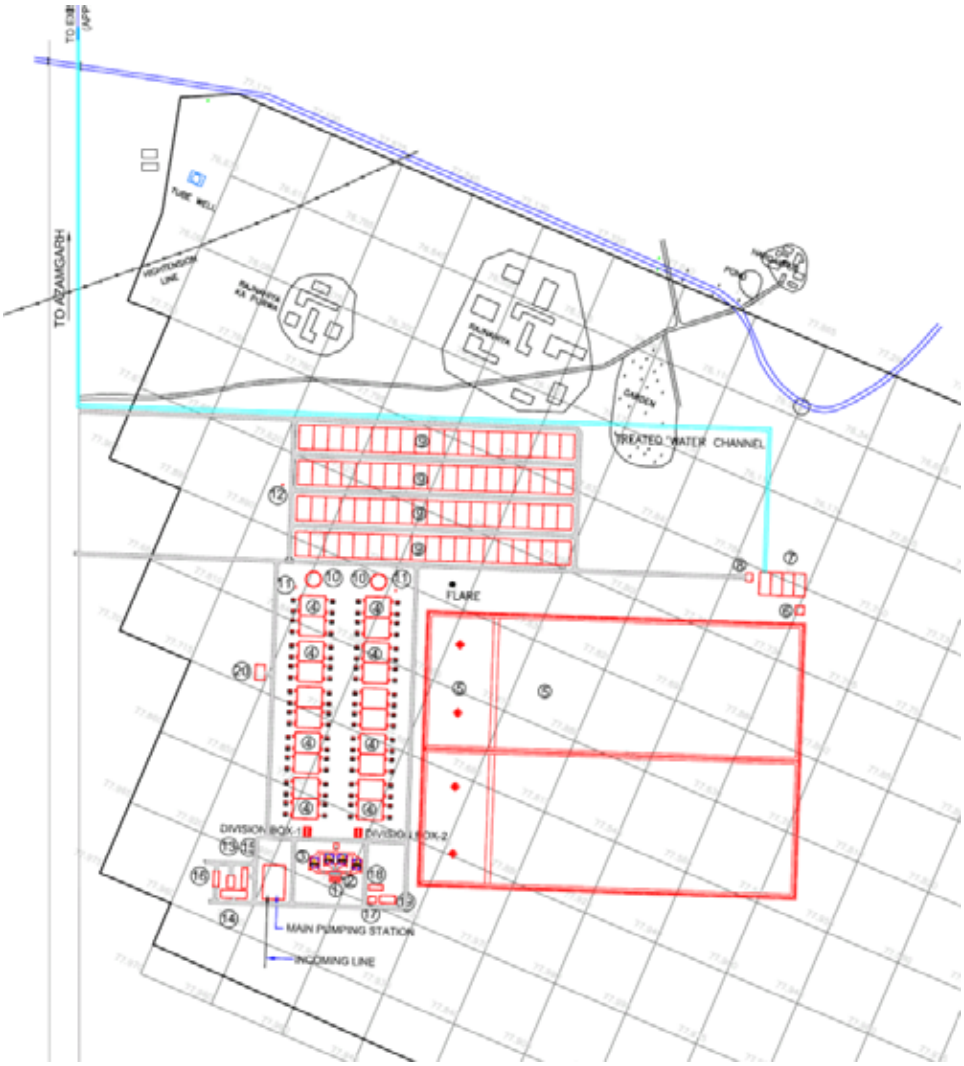


Figure 2.18 Layout Plan of Sathwa Sewage Treatment Plant

2.3.5 Effluent Disposal Channel and Lining of Irrigation Canal

A new treated water disposal channel and lining for existing irrigation canal are proposed.

- Treated Water Disposal Channel from Sathwa STP to Irrigation canal: 1 line, 4 km
- Lining for the existing irrigation canal to increase flow carrying capacity: 1 line, 14 km

Table 2.53 Capital Cost of Effluent Disposal Channel and Irrigation Canal

Sr.	Units	No.	Length m	Width m	Depth m	Amount, Rs.
1	Lining for existing irrigation canal	1.0	14,000.0			82,600,000
2	Treated Water Disposal Channel	1.0	4,000.0	3.4	2.0	53,200,000
	Total					**135,800,000**

The cross section and plan drawing for the existing irrigation canal is shown in Figure 2.19 and Figure 2.20.

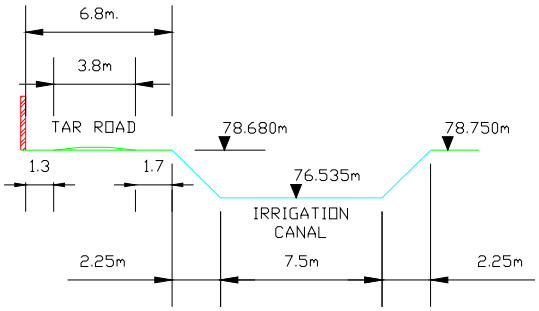


Figure 2.19 Cross Section of Existing Irrigation Canal at Udapuir Culvert on Azamgarh Road

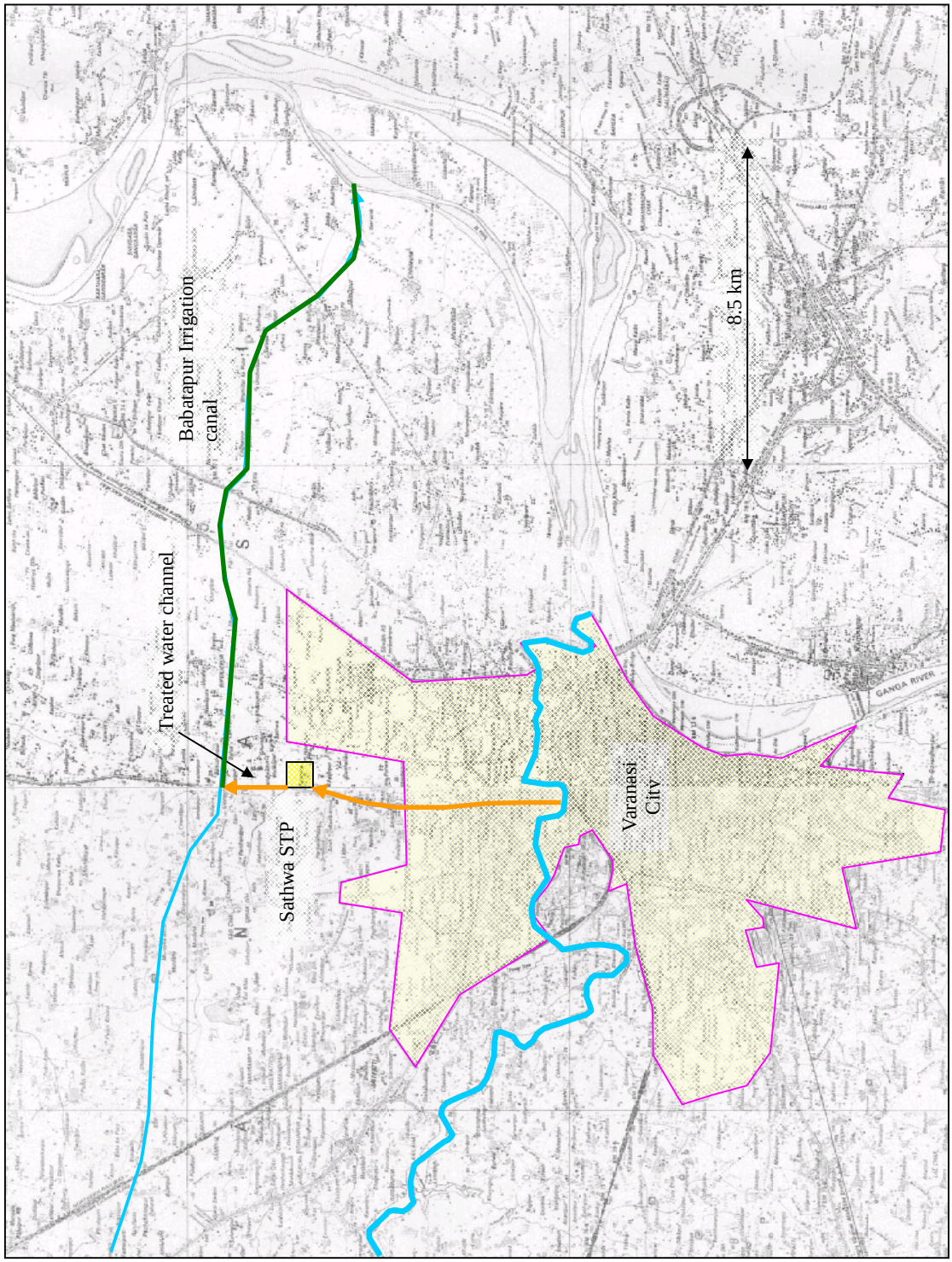


Figure 2.20 Treated Water Disposal Channel and Existing Irrigation Canal

2.4 PROVISIONS FOR DISTRICT III

2.4.1 Planning Scheme

The following table summarises the existing, sanctioned and proposed priority facilities in District III.

4)	Existing Major Sewage Facility
5)	Assi Main Pumping Station and rising main to Bhagwanpur STP
6)	Bhagwanpur STP (8 mld)
7)	Sanctioned Facility
8)	Ramna STP (37 mld)
9)	Assi/Nagwa Nala MPS
10)	Rising Main from Assi/Nagwa Nala MPS to Ramna STP
11)	Proposed Facility for Priority Project
12)	Renovation and rehabilitation of Bhagwanpur STP
13)	Assi Nala interceptor to Assi/Nagwa Nala MPS

2.4.2 Renovation / Rehabilitation of Existing STP at Bhagwanpur

(1) Existing Scheme

The STP is provided in two parts for treating sewage from BHU campus and Assi area of Varanasi. One plant of 1.8 mld capacity consisting of trickling filter and another of 8 mld capacity based on activated sludge process.

1) 1.8 mld Old Treatment Plant

The plant consists of inlet chamber, screen chamber, manual grit chamber, clarigigester, biofilter, secondary clarifier, recirculation pump house, sludge drying beds, treated effluent chamber and channel.

The treated effluent from this plant was supplied to the farms in BHU campus for irrigation purpose. However, this practice has been discontinued, as BHU does not require this water anymore.

2) 8 mld New Treatment Plant

This plant is constructed in two streams of 4 mld each. The plant consists of a collection chamber, screen chamber, grit channel with grit washing arrangement, parshall flume, primary clarifier, aeration tank, secondary clarifier, sludge drying beds, digesters, gas holder, generating room, gas burner, primary sludge pump house, recirculation pump house and filtrate pump house.

Dual fuel engines, of 70 kVA capacity each, have been provided for generating electricity, using biogas produced from the plant.

An underground pipe of 4.6 km length is provided for conveyance of treated wastewater for irrigation purpose to the nearby fields.

Table 2.54 Characteristics of Raw Wastewater Design Purpose for 8 mld STP

Sr.	Parameter	Average Value
1	Minimum Temperature, ^{o}C	20
2	pH	7.8
3	Biochemical Oxygen Demand (BOD_5), mg/l	300
4	Suspended Solids, mg/l	600
5	Volatile Suspended Solids, mg/l	420
6	Chemical Oxygen Demand, mg/l	400

Table 2.55 Characteristics of Treated Wastewater Design Purpose for 8 mld STP

Sr.	Parameter	Average Value
1	pH	7.0 – 8.0
2	Biochemical Oxygen Demand (BOD_5), mg/l	< 20
3	Suspended Solids, mg/l	< 30

(2) Provisions for Upgradation

The observations during site inspection are presented in Table 2.57 with its required upgradation.

(3) Cost Estimation

The rehabilitation cost for interventions is estimated to be Rs. 8,321,000.

Table 2.56 Rehabilitation of Bhagwanpur STP

Sr.	Work Items	Cost (Rs.)
1	Civil Works	4,975,000
2	Mechanical Works	3,010,000
3	Electrical Works	11,000
4	Instrumentation Works	325,000
Total		8,321,000

Table 2.57 Provisions for Upgradation of Bhagwanpur Sewage Treatment Plant

Sr.	Unit	Civil	Mechanical	Electrical	Instrumentation
1	Inlet Chamber	-	-	-	-
2	Bar screen channel	-	1 no. Mechanical screen	DOL starter for mechanised screen	-
		-	1 no. 5 HP motor, forward/reverse drive arrangement for conveyer belt	-	-
3	Grit Chamber	-	1 no. Manual screen	-	-
		-	1 no. Horizontal centrifugal pumps with 1.5 kW motor.	-	-
		-	1 no. Vacuum type pump of 0.5 kW	-	-
		-	1 no. Grit washing arrangement of 0.75 kW motor, gear box, chain drive arrangement and buckets	-	-
4	Parshall Flume	-	1 no. Flow gauge	-	-
5	Primary Clarifier	-	3 HP motor, speed reduction gearbox in two stages - gear boxes to be replaced and rail for clarifier arm to be replaced in 2 units	-	-
6	Secondary Clarifier	-	3 HP motor, speed reduction gearbox in two stages - gear boxes to be replaced and rail for clarifier arm to be replaced in 2 units	-	-
7	Sludge Digester	-	20 HP capacity sludge screw mixers. Safety devices - 2 nos. each on each unit - vacuum breaker valve, high pressure release valve and flame arrestor	-	-
8	Recirculation Pump House	-	3 nos. 7.5 HP motor with 24 lps @ 10 m head, horizontal centrifugal pumps	Level switch, Cables	
9	Gas Holder	-	Safety devices - 1 no. each on each unit - vacuum breaker valve, high pressure release valve	-	Gas flow meter
10	Engine Room	-	3 nos. 70 kVA DFG of Kirloskar Cummins - only Gas moisture separator to be replaced on each motor	-	-
11	Gas Burner	-	1 no. gas burner	-	
12	Raw sludge pump house	-	2 nos. 10 lps @ 10 m head complete with 5 HP motor and transmission shaft (4 m length), Vertical centrifugal pumps	-	Level switch, Cables
13	Filtrate pump house	-	2 nos. 10 lps @ 10 m head complete with 5 HP motor and transmission shaft (4 m length), Vertical centrifugal pumps	-	Level switch, Cables
14	Chlorination room, chlorine contact tank, inter connecting piping and dechlorination by aeration	Provision of chlorination for removal of coliform as per revised NRCD Guidelines. Additional provision of dechlorination is made as the treated water is proposed to be used for irrigation.	-	-	-

2.4.3 Assi Nala Interceptor Sewer

The Assi Nala is located in the south (upstream) of River Ganga (sewerage district III, Zone 3) and presently carries sewage from the southern part of the city and BHU campus, thus pollutes the River Ganga. The F/S has evaluated the various possible alternatives to intercept and divert the sewage and the same is discussed in this section.

(1) Need for the Scheme

The development in the region and increase in the population contributes to this overflow leading to the pollution in River Ganga.

It is estimated that about 85% to 90% of sewage is emanating upstream of existing Assi SPS. Downstream stretch, between existing Assi SPS till proposed Nagwa MPS, is very congested and does not have a proper road network.

Nakha Nala and Samne Ghat Drain situated on the upstream side of the Assi Nala are left untapped in Phase-I works.

(2) Evaluation of Alternatives and Selection of Scheme

Various feasible interceptor sewers alignments were evaluated for the laying of interceptor sewer considering the Master Plan provision. Based on detailed site survey, it was concluded that only a single interceptor alignment (along left bank of Assi Nala in the stretch between Chitaipur upto Sunderpur Culvert and then along the right bank up to Nagwa pumping station) is feasible against the Master Plan provision of two interceptor sewers along the both bank of Nala.

Nakha Nala and Samne Ghat Drain situated on the upstream side of the Assi Nala are left untapped in Phase-I works. These nalas are proposed to be tapped by providing Interception and Diversion works on these nalas and laying an Interceptor, which will be connected, to Assi Interceptor.

(3) Design Engineering Works

Design Population

Catchment boundary was marked for Assi Nala interceptor alignment as per Master Plan and contributing population and sewage flow for various years were calculated.

Table 2.58 Projected Population for Assi Nala Catchment

Sr.	Catchment	Contributing Ward	Contributing population	
			2015	2030
1	Assi Nala Catchment (excluding BHU campus area)	15,56,68,71,89 and 90	155,757	220,102

Design Flow

Wastewater generation for Assi Nala catchment is tabulated below:

Table 2.59 Design Flow for Assi Nala Catchment

(mld)

Sr.	Catchment	Contributing Flow	
		2015	2030
1	Assi Nala catchment (excluding BHU campus area)	21.94	31.01

Design of Interceptor Sewer

Detailed design of interceptor sewer is given in Annexure 3-1 and is summarised below.

Table 2.60 Pipe Length Details of Assi Nala Interceptor Sewer

Sr.	Diameter (mm)	Length (m)
1	600	640
2	700	620
3	800	400
4	900	240
5	1000	1,970
6	1200	1,300
	Total length	**5,170**

Table 2.61 Pipe Length Details of Nakha Nala and Samne Ghat Interceptor Sewer

Sr.	Diameter (mm)	Length (m)
1	400	655
2	500	1,300
	Total length	**1,955**

Secondary Sewer

Around 1.6 kilometers of secondary sewer is proposed in the Assi Nala catchment in addition to main interceptor sewer. Design of secondary sewer is given in Annexure 3-2 and is summarised below.

Table 2.62 Pipe Length Details of Assi nala Secondary Sewer

Sr.	Diameter (mm)	Length (m)
1	300	1,170
2	400	450
	Total length	**1,620**

Provision for Trenchless Technology

Laying of Interceptor along Assi Nala and laying of extension of Trunk Relief Sewer is in a thickly populated area and also in these areas roads are narrow. It is found that laying of sewers in these areas with open cut method is not feasible in certain stretches. Hence provision of laying of sewer lines by trenchless technology is proposed in these areas.

(4) Cost Estimates

Budgetary cost estimation of the interceptor sewers and secondary sewer was carried out based on schedule of rates and prevailing market rates and is tabulated below.

Table 2.63 Cost Estimation of Assi Nala Catchment Sewer

Sr.	Components	Project Execution Cost, Rs.		
		Assi Interceptor	**Nakhha and Samne Ghat Interceptor**	**Secondary Sewer**
A	**Capital Cost**			
1	Excavation for sewers and manholes	7,804,503	3,232,024	1,364,059
2	RCC pipes (supply, laying and jointing)	22,045,371	2,707,684	1,213,062
3	Bedding for sewer lines	10,449,607	692,117	475,374
4	Ancillaries: Manholes and Vent shafts	14,142,305	6,255,885	3,324,906
5	Miscellaneous (road restoration, temporary water connections, shifting of cables)	38,242,138	15,501,813	4,328,875
6	Provision for laying of part of sewer lines by using trenchless technology	204,000,000		136,000,000
7	**Grand Total (1 to 6)**	**296,683,924**	**28,389,522**	**146,706,275**
B	**Operation & Maintenance Cost**			
	Yearly O&M Cost (@0.5%)	1,483,420	141,948	733,531

Annexure 2-1: Ward-wise Population Projections

Ward No.	Ward Name	Area in Ha	Pop 2001	GR 2001-03	Pop 2003	GR 2003-08	Pop 2008	GR 2008-15	Pop 2015	GR 2015-18	Pop 2018	GR 2018-23	Pop 2023	GR 2023-30	Pop 2030
1	Lahar Tara	29	12384	1.00%	12633	0.75%	13114	0.75%	13818	0.50%	14026	0.50%	14380	0.25%	14561
2	Indra Pur	235	15694	10.00%	18990	6.00%	25413	6.00%	38211	3.00%	41754	3.00%	48405	3.50%	62184
3	Chhittanpura	9	13135	0.20%	13188	0.15%	13287	0.10%	13380	0.05%	13400	0.05%	13434	0.02%	13465
4	Narayan	186	14313	7.50%	16540	6.00%	22135	6.00%	33283	5.50%	39082	5.50%	51078	3.00%	59878
5	Tarna	438	13027	10.00%	15763	10.00%	25386	7.50%	42117	7.50%	52321	7.50%	75114	4.00%	99119
6	Nadeshwar	78	12877	5.00%	14197	5.00%	18119	4.00%	23844	3.50%	26436	3.50%	31398	2.50%	37670
7	Pahadiya	160	20506	5.00%	22608	5.00%	28854	4.00%	37970	3.50%	42098	3.50%	49999	2.50%	59988
8	Kamal Garha	30	15874	0.20%	15938	0.15%	16057	0.10%	16170	0.05%	16194	0.05%	16235	0.02%	16272
9	Kaji Saidullapura	32	14561	0.25%	14634	0.20%	14781	0.20%	14989	0.10%	15034	0.10%	15109	0.05%	15147
10	Jalalipura	61	14608	1.50%	15050	1.50%	16213	1.50%	17993	1.00%	18539	1.00%	19484	0.75%	20429
11	Rasulpura	17	15758	0.20%	15821	0.15%	15940	0.10%	16052	0.05%	16076	0.05%	16116	0.02%	16153
12	Nawapura	40	13989	1.00%	14270	0.50%	14631	0.50%	15150	0.50%	15379	0.50%	15767	0.50%	16327
13	Saraiyan	107	15854	3.00%	16820	3.00%	19498	2.00%	22398	2.00%	23768	2.00%	26242	2.00%	31039
14	Alai Pura	78	12823	3.00%	13604	3.00%	15771	1.50%	17503	1.00%	18033	1.00%	18953	0.75%	20766
15	Saray Surjan	95	13669	10.00%	16539	7.50%	23745	5.00%	33411	3.00%	36509	3.00%	42324	2.00%	51165
16	Madan Pura	6	11945	0.10%	11969	0.10%	12029	0.10%	12113	0.10%	12150	0.10%	12211	0.05%	12241
17	Rajghat	88	22373	3.00%	23736	3.00%	27516	2.00%	31607	2.00%	33542	2.00%	37033	1.25%	40988
18	Katehar	8	12678	0.20%	12729	0.15%	12825	0.10%	12915	0.05%	12934	0.05%	12966	0.02%	12996
19	Ghausabad	125	15708	5.00%	17318	5.00%	22103	5.00%	31101	3.50%	34482	3.50%	40954	2.50%	47745
20	Ramerpur	331	16228	7.50%	18753	7.50%	26923	7.50%	44667	6.00%	53199	6.00%	71192	4.00%	90182
21	Sikraul	147	13826	7.50%	15978	6.00%	21382	5.00%	30086	3.50%	33357	3.50%	39618	2.50%	47520
22	Dara Nagar	26	11052	0.25%	11107	0.20%	11219	0.20%	11377	0.10%	11411	0.10%	11468	0.05%	11497
23	Taktakpur	113	11881	7.50%	13730	5.00%	17523	4.00%	23059	3.50%	25566	3.50%	30365	2.50%	36431
24	Senpura	11	7193	0.20%	7222	0.15%	7276	0.10%	7327	0.05%	7338	0.05%	7357	0.02%	7373
25	Mavaiya	481	13169	7.50%	15218	7.50%	21848	7.50%	36247	7.50%	45029	7.50%	64646	6.00%	94509
26	Jaitpura	23	16067	0.20%	16131	0.15%	16253	0.10%	16367	0.05%	16391	0.05%	16432	0.02%	16470
27	Sarnath	764	12049	7.50%	13924	7.50%	19990	7.50%	33164	7.50%	41200	7.50%	59148	6.00%	86472
28	Shivpurwa	105	11757	5.00%	12962	5.00%	16543	2.00%	19003	2.00%	20166	2.00%	22265	1.25%	26106
29	Baluabir	9	10105	0.20%	10145	0.15%	10222	0.10%	10294	0.05%	10309	0.05%	10335	0.02%	10359
30	Salem Pura	26	14312	0.20%	14369	0.15%	14477	0.10%	14579	0.05%	14601	0.05%	14637	0.02%	14671
31	Khojwan	47	10684	3.00%	11335	4.00%	13790	2.50%	16392	2.50%	17653	2.50%	19973	2.00%	23731
32	Loco Hitpura	81	11847	5.00%	13061	5.00%	16670	2.00%	19148	2.00%	20321	2.00%	22436	1.25%	26306
33	Dhup Chandi	60	13490	1.50%	13898	1.50%	14972	1.50%	16616	1.00%	17120	1.00%	17993	0.75%	18866
34	Jagat Ganj	53	15920	1.50%	16401	1.50%	17669	1.50%	19610	1.00%	20204	1.00%	21234	0.50%	21772
35	Dashaswamedh	11	9441	0.10%	9460	0.10%	9507	0.10%	9574	0.10%	9603	0.10%	9651	0.05%	9675
36	Kamalpur	14	14588	0.20%	14646	0.15%	14757	0.10%	14860	0.05%	14882	0.05%	14920	0.02%	14954
37	Bag Hada	20	11206	0.10%	11228	0.10%	11285	0.10%	11364	0.10%	11398	0.10%	11455	0.05%	11484
38	Sarsauli	148	19675	5.00%	21692	3.00%	25147	3.00%	30927	2.00%	32820	2.00%	36236	2.00%	41624
39	Shivala	22	11719	0.10%	11742	0.10%	11801	0.10%	11884	0.10%	11920	0.10%	11980	0.05%	12010
40	Piyari Kala	16	12275	0.20%	12324	0.15%	12417	0.10%	12504	0.05%	12523	0.05%	12554	0.02%	12583
41	Ramapura	21	9700	0.25%	9749	0.20%	9846	0.20%	9985	0.10%	10015	0.10%	10065	0.05%	10090
42	Raj Mandir	6	10749	0.10%	10771	0.10%	10824	0.10%	10900	0.10%	10933	0.10%	10988	0.05%	11015
43	Prahalad Ghat	6	11476	0.10%	11499	0.10%	11557	0.10%	11638	0.10%	11673	0.10%	11731	0.05%	11761
44	Garh Vasi Tola	7	9640	0.10%	9659	0.10%	9708	0.10%	9776	0.10%	9805	0.10%	9854	0.05%	9879
45	Kagi Pura	46	12576	1.50%	12956	1.50%	13957	1.50%	15491	1.00%	15960	1.00%	16774	0.75%	17587
46	Beniya	26	12781	0.20%	12832	0.15%	12929	0.10%	13019	0.05%	13039	0.05%	13072	0.02%	13102

Ward No.	Ward Name	Area in Ha	Pop 2001	GR 2001-03	Pop 2003	GR 2003-08	Pop 2008	GR 2008-15	Pop 2015	GR 2015-18	Pop 2018	GR 2018-23	Pop 2023	GR 2023-30	Pop 2030
47	Eshwar Gangi	27	8177	1.00%	8341	0.50%	8552	0.50%	8856	0.10%	8882	0.10%	8927	0.05%	8949
48	Hadha	20	11621	0.20%	11668	0.15%	11755	0.10%	11838	0.05%	11856	0.05%	11885	0.02%	11913
49	Madhyameshwar	20	9433	0.20%	9471	0.15%	9542	0.10%	9609	0.05%	9623	0.05%	9648	0.02%	9670
50	Kameshwar Mahadev	7	9401	0.10%	9420	0.10%	9467	0.10%	9533	0.10%	9562	0.10%	9610	0.05%	9634
51	Raja Bazar	95	9273	7.50%	10716	5.00%	13677	4.00%	17998	3.50%	19954	3.50%	23700	2.50%	28434
52	Saptasagar	13	9841	0.20%	9880	0.15%	9955	0.10%	10025	0.05%	10040	0.05%	10065	0.02%	10088
53	Braham Nal	16	5339	0.10%	5350	0.10%	5376	0.10%	5414	0.10%	5430	0.10%	5458	0.05%	5471
54	Gola Dina Nath	10	9284	0.20%	9321	0.15%	9391	0.10%	9457	0.05%	9471	0.05%	9495	0.02%	9517
55	Pan Dareeba	20	8269	0.25%	8310	0.20%	8394	0.20%	8512	0.10%	8538	0.10%	8580	0.05%	8602
56	Nariya	65	17068	3.00%	18107	4.00%	22030	2.50%	26187	2.00%	27790	2.00%	30683	1.00%	33691
57	Pande Haweli	13	7601	0.20%	7631	0.15%	7689	0.10%	7743	0.05%	7754	0.05%	7774	0.02%	7792
58	Lallupura Kalan	17	12286	0.20%	12335	0.15%	12428	0.10%	12515	0.05%	12534	0.05%	12565	0.02%	12594
59	Basniyan	20	13327	0.20%	13380	0.15%	13481	0.10%	13576	0.05%	13596	0.05%	13630	0.02%	13661
60	Lallupura Khurd	63	12289	1.50%	12660	1.50%	13639	1.50%	15137	1.00%	15596	1.00%	16391	0.75%	17186
61	Hukul Ganj	94	13781	7.50%	15926	5.00%	20326	4.00%	26747	3.50%	29655	3.50%	35221	2.50%	42257
62	Lahang Pura	10	11634	0.20%	11681	0.15%	11768	0.10%	11851	0.05%	11869	0.05%	11899	0.02%	11926
63	Laksa	33	12788	1.00%	13045	0.50%	13374	0.25%	13610	0.10%	13651	0.10%	13720	0.05%	13857
64	Durga Kund	80	11142	10.00%	13482	7.50%	19355	4.00%	25470	2.50%	27428	2.50%	31032	2.00%	38985
65	Tulsipur	103	18082	3.00%	19183	3.00%	22239	3.00%	27351	2.50%	29454	2.50%	33324	2.00%	37906
66	Til Bhandeshwar	9	13397	0.20%	13451	0.15%	13552	0.10%	13647	0.05%	13667	0.05%	13702	0.02%	13733
67	Bangali Tola	9	6039	0.10%	6051	0.10%	6081	0.10%	6124	0.10%	6142	0.10%	6173	0.05%	6189
68	Sundarpur	55	14414	3.00%	15292	4.00%	18605	2.50%	22115	2.00%	23469	2.00%	25912	1.00%	28452
69	Kaal Bhairav	18	8281	0.25%	8322	0.20%	8406	0.20%	8524	0.10%	8550	0.10%	8593	0.05%	8614
70	Revadi Talab	13	9187	0.20%	9224	0.15%	9293	0.10%	9358	0.05%	9372	0.05%	9396	0.02%	9418
71	Karaundi	160	13862	10.00%	16773	10.00%	27013	6.00%	40618	3.00%	44384	3.00%	51453	2.00%	64774
72	Sigra	68	9303	5.00%	10257	5.00%	13090	3.00%	16099	2.50%	17337	2.50%	19616	2.00%	23638
73	Shivpur	121	13076	7.50%	15111	5.00%	19286	4.00%	25379	3.50%	28138	3.50%	33419	2.50%	40096
74	Binayak	54	14865	1.50%	15314	1.50%	16498	1.50%	18310	1.00%	18865	1.00%	19827	0.75%	20789
75	Bajardiha	118	19864	3.00%	21074	3.00%	24430	3.00%	30046	2.50%	32356	2.50%	36608	2.00%	41642
76	Sarai Gowardhan	14	7319	0.20%	7348	0.15%	7404	0.10%	7456	0.05%	7467	0.05%	7485	0.02%	7503
77	Bhelupur	46	10598	1.50%	10918	1.50%	11762	1.50%	13054	1.00%	13450	1.00%	14136	0.75%	14821
78	Katuapura	12	9193	0.20%	9230	0.15%	9299	0.10%	9365	0.05%	9379	0.05%	9402	0.02%	9424
79	Nai Basti	52	10183	2.50%	10699	2.50%	12104	2.00%	13904	2.00%	14755	2.00%	16291	1.50%	18168
80	Om Kaleshwar	24	8319	1.00%	8486	0.75%	8809	0.75%	9282	0.50%	9422	0.50%	9660	0.50%	10003
81	Jangamwadi	21	8594	0.20%	8628	0.20%	8715	0.20%	8838	0.10%	8864	0.10%	8909	0.05%	8931
82	Pandeypur	76	7907	7.50%	9138	5.00%	11662	4.00%	15346	3.50%	17015	3.50%	20208	3.00%	25331
83	Chetganj	20	6908	1.00%	7047	0.50%	7225	0.50%	7481	0.10%	7504	0.10%	7542	0.05%	7560
84	Khajuri	125	12316	7.50%	14233	5.00%	18165	4.00%	23904	3.50%	26503	3.50%	31477	3.00%	39456
85	Kamachha	73	10386	2.00%	10806	2.00%	11930	2.00%	13704	1.25%	14224	1.25%	15136	0.75%	15792
86	Jolha	50	12018	1.50%	12381	1.50%	13338	1.50%	14803	1.00%	15252	1.00%	16030	0.75%	16807
87	Pishach Mochan	13	8297	0.20%	8330	0.15%	8393	0.10%	8452	0.05%	8464	0.05%	8486	0.02%	8505
88	Ghasyari Tola	67	6958	5.00%	7671	5.00%	9791	2.00%	11246	2.00%	11935	2.00%	13177	2.00%	16511
89	Bhadaini	16	9152	0.10%	9170	0.10%	9216	0.10%	9281	0.10%	9309	0.10%	9355	0.05%	9379
90	Nagwan	102	10197	10.00%	12338	10.00%	19871	6.00%	29879	3.00%	32649	3.00%	37849	2.00%	47648
91	Sp. Charge NER	53	4474	7.50%	5170	7.50%	7423	6.00%	11161	4.00%	12554	4.00%	15274	3.00%	19219
	Total		**1092925**	**2.4385**	**1157509.6**	**2.139**	**1331706.2**	**1.6595**	**1592690.2**	**1.3045**	**1703906.8**	**1.3045**	**1924302.7**	**0.9473**	**2220700.1**

Annexure 3-1: Hydraulic Design of Assi Nala Interceptor Sewer for Year 2015

From	To	Length	Nodal Population	Floating Population	Cumulative Population	Sewage Flow	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Cumulative Peak Flow	Design Dia	Slope	Q full (Qf)	V full (Vf)	Qa/Qf	d/D	v/V	V actual	Q actual	UGL	DGL	UIL	DIL	Drop
		(M)				LPCD	LPD	LPD		LPD	mm	1 in	LPS	m/sec				m/sec	M^3/sec	(M)	(M)	(M)	(M)	(M)
AN2	AN3	620.00	12050	1205	35347	155	1867812	4980832	2.50	12452080	700.00	800.00	328.49	0.851873	0.4387	0.52	0.83	0.70	0.1441	73.85	73.55	70.486	69.711	0.1
AN3	AN4	400.00	13562	1356	50266	155	2102164	7082996	2.25	15936742	800.00	1000.00	419.44	0.832804	0.4398	0.52	0.83	0.69	0.1845	73.55	74.33	69.611	69.211	0.1
AN4	AN5	240.00	14732	1473	66471	155	2283497	9366494	2.25	21074611	900.00	1000.00	574.17	0.900762	0.4248	0.51	0.82	0.74	0.2439	74.33	74.15	69.111	68.871	0.1
AN5	AN6	550.00	3283	328	74859	155	508816	10548542	2.25	23734219	1000.00	1200.00	694.13	0.882052	0.3957	0.49	0.80	0.71	0.2747	74.15	73.00	68.271	67.812	0.6
AN6	AN7	540.00	12447	1245	88551	155	1929326	12477867	2.25	28075201	1000.00	1200.00	694.13	0.882052	0.4681	0.54	0.84	0.74	0.3249	73.00	72.52	67.212	66.762	0.6
AN7	AN8	880.00	2679	268	91498	155	415179	12893046	2.25	29009353	1000.00	1200.00	694.13	0.882052	0.4837	0.55	0.85	0.75	0.3358	72.52	72.84	66.162	65.429	0.6
AN8	AN9	640.00	26983	2698	124116	155	4182430	17489234	2.25	39350776	1200.00	1500.00	1009.45	0.890787	0.4512	0.53	0.84	0.74	0.4554	72.84	72.00	63.029	62.602	2.4
AN9	AN10	600.00	2805	280	154700	155	434726	21798959	2.25	49047658	1200.00	1500.00	1009.45	0.890787	0.5624	0.6	0.89	0.79	0.5677	72.00	68.00	61.850	61.450	0.7
AN10	NAGWA PS	60.00	0	0	155757	155	0	21947805	2.25	49382562	1200.00	1500.00	1009.45	0.890787	0.5662	0.6	0.89	0.79	0.5716	68.00	65.00	61.350	61.310	0.1

Annexure 3-2: Hydraulic Design of Assi Nala Secondary Sewer

From	To	Length	Nodal Population	Floating Population	Cumulative Population	Sewage Flow	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Cumulative Peak Flow	Design Dia	Slope	Q full (Qf)	V full (Vf)	Qa/Qf	d/D	v/V	V actual	Q actual	UGL	DGL	UIL	DIL	Drop
		(M)				LPCD	LPD	LPD		LPD	mm	1 in	LPS	m/sec				m/sec	M^3/sec	(M)	(M)	(M)	(M)	(M)
AN5/1	AN5	450.00	6651	665	7316	155	1030975	1030975	3.00	3092924	400.00	300.00	120.66	0.958	0.2967	0.42	0.73	0.70	0.0358	72.05	74.15	70.550	69.050	
AN8/1	AN8	870.00	4088	409	4497	155	633620	633620	3.00	1900861	300.00	300.00	56.04	0.791	0.3926	0.49	0.80	0.63	0.0220	70.00	72.84	68.500	65.600	
AN10/1	AN10	300.00	1531	153	1684	155	237365	237365	3.00	712095	300.00	200.00	68.63	0.969	0.1201	0.26	0.56	0.54	0.0082	65.50	68.00	64.000	62.500	

Annexure 3-3: Hydraulic Design of Assi Nala Secondary Sewer

From	To	Length	Nodal Population	Floating Population	Cumulative Population	Sewage Flow	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Cumulative Peak Flow	Design Dia	Slope	Q full (Qf)	V full (Vf)	Qa/Qf	d/D	v/V	V actual	Q actual	UGL	DGL	UIL	DIL	Drop
		(M)				LPCD	LPD	LPD		LPD	mm	1 in	LPS	m/sec				m/sec	M^3/sec	(M)	(M)	(M)	(M)	(M)
AN9/1	AN9/2	655.00	10000	1000	11000	155	1550000	1550000	3.00	4650000	400.00	500.00	93.46	0.7423	0.5758	0.61	0.90	0.67	0.0538	76.39	67.59	66.760	65.450	
AN9/2	AN9/3	573.00	15000	1500	27500	155	2325000	3875000	2.50	9687500	500.00	500.00	169.43	0.8612	0.6618	0.66	0.93	0.80	0.1121	67.59	66.30	65.350	64.204	0.1
AN9/3	AN9/4	385.00	0	0	27500	155	0	3875000	2.50	9687500	500.00	500.00	169.43	0.8612	0.6618	0.66	0.93	0.80	0.1121	66.30	66.03	64.104	63.334	0.1
AN9/4	AN9	342.00	0	0	27500	155	0	3875000	2.50	9687500	500.00	500.00	169.43	0.8612	0.6618	0.66	0.93	0.80	0.1121	66.03	72.00	63.234	62.550	0.1

Annexure 4-1: Hydraulic Design of Varuna River Interceptor Sewer for Year 2030

From	To	Length	Nodal Population	Cumulative Population	Sewage Flow	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Design Dia	Slope	Q full (Qf)	V full (Vf)	Qa/Qf	d/D	v/V	V actual	Q actual	UGL	DGL	UIL	DIL	Drop
		(M)			LPCD	LPD	LPD		LPD	mm	1 in	LPS	m/sec				m/sec	M^3/sec	(M)	(M)	(M)	(M)	(M)
VR1	VR2	780.00	0	49032	155	0	7600000	2.25	17100000	700.00	900.00	309.70	0.803	0.6391	0.65	0.92	0.74	0.1979	79.10	77.50	74.100	73.233	
VR2	VR3	1290.00	14194	63226	155	2200000	9800000	2.25	22050000	700.00	900.00	309.70	0.803	0.8240	0.77	0.99	0.80	0.2552	77.50	77.27	73.233	71.800	
VR3	VR4	570.00	15393	78619	155	2385948	12185948	2.25	27418383.12	800.00	1000.00	419.44	0.833	0.7566	0.72	0.96	0.80	0.3173	77.27	73.61	71.700	71.130	0.1
VR4	VR5	420.00	31875	110494	155	4940560	17126508	2.25	38534642.82	1000.00	1200.00	694.13	0.882	0.6425	0.65	0.92	0.81	0.4460	73.61	75.77	68.730	68.380	2.4
VR5	PS2	90.00	0	110494	155	0	17126508	2.25	38534642.82	1000.00	1200.00	694.13	0.882	0.6425	0.65	0.92	0.81	0.4460	75.77	68.00	65.980	65.905	2.4
VR11	VR12	180.00	28365	28365	155	4396625	4396625	2.50	10991562.64	500.00	600.00	154.67	0.786	0.8225	0.77	0.99	0.78	0.1272	74.81	74.60	70.810	70.510	
VR12	VR13	300.00	28205	56570	155	4371719	8768345	2.50	21920861.25	700.00	800.00	328.49	0.852	0.7724	0.73	0.97	0.83	0.2537	74.60	74.33	70.310	69.935	0.2
VR13	VR14	180.00	29042	85612	155	4501467	13269811	2.25	29857074.78	900.00	1200.00	524.15	0.822	0.6593	0.66	0.93	0.76	0.3456	74.33	73.61	69.835	69.685	0.1
VR14	PS2	90.00	0	85612	155	0	13269811	2.25	29857074.78	900.00	1200.00	524.15	0.822	0.6593	0.66	0.93	0.76	0.3456	73.61	68.00	66.085	66.010	3.6
VL1	VL2	390.00	80836	80836	155	12529638	12529638	2.25	28191686.32	900.00	1000.00	574.17	0.901	0.5683	0.6	0.89	0.80	0.3263	77.59	77.05	71.590	71.200	
VL2	VL3	390.00	17286	98122	155	2679326	15208964	2.25	34220168.81	1000.00	1200.00	694.13	0.882	0.5706	0.6	0.89	0.79	0.3961	77.05	76.92	71.200	70.875	
VL3	VL4	390.00	2504	100627	155	388165	15597129	2.25	35093540.37	1000.00	1200.00	694.13	0.882	0.5852	0.61	0.90	0.79	0.4062	76.92	76.43	70.875	70.550	
VL4	VL5	240.00	9498	110125	155	1472186	17069315	2.25	38405958.01	1000.00	1200.00	694.13	0.882	0.6404	0.65	0.92	0.81	0.4445	76.43	75.25	70.550	70.350	
VL5	VL6	540.00	5495	115620	155	851728	17921043	2.25	40322346.73	1100.00	1500.00	800.46	0.841	0.5830	0.61	0.90	0.75	0.4667	75.25	76.81	70.350	69.990	
VL6	PS3	150.00	6150	121770	155	953311	18874354	2.25	42467295.57	1100.00	1500.00	800.46	0.841	0.6140	0.63	0.91	0.76	0.4915	76.81	69.00	66.990	66.890	3
VL11	VL12	240.00	111025	111025	155	17208905	17208905	2.25	38720035.76	1000.00	1200.00	694.13	0.882	0.6456	0.65	0.92	0.81	0.4481	75.30	76.18	72.800	72.600	
VL12	VL13	510.00	24183	135208	155	3748319	20957224	2.25	47153752.97	1100.00	1400.00	828.55	0.870	0.6587	0.66	0.93	0.81	0.5458	76.18	76.96	72.400	72.036	0.2
VL13	VL25	285.00	13691	148898	155	2122039	23079263	2.25	51928341.03	1200.00	1500.00	1009.45	0.891	0.5954	0.62	0.90	0.80	0.6010	76.96	77.82	71.936	71.746	0.1
VL25	VL26	850.00	14805	1113837	155	2294756	172644691	2.00	345289383	2400.00	2000.00	5548.30	1.224	0.7203	0.7	0.95	1.17	3.9964	77.82	79.25	70.546	70.121	1.2
VL26	VL27	850.00	11477	1125313	155	1778867	174423559	2.00	348847117.3	2400.00	2000.00	5548.30	1.224	0.7277	0.71	0.96	1.17	4.0376	79.25	78.59	70.121	69.696	
VL27	VL28	300.00	4964	1130277	155	769410	175192969	2.00	350385937.4	2400.00	2000.00	5548.30	1.224	0.7309	0.71	0.96	1.17	4.0554	78.59	78.45	69.696	69.546	
VL28	VL29	1100.00	0	1171479	155	0	181579211	2.00	363158421.2	2400.00	2000.00	5548.30	1.224	0.7576	0.73	0.97	1.19	4.2032	78.45	78.72	69.546	68.996	
VL29	SSTP	770.00	0	1338992	155	0	207543719	2.00	415087438.1	2400.00	2000.00	5548.30	1.224	0.8659	0.79	1.01	1.23	4.8043	78.72	79.40	68.996	68.611	

Annexure 4-1a: Hydraulic Design of Varuna River Interceptor Sewer for Year 2015

From	To	Length	Nodal Population	Cumulative Population	Sewage Flow	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Design Dia	Slope	Q full (Qf)	V full (Vf)	Qa/Qf	d/D	v/V	V actual	Q actual	UGL	DGL	UIL	DIL	Drop
		(M)			LPCD	LPD	LPD		LPD	mm	1 in	LPS	m/sec				m/sec	M^3/sec	(M)	(M)	(M)	(M)	(M)
PS1	VR1	1620.00	41081	41081	185	7600000	7600000	2.25	17100000	300.00	5000.00	13.73	0.1938	14.4188	1	1.00	0.19	0.1979	75.23	79.10	73.830	74.100	
VR1	VR2	780.00	0	41081	185	0	7600000	2.25	17100000	700.00	900.00	309.70	0.80315	0.6391	0.65	0.92	0.74	0.1979	79.10	77.50	74.100	73.233	
VR2	VR3	1290.00	11892	52973	185	2200000	9800000	2.25	22050000	700.00	900.00	309.70	0.80315	0.8240	0.77	0.99	0.80	0.2552	77.50	77.27	73.233	71.800	
VR3	VR4	570.00	9793	62766	185	1811732	11611732	2.25	26126397.14	800.00	1000.00	419.44	0.8328	0.7209	0.7	0.95	0.79	0.3024	77.27	73.61	71.700	71.130	0.1
VR4	VR5	420.00	22457	85223	185	4154558	15766290	2.25	35474151.91	1000.00	1200.00	694.13	0.88205	0.5915	0.62	0.90	0.80	0.4106	73.61	75.77	68.730	68.380	2.4
VR5	PS2	90.00	0	85223	185	0	15766290	2.25	35474151.91	1000.00	1200.00	694.13	0.88205	0.5915	0.62	0.90	0.80	0.4106	75.77	68.00	65.980	65.905	2.4
VR11	VR12	180.00	27568	27568	185	5100112	5100112	2.50	12750279.61	500.00	600.00	154.67	0.78618	0.9541	0.85	1.04	0.82	0.1476	74.81	74.60	70.810	70.510	
VR12	VR13	300.00	24089	51657	185	4456488	9556600	2.50	23891499.82	700.00	800.00	328.49	0.85187	0.8418	0.78	1.00	0.85	0.2765	74.60	74.33	70.310	69.935	0.2
VR13	VR14	180.00	20588	72246	185	3808842	13365442	2.25	30072244.03	900.00	1200.00	524.15	0.82228	0.6640	0.66	0.93	0.76	0.3481	74.33	73.61	69.835	69.685	0.1
VR14	PS2	90.00	0	72246	185	0	13365442	2.25	30072244.03	900.00	1200.00	524.15	0.82228	0.6640	0.66	0.93	0.76	0.3481	73.61	68.00	66.085	66.010	3.6
PS2	VL25	1650.00	0	157469	185	0	29131732	2.25	65546395.94	500.00	5000.00	53.58	0.27234	14.1591	1	1.00	0.27	0.7586	68.00	77.82	65.905	73.820	
VL1	VL2	390.00	50047	50047	185	9258616	9258616	2.25	20831886.91	900.00	1000.00	574.17	0.90076	0.4199	0.51	0.82	0.74	0.2411	77.59	77.05	71.590	71.200	
VL2	VL3	390.00	10945	60991	185	2024743	11283359	2.25	25387558.75	1000.00	1200.00	694.13	0.88205	0.4233	0.51	0.82	0.72	0.2938	77.05	76.92	71.200	70.875	
VL3	VL4	390.00	1561	62552	185	288752	11572111	2.25	26037250.07	1000.00	1200.00	694.13	0.88205	0.4342	0.52	0.83	0.73	0.3014	76.92	76.43	70.875	70.550	
VL4	VL5	240.00	6065	68617	185	1121949	12694060	2.25	28561635.64	1000.00	1200.00	694.13	0.88205	0.4762	0.54	0.84	0.74	0.3306	76.43	75.25	70.550	70.350	
VL5	VL6	540.00	3329	71946	185	615901	13309962	2.25	29947413.42	1100.00	1500.00	800.46	0.84063	0.4330	0.51	0.82	0.69	0.3466	75.25	76.81	70.350	69.990	
VL6	PS3	150.00	3726	75672	185	689357	13999319	2.25	31498467.44	1100.00	1500.00	800.46	0.84063	0.4554	0.53	0.84	0.70	0.3646	76.81	69.00	66.990	66.890	3
PS3	VL25	1100.00	0	75672	185	0	13999319	2.25	31498467.44	900.00	5000.00	256.78	0.40283	1.4198	1	1.00	0.40	0.3646	69.00	77.82	66.890	73.820	
GM	VL25	1650.00	572973	572973	185	106000000	106000000	2.25	238500000	2000.00	5000.00	2158.21	0.68562	1.2790	1	1.00	0.69	2.7604	73.50	77.82	72.100	73.820	
VL11	VL12	240.00	71584	71584	185	13243063	13243063	2.25	29796891.62	1000.00	1200.00	694.13	0.88205	0.4968	0.56	0.86	0.76	0.3449	75.30	76.18	72.800	72.600	
VL12	VL13	510.00	14103	85687	185	2608999	15852062	2.25	35667138.76	1100.00	1400.00	828.55	0.87014	0.4982	0.56	0.86	0.75	0.4128	76.18	76.96	72.400	72.036	0.2
VL13	VL25	285.00	7198	92885	185	1331683	17183745	2.25	38663425.35	1200.00	1500.00	1009.45	0.89079	0.4433	0.52	0.83	0.74	0.4475	76.96	77.82	71.936	71.746	0.1
VL25	VL26	850.00	8994	907993	185	1663893	167978688	2.00	335957377	2400.00	2000.00	5548.30	1.22403	0.7008	0.69	0.95	1.16	3.8884	77.82	79.25	70.546	70.121	1.2
VL26	VL27	850.00	6010	914003	185	1111935	169090623	2.00	338181246.9	2400.00	2000.00	5548.30	1.22403	0.7055	0.69	0.95	1.16	3.9141	79.25	78.59	70.121	69.696	
VL27	VL28	300.00	2459	916462	185	454848	169545471	2.00	339090942.1	2400.00	2000.00	5548.30	1.22403	0.7074	0.69	0.95	1.16	3.9247	78.59	78.45	69.696	69.546	
SPS1	VL28	1250.00	21697	21697	185	4013884	4013884	2.50	10034710.62	600.00	5000.00	87.12	0.3075	1.3332	1	1.00	0.31	0.1161	70.00	78.45	68.600	72.046	
VL28	VL29	1100.00	0	938159	185	0	173559355	2.00	347118710.6	2400.00	2000.00	5548.30	1.22403	0.7241	0.7	0.95	1.17	4.0176	78.45	78.72	69.546	68.996	
SPS2	VL29	100.00	101417	101417	185	18762054	18762054	2.25	42214620.42	1200.00	8000.00	437.10	0.38572	1.1178	1	1.00	0.39	0.4886	70.00	78.72	68.600	71.496	
VL29	SST	770.00	0	1039575	185	0	192321409	2.00	384642817.7	2400.00	2000.00	5548.30	1.22403	0.8024	0.75	0.98	1.20	4.4519	78.72	79.40	68.996	68.611	

