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 III MASTER PLAN FOR PROJECT CITIES

### VOLUME III-2 SEWERAGE MASTER PLAN FOR KANPUR CITY

JULY 2005

TOKYO ENGINEERING CONSULTANTS CO., LTD.
CTI ENGINEERING INTERNATIONAL CO., LTD.

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**FINAL REPORT**

**ON**

**WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER**

**JULY 2005**

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***VOLUME III-2***

***SEWERAGE MASTER PLAN FOR KANPUR CITY***

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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 |
| **FS** | 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 |
| **MP** | Maturation Pond / Master Plan |
| **MPN** | Most Probable Number per 100ml |
| **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 received 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 Liquor 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***

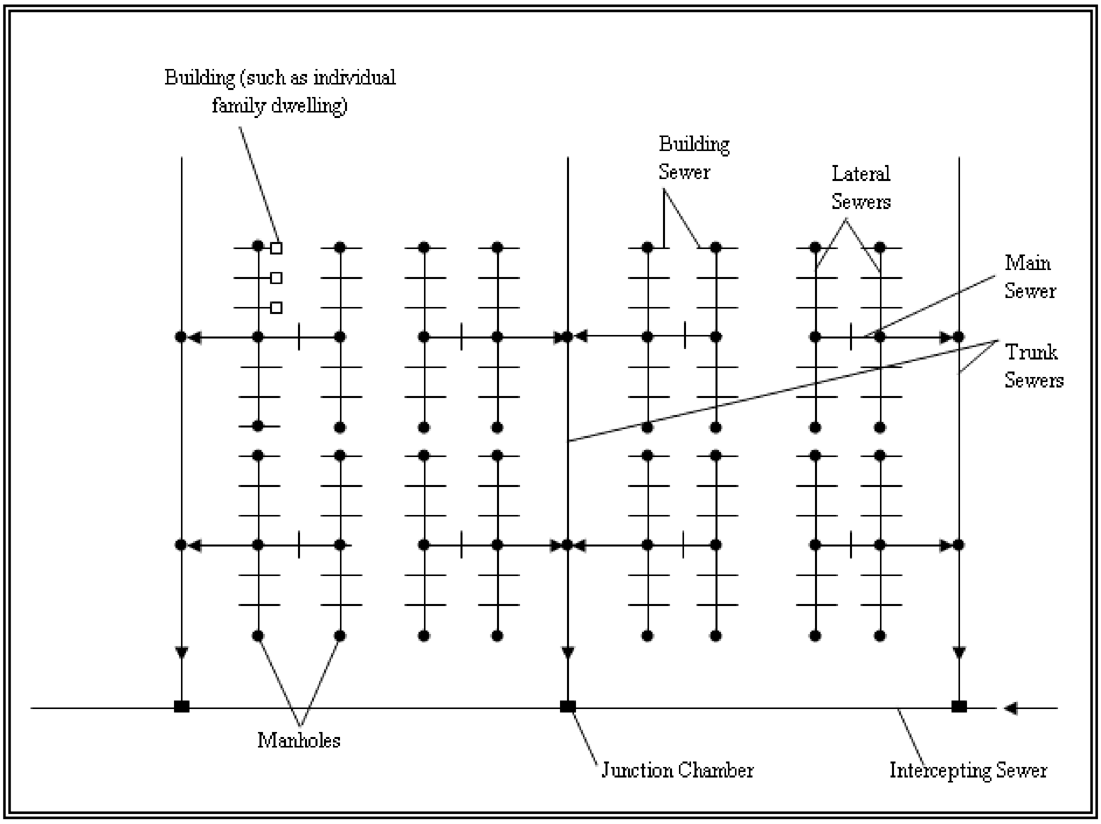
1. ***Interceptor Sewer:*** A sewer that receives flow from a number of other sewers or outlets for disposal or conveyance to a treatment plant.

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

## EXECUTIVE SUMMARY

# CHAPTER 1 EXECUTIVE SUMMARY

## 1.1 GENERAL

This is the Master Plan report for pollution control and sewerage development in Kanpur city. The initial stage of this study has examined prospective urban development to the year 2030, evaluated alternative sewerage projects, and selected the priority components for the Feasibility Study (FS) which has been carried out in subsequent stage.

The methodology of this study has been to determine the least cost approach to meet Kanpur city's sewerage and pollution control needs. This has involved the consideration of existing infrastructure and proposals by UPJN for GAP-II, alternative service coverages, alternative technologies, and alternative wastewater treatment and disposal methods. A summary of relevant population, water supply and wastewater data is presented in Table 1.1.

Kanpur city's population is projected to double from 2.8 million in 2003 to 5.6 million by 2030. At present the total domestic wastewater load is about 395 mld vs. an installed treatment capacity of 171 mld. The amount of wastewater collected and diverted to treatment is on average 79 mld, and represents less than 20% of the total amount generated. Remaining wastewater is discharged to Ganga and Pandu rivers through open drains. The Pandu river is a tributary to the Ganga with its confluence at approximately 25 km downstream of Kanpur.

Water supply and sanitation services are inadequate for Kanpur’s present population. The installed raw water treatment capacity is 380 mld, while the total production from all sources is 502 mld, corresponding to an estimated 182 lpcd. Water supply is intermittent, and adverse sanitation conditions (including defecation in the open) cause increasing hazards to public health.

The sewer infrastructure is old, and poorly maintained. Many of the existing trunk sewers do not have sufficient hydraulic capacity for projected wastewater loads.

The West District has experienced rapid population growth and development of new colonies. At present population is about 335,800 but there is no formal water supply or sewerage in the area. UPJN is implementing improvements to the water supply system. A barrage on the Ganga is being constructed to secure up to 1,600 mld of raw water for the city. A new water treatment plant and distribution system is at present being implemented to augment supply to the area by 200 mld.

Similarly, water supply improvements have been implemented in the South under the Indo-Dutch Project to increase capacity by 42 mld. The amount of wastewater generated in these areas can therefore be expected to increase significantly in the coming years.

### 1.1.1 Need for a Sewerage Master Plan

The GAP projects and proposals have focused on reducing pollution loads by diverting sewage at the tail end of drains during dry weather only. GAP does not address the need for removing sewage from the drains to prevent pollution during wet weather. Nor does it address issues of public health and sanitation within the city.

In the absence of a sewerage master plan urban development continues without adequate infrastructure for public health and sanitation. New sources of pollution crop up as the population grows and as new areas develop:

- Existing sewer facilities are overtaxed, effluent at treatment plants becomes a significant pollutant load

- The amount of wastewater in open drains increases thereby overflowing at existing diversion facilities
- New sources of pollution appear as natural drains serve as outlets for wastewater from new developments

Diversion facilities constructed under GAP are not designed to operate during wet weather, therefore the use of open drains for wastewater disposal will remain a significant source of pollution during wet weather.

Diversion of drains, as proposed under GAP is an important first step for improving water quality. However, the Government of India and NRCD have recognized that the benefits of GAP will be short lived unless these activities are framed within a more holistic approach to the development of sewerage infrastructure in large urban centers. In the absence of a comprehensive plan, efforts at pollution control will always remain reactive, never quite catching up with the source of the problem.

### 1.1.2 Key Issues for the Implementation of Sewerage Master Plan

1) Adopting a decentralized approach
The Sewerage Master Plan divides the urban centre into sewerage districts. A decentralized approach has been favoured to minimize conveyance costs and reduce the size of sewerage facilities. Smaller treatment works will simplify site selection and land acquisition. Furthermore, it is generally easier to manage the operation and maintenance of smaller facilities.

2) Coordinating development of branch sewers with trunk sewers
The trunk facilities identified in the Master Plan are the backbone of the sewerage system. It will open the way for extending the branch sewer network into parts of the city that are not presently served. It is essential that existing and future development areas be connected to this backbone in order achieve water quality, health and sanitation objectives. Jal Sansthans, and Nagar Nigams must implement programs for improving and extending the branch sewer system. A concentrated effort will be required to connect existing and future growth areas, else the trunk sewer system will fail because there will be insufficient wastewater to achieve self-cleansing velocities.

3) Adopting and adhering to the Sewerage Master Plans
The Master Plans for sewerage must be formally adopted by the authorities responsible for the development of cities. A formal mechanism is required to make it mandatory for Development Authorities and Housing Boards to adhere to the Master Plan. Continuing in the present mode whereby new colonies are developed without proper outlet to trunk sewer facilities will only add to the drainage and pollution problems of the city.

4) Cost sharing for trunk facilities: user pay principle
Implementation of new developments must proceed in a planned manner. Major trunk facilities should be extended to service planned communities. In keeping with the user pay principle, it should be made mandatory by law for developers, whether private or Government to share in the cost of trunk sewers and treatment plants.

5) Land acquisition for future facilities
Land identified for sewage treatment works and pumping stations must be acquired as soon as possible and reserved for the future development of the sewerage system. Similarly, right of way and maintenance easements are required along trunk sewer alignments to prevent encroachment.

6) Improving power supply
Pumping stations and treatment plants must be provided with a reliable and continuous

power supply. These facilities must be designated as essential services and should be given top priority for service by the electrical utility. Emergency power generators must be provided at all facilities and funding for fuel must be guaranteed to prevent overflows of untreated sewage during lengthy power cuts.

## 1.2 OVERVIEW OF THE MASTER PLAN

A number of alternative district layouts have been evaluated and a recommended plan is presented in Chapter 7. The proposed sewer service areas and sewerage districts for 2030 are presented in Figure 7.2.

The Sewerage Master Plan is developed for areas within the greater limits of the Municipal Corporation (as defined by the Development Authority) that have or will have population densities greater than 120 persons per hectare. Approximate population densities based on a visual interpretation of land use are derived from satellite images.

The city of Kanpur has been divided into 4 sewerage districts. Each sewerage district having it's own sewage treatment works.

(mld)

| STP | District | Status | 2003 | 2015 | 2030 |
|---|---|---|---|---|---|
| Jajmau tannery | I | E/A | 36 | 52 | 52 |
| Jajmau domestic | I | E /A | 130+5 | 173+5 | 183+5 |
| Bingawan STP | II | PS /A | - | 200 | 365 |
| Panka STP | III | P | - | 120 | 200 |
| Karankhera STP | IV | P | - | 0 | 85 |
| Total | | | 171 | 550 | 890 |

| STP | District | Process | Effluent discharge | Disinfection |
|---|---|---|---|---|
| Jajmau tannery | I | UASB | Irrigation and Ganga River | |
| Jajmau Domestic | I | AS, UASB(Pilot) | Irrigation and Ganga River | Add chlorination or maturation ponds |
| Bingawan STP | II | UASB++ | Irrigation or Pandu River | Chlorination |
| Panka STP | III | UASB++ | Irrigation or Pandu River | Chlorination |
| Karankhera STP | IV | UASB++ | Irrigation or Ganga River | Chlorination or maturation ponds |

PS: in Process of Sanction, E: Existing, A: Augment, S: Sanctioned, ++ post-treatment

## 1.3 RECOMMENDATIONS

Major interventions are necessary to reduce river pollution and improve sanitation to all the population and to cope with its future growth. The following recommendations are identified in this report:

1) ***Rehabilitate main trunk sewers*:** This intervention is required to reduce the amounts of wastewater that overflow to surface drains and to reduce the risk of a catastrophic failure. In addition to cleaning and repair of the system it will be necessary to survey the whole system and to store record drawings and data in a readily accessible form (preferably GIS based) to facilitate maintenance and future planning.
2) ***Rehabilitate existing pumping stations*:** Pumping equipment is getting old and is poorly maintained. Pumps and diesel generators should be updated, and operation

should be automated. The installed capacity at Jajmau pumping station should be increased to improve standby capacity and prevent overflows during peak flow periods. Significant institutional capacity building and reorganization will be required to ensure sustainable operation and maintenance of the pumping stations with emphasis on continuous and reliable operation of diesel generators during power interruptions.

3) ***Increase the amount of wastewater conveyed to Jajmau treatment plant*****:** The existing treatment plant at Jajmau is at present not fully utilized. This intervention is required to reduce pollutant loads to Ganga river and maximize the existing investment in treatment capacity. This intervention includes: rehabilitation of pumping stations, rehabilitation of trunk sewers and lateral sewers in the City District, removing connection of branch sewers to nalas, and increasing the number of household connections to branch sewers.
4) ***Implement a separate domestic wastewater collection system in the Jajmau tannery cluster*****:** At present tannery wastewater is finding its way into the domestic wastewater stream and upsetting the activated sludge treatment process. The domestic wastewater collection system from the tannery cluster must be physically separated from other domestic wastewater systems. This can be achieved by installing a separate service collector connected directly to the UASB. Other minor modifications at the treatment plant site may also be required to fully isolate the tannery wastewater stream. The result will be improved performance of Jajmau activated sludge plant and therefore reduction in pollutant loads.
5) ***Install forced aeration in final polishing pond at Jajmau UASB*****:** This intervention will reduce the levels of BOD and sulphides which at present greatly exceed discharge criteria in NRCD standards.
6) ***Provide trunk sewer facilities and treatment plant in West District*****:** This intervention is required to improve sanitary conditions and reduce pollutant load. The district is experiencing rapid development and population growth. New water supply projects are being implemented and the amount of wastewater will increase significantly.
7) ***Implement regulations, collection and treatment systems for on-site sanitation*****:** Peripheral areas where population densities are less than 120 persons per hectare should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment.

Reducing the pollutant loads to water resources and improving the living environment for residents of Kanpur are important issues that can only be addressed by appropriate sanitation and sewerage interventions. These long-term goals can be met by 2030 if sufficient resources are allocated to the construction of sewage treatment plants and wastewater collection systems.

As shown in Figure 1.1, there is at present a large gap between existing treatment capacity and wastewater load. Therefore there is an urgent need to augment treatment plants and trunk sewers. These urgent projects should be carried out as Stage I, within 5 to 10 years of adopting the Sewerage Master Plan i.e. 2010 to 2015.

After 2015 the emphasis will be on providing branch sewers and connecting households to the collection system in order to increase the amount of wastewater diverted to treatment plants. As shown in Figure 1.2, the largest component of the cost during Stage I is for trunk sewers. At Stage II, the largest cost component becomes branch sewers. Treatment plants are a relatively small part of the overall cost. The total estimated direct costs including contingency and land acquisition are as follows:

(Crores)

| Item | Stage I | Stage II | Total |
|---|---|---|---|
| Direct Cost | 317.9 | 1,259.6 | 1,577.5 |
| Physical Contingency (20%) | 63.6 | 251.9 | 315.5 |
| Land Acquisition | 28.8 | 41.9 | 70.7 |
| Total | 410.3 | 1,553.4 | 1,963.7 |

Direct cost does not include house connection cost

## 1.4 SELECTION OF PRIORITY PROJECTS FOR FEASIBILITY STUDY

Priority projects are defined as projects that should be implemented as soon as possible (before 2015) to achieve pollution reduction targets. These projects include diversion of all drains that have been identified as a source of pollution by UPJN. Priority projects are included in the scope of the Feasibility Study.

Projects that have already been sanctioned by UPJN are not identified as priority projects because it is assumed they will be fully implemented in the near future.

*Priority projects* (listed in order of priority):

1) Develop a plan and identify the cost for inspection of existing trunk sewers and the 90” outfall sewer to Jajmau.

2) Feasibility study to isolate the domestic wastewater collection system in the Jajmau tannery area and treat it at the UASB along with industrial wastewater (to protect the activated sludge process).

3) Feasibility of augmenting the treatment capacity at Jajmau activated sludge treatment plant.

4) Field surveys to confirm alignment, and invert levels of trunk sewers that need to be replaced. Determine the feasibility of installing a parallel pipe or develop a plan for replacement in the same alignment.

5) Field surveys for the following existing pumping stations:

   - Nawab ganj
   - Muir mill
   - Parmat
   - Guptar ghat
   - Jajmau
   - Lakhanpur

6) Determine physical condition of existing mechanical, electrical equipments, rising mains and sumps. Identify repair or replacement needs. Confirm catchment areas (existing and future). Determine future flows, required size of replacement pumps and rising mains if required.

7) Field surveys for new pumping station to intercept and divert Bhagwatdas ghat Nala in Central District, confirm catchment areas (existing and future). Determine future flows, required size of civil structures, pumping plants and rising mains.

8) Feasibility of Panka treatment plant for West District. Confirm and survey site, method of

treatment, method of disposal for effluent and sludge. Develop preliminary design for STP including influent pumping station.

9) Feasibility of Panka outfall sewer, Panki pumping station and main North-South trunk sewers. Confirm and survey proposed alignments, confirm size of pipes, develop profile drawings. Determine feasibility of crossing under Pandu river with gravity sewer; identify river cross section, flood levels and scouring depth. If necessary adjust conceptual trunk sewer layout based on topographic surveys. Develop preliminary designs for proposed pumping stations.

**Table 1.1 Project Data Sheet, Kanpur**

| **Population** | | **2003** | **2015** | **2030** |
|---|---|---|---|---|
| Municipal | | 2,819,827 | 4,342,031 | 5,629,081 |
| Outside municipal boundary | | - | - | - |
| Floating | | - | - | - |
| Total | | 2,819,827 | 4,342,031 | 5,629,081 |

| **Water Supply** | | **2003** | **2015** | **2030** |
|---|---|---|---|---|
| Population served by municipal system | | 2,733,800 | 4,000,000 | 5,629,081 |
| Demand (UPJN estimates) | mld | 589 | 1,067 | 1,534 |
| Water supply treatment capacity | mld | | | |
| Existing | mld | 350 | 350 | 350 |
| Proposed | mld | 28 | 778 | 1,337 |
| Total | mld | 378 | 1,128 | 1,687 |
| Water sources | | | | |
| Municipal-river | mld | 350 | 1,128 | 1,678 |
| Municipal-wells | mld | 112 | 112 | 112 |
| Private | mld | 40 | 40 | 40 |
| Other | mld | - | 7 | 7 |
| Total | mld | 502 | 1,287 | 1,837 |

| **Wastewater** | | **2003** | **2015** | **2030** |
|---|---|---|---|---|
| Population in sewer service area | | 1,848,335 | 2,983,898 | 5,629,081 |
| Population connected to sewer | | 677,264 | 1,686,470 | 4,210,800 |
| Percentage of total population | | 24% | 39% | 75% |
| Wastewater return rate per capita (core) | lpcd | 140 | 145 | 155 |
| Total wastewater generated | mld | 395 | 630 | 873 |
| Amount intercepted | mld | 259 | 433 | 873 |
| Treatment capacity | | | | |
| Existing | mld | 171 | 171 | 171 |
| Sanctioned | mld | - | 200 | 200 |
| Proposed | mld | - | 179 | 519 |
| Total | mld | 171 | 550 | 890 |

## Table 1.2 Stage I Project - Implementation Cost

(Million Rs.)

| Project | Estimated Cost | +Physical Contingency | Cumulative Cost |
|---|---|---|---|
| **1. District I (City Central)** | | | |
| (a) Replacing existing trunk sewers | 169.9 | 203.9 | |
| (b) New Trunk Sewers | 158.7 | 190.4 | |
| (c) Nala tapping pumping stations and rising mains | 54.5 | 65.4 | |
| (d) Branch Sewer | 113.3 | 135.9 | |
| (e) Land acquisition for new pumping station | 4.0 | 4.0 | |
| Sub Total | 500.3 | 599.6 | 599.6 |
| **2. District I (City East)** | | | |
| (a) New Trunk Sewers | 58.3 | 69.9 | |
| (b) Upgrade treatment plant | 129.0 | 154.8 | |
| (c) Upgrade pumping station | 0.3 | 0.4 | |
| (d) Branch Sewer | 282.1 | 338.5 | |
| Sub Total | 469.7 | 563.6 | 1,163.2 |
| **3. District II** | | | |
| (a) New Trunk Sewers | 64.1 | 76.9 | |
| (b) Branch Sewer | 156.3 | 187.5 | |
| Sub Total | 220.3 | 264.4 | 1,427.6 |
| **4. District III** | | | |
| (a) New Trunk Sewers | 423.1 | 507.7 | |
| (b) New treatment plant | 360.0 | 432.0 | |
| (c) New pumping station | 1,066.2 | 1,279.4 | |
| (d) Branch Sewer | 143.8 | 172.6 | |
| (e) Land acquisition for STP and SPS | 284.0 | 284.0 | |
| Sub Total | 2,277.1 | 2,675.7 | 4,103.3 |
| **Total** | 3,467.4 | 4,103.3 | 4,103.3 |

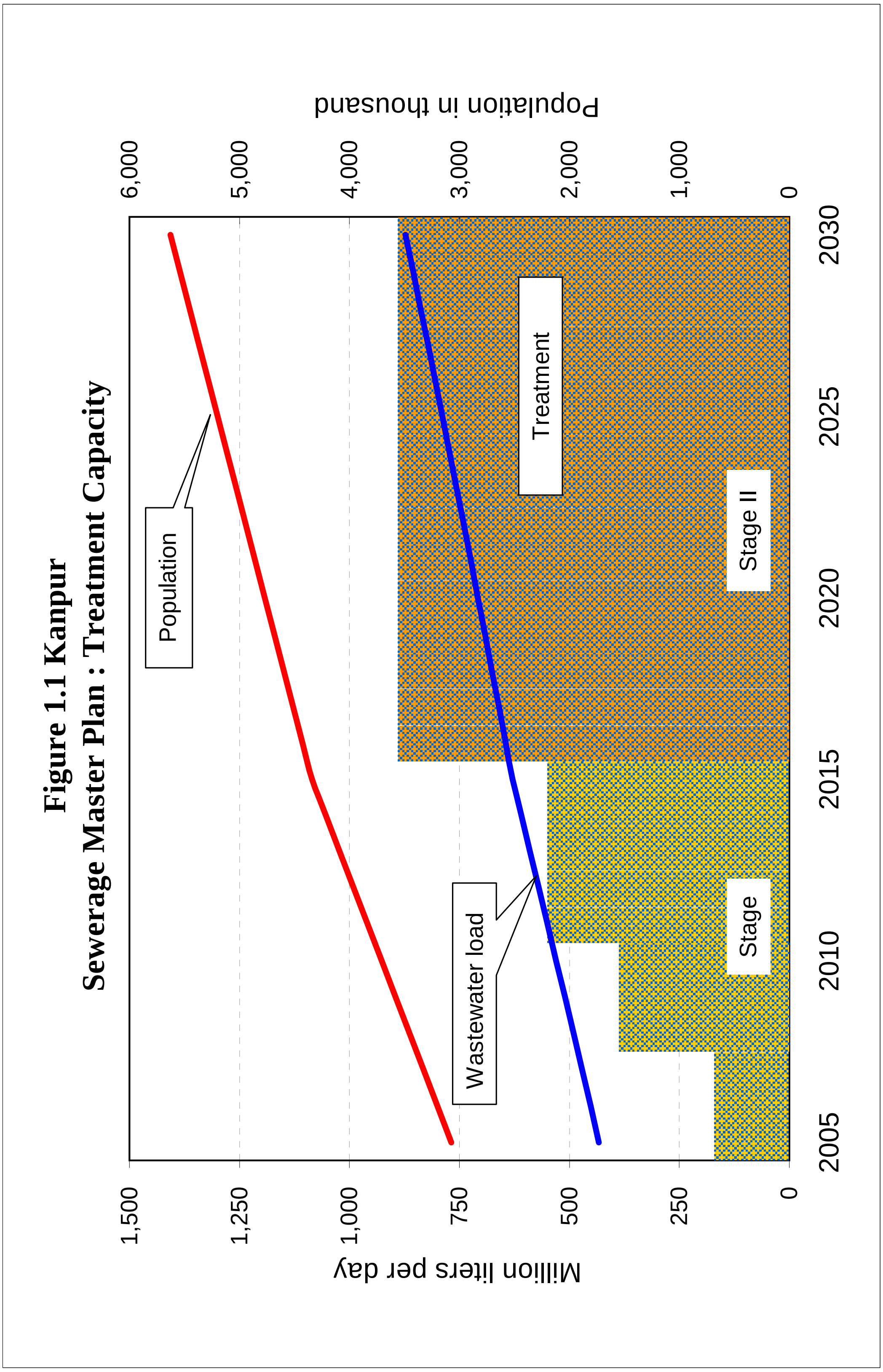



**Figure 1.1 Kanpur**
**Sewerage Master Plan : Treatment Capacity**

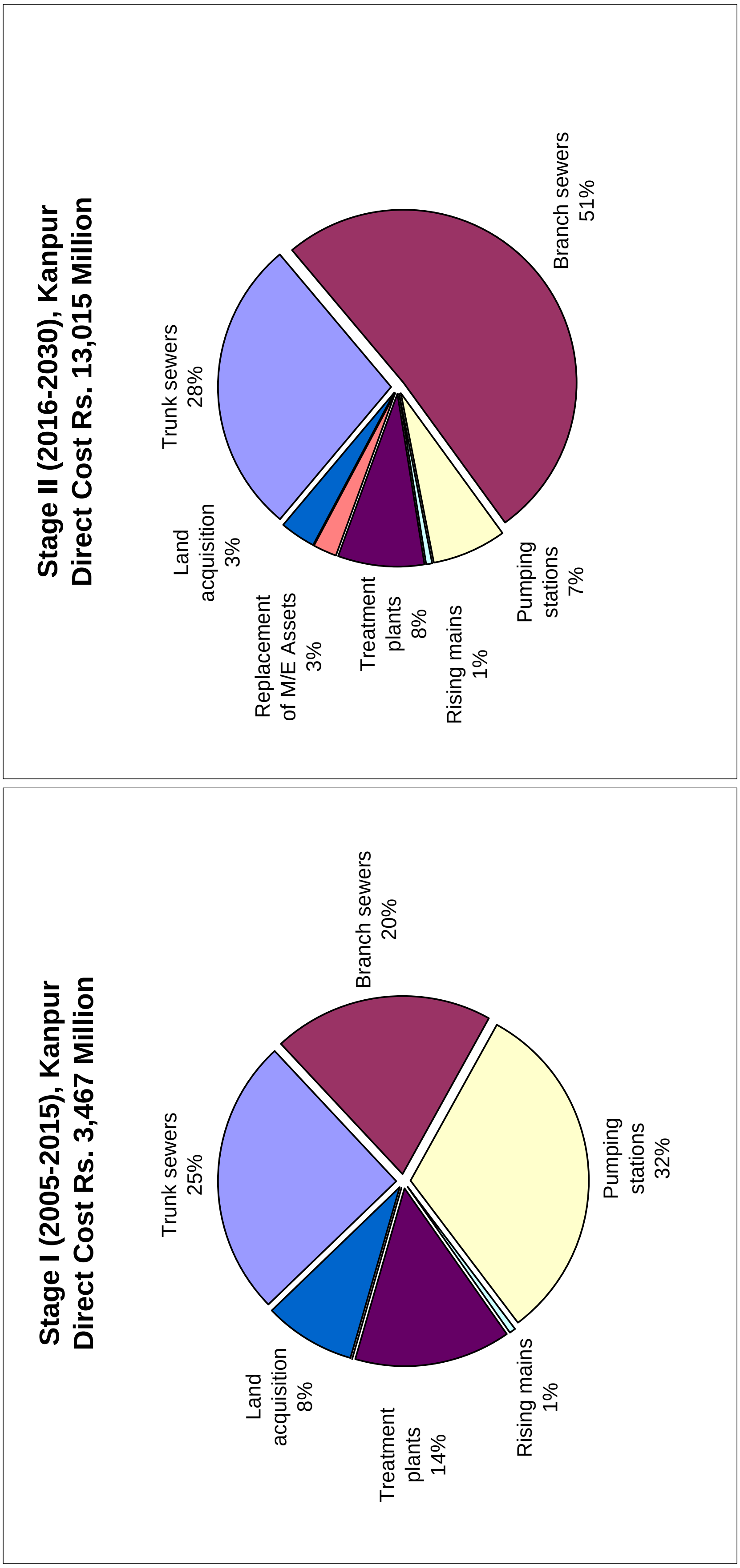



**Figure 1.2 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost**

# CHAPTER 2

## INTRODUCTION

# CHAPTER 2 INTRODUCTION

## 2.1 PRESENT WASTEWATER SYSTEMS

The city of Kanpur's wastewater facilities include a collection system and three wastewater treatment plants at Jajmau:

- 5mld pilot UASB
- 36mld UASB
- 130 mld ASP

The collection system covers about 30 % of the city area and most of this is within the old, densely populated centre core. The total amount of wastewater measured in drains and at the STPs in 1997 was about 370 mld of which 160 mld was intercepted under GAP-I. At present, average inflow to the treatment plants is 79 mld, only about 20% of the total wastewater generated.

A separate collection system serves the tannery industries located in the Jajmau area conveys by pumping stations directly to the 36 mld UASB. Originally designed for 9 mld it now collects approximately13 mld of tannery wastewater.

Households that are not connected to sewers discharge sullage (wastewater from kitchen/bathing and grey water from septic tanks) directly to street drains that ultimately discharge to the rivers. Sanitary wastewater (from toilets) is discharged to soak pits or septic tanks where solids are retained and partially reduced in volume.

UPJN is responsible for pollution prevention and planning capital projects for sewerage. UPJN also operates and maintains large pumping stations and the treatment plants. Jal Sansthan is responsible for maintenance of trunk sewers, lateral sewers and collection of revenue from house connections.

## 2.2 REVIEW OF EXISTING INFORMATION

The following background information regarding the city of Kanpur's wastewater collection and treatment capabilities were provided to the JICA Study Team:

- Influent and effluent wastewater characteristics for Jajmau treatment plants
- UPJN Preliminary Estimate for water supply for east district of Kanpur Nagar through Ganga Barrage, August 2003
- UPJN Preliminary feasibility report for 1,600 mld water supply scheme through Ganga Barrage
- UPJN Detailed project report for laying trunk sewer along COD Nala
- Rapid environmental impact assessment report, 200 mld UASB STP, Kanpur South, May 16,2001, under Indo-Ducth assistance
- UPJN addendum to detailed project report Intermediate sewage pumping station at Munshi Purwa 1999-2000
- UPJN addendum to detailed project report Intermediate sewage pumping station at Rakhi Mandi
- UPJN Kanpur Sewerage Reorganization Master Plan 1979-2001
- Census data 2001 for wards administered by Kanpur Municipal Corporation
- UPJN feasibility report for integrated pollution abatement & river management for Ganga basin at Kanpur, March 2003
- Jal Sansthan drawings of existing trunk, lateral and branch sewers

### 2.2.1 Infrastructure Management Issues

A comprehensive proposal is required for providing adequate sewerage systems to improve sanitary conditions and reduce the impact on water quality of receiving streams. Key issues identified in previous studies that must be addressed by the Master Plan include:

1) On-site systems:

Pour flush toilets discharging to leach pits or septic tanks are the most popular on-site sanitation facility. In the core area, space limitation constrains the installation of on-site sanitation system and construction of a private toilet within the household. Leach pits require periodic emptying, which is done manually in an unhygienic manner. There is no centralized service for cleaning of on-site systems. Septic tanks and leach pits overflow and discharge to street side drains, which contributes to the pathogen load in the environment.

2) Discharge of sullage:

A large proportion of households' sullage water from kitchen, bathing and laundry is discharged into street side drains. This compounds the problem arising from inadequate surface water drainage. The reluctance to discharge sullage to the sewer is due to the frequency of and duration of sewer blockages.

3) Inadequate sewerage coverage and low connection ratios:

Of the total volume of sewage generated within the city, only a small proportion enters the main sewerage system. A large fraction enters the surface water drainage system either directly or through spillage from damaged or blocked sewers. This pollutes the water environment and results in unsanitary living conditions particularly when it rains.

4) Ingress of storm water and solid waste into sewer system:

Damaged manholes, sewer defects particularly around the nalas and connections of nalas to the sewerage system have led to the increased risk of solid waste entering and blocking the system. There is currently no way of controlling the amount of storm water that enters the system at locations where drains have been diverted. Storm water overloads the sewer system and causes overflows to the river. Augmentation of trunk sewers and treatment capacities to deal with the storm water runoff is too costly therefore a solution is required for storm water by-pass.

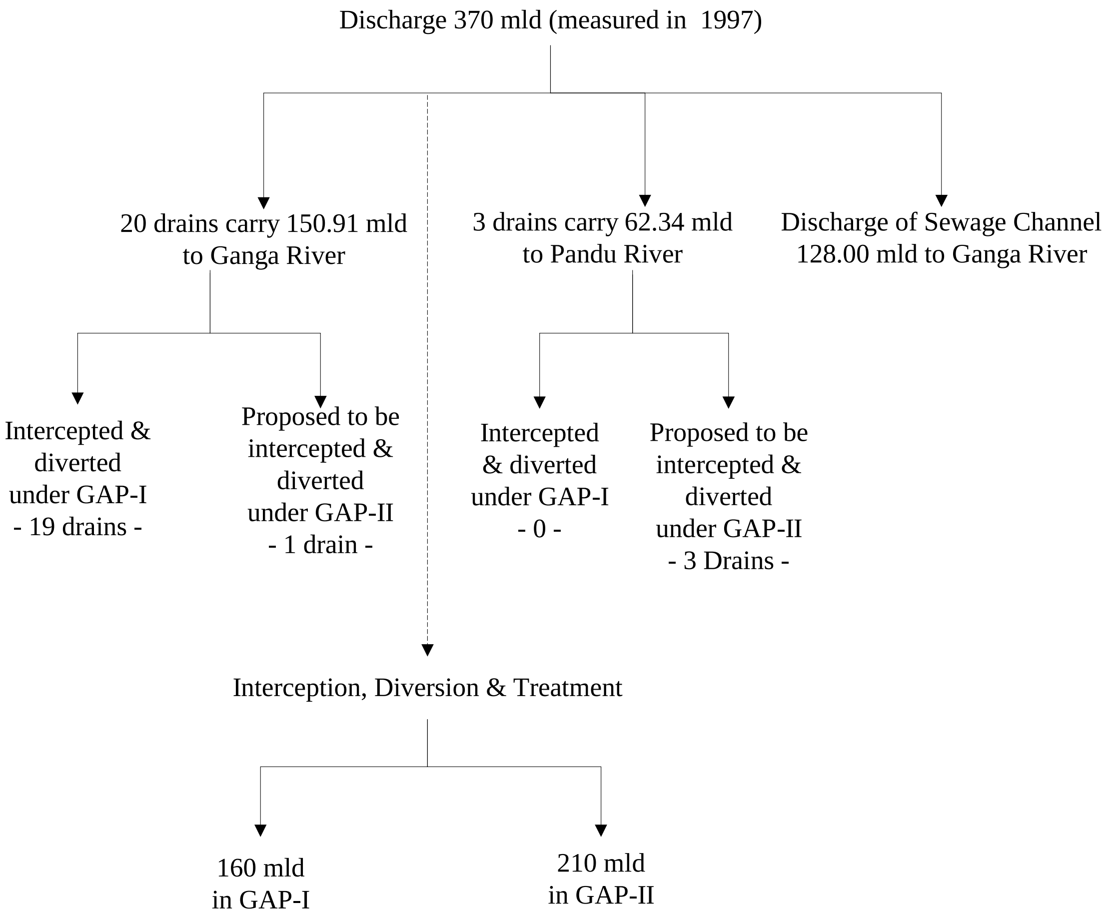
## 2.3 SUMMARY OF GANGA ACTION PLAN

Prior to the Ganga Action Plan, about 240 mld of domestic water and 5-6 mld of tannery wastewater was generated in Kanpur. In response to growing concern over water quality and environmental degradation UPJN planned a phased pollution abatement program. The Ganga Action Plan Phase I (GAP-I) was launched in June, 1986 to reduce the amount of untreated wastewater reaching the Ganga river. The primary focus was on interception and treatment of municipal sewage. Schemes completed by UP Jal Nigam under GAP-I are summarized as follows:

- Cleaning of trunk and main sewers
- Interception of 16 drains
- Construction of 160 mld main sewage pumping station at Jajmau
- Construction of 130 mld domestic wastewater treatment plant (activated sludge process)
- Construction of 5 mld UASB pilot treatment plant under Indo-Dutch assistance

- Construction of 36 mld UASB treatment plant for combined tannery and domestic wastewater under Indo-Dutch assistance
- Construction of a separate open drain collection system and tapping of 4 nalas in the tannery district under Indo-Dutch assistance

Under GAP-I, only 160 mld could be intercepted because of the limitation of the existing 90 inch outfall sewer.




Source: flows measured by UPJN

**Figure 2.1 Flows Intercepted under GAP-I**

GAP-II is aimed at intercepting and diverting the remaining flow of about 210 mld to wastewater facilities being constructed south of the city under Indo-Dutch assistance. The following works have been sanctioned under GAP-II and are at present under construction:

- Tapping Sisamau nala that discharges about 120 mld of domestic wastewater to Ganga river
- Tapping of COD nala, Ganda nala, Halwa Khanda nala that discharge about 50 mld of domestic wastewater to Pandu river which ultimately meets with Ganga river at about 25 kms downstream of Kanpur.
- Relieving sewers, about 8 km
- Intermediate pumping stations at Munshi Purwa and Rakhi Mandi to pump about 180 mld
- Trunk sewer along COD nala to proposed treatment plant
- Land acquisition for proposed STP at Bingawan

Projects not yet sanctioned (but identified in DPR)

- 200 mld UASB STP at Bingawan

Execution of GAP-II projects will significantly reduce the pollutant load of Ganga river. However, increasing population will add to the amount of wastewater generated. A comprehensive plan for the development of sewerage is required to prevent increased flows in nalas and further degradation of the environment.

The proposals contained in previous studies and DPR provide useful information for this master planning effort. Projects implemented under GAP-I have not provided the intended improvements in water quality because there is insufficient collection and treatment capacity. The weakest links in the existing scheme are the pumping stations. At present sewage overflows occur at these stations during daily power failures lasting up to 8 hours. Although emergency power generators are provided, the operating authority (UPJN) has insufficient funds for the purchase of diesel fuel. Furthermore, some of the nala tapping stations have insufficient capacity to deal with dry weather flows which have increased beyond the quantities predicted.

Under GAP-II, UPJN has proposed several new diversion and treatment works to reduce the amount of sewage flowing to the Pandu and Ganga rivers. It is noted, however, that the proposals do not provide a comprehensive plan for the development of a sewerage system that is needed to prevent increased flows in nalas and further degradation of the environment. Most notable is the absence of timeframes for the development of new facilities and budgets for maintenance, rehabilitation or replacement of existing facilities.

# CHAPTER 3

## CITY PLANNING AND POPULATION PROJECTIONS

# CHAPTER 3 CITY PLANNING AND POPULATION PROJECTIONS

The focus of this section of the study is to document from available information the existing population in Kanpur, understand their spatial distribution, and then develop population growth and distribution scenarios.

Kanpur is an industrial city, located about 78 kilometres from Lucknow, the capital of Uttar Pradesh, and 425 km east of the national capital, Delhi. Situated on the right bank of holy river Ganga and developed linearly along this river, the expansion of the city was restricted in southern direction by the river Pandu.

The project study area falls within the jurisdiction of Kanpur Development Authority (KDA), subdivided into rural and urban areas. The rural areas covers Kalyanpur (with some urban area), Bignu and Sarsaul and the urban area covers Kanpur Municipal Corporation, Cantonment, Armapur Industrial Estate, Railway Colony, Chakeri, IIT, etc. The total area under KDA is 829 sq.km out of the total Kanpur Nagar District area of 1040 sq.km.

In this project study the detailed analysis of Kanpur has been focussed on the municipal extents. The peripheral growth areas outside of the municipal extents have also been examined and considered for the future growth and expansion of the city, however in this city, in contrast to Allahabad, Lucknow, and Varanasi, no significant extended urban development was seen outside the municipal areas. The efforts of this study are concentrated on this area, examining intra-area growth patterns and trends using satellite imagery, field observations, and inputs of local agencies.

## 3.1 UNDERSTANDING PAST AND EXISTING POPULATION

The base data used for this study was (provisional census) data obtained from the Census of India, with detailed urban area population and municipal wards for 2001. This data provided the numeric basis for benchmarking the actual population and its decadal growth for the past decade. This information was complemented with past decadal growth rates and population data for earlier decades from the master plan documents.

The city witnessed significant population growth from 1.275 million in 1971 to 2.037 million in 1991 with average annual growth rate of 2.6 percent. Based on the 2001 census records, the population of the Kanpur municipal area was 2,531,138 persons. For the same period, the urban area had a population of 2,721,145 persons of which a population of 94,780 is attributed to the areas under the cantonment board.

**Table 3.1 Decadal Population and Growth Rate of Kanpur Urban Area**

| Year | Urban Area Population | Source | Growth | Growth Rate |
|---|---|---|---|---|
| 1901 | 202,797 | Census Data | | |
| 1911 | 178,557 | Census Data | -24,240 | -11.95% |
| 1921 | 216,436 | Census Data | 37,879 | 21.21% |
| 1931 | 243,755 | Census Data | 27,319 | 12.62% |
| 1941 | 487,324 | Census Data | 243,569 | 99.92% |
| 1951 | 705,383 | Census Data | 218,059 | 44.75% |
| 1961 | 971,062 | Census Data | 265,679 | 37.66% |
| 1971 | 1,275,242 | Census Data | 304,180 | 31.32% |
| 1981 | 1,641,064 | Census Data | 365,822 | 28.69% |
| 1991 | 2,111,284 | Census Data | 470,220 | 28.65% |
| 2001 | 2,721,145 | Census Data | 609,861 | 28.89% |

## 3.2 UNDERSTANDING DISTRIBUTION OF EXISTING POPULATION

As described in the methodology under the City Planning and Population Projections report, the project team developed an understanding of the existing population distribution across the urban areas of Kanpur. Comparing this population distribution with a visual interpretation of the satellite imagery helped in a better characterization of the urban development pattern into patches of varying population density levels. This approach helped in assessing the urban development character of the city in the face of limitations of time and resources under this project.

The linear development of Kanpur city along the right banks of river Ganga in east-west direction is restricted towards south with river Pandu. The land use pattern of the city is marked with a heavily built CBD area near railway station hosting the wholesale market and cantonment area in the eastern side. The development of public, semi-public, residential and other mixed land-uses have come-up in the western direction and mixed with the industrial growth in that direction.

The city of Kanpur addresses multiple functions such as an industrial growth centre with important industrial establishments of urea fertiliser plant, thermal power plant, LML scooters, Indian Oil Corporation and National Textile Corporation Mills, trade and commerce centre as major distribution centre for finished leather products, textile, fertiliser and for the products not manufactured in the city; as a transit point; an educational centre with educational institutes of International reputation (IIT Kanpur), National Sugar Institute, CLRI, National Textile Institute, ICAR, Kanpur University, etc. While these functions have distributed residential demand and development across the city, there still remains a shortage of housing stock for the city residents. In addition, the industrial activity also attracts short-term migrant labour which remains unaccounted for in population estimates and forecasts.

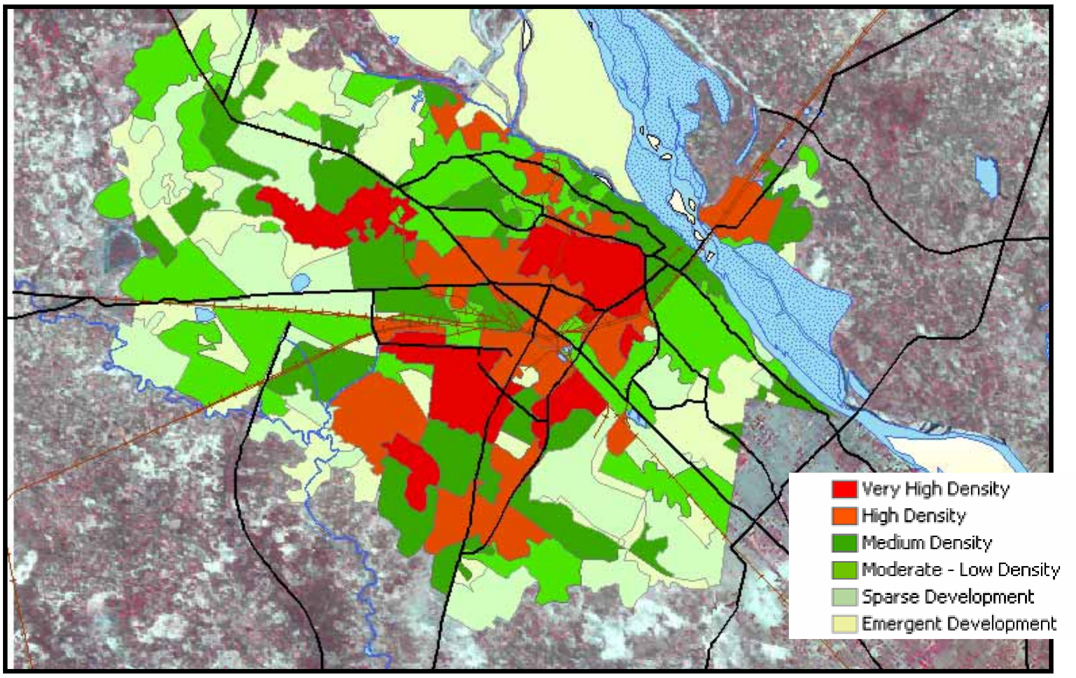



**Figure 3.1 Satellite Imagery Interpretation for Development Density**

## 3.3 POPULATION GROWTH PROJECTIONS

The basis of developing the population projections for this study have been the information collected from the Census Department, Lucknow, information provided by Kanpur Nagar Nigam and from data made available in the master plan documents through the Kanpur Development Authority.

The Master Plan for 2021 was developed with a population projection of 4.5 million. These projections were developed with the background data of 1991 census figures of a population of approximately 2.15 million. This increase over a 30 year period translates in a decadal growth rate of approximately 28.6%, projecting a declining growth rate for the city as compared to earlier decadal intervals which have been upwards at 30% and up to 45% for the period from 1951 to 1991.

While these growth figures projected in the Master Plan appear to be normative and more realistic as compared to the figures observed in the Kanpur Master Plan for the same period, there is also an assumption that Kanpur as a city will have to seriously address the developmental problems and its poor environmental quality. If the direction provided by the 2021 Master Plan and the "Vision Statements" being developed are implemented effectively, in tandem with major infrastructural enhancements to transportation, sewerage, water supply, and solid waste management, only then would it seem possible that these growth rates and projections will be achieved.

Accepting that Master Plan projections are normally more optimistic than that achieved, and given that the ground reality in Kanpur does not reflect much activity to energetically address the poor urban environment, the growth rates should be expected to reflect a further slow-down. Also, examining the regional growth and the national trends of slower growth rates in larger cities, the growth trajectory for the target year of the study, 2030, should be still lower. However, in keeping with the practice of including safety margins in the population forecasts, the decadal growth rate of 28.6% has been adopted for our project target period extending beyond the Master Plan.

While the Master Plan attempts to chart new growth directions for Kanpur as a city, there is no specific activity or development magnet. As such, Kanpur may be considered a city in decline with its deteriorating urban environment, closure of industries, and loss of employment opportunities. Its proximity to Lucknow, further enhanced by the National Highway Development Program, have not resulted in any direct benefit to Kanpur, and in contrast, it has lost some of its growth momentum to Lucknow itself, and to Unnao.

**Table 3.2 Population Projections**

| Year | Urban Area Population | Source | Growth | Growth Rate |
|---|---|---|---|---|
| 2001 | 2,721,145 | Census Data | 609,861 | 28.89% |
| 2011 | 3,499,307 | Projected by Study Team | 778,162 | 28.60% |
| 2021 | 4,500,000 | Master Plan Numbers | 1,000,693 | 28.60% |
| 2031 | 5,786,859 | Projected by Study Team | 1,286,859 | 28.60% |

It is a logical progression then to expect the exercise of population forecasts to be complemented with a spatial distribution of the population and a forecast of the increased extents of urbanization, which will encompass the forecasted population. This has been addressed in the section on Population Distribution Projections.

## 3.4 POPULATION DISTRIBUTION PROJECTIONS

### 3.4.1 Defining Growth Characteristics

Forecasting growth distributions for Kanpur is a difficult task. The city is a heterogeneous mix of opportune development areas which are made immensely less attractive due to the poor infrastructure, traffic networks, and major through traffic of road and rail networks that bisect the city as well as disrupt intra-city movement.

Due to this intersection of the major road and railroad networks, the city is fragmented into separate development quadrants. The peripheral areas of the city, away from Ganga, towards Pandu river on the south are more appropriate for new, planned developments.

On the eastern edge of the city, growth remains relatively slow and is confined due to the presence of the cantonment and the airstrip at Chakeri. There is no development pressure or magnet to catalyse and extend growth beyond this eastern edge.

Based on an analysis of the growth characteristics of each ward, depending on its current density, road network, master-plan designation, and adjacent ward characteristics, the individual ward growth rates were redefined. Although the table below represents the average growth rate for each decadal interval for the categories defined below, the actual ward-wise growth rates are significantly divergent due to the complex character of the urban development potential within the municipal limits of Kanpur.