Annexure 4-1a: Hydraulic Design of Varuna River Interceptor Sewer for Year 2015

From	To	Length	Nodal Population	Cumulative Population	Sewage Flow	Nodal Flow	Cumulative Nodal Flow	Peak Factor	Peak Flow	Design Dia	Slope	Q full (Qf)	V full (Vf)	Qa/Qf	d/D	v/V	V actual	UGL	DGL	UIL	DIL
		(M)			LPCD	LPD	LPD		LPD	mm	1 in	LPS	m/sec				m/sec	(M)	(M)	(M)	(M)
S1	S2	320.00	1604	1604	155	248690	248689.75	3.00	746069.25	300.00	300.00	56.04	0.7912	0.1541	0.3	0.61	0.48	77.82	76.96	75.320	74.2533
S3	S2	500.00	1604	1604	155	248690	248689.75	3.00	746069.25	300.00	300.00	56.04	0.7912	0.1541	0.3	0.61	0.48	76.14	76.96	73.640	71.9733
S2	VL6	940.00	4582	7791	155	710259	1207638.823	3.00	3622916.47	400.00	400.00	104.49	0.8299	0.4013	0.49	0.80	0.66	76.96	76.81	71.9733	69.6233
S4	S5	520.00	14362	14362	155	2226053	2226052.921	3.00	6678158.762	600.00	600.00	251.48	0.8877	0.3074	0.43	0.74	0.66	77	76	75.500	74.6333
S5	VL12	820.00	6914	21276	155	1071719	3297771.591	2.50	8244428.977	600.00	600.00	251.48	0.8877	0.3794	0.48	0.79	0.70	76	76.18	74.6333	73.2667
S6	VL12	400.00	6029	6029	155	934445	934445.4443	3.00	2803336.333	400.00	400.00	104.49	0.8299	0.3105	0.43	0.74	0.62	75.8	76.18	74.300	73.3
S7	VL13	940.00	14207	14207	155	2202125	2202124.71	3.00	6606374.129	600.00	700.00	232.83	0.8218	0.3284	0.44	0.75	0.62	78	76.96	75.500	74.1571
S8	S9	900.00	24990	24990	155	3873421	3873421.227	2.50	9683553.068	600.00	700.00	232.83	0.8218	0.4814	0.55	0.85	0.70	76	76.2	74.500	73.2143
S9	S10	1180.00	13576	38566	155	2104311	5977732.227	2.50	14944330.57	700.00	800.00	328.49	0.8519	0.5266	0.58	0.88	0.75	76.2	78	73.2143	71.7393
S11	S10	1040.00	13576	13576	155	2104311	2104311	3.00	6312933	500.00	600.00	154.67	0.7862	0.4724	0.54	0.84	0.66	77.3	78	74.800	73.0667
S10	VL28	130.00	2838	54981	155	439944	8521987.456	2.25	19174471.78	700.00	800.00	328.49	0.8519	0.6756	0.67	0.93	0.80	78	78.45	71.7393	71.5768
S12	VL1	1300.00	35732	35732	155	5538453	5538452.93	2.50	13846132.32	600.00	700.00	232.83	0.8218	0.6883	0.68	0.94	0.77	79	77.59	76.500	74.6429
S13	VL1	620.00	5675	5675	155	879591	879591.361	3.00	2638774.083	400.00	400.00	104.49	0.8299	0.2923	0.42	0.73	0.61	78	77.59	75.500	73.95
S14	VL2	720.00	11998	11998	155	1859707	1859707.449	3.00	5579122.347	500.00	500.00	169.43	0.8612	0.3811	0.48	0.79	0.68	78	77.05	75.500	74.06
S15	VL4	700.00	6042	6042	155	936456	936455.9706	3.00	2809367.912	400.00	400.00	104.49	0.8299	0.3112	1	0.74	0.62	77	76.43	74.500	72.75
S16	VL4	700.00	3193	3193	155	494934	494933.944	3.00	1484801.832	300.00	300.00	56.04	0.7912	0.3067	0.43	0.74	0.59	77	76.43	74.500	72.1667
S17	VL5	640.00	2066	2066	155	320251	320251.3756	3.00	960754.1267	300.00	300.00	56.04	0.7912	0.1984	0.34	0.65	0.51	76.5	75.25	74.000	71.8667

CHAPTER 3

ENVIRONMENTAL IMPACT ASSESSMENT
FOR
SEWERAGE PRIORITY PROJECT

CHAPTER 3 ENVIRONMENTAL IMPACT ASSESSMENT FOR SEWERAGE PRIORITY PROJECT

3.1 INTRODUCTION

3.1.1 Introduction

Varanasi, one of the biggest cities of Uttar Pradesh and located in North Eastern part of the State has an inadequate water supply and sanitation services for present population. The sewerage system in Varanasi city, which was initially commissioned in the year 1917, is quiet old and poorly maintained. The water supply is intermittent, and adverse sanitation conditions cause increasing hazards to public health. The large amount of wastewater flowing through open drains pollutes the river Ganga and Varuna. Total wastewater load is about 246 million liter per day and the present installed treatment capacity is only of 89.8 million liter per day. Therefore, there is a need for installation of new sewage treatment facilities and augmentation of existing facilities in the Varanasi city.

In order to meet the above objective, interceptor sewers for Varuna river & Assi nala along with Sewage Treatment Plant (STP) at Sathwa and several pumping stations that would overcome the present sanitation scenario of the Varanasi city, is included in the Priority Project on Pollution Abatement of Ganga River in the Republic of India. The possible impacts of the proposed project on the social and natural environment during the project phase of construction and operation are assessed in this Chapter of the Feasibility Study Report.

The objective of the study is to assess the environmental impacts of the priority projects for pollution abatement of river Ganga in Varanasi. Another objective of the study is to assist in carrying out construction and in operating the complete facilities in an environmental sound manner. The EIA study has also assessed how to ensure the sustainability of the project/programme from the environmental point of view.

3.1.2 Justification of the Project

The current proposal is justified on the following considerations:

1. Presently in Varanasi city the wastewater load is about 246 million liters per day (mld or 1000 m^3/day). But the present installed treatment capacity is only 89.8 mld. The amount of wastewater collected and diverted to treatment is only 35% of the total amount generated. Remaining 65% of the wastewater is discharged to Varuna and Ganga rivers through open drains. This causes significant pollution of the rivers. So, there is need for installation of additional treatment capacity.
2. Varanasi city's population is projected to double from 1.27 million in 2003 to 2.35 million by 2030. This increased population will contribute an additional discharge of wastewater to the existing, causing a significant threat to the environment.
3. The present sewer infrastructure is old, and poorly maintained.
4. Water supply and sanitation services are inadequate for Varanasi's present population.
5. The intermittent water supply and adverse sanitation conditions cause increasing hazards to public health.
6. A large amount of wastewater flows into open drains, which pollute the river Ganga and Varuna.
7. Presently only 40% of the total area is sewered. Entire trans-Varuna and some parts of the Cis-Varuna are unsewered.
8. The existing sewerage system was designed to exclusively carry domestic sewage only but storm water also enters the sewers directly or through manholes and open drains.
9. New colonies have been developed in the sub-central city sewerage district but there is no sewerage system. In some localities branch sewers were laid in the past, which have been

either connected to the old existing trunk sewers or to the old drains.

10. In Varanasi, currently power supply is regulated due to energy shortage and daily power cut for several hours is common. Power supply to the existing STPs and pumping stations is also cut. If this situation will continue in future, the proposed sewerage system will cause negative impacts during the power cut.
11. There is no regular sewerage system in the Trans Varuna area. The old Orderly Bazaar Sewer, which exists in the area, discharges in the river Varuna. Some branches have been laid in the area from time to time but their outfall is connected to the storm water drains, which ultimately drain into river Varuna. The existing sewer network covers over 315 km in the city. Though sewerage system has been designed exclusively to carry domestic sewage, storm water finds its way into the system during monsoon.

Thus there is a need to initiate few interceptor sewers, pumping stations & sewage treatment plants (STP) that will serve the purpose of treatment of the generated wastewater in the Varanasi city. The purpose of the EIA study is to identify the major impacts of the proposed projects followed by detailed survey and study on the important environmental impacts.

3.1.3 Objective of the EIA Study

The purpose of the EIA Study is to ensure that development options under consideration are environmentally sound and sustainable and that the environmental consequences of the project are recognized early and taken into account in the project design.

The major objective of this study was to establish present environmental conditions along the project corridor through available data/information supported by field studies, wherever necessary; to predict the impacts on relevant environmental attributes due to the construction and operation of the proposed sewerage facilities, to suggest appropriate & adequate mitigation measures to minimize/reduce adverse impacts and to prepare a Environmental Impact Assessment (EIA) report including Environmental Management Plan (EMP) for timely implementation and scheduling of the mitigation measures. The EIA has been carried out on the Priority Project only. The existing sewerage facilities and sanctioned projects have not been included.

3.1.4 EIA Methodology

(1) Approach of the EIA Study

An EIA study basically includes establishment of the present environmental scenario, study of the specific activities related to the project and evaluation of the probable environmental impacts, thus, leading to the recommendations of necessary environmental control measures. The EIA study has also been carried out from the environmental point of view so as to ensure the sustainability of the project.

An EIA study, thus, necessarily includes collecting detailed data and information on the existing environmental set up for establishing "Baseline Environmental Scenario" and study of related data on the proposed activities, i.e., "Project Description" or project data due to construction and operation of the project. The project data is then superimposed on the baseline data and the resultant environmental conditions and environmental impacts associated with construction and operations are predicted with the help of effective and appropriate impact prediction tools and procedures under "Assessment of Environmental Impacts". To mitigate detrimental impacts on the environment, the necessary environmental control, protective and mitigation measures are finally recommended as "Environmental Management Plan".

The major environmental disciplines in this EIA study include water, wastewater, and sludge quality, land use, & socio-economics. The EIA study has been conducted emphasizing the impact of the different components of the existing sanitation system as well as impact of the proposed sewage

treatment plant (STP). The main components of the project on which EIA study has been conducted are – rehabilitation of existing main trunk sewer, five (5) ghat pumping stations, Konia MPS, Dinapur STP and Bhagwanpur STP, construction of Assi nala interceptor sewer, Chaukaghat MPS and connection to Sathwa STP, Varuna river interceptors, and pumping stations connection to Varuna river interceptor. The entire EIA study has been carried out within existing policy, legal and administrative framework considering the applicable environmental legislations, regulations and guidelines.

In addition to the primary data collected in the Master Plan stage, secondary data was collected with respect to physical, biological and human environment of the study area and other relevant information about the project. Primary field data was generated in the study area on surface water, wastewater, and sludge from the treatment plant. A comprehensive database was established after compilation of both primary and secondary data.

In the way of the study, firstly the relevant aspects of the natural and socio-economic environment are described and the potential beneficial and adverse impacts on the social and natural environment during the implementation and operation phases have been identified. The environmental impacts associated with construction and operation of proposed projects have then been determined through appropriate impact prediction tools and procedures. An Environmental Management Plan (EMP) has been formulated for implementing the proposed mitigative measures as well as institutional arrangements required for the purpose.

So, in brief, the scope of the EIA study includes:

- To carry out the survey at the different sites where the same treatment technology (WSP) is used by collecting existing data, visiting a few existing WSPs, evaluating the cause and level of impacts, and incorporating the results into the evaluation.
- To identify the major impacts such as resettlement, land acquisition, disposal site, change in landscape, land-use and vegetation, groundwater contamination from seepage of the STP, pollution and hydrological changes in receiving bodies of treated water, sludge production and disposal or reuse, odour production, health hazards to the plant operators, etc., of the proposed large sewage treatment plant (STP).
- To carry out the mitigation measures for the risk in construction and operation of the STP due to accident, power cut, etc. and to formulate the necessary mitigation and monitoring plan to reduce the impact of the proposed pumping stations and STP.

The methodology adopted is presented in the form of flow chart (Figure 3.1). The methodology is presented in detail in the subsequent sections.

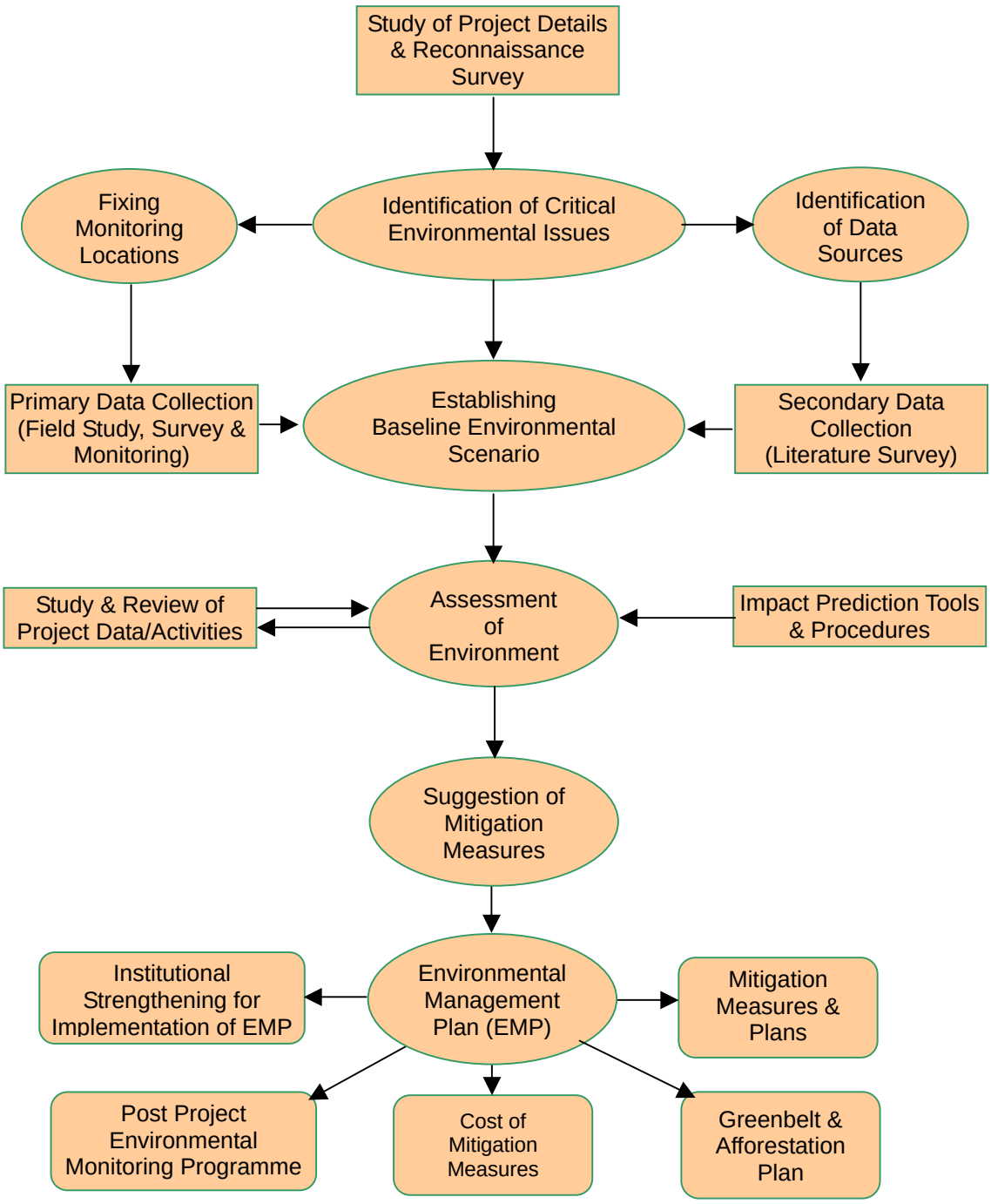


Figure 3.1 Schematic Diagram for Approach and Methodology of EIA

(2) Establishing Baseline Environmental Scenario

"Baseline Environmental Scenario" is generally established through:

- Collection of secondary data through review of existing literature/data/information
- Generation/collection of primary data through survey and monitoring

The baseline environmental conditions of the study area have been established through survey and review of published literature, and field studies/monitoring/survey. At the outset, the relevant secondary data have been collected reviewed and analysed.

Site Visit/Sampling:

After obtaining information, site visit and sample collections have been carried out to generate and collect primary data. The duration of site visit and sampling was about a period of fifteen days. The sampling sites and the area for the EIA study encompassed the city of Varanasi and its surroundings, where the potential impacts of the project would occur. Other than this, in-situ measurement of the dissolved oxygen (DO) levels have been investigated. The survey includes – surface water quality survey, wastewater quality survey, sludge quality survey, etc.

Water Quality:
The water quality of the river Ganga and Varuna at representative locations has been monitored for generating data on water quality parameters. Samples have been collected and analysed for physical, chemical and bacteriological parameters for drawing up the baseline data. Important trace inorganics, heavy metals and toxic constituents for those samples have also been analysed. Parameter selection, sampling and analysis of water samples have been conducted as per established standard methods and procedures.

Wastewater Quality:
The wastewater from different drains has been collected for the baseline data. In addition to this the influent and effluent of different existing sewage treatment plants in Varanasi, namely Dinapur STP and BHU STP have been collected. The sewage samples have been analysed for different physical, chemical, and biological parameters.

Sludge:
The sludge sample has also been collected from the existing sewage treatment plant for the generation of primary data. The calorific value and heavy metal quantity in the sludge have been determined.

The detail description of the sampling locations, study items, and the parameters studied are given in the Table 3.1.

Table 3.1 Detail of Sampling Locations, Study Items, and the Parameters

Sr.	Study components	Sample	Parameters
Proposed Project Activities			For both sewage and surface & ground water: Colour, Odour, Turbidity TDS, TSS, BOD, COD, pH, Alkalinity, Hardness, Conductivity, Metals – Ca, Fe, Mg, Ni, Zn, Hg, Pb, As, %Na, Cd, Cu, Mn, Cr Cl^-, SO_4^{2-},NO_3^-, F^-, PO_4^{3-}, S^{2-}, CN^-, Residual Cl^-, Ammoniacal nitrogen, TKN, Phenolic compounds, Oil and grease, Faecal coliform **For sludge:** Water content, Calorific value, phosphates and Heavy metals – Ni, Zn,
1	Varuna River Interceptor Sewers	Surface water, influent from two major drains/outfalls	
2	Assi Nala Interceptor Sewer	Surface water, influent from drains/outfalls	
3	Sathwa STP (200 mld)	Wastewater (influent)	
4	Augmentation of existing pumping stations and cleaning, inspection & rehabilitation of existing main trunk sewer lines	-	
Existing Wastewater Treatment Facilities			
1	BHU STP (9.8 mld)	Influent, effluent, sludge and water quality at outfall of river Ganga	
2	Dinapur STP (80 mld)	Influent, effluent, sludge and water quality at outfall of river Ganga	
Other Sampling Locations			
1	Downstream of river Varuna	Water quality	
2	Upstream of river Varuna	Water quality	

Sr.	Study components	Sample	Parameters
3	Downstream of river Ganga	Water quality	Hg, Pb, Cu, Cd, As, Cr
4	Upstream of river Ganga	Water quality	
5	Outfall of bypass from Konia pumping station to the downstream of river Varuna	Water quality	
6	Groundwater quality nearby to Sathwa STP and Ramna STP	Water quality	

(3) Assessment of Environmental Impacts

Changes in land use due to the setting up of the project and ancillary facilities have been established from the data collected. Consequential impacts on the terrestrial and aquatic flora and fauna have been studied with reference to past knowledge.

(4) Environmental Management Plan

Environmental Management Plan (EMP) is the key to ensure a safe and clean environment. A project may have considered proper environmental measures but without a management plan to assure its proper implementation and function, the desired results may not be obtained. The EMP envisages the plans for the proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities. The following issues have been addressed in the EMP:

- Mitigatory measures for abatement of the undesirable impacts caused due to the proposed project
- Institutional set up identified/recommended for implementation of the EMP
- Post project environmental monitoring programme including parameters, locations and frequency of monitoring and their implementation programme to be undertaken after commissioning of the project
- Expenditures on environmental protection measures

3.2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

3.2.1 General

The National Water Policy of India adopted in September 1987 states that:

Water resources development projects should as far as possible be planned and developed as multipurpose projects. Provision for drinking water should be a primary consideration. The other uses being in priority order as following: irrigation, flood control, hydropower, navigation, pisciculture and industrial and other uses, unless otherwise dictated by area-specific requirements;

The integrated and co-ordinated development of surface and groundwater and their conjunctive use should be envisaged at the project planning phase and should form an essential part of the project. There should be a close integration of water and land use policies;

There should be an integrated and multi-disciplinary approach to the planning, formulation, clearance and implementation of projects, including catchment management, environmental and ecological aspects, the rehabilitation of affected people and command area development.

The Water (Prevention and Control of Pollution) Act and the Environment Protection Act promulgated in 1974 and 1986 respectively deal with the prevention and control of water pollution. The latter is considered as an umbrella act covering all aspects of the environment, under which the Central Government can take appropriate measures for:

- Protecting and improving the quality of the environment, and
- Preventing, controlling and abating environmental pollution.

The Pollution Control Boards (PCB) was established under this Act both at the Central Government and also at the State Government level for each state.

The sewerage project of Varanasi city will be implemented by the GoUP. The GoUP will co-ordinate with different Government Departments like Varanasi Nagar Nigam (VNN), UP Jal Nigam, Varanasi Jal Sansthan, Varanasi Development Authority, Revenue Department, Irrigation Department, State Pollution Control Board at various stages of the implementation of the project and also during the operation phase of the project.

During the construction phase mitigation measures necessary as per Water Pollution Control Act, 1974, Air (Prevention and Control of Pollution) Act, 1981 and Environmental Protection Act, 1986 will be taken. Since the State Pollution Control Board is the enforcing agency for these Acts, the UPJN/VNN/VJS will seek their advice, whenever necessary.

3.2.2 Legal Framework

(1) Water Pollution Control

The Water (Prevention & Control of Pollution) Act, 1974 was enforced by the Government of India in 1974. The Central Pollution Control Board and the State Boards were established under the provisions of this Act. The Act is applicable to all Union Territories and has been adopted by all the States, by resolution passed on that behalf under clause (I) of Article 252 of the Constitution. Under the provisions of this Act, no discharge of wastewater can be made into the environment without obtaining prior consent from State Pollution Control Boards (from the Central Pollution Control Board, in case of Union Territories). The consent prescribes the volume and quality of wastewater, in terms of concentration of various pollutants, which is permitted for discharge into the environment. The Act allows both the Union Territories and the State Governments and their respective Pollution Control Boards, to make rules for implementation of the Act. In case of a conflict, however, the Union Government rules prevail.

(2) Air Pollution Control

The Air (Prevention and Control of Pollution) Act, 1981 was formulated by the Central Government to regulate air pollution from various sources. Under this Act, the standards for various pollutants namely SO_2, NOx, Suspended Particulate Matter, CO, hydrocarbons and several other air pollutants were stipulated by CPCB to protect the ambient air quality. The emissions from various stacks and other elevated sources were also simultaneously regulated as per recommended standards by the State Boards under the guidelines given by the Central Pollution Control Board. These standards were granted by the Boards by way of granting consent to establish and to operate the industry. The noise levels were also regulated by stipulating noise for residential areas and industrial areas.

(3) Environment Protection Act

The Environment Protection Act, 1986 came into existence after promulgation of the above Acts. This Act has an overriding effect on the other earlier environment Acts. The Ministry of Environment and Forests (MoEF) is responsible for the administration of this Act.

The Act is an Omnibus Act subsuming the various pollution control, wildlife, forest conservation Acts. The Act therefore links the pollution control and natural resource conservation issues. The Act empowers the Union Government to make rules providing standards in excess of which environmental pollutants shall not be discharged or emitted into the environment. It also empowers the Union

Government to make rules regarding handling, storage, manufacture and import of hazardous substances including wastes. Violation of these rules constitutes a crime that is punishable by imprisonment and/or fine.

(4) Hazardous Chemical Storage and Handling

Under the Environment Protection Act, 1986, rules for hazardous waste handling have been defined, under which the State Pollution Control Boards could grant authorisation to the industry only when measures for safe disposal of such wastes is provided.

(5) Notification of Environmental Impact Assessment

The MoEF enforced the Notification in January 1994 for conducting Environmental Impact Assessment (EIA) studies, which are obligatory for the establishment of certain categories of industries specified in Schedule I. The Schedule I industries include the fertiliser, petrochemical, pharmaceutical, dyes and paint, iron and steel manufacturing industries, thermal power plants, mining industries and also port and harbour and the river valley projects. The appraisal committees comprising Experts, Governmental official and Non-Government Organisations (NGOs) were set up by the MoEF to scrutinise various EIA Reports prepared for the establishment of such industries and projects. The appraisal committees would accord an environmental clearance to the project in consultation with MoEF after scrutinising the EIA report for the proposed project.

(6) Land Acquisition Act

Land is normally acquired under the provisions of the Land Acquisition Act, 1894 that is general and basic law in the country for the acquisition of land for public purposes and companies. This Act was comprehensively amended in the year 1984, taking into consideration the recommendations of the Law Commission, the Land Acquisition Review Committee, headed by Justice A. N. Mulla, as well as suggestions from the State Governments and other quarters.

The Conference of the Revenue Secretaries of States (July 1989) have also made recommendations that all land should be acquired under the provisions of the Land Acquisition Act, 1894 and other laws repugnant thereto should be brought in line with it or repealed altogether. However, these efforts have not met with success and a large number of laws, having different procedures and norms of compensation, continue to operate.

In view of the acknowledged superiority of the Land Acquisition Act, 1894 land is acquired under the provisions of this Act. The underlying principle governing the acquisition of land under the Land Acquisition Act, 1894 is that compensation alone is payable in lieu of deprivation. However, there is a provision under Section 31 (3) in the Land Acquisition Act for grant of land in lieu of money compensation (Refer to Appendix A).

3.2.3 Environmental Protection Standards

1) River Water Quality Standards

Until recently the only criteria available for classification of water bodies was as per the ‘Designated Best Use’ (DBU) prescribed by Bureau of Indian Standards and Central Pollution Control Board (CPCB) way back in 1981. According to this concept, out of various purposes for which the water body is used, the one that requires highest quality of water is taken as the benchmark and classified as ‘Designated Best Use’. According to this criteria water bodies are divided in five categories viz.:

Class A :	Drinking water source without conventional treatment, but with chlorination
Class B :	Outdoor bathing
Class C :	Drinking water source with conventional treatment
Class D :	Propagation of wildlife and fisheries
Class E :	Irrigation, industrial cooling and controlled waste disposal

This criteria lays down reference values for among others pH, dissolved oxygen, biological oxygen demand, Coliform etc. For instance specified limits for DO, BOD and coliform for Class A are 6 ppm, 2 ppm and 50/100 ml respectively. For lower category such as Class D, specified values for these indicators are 4 ppm, 6 ppm and 5000/100 ml respectively. A detailed parameter-wise criteria is presented in Appendix B.

Recently, primary quality for class B regarding coliform number has been revised as follows; faecal coliform: <500 MPN/100 ml (Desirable), <2,500 MPN/100 ml (Maximum permissible).

As of now this criteria is followed by various agencies responsible for management and control of water quality in the country including the two ongoing programmes viz. National River Conservation Plan and National Lake Conservation Plan.

However, in the current context of increased pollution loads and concerns for long-term ecological sustainability, it is felt that this criteria has certain fundamental limitations. Some of these are listed below:

- DBU criteria consider only human requirements and exclude ecological aspects and their relation to the human beings. In certain cases ecological violations are not identified while the desired criteria may be satisfied.
- It recognizes only organised uses and ignores the requirements of large rural community.
- Two decades back when the criteria were developed, concerns on non-domestic sources of pollution were not pronounced.
- In case of large water bodies and rivers, adhering to one particular class of water is practically difficult and has high costs associated with any technical intervention.
- There is inherent inconsistency with regard to the set of parameters applicable to higher and lower classes. For instance the category on ‘irrigation, industrial cooling and controlled waste disposal” specifies limits for TDS, sodium absorption ration etc. but does not cover BOD, coliform, helminth, toxicants.

Recognising these limitation, the Central Pollution Control Board has proposed a new criteria for classification of water bodies. The new approach is based on the premise of maintaining and restoring ‘wholesomeness’ of water for the health of ecosystem and environment in general; and protecting the designated organised uses of water by human beings and involving community for water quality management. The term ‘Wholesomeness’ here pertains to taking an ecosystem approach to aquatic environment and including socio-cultural aspects in to consideration.

The new classification system proposes three categories or tiers of indicators of water quality depending on the ease or complexity involved in their determination with regard to knowledge, skills, and equipment. Secondly, it classifies water bodies into three broad categories viz. :

Class A : Excellent (long term goal)
Class B : Desirable level of wholesomeness (medium term goal)
Class C : Minimum acceptable level (Short term goal)

The detailed parameter-wise criteria are presented in Appendix B. The three key parameters typically used for assessments are presented below and salient features are described in the paragraphs that follow. (Water quality criteria and goals, CPCB, February 2002).

Table 3.2 Key Indicators of Inland Surface Water Quality under the Revised Criteria Proposed by CPCB

Indicator	Unit	A- Excellent	B- Desirable	C- Acceptable
DO	(% saturation)	90-110	80-120	60-140
BOD	(mg/l)	< 2	< 5	< 8
Faecal Coliform	MPN/100 ml	< 20	< 200	< 2,000

It is assumed that efforts being put in to restore and manage the quality of various water bodies will move them from Class C to Class A over a period of time. First tier of parameters pertain to visual and sensual observations and include among others, ecological indicators such as presence of fish and insects. The second tier of parameters includes typical chemical and biological indicators, which can be measured by skilled chemists in a water quality laboratory. The lacunae observed in the criteria is that while the 'Acceptable' category specifies a BOD of 8 mg/l or less, it does not recognize 'extremely poor' and 'challenged' categories or status in which many of the major water bodies are currently found to be in. For instance typical BOD levels in Yamuna and Ganga in critically polluted stretches are between 25 to 35 mg/l and these values are way above the reference values provided in the criteria. Similarly, in case of dissolved oxygen, which is referred in terms of % saturation, the criteria have not recognized 'extremely challenged' status of several water bodies wherein the DO levels are very low or almost zero.

The third tier of parameters is recommended only for detailed investigations and it includes among others, nutrients, phenols, pesticides, and heavy metals.

2) Effluent standard

Effluent discharge standards are specified with reference to the type of industry, process or operations and in relation to the receiving environment or water body such as inland surface water, sewers, land or sea. While the Environment Protection Act has laid down discharge standards for a range of industries keeping in view the manufacturing processes, raw materials, technological feasibility, etc., it has also laid down vide Schedule VI of The Environment (Protection) Rules, 1986 general discharge standards which are applicable across the board. The Schedule specifies applicability of these general standards to discharge of sewage. These standards are given in Table 3.3.

The standards vary depending on the nature of the receiving environment or water body. For instance the limits imposed for discharge into inland water bodies are most stringent followed by those specified for discharge onto land for irrigation, and then marine outfalls. The most relaxed standards are specified for discharge into public sewers that are leading to a sewage treatment plant and it is assumed that the wastewater will eventually receive adequate treatment at the plant.

Table 3.3 Discharge Standards

Indicator	Inland surface water	Public sewers	Land for irrigation	Marine outfall
Suspended solids	100	600	200	100
Oil and grease	10	20	10	20
BOD_5	30	350	100	100

Note : All values are in mg/l and are the maximum permissible levels.
Source: Pollution control acts, rules and notifications issued hereunder, CPCB, September, 2001.

The general BOD limit specified for discharge of wastewater from typical industrial sources or domestic wastewater is same at 100 mg/l. However, the rules specify that the discharge limits can be made further stringent if the concerned pollution control authority finds it appropriate depending on the condition of the receiving environment and severity of the discharges from various sources.

With regard to application of sewage for land farming the 'Manual on Sewerage and Sewage Treatment', CPHEEO, Ministry of Urban Development, Govt. of India, provides guidelines on characteristics of irrigation waters. These include conductivity/ salinity sodium absorption ratio, chlorides, boron, etc. In addition, the manual provides maximum permissible concentrations of toxic heavy metals etc. Constituent wise values are given in Appendix B. However, it is noted that while salinity and toxicity aspects have been addressed in these standards and guidelines, the issue of infection to agriculture workers and consumers of cultivated products due to bacterial population in sewage has not been addressed here.

If treated sewage is to be used for irrigation, as is proposed in the sanitation project, upper limits for important parameters will be:

Table 3.4 Treated Water Quality for Irrigation

Parameter	Unit	Limits
BOD_5	mg/l	100
Suspended Solids	mg/l	200
Dissolved Solids	mg/l	2100
pH		5.5-9.0
Oil & Grease	mg/l	10
Arsenic	mg/l	0.2
Boron	mg/l	2.0
Cyanide	mg/l	0.2
Chloride	mg/l	600
Sulphate	mg/l	1000

Source : CPCB, Stds for discharge of Ind./Dom. wastewater

In addition to the standards prescribed by the CPCB, the Project proposes to take into account the WHO guidelines for wastewater reuse for irrigation of level B (cereals, industrial and fodder crops, pasture and trees). These guidelines were elaborated by WHO after reviewing epidemiological studies of untreated wastewater reuse. This review led to the conclusion that the danger of infection is:

1. high with intestinal nematodes;
2. moderate with bacteriological infections and diarrheas;
3. minimal with viral infections and diarrheas, and hepatitis A; and
4. high to non existent with trematode and cestode infections, schistosomiasis,

clonorchiasis, and taeniasis, depending on local practices and circumstances.
The WHO guidelines are given in the following table.

Table 3.5 Recommended Microbiological Quality Guidelines for Wastewater Use in Agriculture

Category	Reuse conditions	Group exposed	Intestinal nematodes (arithmetic mean no of eggs per liter)	Faecal coliforms (geometric mean no.per 100 ml))	Wastewater treatment expected to achieve required microbiological quality
A	Irrigation of crops likely to be eaten uncooked; sports fields, public parks.	Workers, consumers, public	≤1	≤ 1,000	Series of stabilization ponds designed to achieve the microbiological quality indicated, or equivalent treatment
B	Irrigation of cereal crops, industrial and fodder crops; and pasture and trees.	Workers	≤ 1	No standard recommended	Retention in stabilization ponds for 8-10 days for equivalent helminth and faecal coliform removal
C	Localized irrigation of crops in category B if exposure of workers and the public does not occur.	None	Not applicable	Not applicable	Pretreatment as required by irrigation technology, but not less than primary sedimentation

Source: Health Guidelines for the Use of Wastewater in Agriculture and Aquaculture. Technical Report No. 778. WHO, Geneva. 1989

3) Drinking Water Quality Standards

Water quality standards for drinking purpose are given in Appendix B.

4) Air Quality

It will be necessary for the project execution agency to maintain air quality within mentioned limits for various parameters. The detailed ambient air quality standards are given in Appendix B.

5) Noise

The noise levels at project sites and residential areas nearby should be as per stipulated standards given in Appendix B.

3.2.4 Administrative Framework

(1) Pollution Control Boards

The Pollution Control Boards were established under the Water (Prevention and Control of Pollution) Act, 1974 both at the Central Government level and also at the State Government level for each State.

The Central Pollution Control Board was formulated as an Apex Body and was empowered to set up the standards for the environmental components namely water, air, and noise. The Central Pollution Control Board (CPCB) functions under the Chairman, who is the administrative head of the CPCB. The Member Secretary of the CPCB is the technical head for day to day functioning of the Board.

The State Boards are working in a similar fashion to that adopted by the Central Pollution Control

Board.

The Public Liability Insurance Act is also given for enforcement to the Boards. Under the legal framework, the Pollution Control Boards can prosecute the concerned industry or establishment that violates the provisions of the above Act, and if the Courts permit, the industry can be asked to stop their entire business. The NGOs or any individual can also approach the Court for this purpose.

The environmental protection set-up in India is given in Figure 3.2.

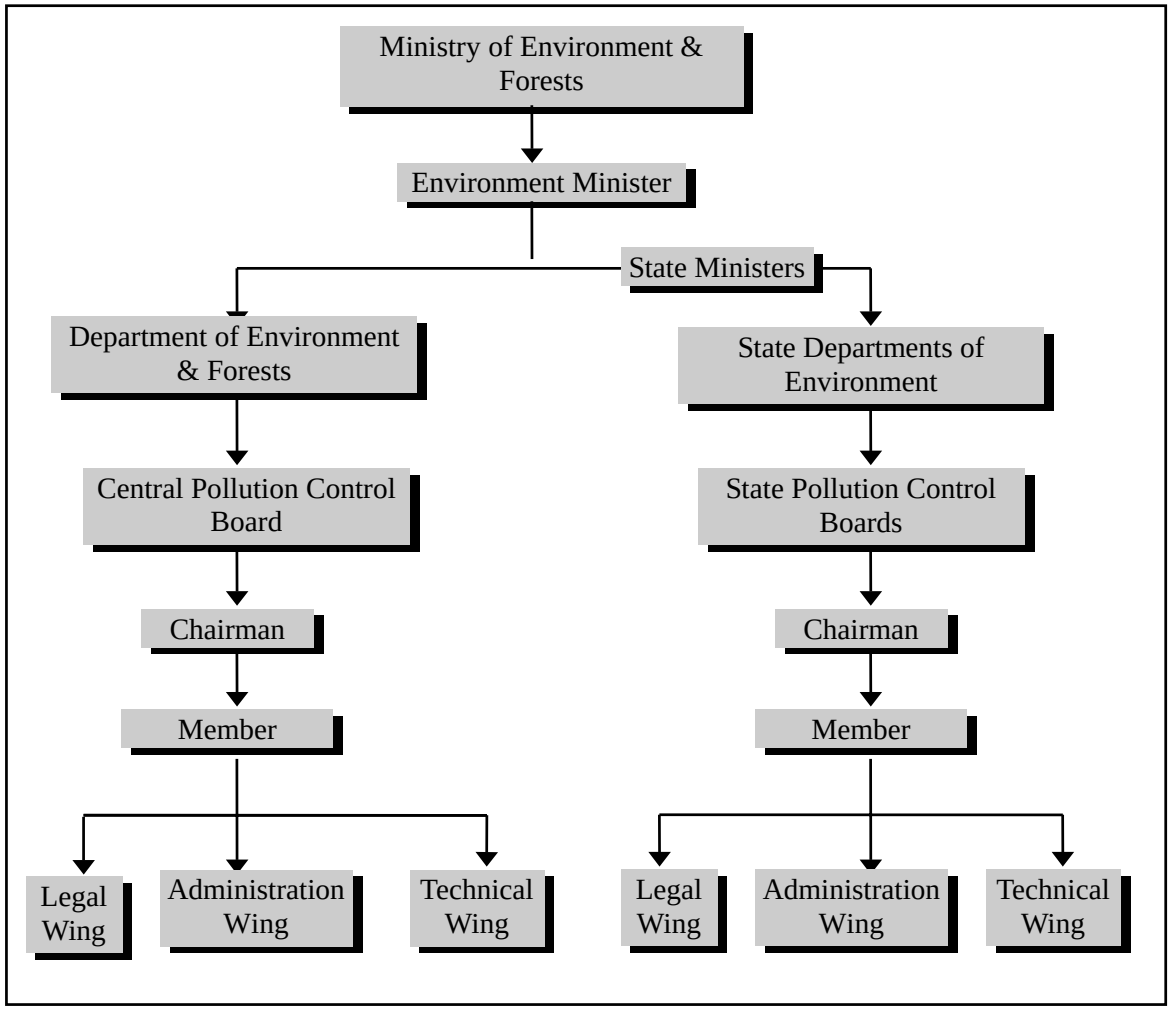


Figure 3.2 Environmental Protection Set Up in India

(2) Uttar Pradesh Pollution Control Board (UP PCB)

The Uttar Pradesh Pollution Control Board was constituted in 1975 under Section 4 of the Water (Prevention and Control of Pollution) Act, 1974. Its original objective was the prevention and control of water pollution but, later, it was also entrusted with the prevention and control of air pollution. The Board's principal function is to control water pollution and it is responsible for all aspects of this function but, in fact, its efforts are focused mainly on the control of industrial pollution.

(3) Uttar Pradesh Jal Nigam (UP JN)

UPJN is a Corporation of the State Government of UP. It was created in 1975 under the provisions of UP Water Supply and Sewerage Act, 1975 by converting the State Local Self Government

Engineering Department into UP Jal Nigam. The UPJN is entrusted with the job of development of water supply and sewerage sector in the State. It has also been designated as the implementing agency for the NRCP and NLCP in the State of UP.

The Ganga Pollution Control Unit in Varanasi was basically formed to undertake the construction, execution of the assets that were created under the Ganga Action Plan – Phase I. Under this, different pumping stations and two sewage treatment plants were built to take care of the sewage and effluent flowing into the Ganga river. Since then, it has been a primary body also responsible for the operation and maintenance of these assets. As per the order from the Central Government, the operation and maintenance of these assets were supposed to be transferred to the local body. However, these have not been transferred so far.

(4) Varanasi Nagar Nigam (VNN)

The Varanasi Nagar Nigam was formed in 1960 with the objective to provide all the necessary basic civic facilities to the residents of and visitors to the Varanasi city. These services include the cleaning of drains and gutters, solid waste management, maintenance of roads, lighting, etc.

Historically Varanasi is a Holy City and attracts a large floating population in the form of pilgrims, which entail additional burden on the existing civic facilities.

Varanasi Nagar Nigam has divided the city into 5 zones and 91 wards for administrative and management purposes. The sanitation aspect of the city is taken care by the Health and Sanitation Department, which has Health Officers, Additional Health Officers, Zonal Health Officers and Sanitary Inspector.

On a broader level, the Nagar Nigam handles the following responsibilities like health and sanitation, primary education, solid waste management, plantation, slaughterhouses, cleaning of roads, maintenance of Ghats etc.

With special reference to the surface and underground drainage system, Varanasi Nagar Nigam is involved in:

- Cleaning of surface drains and desilting of deep drains
- Construction and maintenance of surface drains, deep drains along the roads and lanes within municipal maintenance

Additionally, Varanasi Nagar Nigam is responsible for the maintenance of the branch sewers and some portion of main sewers in the city. The laterals and the branch sewers since they are small in size and form the most initial components of the sewer network, are easier to maintain. Their maintenance does not require heavy mechanical equipment and is generally done manually. Varanasi Nagar Nigam is currently managing this with their staffs that are not formally trained but have gained experience over the years. Generally in case of complex problems where mechanically aided cleaning is required Jal Sansthan is approached for help.

(5) Varanasi Jal Sansthan (VJS)

Till 1975, the Municipal Corporation (Nagar Nigam) was a single organisation that looked after all the operation and maintenance of the infrastructure including water supply and sewerage and the Local Self Government Engineering Department of the State Government did the planning and implementation of the capital works. However, with the arrival of the International Monetary Fund, it was decided that two separate entities will be required. One will be responsible for construction and execution while the other one will be mainly into operation and maintenance of these structures. Accordingly, under the UP Water Supply and Sewerage Act, 1975, Jal Nigam was established for

capital works and Jal Sansthans were created for operation and maintenance.

Varanasi Jal Sansthan came into existence in 1976. It is responsible mainly for the cleaning and maintenance of the main and trunk sewers. The cleaning is mostly done through use of mechanical equipments. Varanasi Jal Sansthan is presently operating with 6 bucket winching machines and 4 jetting cum suction units. In the first phase of the Ganga Action plan, Jal Sansthan has procured one jetting cum suction machine, 3 gully pit emptier and one pay loader which enable the department to clean the sewer lines.

Often on request of Nagar Nigam, Jal Sansthan carries out the cleaning for branch sewers also as Nagar Nigam has neither equipment nor technical expertise to carry out complex operations.

Varanasi Jal Sansthan currently maintains the following main sewer lines:

- Main Old and Trunk Sewer
- Orderly Bazaar sewer
- Kamachchha Brick sewer
- Durga Kund Brick Sewer
- Bengali Tola Brick sewer
- Rewari Talab Brick sewer
- Baluabeer Brick sewer
- G.T. Road Main sewer
- Nawapura Brick sewer
- Maduwadih Main sewer

(6) Varanasi Development Authority (VDA)

The Varanasi Development Authority is responsible for

- Overall development of the city
- Implementation of the land use Master Plan
- Planning for sewerage infrastructure for Varanasi Development Authority colonies
- Zoning of the city
- Maintenance of the sewer lines in the Varanasi Development Authority colonies

Varanasi Development Authority does not have the technical staff specifically with reference to sewerage sector. However, as and when required manpower is hired on contract basis to carry out the job.

3.3 PROJECT DESCRIPTION

3.3.1 General

The sewerage priority projects selected in M/P include the projects to abate the pollution and improve water quality of river Ganga and Varuna with the following objectives:

- To Intercept wastewater in all major drains and sewer outfalls
- To convey collected wastewater to sewage treatment plant (STP)
- To treat wastewater at STP with appropriate technology and discharging effluent that comply with National effluent standards for STP

The following facilities have been identified in the Master Plan for the priority projects.