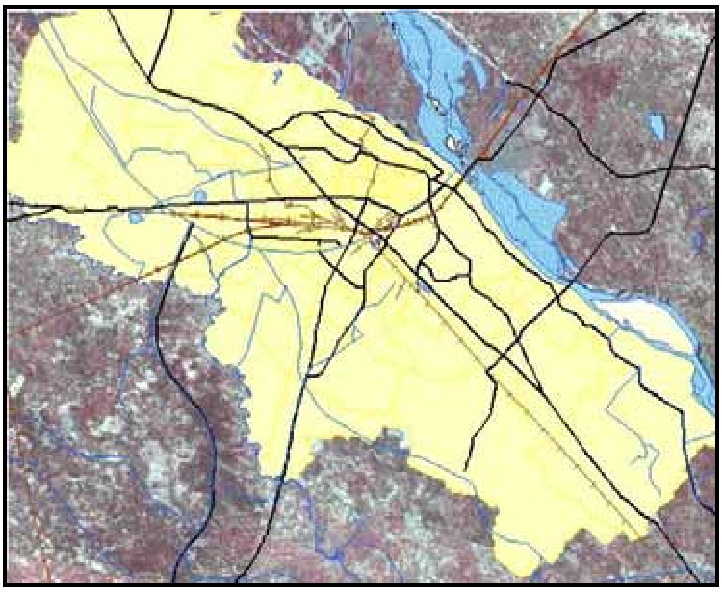


**Figure 3.2 Municipal Extents of Kanpur**

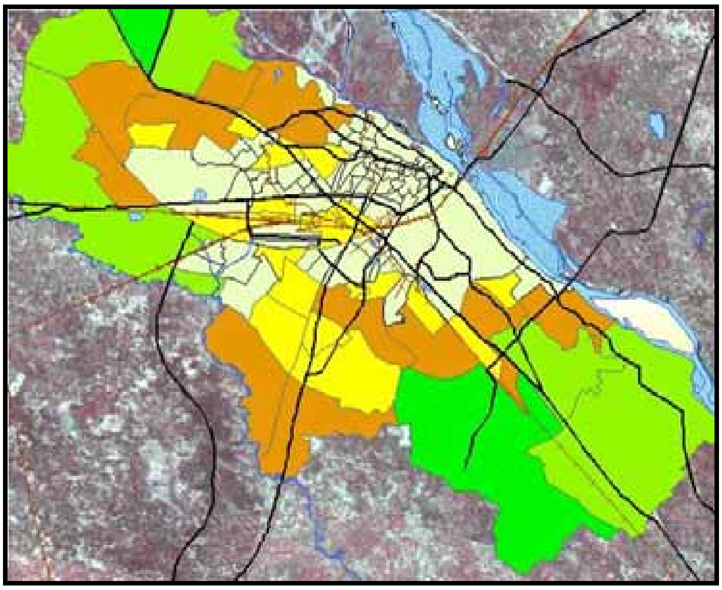


**Figure 3.3 Growth Rates of Kanpur**

The growth characterization of Kanpur area has been organized into three major classes. The approximate decadal growth rates for these classes are also given below. These growth rates were spatially studied in the context of existing development densities, proximity to institutional and industrial facilities, and constraints imposed by presence of cantonments and growth restriction areas such as the Chakeri airstrip.

**Table 3.3 Growth Characteristics Defined**

| Category | Description | Decadal Growth Rate | | |
|---|---|---|---|---|
| | | **2001-2011** | **2011-2021** | **2021-2031** |
| Far-Open | Outer Area, away from Core | 75% | 60% | 50% |
| Proximal | Proximal to Core | 40% | 15% | 10% |
| Core | Core Area | 3% | 1% | 1% |
| Avg | Background Average Growth Rate | 25% | 22% | 20% |

** Outliers to these growth rates exist and are a result of localized characteristics which in instances have a lower or higher growth rate than that for the defined ward characteristics.*

### 3.4.2 Influence on Development Characteristics

The lack of planning, congestion, encroachments and deteriorated environment, acute shortage of housing, over-stressed infrastructure, inadequate drinking water supply and inadequate waste collection & disposal facilities, etc, are detriments to the growth of the city. The present transportation network and system is inadequate to take the load of existing traffic. While the lack of proper public transport system is a problem for the city residents, mobility within the city is further limited by an inadequate road network, a large number of level crossings along existing meter-gauge rail tracks which create bottle-necks to the traffic. Added to this is the through-traffic experienced by the city which adds to the air pollution, increased traffic load, and generally contributes to making a poor living environment in the city.

The housing quality of Kanpur, which by and large depends on civic services (water supply, sewage collection), power supply, roads, greenery, commuting facilities, community shopping centres etc., is difficult to characterise and ranges from average to bad in different areas. The city core area is densely populated, very old blocks in dilapidated condition, old sewerage system, broken-down water supply lines, improper garbage collection and insufficient open spaces.

Kanpur, once an industrial growth centre of the development in the region, faced the problems of unorganised growth coupled with decline in industrial production resulting into the adverse impact on the urban set-up. The cause of decay could be attributed to closure of many large industrial units and deterioration in infrastructure facilities.

The city landscape is dotted with about 75 large & medium scale industries which followed western direction of expansion along the railway line and G.T. road. These industries include Government owned units viz. Elgin Mills, Muir Mill, Cawnpore Woollen Mills, Ordinance factories, New Victoria Mill, M.P. Udyog, HVOC, and Lal Imli which are facing threat of closure owing to problems like old technology, gigantic workforce, high input cost and low output. Despite this grim scenario, Kanpur is still a major industrial centre with few operating textile mills, defence establishments, power plants, fertiliser unit, automobile industry, vanaspathi oil mill and tanneries.

In real terms, the urban infrastructure of Kanpur remains in relatively poor condition and as the city tries to articulate new growth areas beyond the municipal limits, there remains adequate space and opportunity within the current municipal limits of Kanpur. Unless a new vision is crafted, and additional development created, it is probable that Kanpur will see growth rates slower than that projected in this study.

Although a new Master Plan is now being adopted for the city, the existing violations and unauthorized developments make it a difficult task to realize the vision for planned development and improvement of the city. Since the validity of the last Master Plan expired (in 1991) to present day, there has been little action to suggest that the city as a whole is finding new ways to re-invent itself and emerge from this unattractive living environment.

### 3.4.3 Data Constraints and Limitations

Specific concerns of ward areas and population densities was discussed with officers in the Nagar Nigam and in the Development Authority. Although the digital data with Kanpur Nagar Nigam was not accessible to use directly in the project work, GIS resource persons were helpful in reviewing and addressing ward-mapping issues.

The limited time on this project did not allow for detailed ground truthing and assessment of the actual development density across the entire city. Consequently, the inputs of local agencies was essential in validating the existing conditions. The support of the officials of the Nagar Nigam and that of the PPCU is acknowledged in this regard.

### 3.4.4 Population Projections by Ward

The table below gives the finalized ward-wise population figures and the overall summaries of population for each of the years of consideration under this study.

**Table 3.4 Ward Wise Population Prohection (Page 1 of 2)**

| Ward No. | Ward Name | Character | Population 2003 | Population Density 2003 | Population 2015 | Population Density 2015 | Population 2030 | Population Density 2030 |
|---|---|---|---|---|---|---|---|---|
| 1 | Lakshmi Purwa | Core | 26,741 | 268 | 27,627 | 277 | 27,903 | 279 |
| 2 | Makrobertganj | Core | 22,134 | 286 | 22,868 | 296 | 23,097 | 299 |
| 3 | Khalasi Line | Core | 15,699 | 434 | 16,219 | 448 | 16,381 | 453 |
| 4 | Jawahar Nagar | Core | 14,334 | 812 | 14,810 | 839 | 14,958 | 847 |
| 5 | Kalyanpur | Far-Open | 57,346 | 94 | 110,817 | 181 | 150,676 | 246 |
| 6 | Nankari | Far-Open | 14,761 | 21 | 52,697 | 75 | 93,460 | 132 |
| 7 | Rawatpur | Proximal Developed | 39,947 | 369 | 46,678 | 431 | 49,012 | 452 |
| 8 | Old Kanpur | Proximal Open | 24,118 | 946 | 24,118 | 946 | 24,118 | 946 |
| 9 | Chakeri | Far-Open | 30,432 | 11 | 66,061 | 23 | 114,929 | 40 |
| 10 | Colnelgunj | Core | 8,808 | 803 | 9,100 | 830 | 9,191 | 838 |
| 11 | Govendnagar Harijan Basti | Proximal Developed | 29,202 | 123 | 45,384 | 192 | 54,683 | 231 |
| 12 | Trasport Nagar | Core | 19,807 | 254 | 20,463 | 262 | 20,668 | 265 |
| 13 | Bhannana Purwa | Core | 21,215 | 179 | 21,918 | 185 | 22,137 | 187 |
| 14 | Ambedkar Nagar Kakadeo | Proximal Developed | 19,322 | 294 | 30,028 | 458 | 33,456 | 510 |
| 15 | Gwal Toli | Proximal Open | 21,377 | 662 | 23,225 | 720 | 23,549 | 730 |
| 16 | Sisamau | Core | 23,810 | 1,648 | 24,599 | 1,702 | 24,845 | 1,719 |
| 17 | Om Purwa | Proximal Developed | 25,187 | 238 | 41,748 | 394 | 50,500 | 477 |
| 18 | Rai Purwa | Core | 21,379 | 518 | 22,088 | 536 | 22,308 | 541 |
| 19 | Vijay Nagar | Proximal Developed | 25,548 | 358 | 33,277 | 466 | 36,604 | 513 |
| 20 | Ashok Nagar | Proximal Developed | 28,740 | 207 | 45,985 | 331 | 55,408 | 399 |
| 21 | Benajhawar | Proximal Developed | 20,725 | 477 | 25,253 | 581 | 27,778 | 639 |
| 22 | Saraimita Ward | Far-Open | 35,913 | 30 | 128,210 | 108 | 239,045 | 202 |
| 23 | Bakarganj | Proximal Developed | 24,618 | 1,416 | 25,038 | 1,441 | 25,288 | 1,455 |
| 24 | Sanigwan | Far-Open | 27,844 | 10 | 132,202 | 46 | 330,504 | 116 |
| 25 | Tilak Nagar | Proximal Developed | 30,057 | 128 | 51,541 | 220 | 69,580 | 296 |
| 26 | Anwar Ganj | Core | 14,639 | 1,710 | 15,124 | 1,767 | 15,276 | 1,785 |
| 27 | Nawab Ganj | Institutional | 31,176 | 63 | 56,494 | 115 | 76,266 | 155 |
| 28 | Sisamau First | Core | 18,497 | 809 | 19,110 | 836 | 19,301 | 845 |
| 29 | Coolie Bazar | Core | 14,704 | 1,087 | 15,191 | 1,123 | 15,343 | 1,134 |
| 30 | Vishnupuri | Proximal Developed | 19,947 | 243 | 30,078 | 366 | 33,511 | 407 |
| 31 | Safipur | Proximal Developed | 28,995 | 36 | 87,823 | 108 | 146,575 | 180 |
| 32 | Khyoa | Far-Open | 31,471 | 39 | 122,232 | 150 | 205,600 | 252 |
| 33 | Panki | Far-Open | 32,454 | 23 | 105,444 | 74 | 210,888 | 149 |
| 34 | Chunni Ganj | Core | 13,000 | 383 | 13,430 | 396 | 13,565 | 400 |
| 35 | Yashoda Nagar | Proximal Developed | 59,130 | 82 | 101,394 | 141 | 123,114 | 171 |
| 36 | Juhi Hamirpur Road | Proximal Developed | 29,848 | 342 | 36,368 | 416 | 38,365 | 439 |
| 37 | Dabauli | Proximal Developed | 20,685 | 314 | 25,838 | 392 | 27,129 | 412 |
| 38 | Naubasta East | Far-Open | 59,157 | 76 | 133,327 | 171 | 181,898 | 233 |
| 39 | Fahimabad | Core | 8,936 | 1,282 | 9,232 | 1,325 | 9,324 | 1,338 |
| 40 | Tiwaripur | Proximal Developed | 32,500 | 74 | 54,132 | 123 | 73,078 | 166 |
| 41 | Barra World Bank | Far-Open | 61,922 | 82 | 103,137 | 137 | 148,484 | 198 |
| 42 | Maswan Pur | Far-Open | 26,401 | 208 | 42,505 | 335 | 49,483 | 390 |
| 43 | Rambagh | Core | 16,681 | 435 | 17,234 | 450 | 17,406 | 454 |
| 44 | Naubasta | Proximal Developed | 54,571 | 159 | 99,934 | 292 | 122,626 | 358 |
| 45 | Sabji Mandi Kidwainagar | Proximal Developed | 24,683 | 203 | 38,360 | 316 | 42,739 | 352 |
| 46 | Nehru Nagar | Core | 14,008 | 700 | 14,472 | 724 | 14,616 | 731 |
| 47 | Vikas Nagar | Proximal Developed | 16,091 | 65 | 29,467 | 118 | 40,202 | 161 |
| 48 | Gujani Ward | Proximal Developed | 30,263 | 327 | 39,418 | 426 | 41,582 | 449 |
| 49 | Sarojini Nagar | Proximal Developed | 19,199 | 282 | 26,596 | 391 | 28,056 | 412 |
| 50 | Lajpat Nagar | Proximal Developed | 20,653 | 249 | 29,777 | 359 | 32,901 | 397 |
| 51 | Gandhi Nagar | Core | 13,333 | 638 | 13,774 | 659 | 13,912 | 665 |
| 52 | Civil Lines | Proximal Open | 18,184 | 131 | 23,061 | 166 | 26,520 | 190 |
| 53 | Harjendra Nagar | Proximal Developed | 24,043 | 62 | 40,045 | 103 | 54,061 | 139 |
| 54 | Dudhawala Bunglow | Proximal Open | 19,614 | 163 | 24,874 | 206 | 28,605 | 237 |
| 55 | Permat | Proximal Open | 13,619 | 2,214 | 13,619 | 2,214 | 13,619 | 2,214 |
| 56 | Sujat Ganj Gaon | Proximal Developed | 52,287 | 464 | 61,098 | 542 | 64,153 | 569 |
| 57 | Naseemabad | Core | 20,537 | 754 | 21,218 | 779 | 21,430 | 787 |
| 58 | Jajmau | Proximal Developed | 41,871 | 268 | 60,369 | 386 | 66,701 | 427 |
| 59 | Sarvodya Nagar | Proximal Developed | 20,684 | 151 | 35,468 | 259 | 44,678 | 326 |
| 60 | Swaraj Nagar (Panki) | Far-Open | 15,307 | 44 | 36,561 | 104 | 55,197 | 157 |
| 61 | Shastri Nagar II | Proximal Developed | 19,742 | 545 | 23,069 | 637 | 24,222 | 669 |
| 62 | Cooparganj Purwa | Core | 12,176 | 720 | 12,579 | 744 | 12,705 | 752 |
| 63 | Darshan Purwa | Core | 13,717 | 768 | 14,171 | 793 | 14,313 | 801 |
| 64 | Suther Ganj | Proximal Open | 20,412 | 555 | 22,177 | 603 | 23,286 | 633 |
| 65 | Barra ( 1 and 2 ) | Proximal Developed | 77,729 | 345 | 105,375 | 467 | 116,429 | 516 |
| 66 | Kakadev | Proximal Developed | 14,214 | 477 | 16,715 | 561 | 18,386 | 617 |
| 67 | Juhi | Core | 59,221 | 214 | 86,541 | 312 | 100,355 | 362 |
| 68 | Narmau | Far-Open | 11,385 | 21 | 36,989 | 70 | 82,251 | 155 |
| 69 | Dalel Purwa | Core | 15,946 | 636 | 16,474 | 657 | 16,639 | 664 |

**Table 3.4 Ward Wise Population Prohection (Page 2 of 2)**

| Ward No. | Ward Name | Character | Population 2003 | Population Density 2003 | Population 2015 | Population Density 2015 | Population 2030 | Population Density 2030 |
|---|---|---|---|---|---|---|---|---|
| 70 | Babu Purwa | Proximal Developed | 17,454 | 1,034 | 17,751 | 1,052 | 17,929 | 1,062 |
| 71 | Govind Nagar | Core | 20,409 | 422 | 21,086 | 436 | 21,297 | 441 |
| 72 | Patka Pur | Core | 23,809 | 3,674 | 24,023 | 3,707 | 24,263 | 3,744 |
| 73 | Kidwai Nagar K Block | Proximal Developed | 25,424 | 56 | 54,665 | 120 | 79,534 | 175 |
| 74 | Gita Nagar | Proximal Developed | 21,257 | 268 | 32,785 | 413 | 37,864 | 477 |
| 75 | Ajit Nagar | Proximal Developed | 16,968 | 762 | 18,435 | 828 | 19,357 | 869 |
| 76 | Harbansh Mohal | Core | 22,968 | 962 | 23,730 | 994 | 23,967 | 1,004 |
| 77 | Gandigram | Proximal Developed | 28,943 | 63 | 87,663 | 192 | 134,281 | 294 |
| 78 | Hiraman Purwa | Core | 24,545 | 1,348 | 24,766 | 1,360 | 25,013 | 1,374 |
| 79 | Prem Nagar | Core | 20,051 | 782 | 20,716 | 808 | 20,923 | 816 |
| 80 | Fazal Ganj | Proximal Developed | 16,944 | 178 | 29,054 | 305 | 33,953 | 356 |
| 81 | Munshi Purwa | Proximal Developed | 15,811 | 1,322 | 16,081 | 1,345 | 16,242 | 1,358 |
| 82 | Nirala Nagar | Proximal Developed | 26,594 | 243 | 45,602 | 418 | 53,290 | 488 |
| 83 | Juhi Lal Colony | Proximal Developed | 23,049 | 517 | 29,057 | 651 | 30,653 | 687 |
| 84 | Babu Purwa Colony | Proximal Developed | 19,684 | 210 | 33,753 | 360 | 39,444 | 420 |
| 85 | Ratan Lal Nagar | Proximal Developed | 59,316 | 341 | 94,906 | 546 | 105,740 | 609 |
| 86 | Govind Nagar III | Core | 14,088 | 260 | 14,555 | 269 | 14,700 | 272 |
| 87 | Usmanpur | Proximal Developed | 29,990 | 133 | 51,425 | 228 | 64,778 | 287 |
| 88 | Becon Ganj | Core | 32,471 | 1,950 | 32,763 | 1,968 | 33,091 | 1,987 |
| 89 | Maheshwari Mohaal | Core | 22,538 | 1,688 | 22,741 | 1,703 | 22,968 | 1,720 |
| 90 | Pushpant Nagar | Proximal Developed | 25,019 | 148 | 42,902 | 253 | 52,092 | 307 |
| 91 | Dana Khori | Core | 18,973 | 875 | 19,602 | 904 | 19,798 | 913 |
| 92 | Navin Nagar | Proximal Developed | 17,430 | 385 | 25,471 | 562 | 28,378 | 626 |
| 93 | Chandri Ward | Proximal Developed | 28,753 | 206 | 49,305 | 353 | 57,617 | 412 |
| 94 | Parade | Core | 21,413 | 1,638 | 21,606 | 1,653 | 21,822 | 1,670 |
| 95 | Chamanganj | Core | 16,068 | 826 | 16,600 | 853 | 16,766 | 862 |
| 96 | Kidwai Nagar (1) | Proximal Developed | 15,543 | 318 | 26,652 | 546 | 29,923 | 613 |
| 97 | Krishna Nagar Block 11 | Proximal Developed | 15,073 | 94 | 25,846 | 162 | 32,558 | 204 |
| 98 | Kaushal Puri | Core | 14,351 | 427 | 14,826 | 442 | 14,974 | 446 |
| 99 | Chatai Mohal | Core | 15,871 | 1,213 | 16,014 | 1,224 | 16,174 | 1,237 |
| 100 | Begum Purva | Proximal Developed | 22,742 | 684 | 23,860 | 717 | 24,098 | 725 |
| 101 | Shastri Nagar | Proximal Developed | 14,773 | 487 | 18,624 | 614 | 19,646 | 648 |
| 102 | Collecterganj | Core | 22,720 | 784 | 23,473 | 810 | 23,708 | 818 |
| 103 | Colonel Gunj | Core | 23,224 | 1,437 | 23,433 | 1,450 | 23,667 | 1,465 |
| 104 | Vinayak Nagar | Proximal Developed | 24,930 | 45 | 68,122 | 122 | 100,061 | 179 |
| 105 | Sita Ram Mohal | Core | 17,217 | 1,462 | 17,372 | 1,475 | 17,546 | 1,489 |
| 106 | Talak Mohaal | Core | 18,928 | 1,151 | 19,251 | 1,170 | 19,443 | 1,182 |
| 107 | Kidwai Nagar (2) | Proximal Developed | 8,867 | 272 | 11,549 | 354 | 13,223 | 406 |
| 108 | Chowk Sarrafa | Core | 18,106 | 1,116 | 18,415 | 1,135 | 18,599 | 1,146 |
| 109 | Govind Nagar | Core | 27,585 | 314 | 28,055 | 319 | 28,336 | 322 |
| 110 | General Ganj | Core | 21,083 | 457 | 22,119 | 480 | 22,340 | 484 |
| 111 | Akhapur Estate (Cant) | Cantonement | 20,900 | 29 | 21,796 | 30 | 22,341 | 31 |
| 112 | Cantonment Area | Cantonement | 95,249 | 67 | 99,333 | 70 | 101,816 | 72 |
| | TOTALS | | 2,819,827 | | 4,342,031 | | 5,629,081 | |

# CHAPTER 4

## WATER SUPPLY SYSTEMS

# CHAPTER 4 WATER SUPPLY SYSTEMS

## 4.1 MUNICIPAL WATER SUPPLY

The present water supply is insufficient to meet the demand. The main source of raw water for the municipal piped water supply system is the Ganga river and lower Ganga Canal. Intake of water from the river in 2002 was about 350 mld (approximately 83% of the total municipal water supply). The raw water intake is located near Bhairon Ghat upstream of Sisamau nala. The Ganga river has gradually shifted its course since 1941 and as a result the intake well is no longer located in the main channel. Jal Sansthan has to dredge a channel every year to bring water from the Ganga to the intake well.

To overcome this problem a Barrage has been proposed across the Ganga river, 1 km upstream of Bhairon Ghat raw water pumping station. A new 190 mld water treatment plant has also been proposed to supply the western district of the city. This treatment plant is currently under construction. Another water treatment plant is under construction at Gujaini to service the south district (under Indo-Dutch assistance).

**Table 4.1 Total Municipal Water Production**

| Areas | Production Capacity (mld) | | |
|---|---|---|---|
| | Surface | Groundwater | Total |
| Municipal | 350 | 70 | 420 |
| Private wells and hand pumps | | 40 | 40 |
| South district (GAP Support Project) | | 42 | 42 |
| Total | 350 | 152 | 502 |

Source: UPJN Kanpur, 2002 data.

## 4.2 QUANTITY OF WATER SUPPLIED AND CONSUMED

As shown in Figure 4.1, Kanpur city has been divided into 4 districts for the distribution of water. These districts correspond roughly to the boundaries adopted for the sewerage master plan.

The city service district is supplied exclusively from surface water treated at the 350 mld water works constructed under assistance from World Bank. The treatment plant is at present supplying about 240 mld.
The south service district is at present served exclusively by tube wells and hand pumps. This district has experienced rapid population growth. A recent project under Indo-Dutch assistance has increased capacity by 42 mld.

The east service district, which includes the tanneries and other industries of Jajmau has been expanding at a slow pace and there is still agricultural area present in the district. Water supply in this district is dependant on tube wells and hand pumps.

The west service district has been identified as the next growth area for housing colonies. Several colonies have already been developed and these are provided with their own water supply systems using tube wells. UPJN is at present implementing a scheme to augment water supply by 200 mld. Details of the scheme are presented in Figure 4.2.

Based on 2001 census data and projections for 2002 the population of Kanpur was about 2,756,865. Estimated water production from all sources in 2002 was 502 mld, giving a per capita production of 140 lpcd.

**Table 4.2 Estimated Per Capita Water Consumption**

| **Population served** | **2,756,865 (in 2002)** |
|---|---|
| Production capacity per capita | 182 lpcd |
| Less leakage losses estimated at 30% | 140 lpcd |

Including institutional/commercial components but excluding private supplies.

## 4.3 WATER SUPPLY PROBLEMS THAT AFFECT THE DEVELOPMENT OF SEWERAGE

The following water supply deficiencies have been identified in the water supply master plan by UPJN:

### 4.3.1 Severe Power Supply Situation

The prevailing power situation in the city is quite severe with frequent power failures for prolonged periods. Vital components like raw water pumping, equipments in Treatment Works, clear water pumping, tube well pumps in the water supply system are dependent exclusively on power supply for their operation. Poor power situation hence leads to severe dislocation and damage to the system operation as well as operational schedule.

For supply of water to consumers, the intended schedule by the Authority is an intermittent supply spread over a daily period of 10 hours in three shifts, 6 a.m. to 10 a.m., 12.00 a.m. to 2.00 p.m. and 6.00 p.m. to 10.00 p.m. This schedule with adequate level of supply can hardly be met due to various operational constraints. Residents at lower elevations receive water for a longer period while those at higher locations have shorter duration of supply.

### 4.3.2 Unaccounted for Water

Large quantity of water is lost through the system due to leakages in pipeline and appurtenances as well as due to unaccounted for water consumption. A pilot study conducted in a small area, of the city during the previous master plan identified about 40% of water is lost in the system. The component of UFW associated with leakage is estimated at approximately 15%.