Renovation/Rehabilitation

1) Ghat pumping station upgrades
2) Rehabilitation of STP at Dinapur and Sewage Pumping Station (SPS) at Konia
3) Rehabilitation of STP at Bhagwanpur
4) Operational plan for inspection and rehabilitation of existing main trunk sewer

New Construction

1) Construction of relieving trunk sewer
2) Chaukaghat main pumping station, and connection to Sathwa treatment plant
3) Sathwa treatment plant
4) Varuna river interceptor sewer
5) Pump station at Narokhar drain and connection to Varuna river Interceptor
6) Assi Nala Interceptor sewer
7) Secondary trunk sewers in all four sewerage districts

3.3.2 Existing Sewerage Facilities in Varanasi City

(1) Trunk Sewer

Two main sewers exist in the city of Varanasi. The main Sewer (750-2440 mm diameter and 8 km long) runs from Assi to Rajghat outfall. Another is the Orderly Bazaar trunk sewer (600-900 mm diameter), which joins the main sewer at Kabir Chaura. Both these brick sewers are about 75 years old. The existing sewer network covers over 315 km in the city.

(2) Sewage Treatment Plants

Presently in Varanasi there are three major sewage treatment plants. They are:

- Dinapur STP
- Bhagwanpur STP, and
- DLW STP.

1) Dinapur Sewage Treatment Plant

Dinapur STP is based on Activated Sludge Process. It is under direct control of UP Jal Nigam for operation and maintenance purposes. The design capacity of the plant is 80 mld. The work on this plant was initiated during February 1988 and it was fully commissioned in June 1994. Different aspects of the Dinapur STP plant are given below.

The process design parameters are available from original process calculations. However, there is insufficient operating data to compare present unit wise performance with design values. The STP consists of primary clarifiers, aeration tanks, secondary clarifiers, and anaerobic sludge digesters. The design criteria for different components of the treatment plant and the unit wise details of the different units and the pump details are given in Appenndix C.

Major liquid process components of the Dinapur STP consist of head works, primary treatment and secondary treatment. All these three levels have been listed by the treatment stage. The condition of each component has been rated as poor, fair, or good depending upon age and condition. An itemized list of the major plant components related to the liquid process is given in Appendix C. In the sewage treatment plant sludge is produced from the sedimentation tanks as a result of conversion of organic material into cellular mass. After adequate solids retention time the digested sludge is conveyed to the sludge drying beds for dewatering. An inventory of solids handling process also is provided in Appendix C.

Average monthly inflow and effluent characteristics data from the beginning of the year 2000 and up to August 2002 have been obtained. From the BOD, COD, and TSS of influent sewage and effluent the performance of the plant is measured. Average yearly inflow and effluent characteristics for the year 2000-2002 are given in the Table 3.6 and the detail monthly characteristics data are given in Appendix C.

Table 3.6 Average Inflow and Effluent Characteristics of Dinapur STP

Year	Flow (mld)	Influent Sewage (Raw) (mg/l)			Effluent (Treated) (mg/l)			Overall Efficiency (%)		
		BOD	COD	TSS	BOD	COD	TSS	BOD	COD	TSS
2000-2002	78.67	173.87	371.94	450.81	28.75	81.4	85.15	83	78	81

In Dinapur sewage treatment plant, influent wastewater quality appears to be within the treatment plants design parameters. However, the treatment plant is hydraulically overloaded. A comparative study of design parameters versus their actual value is provided in Appendix C. The treated water is utilised for irrigation purpose and unutilised water is discharged to the Ganga downstream of the confluence of Varuna river.

2) Bhagwanpur Sewage Treatment Plant

The Bhagwanpur sewage treatment plant was commissioned in the year 1988 under Ganga Action Plan. The plant receives sewage from two pumping stations within BHU campus and from Assi pumping station. The design capacity of the plant is 9.8 mld (8 mld activated sludge process and 1.8 mld trickling filter). The present wastewater treatment process consists of three overall process stages: preliminary treatment, primary treatment, and secondary treatment. Each phase of treatment acts as a removal mechanism for targeted pollutants in the influent wastewater stream. The major liquid process units of Bhagwanpur STP consist of head works, primary system, and secondary system. An itemized list of major plant components related to the liquid process is provided in Appendix C. The various components are listed by treatment stage. Additionally the condition of each component has been rated poor, fair or good depending on age and condition. In the treatment plant sludge is produced from primary sedimentation and the biological sludge from the secondary clarifier. Average monthly inflow and effluent characteristics data for the recent three years test reports (1999-2001) have been obtained. From the BOD, COD, and TSS of influent sewage and effluent the performance of the plant is measured. The average data is shown in the Table 3.7 and the detail of the monthly data is provided in Appendix C. The treated water is discharged to the Ganga upstream of Assi nala outfall.

Table 3.7 Av. Inflow & Effluent Characteristics of Bhagwanpur STP for Year 1999-2000

	Flow (mld)	Influent Sewage (Raw)			Effluent (Treated)			Overall Efficiency (%)		
		BOD	COD	TSS	BOD	COD	TSS	BOD	COD	TSS
AVG	13.68	93	179	183	17	54	19	82	70	89

3) Diesel Locomotive Works (DLW) Sewage Treatment Plant

The Diesel Locomotive Works (DLW) STP is located in Railway area and it is operated and maintained by Railway Authority. It has a capacity to treat 12 mld of wastewater. This STP receives the raw sewage from DLW compound and treats the sewage by biological treatment process. The sewage is intercepted from Assi nala.

(3) Existing Pumping Stations in Varanasi

There are two main, and five intermediate sewerage-pumping stations, which were commissioned under GAP Phase-I. The detail data of the pumping station are provided in Appendix C.

Assi Pumping Station

Assi main pumping station is located on the bank of Assi nala adjacent to the BHU-Godauliya road. This PS intercepts sewage from Assi nala and pumps to the Bhagwanpur STP through a 400 mm diameter prestressed concrete pipe rising main for treatment. The capacity of the Assi MPS is 9 mld.

Konia Main Pumping Station

The Konia MPS is located in northern part of the Central City Sewerage District, and is isolated with the river Varuna on one side and railway track at Konia near Rajghat. This MPS was built during the GAP Phase-I. The pumping station has a capacity to pump 100 mld of sewage. It has two stage pumping arrangement having three screw pumps in the first stage and a battery of centrifugal pumps in the second stage. The sewage lifted by the screw pumps passes through the grit chamber and during high flow period part of the sewage pumped is bypassed into the river Varuna. The battery of the centrifugal pumps lifts the de-gritted sewage to the Dinapur main Sewage Treatment Plant through 1200 mm rising main about 2.9 km long.

5-Ghat Pumping Stations

There are five intermediate pumping stations (IPS) on the ghats along the left bank of the river Ganga. They are –
1) Harischandra Ghat IPS (Capacity: 4 mld; Rising main: 200 mm)
2) Mansarovar Ghat IPS (Capacity: 6 mld; Rising main: 400 mm)
3) Dr. R. P. Ghat IPS (Capacity: 25 mld; Rising main: 600 mm)
4) Jalesan Ghat IPS (Capacity: 5 mld; Rising main: 250 mm) and
5) Trilochan Ghat IPS (Capacity: 5 mld; Rising main: 300 mm).

These are old pumping stations and were re-commissioned under GAP Phase-I for intercepting sewage and pumping it back into the trunk sewer through rising main. The major units of all these pumping stations are – pump house, pumping plants, diesel generating set, and rising main.

3.3.3 Sanctioned Sewerage Facilities in Varanasi

(1) Sewers and rising main

Around 12.3 km sewers and a rising main is sanctioned under GAP Phase-II.

(2) Sewage Treatment Plants

Under GAP Phase-II one WSP sewage treatment plant with capacity 37 mld has been sanctioned at the Ramna site.

Uttar Pradesh Jal Nigam has identified a 50 ha site near Ramna where a waste stabilization pond of 37 mld has been sanctioned under GAP Phase-II. This system includes pre-treatment facilities to remove grit and inorganic solids, followed by anaerobic ponds, facultative ponds and finally maturation ponds. Preliminary process details are shown in the Table 3.8 in summary form.

Table 3.8 Preliminary Process Calculations for Ramna STP

Basic Data	
Sewage flow	37 mld
Influent BOD	180 mg/l
Total coliform	10^7/100 ml
Effluent BOD	30 mg/l
Total coliform in effluent	10,000/100 ml
BOD removal	For BOD removal anaerobic pond followed by facultative pond is provided
Anaerobic Pond	
Volume of the anaerobic pond	37,000 m^3
Adopt depth of the pond	4.5 m
Area of the pond	8,222 m^2, say 8300 m^2
Provided pond size	52 m x 160 m rectangular ponds
Facultative Pond	
Area of the facultative pond	10 x 72 x 37,000 / 219 = 121,644 m^2
Assuming 1.25 m depth. Detention period	4.1 days
Land requirement	50 ha

(3) Pumping stations

There will be one intermediate pumping station for which the plan has been sanctioned under GAP Phase-II. This pumping station is to be located at Nagwa for a design capacity of 50 mld. Capacity augmentation of existing 5-Ghat pumping stations is also sanctioned.

3.3.4 Proposed Sewerage Facilities in Varanasi City

The proposed sewerage facilities under Feasibility Study were described and are explained briefly hereunder.

(1) Rehabilitation of the Old Trunk Sewer

Sewer system is an important part of infrastructure and plays an essential role for maintaining public health. Yet it is largely out of sight and in the past this has often been a cause of neglect, leading to sewer flooding, pollution, collapse and blockage. A sewer normally fails to receive attention till it starts giving serious trouble.

The Old Trunk Sewer is the main lifeline of the sewerage system of the Varanasi and it cannot be dispensed with or abandoned.

The procedure followed for any rehabilitation plan is divided into three main stages as described below:

Stage 1: Initial planning
Stage 2: Diagnostic study (Inspection Programme)
- Closed Circuit Television (CCTV) Inspection
- Ground water monitoring
- Flow measurement
- Soil investigation
- Ground surface condition
- Waste water analysis
- Structural assessment

Stage 3: Implementation (Rehabilitation)

(2) Rehabilitation of Ghat Pumping Stations

All the five ghat pumping stations located along the bank of the river Ganga have not been operated properly due to the problems as follows.

- During peak hours all pumps are running including standby pumps and some amount of over flow is also observed during the visit
- Alternative power supply (DG Generator) is available at all IPS. However, there is no standby generator, except at Dr. R.P.Ghat
- There is not a single instrument to measure level, flow, pressure, temperature etc for proper operation at any of the IPS
- There is no mechanized screen and only wire mesh is available to screen the sewagewater
- There is no telecommunication facility provided at any of the IPS
- Skilled operation and maintenance staff is not available

Replacement of the existing pumping equipment by new centrifugal pumps with vertical motors is proposed for all of the five pumping stations.

(3) Rehabilitation of Existing Sewage Treatment Works

1) Konia Pumping Station

Following rehabilitation and upgradation works are proposed for Konia Pumping Station.

- Diversion works at Rajghat
- Pumps - Ist stage
- Screen - IInd Stage
- Detritor - IInd Stage
- Pumps - IInd stage
- Miscellaneous works

2) Dinapur STP

Following rehabilitation and upgradation works are proposed for Dinapur Sewage Treatment Plant.

- Inlet Chamber
- Parshall Flume
- Primary Clarifiers
- Distribution Chamber for Trickling Filters
- Roughening Trickling filters
- Aeration Tanks
- Secondary Clarifiers
- Treated Effluent Pump House
- Primary Sludge Pump House
- Return Sludge Pump House
- Sludge Digesters
- Sludge Drying Beds
- Filtrate Pump House
- Gas Holders
- Power Generator Room
- Gas Burner
- Effluent Channel (5000m)

- Chlorination Room, Chlorine Contact Tank, Inter connecting piping and dechlorination by aeration
- Miscellaneous

3) Bhagwanpur STP

Following rehabilitation and upgradation works are proposed for Bhagwanpur Sewage Treatment Plant.

- Inlet Chamber
- Bar Screen Channel
- Grit Chamber
- Parshall Flume
- Primary Clarifiers
- Secondary Clarifiers
- Sludge Digesters
- Recirculation Pump House
- Gas Holders
- Engine Room
- Gas Burner
- Raw Sludge Pump House
- Filtrate Pump House
- Chlorination Room, Chlorine Contact Tank, Inter connecting piping and dechlorination by aeration

(4) Construction of Sathwa Treatment Plant

- Pumping facility
- Treatment plant
- Treated effluent channel to the local canal

For the wastewater generated in central Varanasi and trans Varuna area in future, a new Sewage Treatment Plant in northern area of the city is proposed. Location of the STP is presented in Figure 3.3.

Capacity: 200 mld
Process: UASB + Facultative Aerated Lagoon
Disinfection: Chlorination
Effluent discharge: Irrigation canal

S.N.	Units	Value
1	Effluent BOD, mg/l	< 30
2	Effluent TSS, mg/l	< 50
3	Effluent faecal coliform, MPN/100 ml	< 10,000
4	Odour	Localized
5	Ground water contamination	Moderate
6	Mosquito nuisance	Minimal
8	Land requirement	41 ha

(5) Pumping Stations

In the scheme of the project six pumping stations have been proposed.

- Sathwa Main Pumping Station
- Chaukaghat Right Bank Pumping Station
- Chaukaghat Left Bank Pumping Station
- Narokhar Nala Pumping Station

- Phulwaria Nala Pumping Station
- Saraiya Nala Pumping Station

1) Sathwa Main Pumping Station (MPS)

A pumping station is proposed at Sathwa STP site to maintain the hydraulics of the treatment plant. Various components of MPS will include:

- Main pumping station screen channel, wet well and valve chamber,
- Main Electrical Panel (MEP) and Diesel Genset (DG) room, and
- Twin rising main of 40 m length.

2) Chaukaghat Right Bank Pumping Station

Chaukaghat right bank pumping station is proposed to pump the sewage flow of right bank interceptor sewers and relief trunk sewer (under construction) upto Pandeypur crossing. Various components of pumping station include:

- Sewage pumping station screen channel, wet well and valve chamber,
- MEP and DG room,
- Rising main of 1200 m length from pumping station to Pandeypur crossing, and
- River crossing structure on Varuna river for rising main

3) Chaukaghat Left Bank Pumping Station

Chaukaghat left bank pumping station will receive the sewage flow of left bank u/s interceptor sewer and this flow will be pumped to Pandeypur crossing. Various component of pumping station include:

- Sewage pumping station, screen channel, wet well and valve chamber,
- MEP and DG room,
- Rising main for 1000 m length from pumping station to Pandeypur crossing.

4) Narokhar Nala Pumping Station

- Pumping station at Narokhar nala
- Rising main

It is proposed to intercept and divert the flow of Narokhar nala near the junction of Railway line with Narokhar nala. Flow of this nala shall be pumped to the left bank interceptor sewer (d/s) on Panchkoshi. Proposed scheme for Narokhar nala includes:

- Construction of intake weir and training of nala,
- Diversion of flow to grit channels,
- Intermediate sewage pumping station screen channel, wet well and valve chamber,
- Main Electrical Panel (MEP) and Diesel Genset (DG) room, and
- Rising main of 1830 m length from pumping station to left bank interceptor sewer (d/s) on Panchkoshi road.

5) Phulwaria Nala Pumping Station

It is proposed to intercept and divert the flow of Phulwaria nala, near Cantonment into right bank interceptor sewer. Phulwaria nala catchment falls under District IV, FSA 2, which comes under Lohta STP catchment in Phase II. Therefore, interception and diversion work is proposed for the present flow only and this facility will be decommissioned in the future. Proposed scheme for Phulwaria nala includes:

- Construction of intake weir and training of nala,
- Diversion of flow to grit channels,

- Intermediate sewage pumping station of 7.60 mld average flow capacity including screen channel, wet well and valve chamber,
- Main Electrical Panel (MEP) and Diesel Genset (DG) room, and
- Rising main of 1620 m length from pumping station to right bank interceptor sewer

6) Saraiya Nala Pumping Station

It is proposed to intercept and divert (I&D) the flow of Saraiya nala near the bridge on river Varuna. Flow of this nala shall be pumped to the right bank interceptor sewer (d/s) on Mugalsarai road near Nakkhi nala. Proposed scheme for Saraiya nala includes:

- Construction of intake weir and training of nala,
- Diversion of flow to screen channels,
- Intermediate sewage pumping station wet well and valve chamber,
- Main Electrical Panel (MEP) and Diesel Genset (DG) room, and
- Rising main of 1100 m length from pumping station to right bank interceptor sewer (d/s) on Mugalsarai road near Nakkhi nala.

(6) Assi Nala Interceptor

- Left bank interceptor
- Right bank interceptor
- Secondary trunk sewers and connection facility to the interceptor

The development in the region and increase in the population contributes to overflow resulting into the pollution in river Ganga.

It is estimated that about 85% to 90% of sewage is emanating upstream of existing Assi SPS. Downstream stretch, between existing Assi SPS till proposed Nagwa MPS, is very congested and does not have a proper road network. Also Nakkha nala and Samne Ghat nala situated on the upstream side of the Assi nala will be tapped in a proposed interceptor.

Summary of Assi nala Interceptor and interceptor for Nakkha nala and Samne Ghat nala is summarised below.

Summary of Assi Nala Interceptor Sewer

Sr.	Diameter (mm)	Length (m)
1	600	640
2	700	620
3	800	400
4	900	240
5	1000	1,970
6	1200	1,300
	Total length	5,170

Summary of Interceptor Sewer of Nakkha Nala and Samne Ghat Nala

Sr.	Diameter (mm)	Length (m)
1	400	655
2	500	1,300
	Total length	1,955

(7) Varuna River Interceptors

- Left bank interceptor (up stream)
- Left bank interceptor (down stream)
- Right bank interceptor (up stream)
- Right bank interceptor (down stream)
- Sathwa trunk sewer
- Secondary trunk sewers and connection facility to the interceptors

Around 14 drains discharge sewage in to Varuna river along its left and right banks. Interception and diversion of these drains has been considered under priority projects for immediate reduction of pollution load of Varuna river, which is a tributary of river Ganga.

Summary of Varuna river Interceptors and Sathwa trunk sewer is given below.

Summary of Varuna River Interceptor

Sr.	Diameter (mm)	Sewer Length, meters				
		Varuna river right bank (u/s)	Varuna river right bank (d/s)	Varuna river left bank (u/s)	Varuna river left bank (d/s)	Sathwa Trunk Sewer
1	500		180			
2	700	2,070	300			
3	800	570				
4	900		270	390		
5	1000	510		1,020	240	
6	1100			690	510	
7	1200				285	
8	2400					3,870
	Total	3,150	750	2,100	1,035	3,870

(8) Land Acquisition

Land has to be acquired for proposed Sathwa Sewage Treatment Plant and pumping stations. The land area required for each proposed facility is shown below.

Land Acquisition for Proposed Facilities

Sr.	Name of Facility	Required Land (ha)
1	Sathwa Sewage Treatment Plant	41.00
2	Sathwa Main Pumping Station	0.23
3	Chaukaghat Right Bank Pumping Station	0.19
4	Chaukaghat Left Bank Pumping Station	0.08
5	Narokhar Nala Pumping Station	0.08
6	Phulwaria Nala Pumping Station	0.07
7	Saraiya Nala Pumping Station	0.04

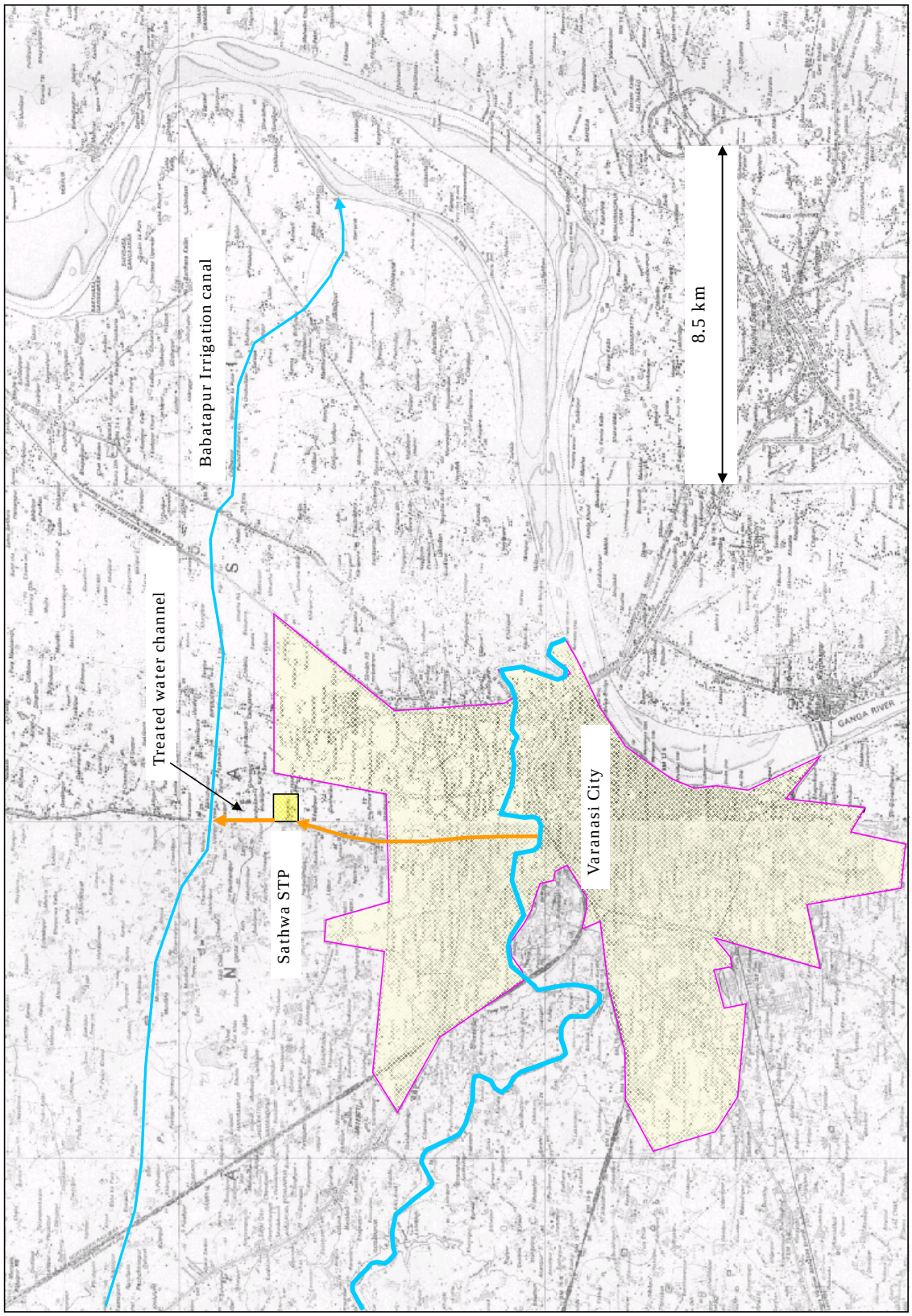


Figure 3.3 The Location Map of Proposed Sathwa STP Site

3.4 BASELINE ENVIRONMENTAL SCENARIO

3.4.1 The Study Area

The eternal and ancient city of Varanasi is a religious place on the bank of the Holiest river Ganga. It is a magnificent city with myriad attractions both as an exalted place of pilgrimage and micro center of faith. It is one of the most important places of pilgrimage for Hindus and Buddhists in the world.

According to 'Vaman Puran', the Varuna and Assi rivers originated from the body of the primordial person at the beginning of time itself. The tract of the land lying between them is called Varanasi and believed to be the holiest of all pilgrimages. The Pali version of Varanasi is 'Banarasi' which ultimately gave birth to the name Banaras. The city is also famous as Kashi [derived from the root Kas which means to shine] the city of spiritual light. Steeped in tradition and mythological legacy, Kashi is believed to be the original ground created by Lord Shiva and Parvati, upon which they stood at the beginning of time.

According to the historians, the city was founded some ten centuries before the birth of Christ. The city is mentioned in the Holy Scriptures like Vaman Puran, Buddhist Texts and in the epic 'Mahabharat'. Puranic literature relates its existence to at least three millennia. Varanasi proudly tells that it was the birthplace of St. Kabir, worship place of Bhakta Ravidas and composing place of Mahakavya Sri Ramcharit Manas by Goswami Tulsidas. Varanasi is also renowned for its rich Tapestry of music, arts, crafts and education.

Thousands of tourists visit the city daily from far and near places of India and all across the world. It is a unique city where the past and present, eternity and continuity live side by side. The city rises through the high northern bank on the outside curve of Ganga to form a magnificent panorama of buildings in many varieties of Indian architecture. The unique relationship between the city and sacred river is the essence of Varanasi – the land of Sacred Light. Varanasi is the microcosm of Hinduism, a city of traditional classical culture. Glorified by myth and legend and sanctified by religion, it has always attracted a large number of pilgrims and worshipped from time immemorial.

Varanasi's principal attractions for pilgrims and tourists are a long string of bathing Ghats along the Ganga river, including famous Dashashwamedh Ghat, Kashi Vishvanath Temple, Nepali Temple, Durga Temple, Sarnath, its silk brocade sarees and carpets, Ramnagar Fort, Chunar Fort, Banaras Hindu University, Kashi Vidya Peeth, etc.

Besides a place of pilgrimage and tourists interests, Varanasi is a fast growing commercial, industrial and trading centre of Uttar Pradesh. It is also a centre of art, craft and education in the form of Banaras Hindu University.

3.4.2 Physical Environment

(1) Climate and Meteorology

1) Month-wise Rainfall

The following tables present monthly rainfall characteristics in Varanasi District. In general, the dry season is October to May and the rainy (monsoon) season is June to September. The average annual rainfall between 1996 and 2000 was around 1,000 mm. The monthly rainfall in August is largest during a year.

Table 3.9 Month-wise Rainfall in Varanasi District

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
96-97	237.7	100.3	314.7	77.9	18.6	0	0	4.4	0	0	15.7	0	769.3
97-98	65.7	292.3	257.7	204.6	20.6	37.6	47.1	0	6	6	0	27.4	965
98-99	116.4	423.8	531.3	138.3	34	1	0	7	0	0	0	22.2	1274
99-00	167.8	343.9	372.5	319.9	96.5	0		0.5	0	0.3	-	-	-
Average	146.9	290.08	369.05	185.18	42.425	9.65	15.7	2.975	1.5	1.575	5.2	16.5	1002.8

Source: Indian Meteorological Department, Govt of India

Table 3.10 Month-wise Surface Rainfall of Varanasi (Bhuj) (Station Index 42483) (During 1998)

Month	Total Surface Rainfall (mm)	No. of Observations	Heaviest in 24 hrs. (mm)	Date	No. of Rainy days
Jan	0.0	31	0	31	0
Feb	0.0	26	0	28	0
Mar	16.2	26	10	23	2
Apr	0.6	28	0.6	25	0
May	0.7	30	0.7	09	0
Jun	22.6	25	7.7	30	3
Jul	354.8	28	136.4	06	9
Aug	324.0	22	120.9	13	10
Sep	164.8	25	45.6	01	10
Oct	30.2	30	11.2	08	4
Nov	46.8	30	25.2	18	3
Dec	0.0	29	0	31	0

Source : Indian Meteorological Department, Govt. of India.

2) Temperature

As shown in the following table, the hottest season is April to June and the coldest is December to February.

Table 3.11 Monthly Maximum and Minimum Temperature Observed During the Year 1991 in Varanasi District

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max	28.8	32.1	39.5	43.0	44.0	42.8	35.6	35.3	35.5	35.5	32.2	27.5
Min	2.6	7.2	9.0	15.0	19.8	22.4	21.5	20.4	20.0	13.4	7.8	4.8

(2) Surface Water Quality

1) Water Quality Monitoring Stations

Ganga River

The Ganga river, being the lifeline of the region, its quality and ecology has been attracting the attention of masses. As the main water body of the region, it receives pollution loads of domestic and industrial run off.

The main pollutant coming to the river Ganga is from Assi nala and the river Varuna. The contribution of the Bhagwanpur treated effluent to the pollution of river Ganga has also been monitored. In addition to these, pollution of river Ganga in Ghat area due to different human activities has also been studied.

To assess the quality of water in the Ganga river, 7 monitoring stations (designated as GSW1, GSW2, GSW3, GSW4, GSW5, GSW6, and GSW7) along the stretch of river Ganga at Varanasi were selected. Station GSW1 was set up at 500 m upstream of the disposal point of Bhagwanpur STP. An intermediate station GSW2 was set up in between the disposal point of treated effluent of Bhagwanpur STP and the Assi nala outfall point. The station GSW3 was set up just after the Assi nala outfall point on the downstream. Three sampling stations namely GSW4, GSW5, and GSW6 were set up near Harischandra ghat, Dr. R.P. ghat, and Jalesan ghat respectively along the downstream stretch of river Ganga. The last monitoring station (GSW7) on the river Ganga was set up at 50 m downstream of the confluence point of Varuna and Ganga.

Varuna River

The other important river, which traverses the northern part of Varanasi, is the river Varuna. This river meets the Ganga at the downstream with a significant amount of pollution load. The old Orderly Bazaar Sewer discharges in to the river Varuna. A number of branch sewers, having been laid in the adjoining area from time to time discharge their pollutants to Varuna through storm water drains. A part of the sewage is bypassed from the main trunk sewer and directly discharged to the river Varuna.

To assess the water quality of the Varuna, monitoring stations were set up at the upstream and at the downstream of the river. In the upstream, the monitoring station VSW1 was set up near Lohta area. In the downstream another monitoring station VSW2 was set up just before the confluence point of the river Ganga and Varuna.

Assi Nala

Assi nala discharges its pollutant near Assi Ghat. This nala contributes to the level of pollution in river Ganga in the upstream side. One monitoring station (ANWQ) before the outfall of Assi nala was established, and quality of the water of the nala at this location was studied.

In total 10 surface water quality monitoring stations in the study area as described above, were selected for the purpose of monitoring, analysis and assessment of surface water quality. The location and brief description of the monitoring stations designated as GSW1, GSW2, GSW3, GSW4, GSW5, GSW6, GSW7, VSW1, VSW2 and ANWQ are listed in Table 3.12 and shown in Figure 3.4.

Table 3.12 Surface Water Quality Monitoring Stations

Sr	Code	Location
1	GSW1	Ganga river (about 500 m U/S of Bhagwanpur STP effluent disposal point)
2	GSW2	Ganga river (in between Assi nala & disposal point from Bhagwanpur STP)
3	GSW3	Ganga river (near Assi ghat)
4	GSW4	Ganga river (near Harischandra ghat)
5	GSW5	Ganga river (near Dr. R.P. ghat)
6	GSW6	Ganga river (near Jalesan ghat)
7	GSW7	Ganga river (downstream of the confluence point of Ganga and Varuna)
8	VSW1	Varuna river (upstream side of the river near Lohta area)
9	VSW2	Varuna river (downstream side, before confluence point of Varuna & Ganga)
10	ANWQ	Assi nala (before the outfall point at Ganga river)

Note: Also refer Figure-3.4 for the locations.

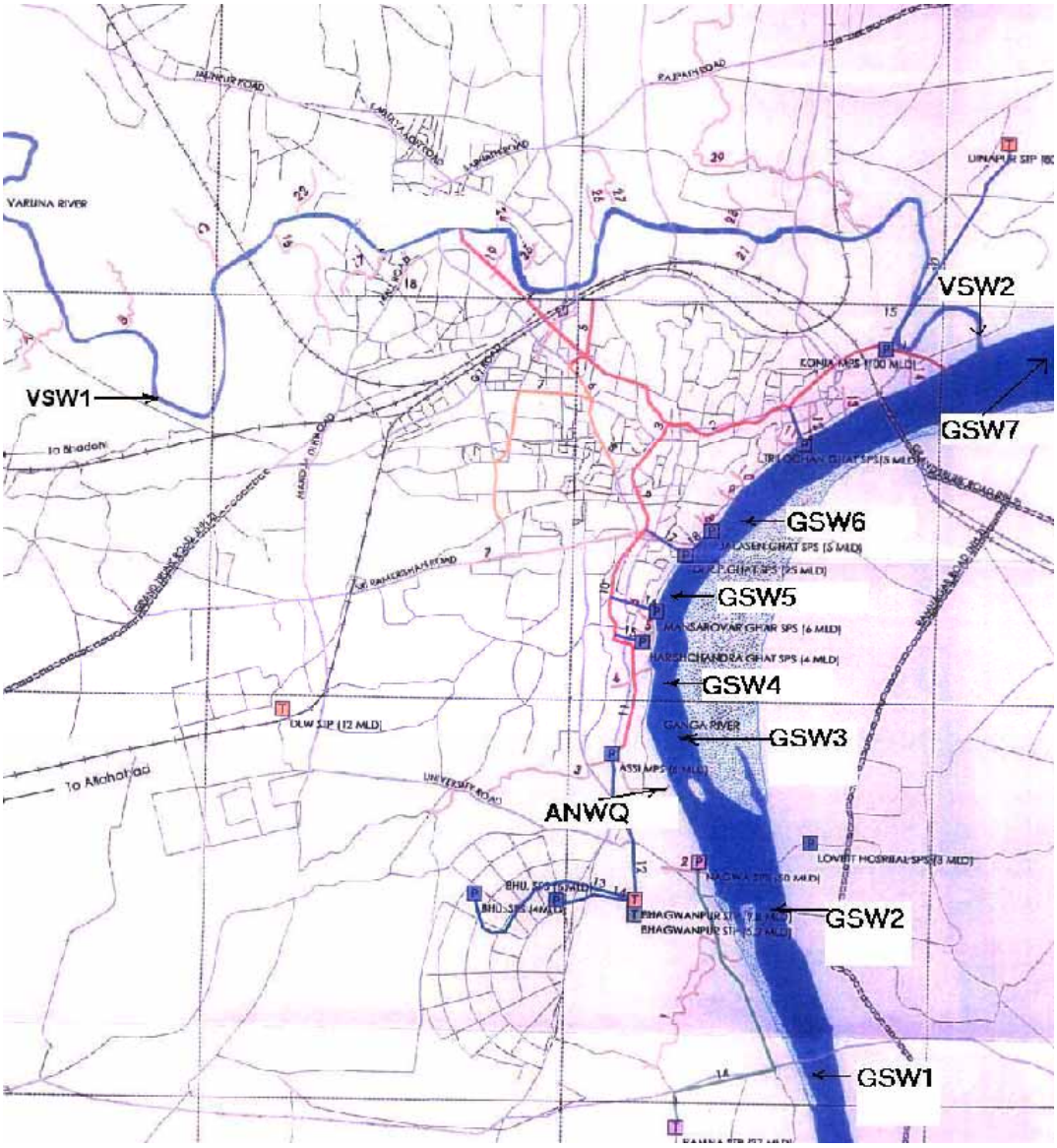


Figure 3.4 Locations of Water Quality Monitoring Stations

2) Methodology of Water Quality Monitoring

Water samples were collected in the month of March 2004 from all these stations. All the basic precautions and care were taken during the sampling to avoid contamination.

The samples were analysed for relevant physical, chemical and bacteriological parameters for drawing up the baseline data. Certain heavy metals, trace elements and toxic constituents of these samples were also analysed. Analysis of the samples was carried out as per established standard methods and procedures prescribed by the CPCB / MoEF and relevant IS Codes.

3) Surface Water Quality in the Study Area

Water Quality of Ganga River

The salient water quality features of Ganga river are shown in Table 3.13. The water quality monitoring results of the Ganga river are statistically analysed in Table 3.14, depicting minimum, maximum, arithmetic mean and standard deviation. The percent time violations (PTV), i.e., the percentages of time the water quality parameters violate the permissible standards are also depicted therein. Details of water quality monitoring results of the Ganga river at location GSW1, GSW2, GSW3, GSWQ4, GSWQ5, GSWQ6, and GSW7 are presented in Table 3.15. The monitoring locations wise variations of pH, TSS, DO & BOD in Ganga river in Varanasi have been pictorially presented in Figure 3.5 and Figure 3.6.

Table 3.13 The Salient Water Quality Features of the Ganga River

Parameter	Range	Mean
pH	7.6-8.1	-
TDS (mg/l)	520-596	569
TSS (mg/l)	20-38	27.7
DO (mg/l)	7.1-8.4	7.84
BOD (5 days at 20°C) (mg/l)	3.1-12.3	4.96
Total hardness (mg/l as $CaCO_3$)	BDL-1.6	0.82
Nitrate nitrogen (mg/l as NO_3)	220-250	236
Oil & grease (mg/l)	BDL-0.5	0.32
Iron (mg/l as Fe)	0.68-1.28	1.03

Table 3.14 Surface Water Quality Statistics of Ganga River
(Based on On-site Water Quality Monitoring during March 04)

Sr	Parameter and Unit	N	Min	Max	AM	SD	PTV	Limit
1	Temperature (°C)	7	28.5	32	31	1.32	-	-
2	Turbidity (NTU)	7	2	6	3.57	1.81	-	-
3	pH	7	7.6	8.1	-	-	0	8.5
4	Conductivity (µmhos/cm)	7	751	910	854	56.1	-	-
5	DO (mg/l)	7	7.1	8.4	7.84	0.489	0	4
6	BOD (5 days at 20°C) (mg/l)	7	3.1	12.3	4.96	3.29	100	3
7	COD (mg/l)	7	8.3	28.4	12.6	7.13	-	-
8	Faecal Coliforms (MPN/100 ml)	7	NIL	14	2	5	-	-
9	Total Coliforms (MPN/100 ml)	7	7000	38060	21459	12328	100	5000
10	TSS (mg/l)	7	20	38	27.7	5.82	-	-
11	TDS (mg/l)	7	520	596	569	28.3	0	1500
12	Oil and Grease (mg/l)	7	BDL	1.6	0.821	0.731	57	0.1
13	Total Residual Chlorine (mg/l)	7	BDL	BDL	BDL	-	-	-
14	Ammonia Nitrogen (mg/l as N)	7	1.4	5.1	2.63	1.51	-	-
15	Kjeldahl Nitrogen (mg/l as N)	7	5.2	10.4	7.37	1.8	-	-
16	Cyanide (mg/l as CN)	7	BDL	BDL	BDL	-	0	0.05
17	Phenol (mg/l as C_6H_5OH)	7	BDL	BDL	BDL	-	0	0.005
18	Total Hardness (mg/l as $CaCO_3$)	7	220	250	236	13.1	-	-
19	Total Alkalinity (mg/l $CaCO_3$)	7	230	280	256	17.2	-	-
20	Chloride (mg/l as Cl)	7	70	80	75	5	0	600
21	Sulphate (mg/l as SO_4)	7	30	45	37.6	4.79	0	400
22	Nitrate (mg/l as NO_3)	7	BDL	0.5	0.319	0.142	0	50
23	Phosphate (mg/l as PO_4)	7	BDL	0.4	0.256	0.126	-	-
24	Fluoride (mg/l as F)	7	NIL	NIL	NIL	NIL	0	1.5
25	Sodium (mg/l as Na)	7	65	68	66.4	1.4	-	-
26	Potassium (mg/l as K)	7	13	16	13.7	1.11	-	-
27	Calcium (mg/l as Ca)	7	64.1	76.1	70.7	4.1	-	-
28	Magnesium (mg/l as Mg)	7	12.1	17	14.6	1.42	-	-
29	Copper (mg/l as Cu)	7	BDL	BDL	BDL	-	0	1.5
30	Iron (mg/l as Fe)	7	0.68	1.28	1.03	0.219	0	50
31	Manganese (mg/l as Mn)	7	BDL	BDL	BDL	-	-	-
32	Zinc (mg/l as Zn)	7	0.25	0.65	0.447	0.155	0	15
33	Nickel (mg/l as Ni)	7	BDL	BDL	BDL	-	-	-
34	Arsenic (mg/l as As)	7	BDL	BDL	BDL	-	0	0.2
35	Mercury (mg/l as Hg)	7	BDL	BDL	BDL	-	-	-
36	Lead (mg/l as Pb)	7	BDL	BDL	BDL	-	0	0.1
37	Cadmium (mg/l as Cd)	7	BDL	BDL	BDL	-	0	0.01
38	Chromium (mg/l as Cr)	7	BDL	0.11	0.066	0.046	-	-
39	Percent Sodium (%)	7	34.7	38.1	36.3	1.24	-	-

N- No of measurements, AM- Arithmetic mean, SD- Standard deviation, BDL- Below detection limit
PTV- Percent time violations over permissible limits* (maximum) stipulated for Inland Surface Waters (Class C) i.e. drinking water source with conventional treatment followed by disinfection (IS:2296).

Table 3.15 Results of On-site Surface Water Quality Monitoring of Ganga
(During March 04)

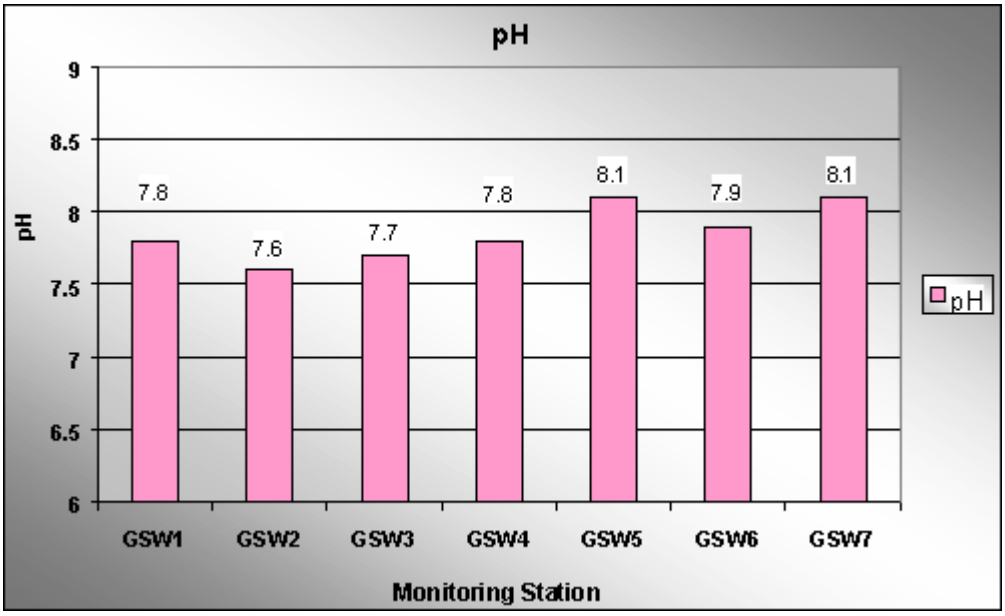
Sr.	Parameter and Unit	Monitoring Stations						
		GSW1	GSW2	GSW3	GSW4	GSW5	GSW6	GSW7
1	Temperature (°C)	28.5	31.5	30	32	32	32	31
2	Odour	Odls	Odls	Odls	Odls	Odls	Odls	Odls
3	Turbidity (NTU)	6	4	2	2	6	2	3
4	pH	7.8	7.6	7.7	7.8	8.1	7.96	8.1
5	Conductivity (μmhos/cm)	850	910	820	751	860	880	910
6	DO (mg/l)	8.3	8.4	7.3	7.8	8.1	7.9	7.1
7	BOD (5 days at 20°C) (mg/l)	3.1	3.3	4.8	4.3	3.4	3.5	12.3
8	COD (mg/l)	8.3	8.8	13	10.8	9.8	9.3	28.4
9	Faecal Coliforms (MPN/100 ml)	NIL	NIL	NIL	NIL	14	NIL	NIL
10	Total Coliforms (MPN/100 ml)	21800	24200	9050	7000	14100	36000	38060
11	TSS (mg/l)	32	38	28	24	26	20	26
12	TDS (mg/l)	570	596	548	520	596	560	590
13	Oil and Grease (mg/l)	1.4	1.6	1.4	1.2	BDL	BDL	BDL
14	Total Residual Chlorine (mg/l)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
15	Ammonia Nitrogen (mg/l as N)	4.5	5.1	2.1	1.8	1.4	1.6	1.9
16	Kjeldahl Nitrogen (mg/l as N)	9.2	10.4	7.2	6.4	5.2	6.4	6.8
17	Cyanide (mg/l as CN)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
18	Phenol (mg/l as C_6H_5OH)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
19	Total Hardness (mg/l as $CaCO_3$)	240	250	230	220	250	220	245
20	Total Alkalinity (mg/l $CaCO_3$)	260	270	250	240	280	230	260
21	Chloride (mg/l as Cl)	70	80	75	70	70	80	80
22	Sulphate (mg/l as SO_4)	35	40	38	35	30	40	45
23	Nitrate (mg/l as NO_3)	0.32	0.46	0.2	0.12	0.23	0.4	0.5
24	Phosphate (mg/l as PO_4)	0.21	0.28	0.4	0.32	BDL	0.26	0.32
25	Fluoride (mg/l as F)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
26	Sodium (mg/l as Na)	65	68	67	65	65	67	68
27	Potassium (mg/l as K)	13	14	14	13	13	13	16
28	Calcium (mg/l as Ca)	72.1	76.1	68.1	64.1	72.1	68.1	74
29	Magnesium (mg/l as Mg)	14.6	14.5	14.5	14.6	17	12.1	14.6
30	Copper (mg/l as Cu)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
31	Iron (mg/l as Fe)	0.86	0.92	1.24	1.14	0.68	1.1	1.28
32	Manganese (mg/l as Mn)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
33	Zinc (mg/l as Zn)	0.46	0.65	0.3	0.25	0.35	0.5	0.62
34	Nickel (mg/l as Ni)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
35	Arsenic (mg/l as As)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
36	Mercury (mg/l as Hg)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
37	Lead (mg/l as Pb)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
38	Cadmium (mg/l as Cd)	BDL	BDL	BDL	BDL	BDL	BDL	BDL
39	Chromium (mg/l as Cr)	0.095	0.09	BDL	BDL	0.066	0.098	0.11
40	Percent Sodium (%)	35.5	35.6	37.1	37.4	34.7	38.1	35.8

The BOD value ranges from 3.1 to 12.3 mg/l with an arithmetic mean of 4.96 mg/l. At the upstream point (station GSW1) the BOD value (3.1 mg/l) was not so high due to low pollution load. At the sampling point GSW2, i.e., downstream point of the disposal of Bhagwanpur STP treated effluent, the BOD value (3.3 mg/l) did not increase too much. This implies that the quality of the effluent from the Bhagwanpur STP was not that much polluting, indicating the beneficial effect of sewage treatment plant to treat the sewage

before disposal. At the monitoring station GSW3 the BOD value was observed to increase to 4.8 mg/l. This is due to the high organic pollutant load of Assi nala. After that, at the downstream of this location, again BOD value was observed to decrease due to regeneration, and at monitoring station GSW4 near Harishchandra ghat it was 4.3 mg/l. Near the monitoring stations GSW5 and GSW6, no high pollution load was discharged to the Ganga. Therefore, the BOD values did not change significantly and limited to 3.5 mg/l. At the last monitoring station, i.e., in the downstream of Ganga and Varuna confluence point, the BOD value (12.3 mg/l) increased significantly. This was due to the high organic pollutant load coming with the Varuna river.

The dissolved oxygen (DO) profile along the stretch also varied accordingly to the variation of BOD. Initially at the upstream (monitoring station GSW1), it was very high (8.3 mg/l). Gradually with the increase of BOD load, the organic pollutants consumed the DO for stabilization. At the monitoring point GSW7 in downstream, the DO value (7.1 mg/l) was observed to be very low due to the high organic pollutants coming from the river Varuna.

Temperature of the river water varied between 28.5-32.0°C. pH values were generally above the neutral mark (7.6-8.1) and were within the tolerance limits of 6.5-8.5. Conductivity varied between 751-910 μmhos/cm (average 854 micromhos/cm) with TDS ranging between 520-596 mg/l (average 569 mg/l). TSS varied between 20-28 mg/l, while turbidity ranged between 2-6 mg/l. Low values of turbidity indicate very low sediment load in the surface run off into the river implying negligible soil erosion in the catchment area. Total coliform was found comparatively higher near the waste disposal points than at the other locations. At the monitoring station GSW7 it was 38060 MPN/100 ml due to the pollution load coming with Varuna river.