## 4.4 MASTER PLAN FOR IMPROVED WATER SUPPLY

The implementation of additional treatment capacity and strengthening of the distribution is essential to support the development of sewerage systems.

UPJN is presently implementing a water supply project under the Ganga Barrage project in which a new treatment plant is being constructed with distribution system for the West district to provide 200 mld supply. UPJN has a master plan for 2031 to augment raw water supply, treatment and distribution capacity up to 1,600 mld. Information regarding the master plan has been provided by UPJN and is presented in Table 4.3 and Table 4.4.

**Table 4.3 Water Demand Estimates**

| Areas | Population | | | Water demand (mld) | | |
|---|---|---|---|---|---|---|
| | 2001 | 2016 | 2031 | 2001 | 2016 | 2031 |
| West | 597,000 | 1,582,000 | 1,974,000 | 208.4 | 503.0 | 600.6 |
| City | 1,121,500 | 1,514,000 | 2,466,000 | 185.1 | 249.8 | 406.9 |
| South | 635,800 | 1,068,000 | 1,795,000 | 104.9 | 176.2 | 296.2 |
| East | 379,500 | 636,000 | 1,065,000 | 62.6 | 104.9 | 175.7 |
| Bulk Consumers | - | - | - | 27.5 | 33.0 | 55.0 |
| Total | 2,733,800 | 4,800,000 | 7,300,000 | 588.5 | 1,067.0 | 1,534.4 |

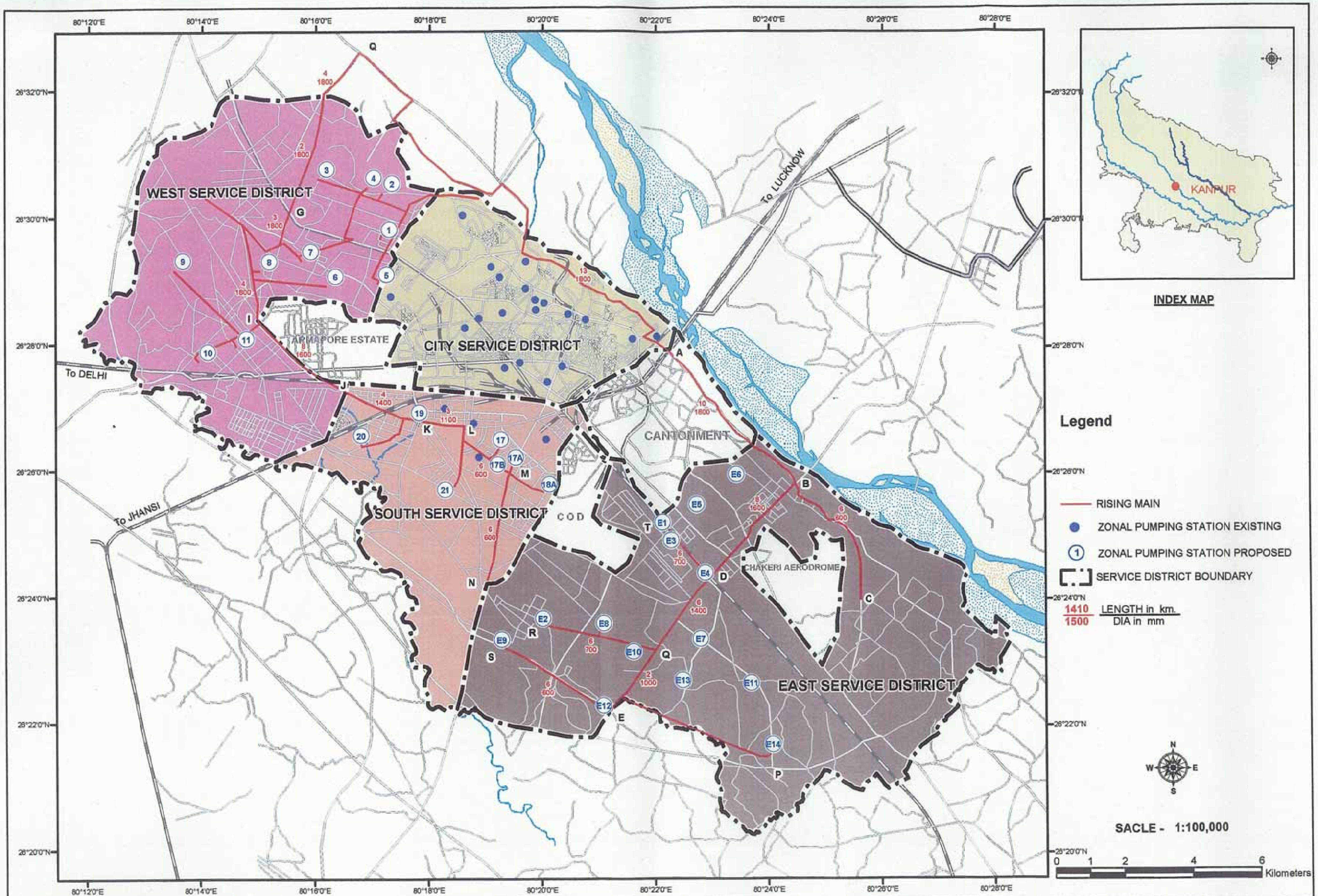
Source: UPJN Kanpur, Feasibility Report for 1600 mld through Barrage on Ganga River

**Table 4.4 Proposed Treatment Plant Capacity**

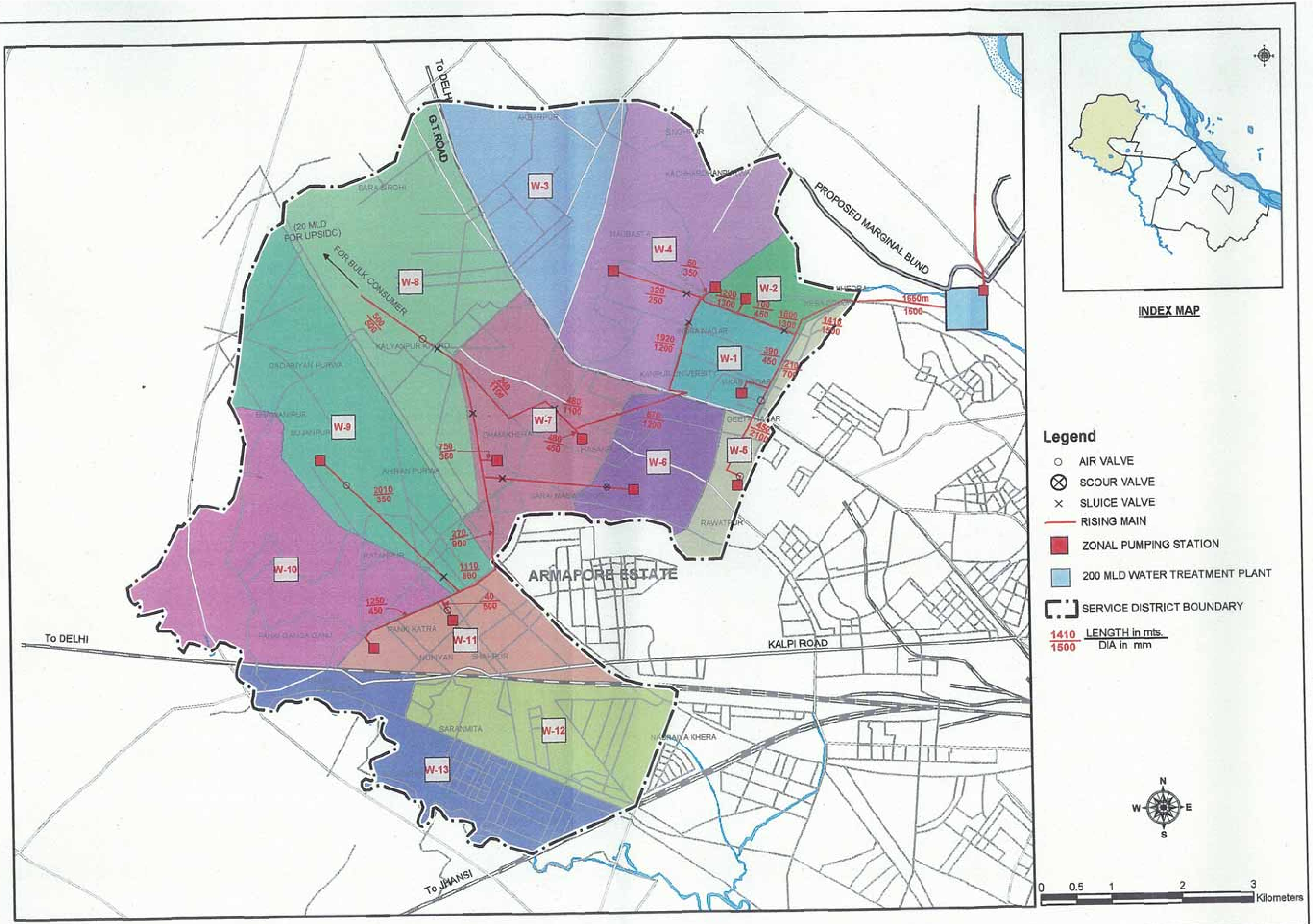
(mld)

| Areas | 2003 | 2004 | 2005 | 2006-07 | 2016-17 | Total |
|---|---|---|---|---|---|---|
| West | 0 | 200 | | 200 | 200 | 600 |
| City | 350 | | | | 200 | 550 |
| South | 28 | | 150 | | 150 | 328 |
| East | 0 | | 200 | | | 200 |
| Total | 378 | 200 | 350 | 200 | 550 | 1,678 |

Source: UPJN Kanpur, Feasibility Report for 1600 mld through Barrage on Ganga River




| JAPAN INTERNATIONAL COOPERATION AGENCY | PROJECT | LOCATION | FIGURE 4.1 |
|---|---|---|---|
| TOKYO ENGINEERING CONSULTANTS CO. LIMITED<br>CTI ENGINEERING INTERNATIONAL CO. LIMITED | THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA | KANPUR CITY | SERVICE DISTRICTS & WATER SUPPLY ZONES |




JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO ENGINEERING CONSULTANTS CO. LIMITED
CTI ENGINEERING INTERNATIONAL CO. LIMITED

| PROJECT | LOCATION | FIGURE 4.2 |
|---|---|---|
| THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA | VARANASI CITY | PROPOSED WATER SUPPLY SCHEME WEST SERVICE DISTRICT |

# CHAPTER 5

## SEWERAGE PLANNING FRAMEWORK

# CHAPTER 5 SEWERAGE PLANNING FRAMEWORK

This section identifies the criteria used for planning sewerage improvements as well as evaluating sewerage development strategies.

## 5.1 PLANNING HORIZON

The planning horizon for the sewerage master plan is 2030 with phased implementation occurring in 5-year intervals. The first phase will consist of priority projects that should be completed within one to five years following the adoption of the Master Plan.

The capacity of civil works is sized for the projected requirements in the year 2030. The capacity of mechanical and electrical systems is planned for the year 2015 with provision for future expansion by adding or changing pumps in subsequent phases as flows increase.

Land requirements for sewage treatment works are based on the projected capacity required for the year 2030. In the first phase, treatment works would be implemented with capacity for the year 2015 and provision for future expansion to ultimate design capacity.

## 5.2 PLANNING CAPACITY

The timing for future sewerage infrastructure and the expansion of capacity depends on actual population growth and wastewater flows. “Planning capacity” refers to maintaining the infrastructure capacity above projected loadings. In general planning capacity serves three purposes:

1) It allows the system to remain effective over the period required to implement capital improvement projects (typically 2 to 5 years). Coupled with projected demands, planning capacity gives the City a mechanism to initiate master planning updates and staged improvements over the planning horizon. This allows the City to stay ahead of system needs.
2) Planning capacity can allow the system to accommodate unplanned growth over short time periods without unduly overtaxing the system, thereby allowing the City to plan or adjust infrastructure upgrade schedules to accommodate the growth.
3) Planning capacity is necessary to address flow variations. Wastewater flow can vary considerably from projected flows depending on actual population growth trends, connection rates and changes in per capita water consumption. Flows can also vary considerably over the short term. In Kanpur, seasonal variations are associated with infiltration and inflow due to rainfall and groundwater during the monsoon season. The floating population (visitors, and workers) magnifies diurnal flow variation.

Based on engineering experience, the JICA study team has included planning capacity when sizing main trunk facilities and treatment plants by assuming a 100% connection ratio.

Future capital improvements such as expansion of treatment plants or augmentation of capacity at pumping stations should be triggered at 10% of the design capacity during the growth phase in each sewerage service district. As the district approaches the phase where it has maximized growth within its boundaries, and it’s population has stabilized (for example central district), wastewater needs will be driven primarily by maintenance of the existing system. During this phase 5% represents a reasonable target for triggering capital improvements.

## 5.3 LEVEL OF SERVICE

Reducing the pollutant loads to water resources and improving the living environment for residents of Kanpur are important issues that must be addressed by appropriate sanitation and sewerage interventions. These long-term goals can only be met if the existing sewerage infrastructure is fully utilized and extended to serve all densely populated urban areas.

Sewerage is an appropriate method of meeting pollution control goals when two criteria are met:

1) As shown in Figure 5.1, the technology used to achieve a given goal depends on the level of water supply. The goal of protecting the water environment can only be met by providing conventional sewerage and only if water supply is sufficient to produce self-cleansing velocities. As prescribed by Indian Standard Code IS 1172 and National Building Code a minimum per capita water supply of 135 lpcd is required to sustain conventional sewerage.
2) Another limiting factor is population density. Current practice and experience in other developing countries indicates that conventional sewerage is seldom cost effective in urban areas where the population density is less than 120 persons per hectare.

Wherever these two criteria cannot be met, properly constructed on-site treatment systems should be used and upgraded over time as population density increases or to complement improvements in water supply services.

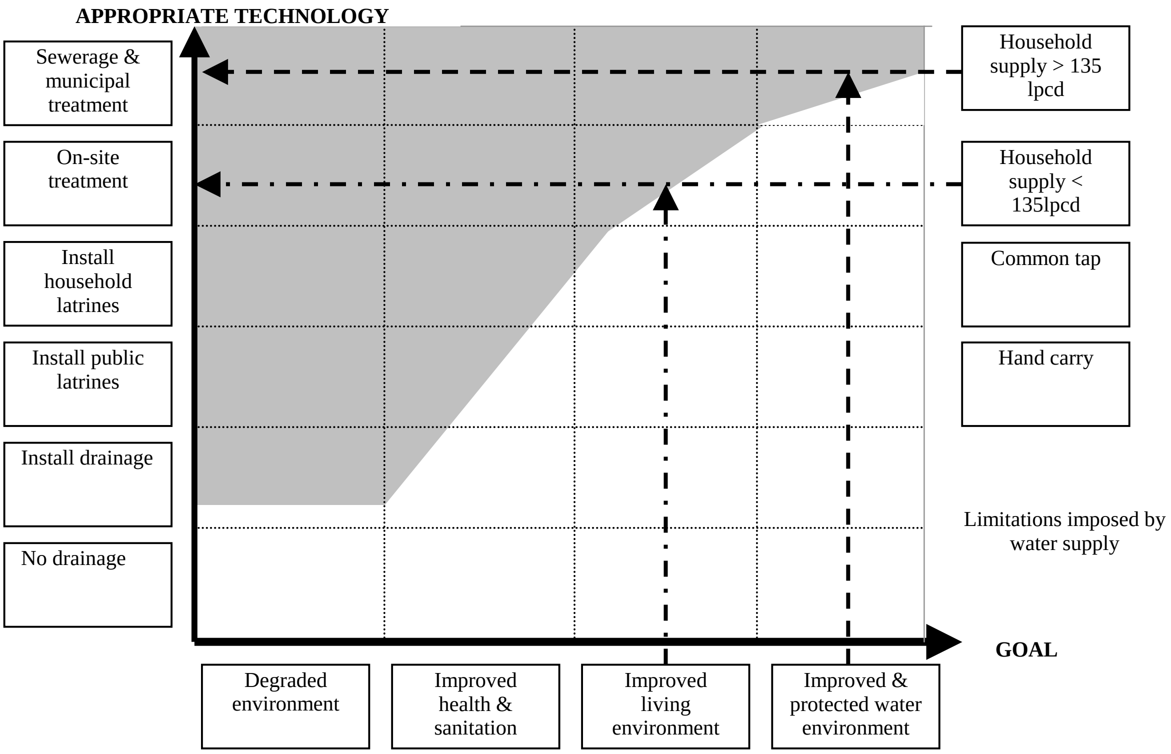



**Figure 5.1 Goal and Level of Service Matrix**

A summary of the goals, levels of service and stepwise implementation approach proposed for each district/area is presented in Table 5.1:

**Table 5.1 Step-wise Progression to Sewerage Development in Kanpur**

| Goal | District I<br>City | District II<br>South | District III<br>West | District IV<br>East |
|---|---|---|---|---|
| Protecting water environment | Sewerage and off-site treatment | Sewerage and off-site treatment | Sewerage and off-site treatment | Sewerage and off-site treatment 2015-2030 |
| Improving living environment | ↑ | ↑ | ↑ | On-site treatment for low population densities |
| Improved health and sanitation | | | | |
| Present situation 2003 | 40% sewerage coverage.<br>High population densities | Sewerage in some colonies<br>High growth area, large drains | Sewerage in some colonies<br>High growth area | No sewerage coverage<br>Low population densities until 2015 |

## 5.4 SEWERAGE DEVELOPMENT STRATEGY

Development of sewerage will, wherever possible, be integrated with existing GAP infrastructure in order to reduce the overall investment cost.

1) Existing infrastructure should, where economically feasible, be rehabilitated before investing in new works. This approach will in most cases be more cost effective and result in more immediate benefits such as improved treatment levels.

2) Eventually sewerage should be provided in all urban areas where densities exceed 120 persons per hectare and water supply is sufficiently developed to support water borne sewerage (i.e. > 135 lpcd).

- Households with water connections should be obligated to connect to sewer systems if they are located in areas that are already sewered.
- Households that have adequate water supply connections but are located in areas where trunk sewers will likely not be provided for some time should be required to improve their sanitation by upgrading their existing cesspits or septic tanks. In later years they should be connected to the extended sewer network.
- Households that do not have adequate water supply should, for the immediate future, be served by pour flush toilets with new cesspits or septic tanks. The choice between cesspits or septic tanks depends on whether enough land is available for the more efficient and cost effective septic tanks.

3) Peripheral areas where population densities are 120 persons per hectare or less should be provided with proper on-site sanitation systems. This intervention is also required to improve sanitary conditions and reduce the amount of pathogens in the environment. Systems for collecting and treating septage are required.

4) Development of new housing colonies in peripheral areas requires special measures to ensure they are in line with urban master plans, water supply and sewerage master plans. It may not be possible or cost effective to extend trunk sewers into these colonies until several years later. It is proposed that in new developments, sewerage systems including small-scale treatment works should be built ahead of trunk sewer facilities with the cost borne by the developer in accordance with user-pay principal. As the overall sewerage master plan is implemented, the small-scale decentralized treatment

facilities in various colonies can be shut down in a planned order once the trunk collector sewers and centralized treatment facilities are completed.

5) Institutional reform and capacity building will be required to ensure that operating authorities have the ability and equipment to properly manage and finance the operation and maintenance of sewerage schemes. Otherwise continued development will not be sustainable.

6) Whether planned or not, it is often the case that people will be living illegally on publicly owned land, land used by railroads, along nalas or similar areas. Although it is undesirable, people are living there, and usually they cannot easily be relocated. Most of these people are living in extremely bad sanitary conditions and their needs for improved sanitation cannot be ignored. It is difficult to move ahead with sewerage in these areas because people do not have land ownership rights or cannot afford such services. The same holds true in economically disadvantaged communities where people cannot afford the connection and service charges for sewerage. Therefore, realistic measures are required to ensure a proper level of sanitation in these areas. Non-sewerage schemes and low cost sanitation improvements are discussed in a separate report.

7) The implementation and monitoring of on-site treatment facilities in urban centers must be formalized to make them more effective. Formalizing on-site treatment will require:

a. Setting standards for construction of pit latrines, septic tanks and soak away pits
b. Regulating construction by issuing permits and follow-up inspections
c. Regulating maintenance intervals of septic tanks and cesspits through mandatory collection
d. Providing equipment and facilities for collection and disposal of septage
e. Regulating municipal and/or private sludge collection services through licensing and manifest system to ensure proper disposal

## 5.5 SEWER SERVICE AREAS AND POPULATIONS

Future population projections are an integral component of planning for future wastewater infrastructure. These projections have been developed by JICA study team with reference to 2001 census data and the City's land use master plan for 2030. Using computerized GIS tools, the projected populations for each ward is allocated to each sewage district in proportion to the area falling within each district.

### 5.5.1 Existing Sewerage Districts

The previous Sewerage Master Plan divided the Municipal Corporation of Kanpur into four sewerage districts with outfall sewers to three treatment facilities:

1. City Central District : to Jajmau outfall
2. East and South District: to Bingawan outfall (proposed Indo-Dutch UASB STP)
3. West District : to Panka outfall

The previously defined districts must be reconfigured to deal with the following new constraints and developments that have occurred since the Master Plan was contemplated:

- Sewage loads in City District have exceeded the capacity of the outfall sewer to Jajmau
- Excess sewage flows from City Central District are being diverted to the South District
- The proposed STP and outfall sewer do not have sufficient capacity to accommodate sewage load from East District

### 5.5.2 Proposed Sewerage Districts

The present Master Plan retains the concept of four sewerage districts. West district will have its own treatment plant as previously proposed. The boundaries for the South district catchment are redefined to match the future sewage load to the ultimate expanded capacity of the proposed Indo-Dutch UASB treatment plant. A separate treatment plant is proposed for the East district instead of expanding the South district treatment plant. The proposed sewer service areas and sewerage districts for 2030 are discussed in more detail in Section 7 of the report and presented in Figure 7.2.

The Sewerage Master Plan is developed for areas within the greater limits of the Municipal Corporation (as defined by the Development Authority) that have or will have population densities greater than 120 persons per hectare. Approximate population densities based on a visual interpretation of land use are derived from satellite images.

### 5.5.3 Populations Served

**Table 5.2 Populations and Sewer Service Areas**

| | **Area** | **2003** | **2015** | **2030** |
|---|---|---|---|---|
| **Sewer Service Areas** | (ha) | | | |
| District I City Central zone | 1,961 | 694,517 | 802,336 | 869,853 |
| District I City East zone | 3,664 | 310,349 | 461,718 | 585,168 |
| District II City Central zone | 2,706 | 843,469 | 1,072,781 | 1,172,659 |
| District II South | 4,254 | 547,771 | 934,330 | 1,172,711 |
| District III West | 7,243 | 335,790 | 801,640 | 1,283,484 |
| District IV East | 3,439 | 69,114 | 211,602 | 428,512 |
| District IV East - NSA | 2,543 | 31,586 | 68,120 | 116,694 |
| Total | 25,810 | 2,819,827 | 4,342,031 | 5,629,081 |

NSA=non-sewered area

Only the area east is proposed as a non sewered area because population densities will remain lower than 120 persons per hectare until 2030.

## 5.6 WATER CONSUMPTION PER CAPITA

The quantity of wastewater to be intercepted and treated will depend on the population and on the amount of water consumed. Unfortunately the amount of water consumed per capita is not well documented because there are no water meters and many households have installed private tube wells.

The Manual on Water Supply and Treatment (Ministry of Urban Development, New Delhi, May 1999) recommends the following values for planning municipal water supply systems for domestic and non-domestic purposes:

**Table 5.3 Guideline Values for Future Per Capita Water Supply**

| Sl. | Classification of towns/cities | Recommended maximum net per capita water supply (lpcd) |
|---|---|---|
| 1 | Towns provided with piped water supply but without sewerage system | 70 |
| 2 | Cities provided with piped water supply where sewerage system is existing or contemplated | 135 |
| 3 | Metropolitan and mega cities provided with piped water supply where sewerage system is existing or contemplated | 150 |

Figures exclude unaccounted for water (UFW) which should be limited to 15%
Figures include requirements for water for commercial, institutional and minor industries. However, the bulk supply to such establishments should be assessed separately with proper justification

Based on production figures reported by UPJN the present estimated per capita consumption is approximately 140 lpcd, which is slightly lower than 150 lpcd proposed by Indian guidelines for planning water supply systems. In accordance with planning guidelines, the lower per capita rates are increased gradually to 150 lpcd by 2030 to reflect water supply system planning criteria. The following values for domestic water consumption are adopted in the Master Plan (including allowance for commercial/institutional (C/I) and minor industries estimated by UPJN):

2003: 140 lpcd + 30% UFW allowance = 182 lpcd
2015: 145 lpcd + 20% UFW allowance = 174 lpcd
2030: 150 lpcd + 15% UFW allowance = 172.5 lpcd

The allowance on 15%for UFW is in accordance with National guidelines. This assumes that some programs for reducing UFW will be implemented.

## 5.7 WASTEWATER RETURN FACTOR AND PER CAPITA CONTRIBUTION

Wastewater generated per capita is calculated using the proposed per capita water supply rates:

**Table 5.4 Per Capita Wastewater Generation Rates**

| Item | 2003 | 2015 | 2030 |
|---|---|---|---|
| Per capita water consumption (lpcd) | 182 | 174 | 172.5 |
| Return factor | 0.70 | 0.75 | 0.80 |
| Per capita wastewater discharge (lpcd) | 127 | 131 | 138 |
| +infiltration allowance (10%) | 140 | 144 (say 145) | 152 (say 155) |

The wastewater return factors are within the range of 0.7 and 0.8 in the “Manual on Sewerage and Sewage Treatment (Ministry of Urban Development, December 1993). A 10% allowance is included for groundwater infiltration.

The return ratio is estimated by comparing total water production to measured wastewater flows as follows: total measured wastewater flow 370 mld ÷ total water supply production 502 mld = 0.7.

It is expected that water distribution will be improved to serve a larger percentage of the population. In parallel with water supply improvements, sewerage coverage will be extended to more homes and hence it is expected that a higher percentage of the population will be able to use flush toilets. Therefore the return factor will increase gradually from 0.7 to 0.8 to reflect larger amounts of wastewater from improved sanitation facilities and water supply conditions.

## 5.8 PREDICTED WASTEWATER QUANTITY

### 5.8.1 Total Wastewater Quantity

The population for each sewered and non-sewered area is multiplied by per capita contribution to obtain estimated wastewater flow.

**Table 5.5 Projected Total Wastewater Production (mld)**

| Sewer Service Areas | 2003 | 2015 | 2030 |
|---|---|---|---|
| Per capita (lpcd) | 140 | 145 | 155 |
| District I City Central | 97.2 | 116.3 | 134.8 |
| District I City East | 43.4 | 66.9 | 90.7 |
| District II City Central | 118.1 | 155.6 | 181.8 |
| District II South | 76.7 | 135.5 | 181.8 |
| District III West | 47 | 116.2 | 198.9 |
| District IV East | 12.3 | 39.0 | 84.5 |
| Total | 394.7 | 629.5 | 872.5 |

Detailed calculations showing sewage generated by ward, by sewerage district and tributary area for the years 2003, 2015 and 2030 are presented in Table 5.6.

### 5.8.2 Sewer Connection Ratios

The number of households connected to sewers at present is unknown but thought to be relatively high in sewer-covered areas. However, a comparison between the total amount of wastewater produced to total amount measured in open drains indicates that only 10 to 15% of the sewage is actually reaching trunk sewers. This indicates a serious problem at the branch sewer level.

The Master Plan identifies a number of trunk sewers facilities and lateral sewers. However the full benefits of these facilities cannot be realized unless a program to improve coverage of branch sewers and household connections is carried in parallel. Future targets are proposed as a means of identifying the quantities of infrastructure and approximate budget requirements required over the planning horizon.

The ultimate sewer connection ratio of 80% has been selected to meet water quality improvement goals. However, achieving such a target may not be realistic given the large number of projects that have to be implemented in such a short timeframe. Furthermore, it is not only a question of providing new infrastructure. There is also a huge backlog of maintenance and repair to restore existing systems.

**Table 5.7 Existing and Proposed Sewer Connection Targets**

| Sewer Service Areas | 2003 | 2010 | 2015 | 2030 |
|---|---|---|---|---|
| District I City Central | 40% | 45% | 55% | 80% |
| District I City East | 20% | 30% | 40% | 50% |
| District II City Central | 40% | 45% | 55% | 80% |
| District II South - Central | 0% | 0% | 0% | 80% |
| District II South – West | 0% | 0% | 0% | 50% |
| District II South - East | 0% | 0% | 0% | 50% |
| District III West-1 | 30% | 40% | 50% | 80% |
| District III West-2 | 0% | 0% | 0% | 80% |
| District IV East | 0% | 0% | 0% | 50% |

Note: the connection ratio for district IV is less than 80% because it is at present less populated and therefore a lower priority. Sewerage will only be implemented later therefore it is not likely that a higher sewer connection ratio can be achieved.

## 5.9 WASTEWATER TREATMENT PLANT DESIGN

### 5.9.1 Wastewater Characteristics

Wastewater composition differs from one situation to the other and is dependant on the level of sanitation, water usage, type of collection system, retention time in sewers and infiltration. Characteristics influence the choice of treatment method, extent of treatment and quantities of solids produced.

Average Biochemical Oxygen Demand (BOD) and Total Suspended Solids (TSS) are the two most important factors for sizing treatment plants in the Master Plan. JICA study team conducted a sampling programme to determine wastewater characteristics. Various contributing drains were identified for this purpose and the influent wastewater at Jajmau STP was also measured.

**Table 5.8 Summary of Measured Wastewater Characteristics**

| Parameter | Nalas (1) | | | | STP(2) |
|---|---|---|---|---|---|
| | Muir Mill | Sisamau | COD | Ganda | (130 mld AS) |
| BOD (mg/l) | 64 | 110 | 65 | 140 | 190 |
| COD (mg/l) | 140 | 174 | 102 | 222 | 488 |
| TSS (mg/l) | 85 | 100 | 76 | 120 | 1,210 |
| pH | 7.4 | 7.0 | 7.5 | 7.4 | 7.5 |
| Temp .($^0$C) | 30 | 29 | 32 | 29 | |

Source: (1) JICA study team, measurements taken May 7 to 18 June, 2003.
(2) Average monthly reported by UPJN

Theoretical wastewater strength is calculated based on the amount of wastewater discharged per capita, i.e., BOD loading of 45 grams/person/day and SS loading of 90 grams/person/day.

**Table 5.9 Theoretical Wastewater Strength**

| Parameter | Unit | 2003 | 2015 | 2030 |
|---|---|---|---|---|
| Per capita wastewater | lpcd | 140 | 145 | 155 |
| BOD | mg/l | 311 | 310 | 290 |
| TSS | mg/l | 622 | 620 | 580 |

The values actually measured at the treatment plant and sewer outfall are much weaker. The dilute wastewater can be easily explained by the very large amount of wastewater from tapped drains. BOD and TSS values during the earlier phases of the project will likely be weaker than those calculated above because a large portion of the flow will be from tapped drains. However, as sewerage coverage and household connection rates are improved, the BOD and SS values will increase. Therefore, wastewater strength used for preliminary process calculations and sizing of treatment facilities should be based on a proportional blend using proposed connection ratios. The BOD strength recommended for design of future wastewater facilities has been calculated for each district and presented in Table 5.10.

## 5.10 TREATMENT EFFLUENT QUALITY STANDARDS

The degree of treatment depends on the standards specified by the Central Pollution Control Board and adopted by the NRCD.

**Table 5.11 Treated Effluent Quality Standards**

| Parameter | Unit | Discharged to water bodies | Discharged to land for agriculture |
|---|---|---|---|
| Total suspended solids | mg/l | 50 | 100 |
| BOD (5 days at 20$^{o}$C) | mg/l | 30 | 50 |
| COD | mg/l | 250 | _ |
| Faecal coliforms** | MPN/100 ml | Désirable < 1000<br>Max < 10,000 | < 10,000 |
| pH value | | 5.5-9.0 | 5.5-9.0 |
| Sulphides | mg/l (as S) | 2.0 | - |
| Total Chromium | mg/l (as Cr) | 2.0 | 5.0 |

** NRCD guidelines August 2002

Irrespective of final mode of disposal, faecal coliform in treated effluent should not exceed 10,000 MPN/100ml which is ten times higher than WHO guideline for unrestricted irrigation. This will require that all treatment plants have some form of disinfection process or tertiary treatment process such as maturation ponds for reducing faecal coliform counts.

## 5.11 EFFLUENT DISCHARGE ALTERNATIVES

In general the cost estimates have assumed that STP effluent will be discharged to nearby rivers. However, one could consider the use of STP effluent for irrigation in agriculture. This would, in most cases, require an effluent pumping station in most locations. Information on required pump capacity and effluent distribution facilities is not available since the master plan didn't include survey of the proposed treatment plant or potential irrigation sites.

### 5.11.1 Unrestricted Irrigation

Unrestricted irrigation, that is, the irrigation of crops having direct contact with humans, either by uncooked consumption or other contacts like recreational use (sport fields, parks), is subjected to effluent FC counts lower than a value of 10,000 per 100ml, according to NRCD standards. The WHO guideline for unrestricted irrigation is 1,000/100ml.

As pointed out in the next paragraph, the application of maturation ponds is the only practicable alternative for the removal of pathogens unless chlorine is used.

### 5.11.2 Restricted Irrigation

Although the health risks of restricted irrigation will be lower, compared to unrestricted irrigation, they will still remain. Furthermore, it will be difficult to enforced that effluent will only be used for restricted irrigation. Therefore, the same standards should be applied to restricted irrigation and suitable post treatment will be required.

## 5.12 CHOICE OF TREATMENT TECHNOLOGY

### 5.12.1 General

The performance of several treatment plants implemented under GAP and YAP has been reviewed by the study team with the objective of identifying which processes would be most suitable for future treatment facilities. Findings of the review are reported Vol. III-11 in Supporting Report. "Case Study of Sewage Treatment Plants".

A qualitative comparison of treatment processes is presented in Table 5.12.

The choice of a treatment technology is driven primarily by the availability of land, the ability of the process to meet required effluent criteria and total life cycle cost. If sufficient land can be provided, then the JICA study team recommends that Waste Stabilization Ponds be used since these will provide the most reliable treatment at the lowest annual operating cost.

Where land is limited, the following processes should be considered (in order of preference) with the addition of tertiary treatment to reduce fecal coliform:

- Aerated facultative ponds (AL) <50 mld
- Up flow anaerobic sludge blanket (UASB) for flows > 50 mld
- Fluidized aerated bed (FAB) for flows up to 70 mld

### 5.12.2 Post Treatment Options for UASB Technology

The Up flow Anaerobic Sludge Blanket (UASB) treatment process is in general unable to meet the required effluent criteria without the addition of post treatment processes. Typically UASB is suitable for treatment of very high BOD waste from industries as a form of pre-treatment before disposal to municipal wastewater treatment systems. Data from a number of UASB plants indicates that the effluent is highly anoxic because of dissolved gases. Thus the effluent exerts a very high immediate oxygen demand on receiving streams, i.e., same effect as a high BOD load. The BOD, sulphides and sulphate contents in UASB effluent generally exceed NRCD effluent standards for discharge to inland waters even with 1 day polishing ponds as post treatment.

The option of combining UASB with some form of aerobic post treatment has been suggested by the Steering Committee for the present Study. For obtaining better effluent quality, the following post-treatment alternatives may be taken into consideration:

- Trickling filter
- Aerated lagoon

(1) Trickling Filter

In this option high rate trickling filters would be applied instead of an effluent polishing pond. The trickling filters are followed by final sedimentation tanks. Sludge from the sedimentation tanks is sent to drying beds. A trickling filter is a biological filter system, in which wastewater is continuously distributed over a bed of media. The wastewater organic and nitrogen components will give rise to bacterial growth as a bio film onto the fixed media. The bacteria remove BOD, and if sufficiently low loading rates are applied the nitrification (conversion of ammonia to nitrate) will also occur.

Trickling filters may be expected to reduce the BOD and sulphide content of the wastewater appreciably, bringing these parameters well within the standards. They will, however, not be sufficient to bring faecal coliform counts to within the desired standards. Nevertheless, they greatly improve effluent quality.

Assuming BOD load of 300 mg/l in raw wastewater, the effluent from a typical 200 mld UASB can be expected to have a BOD of 105 mg/l, representing a loading rate of 21,000 kg/day. A total of 20 trickling filters 36.0 m in diameter would be necessary.

After the trickling filters, final sedimentation should be provided with a surface loading rate of 1 $m^3/m^2/hr$. Three sedimentation tanks with a diameter of 59.5 m would be required.

The total land requirement for 200 mld UASB is roughly 54 hectare. Substituting trickling filters for final polishing ponds would require 42 hectare (54 – 16 for FPU + 4 for TF). The investment cost for trickling filters is relatively high and so are the O&M requirements. Typical energy requirements would be in the range of 100 to 120 kW for pumping and 50 to 60 kW for ventilation.

The effluent quality would be much better than required by the standard. However FC levels remain higher than allowable:

- TSS : 20-30 mg/l
- BOD : 10-15 mg/l
- Sulphides : 0 mg/l
- FC count : aprox. 100,000 MPN/100 ml

(2) Aerated Lagoons

In this alternative aerated lagoons would be applied instead of effluent polishing ponds.

An aerated lagoon is a basin in which the wastewater is treated on a flow-through basis. Generally aeration is provided by floating aerator equipment. From the engineering aspect, they should be considered complete-mix reactors without recycle, having a residence time of minimum three days. After the aerated part, an area should be provided for sedimentation of the solids, which can be an un aerated end-part of the lagoon, or final sedimentation tanks, depending on the amount of solids to be settled.

Aerated lagoons require less surface than ponds because depth can be substantially larger (up to 4.0m), but since decay of faecal coliform is related more to HRT than to any other parameter, pond surface still would have to be fairly substantial unless chlorination is used for disinfection.

For a flow of 200 mld the volume required to reduce BOD from 105 mg/l to 30 mg/l would require about a 1.5 day retention period. This is equivalent to 300,000 $m^3$, with a surface area of 320,000$m^2$ assuming a 3.5 m depth in the aeration zone and 1.0m in the quiescent zone.

The total land requirement for 200 mld UASB including a 1 day FPU is roughly 54 hectare. Substituting aerated lagoons instead of final polishing ponds would require 70 hectare (54 – 16 for FPU + 32 for AL). Investment costs for aerated lagoons are in the order of Rs 53 million.

The effluent quality can be estimated to be:

| | | |
|---|---|---|
| TSS | : | 20 – 30 mg/l; |
| BOD | : | 5 – 10 mg/l; |
| Sulphides | : | 0 mg/l |
| FC count | : | aprox. 10,000 to 100,000 MPN/100 ml. |

Energy use would be in the range of 400 to 600 kW per hour, mainly determined by the energy used for the aerator equipment which varies depending on the season.

(3) Overall Comparison of Post Treatment Options:

| **Criteria** | **Trickling filter** | **Aerated lagoon** |
|---|---|---|
| Land | 1 | 2 |
| Investment cost | 2 | 1 |
| O&M | 2 | 1 |
| Effluent | 2 | 1 |
| Total | 7 | 5 |

Most favorable=1

The ranking indicates that aerated lagoons provide the most cost-effective post treatment of UASB effluent enable it to meet the discharge criteria set by NRCD.

### 5.12.3 Unit Rates Applied in the Calculation of Treatment Costs

Land requirements and cost criteria used for comparison of options in the Master Plan are presented in Table 5.13.

**Table 5.13 Land Requirements and Cost Per mld for Various Treatment Processes**

(million Rs., million Rs./year)

| Treatment Process | | Area Required (ha/mld) | Capital Cost | | | Annual O&M Cost |
|---|---|---|---|---|---|---|
| | | | Total | M/E | Civil | |
| Wastewater Stabilization Pond* | WSP | 1.25 | 1.6 | 0.03 (2%) | 1.57 (98%) | 0.06 |
| Aerated Lagoon + Chlorine Disinfection | AL | 0.35 | 2.5 | 0.50 (20%) | 2.00 (80%) | 0.30 |
| Aerated Lagoon + Maturation Ponds | AL+ | 0.75 | 3.2 | 0.64 (20%) | 2.56 (80%) | 0.32 |
| Activated Sludge + Chlorine Disinfection | AS | 0.20 | 2.7 | 1.08 (40%) | 1.62 (60%) | 0.36 |
| Activated Sludge + Maturation Ponds | AS+ | 0.60 | 3.4 | 1.36 (40%) | 2.04 (60%) | 0.38 |
| Fluidized Aerated Bed + Chlorine Disinfection | FAB | 0.06 | 4.6 | 2.76 (60%) | 1.84 (40%) | 0.59 |
| UASB with + Post Treatment (AL) | UASB++ | 0.35 | 3.0 | 1.05 (30%) | 1.95 (70%) | 0.13 |

Source: JICA Study Team "Evaluation of Sewage Treatment Plants" under GAP and YAP.
* WSP includes maturation ponds and cost of low lift pumps at head works
Capital costs exclude cost of land; O&M costs include energy costs and staffing costs.

WSP includes the use of maturation ponds to reduce faecal coliform counts. Other options assume disinfection using chlorine, which is inexpensive and generally very effective. Other alternative disinfection technologies are still being evaluated at pilot scale plants and have not yet been proven cost effective for large-scale applications. Maturation ponds are added to other treatment processes if the life cycle cost is attractive and sufficient land is available.

## 5.13 SEWER DESIGN CRITERIA

Criteria used for the evaluation and preliminary sizing of trunk sewers, pumping stations criteria are in accordance with the Manual on Sewerage and Sewage Treatment (Ministry of Urban Development, December 1993) and current practice adopted in Detailed Project Reports.

**Sewers**

| | | | |
|---|---|---|---|
| Peak factors | Nalas | | 2.5 |
| | | Trunk sewers | 2.5 for Population < 50,000 |
| | | | 2.25 for population 50,000 – 750,000 |
| | | | 2.00 for population > 750,000 |
| Hydraulic design: | | | |
| | Gravity pipe: | Manning's equation | $V= 1/n R^{2/3} S^{1/2}$, |
| | | Roughness factor | n= 0.015 old concrete pipe |
| | | | n= 0.017 old brick sewer |
| | | Minimum velocity | 0.60 m/s initial flow |
| | | | 0.80 m/s ultimate flow |
| | | Maximum velocity | 3.00 m/s |
| | | Maximum depth | d/D= 0.8 at ultimate peak flow |
| Pressure pipe: | | Hazen William's formula | $V= 0.85 C R^{0.63} S^{0.54}$ |
| | | Roughness factor | C= 100 new cast iron pipe |
| | | | C= 80 old cast iron pipe |
| | | | C= 110 PSC pipes |
| | | Minimum velocity | 0.8 m/s |
| | | Maximum velocity | 3.0 m/s |

**Pumping stations:**

| | | |
|---|---|---|
| Peak factor: | | 2.0 for large stations |
| Sump detention times: | | |
| | Vertical turbine pumps: | 5 minutes at ultimate peak flow |
| | Submersible pumps: | 3.75 minutes at ultimate peak flow |
| | Maximum: | 30 minutes at average flow |
| Minimum number of pumps: | | 3 pumps each with capacity for ½ PF |
| | | 2 pumps each with capacity for the non-PF |
| At critical stations: | | 50% standby capacity at peak hour |
| | | 100% standby capacity at non-peak |

## Table 5.6 District Wise Population and Wastewater Generation

**(1) District Wise Population and Wastewater Generation**

| | Area (ha) | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|
| | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District I (City Central) | 1,961 | 694,517 | 97.2 | 802,336 | 116.3 | 869,853 | 134.8 |
| District I (City East) | 3,664 | 310,349 | 43.4 | 461,718 | 66.9 | 585,168 | 90.7 |
| District II (City Central) | 2,706 | 843,469 | 118.1 | 1,072,781 | 155.6 | 1,172,659 | 181.8 |
| District II (South) | 4,254 | 547,771 | 76.7 | 934,330 | 135.5 | 1,172,711 | 181.8 |
| District III (West) | 7,243 | 335,790 | 47.0 | 801,640 | 116.2 | 1,283,484 | 198.9 |
| District IV (East) | 5,982 | 87,931 | 12.3 | 269,226 | 39.0 | 545,206 | 84.5 |
| Total | 25,810 | 2,819,827 | 394.7 | 4,342,031 | 629.5 | 5,629,081 | 872.5 |

**(2) Contributing Population by Sewer Sub-Catchment (Page 1 of 3)**

| District | Sub-Catchment | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|
| | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District I City Central | CC-01 | 9,871 | 1.38 | 11,153 | 1.62 | 12,001 | 1.86 |
| | CC-02 | 75,434 | 10.56 | 78,960 | 11.45 | 81,695 | 12.66 |
| | CC-03 | 61,947 | 8.67 | 63,546 | 9.21 | 64,148 | 9.94 |
| | CC-04 | 69,584 | 9.74 | 71,930 | 10.43 | 72,706 | 11.27 |
| | CC-07 | 19,608 | 2.75 | 19,909 | 2.89 | 20,112 | 3.12 |
| | CC-08 | 43,621 | 6.11 | 44,397 | 6.44 | 44,902 | 6.96 |
| | CC-09 | 8,213 | 1.15 | 10,400 | 1.51 | 11,899 | 1.84 |
| | CC-10 | 2,910 | 0.41 | 3,683 | 0.53 | 4,225 | 0.65 |
| | CC-11 | 24,321 | 3.40 | 25,984 | 3.77 | 27,090 | 4.20 |
| | CC-12 | 31,658 | 4.43 | 34,831 | 5.05 | 36,712 | 5.69 |
| | CC-13 | 36,516 | 5.11 | 39,276 | 5.70 | 40,377 | 6.26 |
| | CC-14 | 94,738 | 13.26 | 96,526 | 14.00 | 97,490 | 15.11 |
| | CC-16 | 11,521 | 1.61 | 11,910 | 1.73 | 12,021 | 1.86 |
| | CC-17 | 12,864 | 1.80 | 13,329 | 1.93 | 13,480 | 2.09 |
| | CC-18 | 11,118 | 1.56 | 13,378 | 1.94 | 14,499 | 2.25 |
| | CC-19 | 13,100 | 1.83 | 20,684 | 3.00 | 24,695 | 3.83 |
| | CC-20 | 29,616 | 4.15 | 40,272 | 5.84 | 46,796 | 7.25 |
| | CC-21 | 17,316 | 2.42 | 18,983 | 2.75 | 19,753 | 3.06 |
| | CC-22 | 23,532 | 3.29 | 28,413 | 4.12 | 32,176 | 4.99 |
| | CC-23 | 15,682 | 2.20 | 19,754 | 2.86 | 22,300 | 3.46 |
| | CC-24 | 28,826 | 4.04 | 44,195 | 6.41 | 52,314 | 8.11 |
| | CC-25 | 2,152 | 0.30 | 3,929 | 0.57 | 5,295 | 0.82 |
| | CC-26 | 19,214 | 2.69 | 33,547 | 4.86 | 43,593 | 6.76 |
| | CC-28 | 12,326 | 1.73 | 20,835 | 3.02 | 26,233 | 4.07 |
| | CC-29 | 7,092 | 0.99 | 12,550 | 1.82 | 16,900 | 2.62 |
| | CC-30 | 11,737 | 1.64 | 19,962 | 2.89 | 26,441 | 4.10 |
| Sub Total | | 694,517 | 97.22 | 802,336 | 116.34 | 869,853 | 134.83 |
| District II City Central | CC-05 | 23,315 | 3.26 | 24,096 | 3.49 | 24,338 | 3.77 |
| | CC-06 | 77,675 | 10.87 | 80,567 | 11.68 | 81,535 | 12.64 |
| | CC-15 | 49,820 | 6.97 | 51,468 | 7.46 | 51,990 | 8.06 |
| | CC-16 | 11,619 | 1.63 | 12,012 | 1.74 | 12,123 | 1.88 |
| | CC-17 | 12,973 | 1.82 | 13,443 | 1.95 | 13,595 | 2.11 |
| | CC-18 | 11,213 | 1.57 | 13,491 | 1.96 | 14,622 | 2.27 |
| | CC-27 | 12,133 | 1.70 | 19,952 | 2.89 | 24,077 | 3.73 |
| | CC-31 | 48,465 | 6.79 | 72,802 | 10.56 | 84,177 | 13.05 |
| | CC-32 | 60,675 | 8.49 | 82,760 | 12.00 | 92,093 | 14.27 |
| | CC-33 | 10,426 | 1.46 | 14,632 | 2.12 | 15,645 | 2.42 |
| | CC-34 | 23,530 | 3.29 | 29,162 | 4.23 | 30,871 | 4.79 |
| | CC-35 | 11,584 | 1.62 | 15,429 | 2.24 | 17,382 | 2.69 |
| | CC-36 | 56,728 | 7.94 | 72,233 | 10.47 | 77,724 | 12.05 |
| | CC-37 | 40,087 | 5.61 | 42,999 | 6.23 | 44,401 | 6.88 |
| | CC-38 | 32,346 | 4.53 | 42,798 | 6.21 | 47,556 | 7.37 |
| | CC-39 | 25,537 | 3.58 | 34,985 | 5.07 | 39,770 | 6.16 |
| | CC-40 | 11,655 | 1.63 | 12,838 | 1.86 | 13,349 | 2.07 |
| | CC-41 | 5,619 | 0.79 | 8,140 | 1.18 | 9,425 | 1.46 |
| | CC-42 | 17,201 | 2.41 | 24,765 | 3.59 | 28,613 | 4.44 |
| | CC-43 | 31,743 | 4.44 | 36,668 | 5.32 | 38,817 | 6.02 |
| | CC-44 | 15,362 | 2.15 | 26,416 | 3.83 | 31,095 | 4.82 |
| | CC-45 | 39,552 | 5.54 | 55,184 | 8.00 | 61,616 | 9.55 |
| | CC-46 | 11,061 | 1.55 | 20,093 | 2.91 | 26,381 | 4.09 |
| | CC-47 | 9,299 | 1.30 | 13,999 | 2.03 | 16,736 | 2.59 |
| | CC-48 | 30,372 | 4.25 | 41,067 | 5.95 | 44,385 | 6.88 |
| | CC-49 | 10,997 | 1.54 | 13,057 | 1.89 | 13,887 | 2.15 |
| | CC-50 | 15,192 | 2.13 | 16,533 | 2.40 | 17,076 | 2.65 |
| | CC-51 | 8,792 | 1.23 | 11,549 | 1.67 | 12,546 | 1.94 |
| | CC-52 | 25,308 | 3.54 | 41,059 | 5.95 | 46,819 | 7.26 |
| | CC-53 | 11,315 | 1.58 | 15,829 | 2.30 | 18,285 | 2.83 |
| | CC-54 | 5,704 | 0.80 | 9,899 | 1.44 | 12,123 | 1.88 |
| | CC-55 | 17,908 | 2.51 | 25,229 | 3.66 | 28,237 | 4.38 |
| | CC-56 | 45,437 | 6.36 | 47,450 | 6.88 | 48,371 | 7.50 |
| | CC-57 | 22,826 | 3.20 | 30,177 | 4.38 | 32,999 | 5.11 |
| Sub Total | | 843,469 | 118.08 | 1,072,781 | 155.54 | 1,172,659 | 181.76 |