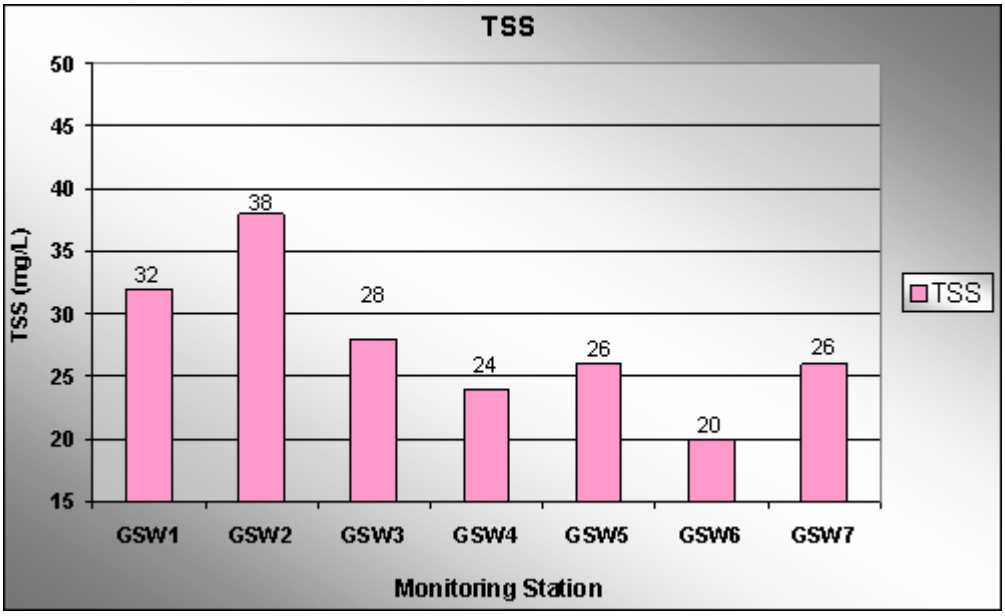
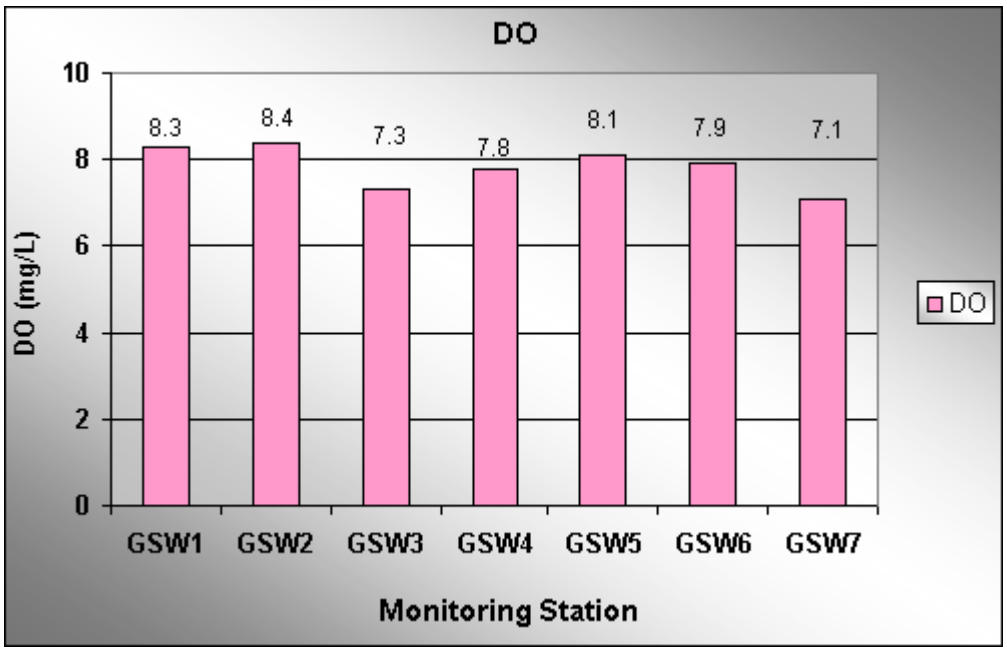


Figure 3.5 Variation in pH & TSS at Various Monitoring Points of Ganga River in Varanasi



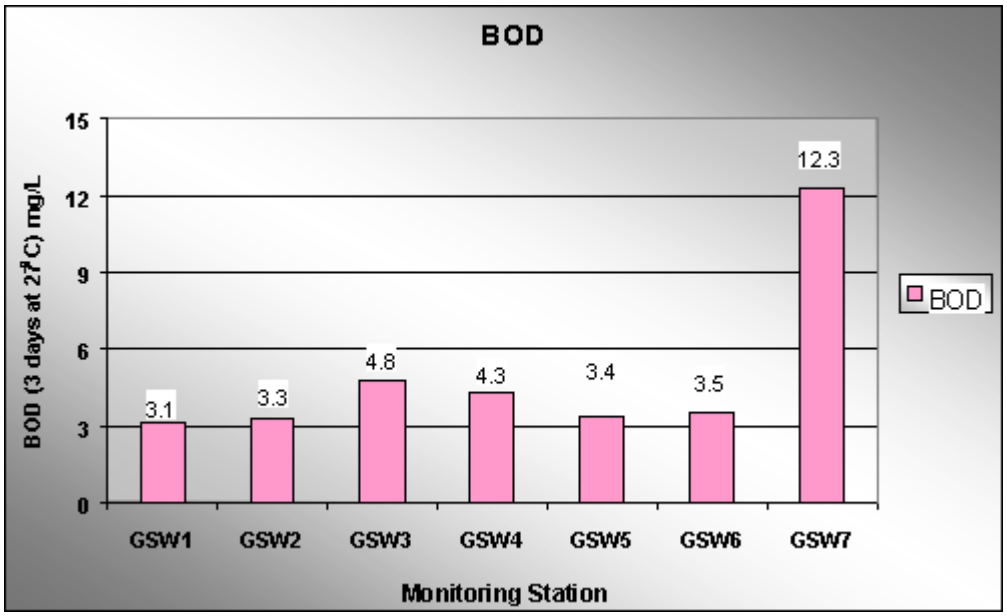


Figure 3.6 Variation in DO & BOD at Various Monitoring Points of Ganga River in Varanasi

Water Quality of Varuna River

The salient water quality features of Varuna are given in the Table 3.16. The water quality monitoring results of the Varuna river are statistically analysed in Table 3.17 depicting minimum, maximum, arithmetic mean and standard deviation. The percent time violations (PTV), i.e., the percentages of time the water quality parameters violate the permissible standards are also depicted therein. Details of water quality monitoring results of the Varuna river and Assi Nala at location VSW1, VSW2 and ANWQ are presented in Table 3.18.

Table 3.16 The Salient Water Quality Features of the Varuna River

Parameter	Range	Mean
pH	7.6-7.91	-
TDS (mg/l)	460-624	542
TSS (mg/l)	20-46	33
DO (mg/l)	2.6-5.2	3.9
BOD_5 (mg/l)	3-30	16.5
Total hardness (mg/l as $CaCO_3$)	2-4	3
Nitrate nitrogen (mg/l as NO_3)	210-273	241
Oil & grease (mg/l)	0.3-0.4	0.35
Iron (mg/l as Fe)	0.67-0.68	0.67

The BOD value ranges from 3 to 30 mg/l with a mean value of 16.5 mg/l. At the upstream point (station VSW1) near Lohta area, the BOD value (3 mg/l) was not so high due to low pollution load. After this point, at number of points pollution load was disposed off to the Varuna. The old Orderly Bazaar sewer and a number of branch sewers having been laid in the adjoining area, discharge their pollutants to Varuna through storm water drains. A part of the sewage is bypassed from the main trunk sewer and the pollution load from the nalas directly discharge their pollutants to the Varuna. Therefore, at the monitoring station (VSW2), i.e., before the confluence point of Ganga and Varuna, the BOD value (30 mg/l) increased significantly. This high organic pollutant load coming with Varuna was observed to have affected the quality of river Ganga also at the downstream of Ganga-Varuna confluence point.

The dissolved oxygen (DO) profile also varied accordingly as the variation of BOD. At the upstream (monitoring station VSW1), it was comparatively high (5.2 mg/l). Gradually with the increase of BOD value, the organic pollutants consumed the DO for stabilization. At the monitoring point VSW2 in downstream the DO value (2.6 mg/l) was observed very low due to the high organic pollutants coming from different sources as mentioned above.

Temperature varied between 30.2-31.7°C. pH values were generally above the neutral mark (7.6-7.91). Conductivity varied between 680-896 μmhos/cm (average 788 micro mhos/cm) with TDS ranging between 460-624 mg/l (average 542 mg/l). TSS varied between 20-46 mg/l, while turbidity ranged between 7.6-7.91 mg/l. The value of total coliform (21800 MPN/100 ml) was found to be comparatively higher at the monitoring station VSW2 located downstream than the monitoring station VSW1 (total coliform value 4400 MPN/100 ml) located upstream.

Table 3.17 Surface Water Quality Statistics of Varuna River
(Based on On-site Water Quality Monitoring during March 04)

Sr.	Parameter and Unit	N	Min	Max	AM	SD	PTV	Limit
1	Temperature (°C)	2	30.2	31.7	31	1.06	-	-
2	Turbidity (NTU)	2	6	8	7	1.41	-	-
3	pH	2	7.6	7.91	-	-	0	8.5
4	Conductivity (μmhos/cm)	2	680	896	788	153	-	-
5	DO (mg/l)	2	2.6	5.2	3.9	1.84	50	4
6	BOD (3 days at 27°C) (mg/l)	2	3	30	16.5	13.5	100	3
7	COD (mg/l)	2	24.2	72.4	48.3	34.1	-	-
8	Faecal Coliforms (MPN/100 ml)	2	NIL	NIL	NIL	NIL	-	-
9	Total Coliforms (MPN/100 ml)	2	4400	21800	13100	12304	50	5,000
10	TSS (mg/l)	2	20	46	33	18.4	-	-
11	TDS (mg/l)	2	460	624	542	116	0	1,500
12	Oil and Grease (mg/l)	2	2	4	3	1.41	100	0.1
13	Total Residual Chlorine (mg/l)	2	BDL	BDL	BDL	-	-	-
14	Ammonia Nitrogen (mg/l as N)	2	2.6	3.2	2.9	0.424	-	-
15	Kjeldahl Nitrogen (mg/l as N)	2	7.4	8.1	7.75	0.495	-	-
16	Cyanide (mg/l as CN)	2	BDL	BDL	BDL	-	0	0.05
17	Phenol (mg/l as C_6H_5OH)	2	BDL	BDL	BDL	-	0	0.005
18	Total Hardness (mg/l as $CaCO_3$)	2	210	273	241	44.3	-	-
19	Total Alkalinity (mg/l $CaCO_3$)	2	225	290	258	46	-	-
20	Chloride (mg/l as Cl)	2	52	70	61	12.7	0	600
21	Sulphate (mg/l as SO_4)	2	26	40	33	9.9	0	400
22	Nitrate (mg/l as NO_3)	2	0.3	0.4	0.35	0.071	0	50
23	Phosphate (mg/l as PO_4)	2	0.25	0.32	0.285	0.049	-	-
24	Fluoride (mg/l as F)	2	NIL	NIL	NIL	NIL	0	1.5
25	Sodium (mg/l as Na)	2	46	65	55.5	13.4	-	-
26	Potassium (mg/l as K)	2	9	13	11	2.83	-	-
27	Calcium (mg/l as Ca)	2	64.1	80.2	72.1	11.4	-	-
28	Magnesium (mg/l as Mg)	2	12.1	17.6	14.9	3.89	-	-
29	Copper (mg/l as Cu)	2	BDL	BDL	BDL	-	0	1.5
30	Iron (mg/l as Fe)	2	0.67	0.68	0.675	0.007	0	50
31	Manganese (mg/l as Mn)	2	BDL	BDL	BDL	-	-	-
32	Zinc (mg/l as Zn)	2	BDL	0.7	0.35	0.494	0	15
33	Nickel (mg/l as Ni)	2	BDL	BDL	BDL	-	-	-
34	Arsenic (mg/l as As)	2	BDL	BDL	BDL	-	0	0.2
35	Mercury (mg/l as Hg)	2	BDL	BDL	BDL	-	-	-
36	Lead (mg/l as Pb)	2	BDL	BDL	BDL	-	0	0.1
37	Cadmium (mg/l as Cd)	2	BDL	BDL	BDL	-	0	0.01
38	Chromium (mg/l as Cr)	2	BDL	0.106	0.054	0.074	-	-
39	Percent Sodium (%)	2	31.1	32.8	32	1.2	-	-

Table 3.18 Results of On-site Surface Water Quality Monitoring of Varuna River and Assi Nala During March 04

Sr.	Parameters and Unit	Monitoring Stations		
		VSW1	VSW2	ANWQ
1	Temperature (°C)	30.2	31.7	29
2	Odour	Unob	Odls	Odrs
3	Turbidity (NTU)	8	6	24
4	pH	7.6	7.91	7.26
5	Conductivity (μmhos/cm)	680	896	1180
6	DO (mg/l)	5.2	2.6	2.3
7	BOD (3 days at 27°C) (mg/l)	3	30	34
8	COD (mg/l)	24.2	72.4	150
9	Faecal Coliforms (MPN/100 ml)	NIL	NIL	50
10	Total Coliforms (MPN/100 ml)	4400	21800	1111
11	TSS (mg/l)	46	20	140
12	TDS (mg/l)	460	624	720
13	Oil and Grease (mg/l)	4	2	5.4
14	Total Residual Chlorine (mg/l)	BDL	BDL	BDL
15	Ammonia Nitrogen (mg/l as N)	2.6	3.2	10.2
16	Kjeldahl Nitrogen (mg/l as N)	7.4	8.1	22.4
17	Cyanide (mg/l as CN)	BDL	BDL	BDL
18	Phenol (mg/l as C_6H_5OH)	BDL	BDL	BDL
19	Total Hardness (mg/l as $CaCO_3$)	210	273	330
20	Total Alkalinity (mg/l $CaCO_3$)	225	290	330
21	Chloride (mg/l as Cl)	52	70	105
22	Sulphate (mg/l as SO_4)	26	40	45
23	Nitrate (mg/l as NO_3)	0.4	0.3	2.6
24	Phosphate (mg/l as PO_4)	0.25	0.32	1.1
25	Fluoride (mg/l as F)	BDL	BDL	BDL
26	Sodium (mg/l as Na)	46	65	77
27	Potassium (mg/l as K)	9	13	26
28	Calcium (mg/l as Ca)	64.1	80.2	84.2
29	Magnesium (mg/l as Mg)	12.1	17.6	29.2
30	Copper (mg/l as Cu)	BDL	BDL	BDL
31	Iron (mg/l as Fe)	0.67	0.68	0.9
32	Manganese (mg/l as Mn)	BDL	BDL	BDL
33	Zinc (mg/l as Zn)	0.7	BDL	BDL
34	Nickel (mg/l as Ni)	BDL	BDL	BDL
35	Arsenic (mg/l as As)	BDL	BDL	BDL
36	Mercury (mg/l as Hg)	BDL	BDL	BDL
37	Lead (mg/l as Pb)	BDL	BDL	BDL
38	Cadmium (mg/l as Cd)	BDL	BDL	BDL
39	Chromium (mg/l as Cr)	0.106	BDL	BDL
40	Percent Sodium (%)	31.1	32.8	31.5

Water Quality of Assi nala

The water quality monitoring results of the Assi nala are shown in Table 3.18. The BOD value (34 mg/l) at the monitoring station ANWQ, before outfall point at river Ganga was observed very high. This indicated the amount of organic pollutants, discharged daily to the

river Ganga through this nala.

The dissolved oxygen (DO) at the monitoring station ANWQ was found to be very low (2.3 mg/l). This was obviously due to the high BOD concentration in the nala, which reduced the DO level because of its stabilization.

Temperature was recorded as 29°C. pH value (7.26) was near the neutral mark with conductivity 1180 μmhos/cm and TDS and TSS values 720 and 140 mg/l, respectively. Total coliform value was found as 1111 MPN/100 ml and faecal coliform was 50 MPN/100 ml.

(3) Ground Water Quality in the Study Area

The ground water quality of the proposed and sanctioned STP sites and their adjoining areas were analyzed for different physical, chemical, and bacteriological parameters, such as – turbidity, temperature, pH, coliforms, BOD, alkalinity, ions, heavy metals, etc. The details of the analysis results are given in the succeeding paragraphs.

1) Ground Water Quality at the Proposed STP Site at Sathwa and its Adjoining Area

The Ground water quality at the proposed Sathwa site and its adjoining area are given in the Table 3.19.

Table 3.19 Ground Water Qualities at Proposed Sathwa STP Site & its Adjoining Area

Sr.	Parameters and Unit	GW1	GW2	GW3	GW4
1	Temperature (^oC)	29.2	29	29.8	28.6
2	Odour	Odls	Odls	Odls	Odls
3	Taste	Nrml	Nrml	Nrml	Nrml
4	Turbidity (NTU)	4	2	4	2
5	pH	7.66	7.35	7.09	7.94
6	Conductivity (μmhos/cm)	1616	2126	1217	1240
7	Total Coliforms (MPN/100 ml)	NIL	NIL	NIL	NIL
8	TSS (mg/l)	12	NIL	10	10
9	TDS (mg/l)	1052	1320	844	832
10	Oil and Grease (mg/l)	BDL	BDL	BDL	BDL
11	Total Residual Chlorine (mg/l)	BDL	BDL	BDL	BDL
12	Free Ammonia (mg/l as NH_3)	BDL	BDL	BDL	BDL
13	Cyanide (mg/l as CN)	BDL	BDL	BDL	BDL
14	Phenol (mg/l as C6H5OH)	BDL	BDL	BDL	BDL
15	Total Hardness (mg/l as $CaCO_3$)	519	810	410	430
16	Total Alkalinity (mg/l $CaCO_3$)	530	570	380	375
17	Chloride (mg/l as Cl)	110	185	110	105
18	Sulphate (mg/l as SO_4)	75	145	0	50
19	Nitrate (mg/l as NO_3)	1.4	1.1	NIL	0.56
20	Phosphate (mg/l as PO_4)	0.5	0.76	0.5	1
21	Fluoride (mg/l as F)	1	1.3	0.6	0.75
22	Sodium (mg/l as Na)	106	74	79	65
23	Potassium (mg/l as K)	14	10	6.5	6
24	Calcium (mg/l as Ca)	128	224	112	120
25	Magnesium (mg/l as Mg)	48.5	60.5	31.5	31.5
26	Copper (mg/l as Cu)	BDL	BDL	BDL	BDL

Sr.	Parameters and Unit	GW1	GW2	GW3	GW4
27	Iron (mg/l as Fe)	0.1	0.26	0.15	0.2
28	Zinc (mg/l as Zn)	BDL	BDL	BDL	BDL
29	Nickel (mg/l as Ni)	BDL	BDL	BDL	BDL
30	Arsenic (mg/l as As)	BDL	BDL	BDL	BDL
31	Mercury (mg/l as Hg)	BDL	BDL	BDL	BDL
32	Lead (mg/l as Pb)	BDL	BDL	BDL	BDL
33	Chromium (VI) (mg/l as Cr)	BDL	BDL	BDL	BDL
34	Percent Sodium (%)	30	16.4	29.2	24.5

Nrml: Normal; Odls: Odourless
BDL: Below Detection Limit
GW1: Open Well from 'Sai village'
GW2: Open well from 'Sathwa village'
GW3: Open well from 'Haridayapur village'
GW4: Open well from 'Rajnaiya village'

2) Ground Water Quality at the Sanctioned STP Site at Ramna and its Adjoining Area

The Ground water quality at the sanctioned Ramna STP site and its adjoining area are given in the Table 3.20.

Table 3.20 Ground Water Quality at Sanctioned Ramna STP Site and its Adjoining Area

Sr.	Parameters and Unit	GW5	GW6	GW7	GW8
1	Temperature (^oC)	28.5	28	29.1	28.4
2	Odour	Odls	Odls	Odls	Odls
3	Taste	Nrml	Nrml	Nrml	Nrml
4	Turbidity (NTU)	4	2	6	4
5	pH	7.15	7.34	7.3	7.46
6	Conductivity (μmhos/cm)	1190	1780	1440	1320
7	Total Coliforms (MPN/100 ml)	NIL	NIL	NIL	NIL
8	TSS (mg/l)	12	NIL	18	NIL
9	TDS (mg/l)	790	1190	920	860
10	Oil and Grease (mg/l)	BDL	BDL	BDL	BDL
11	Total Residual Chlorine (mg/l)	BDL	BDL	BDL	BDL
12	Free Ammonia (mg/l as NH_3)	BDL	BDL	BDL	BDL
13	Cyanide (mg/l as CN)	BDL	BDL	BDL	BDL
14	Phenol (mg/l as C_6H_5OH)	BDL	BDL	BDL	BDL
15	Total Hardness (mg/l as $CaCO_3$)	480	660	560	450
16	Total Alkalinity (mg/l $CaCO_3$)	375	510	410	370
17	Chloride (mg/l as Cl)	105	185	145	140
18	Sulphate (mg/l as SO_4)	30	80	65	56
19	Nitrate (mg/l as NO_3)	NIL	1.6	1.2	0.85
20	Phosphate (mg/l as PO_4)	0.4	0.8	1.15	0.6
21	Fluoride (mg/l as F)	1.3	1.8	1.1	1.5
22	Sodium (mg/l as Na)	29	87	51	76
23	Potassium (mg/l as K)	10	8.5	6.5	9.4
24	Calcium (mg/l as Ca)	120	168	136	112
25	Magnesium (mg/l as Mg)	43.6	58.1	53.3	41.2
26	Copper (mg/l as Cu)	BDL	BDL	BDL	BDL
27	Iron (mg/l as Fe)	0.2	0.25	0.15	0.22
28	Zinc (mg/l as Zn)	BDL	BDL	BDL	BDL
29	Nickel (mg/l as Ni)	BDL	BDL	BDL	BDL
30	Arsenic (mg/l as As)	BDL	BDL	BDL	BDL
31	Mercury (mg/l as Hg)	BDL	BDL	BDL	BDL
32	Lead (mg/l as Pb)	BDL	BDL	BDL	BDL
33	Chromium (VI) (mg/l as Cr)	BDL	BDL	BDL	BDL
34	Percent Sodium (%)	11.4	22	16.3	26.4

Nrml: Normal; Odls: Odourless
BDL: Below Detection Limit
GW5: Open Well from near Ramna STP Site
GW6: Open well from Narotampur
GW7: Open well from Naipurakalan
GW8: Open well from Sir goverdhan

(4) Wastewater Quality

1) Wastewater Sampling Location

Dinapur STP

Dinapur STP is under direct control of UP Jal Nigam for operation and maintenance purposes. The design capacity of the plant is 80 mld. The work on this plant was initiated during February 1988 and it was fully commissioned in June 1994. The wastewater was collected from this treatment plant and was analysed for different parameters. The influent

water was collected before the entrance into the primary clarifier and the effluent water was collected before the disposal.

Bhagwanpur STP

The Bhagwanpur sewage treatment plant was commissioned in the year 1988 under Ganga Action Plan. The plant receives sewage from two pumping stations within BHU campus and from Assi pumping station. The design capacity of the plant is 8 mld. The wastewater samples were collected from this STP and was analysed for different parameters. Similar to Dinapur STP, the influent water was collected before the entrance into the primary clarifier and the effluent water was collected before the disposal. The notation and description of the samples are given in the Table 3.21.

Table 3.21 List of Wastewater Samples

Sr.	Code	Sample
1	BIQ	Influent wastewater from Bhagwanpur STP
2	BEQ	Effluent wastewater from Bhagwanpur STP
3	DIQ	Influent wastewater from Dinapur STP
4	DEQ	Effluent wastewater from Dinapur STP

2) Methodology of Wastewater Sampling

Wastewater samples were collected in the month of March 2004 from all STPs. All the basic precautions and care were taken during the sampling to avoid contamination.

The samples were analysed for relevant physical, chemical and bacteriological parameters for drawing up the baseline data. Certain heavy metals, trace elements and toxic constituents of these samples were also analysed. Analysis of the samples was carried out as per established standard methods and procedures prescribed by the CPCB / MoEF and relevant IS Codes.

3) Wastewater Quality in the STPs

Details of wastewater sampling results of Dinapur and Bhagwanpur STP are presented in Table 3.22.

Wastewater Quality at Dinapur STP

From the 5-Ghat pumping stations, sewage water is conveyed to Konia main lift stations through main brick trunk sewer. From there, through rising main, sewage is delivered to the Dinapur sewage treatment plant. Therefore, the influent BOD at the Dinapur STP was very high and found as 84 mg/l. The dissolved oxygen quantity was below detection limit due to this high BOD. The total coliform concentration (55,600 MPN/100 ml) was also very high and faecal coliform was detected as 33 MPN/100 ml. The temperature of the influent at the sampling time was 31^{o}C. pH of the influent water was near neutral point (7.12). TDS and TSS values were observed as 870 and 110 mg/l, respectively.

Table 3.22 Wastewater Sampling Results of Dinapur and Bhagwanpur STP

Sr.	Parameter and Unit	Sample Description			
		BIQ	BEQ	DIQ	DEQ
1	Temperature (°C)	30	30.5	31	31.5
2	Odour	Odrs	Odls	Odrs	Odls
3	Turbidity (NTU)	8	2	12	4
4	pH	7.14	7.19	7.12	7.22
5	Conductivity (µmhos/cm)	1040	1080	1340	1310
6	DO (mg/l)	BDL	4.6	BDL	5.8
7	BOD (5 days at 20°C) (mg/l)	32	14.6	84	28
8	COD (mg/l)	74.1	33.3	187	72.1
9	Faecal Coliforms (MPN/100 ml)	30	NIL	33	NIL
10	Total Coliforms (MPN/100 ml)	51500	11180	55600	20000
11	TSS (mg/l)	66	44	110	40
12	TDS (mg/l)	710	770	870	830
13	Oil and Grease (mg/l)	5	2	6.4	1.5
14	Total Residual Chlorine (mg/l)	BDL	BDL	BDL	BDL
15	Ammonia Nitrogen (mg/l as N)	64.1	6.4	89	8.2
16	Kjeldahl Nitrogen (mg/l as N)	72.1	12.6	94.5	16.4
17	Cyanide (mg/l as CN)	BDL	BDL	BDL	BDL
18	Phenol (mg/l as C_6H_5OH)	BDL	BDL	BDL	BDL
19	Total Hardness (mg/l as $CaCO_3$)	330	360	380	340
20	Total Alkalinity (mg/l $CaCO_3$)	360	380	330	310
21	Chloride (mg/l as Cl)	50	65	140	130
22	Sulphate (mg/l as SO_4)	40	42	80	70
23	Nitrate (mg/l as NO_3)	3	0.34	1.06	0.92
24	Phosphate (mg/l as PO_4)	2.35	2.1	1.35	0.43
25	Fluoride (mg/l as F)	1.02	BDL	0.9	BDL
26	Sodium (mg/l as Na)	57	60	85	85

Sr.	Parameter and Unit	Sample Description			
		BIQ	BEQ	DIQ	DEQ
27	Potassium (mg/l as K)	14	17.4	36	35
28	Calcium (mg/l as Ca)	88.2	96.2	100	92.2
29	Magnesium (mg/l as Mg)	26.7	29.2	31.6	26.7
30	Copper (mg/l as Cu)	BDL	BDL	BDL	BDL
31	Iron (mg/l as Fe)	0.56	0.92	0.64	0.78
32	Manganese (mg/l as Mn)	BDL	BDL	BDL	BDL
33	Zinc (mg/l as Zn)	BDL	BDL	BDL	BDL
34	Nickel (mg/l as Ni)	BDL	BDL	BDL	BDL
35	Arsenic (mg/l as As)	BDL	BDL	BDL	BDL
36	Mercury (mg/l as Hg)	BDL	BDL	BDL	BDL
37	Lead (mg/l as Pb)	BDL	BDL	BDL	BDL
38	Cadmium (mg/l as Cd)	BDL	BDL	BDL	BDL
39	Chromium (mg/l as Cr)	BDL	BDL	BDL	BDL
40	Percent Sodium (%)	26.3	25.4	30.3	32.5

The effluent water quality at Dinapur STP was satisfactory. The BOD value was observed as only 28 mg/l, which was quite below the influent quality. The DO level (5.8 mg/l) of effluent was much higher than the influent value. The total coliform was found to have decreased to

20,000 MPN/100 ml. The TDS (830 mg/l)) and TSS (40 mg/l) values were also lower than in the influent wastewater.

Wastewater Quality at Bhagwanpur STP

The effluent from Assi MPS is delivered to the Bhagwanpur sewage treatment plant. The influent BOD level at the Bhagwanpur STP was comparatively high and found as 32 mg/l. The dissolved oxygen quantity was below detection limit due to this high BOD. The total coliform concentration (51500 MPN/100 ml) was also very high and faecal coliform was detected as 30 MPN/100 ml. The temperature of the influent at the sampling time was 30^{o}C. pH of the influent water was near neutral point (7.14). TDS and TSS values were observed as 770 and 44 mg/l, respectively.

The effluent water quality at Bhagwanpur STP was observed to be satisfactory. The BOD value was observed as only 14.6 mg/l, which was quite below than that in the influent. It proved the efficiency and beneficial effect of the treatment plant. The DO level (4.6 mg/l) of effluent was much higher than the influent value. The total coliform also decreased to 11800 MPN/100 ml. The TDS (770 mg/l)) and TSS (44 mg/l) values also decreased as compared to the influent wastewater.

(5) Sludge Quality

1) Sludge Sampling Location

Dinapur STP

The sludge was collected from the sludge digester of Dinapur sewage treatment plant and was analysed for phosphate, calorific value, water content, and different heavy metals.

Bhagwanpur STP

Similar to Dinapur STP, sludge sample was also collected from the sludge digester of Bhagwanpur sewage treatment plant. This sludge was also analysed for above-mentioned parameters.

2) Quality of Sludge

Quality of the sludge was analysed with proper precautions and the results are tabulated in the Table 3.23.

Table 3.23 Quality of Sludge from Dinapur and Bhagwanpur Sewage Treatment Plants

Parameter	Values	
	Sludge of Dinapur STP	Sludge of Bhagwanpur STP
Calorific value (cal/g)	1,445 (on dried basis)	1,156 (on dried basis)
Water content (%w/w)	65	48
Phosphate (mg/ L as P)	2.25	2.00
Zn (mg/l)	1.1	0.8
Mn (mg/l)	BDL	BDL
As (mg/l)	BDL	BDL
Hg (mg/l)	BDL	BDL
Pb (mg/l)	0.2	0.1
Cd (mg/l)	BDL	BDL
Cr (mg/l)	0.17	0.08
Cu (mg/l)	BDL	BDL
Ni (mg/l)	BDL	BDL
Fe (mg/l)	2.1	1.8

From the table, it is evident that the sludge from both treatment plants contained good amount of phosphate – 2.25 mg/l for Dinapur and 2.00 mg/l for Bhagwanpur. Therefore, the sludge after drying could serve the purpose of a good fertilizer. The water contents of the sludge are 65% and 48%. Most of the heavy metals in the sludge were below detection limit for both of the STPs.

For Dinapur STP the sludge contained high calorific value (1445 cal/g on dried basis), which can be used for the production of biogas. For Bhagwanpur STP also, the calorific value (1156 cal/g) of the sludge was satisfactory.

(6) Soil Quality

The soil, based on visual and physical inspection is light brown to deep brown in colour and silty clay in texture. The soil profile is extending down to more than 30m. The upper layer of almost 1.5 m is rich in humus, while the lower layer upto 2.5 m is clay and light sandy loam but devoid of organic matter.

1) Soil Monitoring Stations

To assess the impacts of the developmental activities on the soil in the study area, the physico-chemical characteristics of soil within the study area were examined by obtaining soil samples from selected points and analysis of the same.

Two (2) representative sampling stations were selected for studying soil characteristics in the proposed and sanctioned STP areas, the locations of which are listed in Table 3.24. Stations were selected keeping in view the vegetation cover and soil types, which would accord an overall idea of the soil characteristics of the study area.

Table 3.24 Details of Soil Quality Monitoring Stations

Sr.	Code	Location Description
1	SQ1	Proposed Sathwa STP
2	SQ2	Ramna STP

2) Methodology of Soil Monitoring

Soil samples representing the pre-monsoon condition were collected during April 2004. A number of parameters were determined which are indicative of physical, chemical and fertility characteristics. Sampling and analysis was conducted as per established standard methods and procedures prescribed in IS:2720 and ASTM.

3) Soil Characteristics in the Study Area

The physico-chemical characteristics of the soil in the study area, as obtained from the analysis of the soil samples, are presented in Table 3.25.

Soil in the study corridor was found to be silty clay. It was generally alkaline with pH range 7.89-8.14. Electrical conductivity (EC) was low, generally varying between 110-131 μmhos/cm. Sodium level (34.1-37.4 μg/g) in the soil samples was low and therefore good from agricultural viewpoint. Potassium level (38.0-45.3μg/g) and nitrogen level (40.5-8.4μg/g) were normal. Observed phosphorous level (10.1-14.6μg/g) was found low. Organic matter content (organic carbon 0.36-0.61%) was fairly high indicating good vegetation potential of the soil. The soil was observed to possess appreciable level of potassium and nitrogen indicating moderate to good fertility or agricultural potential of the soil. The levels of other elements were appreciably good. Thus, the overall fertility status of the soil in the study area is reasonably good and is not expected to be detrimental to the growth of agricultural and forest crops.

Table 3.25 Physico-Chemical Characteristics of Soil in the Study Corridor

Sr.	Parameter & Unit	Sampling Location	
		SQ1 (Sathwa)	SQ2 (Ramna)
1	Texture	Silty clay	Silty clay
2	Grain size distribution		
3	a) Sand (%)	12.2	14.1
4	b) Silt (%)	47.3	43.4
5	c) Clay (%)	40.5	42.5
6	pH (10%w/v slurry)	8.14	7.89
7	Conductivity (μmhos/cm)*	110	131
8	Organic matter (%)	0.36	0.61
9	Nitrogen (μg/g)	80.4	47.1
10	Phosphorous (μg/g)	14.6	10.1
11	Sodium (μg/g)	37.4	34.1
12	Potassium (μg/g)	38.0	45.3
13	Lead (μg/g)	BDL	BDL

* Conductivity of 10% w/v of slurry at 30°C

3.4.3 Socio-Cultural Environment

(1) Land Use

Proposed lands for six pumping stations are public land, which have already been identified by public organisations for future public purposes. Also these lands are along public roads with heavy traffic laod and /or in open fields that means there is little likelihood of any significant impact due to acquisition of lands. Hereinafter, the discussion is focused on Sathwa STP site; agricultural land where people practice cultivation of crops such as wheat, rice, etc.

Land Use Pattern of Villages Around Sathwa STP Site

The baseline land use pattern of the villages in and around the Sathwa STP site has been primarily established from the village level land use figures adopted from the data of Village & Town Directory, Census of India, 1991, of the State of Uttar Pradesh. Detail analysis of the land use pattern of the area derived from the Census report is portrayed in Table 3.26.

Table 3.26 Land Use Characteristics (in hectares) in Villages around Sathwa STP Site

Item	No of Village	Total Area	Forest Land	Agricultural Area			Culturable Waste Land	Area Not Available for Cultivation
				Irrigated	Un-irrigated	Sub-total		
Land area (ha)	11	986.73	0	481	102	583	122	281.73
% of total area			0.00			59.08	12.36	28.55
% of agrl. area				82.50	17.50			

Source: Census Data

It has been observed that no forest land exists within the area. Majority (about 59%) of the area in the villages in and around the Sathwa STP site consists of agricultural land, most (about 83%) of which is irrigated. Irrigation facilities are not available only for 17% of the land under cultivation. This certainly reveals the presence of good irrigation facilities in the area. The remaining land accounts for about 41% of the total land use, out of which culturable wastelands is about 12% and land not available for cultivation occupies about 29% to the total area.

Source of Irrigation

Canal irrigation system existing in the study area is insufficient as it covers only about 8% of irrigated land (Table 3.27). Whatever canals exist are mainly Government canals. Majority of the irrigated area is irrigated using tube wells (about 83%) & wells (about 9%) through lift irrigation system. About 65% of the irrigation tube wells are driven by electricity.

Table 3.27 Breakup (%) of Irrigated Land in Villages around Sathwa STP Site

Block	% of Irrigated Land Irrigated by							
	Canal	Well	Tube well	Tank	River	Lake	Waterfall	Others
% of irrigated area	8.32	9.15	82.54	0	0	0	0	0
% of Government canal	100.0							
% with electricity		0.00	65.49					

Source: Census Data

(2) Socio-Economics

1) Socio-Economics of Varanasi

The baseline socio-economic characteristics of Varanasi have been described based on the ward level demographic & occupational figures adopted from the data of Primary Census Abstract, Census of India, 1991, of the State of Uttar Pradesh. The town & ward wise demographic profile & occupational pattern is detailed in Appendix D. Varanasi urban area consists of 12 smaller towns. The summary of the socio-economic features of Varanasi is presented in Table 3.28.

Table 3.28 Summary of Socio-economic Features of Varanasi

Area	96.15 sq. km (distributed over 12 towns)
Total population	Male: 5,68,428, Female: 4,89,544, Total: 10,57,972
No of households	1,43,453 (No of occupied residential houses: 1,32,303)
Population density	11,003 persons/sq. km
Family size	7.4 persons per household
SC-ST population	SC: 89,009 (8.4%), ST: 70 (0.01%), Others: 9,68,893 (91.6%)
Sex ratio	Overall: 861 females per 1000 males, SC: 855, ST: 750, General: 862
Literate	Male: 73.3% of male population, 62.7% of literates Female: 52% of female population, 37.3% of literates Total: 63.6 of total population
Worker	Main: 2,83,280 (26.8%),Marginal:4,884 (0.5%), Nonworker:7,69,808(72.7%) Main: M:91.6% (45.6% of total M), F:8.4% (4.9% of total F) Marginal: M:13.9% (0.12% of total M), F:86.1% (0.86% of total F) Non-worker:M:40.0% (54.2% of total M), F:60.0% (94.3% of total F)
Break-up (% of Main worker)	Cultivators & agrl. labourers: 2.6%, Industrial workers: 40.8%, Trade & commerce: 26.6%, Other services: 20.4%, Rest: 9.6%
	Primary sector: 4%, Secondary sector: 43%,Tertiary sector: 53%

Note: If otherwise not mentioned, the figures within ( ) indicates % of total population.
Source: Census data.

Demographic Profile

Total population within the 12 towns in Varanasi urban area is about 10,57,972 occupying about 1,32,303 houses and 1,43,453 households. Population density is very high (11,003 persons/sq. km). Average family size or size of household (persons/per household) is about 7.4. Percentage of scheduled caste (SC) to overall population is about 8.4%. Tribal people (scheduled tribe) are negligible (only 0.01%). Sex ratio (females per 1000 males) is about 861. Overall literacy rate is about 64%, literates among males being about 73% and among females being about 52%.

Occupational Pattern

Working population or main workers comprise about 27% of the total population. Marginal workers and non-workers are observed to be about 0.5% and 73% of the total population respectively. Work participation among females is poor, about 8% of the main workers being females that accounts for about 5% of the total female population. Majority of the main workers are industrial workers (about 41%) and in trade & commerce (about 27%), and in other services (about 20%). Sector wise, majority (about 53%) of the main workers is in tertiary (business & service) sector followed by (about 43%) secondary (industry) sector, while only about 4% are in primary (agricultural) sector. The principal language is Hindi. The main staple food is rice & wheat. The primary source of drinking water is tube well.

2) Socio-Economics of Villages Around Sathwa STP Site

The baseline socio-economic characteristics of the villages neighbouring the Sathwa STP site have been described based on the village level demographic & occupational figures adopted from the data of Primary Census Abstract, Census of India, 1991, of the State of Uttar Pradesh. The village wise demographic profile & occupational pattern are detailed in Table 3.29. The 11 villages in & around the Sathwa STP site fall under 2 blocks namely Chiraigaon & Harhua in the district of Varanasi.

Table 3.29 Village Wise Socio-economic Details around Sathwa STP Site

Sr.	J.L. No.	Name of Village	Area (ha)	No of House	No of HH	Population			Sex Ratio	Family Size	SC (%)	ST (%)	Literate (%)	Worker	
						Total	Male	Feml						Main (%)	Mrg (%)
		Distt: Varanasi													
		Tehsil: Varanasi													
		Block: Chirai Gaon													
1	572	Hasanpur	46.95	49	56	419	215	204	949	7.48	0	0	42.2	25.1	0.5
2	573	Singhpur	113.32	195	199	1469	756	713	943	7.38	1.6	0	37.3	27.3	1.9
3	581	Sathawa	136.38	281	281	1898	1033	865	837	6.75	34.7	0	29.4	37.3	2.2
4	582	Hulasipur	3.24	6	6	42	24	18	750	7	0	0	54.5	35.7	0
5	583	Hirdaipur	44.52	179	179	1345	707	638	902	7.51	1.8	0	37.5	29.4	4.5
6	584	Rajnahiya	59.09	146	151	1015	550	465	845	6.72	0	0	26.5	34.5	0.9
7	585	Goithahan	151.36	141	143	1056	557	499	896	7.38	0	0	27.2	50.1	0
8	586	Akatha	200.73	73	73	449	255	194	761	6.15	0	0	50	49.2	0
		Block: Harhua													
9	773	Dhuripur	19.43	85	90	643	347	296	853	7.14	19.6	0	31.8	25.5	0
10	777	Sai	113.72	85	92	578	294	284	966	6.28	17.5	0	53.2	30.1	3.1
11	789	Soyepur	63.54	120	130	1018	570	448	786	7.83	0	0	36.3	25.9	0
		Total	952.28	1360	1400	9932	5308	4624							
		Average							871	7.09	9.4	0	35.0	33.5	1.6

Sex ratio: Female per 1000 male
Family size: Number of persons per household

Demographic Profile

The summary of the socio-economic features of the villages in & around Sathwa STP site is presented in Table 3.30.

Total population within the 11 villages around the Sathwa STP site is about 9,932 occupying about 1,360 houses and 1,400 households. Population density is high (1043 persons/sq. km). Average family size or size of household (persons/per household) is about 7. Percentage of scheduled caste (SC) to overall population is about 9%. There is no tribal people (scheduled tribe) in these villages. Sex ratio (females per 1000 males) is about 871. Overall literacy rate is only about 35%, literates among males being about 50% and among females being about 18%.

Table 3.30 Summary of Socio-economic Features around Sathwa STP Site

Area	9.52 sq. km (distributed over 11 villages)
Total population	Male: 5,308, Female: 4,624, Total: 9,932
No of households	1,400 (No of occupied residential houses: 1,360)
Population density	1043 persons/sq. km
Family size	7.1 persons per household
SC-ST population	SC: 933 (9.4%), ST: 0 (0%), Others: 8,999 (90.6%)
Sex ratio	Overall: 871 females per 1000 males, SC: 822, ST: NA, General: 876
Literate	Male: 49.5% of male population, 76.8% of literates Female: 17.7% of female population, 23.2% of literates Total: 35% of total population
Worker	Main: 3,327 (33.5%), Marginal:159 (1.6%), Non-worker:6,446 (64.9%) Main: M:76.1% (47.7% of total M), F:23.9% (17.2% of total F) Marginal: M:07.6% (00.2% of total M), F:92.4% (03.2% of total F) Non-worker:M:42.9% (52.1% of total M), F:57.1% (79.7% of total F)
Break-up (% of Main worker)	Cultivators: 36.7%, Agricultural labourers: 29.6%, Industrial workers: 15.5%, Trade & commerce: 3.9%, Other services: 8.4%, Rest: 8.1%
	Primary sector: 67%, Secondary sector: 19.3%,Tertiary sector: 13.7%

Note: If otherwise not mentioned, the figures within ( ) indicates % of total population.
Source: Census data.

Occupational Pattern

Working population or main workers comprise about 33% of the total population. Marginal workers and non-workers are observed to be about 2% and 65% of the total population, respectively. Work participation among females is moderate, about 24% of the main workers being females that accounts for about 17% of the total female population. Majority of the main workers are cultivators (about 37%) and agricultural labourers (about 30%). Sector wise, majority (about 67%) of the main workers is in primary (agricultural) sector, while about 19% in secondary (industry) sector and 14% in tertiary (business & service) sector.

The principal language is Hindi. The staple food is mainly rice & wheat. The primary source of drinking water is tube well.

Amenities Available in the Villages

The village wise details of amenities & infrastructural facilities (educational, medical, drinking water, post & telegraph, market, communication, and power supply) available in the villages in & around the Sathwa STP Site have been presented in Table 3.31.

Table 3.31 Village Wise Amenities (No.) Available around Sathwa STP Site

Sr.	J.L. No.	Name of Village	No. of Educational Institutions						No. of Medical Institutions								Available within the Range in km				
			P	M	H	C	A	O	H	M	HC	D	FP	W	PP	O	DW	P&T	Mkt	Com	Pow
		Distt : Varanasi																			
		Tehsil: Varanasi																			
		Block : Chirai Gaon																			
1	572	Hasanpur	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	<5	<5	<5	0
2	573	Singhpur	1	1	1	1	1	1	0	0	0	0	0	1	0	0	0	<5	<5	0	0
3	581	Sathawa	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	5-10	0	0
4	582	Hulasipur	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	<5	5-10	5-10	0
5	583	Hirdaipur	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	<5	<5	0	0
6	584	Rajnahiya	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	<5	<5	0	0
7	585	Goithahan	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	<5	<5	<5	0
8	586	Akatha	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	<5	<5	<5	0
		Block : Harhua																			
9	773	Dhuripur	1	0	0	0	0	2	0	0	0	0	0	1	0	0	0	<5	5-10	0	0
10	777	Sai	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	<5	0	<5	0
11	789	Soyepur	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	<5	<5	0	0
		Total	1	0	0	0	0	3	0	0	0	0	0	3	0	0					

Educational Institutions: P-Primary School, M-Middle School, H-High School, C-PU/Graduate College, AL-Adult Literacy Centre, O-Others

Medical Institutions: H-Hospital, M-Maternity & Child Welfare Centre, HC-Health Centre/Subcentre, D-Dispensary, FP-Family Planning Centre, W-Community Health Worker, PP-Private Practitioner, O-Others

Other Amenities: DW-Drinking Water Facility, P&T: Post & Telegraph Facility, Mkt-Market Facility, Com-Communication Facility, Pow-Power Supply

Available within 0 km: Means the facility is available within the village.

The salient features of amenities & infrastructural facilities of all the villages in & around the Sathwa STP Site at a time have been summarized in Table 3.32.

Table 3.32 Summary of Amenities & Infrastructural Facilities around Sathwa STP Site

Amenity/Facility	% of Villages Having the Amenities/Facilities			
	Within Village	Within 5 km	Within 5-10 km	Beyond 10 km
Educational	55	45	-	-
Medical	100	-	-	-
Drinking water	100	-	-	-
Post & telegraph	9	91	-	-
Market	9	64	27	-
Communication	55	36	9	-
Power supply	100	-	-	-
No of villages	11			
No. of educational institutions	Primary School (5), Middle School (1), High School (1), PU/Graduate College (1), Adult Literacy Centre (1), Others (4)			
No. of medical institutions	Hospital (2), Maternity/Child Welfare Centre (0), Health Centre/ Primary Health Centre/ Sub-centre (2), Dispensary (0), Family Planning Centre (0), Community Health Worker (8), Registered/Subsidiary Medical Practitioner (0), Others (0)			
% of villages having	Tap (0%), Well (100%), Tube Well (0%) Hand pump (55%)			
% of villages having	Post office (9%), Telegraph office (0%), Telephone (0%)			
% of villages having	Bus Stop (55%), Railway Station (0%)			
% of villages having	Pucca Road (73%), Kuccha Road (36%)			
% of villages having power for	Domestic Purpose (45%), Agricultural Purpose (63%), All Purpose (9%)			

Source: Census data.

Every village in the area has electricity, drinking water and medical facility. Educational

(available in 55% villages) & communication (available in 55% villages) facilities are less than adequate.

Educational facilities are less than adequate, 45% of the villages having no educational facilities. Out of 11 villages, only 5 villages have primary school, and only in 1 village (Singhpur) there is high school & college. Most of the students therefore have to go outside their village for further education after primary school.

Health care facilities are adequate, all (100%) of the villages have access to medical facilities. There are hospitals in 2 villages and primary health sub-centres in 2 villages. In remaining villages, there is at least one community health worker.

(3) Tourism and Cultural Assets

Varanasi is well known as a city of Ghats as well as religious and spiritual city. It is considered very poise to liberate soul from human body to ultimate at Varanasi. Ghats in Varanasi have great religious and historical importance. Many ghats are regarded as Heritage Ghats as these Ghats were constructed long time ago for daily and religious bathing purpose. The Archaeological Survey of India (ASI), Ministry of Tourism and Culture, Government of India was assigned to conserve the Heritage Ghats in Varanasi in April 2003 and all the construction activities related to the Heritage Ghats required approval from ASI after a notification.

According to the Department of Culture, Varanasi, there are 84 Ghats along the river Ganga in Varanasi. Important Ghats along the Ganga river are listed below.