**(2) Contributing Population by Sewer Sub-Catchment (Page 2 of 3)**

| District | Sub-Catchment | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|
| | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District I City East | CE-01 | 146,253 | 20.48 | 157,293 | 22.81 | 163,097 | 25.28 |
| | CE-02 | 17,304 | 2.42 | 30,369 | 4.40 | 39,978 | 6.20 |
| | CE-03 | 14,271 | 2.00 | 31,861 | 4.62 | 49,143 | 7.62 |
| | CE-04 | 32,744 | 4.58 | 54,777 | 7.94 | 69,649 | 10.80 |
| | CE-05 | 47,964 | 6.71 | 71,194 | 10.32 | 81,236 | 12.59 |
| | CE-06 | 6,256 | 0.88 | 10,730 | 1.56 | 14,716 | 2.28 |
| | CE-07 | 23,665 | 3.31 | 40,986 | 5.94 | 56,123 | 8.70 |
| | CE-08 | 4,737 | 0.66 | 13,261 | 1.92 | 21,726 | 3.37 |
| | CE-09 | 17,155 | 2.40 | 51,247 | 7.43 | 89,500 | 13.87 |
| Sub Total | | 310,349 | 43.44 | 461,718 | 66.94 | 585,168 | 90.71 |

| District | Sub-Catchment | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|
| | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District II South | SD-01 | 13,997 | 1.96 | 25,005 | 3.63 | 34,858 | 5.40 |
| | SD-02 | 1,960 | 0.27 | 7,100 | 1.03 | 13,272 | 2.06 |
| | SD-03 | 66,280 | 9.28 | 95,580 | 13.86 | 104,951 | 16.27 |
| | SD-04 | 48,119 | 6.74 | 74,351 | 10.78 | 83,298 | 12.91 |
| | SD-05 | 36,877 | 5.16 | 52,435 | 7.60 | 59,090 | 9.16 |
| | SD-06 | 11,904 | 1.67 | 16,214 | 2.35 | 17,908 | 2.78 |
| | SD-07 | 8,427 | 1.18 | 12,616 | 1.83 | 15,459 | 2.40 |
| | SD-08 | 25,392 | 3.55 | 39,244 | 5.69 | 49,834 | 7.72 |
| | SD-09 | 11,256 | 1.58 | 18,921 | 2.74 | 27,334 | 4.24 |
| | SD-10 | 10,257 | 1.44 | 17,241 | 2.50 | 24,906 | 3.86 |
| | SD-11 | 3,642 | 0.51 | 6,271 | 0.91 | 8,699 | 1.35 |
| | SD-12 | 2,556 | 0.36 | 4,680 | 0.68 | 5,825 | 0.90 |
| | SD-13 | 17,149 | 2.40 | 31,153 | 4.52 | 39,354 | 6.10 |
| | SD-14 | 29,786 | 4.17 | 54,182 | 7.86 | 66,545 | 10.31 |
| | SD-15 | 6,011 | 0.84 | 10,629 | 1.54 | 13,034 | 2.02 |
| | SD-16 | 17,752 | 2.49 | 30,697 | 4.45 | 37,250 | 5.77 |
| | SD-17 | 3,560 | 0.50 | 6,566 | 0.95 | 8,044 | 1.25 |
| | SD-18 | 5,431 | 0.76 | 9,395 | 1.36 | 11,389 | 1.77 |
| | SD-19 | 959 | 0.13 | 1,700 | 0.25 | 2,087 | 0.32 |
| | SD-20 | 10,170 | 1.42 | 19,785 | 2.87 | 25,374 | 3.93 |
| | SD-21 | 2,058 | 0.29 | 4,466 | 0.65 | 5,989 | 0.93 |
| | SD-22 | 9,803 | 1.37 | 20,462 | 2.97 | 27,028 | 4.19 |
| | SD-23 | 6,532 | 0.91 | 14,789 | 2.14 | 20,141 | 3.12 |
| | SD-24 | 2,700 | 0.38 | 6,112 | 0.89 | 8,325 | 1.29 |
| | SD-25 | 6,820 | 0.95 | 15,333 | 2.22 | 20,908 | 3.24 |
| | SD-26 | 10,622 | 1.49 | 21,002 | 3.05 | 29,329 | 4.55 |
| | SD-27 | 13,182 | 1.85 | 22,266 | 3.23 | 32,131 | 4.98 |
| | SD-28 | 3,312 | 0.46 | 7,496 | 1.09 | 10,209 | 1.58 |
| | SD-29 | 4,719 | 0.66 | 10,682 | 1.55 | 14,549 | 2.26 |
| | SD-30 | 5,087 | 0.71 | 11,516 | 1.67 | 15,684 | 2.43 |
| | SD-31 | 1,647 | 0.23 | 3,715 | 0.54 | 5,054 | 0.78 |
| | SD-32 | 7,058 | 0.99 | 13,575 | 1.97 | 17,388 | 2.70 |
| | SD-33 | 8,432 | 1.18 | 17,075 | 2.48 | 23,736 | 3.68 |
| | SD-34 | 6,700 | 0.94 | 11,590 | 1.68 | 14,050 | 2.18 |
| | SD-35 | 9,362 | 1.31 | 16,306 | 2.36 | 19,992 | 3.10 |
| | SD-36 | 5,883 | 0.82 | 10,177 | 1.48 | 12,337 | 1.91 |
| | SD-37 | 4,104 | 0.57 | 7,068 | 1.02 | 8,571 | 1.33 |
| | SD-38 | 5,737 | 0.80 | 10,939 | 1.59 | 14,549 | 2.26 |
| | SD-39 | 3,942 | 0.55 | 7,578 | 1.10 | 10,129 | 1.57 |
| | SD-40 | 8,991 | 1.26 | 19,520 | 2.83 | 27,959 | 4.33 |
| | SD-41 | 6,643 | 0.93 | 11,557 | 1.68 | 14,090 | 2.18 |
| | SD-42 | 48,086 | 6.73 | 62,959 | 9.13 | 69,779 | 10.82 |
| | SD-43 | 16,625 | 2.33 | 36,466 | 5.29 | 49,029 | 7.60 |
| | SD-44 | 9,934 | 1.39 | 21,918 | 3.18 | 31,769 | 4.92 |
| | SD-45 | 8,307 | 1.16 | 15,998 | 2.32 | 21,475 | 3.33 |
| Sub Total | | 547,771 | 76.67 | 934,330 | 135.51 | 1,172,711 | 181.78 |

**(2) Contributing Population by Sewer Sub-Catchment (Page 3 of 3)**

| District | Sub-Catchment | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|
| | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District III West | WD-01 | 19,619 | 2.75 | 61,471 | 8.91 | 99,236 | 15.38 |
| | WD-02 | 13,219 | 1.85 | 48,836 | 7.08 | 88,879 | 13.78 |
| | WD-03 | 2,601 | 0.36 | 8,671 | 1.26 | 19,199 | 2.98 |
| | WD-04 | 6,605 | 0.92 | 23,263 | 3.37 | 43,015 | 6.67 |
| | WD-05 | 3,761 | 0.53 | 13,265 | 1.92 | 24,407 | 3.78 |
| | WD-06 | 5,901 | 0.83 | 15,643 | 2.27 | 29,185 | 4.52 |
| | WD-07 | 9,897 | 1.39 | 21,178 | 3.07 | 30,628 | 4.75 |
| | WD-08 | 6,221 | 0.87 | 12,038 | 1.75 | 16,384 | 2.54 |
| | WD-09 | 7,882 | 1.10 | 23,684 | 3.43 | 36,979 | 5.73 |
| | WD-10 | 12,003 | 1.68 | 35,340 | 5.12 | 56,299 | 8.73 |
| | WD-11 | 6,348 | 0.89 | 13,326 | 1.93 | 18,743 | 2.91 |
| | WD-12 | 3,039 | 0.43 | 8,239 | 1.19 | 12,089 | 1.87 |
| | WD-13 | 63,541 | 8.90 | 99,917 | 14.49 | 120,621 | 18.70 |
| | WD-14 | 11,920 | 1.67 | 26,014 | 3.77 | 36,203 | 5.61 |
| | WD-15 | 12,345 | 1.73 | 23,140 | 3.36 | 30,734 | 4.76 |
| | WD-16 | 6,633 | 0.93 | 12,772 | 1.85 | 17,358 | 2.69 |
| | WD-17 | 9,019 | 1.26 | 17,366 | 2.52 | 23,602 | 3.66 |
| | WD-18 | 2,894 | 0.41 | 6,587 | 0.96 | 9,837 | 1.52 |
| | WD-19 | 1,557 | 0.22 | 5,559 | 0.81 | 9,784 | 1.52 |
| | WD-20 | 3,357 | 0.47 | 11,714 | 1.70 | 21,251 | 3.29 |
| | WD-21 | 2,879 | 0.40 | 8,111 | 1.18 | 15,160 | 2.35 |
| | WD-22 | 3,918 | 0.55 | 12,605 | 1.83 | 25,380 | 3.93 |
| | WD-23 | 3,518 | 0.49 | 10,987 | 1.59 | 21,799 | 3.38 |
| | WD-24 | 7,979 | 1.12 | 19,388 | 2.81 | 31,206 | 4.84 |
| | WD-25 | 5,394 | 0.76 | 17,282 | 2.51 | 34,699 | 5.38 |
| | WD-26 | 3,813 | 0.53 | 12,269 | 1.78 | 24,703 | 3.83 |
| | WD-27 | 6,378 | 0.89 | 20,860 | 3.02 | 41,546 | 6.44 |
| | WD-28 | 1,503 | 0.21 | 4,836 | 0.70 | 9,736 | 1.51 |
| | WD-29 | 1,675 | 0.23 | 5,181 | 0.75 | 10,141 | 1.57 |
| | WD-30 | 4,185 | 0.59 | 9,709 | 1.41 | 14,544 | 2.25 |
| | WD-31 | 12,771 | 1.79 | 14,764 | 2.14 | 16,361 | 2.54 |
| | WD-32 | 7,888 | 1.10 | 21,258 | 3.08 | 35,133 | 5.45 |
| | WD-33 | 2,809 | 0.39 | 8,112 | 1.18 | 15,043 | 2.33 |
| | WD-34 | 2,803 | 0.39 | 9,535 | 1.38 | 18,505 | 2.87 |
| | WD-35 | 4,499 | 0.63 | 16,194 | 2.35 | 30,290 | 4.69 |
| | WD-36 | 18,437 | 2.58 | 65,245 | 9.46 | 121,510 | 18.83 |
| | WD-37 | 36,979 | 5.18 | 57,281 | 8.31 | 73,295 | 11.36 |
| Sub Total | | 335,790 | 47.02 | 801,640 | 116.24 | 1,283,484 | 198.94 |

| District | Sub-Catchment | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|
| | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District IV East | ED-01 | 11,883 | 1.66 | 33,491 | 4.86 | 50,600 | 7.84 |
| | ED-02 | 935 | 0.13 | 3,163 | 0.46 | 6,684 | 1.04 |
| | ED-03 | 5,650 | 0.79 | 17,887 | 2.59 | 29,347 | 4.55 |
| | ED-04 | 4,447 | 0.62 | 15,976 | 2.32 | 31,570 | 4.89 |
| | ED-05 | 5,816 | 0.81 | 17,393 | 2.52 | 33,907 | 5.26 |
| | ED-06 | 1,303 | 0.18 | 5,994 | 0.87 | 15,114 | 2.34 |
| | ED-07 | 2,281 | 0.32 | 10,492 | 1.52 | 26,459 | 4.10 |
| | ED-08 | 1,635 | 0.23 | 7,520 | 1.09 | 18,963 | 2.94 |
| | ED-09 | 261 | 0.04 | 1,199 | 0.17 | 3,023 | 0.47 |
| | ED-10 | 747 | 0.10 | 3,435 | 0.50 | 8,662 | 1.34 |
| | ED-11 | 6,078 | 0.85 | 23,482 | 3.40 | 56,266 | 8.72 |
| | ED-12 | 1,763 | 0.25 | 8,109 | 1.18 | 20,448 | 3.17 |
| | ED-13 | 1,891 | 0.26 | 8,700 | 1.26 | 21,939 | 3.40 |
| | ED-14 | 3,683 | 0.52 | 16,942 | 2.46 | 42,723 | 6.62 |
| | ED-15 | 607 | 0.08 | 2,790 | 0.40 | 7,036 | 1.09 |
| | ED-16 | 1,338 | 0.19 | 6,052 | 0.88 | 15,194 | 2.36 |
| | ED-17 | 1,479 | 0.21 | 3,974 | 0.58 | 8,178 | 1.27 |
| | ED-18 | 4,548 | 0.64 | 14,507 | 2.10 | 32,399 | 5.02 |
| | NSA | 31,586 | 4.42 | 68,120 | 9.88 | 116,694 | 18.09 |
| Sub Total | | 87,931 | 12.30 | 269,226 | 39.04 | 545,206 | 84.51 |

**(3) Contributing Population by Ward (Page 1 of 3)**

| District | Ward Number/Ward Name | | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|---|
| | | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District I City Central | 1 | Lakshmi Purwa | 4,194 | 0.59 | 4,334 | 0.63 | 4,366 | 0.68 |
| | 2 | Makrobertganj | 22,121 | 3.10 | 22,896 | 3.32 | 23,128 | 3.58 |
| | 3 | Khalasi Line | 15,711 | 2.20 | 16,219 | 2.35 | 16,399 | 2.54 |
| | 4 | Jawahar Nagar | 942 | 0.13 | 974 | 0.14 | 983 | 0.15 |
| | 8 | Old Kanpur | 24,126 | 3.38 | 24,126 | 3.50 | 24,126 | 3.74 |
| | 10 | Colnelgunj | 8,812 | 1.23 | 9,108 | 1.32 | 9,196 | 1.43 |
| | 13 | Bhannana Purwa | 10,622 | 1.49 | 10,978 | 1.59 | 11,097 | 1.72 |
| | 14 | Ambedkar Nagar Kakadeo | 4,460 | 0.62 | 6,947 | 1.01 | 7,736 | 1.20 |
| | 15 | Gwal Toli | 21,360 | 2.99 | 23,232 | 3.37 | 23,554 | 3.65 |
| | 20 | Ashok Nagar | 22,761 | 3.19 | 36,397 | 5.28 | 43,875 | 6.80 |
| | 21 | Benajhawar | 20,745 | 2.90 | 25,269 | 3.66 | 27,790 | 4.31 |
| | 25 | Tilak Nagar | 30,045 | 4.21 | 51,640 | 7.49 | 69,481 | 10.77 |
| | 27 | Nawab Ganj | 28,599 | 4.00 | 52,203 | 7.57 | 70,361 | 10.91 |
| | 28 | Sisamau First | 5,980 | 0.84 | 6,180 | 0.90 | 6,246 | 0.97 |
| | 29 | Coolie Bazar | 11,022 | 1.54 | 11,387 | 1.65 | 11,499 | 1.78 |
| | 30 | Vishnupuri | 19,988 | 2.80 | 30,105 | 4.37 | 33,478 | 5.19 |
| | 34 | Chunni Ganj | 13,006 | 1.82 | 13,446 | 1.95 | 13,582 | 2.11 |
| | 39 | Fahimabad | 830 | 0.12 | 858 | 0.12 | 866 | 0.13 |
| | 43 | Rambagh | 4,182 | 0.59 | 4,326 | 0.63 | 4,364 | 0.68 |
| | 46 | Nehru Nagar | 294 | 0.04 | 304 | 0.04 | 307 | 0.05 |
| | 47 | Vikas Nagar | 2,132 | 0.30 | 3,870 | 0.56 | 5,281 | 0.82 |
| | 50 | Lajpat Nagar | 11,193 | 1.57 | 16,138 | 2.34 | 17,847 | 2.77 |
| | 52 | Civil Lines | 18,249 | 2.55 | 23,127 | 3.35 | 26,470 | 4.10 |
| | 54 | Dudhawala Bunglow | 15,667 | 2.19 | 19,801 | 2.87 | 22,781 | 3.53 |
| | 55 | Permat | 13,624 | 1.91 | 13,624 | 1.98 | 13,624 | 2.11 |
| | 57 | Naseemabad | 2,782 | 0.39 | 2,874 | 0.42 | 2,904 | 0.45 |
| | 59 | Sarvodya Nagar | 2,307 | 0.32 | 3,956 | 0.57 | 4,980 | 0.77 |
| | 62 | Cooparganj Purwa | 6,187 | 0.87 | 6,394 | 0.93 | 6,462 | 1.00 |
| | 64 | Suther Ganj | 20,412 | 2.86 | 22,177 | 3.22 | 23,281 | 3.61 |
| | 69 | Dalel Purwa | 595 | 0.08 | 615 | 0.09 | 622 | 0.10 |
| | 72 | Patka Pur | 23,791 | 3.33 | 24,005 | 3.48 | 24,245 | 3.76 |
| | 74 | Gita Nagar | 5,503 | 0.77 | 8,481 | 1.23 | 9,795 | 1.52 |
| | 76 | Harbansh Mohal | 20,057 | 2.81 | 20,726 | 3.01 | 20,933 | 3.24 |
| | 78 | Hiraman Purwa | 21,814 | 3.05 | 22,008 | 3.19 | 22,234 | 3.45 |
| | 79 | Prem Nagar | 9,089 | 1.27 | 9,390 | 1.36 | 9,484 | 1.47 |
| | 88 | Becon Ganj | 32,376 | 4.53 | 32,674 | 4.74 | 32,990 | 5.11 |
| | 89 | Maheshwari Mohaal | 22,535 | 3.15 | 22,735 | 3.30 | 22,962 | 3.56 |
| | 91 | Dana Khori | 18,967 | 2.66 | 19,595 | 2.84 | 19,791 | 3.07 |
| | 94 | Parade | 21,412 | 3.00 | 21,609 | 3.13 | 21,831 | 3.38 |
| | 95 | Chamanganj | 11,320 | 1.58 | 11,690 | 1.70 | 11,813 | 1.83 |
| | 98 | Kaushal Puri | 4,200 | 0.59 | 2,056 | 0.30 | 1,559 | 0.24 |
| | 99 | Chatai Mohal | 15,866 | 2.22 | 16,012 | 2.32 | 16,181 | 2.51 |
| | 102 | Collecterganj | 22,568 | 3.16 | 23,316 | 3.38 | 23,547 | 3.65 |
| | 103 | Colonel Gunj | 23,229 | 3.25 | 23,439 | 3.40 | 23,681 | 3.67 |
| | 104 | Vinayak Nagar | 157 | 0.02 | 424 | 0.06 | 623 | 0.10 |
| | 105 | Sita Ram Mohal | 17,216 | 2.41 | 17,370 | 2.52 | 17,534 | 2.72 |
| | 106 | Talak Mohaal | 18,935 | 2.65 | 19,249 | 2.79 | 19,445 | 3.01 |
| | 108 | Chowk Sarrafa | 18,109 | 2.54 | 18,417 | 2.67 | 18,597 | 2.88 |
| | 110 | General Ganj | 20,854 | 2.92 | 21,904 | 3.18 | 22,085 | 3.42 |
| | 112 | Cantonment Area | 3,572 | 0.50 | 3,732 | 0.54 | 3,838 | 0.59 |
| | Sub Total | | 694,517 | 97.23 | 802,336 | 116.36 | 869,853 | 134.83 |