Table 3.33 List of Ghat along the Ganga River in Varanasi

Sr.	Site Name	Sr.	Site Name	Sr.	Site Name
	Bhelupur Ward		**Dashashwamegh Ward**		**Kotawali Ward**
1	Assi Ghat	29	Raja Ghat	53	Mehta Ghat
2	Ganga Mahal Ghat	30	Babuwa Pandey Ghat	54	Ram Ghat
3	Revan Ghat	31	Pandey Ghat	55	Jatar Ghat
4	Tulsi Ghat	32	Dimpatiya Ghat	56	Raja Gwalior Ghat
5	Bhadaini Ghat	33	Chwshahi Ghat	57	Bala Ghat
6	Janki Ghat	34	Rajamahal Ghat	58	Panch Ganga Ghat
7	Annadi Mai Ghat	35	Munshi Ghat	59	Durga Ghat
8	Vacchraj Ghat	36	Darbhanga Ghat	60	Brahma Ghat
9	Jain Ghat	37	Ahilyabai Ghat	61	Bundi Parkota Ghat
10	Shri Nishadraj Ghat	38	Sheetla Ghat	62	Lal Ghat
11	Panch Kot Ghat	39	Prayag Ghat	63	Shir Hanuman Garhi Ghat
12	Prabhu Ghat	40	Dashashwamegh Ghat	64	Gai Ghat
13	Chet Singh Ghat	41	Dr. Rajendra Prasad Ghat		
14	Niranjani Ghat	42	Maan Mandir Ghat		**Adampur IInd Ward**
15	Mahanirvani Ghat	43	Tripura Bhairavi Ghat	65	Badrinath Ghat
16	Shivala Ghat	44	Meer Ghat	66	Trilochan Ghat
17	Gularia Ghat	45	Lalita Ghat	67	Gola Ghat
18	Dandi Ghat			68	Maheshwar Ghat
19	Prachin Hanuman Ghat		**Chowk Ward**	69	Samka Ghat
20	Karnatak State Ghat	46	Sindia Ghat	70	Teliyana Nala Ghat
21	Harishchandra Ghat	47	Manikarnika Ghat	71	Naya Ghat
22	Lali Ghat	48	Sankta Ghat	72	Nishad Ghat
23	Vijay Nagar Ghat	49	Bohshala Ghat	73	Prahalad Ghat
24	Kedar Ghat	50	Jalasen Ghat	74	Raj Ghat
25	Chowki Ghat	51	Gnagamahal Ghat	75	Bhaisasur (Raj Ghat) Ghat
26	Someshwar Ghat	52	Ganesh Ghat	76	Khrikeya Ghat
27	Mansarovar Ghat			77	Keshaw Ghat
28	Narad Ghat				

According to an interview survey conducted by JICA Study Team in 2003, the following number of Ghat users for bathing is estimated.

Regular users: 24,000 person/day
Occasional users: 300,000 person/day

(4) Water Consumption

The total quantity of water supplied to the present population (in 2003) is approximately 340 mld. The composition of population served by water supply system is approximately as follows:

Table 3.34 Average per Capita Water Production: Varanasi City

	Water Production (mld)	Population 2003	Average per Capita Production (lpcd)
Municipal & private systems (1)	323	1,174,408	275
Cantonment	5	17,500	290
BHU	11.75	22,500	511

(1) Population is municipal area population plus 5% net in-migration less BHU population as estimated by JICA Study Team.

Presently, the average per capita water production (excluding Cantonment and BHU campus) is

approximately 275 lpcd. It is impossible to determine actual water consumption since most services are un-metered. Assuming UFW of 30% (as estimated by Jal Sansthan), the actual consumption would be of the order of 212 lpcd.

As noted in a recent report "Report on State of the Environment for Varanasi, CPCB, 2000", not all areas are served equally. The trans-Varuna area is facing an acute shortage of water because the distribution system is not well developed. Findings from the CPCB report indicate a supply of only 60 lpcd in the trans-Varuna, which would be insufficient to support water borne sewerage.

3.5 ANALYSIS OF ALTERNATIVES (INCLUDING WITHOUT PROJECT OPTION)

3.5.1 Project Benefits and Positive Impacts

Objective of implementation of the sewerage and pollution control projects is to ameliorate overall development and betterment of public health and hygiene coupled with upgradation of environmental management in the target project area through abatement of pollution; improvement of public health and aesthetics leading to improvement in quality of living and inducing economic growth. The project therefore, is associated with following benefits and positive impacts:

- Varanasi is one of the sacred cities of Hindu. The river is a part and parcel of everyday life in the town and thousands of people bathe daily in the river along the famous seven kilometers stretch of ancient ghats of the town. The project benefits these people who come for bathing in the River.
- The collection and treatment of untreated wastewater before entering the rivers will improve water quality of the rivers and river environment.
- The project will improve river water quality of upstream of the city, where municipal water supply intake is located.
- Proper collection, treatment and disposal system of wastewater will reduce the risks of parasitic infections, incident of various diseases including malaria, typhoid etc.
- A proper wastewater handling and disposal arrangement will minimize the chances of contamination of ground and surface water.
- Such provisions assist to maintain ecological balance by reducing damages to flora and fauna.
- Controlled reuse of wastewater supplements agricultural activities and development and sustenance of environmental protection components like greenbelt development.
- Improvement in the existing sewerage system will help reduce the nuisance in streets and road blockages.
- Development of the project will encourage increased economic activities like commercial, industrial, etc. and will generate enhanced employment alternatives and economic growth for the city.
- Improvement in the existing sewerage facilities will help tourism and boost the economy of the area.
- Public health gains such as increased output through improved health resulting in higher economic activity and productivity.
- The construction activity can provide opportunities to the local population and residents of the neighbouring area to earn. They may come to provide labour or to service the construction camps.
- Nutrient rich treated water and dried sludge can be used for irrigation

3.5.2 With and Without Proposed Project

The with and without project scenarios are compared in the following table.

Table 3.35 Comparison of With and Without Project

	Without Project	With Project
Estimated wastewater discharge in 2003	292 mld	292 mld
Untreated wastewater in 2003	204 mld	204 mld
Estimated wastewater discharge in 2015	369 mld	369 mld
Treatment capacity in 2015	88 mld	325 mld
Untreated wastewater in 2015	281 mld	44 mld
Percentage of untreated wastewater in 2015	76 %	12 %
Estimated BOD discharge	70.5 ton/day	18.8 ton/day
BOD concentration in the River	2.3 mg/l	0.6 mg/l
Environment for bathing	Raw wastewater is discharged in the Ganga and Varuna, which will cause unhygienic condition for bathing	Most raw wastewater will be intercepted before entering the Ganga and Varuna and treated. Bathing environment will be improved
Protection of water source of drinking water	Raw wastewater is discharged upstream of the municipal water intake and pollution of the source will be increased.	The raw wastewater discharged upstream of the municipal intake will be intercepted and treated and thus the source will be protected.
Water quality of effluent of existing and proposed STP	Bacteria pollution because of no disinfection facility	Chlorination will be applied to both existing and proposed STPs. Bacterial pollution will be reduced

If the project are implemented (with the project scenario), 88 % of the wastewater discharge will be intercepted and treated in 2015 while if the project are not implemented (without the project scenario) only 24 % is treated and 76 % of wastewater discharge (70.5 ton/day) finds its way to the Ganga and Varuna degrading bathing environment of ghat in Varanasi. The preliminary estimation shows that the BOD concentration in Varanasi will be increased by 2.3 mg/l without the project and 0.6 mg/l with the project.

3.5.3 Alternatives

The various treatment technologies considered include:

- Waste Stabilisation Ponds (WSP)
- Conventional Activated Sludge Process (ASP) + Chlorination (CL)
- Facultative Aerated Lagoons (AL) + Maturation Ponds (MP)
- UASB + Facultative Aerated Lagoons (AL) + Chlorination (CL)
- UASB + Mechanical Aeration followed by Solids Separation + Chlorination (CL)
- Fluidised Aerated Bio-reactor (FAB) + Chlorination (CL)

These treatment technologies are usually, in a techno-economic analysis, compared on the basis of the following general parameters:

- Suitability to meet discharge standards
- Capital costs
- O&M costs
- Power requirement

- Land requirement
- Treated effluent discharge
- Sludge disposal requirements
- Resource recovery in terms of re-use of methane gas

The present project discharge standards are:

(i) BOD – 30 mg/l
(ii) SS – 50 mg/l
(iii) Faecal Coli -10,000 MPN/100 ml

The table below presents summary of technical and financial comparison of six alternatives.

Table 3.36 Comparison of Treatment Technologies

Sr.	Units	WSP	ASP+CL	AL+ MP	UASB+ AL+CL	UASB+ Aeration +CL	FAB+CL
1	Effluent BOD, mg/l	< 30	< 30	< 30	< 30	< 30	< 30
2	Effluent TSS, mg/l	< 50	< 50	< 50	< 50	< 50	< 50
3	Effluent faecal coliform, MPN/100 ml	< 10,000	< 10,000	< 10,000	< 10,000	< 10,000	< 10,000
4	Reuse of treated effluent for irrigation	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable
5	Power Requirement (O&M costs)	Least	High	High	Medium	High	High
6	Environmental Risk*1	Least	High	Medium	Medium	High	High
7	Air Quality	Medium *2	Minimum	Medium	Medium	Minimum	Minimum
8	Ground water contamination *3	Minimum	Minimum	Minimum	Minimum	Minimum	Minimum
9	Land Requirement	Highest	High	High	Medium	Medium	Low
10	Maintenance Requirement	Least	High	Low	Low	Low	Medium
11	Sludge Disposal Requirement	Least	High	Low	Medium	Medium	High
12	Land requirement	Highest	Low	High	Medium	Low	Least
13	Life cycle cost	Least, if land is available	High	High	Low	High	High
14	General recommendation	Depending on the situation	No	No	Depending on the situation	No	Depending on the situation

*1: Measured in terms of loss of treatment efficiency due to long and frequent power cuts
*2: Some odour problems if ponds not operated properly.
*3: Since lining or coating is proposed to the wall and bed of STP, local groundwater contamination is minimized.

Regarding the above parameters, their related importance in the comparison of alternative sewage treatment technologies for the present project has been decided in view of the following site constraints:

(i) Power Constraint: - Power outages are common in Varanasi. Hence a technology with a high dependency on power for effective and reliable treatment of waste water would not be desirable for the cities where power cuts occur.
(ii) Land Constraint: - The city is densely populated and hence, offers few choices for locating the sewage treatment facilities

If the land availability is the major parameter to be considered for treatment process, the following

options are recommended.

1. If availability of land is not a major constraint, Waste Stabilization Pond (WSP) is the best alternative.
2. If availability of land is a constraint and is not enough for WSP, UASB+AL+CL is the best alternative.
3. If availability of land is very limited, FAB is recommended.

This site of proposed Sathwa STP is located in the northern area of Varanasi city, bounded by several villages. Sufficient land for WSP is not available at this site. Also there is potential for re-use of treated effluent for irrigation. Hence, for this site UASB followed by AL and chlorination would be a better environmental solution than aerobic technologies like ASP and FAB in view of the frequent power cuts in Varanasi.

3.6 IMPACT IDENTIFICATION AND MITIGATION MEASURES

3.6.1 Overall Impact Identification

(1) General

The first step in EIA is to identify the potentially significant impacts. The various aspects considered in impact identification of the project are as follows:

Project components
Project phases
Impact generating activities
Type of impact

The overall identification of the impacts has been carried out by using a matrix table, which is a common tool to identify and present the various impacts of a project in a compact way. Thereafter, the impacts are being described (Description Method) in more detail for the construction phase and the operation phase.

(2) Activities During Construction Phase

During the construction phase, the following activities among many are considered to be important towards contributing significant environmental impacts:

- Site preparation (fencing, grading & clearing of site)
- Excavation
- Hauling and dumping of earth materials & construction spoils
- Erection of village houses
- Clean up operations, landscaping and plantations
- Employment of people

Several types of negative impacts upon environment may be caused during construction phase, primarily due to negligent practices. Appropriate techniques and responsible supervision are needed to avoid/ minimize/ mitigate these adversities.

(3) Activities During Operational Phase

The major project activities, which are likely to impact the environment when the project is operational, are:

- Energy requirement
- Operation of DG sets in pumping stations
- Operation of pumps and related equipments in the pumping stations
- O & M of STPs
- Treated effluent discharge from the STPs
- Sludge disposal from the STPs

(4) Overall Impact Identification

In the matrix table, the activities are arranged in rows and environmental parameters in columns (Table 3.37).

The matrix thus identifies the environmental factors likely to be affected, and the activities responsible for this. The cells, which fall at the junction of an activity and an affected parameter, have been graded as A, B, C and blank.

The environmental parameters that can be affected are:

1. Natural parameters: soil, air, noise/vibration, water, flora and fauna
2. Socio-cultural parameters: population, land use, traffic, socio-economic, public health, culture & lifestyle, aesthetics, land acquisition

The adverse impacts have been classified in two categories namely construction stage and operational stage. Impacts during construction phase may be regarded as temporary or short-term whereas those during operation stage are likely to have long-term effects. The environmental impacts have been discussed separately for the construction phase and the operational stage.

Key objective of this study is prediction of likely environmental impacts and subsequently to frame up a comprehensive Environmental Management Plan (EMP) to offset/ reduce/ eliminate the adversities arising due to implementation of project.

Table 3.37 Scope Matrix for Project Components

Environmental Elements / Development Scheme		Social Environment									Natural Environment								Pollution					
		Resettlement	Economic Activity	Traffic/Public Facilities	Split of Communities	Cultural Properties	Water Right/Right of Common	Public Health Condition	Solid Waste	Hazard	Topography and Geology	Soil Erosion	Groundwater	Hydrological Situation	Coastal Zone	Flora and Fauna	Local Meteorology	Landscape	Air Pollution	Water Pollution	Soil Contamination	Noise and Vibration	Ground Subsidence	Odor
Sathwa STP	C	B	B	C	C				C													C		
	O		B		C			C	C				B	B				B		B	B	C		B
Chakughat MPS, Narokhar SPS and other 3 PSs	C	C		C																		C		
	O							C	C													C		
Ghat PS Rehabilitation	C			C				C	C													C		
	O			C																		C		
Varuna River Interceptor Sewer	C			B																		C		
	O																							
Assi Nala Interceptor Sewer	C			B																		C		
	O																							
Installation of the Main Trunk Sewer	C		C	B																		C		
	O																							
Cleaning and Rehabilitation of Existing Trunk Sewer	C		C	B				C														C		C
	O																							

Note:
C: Indicates construction (rehabilitation) stage.
O: Indicates operation stage.
A: Indicates that the development scheme is foreseen to have strong impact on the environmental element.
B: Indicates that the development scheme is foreseen to have some impact on the environmental element.
C: Indicates the impact is not quite sure but minor impact is expected.

3.6.2 Prediction of Impacts and Mitigation Measures during Construction Phase

(1) Sewer Lines (Construction Phase)

Most of the proposed trunk sewers are though in the developed areas, these sewers are proposed to be laid on the right of way of the road.

1) Noise Quality

Impacts

- Various site preparation and construction activities will generate increased noise levels due to operation of mechanical equipment. Construction activities are expected to produce noise levels in the range of 80 – 95 dB (A). Table 3.38 presents international standards for noise from different construction equipment.

Table 3.38 International Standards for Noise of Construction Equipment

Equipment	Noise Level dB(A) at 2 m	Equipment	Noise Level dB(A) at 2 m
Air Compressor	74 - 87	Front-end-Loader	72 - 84
Backhole	72 - 93	Grader	80 - 93
Bulldozer	80	Jack Hammer	81 - 98
Concrete Mixer	74 - 88	Paver	86 - 88
Concrete Pump	81 - 84	Roller	73 - 75
Concrete Vibrator	76	Craper	80 - 93
Crane	75 - 77	Tamper	74 - 77
Crane with ball	75 - 87	Welding Generator	71 - 82
Dump Truck	72 - 84		

- The construction equipment such as jack hammers, excavators, pay loaders, generators and concrete mixers will have noise levels above working environmental limits. Workers operating these machines may be affected if equivalent 8-hour exposure is more than safety limits. Exposures to impulses of impact noise should not exceed 140 dB(A) at peak acoustic pressure. Exposure to 10,000 impulses of 120 dB(A) is permissible per day.
- Noise likely to be generated near the construction site will be in the range of 90 – 105 dB (A) when all equipments are working together and simultaneously. This seems to be a remote possibility. Hence, workers working near the construction equipment are likely to be exposed to a level between 80 dB(A) and 90 dB(A) in an 8-hour shift.

Mitigation Measures and Recommendations

- Movement of heavy vehicles and operation of construction equipment will generate high noise levels and will adversely influence the existing environmental conditions. These impacts will be, however, limited to the construction period only and can be mitigated by adopting the following measures:
- The equipment to be utilised in the construction of the project should be fitted with vibration isolators. These equipments should conform to the sound level emissions as stipulated as appropriate standards.
- Vehicles producing noise levels exceeding the prescribed limits due to poor engine adjustments, damage to noise amelioration equipment or other inefficient operating conditions should not be used.
- Protective devices such as earplugs, muff, etc. should be provided to the workers working in the noisy areas.
- Construction activities should be strictly prohibited between 10.00PM to 06.00AM in the residential areas.
- Near sensitive areas like mosques, schools, hospitals/health centres and important public buildings due care should be taken by adjustments of time to avoid interference with main functions.

2) Air Quality

Impacts

- Particulate matter would be the predominant pollutant affecting the air quality during the construction phase. The soil of the proposed sewer line area is likely to generate considerable quantity of dust, especially during dry conditions.
- The impact on air quality during construction phase could be due to material transport, operation of construction yard and fugitive emissions from the construction sites.
- There may be fugitive emissions during loading/unloading and transport of construction materials. Though localized in nature mitigation measures in this respect especially in residential areas are very important.

- The air quality impacts from the construction yard will be due to operation of equipment. The air pollution from the construction yard will be ground based and the effect will be mostly localized for the entire construction period. However, if the construction yard is located at a minimum distance of 500 m away from any residential areas, the impacts of air pollution arising out of the construction yard activities will be insignificant.

Mitigation Measures and Recommendations

- Moderate air quality impacts during the construction phase of the project can be anticipated due to fugitive dust generation in and around the working area and construction yards from the movement of vehicles, operation of the construction machinery and handling (loading/ unloading) of materials.
- Following mitigation measures should be taken for reducing the impacts on air quality:
- The method of handling cement and other materials should include means of eliminating atmosphere discharge of dust.
- Equipment and vehicles producing excessive emissions of exhaust gases due to any mechanical fault should not be allowed for operation.
- Regular maintenance of vehicles and equipment should be carried out.
- Regular third party inspection of construction sites should be carried out to ensure the disposal of the construction debris to the approved landfill sites.
- Low emission equipment should be used.
- Vehicles carrying construction material should be covered with tarpaulin or canvas sheet to avoid spilling. Additionally, left over of such materials deposited on the surfaces of vehicles should be removed before transportation.
- Sprinkling of water at construction sites for dust suppression wherever necessary.
- Construction debris should be properly dumped into a closed area to prevent dust propagation with the air.

3) Land

Impacts

- Due to trenching activities solid waste will be generated, which may cause pollution to the land. Prolonged storage and surplus earth may cause dust pollution and soil transportation by rainwater into low areas.
- During construction stage, water pools are also likely to be generated due to spillage of wastewater (during rehabilitation of sewers) resulting in stagnant pools. These can be minimized by appropriate water and wastewater management practices at worksites. In addition, considerable amount of solid wastes out of scraps, packing materials, unused materials, etc. are also likely to be generated at construction sites. These need to be disposed off at the earliest as otherwise may lead to aesthetic nuisance and might cause obstruction to other services.

Mitigation Measures and Recommendations

- For laying of the pipes in the trenches, fill material will be required for preparing the bed of pipes and back-filling the trenches. Considering the urban nature of construction site and to minimise the inconvenience, prolonged storage of material near the site should not be permitted. Contractors should transport and use material preferably without any temporary storage on site.
- Solid Wastes should be properly managed.
- Proper care should be taken during excavation.
- Proper collection, handling, transport, and disposal of solid waste into places demarkated by local authorities should be done.
- If necessary, temporary storage may be permitted with the following conditions:
- Temporary storage of materials will not be allowed more than two (2) days;
- No existing access shall be disturbed unless unavoidable;

- No residual material will be allowed to be left at site,
- Heaps shall be located only in that area, which is temporarily acquired for construction purposes with proper approval.

4) Soil Quality

Impacts

Digging and backfilling of trench for laying sewer lines may render topsoil loose. Soil of the construction area may be contaminated by wastewater also. This contamination will be due to:

- Alteration of chemical make-up of the soil, increased acidity/alkalinity
- Presence of pathogens and other organic material in the excavated material

These impacts will be minor and limited to the construction phase only. No major impact on soil quality is anticipated.

Mitigation Measures and Recommendations

- As standard practice, proper shuttering with struts and props should be provided in the excavated trenches during construction. The trenches should be backfilled and compacted properly at the earliest after laying and jointing of pipes. To minimize the soil erosion, vegetation cover/paving of appropriate type should be provided over reinstated surface.
- Backfilling in trenches and in other excavations must be compacted properly and reinstated to its original conditions with neat finish by providing vegetation cover or paving as the case may be.

5) Water Quality and Water Use

Impacts

- The drainage pattern of overland water flow of the project sites may be changed due to alteration of the existing profile and slope of the land.
- Large quantity of water will be used at construction sites for water tightness tests, curing of concrete, flushing and washing of piles, etc. Some portion of such spent water will be wasted. During disconnection and making connections in sewerage system, there are chances of major spillage.

Mitigation Measures and Recommendations

To avoid the spillages following measures are recommended:

- Operations should be carried out with extreme care to avoid any spillage, by using appropriate pumping, storage and transportation arrangements.
- Spillages should not be allowed to flow into nearby drains/low lying areas or to accumulate as stagnant pools.
- All necessary equipment/machinery must be in readiness with standby units to take care of any exigency.
- Surplus quantity of used water and sewage should be collected neatly and transported to designated disposal site.
- No spillage of such wastewater should be allowed during transportation.
- Transportation of wastewater should follow routes relatively clear of traffic and congestion and such route plans should be prepared with due care.
- Transportation tankers, piping, etc. should be washed properly at the end of every day or after every operation, so that fly and odour nuisance is avoided.

6) Augmentation of Sewer Lines

Impacts

The augmentation of the existing sewer lines may render the following impacts to the natural environment.

- Additional land requirement
- Interference with other existing buried utilities
- Growth of breeding grounds for rodents and pests in future inside discarded sewer lines if left as it is.
- Disturbance to existing branch lines
- Accident due to sudden collapse of sewers in future
- Disruption of existing sewerage facilities
- If the existing main sewer pipes are to be replaced by new pipes, dismantling of these pipes will generate debris.

Mitigation Measures and Recommendations

- During the augmentation of existing sewer lines and relaying of new sewers, the existing system will meet with severe disruption, and the situation should be managed with extreme care so that liquid waste does not overflow, causing serious environmental hazards. Following mitigating steps should be adopted.
- Work schedule and sequencing should be worked out in advance with appropriate care commensurate with availability of resources and feasibility of operation.
- Critical stretches of sewer lines should be identified for priority action. Such priority stretches should generally be the downstream sections.
- Incoming sewage has to be by-passed to keep the work area free from hold ups. Bypassing arrangements may be by laying temporary by-pass sewer lines with gravity flow or combination of sewage pumping and temporary piping.
- By-pass arrangements should be worked out through appropriate design so that no sewage built-up occurs in upstream sections and also the downstream sections are not overloaded.
- The work scheduling/sequencing and by-pass arrangements should be finalised after comprehensive discussions with the appropriate authorities.
- If blockages to roads and other services are unavoidable, such blockage areas should be identified well in advance and circulated to public with appropriate details in maps.
- Blockage areas should be barricaded well in advance at least by a week before actual commencement of works so that the road users get accustomed to such blockages. Such blockage areas should be appropriately barricaded with warning signs.
- All actual works at site should commence only after mobilization of required resources including standby, back-up, spare parts, power connections, etc.

7) Traffic

Impacts

During the construction of the sewer lines traffic congestion will take place, which will have some temporary impact on the social environment. Hindrance to pedestrian movement will occur due to the construction of sewer lines.

Mitigation Measures and Recommendations

- Traffic diversion management should be properly implemented to control pedestrian movement.
- Proper demarcation by trenching, fencing should be done.
- Precautionary signs for public movement should be incorporated.

8) Public Safety

Impacts

The city of Varanasi is a very congested one and construction activities comprising of

rehabilitation and laying of sewer lines are expected to take place inside densely populated city area. Following combination of the activities increases the risks of accidents (especially local population) during construction phase:

- Unauthorized access to a construction site
- Absence of control over access to construction sites
- Conflict with construction vehicles
- Poor site safety measures and warning system
- Inadequate site management

Mitigation Measures and Recommendations

- At the time of construction, the safety of public is one of the most important issues. To minimize the risk-involving public, the following measures are suggested:
- Trenches for laying the sewer lines should be opened for minimum possible time period.
- To permit safe crossing of trenches and to have access to properties and premises appropriate trench-crossing facilities should be provided in sufficient numbers.
- To separate the pedestrians from road traffic alternative appropriate pedestrian route/crossings should be provided. Where roadway is restricted, the risk of pedestrian and vehicle conflict is significantly high. In such cases, temporary closure of the access may be considered.
- Temporary fences with appropriate warning signs should be used to isolate the trenches.
- Trenches should be strictly fenced in the vicinity of schools, mosques and locations of public concentration.
- Precaution notice should be provided at required locations.
- All traffic and pedestrian diversion plans should be finalized in consultation with appropriate authority.
- Excavation works should be commenced only after ensuring ready availability of all resources.
- In order to minimize such risks due to delay and avoid other adverse environmental impacts, advanced construction techniques like trenchless technology should be considered for working in vital areas and busy roads.
- The use of all heavy and mobile equipment should be strictly controlled with all drivers and operators required to be licensed and all heavy equipment operated in strict accordance with manufacturer's guidelines as applicable.
- All workers should be protected with adequate safety measures and insurance policies.

9) Public Hygiene

Impacts

Generation of sewage and domestic solid waste is the main source of pollution from construction camps. The waste generated at construction camp should be properly disposed to the approved landfill sites. Improper management of this waste, otherwise, may lead to health and hygiene related problems.

Mitigation Measures and Recommendations

- The contractor should provide adequate lavatories at construction camp to cater to the requirement of the workers.
- The contractor should build on-site facilities or other appropriate arrangements for safe disposal of such wastes.
- Periodic health check-ups of construction workers should be undertaken and basic medical facilities should be made available.

10) Employment Opportunities and Temporary Establishment

Impacts

The construction activity can provide opportunities to the local population and residents of the neighbouring area to earn. They may come to provide labour or to service the construction camps. After the completion of the construction the temporary residences of the labours may not be demolished and squatter colonies may develop.

Mitigation Measures and Recommendations
It is necessary to ensure that the persons after completion of construction work remove all temporary establishments that may prevent setting up of squatter colonies.

11) Rehabilitation of Sewer Line

Impacts
The existing sewer line passes through the busy roads of congested old town of Varanasi. On both the sides of the road there are residential buildings, shops and institutions. Therefore, during the rehabilitation of the sewer line the inconvenience to public may occur, especially with respect to traffic.

However, replacement along the existing alignment will cause following impacts:
- Disruption of existing sewerage facilities
- Health hazard to construction workers
- Public nuisance due to obnoxious odour

Mitigation Measures and Recommendations
- To minimise the inconvenience to public, special traffic management programme should be undertaken to divert the vehicular traffic and pedestrians. The plan for narrow roads should be based on a diversion programme along parallel roads with restricted access for local residents and in case of wider roads by closure of one side of the roads. The Contractor should prepare and submit all plans to the local Nagar Nigam, traffic department and the local Civil Defense and other relevant authorities for approval before starting construction programme.
- Impacts, due to the replacement of the existing alignments can be mitigated by extensive pumping of the sewage from disconnected portion using mobile pumping units; Construction workers involved in the replacement activities should be provided with safety equipment, i.e., gloves, boots, etc. to avoid direct contact with wastewater and spillage of wastewater at construction site should be minimised and disposed off expeditiously.

12) Public Properties

Impacts
Access to the buildings adjacent to which construction activities are ongoing will be affected. Such disruption of access to commercial establishments leads to direct economic loss. These impacts will be minor and restricted to the construction phase only.

Mitigation Measures and Recommendations
Temporary access should be provided for such premises and proper areas should be restored at the earliest.

13) Public Utility Services

Impacts
- During the construction of sewer lines, there will be instances where water supply may be disrupted for a certain period of time.
- Due to road blockage during construction phase, the residents have to cope up with the

temporary situation of hardship, as they have to traverse longer distance to reach their destination.
- There would be every possibility of interference and minor shifting with other utility lines such as, electrical cables, communication cables, water supply lines, etc.

Mitigation Measures and Recommendations
Residents of the project area will have to devise coping strategies to meet the prevailing situation, i.e.,
- Storing appropriate quantity of water before hand
- Buying water
- Sharing water with neighbours
- Fetching water by tankers
- Rehabilitation of affected utilities should be done.
- Proper compensation for loss of crops and for agricultural land should be made, if required.

14) Water Use

Impacts
Substantial amount of water would be required at the time of construction. To meet such requirement of water, local communities may be affected in the following ways:
- The quantity of water available from their source may be reduced by construction activities.
- Their water sources may be contaminated.

Mitigation Measures and Recommendations
To avoid the impacts on the water use certain rules and regulations are to be followed. Those are as follows:
- Contractors should bring all water on site in tankers and they would be allowed to fill their tankers at the sites defined in agreement with the local authorities. These may be new facilities located at construction yard, in communities or pre-existing facilities.
- Off-site water source proposed for use by the contractor should be approved in the context of existing local pattern of use, availability of alternative supplies, etc.

(2) Pumping Stations (Construction Phase)

The construction impacts of the pumping stations are similar in nature to the impacts due to laying sewer line.

1) Noise Quality

Impacts
Due to construction of the pumping stations the generated noise may exceed the allowable limit, causing nuisance to the adjoined residents.

Mitigation Measures
Low noise generating equipment should be used during the construction of the pumping stations.

2) Air Quality

Impacts
The fugitive emission during the construction of the pumping stations would pollute the ambient air quality.

Mitigation Measures
Water should be sprinkled to avoid the emission of the dust generated from the construction activities.

3) Land

Impacts
The installation of the proposed pumping stations will not require much land. Therefore, it has very low impact to the natural environment. No significant mitigation measures are necessary.

(3) Sewage Treatment Plant (Construction Phase)

The construction impacts for the treatment plant are similar in nature to the impacts for laying sewer lines but they may vary in intensity. The proposed site is in the rural area therefore the impact of setting up the sewage treatment plant in this location would be noticeable.

The intensity of the impacts depends on the area to be covered by the treatment plant, which depends in turn on the process and the flow to be treated. Basically the proposed treatment processes are of two extreme types: (i) extensive treatment by lagoons; (ii) intensive conventional treatment. For the lagoon system, huge land area is required for the treatment. For conventional treatment, the land requirement is less for the treatment.

The construction impacts are also related to the phasing of the works. In general the impacts will be more intense during the first phase of works because the land use of the site will change radically. Thereafter, when extension works will be executed, some of the construction impacts will affect the area again, but the nature of these impacts will not change.

Project activities during construction phase may include demolishing of village houses, uprooting of plants and vegetations, and digging of soil for the construction of ponds. These activities will result in cutting of few trees, dust generation, noise generation by construction equipment, inflow of construction labour, sediment load in construction water, and generation of solid waste in the form of construction spoils.

Construction phase activities would have moderate impacts on on-site noise & air quality, land use and ecology. It could also develop minor impacts on on-site soil, water use and water quality.

The main impacts of construction phase are loss of village houses, agricultural land and few trees and such impacts are long term. The other impacts of construction phase will be small in magnitude as well as temporary in nature and are expected to wear out gradually once the construction activity is completed.

Impacts on various environmental components during construction phase are discussed below along with suitable mitigation measures.

The following description is made assuming the selected treatment process of UASB + Facultative Aerated Lagoons + Chlorination at Sathwa Village. However the comparison between the alternative treatment plant processes is presented in Section 3.5.5 of this Chapter.

Type of STP	:	UASB + Facultative Aerated Lagoons + Chlorination
Capacity :		200 mld
Area required	:	41.00 hectares
Location :		Near Village Sathwa on Varanasi-Azamgarh Road

1) Soil Quality

Impacts
- The proposed STP requires a land of nearly 41 ha. Excavation denudes the topsoil as well as soil up to the depth of the proposed STP and makes it loose.
- Destruction of topsoil leads to reduction of fertility and removal of vegetation cover with associated hazards of soil erosion.
- During storms, some of the excavated soil would be blown up in the air and dispersed around the proposed sites; some would also tend to be compacted into the soil and clog intergranular spaces.

Mitigation Measures
- Appropriate measures like plantation wherever needed in the neighbourhood of the proposed site should be undertaken to appease the chances of soil erosion.
- Earth materials should be stored in covered godowns or enclosed spaces.

2) Land Use

Impacts
- Preparatory activities like construction of access roads, temporary offices, quarters, etc. will be confined within the proposed site. These will not generally exercise any significant impact except altering the land use pattern of the proposed STP site. There will be no impact on the adjoining land.
- The land, which is mostly private agricultural land, has to be acquired and to be diverted from its present use for creation of the proposed STP. As a result the impact on land use would have some significance and any impact due to construction will be confined within the boundary limits of the project area and will not hamper the land use aspects outside. However, indirectly there may be some change in the land use pattern of the proximate area due to influx of construction work force and suppliers who are likely to construct temporary tents in the vicinity.

Mitigation Measures
- Construction camp should be provided for construction personnel to avoid indiscriminate settlement of construction labourers.
- The excavated material should be disposed of in suitable pre-identified areas.
- Appropriate earthwork suppression measures should be implemented within the project site during construction of the proposed wastewater treatment plant.
- Appropriate compensatory plantation should be initiated to make up loss of trees and vegetation due to the proposed project.

3) Hydrology and Water Use

Impacts
As the proposed site of the project does not have any rivers or canals, no impact on hydrological regime is envisaged. Only the drainage pattern of overland water flow of the project sites may be changed due to alteration of the existing profile and slope of the land.

Mitigation Measures
- The water demand during construction of the proposed STP should be met from such water sources, which is not likely to have impacts on other users.

4) Water Quality

Impacts

- Water will be used in the construction process of the STP, of which some portion will drain out as wastewater. Wastewater from construction activities would mostly contain suspended impurities. Other pollutants, which may find their way to it, will be in insignificant concentrations and may be safely disregarded.
- The deterioration of water quality during construction phase is expected due to wastewater disposal from the workers camp and sullage generated from construction sites. If adequate arrangements are not made to ensure proper drainage of wastewater from the construction sites, such waters may form stagnant pools and aggravate soil erosion. Stagnant pools of water promote breeding of mosquitoes and generally create unsanitary conditions.

Mitigation Measures

- The construction activities/erosion should be limited to small area.
- Drains from proposed construction sites should be led to sedimentation pits where excess suspended solids will be settled out and relatively clear supernatant will be discharged into existing surface water drains.
- Proper sanitation facilities should be provided at the construction site.

5) Air Quality

Impacts

- Particulate matter would be the predominant pollutants affecting the air quality during the construction phase. The soil of the project area is likely to generate considerable quantity of dust, especially during dry conditions. Dust will be generated mainly during excavation operations along with transportational activities and open storage of fine earth material. However, wind in the area generally being low to medium, wind blown dust is not expected to have tangible effects.
- Mostly the automobile traffic and construction machineries will generate undesirable gaseous pollutants. However, this would not lead to any tangible effect, as the expected traffic volume is low.

Mitigation Measures

- Earth material should be stored in enclosed spaces.
- To reduce fugitive dust emission at project site due to vehicular movement and material transportation sprinkling of water should be undertaken wherever unpaved haul roads pass through habitation.
- Regular inspection of construction site should be carried out to ensure regular and timely removal of construction debris to the dumping sites.
- The quantity of earth generated from cuttings should be used to the maximum possible extent during site development.
- Low emission construction vehicles and generator sets should be used.
- It should be ensured that all the vehicles plying during construction are properly tuned and maintained to keep emissions within the permissible limits.

6) Noise Quality

Impacts

- During the construction phase, noise will be generated due to movement of vehicles, and operation of light & heavy construction machineries including pneumatic tools (bull dozers, scrapers, concrete mixers, generators, pumps, vibrators, cranes, compressors, etc.) that are known to emit sounds with moderate to high decibel value.
- Noise generated from sources mentioned above will be intermittent and of short duration

mostly during daytime. Therefore, no significant impact is anticipated on account of noise generation around the project site. However, the workers are likely to be exposed to high noise levels that may affect them.

Mitigation Measures
- Careful planning of the operation of construction equipment is required during this period so that minimum disturbances are caused.
- Construction camp should be located away from the construction sites.
- Impacts of noise on construction workers should be minimized through adoption of adequate protective measures in the form of (a) use of personal protective equipment (ear plugs, ear muffs, noise helmets etc.), (b) education and public awareness, and (c) exposure control through the rotation of work assignments in the intense noise (above 90 dBA for 8-hr exposure as per Factories Act) areas.
- Low noise construction equipment should be used.
- It should be ensured that all the equipments used during construction are properly maintained to keep noise within the permissible limits.
- Construction machinery should be in good working condition and engines turned off when not in use.

7) Ecology

Impacts
- The impact of construction activities will be primarily confined to the proposed project site. The site is presently in use as agricultural land and has some trees. The site does not involve any forestland. Thus, the site development works will not lead to any significant loss of any important taxa.
- A few species of common birds and animals are sited in and around the proposed site area. As the proposed site of the STP covers this area, there will be some impact on the inhabitation of fauna.
- As the water quality of the surface water bodies is not likely to change due to the construction activities, no impact on the aquatic life is expected.

Mitigation Measures
- Plantation in the available balance open spaces is proposed to be implemented.
- More valuable tree species could be planted in place of existing tree species of the project area under plantation & landscaping programme.

8) Visual Impacts

Impacts

The visual impacts at the construction site of the treatment plant will be unaesthetics. The dumping of construction materials will not look any better. Extensive movement of vehicles with badly maintained engines will generate smoke all around the site. The dust at the site will be carried over to nearby areas in windy or stormy weather conditions. Broken pavements and opened roads would add up giving an unaesthetic look to the construction site. However, the impact will be temporary and localised.

Mitigation Measures

To minimize visual impacts and landscape change, plantation of trees in surrounding area of the STP site is recommended.

9) Spoil and Soil Disposal

Impacts

The spoil will be generated during construction of the treatment plant by way of rejected plant materials, bushes during site clearing, excess earth, etc. Solid waste from the proposed plant during construction stage will be mainly earthwork and rubble.

Mitigation Measures

The spoil will have to be disposed of in a proper manner at the pre-identified safe disposal sites. Suitable dumping sites will have to be identified near the proposed treatment plant location for any of the options. If not disposed of in an environmentally compatible manner, it will create minor adverse impacts in the surrounding area.

The excavated soil may be used for two distinct purposes:

- The soil could be provided to the farmers, so that they can fill their low lands.
- The excavated soil could be sold to the contractors for the construction of road embankments.

10) Land Acquisition

Impacts

The land requirement (41.0 ha) is of substantial amount, equivalent of a square area of 640 m x 640 m. The land falls on the right side of the canal (which remains dry almost through the year except monsoon) that crosses the Varanasi-Azamgarh road after the village Rajnahiya and is situated at about 1.8 km south from the irrigation canal where the treated wastewater is to be discharged. The location of proposed Sathwa STP site is shown in Figure 3.3 and the proposed layout of Sathwa STP is in Figure 3.7.

As per the original proposal, the settlement of 1 village (Rajnahiya) will be partly affected by land acquisition.

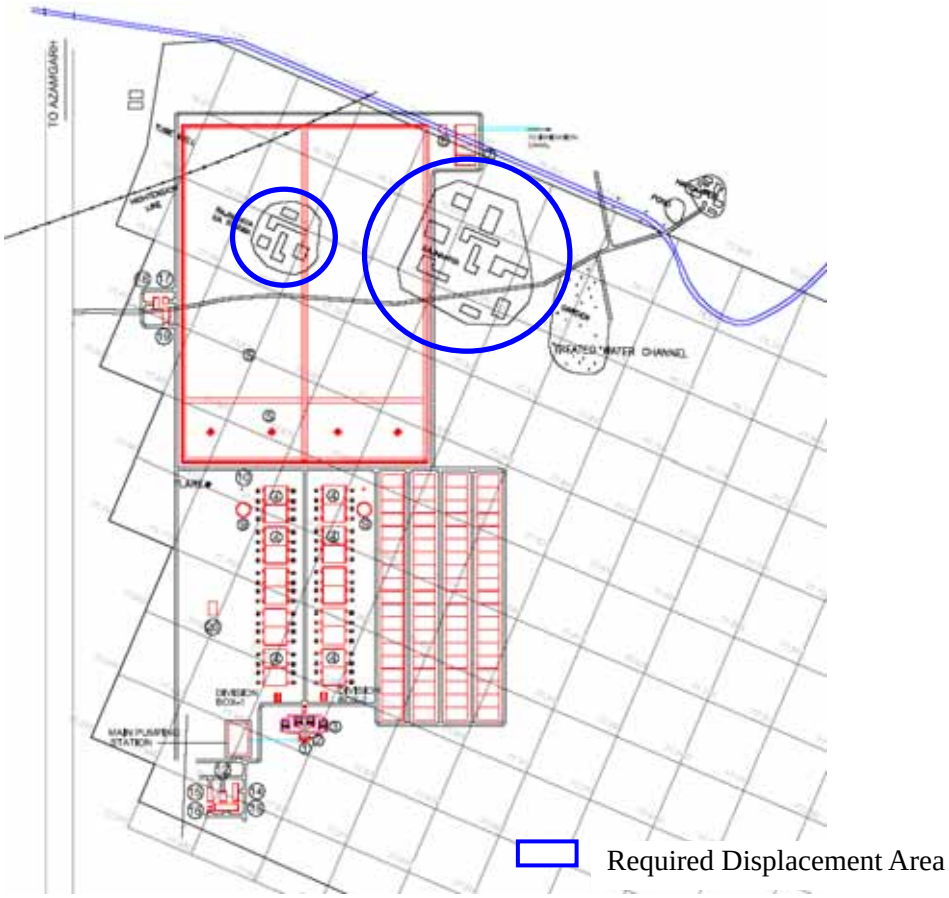


Figure 3.7 Proposed Layout of Sathwa Sewage Treatment Plant

Mitigation Measures

- Minimization or avoidance of village displacement

The original layout plan of Sathwa STP requires part displacement of 1 village. However, the revised layout plan (Figure 3.8) can avoid displacement of the village but would require agricultural land. The impact of both layouts is compared in Table 3.39.

Table 3.39 Comparison of the Impact for Two Proposed Layouts

	Resettlement (HH)	Land owner (HH)	
		Rajnahiya	Goithahan
Layout (Figure 3.7)	17	51	76
Revised Layout (Figure 3.8)	0	15	149

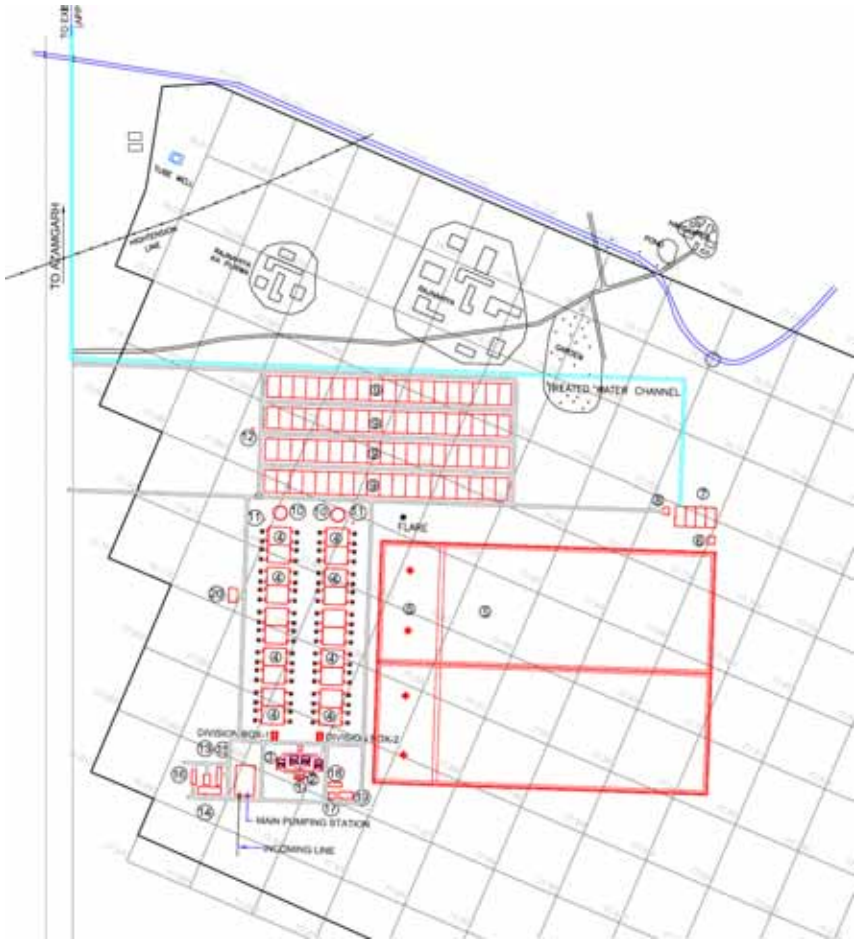


Figure 3.8 Recommended Layout of Sathwa Sewage Treatment Plant

- Appropriate Compensation

Land is normally acquired under the provisions of the Land Acquisition Act, 1894 which is general and basic law in the country for the acquisition of land for public purposes and companies. This Act was comprehensively amended in the year 1984, taking into consideration the recommendations of the Law Commission, the Land Acquisition Review Committee.

There are two types of compensation. Monetary compensation has to be provided to direct Project Affected Persons (PAPs) if their houses have to be acquired and demolished. It has to be provided to indirect PAPs for their agricultural land to be acquired. Alternate land has to be provided to the displaced persons for their resettlement. If land for resettlement can not be provided or PAPs are not willing to resettle in the new resettlement site, then monetary compensation has to be provided to direct PAPs for their homestead (i.e., residential) land to be acquired.

3.6.3 Prediction of Impacts and Mitigation Measures during Operation Phase

Treatment works, pumping and sewerage conveyance system will not perform satisfactorily unless they are operated and maintained properly. Malfunctioning of this system may pose risks of health hazards. Hence, this system should be operated and maintained properly by trained technicians.

Following preventive measures should be adopted:

- Provision of adequate sewer cleaning and evacuating machines
- Provision of generator sets at pumping stations
- All spare parts should be readily available in case of emergency
- Provision of standby units of pumps at each station
- Provision of adequate maintenance staff with accessories
- Regular training of system staff, skilled technicians and craftsman
- Proper operating budgets and attractive salaries

The impacts of sewer lines, pumping stations and STPs are described below with proper mitigation measures.

(1) Sewer Lines (Operational Phase)

1) Soil & Water Quality

Impacts
Blockages in the sewer lines due to inappropriate maintenance may lead to profuse leakage and occasional overflow from manholes. This results in impacts as identified below:

- On soil quality by contaminating the same and disturbing the soil stability leading to settlement
- On water supply through intrusion of contaminants into system
- On aesthetic environment due to fly, mosquito and odour nuisance.

Mitigation Measures and Recommendations
In order to avoid above adverse impacts, following precautionary measures are already envisaged in development plan:

- Sewer pipes will be laid away from the water supply lines and at a greater depth
- Minimum vertical separation from water supply line will be 0.5m and horizontal distance of 3.0m.
- Leakage problem would be localized and will be readily dealt with by practising adequate maintenance measures like inspection, detection, cleaning and repairing.

2) Sewer Lines

Impacts
Sewer overflows might occur during operation phase.

Mitigation Measures and Recommendations
To avoid sewer overflows, following mitigation measures should be adopted:

- Regular cleaning of sewers (removal of blockages, debris, rags, etc.)
- Proper access arrangement to mechanical and electrical equipment
- Routine inspections of sewers for illegal connections and obstructions
- Mechanical equipments should be regularly checked for deterioration, wear of critical parts and security of fixings
- Provision of spare parts
- Public awareness to prevent the disposal of solid wastes in sewers
- Sewer lines should be inspected regularly to detect any malfunctioning, chocking, leakage and other defects.
- Manhole covers should have a minimum 600mm dia. clear opening for entry.

- It should be checked regularly for soundness and security.
- Each time a manhole cover is opened, it should be cleaned, inspected and greased, if necessary.
- Manhole shaft, landings and benching should be inspected for defects such as cracks, water ingress, corrosion and concrete spilling.
- Where surcharging occurs, the manhole shafts should be cleaned down and any build-up of grease, sewage solids or rags removed.
- Trained work gangs should carry out routine operation and maintenance of sewerage network and rectification works taken up expeditiously.

3) Occupational Health of Workers

Impacts

Likely impacts on occupational health of workers during operation phase are due to accidents caused by:

- In deep trenching operations
- Accumulation of gases in sewers and other confined spaces
- Contact with wastewater during repair/maintenance

Mitigation Measures and Recommendations

The impacts on occupational health of the workers can be avoided by adopting the mitigation measures as given below:

- Regular safety education and training for system staff
- Workers should be provided with adequate protective clothing, gloves, footwear (safety boots, gumboots) and safety goggles for handling sewage and its bi-products.
- Provision of providing laundry services for the personnel when employed in operation and maintenance of sewer system and treatment plant
- Provision of safety equipment (gas detection equipment, self-contained breathing apparatus, safety harnesses)
- Designing facilities, which provide for worker's safety (lifting equipment, access manholes, ladders, walkways, safety around rotating mechanical equipment)
- Implementation of effective industrial waste pre-treatment system through enforcement of adequate regulations
- Training of operators in hygiene after handling sewage or working in sewerage system
- Training of operators about safety procedures for working in confined places (sewers, manholes, pump station, wet and dry wells, screw chambers at pumping stations)
- Periodic health check-up of workers as they will be exposed to toxic and flammable gases (e.g. hydrogen sulphide or rotten egg gas, methane and air mixtures)
- Public awareness programmes should be conducted to generate awareness regarding serious hazards of insanitary living conditions, measures and modes for following proper sanitary methods. Such awareness programmes will generate participatory feeling among the public and will benefit the process of maintenance as well as encourage residents to opt for house connections instead of continuing with existing hazardous on-site facilities.
- Proper restriction and legislation should be applied to prevent the entry of unwanted materials along with the sewage from the houses. To ensure it properly, fines, charges, taxes, etc. should levied. In addition, public awareness should also be enhanced by conducting different types of study-awareness programmes.

(2) Pumping Stations (Operational Phase)

Impacts

During the operation of pumping stations following impacts may be observed:

- The noise generated from the pumps may cause annoyance to the nearby people.
- Pumping stations are the most critical and vulnerable component in operation phase of sewerage system. The disruption of pumping stations will cause outfall of untreated sewage to water bodies and land.

Mitigation Measures and Recommendations

Following measures are suggested to reduce the impacts:

- Pumping stations should be permanently manned;
- Regular inspection of mechanical and electrical equipment, instrumentation including structural and building components;
- Planned maintenance programme should be prepared, and mounted on the pumping stations and on control panels;
- Screenings should be regularly collected and disposed to approved disposal sites;
- All spare parts should be readily available;
- In case of emergency, spare set of pumps should be available; and
- Provision of alternative power supply (such as diesel powered generating sets) and fuel.

(3) Sewage Treatment Plant (Operational Phase)

Project activities during operation phase include inflow of untreated wastewater to the UASB reactor, facultative aeration lagoons and chlorination and disposal of treated effluent to the irrigation land through the canal. The main impacts of operation phase are chemical hazards & enhanced risk level and such operational impacts are long term. By analyzing the treatment efficiency of Dinapur wastewater treatment plants, impacts of the proposed plant can be identified and proper mitigation measures can be taken. Impacts on discreet environmental attributes during operation phase have been discussed below along with suitable mitigation measures.

1) Ground Water Quality

Impacts

The population of the 9 villages around the Sathwa STP site is about 9,932. The principal source of the water in these villages is ground water drawn from either hand pumps or the open wells that tap the upper unconfined aquifer. The depth of the ground water table has been monitored and given in Table 3.40.

Table 3.40 Depth of the Ground Water Table

Name of the Village	Ground Water Table Depth (m)
Sai	12
Sathwa	11
Hirdaipur	18
Rajnahiya	22

The soil of the proposed STP site is generally silty-clay. Wastewater in the facultative lagoon ponds, which will be basically water-tight, may percolate through the underlain soil layer by seepage and pollute the ground water table of the nearest unconfined upper aquifer. These aquifers are connected with a number of open wells from which villagers draw water for drinking and other purposes. However, the wastewater of Varanasi does not contain any

appreciable level of toxic heavy metals (e.g., Hg, Cr, Cd, Pb, As etc.). Therefore, chance of groundwater contamination due to toxic heavy metals is remote.

Existing Dinapur STP is not equipped with any treatment process for reducing the number of bacteria such as maturation pond or chlorination. Bacterial contamination in aquifer in the villages surrounding existing Dinapur STP has been reported due to seepage of treated water from irrigation canal.

It is proposed that chlorination facility will be installed in Sathwa STP and therefore any bacterial contamination should not occur. In addition, aerated lagoons and treated water channel will be lined with waterproof material to avoid seepage of wastewater from the lagoons or treated water from the channel into groundwater.

Mitigation Measures and Recommendations
First and foremost, care should be taken to ensure adequate treatment to meet the discharge standards.

It has been planned that the aerated lagoons and treated water channel will be lined with waterproof material to avoid seepage of wastewater into the soil and thus prevent contamination of ground water.

It has also been planned that chlorination facility will be installed in proposed Sathwa STP and existing Dinapur STP and therefore any bacterial contamination should not occur in the irrigation canal and through land application of treated effluent. If the STP is well functioned and wastewater is appropriately treated, the groundwater in the aquifer has remote possibility of any contamination. Removal of pathogens is the prime objective in treating wastewater for re-use.

In addition, the wastewater of Varanasi does not contain any appreciable level of toxic heavy metals (e.g., Hg, Cr, Cd, Pb, As etc.). Therefore, chance of groundwater contamination due to toxic heavy metals is remote.

2) Noise Quality

Impacts
There will be no such significant machine/industrial noise during operation of the project. The movement of few cars in the area and blowing of their horns would contribute to the machinery noise. However, neither its sound intensity nor its duration is expected to be large enough to cause significant impact. Residential areas are quite far away. This would imply that no impact of such noise is likely to be felt by the local people.

Mitigation Measures and Recommendations
There is no such requirement for mitigation for noise environment.

3) Treated Effluent Use

Impacts
Over all, the impact of the wastewater treatment on the receiving water bodies will be positive, as no wastewater will be discharged untreated into natural drains any more. The impact may also be highly positive for crop irrigation.

The treated effluent from the proposed STP will be discharged to the irrigation land of the adjoining area. This effluent would be rich in phosphates and nitrates. The fertility of the

agricultural land would increase. This would be a positive impact to the nearby villagers.

Quantity of the discharging water
The flow characteristics of the irrigation canal and the treated effluent are summarized in the table below. The current flow of the canal is 0.6 m^3/sec and the effluent volume discharged from the STP will be 2.3 m^3/sec after the project. Thereby, the total flow with the project will be 2.9 m^3/sec in the canal. The canal has enough capacity to convey the increased flow since its design capacity is 5.0 m^3/sec.

Table 3.41 Canal Design Capacity and STP Effluent Flow

Designed capacity of canal	Present water volume of canal	Effluent volume discharged from STP	Estimated water volume of canal with project
5.0 m^3/sec	0.6 m^3/sec	2.3 m^3/sec (200 mld)	2.9 m^3/sec

After the project, the nutrient rich 200 mld effluent can be used for irrigation. This would increase fertile agricultural land by 3,565 ha more as summarized below.

Table 3.42 Cultivated Area Increase With Project

	Cultivated area using irrigated water	Cultivated area using non irrigated water	Total
Pre- project	930 ha	4,962 ha	5,892 ha
Post-project (estimation)	**4,495 ha**	1,397 ha	5,892 ha
Difference	**3,365 ha**	3,365 ha	0 ha

*Estimation had been made under the condition where every 10ha of cultivated land consumes 0.064m^3/sec. (Source: Irrigation Department, Varanasi)

Basically, irrigation water in the canal is used in the dry season and is not used in the wet season. Even in the dry season some fraction of the canal water may not be used. The unused canal water is finally discharged into the Ganga river at about 15 km downstream of the Varanasi city.

The effluent quality of the STP will comply with the national standards and thus no impact is foreseen on the river Ganga. In addition, the canal joins the Ganga river at the downstream of the Varanasi city and there is no major city within 100 km after the joining so that no impact would be foreseen.

Quality of the discharging water
The volume that will be discharged from the STP is almost 4 times larger than the existing canal flow. Therefore, quality of canal water after the project is implemented will be dominated by the quality of treated water from the STP. So as long as wastewater is treated properly in the STP, the impact for canal is positive for irrigation use.

However, since it has been designed for use for agricultural irrigation, the project has to be aware of following impacts that might be brought by the water discharged from the STP.

i) Direct impact of the water
If the treated effluent contains large concentration of inorganic salts or the metals, it would eventually lead to stunted growth of the crops that are irrigated using this effluent.

ii) Indirect impact from the soil

Toxic substances such as heavy metals that might be present in the irrigation water stay as alimentation in the soil and are then absorbed into vegetation. Consuming such vegetables might harm human health.

Quality of soil governs the pattern and quality of the vegetation. The concentrations of different heavy metals in the treated effluent will be adsorbed by the soil grains, which may affect the vegetation and crop quality. This may lead to a negative impact on the soil.

iii) Indirect and direct impact from the environment

Insoluble inorganics make the soil solidify, and obstruct absorption of water. The presence of excess organic in irrigation water may give direct effect to the cultivated land, and indirect effect as abnormal growth due to lack of oxygen in water. This eventually gives negative influences to vegetation.

Mitigation Measures and Recommendations

Since it is recommended that the treated wastewater will be reused for irrigation purposes, the treated wastewater should meet the required standards for irrigation re-use. Also treated water quality should be monitored carefully so as to meet the discharge standards effectively.

Effluent discharge standards are specified with reference to the type of industry, process or operations and in relation to the receiving environment or water body such as inland surface water, sewers, land or sea. These standards are given in Table 3.43.

Table 3.43 Discharge Standards

Indicator	Inland surface water	Public sewers	Land for irrigation
Suspended solids	100	600	200
Oil and grease	10	20	10
BOD_5	30	350	100

Note : All values are in mg/l and are the maximum permissible levels.
Source: Pollution control acts, rules and notifications issued hereunder, CPCB, September, 2001.

With regard to application of sewage for land farming, the 'Manual on Sewerage and Sewage Treatment', CPHEEO, Ministry of Urban Development, Govt. of India, provides guidelines on characteristics of irrigation waters. These include conductivity, salinity, sodium absorption ratio, chlorides, boron, etc. In addition, the manual provides maximum permissible concentrations of toxic heavy metals, etc. If treated sewage is to be used for irrigation, as is proposed in the Project, upper limits for important parameters shoul be as given in the following table.

Table 3.44 Treated Water Quality for Irrigation

Parameter	Unit	Limits
BOD_5	mg/l	100
Suspended Solids	mg/l	200
Dissolved Solids	mg/l	2100
pH		5.5-9.0
Oil & Grease	mg/l	10
Arsenic	mg/l	0.2
Boron	mg/l	2.0
Cyanide	mg/l	0.2
Chloride	mg/l	600
Sulphate	mg/l	1000

Source : CPCB, Standards for discharge of Industrial /Domestic wastewater

4) Sludge Production and Disposal

Impacts

The sludge production will be to the tune of several tens t/day from the sewage treatment plant. It will be dried on the sludge drying beds. During the drying process, there will be a nuisance of insects around the sludge drying beds. It can be minimised by spraying insecticides in the area, also by proper maintenance of sludge drying beds, and proper drainage. The wet sludge should be raked often and the dried sludge removed frequently.

The dried sludge can be given or sold to farmers as manure if it can be handled properly by them. The value of sludge as an organic fertiliser has long been recognised and this offers reduced fertiliser costs to the farmer. Monitoring of the quality of the sludge is however required, especially the monitoring of the heavy metals. The sludge should also not contain non-degradable materials. Movement of sludge tankers from sewage treatment plant to agricultural land can create traffic problems and give rise to noise and odour nuisance. Mode of transport should be appropriate and routes chosen so as to minimize inconvenience to the public. Odour control is also required. It is preferable to use enclosed tankers for transporting sludge.

Besides the use of sludge as fertilizer, the dry sludge can also be disposed of in specified landfill sites. In general the two options are applied. Codisposal of sludge with domestic waste is acceptable.

When carrying out the detailed design of the treatment plant, a sludge disposal plan must be prepared whose objectives are: (i) to identify the land where the sludge can be disposed of, (ii) to define the frequency of land application and (iii) the quantity of sludge to be applied each time. The area where the sludge will have to be stored must also be defined. The sludge disposal plan should also take into account the type of crops and the soil characteristics.

Mitigation Measures and Recommendations

The sludge from the treatment plant should be disposed of in an environmentally acceptable manner. The sludge should be dewatered in sludge drying beds and the dried sludge be used as fertilizers in the nearby irrigation land since it is biological in nature and has soil quality enhancing properties.

Nuisance of insects can be minimized by spraying insecticides on sludge drying beds, also by proper maintenance of sludge drying beds and proper drainage. The following

precautions should be taken in the treatment, handling and disposal of the sludge:

(i) to rake the wet sludge frequently and remove dried sludge immediately and frequently,
(ii) to facilitate proper drainage to avoid stagnant water leading to mosquito breeding,
(iii) to store the dry sludge in a covered place before its distribution to farmers,
(iv) to develop a green belt all around treatment plant, especially around sludge drying beds to reduce odour nuisance,
(v) to take care that the operators handling the sludge are properly clothed with gloves and gum boots and will not handle the sludge with bare hands.

Monitoring of the quality of the sludge is required, especially the monitoring of the presence of heavy metals in the sludge. The sludge should not contain non-degradable materials.

The effectiveness of the sludge production for agricultural/vegetation use is not constant to any crops. Use of the sludge production in the region must be done with soil observation of its effect to avoid negative effects to crops. After the observation period, recommended method of the use should be established and the local farmer be educated. The paramenters that should be monitored are Zinc, Copper, Total Carbon, Total Nitrogen, Phosphates and pH.

Use of the sludge must be done strictly under the continuous monitoring of sludge contents especially with respect to toxic substances.

5) Odour Production

Impacts
There is a possibility of bad smell in the case of anaerobic UASB and aerated lagoons proposed. However, the impact will be lower since the plant is located outside the residential areas of Varanasi city.

Mitigation Measures and Recommendations
As stated above, the following mitigation measures should be taken to minimize odour problems although the impact is minimal because the STP is not located in urban area.

(i) to rake the wet sludge frequently and remove dried sludge immediately and frequently
(ii) to develop a green belt all around treatment plant, especially around sludge drying beds to reduce odour nuisance

6) Worker's and Public Health

Impacts
Even though the sewage treatment plant will be useful to improve the health of the citizens, it may not be so in regard to the health of the workers who are operating the plant. In the operation phase of the sewage treatment plant, care needs to be taken for the workers' health. The workers may suffer from diseases like, malaria and respiratory diseases. The impact on their health would be adverse and significant. The workers should be provided with safety equipments for safe handling of the sewage treatment plant - sewage and sludge - and must be instructed in their use. This will reduce the chances of adverse health effects on the workers during plant operations. Adequate medical help should also be provided.

Similarly, the farmers will also have to be protected against infections, and to handle the sludge, special equipments should be made available and they should be educated on how to use these equipments.

Sewage sickness can be encountered in the use of raw or settled sewage but this negative effect is considerably reduced when an appropriate treatment is proposed for irrigation re-use.

Mitigation Measures and Recommendations

The workers' health should be monitored with medical check-ups at the time of joining and thereafter annually. In between, in case of any complaints, respiratory ailments, accidental chlorine leakage, etc., medical check-up should be conducted.

All the workers should be trained in first aid practices and emergency medical help should be available round the clock. It is also recommended from the safety point of view that one officer of the managerial cadre is available on duty at all times.

3.6.4 Risk Analysis and Mitigation Plan

(1) General

The sewerage project comprises of sewer laying, construction of sewage pumping stations and treatment plant and their operation. The risk involved in laying the sewers is mainly for large diameter pipelines, which require lifting by cranes. The risk of mechanical equipment failure and thereby occurrence of accidents cannot be overlooked.

Contingency measures/plans shall be prepared for:

(i) sewage treatment plant and pumping stations that could reasonably be expected to cause significant environmental impacts as a consequence of operational disruption (i.e. maintenance, etc. or breakdown);
(ii) accidents which may occur while laying sewers or during construction of the treatment works;
(iii) discharge of sub-standard wastewater into the environment from treatment plant which could cause a significant public health impact, and which therefore requires a continuous system of influent/effluent monitoring to identify potential problems as and when they arise.

In the preparation of the contingency measures:
the most likely causes of process disruption/breakdown have been identified;
an attempt has been made to estimate their probability of occurrence;
the possible resultant environmental adverse impacts are presented;
the recommended courses of action to minimise the severity of the impacts has been highlighted;
the responsible agency who will act in case of emergencies has been indicated.

The major risks, which can result in breakdowns and disruptions, are described below.

(2) Power Supply

One of the main reasons for disruption during the operation phase of the treatment plant and pumping stations is energy shortage. It is suggested that standby power generators and fuel are provided to ensure at least minimum services in case of power cuts.

(3) Electrical & Mechanical Equipment Disruptions

Operational disruption due to E&M equipment can be avoided by spare parts and stand-by provision available at site.

O&M instructions and manuals should be provided by the contractor of the treatment plant with training to the operation staff for the new plant.

3.7 ENVIRONMENTAL MANAGEMENT PLAN

3.7.1 Environmental Mitigation Plan

Environmental Management Plan (EMP) is the key to ensure a safe and clean environment. A plant/project may have taken proper pollution control measures but without a management plan to assure its proper function, the desired results may not be obtained. The present section on Environment Management Plan envisages the management plan, which is going to be adopted for the Project for the proper implementation of mitigation measures to reduce the adverse impacts arising out of the project activities.

The following issues have been addressed in the EMP:
- Mitigatory measures for abatement of the undesirable impacts caused during the construction and operation stage
- Details of management plan
- Institutional set up identified/recommended for implementation of the EMP
- Post project environmental monitoring programme to be undertaken after commissioning of the project
- Expenditures on environmental protection measures.

3.7.2 Mitigatory Measures

The major impacts due to different project activities and their mitigation measures have been identified in the previous sections. These measures together constitute part of Environmental Management Plan (EMP). The environmental mitigation measures for construction and operation phases have been given below:

(1) During Construction

The impacts of the construction phase on the environment would be basically of transient nature and are expected to wear out gradually on completion of the construction programme. However, once the construction of the project is completed and its operation started, the operation stage impacts would overlap the impacts due to the construction activities.

The impacts in different aspects of environment due to the construction programmes have been elucidated earlier. In order to mitigate such impacts and restrict them within tolerable levels, the following measures shall be adopted:

- Proper and prior planning of approach and access roads, and appropriate sequencing and scheduling of all major construction activities
- Identification of infrastructural supports needed for the construction programme and ensuring their timely availability
- Adoption of appropriate soil conservation programme and its timely implementation at proposed sites
- Dust suppression measures such as regular sprinkling of water around vulnerable areas of the proposed construction sites from tankers or through installation of water sprinklers or any other suitable methods, to control fugitive dust during construction material handling/over hauling activities for proposed treatment plant
- Stringent construction material handling/overhauling procedures
- Control on construction wastewater within the construction area through suitable drainage system with traps for arresting the sediment load for its proposed disposal into the main natural

drainage system around the site
- Implementation of suitable disposal methods of sediment/construction debris in tune with the local conditions to avoid water logging at construction site
- Adequate safety measures complying with the occupational safety manuals to prevent accidents/hazards to the construction workers
- Provision of protective gears such as ear mufflers, etc. for construction personnel exposed to high noise levels and locating the temporary labour sheds for housing the construction labourers away from the construction site
- Provision of construction camps/housing facilities at designated and demarcated sites for all construction workers with the following amenities to meet requirements of the construction personnel:
    a) Adequate potable water supply
    b) Sanitary facilities such as dry pit latrines
    c) Solid waste collection and disposal system
    d) Primary health facilities at construction site
    e) Electrification and fuel for cooking
- Disposal of construction debris at designated place

(2) During Operation

The following environmental protection/mitigation measures shall be adopted during the operation stage of the project:

- Proper operation & maintenance of the STPs to adequately treat the wastewater to meet the effluent standards
- Proper disposal at appropriate place of solid wastes arrested in screen chamber of pumping stations & STPs to control pollution due to solid wastes
- Monitoring the waste water and treated wastewater quality
- Adequate safety measures complying with the occupational safety manuals to prevent accidents/hazards to the workers
- Providing suitable human management and stable working conditions in order to alleviate socio-economic unrest
- Undertaking all necessary pollution control measures to maintain the discharges within the prescribed/stipulated limits
- Maintaining tree plantations around the pumping stations and the periphery of the sewage treatment plant.

3.7.3 Environmental Management, Monitoring Plan, and Training

(1) Institutional Set Up

1) Key Players for Implementation of EMP

Varanasi Nagar Nigam/Jal Sansthan and Uttar Pradesh Jal Nigam (UPJN) would take care of proper operation and maintenance of the proposed treatment plant.

Ministry of Environment & Forests (MoEF), and State Pollution Control Board, Govt. of Uttar Pradesh, would help for sorting out various environmental issues arising out of the different project activities.

The problems arising out of the construction sites and labour camps are to be controlled by construction contractors. This includes provision of fuel wood to labourers and provision of proper sanitation facilities at the project site.

The responsibility of environmental management of the project during operation will lie mainly with Environmental Management Cell (EMC) at site, which will act as a coordinator for environmental matters.

2) Environmental Management Cell

The responsibility of environmental management of the project during operation would lie mainly with the Environmental Management Cell (EMC) at site, which would act as a coordinator for environmental matters and supervise the proper implementation of the EMP. This cell will act as a nodal agency for various groups at Project and Head Quarters as well as outside agencies like State Pollution Control Board and other Govt. Departments.

Functions of EMC:

- Co-ordination with Statutory bodies, various Departments, etc. in the Project activities and with Head Quarters, etc.
- Compliance with Statutory guidelines and Statutory requirements
- Obtaining consent letters from the State Pollution Control Board (SPCB)
- Post project environmental monitoring in and around the project
- Maintenance of environmental database, analysis of environmental data, preparation of reports, and transmission of reports to Statutory Authorities, Head Quarters, etc.
- Interactions for evolving and implementation of modification programmes to improve the efficiency of pollution control devices/systems.
- Environmental appraisal (internal) and environmental audit
- Follow-up of compensations
- To strengthen the public image in respect of social aspects and maintain good relationship with community in the vicinity
- Organizing environmental trainings, workshops, seminars, etc

A two-member team comprising of a Senior Environmental Scientist of the rank of an Executive Engineer, and a Junior Environmental Scientist of the rank of an Assistant Engineer would operate the cell. The Senior Environmental Scientist will head the EMC as Manager.

Senior Environmental Scientist will be responsible for:

- Overall responsibility of proper running of the EMC
- Reporting to the Project Director
- Environmental assessment and compliance at the project site during construction and operation stages
- Coordination and interaction with SPCB, MoEF and other related Govt. Departments/Agencies
- Procurement of equipment for pollution control & their testing
- Water supply and sanitation at the project site
- Looking after occupational safety and health aspects in absence of safety officer

Junior Environmental Scientist will be responsible for:

- Testing/monitoring of functions of the pollution control systems
- Environmental field monitoring and analysis during construction & operation
- Analysis of environmental data and preparation of reports

Regular training programmes will be organised to train up the project staff in various environmental and project related issues. Specialists from various fields of environment, health, and project safety would impart the training. The training would mainly focus on how to handle problem areas.

The monitoring and analysis of various environmental parameters and safety measures will be carried out as per the guidelines laid down by Government of Uttar Pradesh and Government of India.

The EMC, which is part of the project proponent, will regularly monitor the pollution during the construction and operation stages. The State Pollution Control Board (SPCB) will make occasional checks.

(2) Post Project Environmental Monitoring

It is imperative that the Project Authorities set up regular monitoring stations to assess the quality of the neighboring environment after the commissioning of the project. An environmental monitoring programme is important as it provides useful information and helps to:

- Verify the predictions on environmental impacts presented in this study,
- Assist in detecting the development of any unwanted environmental situation, and thus, provides opportunities for adopting appropriate control measures, and
- Identify the effectiveness of mitigative measures suggested in the EMP.

1) Monitoring Programme

After commissioning of the project, post project monitoring of environmental parameters will be carried out at regular intervals. The monitoring programme in different areas of the environment has been based on the findings of the impact assessment studies. The post project monitoring programme including areas, number and locations of monitoring stations, frequency of sampling and parameters to be covered is summarised in Table 3.45 and are elaborated in this section. The monitoring will be the responsibility of EMC.

Ambient air quality: Ambient air quality would be monitored for methane and sulphide gases, in order to compare and ensure that the ambient air quality is maintained within the stipulated limits.

Effluents: Quality of all effluents from the treatment plant would be monitored on a regular basis and the water quality at the disposal site would be monitored once in a month.

Table 3.45 Preliminary Post Project Environmental Monitoring Programme

Sr.	Parameter	Monitoring Location	Frequency
1	Air Quality: Methane, Hydrogen sulphide gas	STP at Sathwa and Existing STPs	Three consecutive days in a season for two seasons
2	Effluents: BOD, COD, DO, pH, Heavy metals etc.	From effluent discharge points	Daily (Once in a year for heavy metals)
3	Water quality: BOD, COD, DO, Heavy metals, Total coliform, Faecal coliform etc.	At effluent disposal points	Daily (Once in a year for heavy metals)
4	Water quality: BOD, COD, DO, Heavy metals, Total coliform, Faecal coliform etc.	In aquifer nearby Sathwa STP and existing STPs	Once in a season for two seasons
5	Sludge contents: Heavy metals etc.	Sludge	Twice in a year
6	Soil quality: Salinity	Agricultural land irrigated by effluent from STPs	Twice in a year

The post-operational monitoring programme and environmental affairs would be taken care of by a competent person nominated by the Plant Manager.

2) Institutional Set-up for Monitoring

The post operational monitoring programme will be under the supervision of the EMC at the project site. Monitoring can be got carried out by outside recognized laboratories.

(3) Other Related Aspects

1) Compensation

The project involves loss of agricultural lands. So proper compensation should be made to the owners of the lands.

Compensation for loss of lands during construction of the treatment plant: 100% compensation to be paid for the agricultural & homestead land decided by Competent Authority at the time of construction of the treatment plant.

Compensation for demolition of houses during construction of treatment plant (if any): 100% compensation to be paid for houses at the proposed site as decided by Competent Authority at the time of construction of the treatment plant.

2) Legal and Statutory Compliance

All the environmental standards/stipulations should be fully complied with. The plant has to obtain yearly Consent from the State Pollution Control Board for liquid and gaseous wastes disposal as per Water (Prevention & Control of Pollution) Act and Air (Prevention & Control of Pollution) Act. It should be supervised that all requirements under these Acts and Rules are met, and if not met, the satisfactory explanations for it are sought. The officer in charge for environmental aspects should prepare these reports.

3) Documentation and Quality Assurance

All the monitoring data, environmental and safety & health related, should be stored in systematic manner so that the specific records are easily available whenever required. A quality assurance plan should be developed that includes all reference methods for

monitoring, relevant analytical techniques, calibration of equipments, standard of reagents, collection and presentation of results, frequency of monitoring, etc.

4) Information Dissemination and Public Relations

Everybody nowadays is concerned about environment. It is needed that people should be provided with environmental data related to the plant so that wrong apprehensions can be removed. This requires a well-planned public relations and information dissemination process so that unnecessary public interventions are avoided. This can be done through organizing different programmes with participation from local bodies, encouraging local community in environmental projects (like tree plantation), etc. The Management should be entrusted with all these responsibilities.

(4) Occupational Health & Safety Measures

In large projects, where multifarious activities are involved during construction, erection, testing, commissioning, operation & maintenance, the men, materials and machines are the basic inputs. And this may bring several problems for occupational health & safety (OHS). The project planner, therefore, has to properly plan and take the steps to minimize the impacts of accidents to ensure appropriate occupational health & safety.

The occupational health problems envisaged in this case in construction stage can mainly be due to noise and accidents. The problems of occupational health, in the operation and maintenance phase are due to accidents. To overcome these hazards following occupation health & safety measures will be undertaken:

- Arrangements will be made to reduce noise levels within limit.
- Suitable personnel protective equipment/gears shall be supplied to workers.
- First aid facilities will be provided.
- Safety training will be provided regularly.

Personnel Protective Equipment:

The workers will be given the following suitable personnel protective equipment while working in high noise and hazard prone areas:

1. Industrial safety helmets/Crash helmets
2. Face shield/Welders equipment for eye & face protection
3. Goggles
4. Ear plugs/Ear muffs
5. Gas masks/Breathing apparatus
6. Safety suits
7. Safety belts
8. Hand gloves
9. Gum boots/Safety shoes

Medical Facilities:

First aid facilities will be provided to treat the affected people as and when need arises or to shift the injured to the nearby hospitals in case of any trauma. Nearby hospital facilities will also have to be available round the clock for attending emergency arising out of accidents, if any. All working personnel will be medically examined prior to their employment.

Safety Officer:

Every contractor shall employ one safety officer to ensure safety of the workers. The responsibilities of the safety officer shall include identification of the hazardous conditions and unsafe acts of workers and advise on corrective actions, provide safety training to labourers and provide professional expert advice on various issues related to occupational safety & health. The safety officer shuold also see compliance of safety rules/statutory provisions. The contractors will be forced to follow safety rules to ensure safety to all construction workers.

(5) Environmental Training

The Environmental Monitoring Plan will be successful only if it is implemented by trained and skilled staff. The training of the qualified staff should be necessary not only in day-to-day operation and maintenance of the treatment plants, but also in environmental aspects. National Environmental Engineering Research Institute, NEERI, Nagpur, and Pollution Central Boards conduct training courses for environmental management which will increase the capabilities of the staff in the Environmental Management Cell to execute independent plans for environmental management.

The training should include:

1. Basic concepts of pollution control techniques in the various methods of sewage treatment,
2. Operation and maintenance of the sewage treatment plants,
3. Emergency preparedness to handle adverse situations,
4. Principles of wastewater analysis,
5. Other environmental monitoring techniques,
6. Development of green belt and its maintenance,
7. Sewage farming,
8. Communication with farmers and general public.

This training is different from the mandatory training required for operation and maintenance of the sewagewater treatment plants.

3.8 CONCLUSIONS

The project will have beneficial impacts in terms of reduction of pollution load in Ganga river in the region with incidental benefits like irrigation by effluent from Sathwa STP, and employment opportunities particularly in the construction stage.

Based on the findings of the EIA Study, followings are the possible critical areas for project implementation:

- Impact of land acquisition for Sathwa STP site
- Impact of operation of STP including reuse of treated water and dried sludge
- Impact due to disruption of operation of STPs and PSs (power cut and mechnical and electrical accident)

To properly address these impacts and mitigate and avoid the same, Environmental Management Cell (EMC) shall be set up and a detailed Environmental Management Plan shall be prepared for implementation.

CHAPTER 4

COST ESTIMATION AND IMPLEMENTATION PROGRAMME

CHAPTER 4 COST ESTIMATION AND IMPLEMENTATION PROGRAMME

4.1 CAPITAL COST ESTIMATION OF THE PRIORITY PROJECTS

Cost estimates for various works are worked out on the basis of prevailing Schedule of Rates and market rates. Rates for land acquisition are obtained from Finance and Revenue Department, Govt. of Uttar Pradesh. All the figures are in Rs.

Unit prices for the estimate of capital costs are, in principle, derived from the list of prices provided by UPJN. However, prices not provided by UPJN are calculated using Varanasi rates on the basis of Delhi Schedule of Rates taking localities and deflator into account. Furthermore, prices of items such as sewer pipes, reinforcing steel bars, manhole covers and so on that are not found in UPJN Schedule or DSR are obtained by quotation. The following are cost estimation conditions.

1) The rates assumed for major civil works are based on UPJN Schedule of Rates for Varanasi and market rates.
   - To apply schedule of rates provided by UPJN in principle.
   - For rates of items not provided by UPJN, to use modified rates based on Delhi Schedule of Rates.
   - To use market prices for items not available in (1) and (2).
2) Costing of electrical equipment is based on the price list of standard suppliers.
3) Costing of the pump houses is based on actual quantities worked out from preliminary design.
4) Costing of pumps and motors is based on the price of reputed suppliers, and other facilities like screens, pipes, valves etc. are based on prevailing market rates.
5) Current market rates have been considered for pipes, reinforcement steel, structural steel and specialized items like geo-synthetics etc.
6) For STPs based on UASB technology, costs have been calculated on the basis of preliminary design of process units.
7) Physical contingencies: 5% of capital cost
8) Engineering costs (detailed design (6%) and project management (5%)): 11 % of capital cost
9) Project administration: 5 %, including the cost of "Environment Monitoring Plan", which is discussed in the section on Environmental Impact Assessment.

The capital costs of each component are provided in the relevant Chapters and the abstract of cost estimation is shown in Table 4.1.

4.2 IMPLEMENTATION PROGRAMME

In the F/S, a detailed list of the works identified for implementation of the priority projects has been provided.

The implementation programme for the priority projects in Varanasi has been prepared considering the following assumptions (Table 4.2).

1) Necessary technical and financial sanctions and inter government agreement (between Japanese Government and Indian Government) shall be finalised within 2005.
2) Process of appointment of Project Management Consultant for the project shall start by August 2005 by NRCD, Ministry of Environment and Forests, Government of India.
3) Appointment of consultants for detailed engineering and preparation of detailed project reports and tender documents for project component shall be completed within 2006.
4) Actual execution of various priority project components shall start from 2007.
5) During execution, various project components shall be executed in parallel.
6) UPJN, Lucknow, will acquire 100 % of the land required for construction of proposed

sewage treatment plants and pumping stations before the commencement of tendering.

4.3 OPERATION & MAINTENANCE COST ESTIMATION

The following is the summary of the basis of preliminary estimation of operation & maintenance (O&M) cost for the proposed sewerage system.

(1) Estimation Conditions

1) Sewers and rising mains

- Annual maintenance cost of trunk sewers: @ 0.5% of capital cost (New & Replacement)
- Annual maintenance cost of rising mains: @ 0.25% of capital cost
- Annual maintenance cost of branch sewers: @ 0.5% of capital cost
- Annual operation cost: manpower cost
- Manpower cost - As per actual salaries and proposed staff requirement *1
- The capital cost of existing and sanctioned sewers is estimated based on unit cost of proposed facilities or Master Plan (M/P).

2) Pumping stations

- Power cost (required power) - Rs. 3.25 per unit
- Diesel cost (for power cut) - As per market rate
- Annual power cost is estimated based on average flow
- Maintenance of civil works: @ 1.5% of capital cost of civil works
- Maintenance of mechanical & electrical (M&E) works: @ 3% of capital cost of M&E works
- Manpower cost - As per actual salaries and proposed staff requirement *1
- The capital costs of existing and sanctioned PSs are estimated based on unit cost of proposed facilities or M/P.

3) Treatment plants

- Power cost (required power) - Rs. 3.25 per unit
- Gas power generator installed in the STP will be used during power cut
- Chemicals – actual cost
- Maintenance of civil works @ 1.5% of capital cost of civil works
- Maintenance of M&E works @ 3% of capital cost of M&E works
- Manpower cost - As per actual salaries and proposed staff requirement *1
- The capital costs of existing and sanctioned STPs are estimated based on unit cost of proposed facilities or M/P.

Note: *1 The manpower requirement of O&M for sewers, pumping stations and treatment plants for 2015 is proposed in the PART IV of VOLUME IV-4, Institutional Development Programme.

(2) Facilities Considered for O&M Cost Estimation

The O&M costs of all facilities including existing, sanctioned and proposed facilities are estimated.

(3) Power Supply Conditions

The O&M costs in following two cases in terms of power supply conditions are estimated.

- Operation by power from grid (24 hours a day)
- Operation by power from grid (20 hours a day) and diesel (4 hours)

(4) Estimation Results

Table 4.3 presents annual O&M costs of all major facilities including existing, sanctioned and proposed facilities for 2015 and the following table summarises annual O&M costs for 2015.

Summary of Annual O&M Costs in 2015 (Varanasi)

(1,000 Rs./year)

Facility	Case-1 Grid Power Supply	Case-2 Grid Power Supply Supplemented by Diesel
(1) Sewers and Rising Mains	15,825	15,825
(2) Pumping Stations	78,351	138,803
(3) Sewage Treatment Plants	83,205	83,205
Total	177,382	237,834

Note: The O&M cost includes all major existing, sanctioned and proposed facilities.

Table 4.1 Summary of Estimated Sewerage Project Cost

	Capital Cost (Rs.)	Contingencies	Detail Design	Supervision	Project Administration	Total Cost (Rs.)	Land Acquisition (Rs.)	Total Project Cost (Rs.)
		5%	6%	5%	5%			
Assi Nala Interceptor Sewer								
1) Construction of Assi Interceptor	296,683,000	14,834,000	17,800,000	14,834,000	14,834,000	358,985,000		358,985,000
2) Construction of Nakhha and Samne Ghat Interceptor	28,389,000	1,419,000	1,703,000	1,419,000	1,419,000	34,349,000		34,349,000
3) Construction of Secondary Sewer	146,706,000	7,335,000	8,802,000	7,335,000	7,335,000	177,513,000		177,513,000
Varuna River Interceptor Sewer & Sathwa STP Sewer	0							
4) Construction of Varuna River Interceptor Sewer	495,470,000	24,773,000	29,728,000	24,773,000	24,773,000	599,517,000		599,517,000
5) Extension of Relief Trunk Sewer	250,000,000	12,500,000	15,000,000	12,500,000	12,500,000	302,500,000		302,500,000
6) Construction of Secondary Sewer	78,121,000	3,906,000	4,687,000	3,906,000	3,906,000	94,526,000		94,526,000
Pumping Stations	0							
7) Construction of Sathwa MPS	221,197,000	11,059,000	13,271,000	11,059,000	11,059,000	267,645,000		267,645,000
8) Construction of Chaukaghat Right Bank SPS	236,781,000	11,839,000	14,206,000	11,839,000	11,839,000	286,504,000	12,551,000	299,055,000
9) Construction of Chaukaghat Left Bank SPS	45,015,000	2,250,000	2,700,000	2,250,000	2,250,000	54,465,000	4,967,000	59,432,000
10) Construction of Narokhar Nala SPS	51,256,000	2,562,000	3,075,000	2,562,000	2,562,000	62,017,000	3,372,000	65,389,000
11) Construction of Pulwaria Nala SPS	29,903,000	1,495,000	1,794,000	1,495,000	1,495,000	36,182,000	3,620,000	39,802,000
12) Construction of Saraiya Nala SPS	22,478,000	1,123,000	1,348,000	1,123,000	1,123,000	27,195,000	1,592,000	28,787,000
Sathwa STP	0							
13) Construction of Sathwa STP	522,405,000	26,120,000	31,344,000	26,120,000	26,120,000	632,109,000	172,159,000	804,268,000
14) Lining for existing irrigation canal and treated water channel	135,800,000	6,790,000	8,148,000	6,790,000	6,790,000	164,318,000		164,318,000
Old Trunk Sewer Rehabilitation Work	0							
15) Detailed Investigation of Old Trunk Sewer	4,315,000	215,000	258,000	215,000	215,000	5,218,000		5,218,000
16) Rehabilitation Work of Old Trunk Sewer	608,146,000	30,407,000	36,488,000	30,407,000	30,407,000	735,855,000		735,855,000
Ghat PS Rehabilitation Works	0							
17) Rehabilitation Work of Trilochan Ghat PS	8,052,000	402,000	483,000	402,000	402,000	9,741,000		9,741,000
18) Rehabilitation Work of Harsichandra Ghat PS	4,959,000	247,000	297,000	247,000	247,000	5,997,000		5,997,000
19) Rehabilitation Work of Jalesan Ghat PS	5,153,000	257,000	309,000	257,000	257,000	6,233,000		6,233,000
20) Rehabilitation Work of Dr. R.P. Ghat PS	19,506,000	975,000	1,170,000	975,000	975,000	23,601,000		23,601,000
21) Rehabilitation Work of Mansarovar Ghat PS	4,074,000	203,000	244,000	203,000	203,000	4,927,000		4,927,000
Existing Sewage Treatment Renov/Rehab. Works	0							
22) Rehabilitation Work of Konia MPS	9,870,000	493,000	592,000	493,000	493,000	11,941,000		11,941,000
23) Rehabilitation Work of Dinapur STP	29,765,000	1,488,000	1,785,000	1,488,000	1,488,000	36,014,000		36,014,000
24) Rehabilitation Work of Bhagwanpur STP	8,321,000	416,000	499,000	416,000	416,000	10,068,000		10,068,000
Total	**3,262,365,000**	**163,108,000**	**195,731,000**	**163,108,000**	**163,108,000**	**3,947,420,000**	**198,261,000**	**4,145,681,000**

Table 4.2 Implementation Schedule of Sewerage Priority Project (Varanasi)

(Unit: Rs.)

Project	Capital Cost	Detailed Design	Total Project Cost	2006	2007	2008	2009	2010	2011
Assi Nala Interceptor Sewer				Capital and Detailed Design Cost Schedule					
1) Construction of Assi Interceptor	296,683,000	17,800,000	358,985,000	17,800,000	59,337,000	59,337,000	59,337,000	89,005,000	29,667,000
2) Construction of Nakhha and Samne Ghat Interceptor	28,389,000	1,703,000	34,349,000	1,703,000	5,678,000	5,678,000	5,678,000	8,517,000	2,838,000
3) Construction of Secondary Sewer	146,706,000	8,802,000	177,513,000		8,802,000	29,341,000	29,341,000	29,341,000	58,683,000
Varuna River Interceptor Sewer & Sathwa STP Sewer									
4) Construction of Varuna River Interceptor Sewer	495,470,000	29,728,000	599,517,000	29,728,000	99,094,000	99,094,000	99,094,000	148,641,000	49,547,000
5) Extension of Relief Trunk Sewer	250,000,000	15,000,000	302,500,000	15,000,000	125,000,000	125,000,000			
6) Construction of Secondary Sewer	78,121,000	4,687,000	94,526,000		4,687,000	15,624,000	15,624,000	15,624,000	31,249,000
Pumping Stations									
7) Construction of Sathwa MPS	221,197,000	13,271,000	267,645,000	13,271,000	44,239,000	44,239,000	44,239,000	66,359,000	22,121,000
8) Construction of Chaukaghat Right Bank SPS	236,781,000	14,206,000	299,055,000	14,206,000	47,356,000	47,356,000	47,356,000	71,034,000	23,679,000
9) Construction of Chaukaghat Left Bank SPS	45,015,000	2,700,000	59,432,000	2,700,000	9,003,000	9,003,000	9,003,000	13,505,000	4,501,000
10) Construction of Narokhar Nala SPS	51,256,000	3,075,000	65,389,000	3,075,000	10,251,000	10,251,000	10,251,000	15,377,000	5,126,000
11) Construction of Pulwaria Nala SPS	29,903,000	1,794,000	39,802,000	1,794,000	5,981,000	5,981,000	5,981,000	8,971,000	2,989,000
12) Construction of Saraiya Nala SPS	22,478,000	1,348,000	28,787,000	1,348,000	4,496,000	4,496,000	4,496,000	6,743,000	2,247,000
Sathwa STP									
13) Construction of Sathwa STP	522,405,000	31,344,000	804,268,000	31,344,000	104,481,000	104,481,000	104,481,000	156,722,000	52,240,000
14) Lining for existing irrigation canal and treated water channel	135,800,000	8,148,000	164,318,000	8,148,000	67,900,000	67,900,000			
Old Trunk Sewer Rehabilitation Work									
15) Detailed Investigation of Old Trunk Sewer	4,315,000	258,000	5,218,000	4,573,000					
16) Rehabilitation Work of Old Trunk Sewer	608,146,000	36,488,000	735,855,000	36,488,000	152,037,000	152,037,000	152,037,000	152,035,000	
Ghat PS Rehabilitation Works									
17) Rehabilitation Work of Trilochan Ghat PS	8,052,000	483,000	9,741,000	483,000	4,026,000	4,026,000			
18) Rehabilitation Work of Harsichandra Ghat PS	4,959,000	297,000	5,997,000	297,000	2,480,000	2,479,000			
19) Rehabilitation Work of Jalesan Ghat PS	5,153,000	309,000	6,233,000	309,000	2,577,000	2,576,000			
20) Rehabilitation Work of Dr. R.P. Ghat PS	19,506,000	1,170,000	23,601,000	1,170,000	9,753,000	9,753,000			
21) Rehabilitation Work of Mansarovar Ghat PS	4,074,000	244,000	4,927,000	244,000	2,037,000	2,037,000			
Existing Sewage Treatment Renov/Rehab. Works									
22) Rehabilitation Work of Konia MPS	9,870,000	592,000	11,941,000	592,000	4,935,000	4,935,000			
23) Rehabilitation Work of Dinapur STP	29,765,000	1,785,000	36,014,000	1,785,000	14,883,000	14,882,000			
24) Rehabilitation Work of Bhagwanpur STP	8,321,000	499,000	10,068,000	499,000	4,161,000	4,160,000			
Total	3,262,365,000	195,731,000	4,145,681,000	186,557,000	793,194,000	824,666,000	586,918,000	781,874,000	284,887,000

(Unit: Million Rs.)