**(3) Contributing Population by Ward (Page 2 of 3)**

| District | Ward Number/Ward Name | | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|---|
| | | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| | 1 | Lakshmi Purwa | 13,460 | 1.88 | 13,912 | 2.02 | 14,013 | 2.17 |
| | 4 | Jawahar Nagar | 13,401 | 1.88 | 13,847 | 2.01 | 13,978 | 2.17 |
| | 7 | Rawatpur | 9,920 | 1.39 | 11,587 | 1.68 | 12,151 | 1.88 |
| | 11 | Govendnagar Harijan Basti | 8,349 | 1.17 | 13,031 | 1.89 | 15,677 | 2.43 |
| | 12 | Trasport Nagar | 11,639 | 1.63 | 12,006 | 1.74 | 12,143 | 1.88 |
| | 13 | Bhannana Purwa | 10,622 | 1.49 | 10,978 | 1.59 | 11,097 | 1.72 |
| | 14 | Ambedkar Nagar Kakadeo | 14,834 | 2.08 | 23,109 | 3.35 | 25,733 | 3.99 |
| | 16 | Sisamau | 23,805 | 3.33 | 24,585 | 3.56 | 24,831 | 3.85 |
| | 18 | Rai Purwa | 21,362 | 2.99 | 22,105 | 3.21 | 22,312 | 3.46 |
| | 19 | Vijay Nagar | 20,275 | 2.84 | 26,390 | 3.83 | 29,052 | 4.50 |
| | 20 | Ashok Nagar | 5,998 | 0.84 | 9,591 | 1.39 | 11,560 | 1.79 |
| | 23 | Bakarganj | 24,605 | 3.44 | 25,039 | 3.63 | 25,283 | 3.92 |
| | 26 | Anwar Ganj | 14,637 | 2.05 | 15,125 | 2.19 | 15,279 | 2.37 |
| | 28 | Sisamau First | 12,507 | 1.75 | 12,924 | 1.87 | 13,063 | 2.02 |
| | 29 | Coolie Bazar | 3,686 | 0.52 | 3,809 | 0.55 | 3,846 | 0.60 |
| | 36 | Juhi Hamirpur Road | 29,880 | 4.18 | 36,344 | 5.27 | 38,354 | 5.94 |
| | 39 | Fahimabad | 8,101 | 1.13 | 8,373 | 1.21 | 8,455 | 1.31 |
| | 43 | Rambagh | 12,497 | 1.75 | 12,929 | 1.87 | 13,044 | 2.02 |
| | 45 | Sabji Mandi Kidwainagar | 24,630 | 3.45 | 38,339 | 5.56 | 42,707 | 6.62 |
| | 46 | Nehru Nagar | 13,707 | 1.92 | 14,177 | 2.06 | 14,314 | 2.22 |
| | 49 | Sarojini Nagar | 19,191 | 2.69 | 26,609 | 3.86 | 28,039 | 4.35 |
| | 50 | Lajpat Nagar | 9,433 | 1.32 | 13,600 | 1.97 | 15,040 | 2.33 |
| | 51 | Gandhi Nagar | 13,339 | 1.87 | 13,777 | 2.00 | 13,902 | 2.15 |
| | 56 | Sujat Ganj Gaon | 7,491 | 1.05 | 8,750 | 1.27 | 9,185 | 1.42 |
| | 57 | Naseemabad | 17,740 | 2.48 | 18,329 | 2.66 | 18,517 | 2.87 |
| | 59 | Sarvodya Nagar | 18,396 | 2.58 | 31,553 | 4.58 | 39,715 | 6.16 |
| | 61 | Shastri Nagar II | 19,740 | 2.76 | 23,073 | 3.35 | 24,232 | 3.76 |
| | 62 | Cooparganj Purwa | 5,984 | 0.84 | 6,184 | 0.90 | 6,250 | 0.97 |
| | 63 | Darshan Purwa | 13,714 | 1.92 | 14,161 | 2.05 | 14,304 | 2.22 |
| | 66 | Kakadev | 14,215 | 1.99 | 16,718 | 2.42 | 18,387 | 2.85 |
| | 67 | Juhi | 58,144 | 8.14 | 84,772 | 12.29 | 98,359 | 15.25 |
| | 69 | Dalel Purwa | 15,349 | 2.15 | 15,856 | 2.30 | 16,025 | 2.48 |
| | 70 | Babu Purwa | 10,681 | 1.50 | 10,867 | 1.58 | 10,971 | 1.70 |
| | 71 | Govind Nagar | 20,386 | 2.85 | 21,062 | 3.05 | 21,303 | 3.30 |
| | 73 | Kidwai Nagar K Block | 5,664 | 0.79 | 12,136 | 1.76 | 17,698 | 2.74 |
| | 74 | Gita Nagar | 15,767 | 2.21 | 24,298 | 3.52 | 28,062 | 4.35 |
| | 75 | Ajit Nagar | 16,970 | 2.38 | 18,439 | 2.67 | 19,353 | 3.00 |
| | 78 | Hiraman Purwa | 2,728 | 0.38 | 2,752 | 0.40 | 2,780 | 0.43 |
| | 79 | Prem Nagar | 10,964 | 1.53 | 11,328 | 1.64 | 11,440 | 1.77 |
| | 80 | Fazal Ganj | 16,973 | 2.38 | 29,082 | 4.22 | 33,945 | 5.26 |
| | 81 | Munshi Purwa | 8,600 | 1.20 | 8,750 | 1.27 | 8,834 | 1.37 |
| | 82 | Nirala Nagar | 23,086 | 3.23 | 39,713 | 5.76 | 46,364 | 7.19 |
| | 83 | Juhi Lal Colony | 23,071 | 3.23 | 29,051 | 4.21 | 30,657 | 4.75 |
| | 84 | Babu Purwa Colony | 19,600 | 2.74 | 33,602 | 4.87 | 39,201 | 6.08 |
| | 85 | Ratan Lal Nagar | 159 | 0.02 | 255 | 0.04 | 284 | 0.04 |
| | 86 | Govind Nagar III | 14,073 | 1.97 | 14,561 | 2.11 | 14,723 | 2.28 |
| | 87 | Usmanpur | 20,714 | 2.90 | 35,510 | 5.15 | 44,698 | 6.93 |
| | 88 | Becon Ganj | 99 | 0.01 | 100 | 0.01 | 101 | 0.02 |
| | 90 | Pushpant Nagar | 576 | 0.08 | 984 | 0.14 | 1,194 | 0.19 |
| | 92 | Navin Nagar | 17,450 | 2.44 | 25,472 | 3.69 | 28,373 | 4.40 |
| | 93 | Chandri Ward | 5,063 | 0.71 | 8,677 | 1.26 | 10,127 | 1.57 |
| | 95 | Chamanganj | 4,758 | 0.67 | 4,913 | 0.71 | 4,965 | 0.77 |
| | 96 | Kidwai Nagar (1) | 15,532 | 2.17 | 26,668 | 3.87 | 29,940 | 4.64 |
| | 98 | Kaushal Puri | 10,136 | 1.42 | 12,784 | 1.85 | 13,413 | 2.08 |
| | 100 | Begum Purva | 15,387 | 2.15 | 16,130 | 2.34 | 16,310 | 2.53 |
| | 101 | Shastri Nagar | 14,763 | 2.07 | 18,612 | 2.70 | 19,643 | 3.04 |
| | 104 | Vinayak Nagar | 1,556 | 0.22 | 4,219 | 0.61 | 6,189 | 0.96 |
| | 107 | Kidwai Nagar (2) | 8,865 | 1.24 | 11,538 | 1.67 | 13,234 | 2.05 |
| | 109 | Govind Nagar | 27,601 | 3.86 | 28,041 | 4.07 | 28,306 | 4.39 |
| | 110 | General Ganj | 219 | 0.03 | 230 | 0.03 | 232 | 0.04 |
| | 111 | Akhapur Estate (Cant) | 1,378 | 0.19 | 1,426 | 0.21 | 1,473 | 0.23 |
| | Sub Total | | 843,469 | 118.07 | 1,072,781 | 155.54 | 1,172,659 | 181.77 |

**(3) Contributing Population by Ward (Page 3 of 3)**

| District | Ward Number/Ward Name | | 2003 | | 2015 | | 2030 | |
|---|---|---|---|---|---|---|---|---|
| | | | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) | Population | Wastewater Generation (MLD) |
| District II South | 11 | Govendnagar Harijan Basti | 3,396 | 0.48 | 5,334 | 0.77 | 6,415 | 0.99 |
| | 22 | Saraimita Ward | 5,670 | 0.79 | 20,538 | 2.98 | 38,394 | 5.95 |
| | 24 | Sanigwan | 147 | 0.02 | 683 | 0.10 | 1,721 | 0.27 |
| | 35 | Yashoda Nagar | 58,541 | 8.20 | 101,274 | 14.68 | 122,766 | 19.03 |
| | 37 | Dabauli | 17,789 | 2.49 | 22,343 | 3.24 | 23,472 | 3.64 |
| | 38 | Naubasta East | 55,608 | 7.79 | 125,884 | 18.25 | 171,446 | 26.57 |
| | 41 | Barra World Bank | 60,993 | 8.54 | 102,523 | 14.87 | 148,105 | 22.96 |
| | 44 | Naubasta | 54,357 | 7.61 | 100,437 | 14.56 | 123,084 | 19.08 |
| | 48 | Gujani Ward | 28,834 | 4.04 | 37,793 | 5.48 | 39,815 | 6.17 |
| | 56 | Sujat Ganj Gaon | 41,645 | 5.83 | 48,942 | 7.10 | 51,358 | 7.96 |
| | 65 | Barra ( 1 and 2 ) | 77,607 | 10.86 | 105,690 | 15.33 | 116,728 | 18.09 |
| | 73 | Kidwai Nagar K Block | 19,706 | 2.76 | 42,482 | 6.16 | 61,923 | 9.60 |
| | 77 | Gandigram | 10,625 | 1.49 | 32,580 | 4.72 | 49,863 | 7.73 |
| | 82 | Nirala Nagar | 3,447 | 0.48 | 5,965 | 0.86 | 6,960 | 1.08 |
| | 84 | Babu Purwa Colony | 98 | 0.01 | 168 | 0.02 | 196 | 0.03 |
| | 85 | Ratan Lal Nagar | 58,952 | 8.25 | 94,967 | 13.77 | 105,878 | 16.41 |
| | 87 | Usmanpur | 9,254 | 1.30 | 15,963 | 2.31 | 20,084 | 3.11 |
| | 90 | Pushpant Nagar | 24,468 | 3.43 | 42,083 | 6.10 | 51,042 | 7.91 |
| | 93 | Chandri Ward | 16,634 | 2.33 | 28,681 | 4.16 | 33,461 | 5.19 |
| | Sub Total | | 547,771 | 76.70 | 934,330 | 135.46 | 1,172,711 | 181.77 |
| District I City East | 1 | Lakshmi Purwa | 9,123 | 1.28 | 9,429 | 1.37 | 9,498 | 1.47 |
| | 9 | Chakeri | 600 | 0.08 | 1,255 | 0.18 | 2,183 | 0.34 |
| | 12 | Trasport Nagar | 8,201 | 1.15 | 8,459 | 1.23 | 8,556 | 1.33 |
| | 17 | Om Purwa | 25,200 | 3.53 | 41,717 | 6.05 | 50,504 | 7.83 |
| | 24 | Sanigwan | 1,550 | 0.22 | 7,136 | 1.03 | 17,995 | 2.79 |
| | 31 | Safipur | 26,220 | 3.67 | 78,661 | 11.41 | 131,097 | 20.32 |
| | 40 | Tiwaripur | 30,800 | 4.31 | 51,193 | 7.42 | 69,092 | 10.71 |
| | 53 | Harjendra Nagar | 23,091 | 3.23 | 38,362 | 5.56 | 51,768 | 8.02 |
| | 54 | Dudhawala Bunglow | 3,987 | 0.56 | 5,039 | 0.73 | 5,798 | 0.90 |
| | 56 | Sujat Ganj Gaon | 3,084 | 0.43 | 3,602 | 0.52 | 3,782 | 0.59 |
| | 58 | Jajmau | 41,813 | 5.85 | 60,222 | 8.73 | 66,620 | 10.33 |
| | 67 | Juhi | 1,126 | 0.16 | 1,642 | 0.24 | 1,905 | 0.30 |
| | 70 | Babu Purwa | 6,769 | 0.95 | 6,887 | 1.00 | 6,952 | 1.08 |
| | 76 | Harbansh Mohal | 2,909 | 0.41 | 3,005 | 0.44 | 3,036 | 0.47 |
| | 77 | Gandigram | 243 | 0.03 | 741 | 0.11 | 1,133 | 0.18 |
| | 81 | Munshi Purwa | 7,211 | 1.01 | 7,337 | 1.06 | 7,408 | 1.15 |
| | 84 | Babu Purwa Colony | 13 | 0.00 | 22 | 0.00 | 26 | 0.00 |
| | 93 | Chandri Ward | 4,821 | 0.67 | 8,261 | 1.20 | 9,641 | 1.49 |
| | 97 | Krishna Nagar Block 11 | 14,811 | 2.07 | 25,524 | 3.70 | 32,140 | 4.98 |
| | 100 | Begum Purva | 7,361 | 1.03 | 7,716 | 1.12 | 7,802 | 1.21 |
| | 102 | Collecterganj | 151 | 0.02 | 156 | 0.02 | 157 | 0.02 |
| | 112 | Cantonment Area | 91,265 | 12.78 | 95,352 | 13.83 | 98,075 | 15.20 |
| | Sub Total | | 310,349 | 43.44 | 461,718 | 66.95 | 585,168 | 90.71 |
| District III West | 5 | Kalyanpur | 57,564 | 8.06 | 110,838 | 16.07 | 150,639 | 23.35 |
| | 6 | Nankari | 14,771 | 2.07 | 52,752 | 7.65 | 92,846 | 14.39 |
| | 7 | Rawatpur | 30,070 | 4.21 | 35,122 | 5.09 | 36,833 | 5.71 |
| | 11 | Govendnagar Harijan Basti | 17,352 | 2.43 | 27,086 | 3.93 | 32,588 | 5.05 |
| | 19 | Vijay Nagar | 5,274 | 0.74 | 6,864 | 1.00 | 7,557 | 1.17 |
| | 22 | Saraimita Ward | 29,703 | 4.16 | 106,929 | 15.50 | 199,997 | 31.00 |
| | 27 | Nawab Ganj | 2,462 | 0.34 | 4,495 | 0.65 | 6,058 | 0.94 |
| | 32 | Khyoa | 31,839 | 4.46 | 122,461 | 17.76 | 205,736 | 31.89 |
| | 33 | Panki | 32,400 | 4.54 | 104,241 | 15.11 | 209,892 | 32.53 |
| | 37 | Dabauli | 2,860 | 0.40 | 3,571 | 0.52 | 3,753 | 0.58 |
| | 42 | Maswan Pur | 26,358 | 3.69 | 42,452 | 6.16 | 49,423 | 7.66 |
| | 47 | Vikas Nagar | 14,065 | 1.97 | 25,534 | 3.70 | 34,839 | 5.40 |
| | 48 | Gujani Ward | 1,365 | 0.19 | 1,778 | 0.26 | 1,874 | 0.29 |
| | 60 | Swaraj Nagar (Panki) | 15,432 | 2.16 | 36,477 | 5.29 | 55,066 | 8.54 |
| | 68 | Narmau | 11,097 | 1.55 | 36,993 | 5.36 | 81,912 | 12.70 |
| | 85 | Ratan Lal Nagar | 28 | 0.00 | 45 | 0.01 | 50 | 0.01 |
| | 104 | Vinayak Nagar | 23,479 | 3.29 | 63,651 | 9.23 | 93,391 | 14.48 |
| | 111 | Akhapur Estate (Cant) | 19,671 | 2.75 | 20,351 | 2.95 | 21,030 | 3.26 |
| | Sub Total | | 335,790 | 47.01 | 801,640 | 116.24 | 1,283,484 | 198.95 |
| District IV East | 9 | Chakeri | 31,147 | 4.36 | 65,124 | 9.44 | 113,260 | 17.56 |
| | 24 | Sanigwan | 26,783 | 3.75 | 123,194 | 17.86 | 310,662 | 48.15 |
| | 31 | Safipur | 3,087 | 0.43 | 9,263 | 1.34 | 15,438 | 2.39 |
| | 35 | Yashoda Nagar | 458 | 0.06 | 787 | 0.11 | 954 | 0.15 |
| | 38 | Naubasta East | 3,421 | 0.48 | 7,698 | 1.12 | 10,489 | 1.63 |
| | 40 | Tiwaripur | 1,721 | 0.24 | 2,861 | 0.41 | 3,862 | 0.60 |
| | 53 | Harjendra Nagar | 1,023 | 0.14 | 1,700 | 0.25 | 2,295 | 0.36 |
| | 77 | Gandigram | 17,859 | 2.50 | 54,429 | 7.89 | 83,345 | 12.92 |
| | 97 | Krishna Nagar Block 11 | 2,432 | 0.34 | 4,170 | 0.60 | 4,901 | 0.76 |
| | Sub Total | | 87,931 | 12.30 | 269,226 | 39.02 | 545,206 | 84.52 |
| Total | | | 2,819,827 | 394.75 | 4,342,031 | 629.57 | 5,629,081 | 872.55 |

### Table 5.10 Calculated Future Wastewater Strength

| | | Condition | Ratio | BOD (mg) | |
|---|---|---|---|---|---|
| | | | | Respective | Composite |
| District I(CC) | 2015 | Sewered | 55% | 310 | 213 |
| | | Via Nalas | 45% | 95 | |
| | 2030 | Sewered | 80% | 290 | 251 |
| | | Via Nalas | 20% | 95 | |
| District I(CE) | 2015 | Sewered | 40% | 310 | 181 |
| | | Via Nalas | 60% | 95 | |
| | 2030 | Sewered | 80% | 290 | 251 |
| | | Via Nalas | 20% | 95 | |
| District II | 2015 | Sewered | 1% | 310 | 98 |
| | | Via Nalas | 99% | 95 | |
| | 2030 | Sewered | 51% | 290 | 195 |
| | | Via Nalas | 49% | 95 | |
| District III | 2015 | Sewered | 25% | 310 | 148 |
| | | Via Nalas | 75% | 95 | |
| | 2030 | Sewered | 80% | 290 | 251 |
| | | Via Nalas | 20% | 95 | |
| District IV | 2015 | Sewered | 0% | 310 | 95 |
| | | Via Nalas | 100% | 95 | |
| | 2030 | Sewered | 50% | 290 | 193 |
| | | Via Nalas | 50% | 95 | |

**Calculated Future Westawater Strength**

| | | 2003 | 2015 | 2030 |
|---|---|---|---|---|
| Per capita wastewater | lcpd | 140 | 145 | 155 |
| Per capita BOD loading | g/d | 45 | 45 | 45 |
| BOD | mg/l | 321 | 310 | 290 |

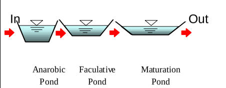
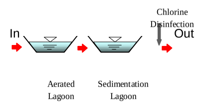
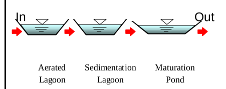
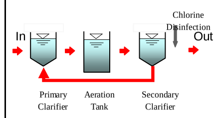
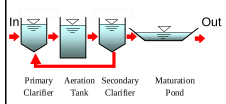
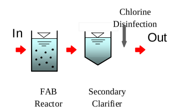
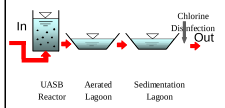
**Measured Nala BOD Strength**

| Name of Nala | BOD(mg/l) |
|---|---|
| Muir Mill Nala | 64 |
| Sisamu Nala | 110 |
| COD Nala | 65 |
| Ganda Nala | 140 |
| Average | 95 |

**District wise Overall Connecting Rate**

| | Year | Zone | Population | Connecting Rate | Pop. Connected | Overall Rate |
|---|---|---|---|---|---|---|
| District I(CC) | 2015 | | | 55% | 0 | 55% |
| | 2030 | | | 80% | 0 | 80% |
| District I(CE) | 2015 | | | 40% | 0 | 40% |
| | 2030 | | | 80% | 0 | 80% |
| District II | 2015 | Central | 38,929 | 30% | 11,679 | |
| | | West | 608,134 | 0% | 0 | |
| | | East | 287,267 | 0% | 0 | |
| | | Total | 934,330 | | 11,679 | 1% |
| | 2030 | Central | 49,975 | 80% | 39,980 | |
| | | West | 754,628 | 50% | 377,314 | |
| | | East | 368,108 | 50% | 184,054 | |
| | | Total | 1,172,711 | | 601,348 | 51% |
| District III | 2015 | West-1 | 250,612 | 35% | 87,714 | |
| | | West-2 | 551,028 | 20% | 110,206 | |
| | | Total | 801,640 | | 197,920 | 25% |
| | 2030 | West-1 | 354,016 | 80% | 283,213 | |
| | | West-2 | 929,468 | 80% | 743,574 | |
| | | Total | 1,283,484 | | 1,026,787 | 80% |
| District IV | 2015 | | | 0% | 0 | 0% |
| | 2030 | | | 50% | 0 | 50% |

# Table 5.12 Qualitative Comparison of Treatment Process

| | | Treatment Method | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | WSP | AL | AL+ | AS | AS+ | FAB | UASB++ |
| Process | | Anarobic Pond<br>+Faculative Pond<br>+Maturation Pond | Aerated Lagoon<br>+Sedimentation Lagoon<br>+Chlorine Disinfection | Aerated Lagoon<br>+Sedimentation Lagoon<br>+Maturation Pond | Primary Clarifier<br>+Aeration Tank<br>+Secondary Clarifier<br>+Chlorine Disinfection | Primary Clarifier<br>+Aeration Tank<br>+Secondary Clarifier<br>+Maturation Pond | FAB reactor<br>+Secondary Clarifier<br>+Chlorine Disinfection | UASB reactor<br>Aerated Lagoon<br>+Sedimentation Lagoon<br>+Chlorine Disinfection |
| Flow Sheet | |  |  |  |  |  |  |  |
| HRT (days) | | 14.0 | 5.5 | 9.5 | 0.5 | 4.5 | 0.2 | 4.3 |
| | | Anarobic Pond(1d)<br>+Faculative Pond(7d)<br>+Maturation Pond(6d) | Aerated Lagoon(3.5d)<br>+Sedimentation Lagoon(2d)<br>+Chlorine Disinfection | Aerated Lagoon(3.5d)<br>+Sedimentation Lagoon(2d)<br>+Maturation Pond(4d) | Primary Clarifier(4hr)<br>+Aeration Tank(4hr)<br>+Secondary Clarifier(4hr)<br>+Chlorine Disinfection | Primary Clarifier(4hr)<br>+Aeration Tank(4hr)<br>+Secondary Clarifier(4hr)<br>+Maturation Pond(4d) | FAB reactor(2hr)<br>+Secondary Clarifier(2hr)<br>+Chlorine Disinfection | UASB reactor(8hr)<br>Aerated Lagoon(2d)<br>+Sedimentation Lagoon(2d)<br>+Chlorine Disinfection |
| Land area (ha/mld) | | 1.25 | 0.35 | 0.75 | 0.2 | 0.6 | 0.06 | 0.35 |
| Cost | Capital costs (Rs.$10^6$/mld) | 1.6 | 2.5 | 3.2 | 2.7 | 3.4 | 4.6 | 3.5 |
| | M&E cost (% of total) | 0.02 | 0.2 | 0.2 | 0.4 | 0.4 | 0.6 | 0.35 |
| | Annual O&M (Rs.$10^6$/mld) | 0.06 | 0.2 | 0.22 | 0.36 | 0.38 | 0.59 | 0.4 |
| Sludge handling | | Manual desludging once in several years, then dry on beds. | Manual desludging once in several years, then dry on beds. | Manual desludging once in several years, then dry on beds. | Fitst thicken and digest, then dry on beds. | Fitst thicken and digest, then dry on beds. | Fitst thicken, then directly dry on beds. | Directly dry on beds. |
| Operational characteristics | | Simplest | Simple | Simple | Skilled operation required | Skilled operation required | Skilled operation required | Simpler than activated sludge |
| Energy requirement (except initial pumping) | | Negligible | Lower than activated sludge | Lower than activated sludge | Highest | Highest | Highest | Lelatively low |
| Performance stability | | Affected by temperature and seasonal changes.<br>Not susceptivle to power failure. | Less affected by temperature and seasonal changes than WSP.<br>But affected by power failure. | Less affected by temperature and seasonal changes than WSP.<br>But affected by power failure. | Not affected by wastewater characteristices and seasonal changes.<br>But adversely affected by power failure. | Not affected by wastewater characteristices and seasonal changes.<br>But adversely affected by power failure. | Not affected by wastewater characteristices and seasonal changes.<br>But adversely affected by power failure. | Not affected by wastewater characteristices and seasonal changes.<br>Not susceptivle to power failure. |
| Resorce recovery | Sludge | Less potential for application because the sludge is not be produced on continuous basis. | Less potential for application because the sludge is not be produced on continuous basis. | Less potential for application because the sludge is not be produced on continuous basis. | Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner. | Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner. | Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner. | Substantial quantity of sludge is produced and have potential for application to manure or soil conditioner. |
| | Biogas | No biogas is produced. | No biogas is produced. | No biogas is produced. | Biogas is produced and have potential for generating electricity or selling them to consumers. | Biogas is produced and have potential for generating electricity or selling them to consumers. | No biogas is produced. | Biogas is produced and have potential for generating electricity or selling them to consumers. |

# CHAPTER 6

## EVALUATION OF ALTERNATIVES

# CHAPTER 6 EVALUATION OF ALTERNATIVES

## 6.1 SUMMARY

Projected wastewater flows of 873 mld far exceed the present treatment capacity of 171 mld at Jajmau. The treatment plants at Jajmau can be expanded however the additional capacity would be insufficient to treat all wastewater flows. Furthermore, conveying sewage across the city to Jajmau would be too costly. It will therefore be necessary to build new treatment plants and the location of these treatment plants must be within reasonable proximity to the service area to minimize conveyance costs. Land for new STPs is available east of Jajmau along Ganga river and south of the city at various locations along the Pandu river.

Proposals identified in the previous master plan will be implemented as far as they are still practical. As planned, sewage from the west district will be conveyed in a southerly direction towards the Pandu river. A new 200 mld STP will be required to meet the sewage load projected for the year 2030.

For South and East Districts the previous master plan identified a common STP to serve both districts. The plan also identified the need to relieve flows from the City District by diverting flows from part of the catchment area to the new treatment plant in the South. The scheme has been sanctioned and is at present under construction. A 200 mld UASB plant is being sanctioned and the site plan indicates that sufficient land has been reserved for a future capacity of 350 to 365 mld. The projected sewage load for the South and East Districts including the amount diverted from City District is expected to be 430 mld by the year 2030. This will exceed the present capacity therefore a number of alternatives must be evaluated to determine the most cost effective option for servicing the South and East Districts.

Each alternative has implications for the collection system, the sizing of pumping stations and capacity of new treatment plants. Conceptual development of the collection system and treatment plant requirements for each alternative is discussed and evaluated in the following sub-sections.

The key focus for evaluating the alternatives involves comparison of the estimated capital costs, and O&M costs to determine the least cost solution. Cost comparison tables for the alternatives are presented in this volume in Appendix A.

If the cost of two or more alternatives is relatively close the alternatives are screened through a qualitative evaluation using criteria such as reliability of operation, availability of land, ease of construction, and potential impact on water quality and downstream users. Alternatives that appear to be impractical, too difficult to construct, operate or maintain are screened out.

## 6.2 DESCRIPTION OF ALTERNATIVE LAYOUTS FOR EAST DISTRICT

Five alternatives are considered for servicing East District. A brief description of each alternative is provided in the following paragraphs with capacities indicated for 2030. Increasing the flow to Jajmau activated sludge treatment plant is common to all alternatives.

***Alternative I* (4 STPs)**: presented schematically in Figure 6.1. Bingawan STP (Indo-Dutch UASB), treats 364 mld of sewage from South District including 182 mld relieved from City District. A new STP at Karankhera would treat 151 mld of sewage from the East District and City District-East zone. Sewage would be collected at a main pumping station in Ruman and pumped to the STP. Treated effluent would be discharged to irrigation or to Ganga river. The capacity of the existing activated sludge plant at Jajmau would remain at its present 130 mld.

***Alternative II* (4 STPs):** presented in Figure 6.2. Similar to Alternative I except that flows to Karankhera STP would only be 84 mld because sewage from City District-East zone is conveyed to Jajmau. The activated sludge treatment plant at Jajmau would be augmented to 173 mld.