Items		Total	2006	2007	2008	2009	2009	2010
Capital Cost		3,262.37	4.31	779.71	824.67	586.92	781.87	284.89
Detailed Design		195.73	182.24	13.49	0.00	0.00	0.00	0.00
Contingencies		163.11	0.22	38.99	41.23	29.34	39.09	14.24
Supervision		163.11	0.22	38.99	41.23	29.34	39.09	14.24
ProjectAdmin		163.11	0.22	38.99	41.23	29.34	39.09	14.24
Total Cost		3,947.43	187.21	910.17	948.36	674.94	899.14	327.61
Land Acquisition		198.26	198.26	0.00	0.00	0.00	0.00	0.00
Total Project Cost		4,145.69	385.47	910.17	948.36	674.94	899.14	327.61

Detaied Design
Construction Cost

Table 4.3 Operation and Maintenance Cost Estimation

									Power condition : Grid power supply (24 hours a day)					Power Condition : Grid power (20 hours a day) and diesel power (4 hours) supply						Assumptions and Conditions for Estimation	
		Status	Sewerage District	Ave. Capacity at 2015 (mld)	Diameter (mm)	Length (m)	Unit Cost (Rs./m)	**Capital Cost (Thousand Rs.)**	Staff Cost (Thousand Rs. /year)			**Maintenance Cost (Thousand Rs.)**	**Total O&M Cost (Thousand Rs. /year)**	Staff Cost (Thousand Rs. /year)[1]				**Maintenance Cost (Thousand Rs.)**	**Total O&M Cost (Thousand Rs. /year)**	Basis of Capital Cost	Basis of Maintenance Cost
1	**Trunk Sewer**																				
	Existing/Rehabilitation (Old Trunk sewer)	E	1		800-2400	7,172	see relevant part	254,056				1,270	1,270					1,270	1,270	M/P Unit cost base	@ 0.5 %
	Existing (Relief Trunk Sewer, District 2)	S/P	2		600-2000	7,950	see relevant part	348,707				1,744	1,744					1,744	1,744	M/P Unit cost base	@ 0.5 %
	Proposed (Varuna River interceptor)	P	2		500-2400	10,905		495,471				2,477	2,477					2,477	2,477	F/S estimate	@ 0.5 %
	Proposed (Secondary Trunk Sewer, District 2)	P	2		300-700	12,370		78,122				391	391					391	391	F/S estimate	@ 0.5 %
	Proposed (Assi Nala Interceptor)	P	3		600-1200	5,170		92,683				463	463					463	463	F/Sestimate (except trenchless)	
	Proposed (Nakhha Nala Interceptor)	P	3		400-500	1,955		28,390				142	142					142	142	F/S estimate	
	Proposed (Secondary Trunk Sewer, District 3)	P	3		300-400	1,620		10,706				54	54					54	54	F/Sestimate (except trenchless)	
	Sub Total					**47,142**		**1,308,135**				**6,541**	**6,541**					**6,541**	**6,541**		
2	**Branch Sewer**																	0			
	District 1		1	(1,022 ha x 80% x 385 m/ha)		314,776	1,000	314,776				1,574	1,574					1,574	1,574	M/P Unit cost base	@ 0.5 %
	District 2 (Zone 2A)		2	(1,451 ha x 50% x 385 m/ha)		279,317	1,000	279,317				1,397	1,397					1,397	1,397	M/P Unit cost base	@ 0.5 %
	District 2 (Zone 2B)		2	(686 ha x 40% x 385 m/ha)		105,644	1,000	105,644				528	528					528	528	M/P Unit cost base	@ 0.5 %
	District 3 (Zone 3)		3	(1,382 ha x 70% x 385 m/ha)		372,449	1,000	372,449				1,862	1,862					1,862	1,862	M/P Unit cost base	@ 0.5 %
	Sub Total					**1,072,186**		**1,072,186**				**5,361**	**5,361**					**5,361**	**5,361**		
3	**Rising Main**																	0			
	From Trilochan Ghat PS	E	1		300	500	8,016	4,008				10	10					10	10	M/P Unit cost base	@0.25%
	From Harisichandra Ghat PS	E	1		200	500	8,016	4,008				10	10					10	10	M/P Unit cost base	@0.25%
	From Jalesan Ghat PS	E	1		250	500	8,016	4,008				10	10					10	10	M/P Unit cost base	@0.25%
	From Dr. R.P. Ghat PS	E	1		600	500	9,327	4,664				12	12					12	12	M/P Unit cost base	@0.25%
	From Mansarovar Ghat PS	E	1		400	500	8,016	4,008				10	10					10	10	M/P Unit cost base	@0.25%
	From Konia PS (1)	E	1		1200	500	15,142	7,571				19	19					19	19	M/P Unit cost base	@0.25%
	From Konia PS (2)	E	1		900	500	11,530	5,765				14	14					14	14	M/P Unit cost base	@0.25%
	From Chakaghat PS (Right)	P	2		1800	1,200		30,771				77	77					77	77	F/S estimate	@0.25%
	From Chakaghat PS (Left)	P	2		600	1,000		7,795				19	19					19	19	F/S estimate	@0.25%
	From Narokhar Nala PS	P	2		600	1,600		12,428				31	31					31	31	F/S estimate	@0.25%
	From Pulwaria Nala PS	P	2		400	1,620		6,634				17	17					17	17	F/S estimate	@0.25%
	From Saraiya Nala PS	P	2		350	1,100		4,540				11	11					11	11	F/S estimate	@0.25%
	From Sathwa PS to STP	P	2		1400	80		1,059				3	3					3	3	F/S estimate	@0.25%
	From Assi Nala PS	E	2		400	500	8,016	4,008				10	10					10	10	M/P Unit cost base	@0.25%
	From Nagwa PS	S	3		600	2,300	9,327	21,452				54	54					54	54	M/P Unit cost base	@0.25%
	Sub Total					**12,900**		**122,719**				**307**	**307**					**307**	**307**		
	Total					**1,132,228**		**2,503,040**				**12,208**	**12,208**					**12,208**	**12,208**		
									3,617				**15,825**	**3,617**					**15,825**	**See IDP report for staff cost**	

		Status	Sewerage District	**Ave. Capacity at 2015 (mld)**	Civil Cost (Thousand Rs.)	E & M Cost (Thousand Rs.)	Utility Cost (Thousand Rs.)	**Total Capital Cost (Thousand Rs.)**	Staff Cost (Thousand Rs. /year)	Power Cost (Thousand Rs. /year)	Chemical Cost (Thousand Rs. /year)	**Maintenance Cost (Thousand Rs. /year)**	**Total O&M Cost (Thousand Rs. /year)**	Staff Cost (Thousand Rs. /year)[1]	Power Cost (Thousand Rs. /year)	Chemical Cost (Thousand Rs. /year)	Diesel Cost (Thousand Rs. /year)	**Maintenance Cost (Thousand Rs. /year)**	**Total O&M Cost (Thousand Rs. /year)**	Basis of Capital Cost	Basis of Maintenance Cost
4	**Pumping Station**																				
	Trilochan Ghat PS	E/R	1	6.5	5,083	13,824	0	18,907		863	0	491	1,354		719	0	675	491	1,885	Purwaria PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Harisichandra Ghat PS	E/R	1	7.1	5,552	15,100	0	20,652		943	0	536	1,479		785	0	738	536	2,059	Purwaria PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Jalesan Ghat PS	E/R	1	3.3	5,012	9,788	0	14,800		350	0	369	719		292	0	1,071	369	1,732	Saraiya PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Dr. R.P. Ghat PS	E/R	1	22.3	17,439	47,427	0	64,865		2,960	0	1,684	4,645		2,467	0	2,316	1,684	6,468	Purwaria PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Mansarovar Ghat PS	E/R	1	2.2	3,341	6,525	0	9,866		234	0	246	480		195	0	714	246	1,154	Saraiya PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Konia PS (1st Stage)	E/R	1	80	40,665	81,414	0	122,079		6,041	0	3,052	9,094		5,034	0	9,844	3,052	17,931	Chaukaghat (R) PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Konia PS (2nd Stage)	E/R	1	80	40,665	81,414	0	122,079		6,041	0	3,052	9,094		5,034	0	9,844	3,052	17,931	Chaukaghat (R) PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Chaukaghat Right Bank PS	P	2	135	68,623	137,386	0	206,009		10,195	0	5,151	15,346		8,496	0	16,612	5,151	30,258	F/S estimate	@1.5% of civil, 3.0% of E&M
	Chaukaghat Left Bank PS	P	2	14	13,835	23,385	0	37,220		1,062	0	909	1,971		885	0	1,298	909	3,092	F/S estimate	@1.5% of civil, 3.0% of E&M
	Narokhar Nala PS	P	2	14	12,810	26,019	0	38,829		1,062	0	973	2,035		885	0	1,298	973	3,156	F/S estimate	@1.5% of civil, 3.0% of E&M
	Pulwaria Nala PS	P	2	8	6,256	17,014	0	23,270		1,062	0	604	1,666		885	0	831	604	2,320	F/S estimate	@1.5% of civil, 3.0% of E&M
	Saraiya Nala PS	P	2	4	6,075	11,864	0	17,939		425	0	447	872		354	0	1,298	447	2,099	F/S estimate	@1.5% of civil, 3.0% of E&M
	Sathwa MPS	P	2	200	60,113	160,024	0	220,137		11,469	0	5,702	17,171		9,558	0	16,612	5,702	31,872	F/S estimate	@1.5% of civil, 3.0% of E&M
	Nagwa Nala PS	S	3	40	20,333	40,707	0	61,040		3,021	0	1,526	4,547		2,517	0	4,922	1,526	8,965	Chaukaghat (R) PS F/S cost base	@1.5% of civil, 3.0% of E&M
	Sub Total				**285,470**	**631,183**	**0**	**916,653**		**45,727**	**0**	**24,744**	**70,471**		**38,106**	**0**	**68,073**	**24,744**	**130,923**		
									7,880				**78,351**	**7,880**					**138,803**	**See IDP report for staff cost**	
5	**Treatment Plant**																	0			
	Dinapur STP (ASP)	E	1	80	129,600	86,400	0	216,000	7,207	17,833	1,200	4,536	30,776	7,207	17,833	1,200	-	4,536	30,776	M/P Unit cost base	@1.5% of civil, 3.0% of E&M
	Sathwa STP (UASB)	P	2	200	587,167	55,181	15,858	658,206	8,184	17,922	2,976	10,463	39,545	8,184	17,922	2,976	-	10,463	39,545	F/S estimate	@1.5% of civil, 3.0% of E&M
	Bagwanpur STP (UASB)	E	3	8	23,487	2,207	634	26,328	3,749	717	-	419	4,884	3,749	717	-	-	419	4,884	Sathwa STP F/S cost base	@1.5% of civil, 3.0% of E&M
	Ramuna STP (WSP)	S	3	37	218,788	23,872	0	242,661	1,782	2,220	-	3,998	8,000	1,782	2,220	-	-	3,998	8,000	Numaya Dahi STP F/S cost base	@1.5% of civil, 3.0% of E&M
	Sub Total				**959,042**	**167,661**	**16,492**	**1,143,195**	**20,922**	**38,692**	**4,176**	**19,415**	**83,205**	**20,922**	**38,692**	**4,176**	**0**	**19,415**	**83,205**		
	Total				**1,244,512**	**798,844**	**16,492**	**2,059,848**	**28,802**	**84,419**	**4,176**	**44,159**	**161,556**	**28,802**	**76,798**	**4,176**	**68,073**	**44,159**	**222,008**		
	Grand-Total							4,562,888	32,419	84,419	4,176	56,368	177,382	32,419	76,798	4,176	68,073	56,368	237,834		

Note:
(1) See Institutional Development Programme (ID) report for Manpower (Staff) Cost.
E: Existing, S: Sanctioned, P: Proposed, A: Proposed augementation

Appendix A

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APPENDIX A
PROCESS OF LAND ACQUISITION

LAND ACQUISITION ACT

Land is normally acquired under the provisions of the Land Acquisition Act, 1894 that is general and basic law in the country for the acquisition of land for public purposes and companies. This Act was comprehensively amended in the year 1984, taking into consideration the recommendations of the Law Commission, the Land Acquisition Review Committee, headed by Justice A. N. Mulla, as well as suggestions from the state governments and other quarters.

The Conference of the Revenue Secretaries of States (July 1989) have also made recommendations that all land should be acquired under the provisions of the Land Acquisition Act, 1894 and other laws repugnant thereto should be brought in line with it or repealed altogether. However, these efforts have not met with success and a large number of laws, having different procedures and norms of compensation, continue to operate.

In view of the acknowledged superiority of the Land Acquisition Act, 1894 land is acquired under the provisions of this Act. The underlying principle governing the acquisition of land under the Land Acquisition Act, 1894 is that compensation alone is payable in lieu of deprivation. However, there is a provision under Section 31 (3) in the Land Acquisition Act for grant of land in lieu of money compensation.

LAND ACQUISITION PROCESS

In the table below, relevant sections of the LA Act, 1894 and the relevance of such sections in the land acquisition process has been given.

Table A.1 Summary of Land Acquisition Act, 1894

Relevant Sections	Description	Relation with the Project
3	Definition	-
4	Publication of preliminary notification and powers of officers thereupon	-
5	Payment for damage	Compensation for the damage done to the property during the course of surveying will be paid by the Project
5A	Hearing of Objections	Will be followed by the Project
6	Declaration that land is required for a public purpose	Declaration will be published in the Official Gazette and in two daily newspapers circulating in the locality where the land is situated of which at least one shall be in the regional language. Project Authority through concerned Collector/District Magistrate (DM) will cause public notice of the substance of the declaration at convenient places in the locality.
7	After declaration, Collector/(DM) to take order for acquisition	Will be followed by the Project
8	Land to be marked out, measured and planned	Will be followed by the Project
9	Notice to persons interested	Will be followed by the Project
10	Powers to require and enforce the making of statements as to names and interests	Will be followed by the Project
11	Enquiry into measurements, value and claims and award by Collector	Project to make use of "The Uttar Pradesh Land Acquisition (Determination of Compensation and Declaration of Award

Relevant Sections	Description	Relation with the Project
		by Agreement) Rules, 1997"
12	Award of Collector when to be final	Will be guided by provision made in "The Uttar Pradesh Land Acquisition (Determination of Compensation and Declaration of Award by Agreement) Rules, 1997"
13A	Correction of Clerical Errors, etc.	Will be followed by the Project
16	Power to take possession	Will be followed by the Project
17	Special powers in cases of urgency	May not be required in the Project
18	Reference to court	May not be required, as Project, will follow "The Uttar Pradesh Land Acquisition (Determination of Compensation and Declaration of Award by Agreement) Rules, 1997".
23	Matters to be considered in determining compensation	May not be required, as Project, will follow "The Uttar Pradesh Land Acquisition (Determination of Compensation and Declaration of Award by Agreement) Rules, 1997".
24	Matters to be neglected in determining compensation	May not be required, as Project, will follow "The Uttar Pradesh Land Acquisition (Determination of Compensation and Declaration of Award by Agreement) Rules, 1997".

In private transaction the buyer and the seller negotiate the "price" of land between themselves. The seller is willing to sell. The buyer is willing to buy. The price offered and accepted is decided mutually and finally agreed upon. The level at which the price is fixed is determined based on the "market conditions".

Contrarily, in the acquisition of private lands by the state the landowner's consent and willingness is not necessarily (section 24) of the LA Act. The person will lose land even if he/she does not want to part with it. Secondly, while fixing the compensation amount the land owners' objections and opinions are heard (under section 9 and 11 of the LA Act), but it is not necessary that the amount quoted by him/her must be agreed to. The landowner thus has no control over his/her right of ownership or on the level of compensation. It may be said therefore that compensation is not a price.

Market Value

The Land Acquisition Act (u/s 23) stipulates that while determining compensation the "market value" prevailing on the date of preliminary notification (u/s 4(1)) should be taken into consideration. However, the Act or the Rules neither define "market value" not specify the mechanisms to fix the same.

Solatium

Acquisition of lands by the state is compulsory in nature. Such compulsion injures the feelings and causes inconvenience to the owners. The law therefore provide for the payment of mandatory "solatium". The percentage of solatium has varied from time to time. With effect from September 1984 when LA Act was amended, it is **30 percent** of the market value.

Additional Market Value

The reckoning date for ascertaining the market value is the date on which preliminary notification (u/s 4(1)) is published. Between this notification and actually taking possession of the land, ordinarily there will be a **time gap varying between three months to three years**. Retrofitting the market value as on the date of 4(1) notification would cause a great loss to the owner. The law therefore, provides for an **additional market value at the rate of 12 percent per annum** of the market value from the date of 4(1) notification till the date of award or taking possession which ever is earlier.

Interest

In case of delay, the law provides for payment of interest on the compensation. For the **first 12 months**, the interest at the rate of **9 percent** is payable from the date of the award. For delays **beyond 12 months** from the date of declaration of the award, **15 percent** is the rate of interest.

METHODS OF CALCULATING COMPENSATION

As said earlier, there is no fixed method of calculating compensation in the Act. However, the basic element in deciding the amount of compensation is the **market value (u/s 23)**. Within the framework of law, the courts have interpreted market value as the price that a willing purchaser would pay to a willing seller for a property giving due regard to its existing condition, with all its advantages and potential possibilities. It is however, not easy to precisely determine what should be the most accurate market value of a given property. The market conditions are never constant. The demand and supply factors vary enormously over a period of time and from place to place. The uniqueness of each property, its location, size, quality and possible potentialities need to be considered. With these constraints, different methods determining compensation are in vogue. Some of the methods are discussed here:

(1) Sale Statistics Method

Land being an immovable property, all its sales and purchases have to be registered. The registered sale prices can be taken as adequate indicator of market value of a given piece of land. Sale prices of those lands, which are comparable in time and quality, are only to be considered. Following steps are involved in calculating compensation according to sales statistics method.

Step1: Collect statistics of sales of land/buildings adjacent to ones being acquired in three to four years preceding 4(1) notification from Registration Department.
Step2: Workout average of 3 to 4 years per acre/hectare.
Step3: Average Price(AP) + 0.3 AP+0.12AP per annum from the date of 4(1) notification to date of award to arrive at compensation.
Step4: Add damages, if any or incidental, if any.
Step5: Calculate interest from date of award at 9% for first 12 months and 15% for the period thereafter.

(2) Capitalisation Method

Where reliable information is not available about the prevailing market value of the land, capitalisation method is used to decide compensation. Following steps are involved in calculating compensation according to capitalisation method.

Step1: Gross Income - Cost=Net Income
Step2: Net Income x Multiplier***** = Market Value
Step3: Market Value (MV) +30% of MV as solatium + 12% of MV per annum as Additional Market Value =Compensation
Step4: Compensation + Damages / incidental + interest
*****There are no fixed limits on the choice of the multiplier. It is based on conjectures or precedents. Generally, a multiplier of 10 to 12 is used for valuing non-irrigated land whereas 8 to 10 is deemed sufficient for irrigated lands. For buildings based on net rental income, a multiplier of 15 or 20 is used. In assessing the value of plantation or horticultural crops, generally a multiplier of 10 is acceptable.

(3) Expert Assessment

Assessment of value of certain horticultural crops, plantation crops, buildings, waterways, bunds, etc. requires special expertise. Professional valuers are used for valuing such immovable properties. Valuers take into account the longevity, health and expected yield levels while assessing income and standard practices along with the age. Experts use certain multipliers to arrive at a capitalized value

of the assets. The multiplier generally used relates to the remaining period in the longevity of the structures or remaining age of the crops or rental expected.

(4) Consent Award

Negotiated settlement of compensation stands on a footing different from those of other methods of deciding the market value of the acquired asset. The essential elements are:

that the landowners and the collector reach an agreement on the matter to be included in the compensation.
that the terms of such agreement form the basis of the award and no further enquiry is necessary
that other provisions of the Act do not apply to such awards.

The consent of landowner is essential to finalise such awards. Once consent is obtained it cannot be questioned at a later stage. This process comes very close to market mechanism, where in buyers and sellers negotiate the price. It also provides an opportunity to the landowners to participate in the process of determining compensation.

(5) Replacement Value

It is argued that the compensation awarded for the acquired land and other amenities, buildings, etc. should be adequate to enable purchase of comparable assets elsewhere by the affected people. In this direction, the proponents of rehabilitation emphasise that wherever compensation is not adequate enough to buy replacement lands/buildings, the project authorities must provide other topping up devices to overcome the shortfall.

A COMPARATIVE ANALYSIS OF ALL THE METHODS

All the five methods of assessing market value of acquired lands may be compared as shown in the table below under following heads:

Proximity to market value
Time taken
Who uses?
Degree of participation of PAPs
Equity
Frequency of use

TableA.2 Comparison of Different Methods of Assessing Market Value

SN	Criteria	Sale Statistics	Capitalisation	Expert Assessment	Consent Award	Replacement Value
1	Proximity to Market value	Remote	Closer	Closer	Closest	Equal to or more
2	Time Taken	Shorter	Average	Average	Shortest	Longer
3	Who uses?	Government	Courts Govt. rarely	Courts Govt.	Govt.	Govt./Bank Financed
4	Degree of Participation	None	Some	None	Maximum	Maximum
5	Equity	Somewhat reasonable	Reasonable	Reasonable	Highly reasonable	Highly reasonable
6	Frequency of use	Most common	More	Less	Less	Least common

On all these counts the replacement value method emerges as the best way of compensating landowners. Though it is the least used by the government and takes long time, it is highly equitable as it provides maximum opportunity to the affected people to participate in the acquisition process.

The compensation thus offered is equal to or greater than the real market value. Consent award could be rated second, while expert assessment and capitalisation method stand close to each other in the third place.

Appendix B

APPENDIX B

Table B.1 Tolerance Limits for Inland Surface Waters (as per IS:2296)

SN	Parameter and Unit	Class-A	Class-B	Class-C	Class-D	Class-E
1.	Colour (Hazen Units)	10	300	300	-	-
2.	Odour	Unobject	-	-	-	-
3.	Taste	Tasteless	-	-	-	-
4.	pH (max) (min:6.5)	8.5	8.5	8.5	8.5	8.5
5.	Conductivity (25^{o}C) (μmhos/cm)	-	-	-	1000	2250
6.	DO (mg/L)(min)	6	5	4	4	-
7.	BOD (5 days at 20^{o}C) (mg/L)	2	3	3	-	-
8.	Total Coliforms (MPN/100 mL)	50	500	5000	-	-
9.	TDS (mg/L)	500	-	1500	-	2100
10.	Oil and Grease (mg/L)	-	-	0.1	0.1	-
11.	Mineral Oil (mg/L)	0.01	-	-	-	-
12.	Free Carbon Dioxide (mg/L CO_2)	-	-	-	6	-
13.	Free Ammonia (mg/L as N)	-	-	-	1.2	-
14.	Cyanide (mg/L as CN)	0.05	0.05	0.05	-	-
15.	Phenol (mg/L C_6H_5OH)	0.002	0.005	0.005	-	-
16.	Total Hardness (mg/L as $CaCO_3$)	300	-	-	-	-
17.	Chloride (mg/L as Cl)	250	-	600	-	600
18.	Sulphate (mg/L as SO_4)	400	-	400	-	1000
19.	Nitrate (mg/L as NO_3)	20	-	50	-	-
20.	Fluoride (mg/L as F)	1.5	1.5	1.5	-	-
21.	Calcium (mg/L as Ca)	80	-	-	-	-
22.	Magnesium (mg/L as Mg)	24.4	-	-	-	-
23.	Copper (mg/L as Cu)	1.5	-	1.5	-	-
24.	Iron (mg/L as Fe)	0.3	-	50	-	-
25.	Manganese (mg/L as Mn)	0.5	-	-	-	-
26.	Zinc (mg/L as Zn)	15	-	15	-	-
27.	Boron (mg/L as B)	-	-	-	-	2
28.	Barium (mg/L as Ba)	1	-	-	-	-
29.	Silver (mg/L as Ag)	0.05	-	-	-	-
30.	Arsenic (mg/L as As)	0.05	0.2	0.2	-	-
31.	Mercury (mg/L as Hg)	0.001	-	-	-	-
32.	Lead (mg/L as Pb)	0.1	-	0.1	-	-
33.	Cadmium (mg/L as Cd)	0.01	-	0.01	-	-
34.	Chromium (VI) (mg/L as Cr)	0.05	0.05	0.05	-	-
35.	Selenium (mg/L as Se)	0.01	-	0.05	-	-
36.	Anionic Detergents (mg/L MBAS)	0.2	1	1	-	-
37.	PAH (mg/L)	0.2	-	-	-	-
38.	Pesticides (μg/L)	Absent	-	-	-	-
39.	Insecticides (mg/L)	-	-	Absent	-	-
40.	Alpha Emitters (10^{-6}μc/mL)	0.001	0.001	0.001	0.001	0.001
41.	Beta Emitters (10^{-6}μc/mL)	0.01	0.01	0.01	0.01	0.01
42.	Percent Sodium (%)	-	-	-	-	60
43.	Sodium Absorption Ratio	-	-	-	-	26

Class-A: Drinking water source without conventional treatment but after disinfection.
Class-B: Outdoor bathing.
Class-C: Drinking water source with conventional treatment followed by disinfection.
Class-D: Fish culture and wild life propagation.
Class-E: Irrigation, industrial cooling and controlled waste disposal.

Table B.2 Drinking Water Quality Standards (as per IS:10500)

Sl. No.	Parameter and Unit	Desirable Limit	Permissible Limit in Absence of Alternate Source
1.	Colour (Hazen units)	5	25
2.	Odour	Unobjectionable	-
3.	Taste	Agreeable	-
4.	Turbidity (NTU)	5	10
5.	pH	5-8.5	No relaxation
6.	Total Coliforms (MPN/100 mL)	nil	-
7.	Pathogenic Organisms or Virus	nil	-
8.	TDS (mg/L)	500	2000
9.	Mineral Oil (mg/L)	0.01	0.03
10.	Free Residual Chlorine (mg/L)	0.2	-
11.	Cyanide (mg/L as CN)	0.05	No relaxation
12.	Phenol (mg/L C_6H_5OH)	0.001	0.002
13.	Total Hardness (mg/L as $CaCO_3$)	300	600
14.	Total Alkalinity (mg/L as $CaCO_3$)	200	600
15.	Chloride (mg/L as Cl)	250	1000
16.	Sulphate (mg/L as SO_4)	200	400
17.	Nitrate (mg/L as NO_3)	45	100
18.	Fluoride (mg/L as F)	1	1.5
19.	Calcium (mg/L as Ca)	75	200
20.	Magnesium (mg/L as Mg)	30	100
21.	Copper (mg/L as Cu)	0.05	1.5
22.	Iron (mg/L as Fe)	0.3	1
23.	Manganese (mg/L as Mn)	0.1	0.3
24.	Zinc (mg/L as Zn)	5	15
25.	Boron (mg/L as B)	1	5
26.	Aluminium (mg/L as AL)	0.03	0.2
27.	Arsenic (mg/L as As)	0.05	No relaxation
28.	Mercury (mg/L as Hg)	0.001	No relaxation
29.	Lead (mg/L as Pb)	0.05	No relaxation
30.	Cadmium (mg/L as Cd)	0.01	No relaxation
31.	Chromium (VI) (mg/L as Cr)	0.05	No relaxation
32.	Selenium (mg/L as Se)	0.01	No relaxation
33.	Anionic Detergents (mg/L MBAS)	0.2	1
34.	PAH (mg/L)	nil	-
35.	Pesticides (µg/L)	Absent	0.001
36.	Alpha Emitters (10^{-6}µc/mL)	nil	0.0001
37.	Beta Emitters (10^{-6}µc/mL)	nil	0.001

TableB.3 General Standards for Discharge of Effluents

[as per Environment (Protection) Rules, 1986]

Sl. No.	Parameter and Unit	Inland Surface Water	Public Sewers	Land for Irrigation	Marine Coastal Water
1.	Temperature (^oC)	#	-	-	#
2.	Colour and Odour	$	-	$	$
3.	pH	5.5-9.0	5.5-9.0	5.5-9.0	5.5-9.0
4.	BOD (5 days at 20^oC) (mg/L)	30	350	100	100
5.	COD (mg/L)	250	-	-	250
6.	Bio-assay (% 96-hrs Survival)	@	@	@	@
7.	TSS (mg/L)	100	600	200	100*
8.	SS Particle size (pass IS Sieve)	850	-	-	&
9.	Oil and Grease (mg/L)	10	20	10	20
10.	Total Residual Chlorine (mg/L)	1	-	-	1
11.	Nitrate Nitrogen (mg/L as N)	10	-	-	20
12.	Ammonia Nitrogen (mg/L N)	50	50	-	50
13.	Kjeldahl Nitrogen (mg/L as N)	100	-	-	100
14.	Free Ammonia (mg/L as N)	5	-	-	5
15.	Cyanide (mg/L as CN)	0.2	2	0.2	0.2
16.	Phenol (mg/L C_6H_5OH)	1	5	-	5
17.	Fluoride (mg/L as F)	2	15	-	15
18.	Sulphide (mg/L as S)	2	-	-	5
19.	Dissolved Phosphate (mg/L P)	5	-	-	-
20.	Copper (mg/L as Cu)	3	3	-	3
21.	Iron (mg/L as Fe)	3	3	-	3
22.	Manganese (mg/L as Mn)	2	2	-	2
23.	Zinc (mg/L as Zn)	5	15	-	15
24.	Nickel (mg/L as Ni)	3	3	-	5
25.	Vanadium (mg/L as V)	0.2	0.2	-	0.2
26.	Arsenic (mg/L as As)	0.2	0.2	0.2	0.2
27.	Mercury (mg/L as Hg)	0.01	0.01	-	0.01
28.	Lead (mg/L as Pb)	0.1	1	-	1
29.	Cadmium (mg/L as Cd)	2	1	-	2
30.	Chromium (VI) (mg/L as Cr)	0.1	2	-	1
31.	Chromium (Total) (mg/L as Cr)	2	2	-	2
32.	Selenium (mg/L as Se)	0.05	0.05	-	0.05
33.	Alpha Emitters (10^{-6}μc/mL)	0.1	0.1	0.01	0.1
34.	Beta Emitters (10^{-6}μc/mL)	1	1	0.1	1

Shall not exceed 5^oC above the receiving water temperature.
$ All efforts should be made to remove colour and unpleasant odour as far as practicable.
@ 90% survival of fish after 96 hours in 100% effluent.
* For cooling water effluent 10% above TSS of influent.
& (a) Floatable solids 3 mm, (b) Settleable solids 850 micron.

Table B.4 Revised Criteria for Classification of Inland Water Quality Proposed by CPCB

Tier I : Simple parameters

Sl. No.	Parameters	Requirement for Waters of Class		
		A-Excellent	**B-Desirable**	**C-Acceptable**
(i)	Sanitary Survey	Very clean neighbourhood and catchment	Reasonably clean neighbourhood	Generally clean neighbourhood
(ii)	General Appearance	No floating matter	No floating matter	No floating matter
(iii)	Colour	Absolutely Colourless	Almost colourless, very light shade if any	No colour of anthropogenic origin
(iv)	Smell	Odourless	Almost odourless	No unpleasant odour
(v)	Transparency	>1.0m depth	>0.5m to 1.0m depth	>0.2m to 0.5m depth
(vi)	Ecological* (Presence of Animals)	Fish & insects	Fish and insects	Fish and insects

Note: *****Applicable to only surface water

Source : Water quality criteria and goals, CPCB, February, 2002

Tier II : Regular monitoring parameters

Sl. No.	Parameters	Requirement for Waters of Class		
		A-Excellent	B-Desirable	C-Acceptable
(i)	pH	7.0 to 8.5	6.5 to 9.0	6.5 to 9.0
(ii)	DO (% Saturation)	90 - 110	80 - 120	60 - 140
(iii)	BOD, mg/l	Below 2	Below 5	Below 8
(iv)	EC, pmhos/cm	<1000	<2250	<4000
(v)	NO_2 + NO_3) - Nitrogen, mg/l	<5	<10	<15
(vi)	Suspended Solid, mg/l	<25	<50	<100
(vii)	Faecal Coliform, MPN/100 ml	<20 per 100 ml	<200 per 100 ml	<2000 per 100 ml
(viii)	Bio-assay (Zebra Fish)	No death in 5 days	No death in 3 days	No death in 2 days

Note: 1) Dissolved Oxygen (DO) not applicable for ground waters

2) Dissolved oxygen in eutrophicated waters should include diurnal variation

3) Suspended solid limit is applicable only during non-monsoon period.

4) Fecal coliform values should meet for 90% times.

5) Static Bio-Assay method may be adopted.

Source : Water quality criteria and goals, CPCB, February, 2002

Tier III : Special parameters (Only in cases of need/apprehensions)

Sl. No.	Parameters	Requirement for Waters of Class		
		A-Excellent	B-Desirable	C-Acceptable
1	Total Phosphorous	<0.1 mg/l	<0.2 mg/l	<0.3 mg/l
2	T.K.N.	<1.0 mg/l	<2.0 mg/l	<3.0 mg/l
3	Total Ammonia ($NH_4 + NH_3$) - Nitrogen	<0.5 mg/l	<1.0 mg/l	<1.5 mg/l
4	Phenols	<2µg/l	<5µg/l	<10µg/l
5	Surface Active Agents	<20µg/l	<100µg/l	<200µg/l
6	Organo Chlorine Pesticides	<0.05µg/l	<0.1µg/l	<0.2µg/l
7	PAH	<0.05µg/l	<0.1µg/l	<0.2µg/l
8	PCB and PCT	<0.01µg/l	<0.01µg/l	<0.02µg/l
9	Zinc	<100µg/l	<200µg/l	<300µg/l
10	Nickel	<50µg/l	<100µg/l	<200µg/l
11	Copper	<20µg/l	<50µg/l	<100µg/l
12	Chromium (Total)	<20µg/l	<50µg/l	<100µg/l
13	Arsenic (Total)	<20µg/l	<50µg/l	<100µg/l
14	Lead	<20µg/l	<50µg/l	<100µg/l
15	Cadmium	<1.0µg/l	<2.5µg/l	<5.0µg/l
16	Mercury	<0.2µg/l	<0.5µg/l	<1.0µg/l

Note: Failure to comply with one or more of the above limits shall imply assignment of the next lower class
Source : Water quality criteria and goals, CPCB, February, 2002

Table B.5 Discharge Criteria for Wastewaters Used for Irrigation

Suggested Values for Major Inorganic Constituents in Water Applied to the Land

Problem and Related Consultant	Impact on the Land*		
	No Problem	Increasing Problem	Service
Salinity			
Conductivity of Irrigation Water Millimhos/cm	< 0.75	0.75 - 3.00	> 3.00
Permeability			
Conductivity of Irrigation Water Millimhos/cm	< 0.50	< 0.50	< 0.20
SAR	< 6.00	6.00 - 9.00	> 9.00
Specific Ion Toxicity			
From root absorption			
Sodium (evaluated by SAR) me/l	< 3.00	3.00 - 9.00	> 9.00
Chloride, me/l	< 4.00	4.00 - 10.00	> 10.00
Chloride, mg/l	< 142.00	142.00 - 355.00	> 355.00
Boron, mg/l	< 0.50	0.50 - 2.00	2.00 - 10.00
From foliar absorption (Sprinklers)			
Sodium, me/l	< 3.00	> 3.00	-
Sodium, mg/l	< 69.00	> 69.00	-
Chloride, me/l	< 3.00	> 3.00	-
Chloride, mg/l	< 106.00	> 106.00	-
Miscellaneous			-
NO_3 - N, NH_4 - N mg/l for sensitive crops	< 5.00	5.00 - 30.00	> 30.00
HCO_3 - mg/l (only with overhead sprinklers)	< 1.50	1.50 - 8.50	> 8.50
HCO_3 - mg/l	< 90.00	90.00 - 520.00	> 520.00
pH	Normal range 6.5 - 8.4		

* : Interpretations are based on possible effects of constituents on crops and/or soils. Suggested values are flexible and should be modified when warranted by local experience or special conditions of crop, soil and method of irrigation

.SAR : Sodium Absorption Ratio.

Source : Manual on sewerage and sewage treatment', CPHEEO, Ministry of Urban Development, Govt. of India, December 1993.

Table B.6 Suggested Limits for Salinity in Irrigation Waters

Crop Response	Total Dissolved Solids mg/l	Electrical Conductivity mhos/cm
No detrimental effects will usually be noticed	500	0.75
Can have detrimental effects on sensitive crops	500 - 1000	0.75 - 1.50
May have adverse effects on many crops	1000 - 2000	1.50 - 3.00
Can be used for salt tolerant plants on permeable soils with careful management practices	2000 - 5000	3.00 - 7.50

Source : Manual on sewerage and sewage treatment', CPHEEO, Ministry of Urban Development, Govt. of India, December 1993.

Table B.7 Maximum Permissible Concentration of Toxic Elements in Irrigation Waters

Element		Maximum Permissible Concentration (mg/l)	
		For water used continuously on all soils	For short term use of fine texture soils
Aluminium	Al	1.00	20.00
Arsenic	As	1.00	10.00
Beryllium	Be	0.50	1.00
Boron	Be	0.75	2.00
Cadmium	Cd	0.01	0.05
Chromium	Cr	5.00	20.00
Cobalt	Co	0.20	10.00
Copper	Cu	0.20	5.00
Fluorine	F	0.00	10.00
Lead	Pb	5.00	20.00
Lithium	Li	5.00	5.00
Manganese	Mn	2.00	20.00
Molybdenum	Mo	0.01	0.05
Nickel	Ni	0.05	2.00
Selenium	Se	0.05	2.00
Vanadium	V	10.00	10.00
Zinc	Zn	5.00	10.00

Source : Manual on sewerage and sewage treatment', CPHEEO, Ministry of Urban Development, Govt. of India, December 1993.

Table B.8 National Ambient Air Quality Standards

[as per Environment (Protection) Rules, 1986]

Pollutant	Time Weighted Average	Concentration ($\mu g/m^3$) in Ambient Air		
		Industrial Area	Residential, Rural and Other Areas	Sensitive Area
Sulphur Dioxide (SO_2)	Annual*	80	60	15
	24 Hours**	120	80	30
Oxides of Nitrogen (as NO_2)	Annual*	80	60	15
	24 Hours**	120	80	30
Suspended Particulate Matter (SPM)	Annual*	360	140	70
	24 Hours**	500	200	100
Respirable Particulate Matter (RPM) (size less than 10 μm)	Annual*	120	60	50
	24 Hours**	150	100	75
Lead (Pb)	Annual*	1	0.75	0.5
	24 Hours**	1.5	1	0.75
Ammonia	Annual*	100	100	100
	24 Hours**	400	400	400
Carbon Monoxide (CO)	8 Hours**	5000	2000	1000
	1 Hour	10000	4000	2000

* Annual arithmetic mean of minimum 104 measurements in a year taken twice a week 24-hourly at uniform interval.

** 24-hourly/8-hourly values should be met 98% of the time in a year. However, 2% of the time, it may exceed but not on two consecutive days.

Table B.9 Ambient Air Quality Standards in Respect of Noise

[as per Noise Pollution (Regulation and Control) Rules, 2000]

Area Code	Category of Area	Limits in dB(A) L_{eq}*	
		Day Time	Night Time
A	Industrial Area	75	70
B	Commercial Area	65	55
C	Residential Area	55	45
D	Silence Zone	50	40

Notes:
1. Day time shall mean from 6.00 a.m. to 10.00 p.m.
2. Night time shall mean from 10.00 p.m. to 6.00 a.m.
3. Silence zone is defined as an area comprising not less than 100 metres around hospitals, educational institutions and courts. The silence zones are zones that are declared as such by the competent authority.
4. Mixed categories of areas may be declared as one of the four above-mentioned categories by the competent authority.

* dB(A) Leq denotes the time weighted average of the level of sound in decibels on scale A which is relatable to human hearing.

Table B.10 Permissible Exposure Levels of Impulse or Impact Noise for Work Zone Area

[as per Model Rules of Factories Act, 1948]

Peak Sound Pressure Level in dB	Permitted Number of Impulses or Impacts/day
140	100
135	315
130	1,000
125	3,160
120	10,000

Notes: 1. No exposure in excess of 140 dB peak sound pressure level is permitted.

2. For any peak sound pressure level falling in between any figure and the next higher or lower figure as indicated in column 1, the permitted number of impulses or impacts per day is to be determined by extrapolation on a proportionate basis.

Table B.11 Permissible Exposure in Case of Continuous Noise for Work Zone Area

[as per Model Rules of Factories Act, 1948]

Total Time of Exposure (continuous or a number of short term exposures) per day, in hr	Permissible Sound Pressure Level in dB(A)
8	90
6	92
4	95
3	97
2	100
1	102
1&1/2	105
1/2	107
1/4	110
1/8	115

Notes: 1. No exposure in excess of 115 dB(A) is to be permitted.

2. For any period of exposure falling in between any figure and the next higher or lower figure as indicated in column 1, the permissible sound pressure level is to be determined by extrapolation on a proportionate basis.

Appendix C

APPENDIX C

Project Details

Table C.1 Dinapur STP: Design Criteria

Components	Parameter	Unit	Design value	Recommended
Primary clarifiers	Hydraulic overflow rate at average flow	$m^3/m^2/d$	35	35-50
	Weir loading at average flow	$m^3/m^2/d$	140.5	125
Aeration tank	HRT	Hours	3.5	4-5
	MLSS	mg/L	3000-4000	3000-4000
Secondary clarifier	Hydraulic overflow rate at average flow	$m^3/m^2/d$	15.35	15-35
	Weir loading	$m^3/m^2/d$	212.2	185
	Solids loading	$Kg/m^3/day$	84.4	70-140
Anaerobic sludge digesters	Minimum solids retention time at 30^0 C	Days	15	14
	Additional storage capacity	Days		10-15

Table C.2 Details of Different Units of Dinapur STP

Units	No.	Size
Inlet chamber 1	1	Length: 3.65m; Width: 1.20 m; Depth: 4.20 m
Parshall flume	1	Throat width: 1.525 m; Range: 40-180 MLD
Distribution chamber	1	Length: 2.50 m; Width: 1.56 m; Depth: 5.0 m
Primary settling tank	3	Diameter: 28 m; Depth: 3.5 m; Detention time: 1 h at av. flow
Roughening trickling filter	3	Diameter: 22.5 m; Depth: 1.135 m; Media depth: 1m; Media size: 100-80 mm; Type: Hard stone pieces
Aeration tank	3	Length: 60 m; Width: 20 m; Depth: 3.75 m; Detention time: 3.5 h at average flow; MLSS: 2500-3000 mg/L; F/M: 0.3456
Secondary settling tank	3	Diameter: 40 m; Depth: 3.5 m; Detention time: 3.95 h
Sludge digesters	3	Diameter: 29 m; Detention time: 15 days
Gas holders	2	Diameter: 21 m; Height: 8.7 m; Capacity: 2500 m^3
Sludge drying beds	29	25 Nos – Length: 30 m; Width: 30 m, 3 Nos – Length: 30 m; Width: 20 m, 1 Nos – length: 30 m; Width: 15 m, Drying period including disposal: 18 Days

Table C.3 Details of Pump Facilities Provided to Dinapur STP

Plant place	Plant description	Nos	H.P.	Discharge (L/min)	Total head
Raw sludge pump house	Sludge pumps	2	15	1333	12
Treated effluent pump house	Sewage pumps	6	100	27000	12
Return sludge pump house	Sewage pumps	3	60	13885	11
Filtrate pump house	Sewage pumps	4	5	1165	18.5
Aeration tank	Aerator 'HYLIC'	9	30	400	-
Power generation room	Dual fuel (WH Allen, UK)	4	-	-	-
Channel pump house	Sewage pump	2	40	21000	5
SCREW mixers at digesters	HYLIC	9	20	-	-

Table C.4 Major Liquid Process Components of Dinapur STP

Level	Process	Component	Condition
Head works	Inlet chamber	1 - 3.65 m X 1.20 m, SWD: 4.20 m	Good
	Flow measurement	1 - Parshall flume, TW: 1.525 m, 40-180 MLD	Fair
	Distribution chamber	1 – 2.50 m X 1.56 m X 5.00 m	Good
Primary treatment	Primary clarifier	3 – 28 m diameter, SWD: 5.00 m	Good
	Trickling filter	3 – 22.5 m diameter, MD: 1 m, course stone	Fair
Secondary treatment	Aeration tank	3 – aeration basins 60 m X 20 m, SWD: 3.75 m	Fair
	Secondary clarifier	3 – 40 m diameter, SWD: 3.5 m	Good
	Effluent lift station	6 – 27000 lpm X 12 m X 100 H.P.	Good

TableC.5 Major Solid Handling Components of Dinapur STP

Process	Components	Condition
Digesters	3 – 29 m, SWD: 7.0 m	Fair
Gas holder	2 – 21 m diameter, Volume: 2500 m^3	Fair
Sludge drying bed	25 – Length: 30 m, Width: 30 m 3 – Length: 30 m, Width: 20 m 1 – Length: 30 m, Width: 15 m	Fair
Raw sludge pump house	2 – 1333 lpm X12 m X 15 H.P.	Fair
Return sludge pump house	3 – 13885 lpm X11 m X 60 H.P.	Fair
Filtrate pump house	4 – 1165 lpm X18.5 m X 5 H.P.	Fair
SCREW Mixers at digester	9-20 H.P.	Fair

Table C.6 Average Monthly Inflow and Effluent Characteristics of Dinapur STP

Month	Flow (MLD)	Influent Sewage (Raw) (mg/L)			Effluent (Treated) (mg/L)			Overall Efficiency (%)		
		BOD	COD	TSS	BOD	COD	TSS	BOD	COD	TSS
Jan-00	83.92	167.3	348	438	24.69	73.57	79.28	85	79	82
Feb-00	91.13	165.71	334.75	397	27.28	76.2	86.75	84	77	78
Mar-00	81.34	178	350.96	433	27.92	80.29	84.52	84	77	81
Apr-00	83.8	181.2	377.68		28.32	77.84		84	79	
May-00	72.21	181.92	386.57		28.3	84.14		84	78	
Jun-00	74.75	183.92	386.2	490.82	29.5	83.86	81.65	84	78	83
Jul-00	70.62	180.71	384.57	441.14	30.78	91	82.21	83	76	81
Aug-00	81.93	160.74	371.72	432.96	28.59	72.26	79.72	82	80	82
Sep-00	80	149.23	358	440.07	27.69	77.07	75.7	81	78	83
Oct-00	83.22	163.63	367.54	423.08	28.63	76.05	84.41	83	79	80
Nov-00	78.14	161.9	371.04	428.88	30.38	75.84	85.36	81	80	80
Dec-00	79.44	155	366	438.07	27.23	75.14	78.58	82	79	82
Jan-01	66.2	161.78	348.88	463.29	28	76.85	84.37	83	78	82
Feb-01	71.73	165.2	351.23	416	28.4	78.61	80.37	83	78	81
Mar-01	77.74	169.31	363.68	441.28	28.3	81.6	89.76	83	78	80
Apr-01	92.22	173.04	355.2	426.08	27.39	77.28	86.4	84	78	80
May-01	82.18	191.6	379.03	455.56	29.28	81.71	87.48	85	78	81
Jun-01	94.23	165.92	366.51	439.25	28.51	80.44	89.48	83	78	80
Jul-01	54.01	174.13	382.13	468.68	31.03	88.41	94.2	82	77	80
Aug-01	60.95	159.6	380	482.3	29.12	77.18	85.33	82	80	82
Sep-01	63.71	174	386	499.42	31	93.64	100	82	76	80
Oct-01	89.39	164.11	360.66	437.61	29.52	83.04	85.2	82	77	81
Nov-01	78.16	179	406.33	475	29.77	85.88	89.29	83	79	81
Dec-01	96.09	203.75	394.36	458.18	30	84	87.63	85	79	81
Jan-02	67.12	171	352	483	30	87	91	82	75	81
Feb-02	81.1	193	401	447	29	79	80	85	80	82
Mar-02	97.49	179	377	472	29	82	88	84	78	81
Apr-02	89.45	167	368	402	30	86	88	82	77	78

Month	Flow (MLD)	Influent Sewage (Raw) (mg/L)			Effluent (Treated) (mg/L)			Overall Efficiency (%)		
		BOD	COD	TSS	BOD	COD	TSS	BOD	COD	TSS
May-02	79.32	180	366	486	29	88	86	84	76	82
Jun-02	55.49	201	401	468	28	87	86	86	78	82
Jul-02	72.59	178	380	470	28	79	76	84	79	84
Aug-02	87.8	184	380	470	27	84	81.77	85	78	83
AVG	78.67	173.87	371.94	450.81	28.75	81.4	85.15	83	78	81

Table C.7 Design Parameter vs. Actual Parameter of Dinapur STP

Parameter		Design Value	Actual Value
Flow	Peak m^3/min	160,000	n.a.
	Average m^3/day	80,000	54,000-98,000
	Minimum m^3/min	32,000	n.a.
Wastewater Quality	BOD_5 (mg/L)	300	149-204
	SS (mg/L)	600	397-499
	COD (mg/L)	400	335-406
Effluent quality	BOD_5 (mg/L)	20	25-31
	SS (mg/L)	30	73-94

Table C.8 Major Liquid Process Components of Bhagwanpur STP

Level	Process	Component	Condition
Head works	Inlet collection chamber	1 – 2.0 m X 1.5 m X 5.0 m	Fair
	Screen chamber	2 – 3.0 m (L) X 0.5 m (W) X 1.0 m (D)	Fair
	Grit chamber	2 – 7.15 m (L) X 2.0 m (W) X 1.3 m (D)	Fair
	Flow measurement	1 - Parshall flume, TW: 150 mm, 4-20 MLD	Good
Primary treatment	Primary clarifier	2 – 14.6 m diameter, SWD: 2.5 m	Good
Secondary treatment	Aeration tank	2 – 15.6 m diameter, SWD: 3.5 m	Good
	Secondary clarifier	2 – 16.0 m diameter, SWD: 3.5 m	Good

Table C.9 Average Monthly Inflow and Effluent Characteristics of Bhagwanpur STP

Month	Flow (MLD)	Influent Sewage (Raw)			Effluent (Treated)			Overall Efficiency (%)		
		BOD	COD	TSS	BOD	COD	TSS	BOD	COD	TSS
Jan	12.47	98	218	185	22	48	22	78	78	88
Feb	11.42	92	180	176	15	32	17	84	82	90
Mar	10.2	98	176	250	18	65	20	82	63	92
Apr	10.66	92	140	195	18	76	19	80	46	
May	11.92	102	173	230	15	52	22	85	70	
Jun	12.2	110	196	151	20	41	17	82	79	89
Jul	14.62	96	215	164	14	54	18	85	75	89
Aug	16.72	79	156	158	22	70	16	72	55	90
Sep	15.62	72	150	156	12	36	19	83	76	88
Oct	16	76	184	175	12	52	18	84	72	90
Nov	16.62	97	275	182	16	83	22	84	70	88
Dec	15.75	98	160	178	15	38	20	85	76	89
AVG	13.68	93	179	183	17	54	19	82	70	89

Table C.10 Assi Main Pumping Station Detail

Capacity	9 MLD
Pump House	No details
Pumping plants	3 Nos 50 H.P. 5000 lpm at 24 m head
Diesel generating set	1 No 70 kVA capacity
Rising main	400 mm dia, 190 m long PSC rising main from Assi MPS to BHU STP

Table C.11 Konia MPS and Pretreatment Works

Diversion sewer		305 m long 2286 dia brick sewer (old existing)
Emergency overflow at Konia high lift		250 m long 2200 mm dia pipe
Old pump house		Screen chamber of 48.33 ft with 2 nos manually cleaned screen
		Sump of 30 ft diameter with partition wall in between
		2 nos pumps of 150 H.P. capacity each with head
		1 no pump of 150 H.P. with 2700 lpm discharge at 1.6.6 m head
First stage pumping	No. of pumps	3
	Type	Screw type
	H.P.	215 H.P. each
	Capacity	1158 lps each
	Head	8.51 m
	RPM	29
	Make	Spans Babcock (Netherlands)
	Screens	2 nos. mechanically operated, 50 MLD capacity each, Dorr-Oliver make
	Detritor	2 nos. each of 100 MLD capacity with 20% overloading capacity
Second stage pumping	Sump size	32 m X 6 m with partition wall
	No. of pumps	6 Nos
	Type	Non clog horizontal centrifuge
	H.P.	3 nos 215 and 3 nos 150
	Capacity	740 lps and 420 lps respectively
	RPM	590 each
	Make	Beacon weir
Rising main		1200 mm dia PSC pipe 2.9 km (new); 900 mm dia hume steel pipe 2860 m long (old)
Switch yard		Capacity 1600 kVA, transformer 3 nos 1000 kVA each

Table C.12 Summary of Capacity of Konia MPS

Pumping station	**Installed capacity (lps)**	**Firm capacity (lps)**
Konia stage 1 – present	3 X 1158 lps = 3474 lps	67% = 2316
Konia stage 2 – present	3 X 420 lps = 1260 lps 3 X 740 lps = 2220 lps	67% = 2320
Konia stage 1 – future	4 X 1158 lps = 4632 lps	75% = 3474
Konia stage 2 – future	3 X 420 lps = 1680 lps 3 X 740 lps = 2960 lps	75% = 3480

Table C.13 Summary of Discharge to Konia MPS via Main Trunk Sewer

Parameter	**Year**		
	2003	**2015**	**2030**
Average flow (MLD)	108	103	93
Peak flow (lps)	2810	2689	2413
Present firm capacity (lps)	2316	2316	2316
Firm capacity with additional pumps (lps)	3474	3474	3474

Table C.14 Unit wise Details of the 5-Ghat Sewage Pumping Stations

Harischandra Ghat Intermediate Sewage Pumping Station	
Pump house	6 m dia circular sump cum pump house Sump floor is 6.5 m below the floor of pump house
Pumping plants	1 no. 50 H.P. 5000 lpm at 24.0 m head 1 no. 25 H.P. 2600 lpm at 13.5 m head 1 no. 10 H.P. 1150 lpm at 9.5 m head
Diesel generating set	1 no. of 70 kVA capacity
Rising main	200 mm dia C.I.
Mansarovar Ghat Intermediate Sewage Pumping Station	
Pump house	9 m dia circular sump cum pump house Sump floor is 11.0 m below the floor of pump house
Pumping plants	2 nos. 10 H.P. 1300 lpm at 15.0 m head 1 nos. 25 H.P. 2600 lpm at 21.0 m head
Diesel generating set	1 no. of 100 kVA capacity
Rising main	400 mm dia C.I.
R.P. Ghat Intermediate Sewage Pumping Station	
Pump house	6.1 m internal dia circular sump cum pump house Sump floor is 18.3 m below the floor of pump house
Pumping plants	2 nos. 125 H.P. 15000 lpm at 23.0 m head 2 nos. 75 H.P. 8800 lpm at 22.0 m head
Diesel generating set	3 nos. of 160 kVA capacity
Rising main	600 mm dia C.I.
Jalesan Ghat Intermediate Sewage Pumping Station	
Pump house	6.1 m internal dia circular sump cum pump house Sump floor is 16.3 m below the floor of pump house 3.65 m internal dia and 16.45 m deep special manhole
Pumping plants	2 nos. 30 H.P. 3600 lpm at 20.0 m head 2 no. 15 H.P. 1200 lpm at 15.0 m head
Diesel generating set	1 no. of 70 kVA capacity
Rising main	250 mm dia C.I.
Trilochan Ghat Intermediate Sewage Pumping Station	
Pump house	6.1 m internal dia circular sump cum pump house Sump floor is 18.3 m below the floor of pump house 3.65 m internal dia and 18.63 m deep special manhole
Pumping plants	2 nos. 35 H.P. 4100 lpm at 20.5 m head 2 nos. 12 H.P. 1365 lpm at 18.0 m head

Table C.15 Capacity Analysis of Ghat Pumping Stations

Ghats	Capacity of each pumping plant					Estimated flow without sewerage improvements (lps)								
	Nos	Power	Head	Dis-charge	Alow-able at 5/4 lps	2003			2015			2030		
		H.P.	(m)	(lps)		Avg	Peak	Reqd	Avg	Peak	Reqd	Avg	Peak	Reqd
Harischandra Ghat	1	50	24	83.3	116.7	92.6	232	290	82.2	206	258	71.8	179	224
	1	25	13.5	43.3										
	1	10	9.5	19.2										
	Total			145.8										
Mansarovar Ghat	2	10	15	43.3	138.7	29.0	72	90	25.5	65	81	22	56	70
	3	25	21	130.0										
	Total			173.3										
R.P. Ghat	2	125	23	500.0	634.7	289.4	723	904	258.1	644	805	224.5	560	701
	2	75	22	293.3										
	Total			793.3										
Jalesan Ghat	2	30	20	120.0	128.0	44	109	136	38.2	97	121	33.6	84	105
	2	15	15	40.0										
	Total			160.0										
Trilochan Ghat	2	35	20.5	136.7	145.7	84.5	210	262	75.2	187	233	65	162	203
	2	12.5	18	45.5										
	Total			182.2										

Appendix D

APPENDIX D

Table D.1 Ward Wise Socio-economic Details of Varanasi

Sl. No.	Ward No.	Name of Ward	Area (sq. km)	No of House	No of HH	Population			Sex Ratio	Fam-ily Size	SC (%)	ST (%)	Lite-rate (%)	Worker	
						Total	Male	Feml						Main (%)	Mrg (%)
		State : UTTAR PRADESH													
		Distt : Varanasi													
		Tehsil: Varanasi													
		Town : Lohta C.T.													
1	1	Lohta C.T.	2	1324	1348	12394	6651	5743	863	9.2	5	0	33.4	32.3	1.3
		Town : Kotwa C.T.													
2	1	Kotwa C.T.	2	838	880	9076	4827	4249	880	10.3	6.1	0	35.6	27.7	7.3
		Town : Gangapur TA													
3	1	Balwanta Nagar	0.2	73	74	699	362	337	931	9.4	0	0	30.5	19.9	0
4	2	Gandhi Nagar	0.1	73	73	522	269	253	941	7.2	37	0	43.3	18	0
5	3	Patel Nagar	0.3	79	79	836	441	395	896	10.6	1.4	0	52.8	22.5	0
6	4	Jawahar Nagar	0.2	65	65	644	327	317	969	9.9	5.1	0	63.2	16.6	0.2
7	5	Malviya Nagar	0.2	64	65	491	261	230	881	7.6	18.3	0	60.9	25.1	0
8	6	Azad Nagar	0.2	87	103	724	403	321	797	7	14.1	0	32.7	30.4	1.4
9	7	Moti Lal Nagar	0.2	36	36	339	187	152	813	9.4	0	0	52.5	27.1	0.3
10	8	Subhas Nagar	0.3	46	46	502	258	244	946	10.9	0	0	21.1	23.3	0
11	9	Lokmanya Nagar	0.3	82	84	882	451	431	956	10.5	2.7	0	43.2	20.9	0
		Town : Varanasi MC													
12	1	Bazardiha	3.95	4211	4543	34140	18219	15921	874	7.5	5.5	0	51.4	26	0.3
13	2	Jolha	2.9	4083	4334	30999	16443	14556	885	7.2	16.9	0.1	50.3	26.9	0.5
14	3	Assi	4.62	3847	4057	25791	14092	11699	830	6.4	10.6	0	80.9	24.8	0.4
15	4	Shiwala	1.75	2417	2582	18006	9607	8399	874	7	4.7	0	57.6	25.9	0.1
16	5	Pandey Haweli	0.87	2603	2708	20215	10644	9571	899	7.5	3.1	0	71.3	26.8	0.1
17	6	Madanpura	0.53	2138	2211	16702	8856	7846	886	7.6	0.9	0	76.4	29.1	0.4
18	7	Jangam Badi	0.45	2950	3134	20862	11092	9770	881	6.7	4.8	0	81.8	28.3	0
19	8	Dashashwamedh	1	1654	1876	11507	6330	5177	818	6.1	0.8	0	81.5	28.2	0.1
20	9	Garhwali Tola C.K.	0.78	2207	2498	15900	8585	7315	852	6.4	2.8	0	86.3	28	0.4
21	10	Rajmandir	0.7	1780	2424	14834	7970	6864	861	6.1	2.9	0	83.8	28.3	0.3
22	11	Kameshar Mahadao	0.67	2156	2224	15092	8182	6910	845	6.8	7.7	0	80.7	27.8	0
23	12	Bhagatpuri	1.18	3275	3437	24098	13000	11098	854	7	10.9	0	63.4	25.8	0.1
24	13	Chhittanpura	0.38	3086	3193	26948	14075	12873	915	8.4	2.3	0	46.3	28.7	0.7
25	14	Madhaymeshawar	0.46	2496	2584	19802	10501	9301	886	7.7	5.3	0	64.3	27.1	0.2
26	15	Ishawargangi	0.63	2809	2923	20912	11157	9755	874	7.2	3.9	0	72.3	26.4	0.2
27	16	Sapat_Sagar K.	0.39	2238	2365	18015	9655	8360	866	7.6	4.5	0	73.5	26.6	0.2
28	17	Piyari Kalan	0.39	2216	2324	17132	9199	7933	862	7.4	3.7	0	71.9	24.7	0
29	18	Raja Darwaja C.K.	0.37	2137	2253	18939	10139	8800	868	8.4	1.1	0	72.5	26	0.2
30	19	Kazipur Kalan	0.5	2072	2126	16759	8926	7833	878	7.9	4.5	0	74.9	26	0
31	20	Mishra Pokhara	1.11	2307	2412	17945	9540	8405	881	7.4	7.2	0	73.1	25.1	0.1
32	21	Bhelupur	0.86	2773	2817	23275	12519	10756	859	8.3	2.6	0	59.5	26.4	0.8
33	22	Kamachha	1.2	3541	3708	27055	14584	12471	855	7.3	9.9	0	70.2	27.7	0.1
34	23	Lahartara	1.75	4791	4949	31406	17274	14132	818	6.3	17.6	0	71.5	24.9	0.2
35	24	Lallapur kalan	0.9	1829	1981	13763	7394	6369	861	6.9	5.3	0	64	26.1	0.1
36	25	Pichasmochan	0.82	3516	3796	30117	16205	13912	859	7.9	7.1	0	70.6	25.7	0.5
37	26	Kazipura Khurd	0.5	2505	2788	21679	11492	10187	886	7.8	4.6	0	65.9	26.8	0
38	27	Sarai Gobardhan	0.42	2202	2419	19093	10260	8833	861	7.9	4.5	0	78	27.2	0.4
39	28	Dhoopchandi	1.2	2589	2821	19218	10377	8841	852	6.8	4.5	0	77.6	25.5	0.4
40	29	Nawapura	0.63	2705	3176	25253	13281	11972	901	8	3.8	0	44.9	29.6	0.9
41	30	Gopalganj	0.47	1897	2283	21200	11234	9966	887	9.3	1.6	0	41.5	31.9	1
42	31	Vandhu Kachchibag	4.52	3488	3933	34218	17818	16400	920	8.7	6	0	39.8	28.4	0.9
43	32	Alaipura	1.13	2928	3387	30448	16223	14225	877	9	5.4	0	36.2	33.1	0.1
44	33	Kamakgarha	0.49	1936	2448	22652	11932	10720	898	9.3	1.9	0	35.1	30.3	2.6
45	34	Ghausabad	1.42	2980	3419	26383	14071	12312	875	7.7	9.1	0	52.2	29	0.2
46	35	Nadesar	1.68	3010	3371	21529	11801	9728	824	6.4	15.7	0	70.3	27.9	0.2
47	36	Sikraul	4.92	4151	4528	31391	17336	14055	811	6.9	13	0	77.5	24.3	0.3
48	37	Khajuri	3.52	4144	4595	32671	17783	14888	837	7.1	13.7	0	60.7	24.4	1.2
49	38	Sarnath	12.29	3684	4277	31689	16780	14909	888	7.4	10.7	0	51.2	26.7	0.3
50	39	Pandeypur	5.28	4130	4430	33441	18040	15401	854	7.5	13	0	64.3	25.3	0.1
51	40	Shiopur(Reserve)	6.18	3469	3774	28191	14982	13209	882	7.5	21.5	0	60.5	24.7	0.1
		Town : Lahartara OG													
52	1	Lahartara O.G.	0.95	451	494	3129	1719	1410	820	6.3	62.3	0	45.8	27.6	1.3
		Town : Varanasi Cant.													
53	1	Purvottar Rly Colony	0.23	450	455	2510	1443	1067	739	5.5	6.1	0	85.4	27.4	0
54	2	New Loco Colony	0.11	381	386	2070	1258	812	645	5.4	14.4	0	88.8	31.6	0

Sl. No.	Ward No.	Name of Ward	Area (sq. km)	No of House	No of HH	Population			Sex Ratio	Fam-ily Size	SC (%)	ST (%)	Lite-rate (%)	Worker	
						Total	Male	Feml						Main (%)	Mrg (%)
55	3	Main Banlow Area & D.M. Compo.	2.18	360	363	1950	1045	905	866	5.4	11.4	0	76.9	26.9	0.1
56	4	Mint Road Area	1.17	261	273	1495	838	657	784	5.5	18.4	0	63.4	29.8	0
57	5	Reserved Ward	0.89	541	648	3451	1822	1629	894	5.3	17.9	0	71.5	23.2	0.1
58	6	Sadar Bazar	0.06	173	174	1582	835	747	895	9.1	15	0	66.7	22.5	0
59	7	Bhrihattar SadarBazar	0.06	305	310	2024	1051	973	926	6.5	23.7	0	74.7	22.7	0.1
		Town : BHU													
60	1	Ward_1	0	75	84	1329	334	995	2979	15.8	1.5	0	95.8	19.6	0
61	2	Ward_2	0	29	44	632	474	158	333	14.4	9	0	95.1	23.4	0
62	3	Ward_3	0	137	140	2198	1865	333	179	15.7	3.9	0	95.3	7.1	0
63	4	Ward_4	0	92	109	911	657	254	387	8.4	5.8	0.1	89.9	17.9	0.1
64	5	Ward_5	0	145	148	1839	1499	340	227	12.4	5.5	0	94.7	12	0
65	6	Ward_6	0	113	114	1209	956	253	265	10.6	1.2	0	93.4	11.2	0
66	7	Ward_7	0	113	118	522	254	268	1055	4.4	0.8	0	97.8	29.5	0
67	8	Ward_8	0	90	96	853	656	197	300	8.9	14.1	0	85.6	17.9	0.2
68	9	Ward_9	0	219	229	1253	638	615	964	5.5	5.5	0	92.4	25.5	0.1
69	10	Ward_10	0	136	136	762	401	361	900	5.6	55.5	0	56.5	31.9	0
		Town : Maruadih Rly. Settlement NA													
70	1	Ward_1	0	615	659	3344	1839	1505	818	5.1	12.9	0.2	90	24.6	0
71	2	Ward_2	0	551	560	2996	1629	1367	839	5.4	7.9	0.1	93.9	28.2	0
72	3	Ward_3	0	636	649	3924	2016	1908	946	6	8.8	0	87.6	22.1	0
73	4	Ward_4	0	585	599	3432	1837	1595	868	5.7	10.1	0	90.5	20.7	0.1
74	5	ward_5	0	559	577	3044	1684	1360	808	5.3	18	0	87.3	21.3	0.1
75	6	Ward_6	0	437	459	2446	1358	1088	801	5.3	14.3	0.2	87.2	20.5	0
76	7	Ward_7	0	20	33	90	59	31	525	2.7	3.3	0	83.3	43.3	0
		Town : Maruadih OG													
77	1	Maruadih	0.94	684	727	5033	2799	2234	798	6.9	12.7	0	56.2	26.6	1.2
		Town : Ramnagar MB													
78	1	Thatheri Bazar Paschimi	0.28	219	293	1837	977	860	880	6.3	3.9	0	57.8	30.9	0.1
79	2	Thatheri Bazar Madhya	0.29	187	196	1806	936	870	929	9.2	7.8	0	67.6	24.1	0.1
80	3	Thatheri Bazar purvi	0.3	184	199	1639	870	769	884	8.2	14.9	0	59.1	26	0
81	4	Sihavir	0.26	236	253	1617	842	775	920	6.4	1.1	0	56.7	26.3	0
82	5	Harizan Basti	0.36	206	277	1800	1024	776	758	6.5	35.9	0	48.6	24.5	0.4
83	6	Machhartta SW	0.25	268	278	2165	1118	1047	936	7.8	7.4	0	63.2	25.5	0.2
84	7	Machhartta M.P.	0.26	150	181	1319	692	627	906	7.3	3.2	0	76	25.8	1.3
85	8	Machhartta M.P.	0.23	216	236	1951	1021	930	911	8.3	22.8	0	57.7	26.9	0.4
86	9	Machhartta Rattapur	0.33	418	422	2939	1573	1366	868	7	24.1	0	53.9	28.1	0.3
87	10	Rampur	0.28	289	314	2610	1344	1266	942	8.3	18.2	0	56.3	24.3	0.2
88	11	Kutalupur	0.33	574	614	2807	1567	1240	791	4.6	21.4	0	59.7	27.4	0.1
89	12	Tapoban	0.25	332	341	2459	1347	1112	826	7.2	9.4	0	69.1	23	0.8
90	13	Warighari	0.26	340	375	2596	1422	1174	826	6.9	7.7	0	41.4	27.9	2.6
91	14	Purana Ram Nagar	0.26	114	118	901	466	435	933	7.6	3.7	0	75.7	25.1	4.7
92	15	Mallaghiya	0.31	227	228	1670	873	797	913	7.3	0.7	0	53	24.4	0.1
		Town : Shivdaspur CT													
93	1	Shivdaspur C.T.	2.5	1149	1215	7671	4119	3552	862	6.3	18.6	0	52	26.5	0
		Town : Phulwaria CT													
94	1	Phulawaria C.T.	3	1319	1368	9778	5236	4542	867	7.1	26	0	45.1	22.5	0.4

Table D.2 Area, Households, Population and Density in Varanasi

Town	No of Wards	Total Area* (Sq km)	No of Occ. Residential Houses	No of House -holds	Total Population			Population Density (per km^2)	House -hold Size
					Male	Female	Total		
Lohta C.T.	1	2	1324	1348	6651	5743	12394	6197	9.194
		{ 2.08}					[1.17]		
Kotwa C.T.	1	2	838	880	4827	4249	9076	4538	10.314
		{ 2.08}					[0.86]		
Gangapur T.A.	9	2	605	625	2959	2680	5639	2820	9.022
		{ 2.08}					[0.53]		
Varanasi M.C.	40	73.81	114950	125108	497598	431672	929270	12590	7.428
		{76.77}					[87.84]		
Lahartara O.G.	1	0.95	451	494	1719	1410	3129	3294	6.334
		{ 0.99}					[0.30]		
Varanasi Cantt.	7	4.7	2471	2609	8292	6790	15082	3209	5.781
		{ 4.89}					[1.43]		
BHU	10	0	1149	1218	7734	3774	11508	0	9.448
		{ 0.00}					[1.09]		
Maruadih Rly. Settlem	7	0	3403	3536	10422	8854	19276	0	5.451
		{ 0.00}					[1.82]		
Maruadih O.G.	1	0.94	684	727	2799	2234	5033	5354	6.923
		{ 0.98}					[0.48]		
Ramnagar M.B.	15	4.25	3960	4325	16072	14044	30116	7086	6.963
		{ 4.42}					[2.85]		
Shivdaspur C.T.	1	2.5	1149	1215	4119	3552	7671	3068	6.314
		{ 2.60}					[0.73]		
Phulwaria C.T.	1	3	1319	1368	5236	4542	9778	3259	7.148
		{ 3.12}					[0.92]		
Total	**94**	**96.15**	**132303**	**143453**	**568428**	**489544**	**1057972**		
Average								**11003**	**7.375**

Notes: 1. Figures in { } indicate percentage of that in the total area.
2. Figures in [ ] indicate percentages of total population.
3. * indicates area of the block falling within the study area.

Table D.3 SC-ST Population in Varanasi

Town	Scheduled Caste (SC)			Scheduled Tribe (ST)			Non-SC/ST Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Lohta C.T.	321	297	618	0	0	0	6330	5446	11776
			[4.99]			[0.00]			[95.01]
Kotwa C.T.	289	262	551	0	0	0	4538	3987	8525
			[6.07]			[0.00]			[93.93]
Gangapur T.A.	235	219	454	0	0	0	2724	2461	5185
			[8.05]			[0.00]			[91.95]
Varanasi M.C.	38414	32897	71311	30	23	53	459154	398752	857906
			[7.67]			[0.01]			[92.32]
Lahartara O.G.	1061	888	1949	0	0	0	658	522	1180
			[62.29]			[0.00]			[37.71]
Varanasi Cantt.	1243	1041	2284	0	0	0	7049	5749	12798
			[15.14]			[0.00]			[84.86]
BHU	565	383	948	1	0	1	7168	3391	10559
			[8.24]			[0.01]			[91.75]
Maruadih Rly. Set	1254	1003	2257	9	7	16	9159	7844	17003
			[11.71]			[0.08]			[88.21]
Maruadih O.G.	345	295	640	0	0	0	2454	1939	4393
			[12.72]			[0.00]			[87.28]
Ramnagar M.B.	2148	1880	4028	0	0	0	13924	12164	26088
			[13.37]			[0.00]			[86.63]
Shivdaspur C.T.	773	656	1429	0	0	0	3346	2896	6242
			[18.63]			[0.00]			[81.37]

Town	Scheduled Caste (SC)			Scheduled Tribe (ST)			Non-SC/ST Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Phulwaria C.T.	1345	1195	2540	0	0	0	3891	3347	7238
			[25.98]			[0.00]			[74.02]
Total	**47993**	**41016**	**89009**	**40**	**30**	**70**	**520395**	**448498**	**968893**
			[8.41]			**[0.01]**			**[91.58]**

Note: Figures in [ ] indicate percentages of total population.

Table D.4 Sex Ratio and Literacy Rate in Varanasi

Town	Population (0-6 Years)			Sex Ratio (F/1000 M)					Literacy Rate (%6+)		
	Male	Female	Total	0-6Y	SC	ST	Gen.	Overall	Male	Female	Overall
Lohta C.T.	1603	1576	3179	983	925	0	860	863	42.75	22.03	33.38
			[25.65]						{70.2}	{29.8}	
Kotwa C.T.	1228	1174	2402	956	907	0	879	880	46.6	22.73	35.6
			[26.47]						{70.6}	{29.4}	
Gangapur T.A.	720	654	1374	908	932	0	903	906	58.28	28.63	44.2
			[24.37]						{69.2}	{30.8}	
Varanasi M.C.	90604	87597	178201	967	856	767	868	868	73.22	52.32	63.64
			[19.18]						{62.3}	{37.7}	
Lahartara O.G.	335	313	648	934	837	0	793	820	59.97	27.89	45.79
			[20.71]						{73.1}	{26.9}	
Varanasi Cantt.	1338	1352	2690	1010	837	0	816	819	85.55	64.55	76.33
			[17.84]						{62.9}	{37.1}	
BHU	287	280	567	976	678	0	473	488	95.43	82.86	91.42
			[4.93]						{71.1}	{28.9}	
Maruadih Rly. Set	1118	930	2048	832	800	778	856	850	96.86	80.64	89.4
			[10.62]						{58.5}	{41.5}	
Maruadih O.G.	565	504	1069	892	855	0	790	798	68.49	40.4	56.23
			[21.24]						{68.6}	{31.4}	
Ramnagar M.B.	3047	2960	6007	971	875	0	874	874	69.96	45.08	58.52
			[19.95]						{64.6}	{35.4}	
Shivdaspur C.T.	904	816	1720	903	849	0	866	862	66.38	35.16	52.02
			[22.42]						{68.9}	{31.1}	
Phulwaria C.T.	1133	1048	2181	925	888	0	860	867	60.2	27.45	45.14
			[22.31]						{72.0}	{28.0}	
Total	**102882**	**99204**	**202086**								
			[19.10]								
Average				**964**	**855**	**750**	**862**	**861**	**73.31**	**51.99**	**63.58**
									{62.7}	**{37.3}**	

Notes: 1. Figures in [ ]) indicate percentages of total population.
2. Figures in { } indicate percentages of total literates.

Table D.5 Work Participation Rate in Varanasi

Town	No of Wards	Total Populn	Workers			Non Workers	% of Total Population		
			Main	Marginal	Total		Main	Marginal	Non-Wkr
Lohta C.T.	1	12394	3999	158	4157	8237	32.27	1.27	66.46
			{96.20}	{ 3.80}	[33.54]				
Kotwa C.T.	1	9076	2517	667	3184	5892	27.73	7.35	64.92
			{79.05}	{20.95}	[35.08]				
Gangapur T.A.	9	5639	1264	12	1276	4363	22.42	0.21	77.37
			{99.06}	{ 0.94}	[22.63]				
Varanasi M.C.	40	929270	250900	3703	254603	674667	27	0.4	72.6
			{98.55}	{ 1.45}	[27.40]				
Lahartara O.G.	1	3129	863	42	905	2224	27.58	1.34	71.08
			{95.36}	{ 4.64}	[28.92]				
Varanasi Cantt.	7	15082	3927	6	3933	11149	26.04	0.04	73.92
			{99.85}	{ 0.15}	[26.08]				
BHU	10	11508	1953	4	1957	9551	16.97	0.03	82.99
			{99.80}	{ 0.20}	[17.01]				
Maruadih Rly. Set	7	19276	4430	5	4435	14841	22.98	0.03	76.99
			{99.89}	{ 0.11}	[23.01]				
Maruadih O.G.	1	5033	1339	58	1397	3636	26.6	1.15	72.24

Town	No of Wards	Total Populn	Workers			Non Workers	% of Total Population		
			Main	Marginal	Total		Main	Marginal	Non-Wkr
			{95.85}	{ 4.15}	[27.76]				
Ramnagar M.B.	15	30116	7862	190	8052	22064	26.11	0.63	73.26
			{97.64}	{ 2.36}	[26.74]				
Shivdaspur C.T.	1	7671	2029	3	2032	5639	26.45	0.04	73.51
			{99.85}	{ 0.15}	[26.49]				
Phulwaria C.T.	1	9778	2197	36	2233	7545	22.47	0.37	77.16
			{98.39}	{ 1.61}	[22.84]				
Total	**94**	**1057972**	**283280**	**4884**	**288164**	**769808**			
			{98.31}	**{ 1.69}**	**[27.24]**				
Average							**26.78**	**0.46**	**72.76**

Notes: 1. Figures in [ ] indicate percentages of total population.
2. Figures in { } indicate percentages of total workers.

Table D.6 Male-Female Distribution (%) of Workers in Varanasi

Town	Main Worker		Marginal Worker		Total Worker		Non Worker		Female Main Wkr
	Male	Female	Male	Female	Male	Female	Male	Female	
Lohta C.T.	81.35	18.65	0	100	78.25	21.75	41.25	58.75	746
	<48.91>	{12.99}	< 0.00>	{ 2.75}	<48.91>	{15.74}	<51.09>	{84.26}	
Kotwa C.T.	95.27	4.73	4.65	95.35	76.29	23.71	40.7	59.3	119
	<49.68>	{ 2.80}	< 0.64>	{14.97}	<50.32>	{17.77}	<49.68>	{82.23}	
Gangapur T.A.	96.36	3.64	0	100	95.45	4.55	39.9	60.1	46
	<41.16>	{ 1.72}	< 0.00>	{ 0.45}	<41.16>	{ 2.16}	<58.84>	{97.84}	
Varanasi M.C.	91.69	8.31	15.83	84.17	90.59	9.41	39.57	60.43	20840
	<46.23>	{ 4.83}	< 0.12>	{ 0.72}	<46.35>	{ 5.55}	<53.65>	{94.45}	
Lahartara O.G.	90.03	9.97	26.19	73.81	87.07	12.93	41.86	58.14	86
	<45.20>	{ 6.10}	< 0.64>	{ 2.20}	<45.84>	{ 8.30}	<54.16>	{91.70}	
Varanasi Cantt.	93.51	6.49	83.33	16.67	93.49	6.51	41.39	58.61	255
	<44.28>	{ 3.76}	< 0.06>	{ 0.01}	<44.34>	{ 3.77}	<55.66>	{96.23}	
BHU	80.54	19.46	0	100	80.38	19.62	64.51	35.49	380
	<20.34>	{10.07}	< 0.00>	{ 0.11}	<20.34>	{10.17}	<79.66>	{89.83}	
Maruadih Rly. Set	93.14	6.86	100	0	93.15	6.85	42.39	57.61	304
	<39.59>	{ 3.43}	< 0.05>	{ 0.00}	<39.64>	{ 3.43}	<60.36>	{96.57}	
Maruadih O.G.	93.13	6.87	12.07	87.93	89.76	10.24	42.49	57.51	92
	<44.55>	{ 4.12}	< 0.25>	{ 2.28}	<44.80>	{ 6.40}	<55.20>	{93.60}	
Ramnagar M.B.	91.85	8.15	17.89	82.11	90.1	9.9	39.96	60.04	641
	<44.93>	{ 4.56}	< 0.21>	{ 1.11}	<45.14>	{ 5.68}	<54.86>	{94.32}	
Shivdaspur C.T.	88.32	11.68	0	100	88.19	11.81	41.27	58.73	237
	<43.51>	{ 6.67}	< 0.00>	{ 0.08}	<43.51>	{ 6.76}	<56.49>	{93.24}	
Phulwaria C.T.	93.99	6.01	5.56	94.44	92.57	7.43	42	58	132
	<39.44>	{ 2.91}	< 0.04>	{ 0.75}	<39.48>	{ 3.65}	<60.52>	{96.35}	
Total									**23878**
Average	**91.57**	**8.43**	**13.94**	**86.06**	**90.26**	**9.74**	**40.05**	**59.95**	
	<45.63>	**{ 4.88}**	**< 0.12>**	**{ 0.86}**	**<45.75>**	**{ 5.74}**	**<54.25>**	**{94.26}**	

Notes: 1. Figures in < > indicate percentages of total male population.
2. Figures in { } indicate percentages of total female population.

Table D.7 Category Wise Distribution (%) of Main Workers in Varanasi

Town	Cat-1	Cat-2	Cat-3	Cat-4	Cat-5	Cat-6	Cat-7	Cat-8	Cat-9
	Cultivator	Agrl. Labourer	Forestry & Fishing	Mining	Industry	Construc-tion	Trade & Com.	Transport	Other Services
Lohta C.T.	1.5	1.6	0	0	85.5	0.18	7.65	0.93	2.65
	[0.48]	[0.52]	[0.00]	[0.00]	[27.59]	[0.06]	[2.47]	[0.30]	[0.86]
Kotwa C.T.	5.6	0.64	0.2	0.04	90.07	0.2	0.91	0.2	2.15
	[1.55]	[0.18]	[0.06]	[0.01]	[24.98]	[0.06]	[0.25]	[0.06]	[0.59]
Gangapur T.A.	15.51	1.58	0.4	0	43.43	1.19	23.42	2.06	12.42
	[3.48]	[0.35]	[0.09]	[0.00]	[9.74]	[0.27]	[5.25]	[0.46]	[2.78]
Varanasi M.C.	1.38	0.84	1.18	0.03	40.51	2.3	28.2	5.71	19.84
	[0.37]	[0.23]	[0.32]	[0.01]	[10.94]	[0.62]	[7.61]	[1.54]	[5.36]
Lahartara O.G.	0.23	0.23	1.85	0	25.03	14.02	11.82	18.42	28.39
	[0.06]	[0.06]	[0.51]	[0.00]	[6.90]	[3.87]	[3.26]	[5.08]	[7.83]

Town		Cat-1	Cat-2	Cat-3	Cat-4	Cat-5	Cat-6	Cat-7	Cat-8	Cat-9
		Cultivator	Agrl. Labourer	Forestry & Fishing	Mining	Industry	Construc-tion	Trade & Com.	Transport	Other Services
Varanasi Cantt.		0.33	0.41	1.02	0.03	7.08	4.02	13.88	34.28	38.96
		[0.09]	[0.11]	[0.27]	[0.01]	[1.84]	[1.05]	[3.61]	[8.92]	[10.14]
BHU		0	0	0.77	0	1.48	0.46	3.74	0.46	93.09
		[0.00]	[0.00]	[0.13]	[0.00]	[0.25]	[0.08]	[0.63]	[0.08]	[15.80]
Maruadih Rly. Set		0.38	0.07	0.29	0	80.74	1.42	3.91	1.24	11.94
		[0.09]	[0.02]	[0.07]	[0.00]	[18.56]	[0.33]	[0.90]	[0.29]	[2.74]
Maruadih O.G.		6.8	19.42	0.9	0.07	22.48	4.85	26.89	4.78	13.82
		[1.81]	[5.17]	[0.24]	[0.02]	[5.98]	[1.29]	[7.15]	[1.27]	[3.68]
Ramnagar M.B.		4.17	2.45	3.18	0.05	31.71	3.08	21.28	5.24	28.83
		[1.09]	[0.64]	[0.83]	[0.01]	[8.28]	[0.80]	[5.56]	[1.37]	[7.53]
Shivdaspur C.T.		3.4	0.79	4.29	0.1	25.58	5.13	28.04	9.51	23.16
		[0.90]	[0.21]	[1.13]	[0.03]	[6.77]	[1.36]	[7.42]	[2.52]	[6.13]
Phulwaria C.T.		8.06	11.97	1.32	0	18.16	4.64	19.21	14.52	22.12
		[1.81]	[2.69]	[0.30]	[0.00]	[4.08]	[1.04]	[4.32]	[3.26]	[4.97]
Average		**1.6**	**1.04**	**1.21**	**0.03**	**40.84**	**2.35**	**26.58**	**5.98**	**20.35**
		[0.43]	**[0.28]**	**[0.32]**	**[0.01]**	**[10.94]**	**[0.63]**	**[7.12]**	**[1.60]**	**[5.45]**
		<86.20>	**<85.50>**	**<95.00>**	**<96.51>**	**<90.56>**	**<98.02>**	**<96.75>**	**<98.80>**	**<84.47>**
		{13.80}	**{14.50}**	**{ 5.00}**	**{ 3.49}**	**{ 9.44}**	**{ 1.98}**	**{ 3.25}**	**{ 1.20}**	**{15.53}**
Average (Male)	**A**	1.51	0.97	1.26	0.03	40.39	2.52	28.09	6.46	18.77
	B	< 0.69>	< 0.44>	< 0.57>	< 0.01>	<18.43>	< 1.15>	<12.82>	< 2.95>	< 8.57>
Average (Female)	**C**	2.63	1.79	0.72	0.01	45.73	0.55	10.24	0.85	37.48
	D	{ 0.13}	{ 0.09}	{ 0.04}	{ 0.00}	{ 2.23}	{ 0.03}	{ 0.50}	{ 0.04}	{ 1.83}

Cat-1: Cultivators, Cat-2: Agricultural Labourers, Cat-3: Livestock, Forestry, Fishing, Plantation & Allied Activities, Cat-4: Mining & Quarrying, Cat-5: Manufacturing, Processing, Servicing & Repairs in Industry, Cat-6: Construction, Cat-7: Trade & Commerce, Cat-8: Transport, Storage & Communications, Cat-9: Other Services

Notes:
1. Figures in [ ] indicate percentages of total population.
2. Figures in < > indicate male percentages in that category.
3. Figures in { } indicate female percentages in that category.
4. A indicates category wise % distribution of male main workers.
5. B indicates percentages of total male population.
6. C indicates category wise % distribution of female main workers.
7. D indicates percentages of total female population.

Table D.8 Sector Wise Distribution (%) of Main Workers in Varanasi

Town	Primary (Cat-1+2+3+4)			Secondary (Cat-5+6)			Tertiary (Cat-7+8+9)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Lohta C.T.	2.8	0.3	3.1	68.47	17.2	85.67	10.08	1.15	11.23
	< 1.68>	{ 0.21}	[1.00]	<41.17>	{11.98}	[27.64]	< 6.06>	{ 0.80}	[3.62]
Kotwa C.T.	6.2	0.28	6.48	85.98	4.29	90.27	3.1	0.16	3.26
	< 3.23>	{ 0.16}	[1.80]	<44.83>	{ 2.54}	[25.03]	< 1.62>	{ 0.09}	[0.90]
Gangapur T.A.	16.93	0.55	17.48	43.12	1.5	44.62	36.31	1.58	37.9
	< 7.23>	{ 0.26}	[3.92]	<18.42>	{ 0.71}	[10.00]	<15.51>	{ 0.75}	[8.49]
Varanasi M.C.	3.02	0.41	3.42	38.92	3.89	42.82	49.75	4.01	53.76
	< 1.52>	{ 0.24}	[0.92]	<19.63>	{ 2.26}	[11.56]	<25.09>	{ 2.33}	[14.51]
Lahartara O.G.	2.2	0.12	2.32	36.04	3.01	39.05	51.8	6.84	58.63
	< 1.11>	{ 0.07}	[0.64]	<18.09>	{ 1.84}	[10.77]	<26.00>	{ 4.18}	[16.17]
Varanasi Cantt.	1.53	0.25	1.78	10.92	0.18	11.1	81.05	6.06	87.11
	< 0.72>	{ 0.15}	[0.46]	< 5.17>	{ 0.10}	[2.89]	<38.39>	{ 3.51}	[22.68]
BHU	0.67	0.1	0.77	1.84	0.1	1.95	78.03	19.25	97.29
	< 0.17>	{ 0.05}	[0.13]	< 0.47>	{ 0.05}	[0.33]	<19.71>	{ 9.96}	[16.51]
Maruadih Rly. Set	0.7	0.05	0.74	79.41	2.75	82.17	13.02	4.06	17.09
	< 0.30>	{ 0.02}	[0.17]	<33.76>	{ 1.38}	[18.88]	< 5.54>	{ 2.03}	[3.93]
Maruadih O.G.	26.74	0.45	27.18	26.29	1.05	27.33	40.1	5.38	45.48
	<12.79>	{ 0.27}	[7.23]	<12.58>	{ 0.63}	[7.27]	<19.19>	{ 3.22}	[12.10]
Ramnagar M.B.	8.48	1.37	9.86	32.28	2.51	34.79	51.08	4.27	55.35
	< 4.15>	{ 0.77}	[2.57]	<15.79>	{ 1.40}	[9.08]	<24.99>	{ 2.39}	[14.45]
Shivdaspur C.T.	8.18	0.39	8.58	27.7	3.01	30.7	52.44	8.28	60.72
	< 4.03>	{ 0.23}	[2.27]	<13.64>	{ 1.72}	[8.12]	<25.83>	{ 4.73}	[16.06]

Town	Primary (Cat-1+2+3+4)			Secondary (Cat-5+6)			Tertiary (Cat-7+8+9)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Phulwaria C.T.	19.3	2.05	21.35	20.94	1.87	22.8	53.76	2.09	55.85
	< 8.10>	{ 0.99}	[4.80]	< 8.79>	{ 0.90}	[5.12]	<22.56>	{ 1.01}	[12.55]
Average	**3.46**	**0.43**	**3.89**	**39.3**	**3.9**	**43.2**	**48.82**	**4.09**	**52.91**
	< 1.72>	**{ 0.25}**	**[1.04]**	**<19.58>**	**{ 2.26}**	**[11.57]**	**<24.33>**	**{ 2.37}**	**[14.17]**

Notes: 1 Figures in < > indicate percentages of total male population.
2. Figures in { } indicate percentages of total female population.
3. Figures in [ ] indicate percentages of total population.

Table D.9 Area, Households, Population and Density in Villages around Sathwa STP Site

	No of Village	Total Area* (Sq km)	No of Occ. Residential Houses	No of House -holds	Total Population			Population Density (per km^2)	House -hold Size
					Male	Female	Total		
Total	11	9.52	1360	1400	5308	4624	9932		
Average								1043	7.094

Notes: 1. Figures in { } indicate percentage of that in the total area.
2. Figures in [ ] indicate percentages of total population.
3. * indicates area of the block falling within the study area.

Table D.10 SC-ST Population in Villages around Sathwa STP Site

	Scheduled Caste (SC)			Scheduled Tribe (ST)			Non-SC/ST Population		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Total	512	421	933	0	0	0	4796	4203	8999
			[9.39]			[0.00]			[90.61]

Note: Figures in [ ] indicate percentages of total population.

Table D.11 Sex Ratio and Literacy Rate in Villages around Sathwa STP Site

	Population(0-6 Years)			Sex Ratio (F/1000 M)					Literacy Rate (%6+)		
	Male	Female	Total	0-6Y	SC	ST	Gen.	Overall	Male	Female	Overall
Total	1167	1136	2303								
			[23.19]								
Average				973	822	0	876	871	49.53	17.72	34.98
									{76.8}	{23.2}	

Notes: 1. Figures in [ ]) indicate percentages of total population.
2. Figures in { } indicate percentages of total literates.

Table D.12 Work Participation Rate in Villages around Sathwa STP Site

	No of Village	Total Populn	Workers			Non Workers	% of Total Population		
			Main	Marginal	Total		Main	Marginal	Non-Wkr
Total	11	9932	3327	159	3486	6446			
			{95.44}	{ 4.56}	[35.10]				
Average							33.5	1.6	64.9

Notes: 1. Figures in [ ] indicate percentages of total population.
2. Figures in { } indicate percentages of total workers.

Table D.13 Male-Female Distribution (%) of Workers in Villages around Sathwa STP Site

	Main Worker		Marginal Worker		Total Worker		Non Worker		Female Main Wkr
	Male	Female	Male	Female	Male	Female	Male	Female	
Total									794
Average	76.13	23.87	7.55	92.45	73.01	26.99	42.86	57.14	
	<47.72>	{17.17}	< 0.23>	{ 3.18}	<47.95>	{20.35}	<52.05>	{79.65}	

Notes: 1. Figures in < > indicate percentages of total male population.
2. Figures in { } indicate percentages of total female population.

Table D.14 Category Wise Distribution (%) of Main Workers in Villages around Sathwa STP Site

		Cat-1	Cat-2	Cat-3	Cat-4	Cat-5	Cat-6	Cat-7	Cat-8	Cat-9
		Cultivator	Agrl. Labourer	Forestry & Fishing	Mining	Industry	Construction	Trade & Com.	Transport	Other Services
Average		36.7	29.61	0.69	0	15.54	3.79	3.85	1.41	8.42
		[12.29]	[9.92]	[0.23]	[0.00]	[5.21]	[1.27]	[1.29]	[0.47]	[2.82]
		<77.81>	<56.85>	<95.65>	< 0.00>	<89.75>	<90.48>	<94.53>	<100.0>	<91.07>
		{22.19}	{43.15}	{ 4.35}	{ 0.00}	{10.25}	{ 9.52}	{ 5.47}	{ 0.00}	{ 8.93}
Average	**A**	37.5	22.11	0.87	0	18.32	4.5	4.78	1.86	10.07
(Male)	**B**	<17.90>	<10.55>	< 0.41>	< 0.00>	< 8.74>	< 2.15>	< 2.28>	< 0.89>	< 4.80>
Average	**C**	34.13	53.53	0.13	0	6.68	1.51	0.88	0	3.15
(Female)	**D**	{ 5.86}	{ 9.19}	{ 0.02}	{ 0.00}	{ 1.15}	{ 0.26}	{ 0.15}	{ 0.00}	{ 0.54}

Cat-1: Cultivators, Cat-2: Agricultural Labourers, Cat-3: Livestock, Forestry, Fishing, Plantation & Allied Activities, Cat-4: Mining & Quarrying, Cat-5: Manufacturing, Processing, Servicing & Repairs in Industry, Cat-6: Construction, Cat-7: Trade & Commerce, Cat-8: Transport, Storage & Communications, Cat-9: Other Services

Notes: 1. Figures in [ ] indicate percentages of total population.
2. Figures in < > indicate male percentages in that category.
3. Figures in { } indicate female percentages in that category.
4. A indicates category wise % distribution of male main workers.
5. B indicates percentages of total male population.
6. C indicates category wise % distribution of female main workers.
7 D indicates percentages of total female population.

Table D.15 Sector Wise Distribution (%) of Main Workers in Villages around Sathwa STP Site

	Primary (Cat-1+2+3+4)			Secondary (Cat-5+6)			Tertiary (Cat-7+8+9)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Average	46.05	20.95	67	17.37	1.95	19.33	12.71	0.96	13.68
	<28.86>	{15.07}	[22.44]	<10.89>	{ 1.41}	[6.47]	< 7.97>	{ 0.69}	[4.58]

Notes: 1 Figures in < > indicate percentages of total male population.
2. Figures in { } indicate percentages of total female population.
3. Figures in [ ] indicate percentages of total population.

Table D.16 Amenities and Facilities Available in Villages around Sathwa STP Site

Amenity/Facility Description	No of Facility	No of Village	% of Total Villages
Total no of village		11	
No of un-inhabited village		0	
Educational Facilities:			
No of village having facility:			
Within village		6	54.55
Within 5 km		5	45.45
Within 5-10 km		0	0
Beyond 10 km		0	0
No of educational institutions:			
Primary school	5		
Middle school	1		
High school	1		
Pre-university college	1		
Graduate college	0		
Adult literacy centre	1		
Industrial school	0		
Training school	0		
Other educational institutions	4		
Medical Facilities:			
No of village having facility:			
Within village		11	100
Within 5 km		0	0

Amenity/Facility Description	**No of Facility**	**No of Village**	**% of Total Villages**
Within 5-10 km		0	0
Beyond 10 km		0	0
No of medical institutions:			
Hospital	2		
Maternity & child welfare centre	0		
Maternity homes	0		
Child welfare centre	0		
Primary health centre	0		
Health centre	0		
Primary health sub-centre	2		
Dispensary	0		
Family planning centre	0		
Tuberculosis clinic	0		
Nursing home	0		
Community health worker	8		
Registered private practitioner	0		
Subsi. medical practitioner	0		
Other medical centre	0		
Drinking Water Facilities:			
No of village having facility:			
Within village		11	100
Within 5 km		0	0
Within 5-10 km		0	0
Beyond 10 km		0	0
No of village having:			
Tap water		0	0
Well water		31	281.82
Tank water		0	0
Tube well water		0	0
Hand pump water		7	63.64
River water		0	0
Fountain water		0	0
Canal water		0	0
Lake water		0	0
Spring water		0	0
Nala water		0	0
Other drinking water sources		0	0
Post & Telegraph Facilities:			
No of village having facility:			
Within village		1	9.09
Within 5 km		10	90.91
Within 5-10 km		0	0
Beyond 10 km		0	0
No of village having:			
Post office		1	9.09
Telegraph office		0	0
Post & telegraph office		0	0
Telephone connection		0	0
Market Facilities:			
No of village having facility:			
Within village		1	9.09
Within 5 km		7	63.64
Within 5-10 km		3	27.27
Beyond 10 km		0	0
No of village having market on:			
Monday		0	0
Tuesday		0	0
Wednesday		0	0
Thursday		0	0

Amenity/Facility Description	**No of Facility**	**No of Village**	**% of Total Villages**
Friday		0	0
Saturday		0	0
Sunday		0	0
Daily		1	9.09
Fortnightly		0	0
Monthly		0	0
Communication Facilities:			
No of village having facility:			
Within village		6	54.55
Within 5 km		4	36.36
Within 5-10 km		1	9.09
Beyond 10 km		0	0
No of village having:			
Bus stop		6	54.55
Taxi/tempo stand		0	0
Railway station		0	0
Navigable waterways		0	0
No of village having approach:			
Pucca road		8	72.73
Kuccha road		4	36.36
Footpath		1	9.09
Navigable river		0	0
Navigable canal		0	0
Navigable other waterways		0	0
Power Supply Facilities:			
No of village having power supply		11	100
No of village having power for:			
Domestic purpose		5	45.45
Agricultural purpose		7	63.64
Industrial/commercial purpose		0	0
All purpose		1	9.09

Source: Census Data