Augmentation would be achieved as identified in the original design and layout of the plant by adding a third line to the liquid process, a third primary digester and a second secondary digester. Sewage from the East District would be collected at a main pumping station in Ruman and pumped 4,200 m through a 1400 mm dia. rising main to Karankhera STP. Bingawan STP, would treat 364 mld of sewage from the South District including 182 mld relieved from City District.

***Alternative III*** **(5 STPs):** presented in Figure 6.3. Bingawan STP, would treat 364 mld of sewage from the South District including 182 mld relieved from City District. A new STP at Kathonagar would treat 66 mld of sewage from the East District south of the railway. Treated effluent would be discharged to irrigation. The new STP at Karankhera would take 85 mld of sewage from the City District - East zone (north of the railway). Sewage would be collected at a main pumping station in Ruman and pumped 4,200 m through a 1400 mm dia. rising main to the STP. The capacity of the existing activated sludge plant at Jajmau would remain at its present 130 mld.

***Alternative IV*** **(4 STPs):** presented schematically in Figure 6.4. Similar to Alternative III except there would be no new treatment plant at Karankhera. Sewage from the City District-East zone would be treated at the Jajmau activated sludge plant, which would be expanded to treat a total domestic sewage load of 203mld. Bingawan STP, would treat 364 mld of sewage from the South District including 182 mld relieved from City District. A new treatment plant at Kathonagar with capacity 66 mld would treat sewage from the East district (south of railway).

***Alternative V*** **(3 STPs):** presented schematically in Figure 6.5. Similar to Alternative IV except that 66 mld from the East District (south of railway) would be pumped 4,000m through a 1200 mm dia. rising main to the UASB plant at Bingawan which would be expanded to treat 430 mld.

## 6.3 SELECTION OF TREATMENT PROCESS

The type of treatment process at proposed treatment plants must be selected before proceeding with a cost comparison of the alternative sewerage layouts for the East District. The preliminary selection of a treatment processes is based on a comparison of life cycle costs for various treatment processes that could be used to meet effluent criteria. Land requirements and costs are based on a survey of existing installations provided under GAP and YAP and typical values reported in literature. In the case of UASB installations it assumed that post treatment will be achieved by adding aerated lagoons to meet discharge criteria for BOD and sulphides and a 3 day retention period to reduce faecal coliform counts.

Detailed cost calculations for each treatment plant are presented in Appendix A. The following treatment capacities have been identified for the year 2030 based on population and wastewater generated by sewerage district.

**Table 6.1 Summary of Treatment Capacities for Comparison of Alternatives (in mld)**

| Treatment Plants | | Alt I | Alt II | Alt III | Alt IV | Alt V |
|---|---|---|---|---|---|---|
| Jajmau (ASP) | AE | 130 | 173 | 130 | 203 | 130 |
| Bingawan | P | 365 | 365 | 365 | 365 | 430 |
| Karankhera | P | 155 | 85 | 85 | 0 | 0 |
| Kathonagar | P | 0 | 0 | 70 | 70 | 0 |

AE = augment existing    P = proposed    S = sanctioned

The following abbreviations and assumptions are used in the cost comparison tables that are presented in the following sub-sections:

- WSP: waste stabilization pond, including maturation ponds;

- AL: facultative aerated lagoon;
- ASP: activated sludge process
- UASB: upflow anaerobic sludge blanket
- + indicates additional maturation ponds, sized for minimum 3 day retention time
- ++ indicates post treatment provided by aerated lagoons.
- Land costs: 40 lakhs per ha (reported by UPJN Varanasi at Workshop on Feb 17 2004)
- Land area: taken from NRCD guidelines and review of existing STPs implemented under GAP
- Capital and O&M costs taken from a review of STPs implemented under GAP
- Present value based on 5% and 30 year life with replacement of mechanical equipment after 15 years

### 6.3.1 Jajmau STP

The existing activated sludge plant at Jajmau has been designed and constructed with provision for future expansion. The site plan identifies space for the addition of a third line to the liquid process, and an additional primary and secondary anaerobic sludge digester.
Other process options could be selected to treat the incremental flows however these could not be accommodated within the existing site and as such would require significant investment in land and new infrastructure. Therefore, the comparison of servicing alternatives is based on expansion of the existing activated sludge plant.

### 6.3.2 Bingawan STP

A 200 mld UASB treatment plant with 1 day final polishing pond discharging to Pandu river has been identified under the Indo-Dutch project. Land acquisition is for 56 hectare. The site plan indicates provision for future expansion by providing additional UASB modules and polishing ponds. The site could potentially accommodate from 350 to 365 mld. As noted in the rapid environmental assessment, effluent from the final polishing ponds will not comply with NRCD standards therefore cost comparison of sewerage layout alternatives will be based on UASB++.

### 6.3.3 Karankhera STP

Karankhera STP is common to Alternatives I, II and III. The capacity required for Alternative I is 155 mld while the capacity for Alternative II & III is 85 mld. A comparison of costs for various process alternatives indicates that UASB with post treatment by aerated lagoon offers the lowest life cycle cost. The cost of waste stabilization ponds is relatively close and this option is attractive because it has the lowest O&M cost of all options. However, the land requirement for WSP is significant and it is doubtful that such a large site can be obtained, therefore cost comparison of sewerage layout alternatives will be based on UASB++ at Karankhera STP.

**Table 6.2 Karankhera STP: Preliminary Cost Comparison of Process Alternatives**

| Cost (Rs. million) | WSP | AL | AL+ | AS | AS+ | FAB | UASB ++ |
|---|---|---|---|---|---|---|---|
| | Alternative I - 155 mld | | | | | | |
| Land area for treatment process (ha) | 194 | 54 | 116 | 31 | 93 | 9 | 54 |
| Land cost | 775 | 217 | 465 | 124 | 372 | 37 | 217 |
| Capital cost | 248 | 388 | 496 | 419 | 527 | 713 | 465 |
| Annual O&M | 9 | 47 | 50 | 56 | 59 | 91 | 20 |
| Total present value (including land cost) | 1,168 | 1,357 | 1,761 | 1,481 | 1,885 | 2,362 | 1,059 |
| | Alternative II&III - 85 mld | | | | | | |
| Land area for treatment process (ha) | 106 | 32 | 68 | 18 | 54 | 5 | 32 |
| Land cost | 425 | 126 | 270 | 72 | 216 | 22 | 126 |
| Capital cost | 136 | 225 | 288 | 243 | 306 | 414 | 270 |
| Annual O&M | 5 | 27 | 29 | 32 | 34 | 53 | 12 |
| Total present value (including land cost) | 641 | 788 | 1,022 | 860 | 1,094 | 1,371 | 615 |

### 6.3.4 Kathonagar STP

Kathonagar STP is common to Alternatives III & IV only. The capacity required for both alternatives is 70 mld. A comparison of costs for various process alternatives indicates that UASB with post treatment by aerated lagoons offers the lowest life cycle cost. The cost of waste stabilization ponds is relatively close and this option is attractive because it has the lowest O&M cost of any option. However, the land requirement for WSP is significant and it is doubtful that such a large site can be obtained; therefore cost comparison of sewerage layout alternatives will be based on UASB++.

**Table 6.3 Kathonagar STP: Preliminary Cost Comparison of Process Alternatives**

| Cost (Rs. million) | WSP | AL | AL+ | AS | AS+ | FAB | UASB ++ |
|---|---|---|---|---|---|---|---|
| Alternative III & IV 70 mld | | | | | | | |
| Land area for treatment process (ha) | 88 | 25 | 53 | 14 | 42 | 4 | 25 |
| Land cost | 350 | 98 | 210 | 56 | 168 | 17 | 98 |
| Capital cost | 112 | 175 | 224 | 189 | 238 | 322 | 210 |
| Annual O&M | 4 | 21 | 22 | 25 | 27 | 41 | 9 |
| Total present value (including land cost) | 528 | 613 | 795 | 669 | 851 | 1,067 | 478 |

## 6.4 COLLECTION SYSTEM FOR COST COMPARISONS

Conveyance costs for trunk sewers are calculated for each layout. The carrying capacity (and size) of the trunk sewers have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to concrete pipes. Flows in each segment are peak flows, based on contributing populations. Conveyance costs include the cost of pumping where the invert depth of gravity sewer exceeds 10m. Pumping costs are also included at the head of treatment plants where the incoming flow is by gravity sewer.

**Table 6.4 Summary of Pumping Requirements for Alternatives**

(mld)

| Pumping stations | | Alt I | Alt II | Alt III | Alt IV | Alt V |
|---|---|---|---|---|---|---|
| Jajmau SPS | E | 25 | 89 | 25 | 107 | 107 |
| Ruman SPS | P | 133 | 66 | 67 | 0 | 0 |
| PS at Kathonagar STP | P | 0 | 0 | 66 | 66 | 0 |
| PS East district to Bingawan STP | P | 0 | 0 | 0 | 0 | 66 |

Capacity at Jajmau SPS is incremental to the existing capacity of the two existing domestic wastewater pumping stations at Jajmau. The maximum allowable average flow for the two pumping stations is 137 mld with 50% reserve capacity. Costs assume that a new pumping station will be required, complete with a 5 minute sump, and a new rising main to the activated sludge treatment plant.

Ruman SPS is common to Alternatives I, II, and III. This station would be required to pump the flows to a distance of 4,200 m through a 1600 mm dia. rising main directly to Karankhera STP.

The pumping station at Kathonagar is common to Alternatives II and IV. It is required to lift sewage at the head of the treatment process. The lift exceeds 9 m therefore the use of screw pumps would not be feasible unless two-stage pumping is considered. To simplify the analysis the comparison of options is based on the use of vertical centrifugal pumps.

The pumping station for Alternative V would be located at the same site as the STP proposed for Alternative II and IV. The pumping station would collect flows from the entire East District (south of the railway) and pump approximately 4,000m through a 1200 mm dia. rising main to the UASB treatment plant at Bingawan.

Pumping station costs include initial investment cost and energy costs, which depend on flow, static head and size of rising main. The size of rising main is based on the most economical combination of energy costs, supply and installation costs, cost of pumps and annual maintenance costs. Preliminary calculations for the selection of the most economic diameter are presented in Appendix A.

## 6.5 COST COMPARISON OF ALTERNATIVES

A comparison of investment and O&M costs for each alternative is summarized in Table 6.5 and presented in more detail in Appendix A. Alternative I is rejected because it has the highest life cycle cost, Alternative V, augmentation of UASB plant in South District, is rejected because it has a higher life cycle cost and the highest annual O&M cost. The lowest life cycle cost is provided by Alternative II followed closely by Alternative IV. Since the costs are relatively close it is necessary to consider other factors before making a final decision.

**Table 6.5 Preliminary Cost Comparison of Alternatives East District**

| Item | Alt I | Alt II | Alt III | Alt IV | Alt V |
|---|---|---|---|---|---|
| Land (ha) | 53.5 | 32.0 | 53.5 | 28.5 | 29.0 |
| Land cost (million Rs.) | 214.0 | 128.0 | 214.0 | 114.0 | 116.0 |
| Capital Cost (Rs. million) | | | | | |
| Treatment plants | 453 | 392 | 453 | 387 | 387 |
| Pumping stations | 474 | 487 | 496 | 487 | 487 |
| Trunk sewers | 214 | 128 | 214 | 114 | 116 |
| Sub-total | 1,471 | 1,271 | 1,423 | 1,266 | 1,338 |
| Annual O&M (1) | 54.38 | 58.44 | 55.72 | 65.22 | 67.18 |
| Life Cycle Cost (2) | 3,520 | 3,264 | 3,516 | 3,349 | 3,503 |

(1) Includes energy costs, repair and maintenance of mechanical and civil works, staff costs
(2) At 5% interest, 30 year life, and replacement of M&E at treatment plants and pumping stations after 15 years

## 6.6 QUALITATIVE COMPARISON AND SELECTION OF PREFERED ALTERNATIVE

This subsection of the report provides a qualitative comparison of Alternatives II and IV. The relative merits of each alternative are discussed in the following paragraphs.

### 6.6.1 Evaluation Criteria

A series of factors are developed to provide qualitative evaluation for plan alternatives. These factors are:

- ***Reliability*** – The potential for mechanical and electrical failure of the system must be minimized by reducing the number of pumping stations and selecting treatment processes that can meet effluent criteria even under adverse operating conditions.
- ***Compatibility*** – All new options must be compatible with the existing system in order to minimize disruption and cost.
- ***Implementability*** – The plan must minimize construction costs and have the ability to be phased into connection with the existing system. This allows for ease of construction and reduces the overall financial burden.
- ***Environmental impact*** – Treatment plant location and selection of process must reduce the impact on water quality. Outfalls should not be located upstream of raw water supply intakes or within close proximity of religious bathing sites.
- ***Stability of Treatment processes*** – Processes that are easily upset by prolonged and frequent power outrages (e.g. activated sludge) are less favorable because they will not easily recover and have the potential to produce poor quality effluent day after day resulting in high pollutant loads. Alternatives that allow for more robust treatment processes such as waste stabilization ponds or aerated lagoons are more favorable.
- ***Flexibility*** – The plan should consider the ability to expand for future increased flows and be able to meet effluent criteria and potential future regulations.

### 6.6.2 Evaluation of Alternatives II and IV for East District

Plan alternatives are ranked relative to each other using the qualitative criteria discussed above. A ranking of 1 to 3 is given with 3 being the least favorable.

**Table 6.6 Qualitative Ranking of Sewerage Alternatives**

| Item | ALT II | ALT IV |
|---|---|---|
| Operational reliability | 1 | 3 |
| Compatibility | 2 | 2 |
| Implementability | 2 | 2 |
| Potential environmental impact | 2 | 2 |
| Stability of treatment process | 1 | 3 |
| Flexibility | 1 | 3 |
| Total | 9 | 15 |
| **Overall Ranking** | **1** | **3** |

1 = most favorable 3= least favorable

**Operational reliability**: Alternative IV requires a larger pumping station at Jajmau and a larger activated sludge treatment plant. Larger pumps and mechanical requirements at the activated sludge plant make Alternative IV more susceptible to mechanical failure, thus less reliable.

**Compatibility**: Both alternatives are the same. There are no existing sewer systems in the East District therefore no re-organization or disruption of services. The expansion of the existing pumping station at Jajmau and the activated sludge plant is required in both alternatives. Although the capacity for Alternative IV is larger the level of disruption to the existing installations will be minimal.

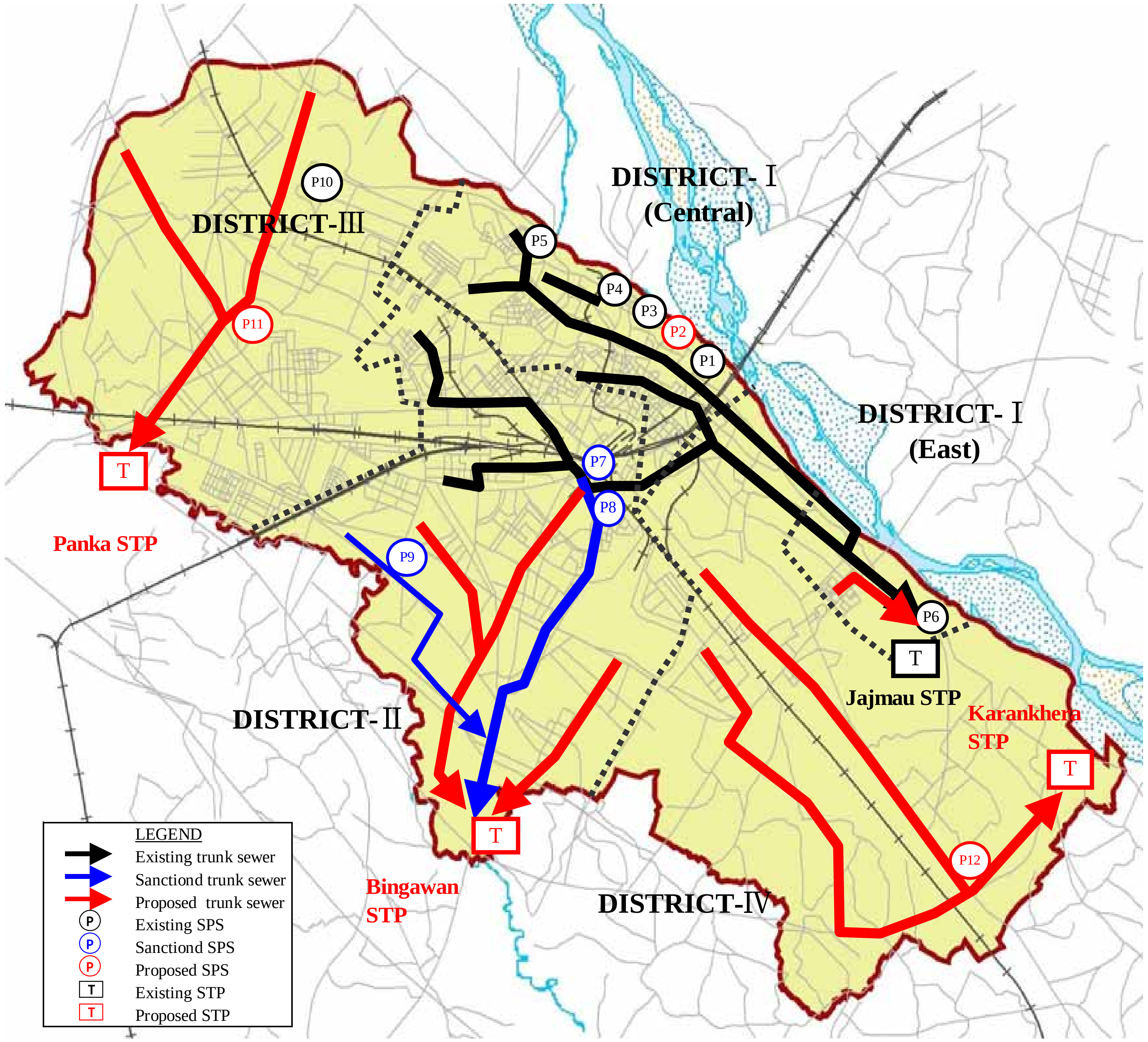
**Implementability:** Both alternatives are the same and can easily be implemented in a phased approach.

**Potential environmental impact**: Both options can be designed with discharge to irrigation therefore they are equal in terms of potential impacts. Alternative IV has a slight disadvantage since the amount of wastewater treated at the ASP is larger and the process produces more sludge than the aerated lagoon.

**Stability of treatment process:** Alternative II is more favorable because a larger flow would be treated by the aerated lagoon process. The aerated lagoon is operationally simpler and more stable than the activated sludge process. It is also easier and faster to recover after prolonged daily power outrages.

**Flexibility:** Alternative II provides more options for future expansion and growth as well as the potential of diverting flow from Jajmau STP in case of rehabilitation or major maintenance. Alternative IV is less favorable because the ASP site will have been fully utilized with augmentation of capacity.

On the basis of the qualitative evaluation and the cost comparison, Alternative II is selected as the preferred alternative and will be used for preparing the master plan and preliminary infrastructure cost estimates.




## ALTERNATIVE - I

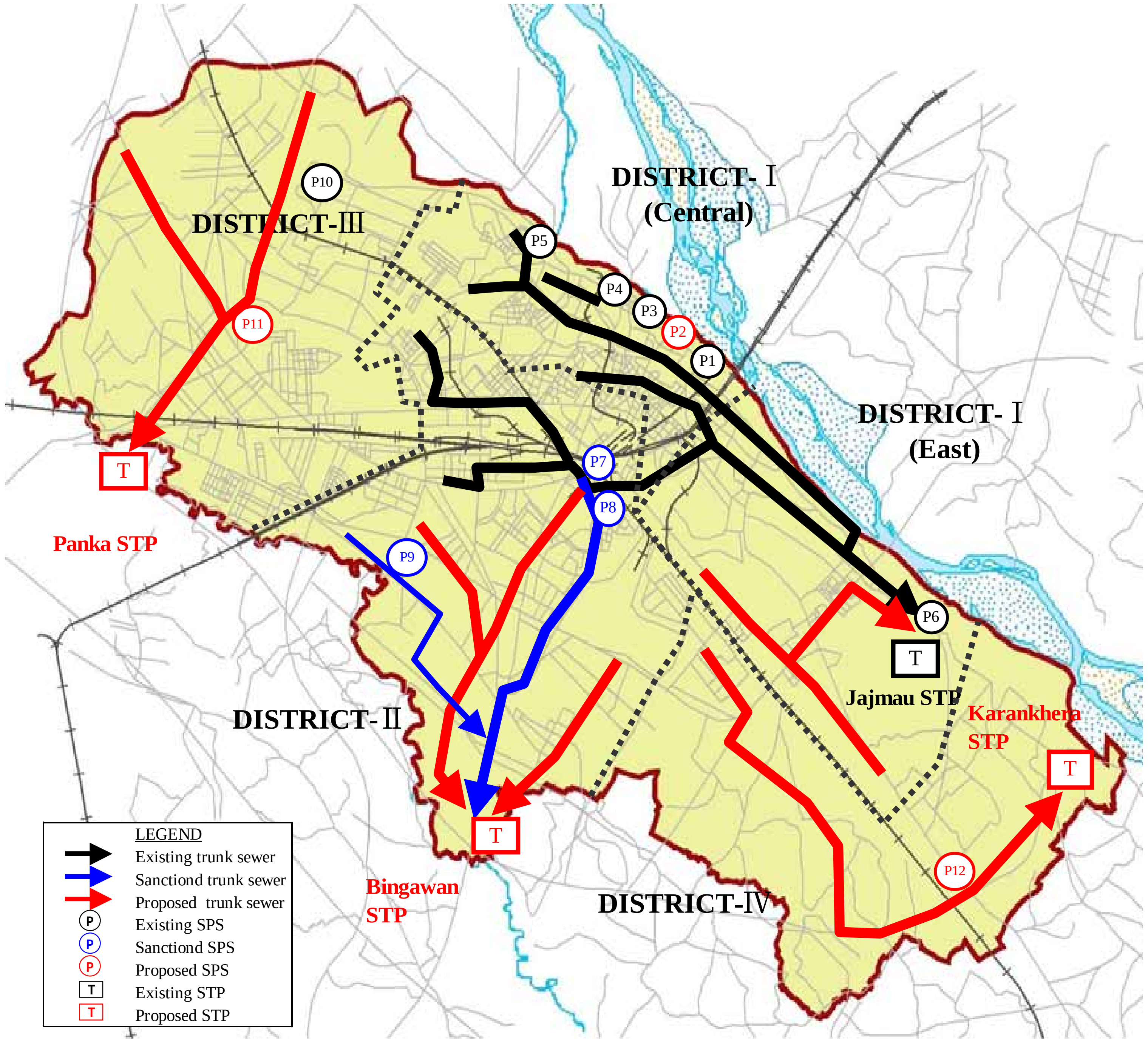
| DISTRICT | | Population 2003 | Population 2015 | Population 2030 | Wastewater Generation (mld) 2003 | Wastewater Generation (mld) 2015 | Wastewater Generation (mld) 2030 |
|---|---|---|---|---|---|---|---|
| DISTRICT- Ⅰ | Central | 694,517 | 802,336 | 869,853 | 97 | 116 | 135 |
| DISTRICT- Ⅰ | Tannety | 77,885 | 122,910 | 152,075 | 11 | 18 | 24 |
| DISTRICT- Ⅱ | Central | 843,469 | 1,072,781 | 1,172,659 | 118 | 156 | 182 |
| DISTRICT- Ⅱ | South | 547,771 | 934,330 | 1,172,711 | 77 | 135 | 182 |
| DISTRICT-Ⅲ | | 335,790 | 801,640 | 1,283,484 | 47 | 116 | 199 |
| DISTRICT-Ⅳ | SA | 288,809 | 539,914 | 861,605 | 41 | 79 | 133 |
| | NSA | 31,586 | 68,120 | 116,694 | 4 | 10 | 18 |
| Total | | 2,819,827 | 4,342,031 | 5,629,081 | 395 | 630 | 873 |
| Tannery industrial wastewater | | | | | 13 | 13 | 13 |
| Total | | | | | 408 | 643 | 886 |

| No. | Pumping Station | Status | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Guptar | Existing | 4 | 4 | |
| 2 | Bhagwatdas ghat nala | Proposed | 8 | 8 | |
| 3 | Muirmill | Existing | 4 | 5 | |
| 4 | Parmat | Existing | 54 | 54 | |
| 5 | Nawabganj | Existing | 6 | 8 | |
| 6 | Jajmau | Existing | 116 | 135 | |
| | Jajmau | Existing | 18 | 24 | For tannery area domestic |
| 7 | Rahkimandi | Sanctioned | 86 | 99 | |
| 8 | Munshipurwa | Sanctioned | 70 | 82 | |
| 9 | Ganda nala | Sanctioned | 19 | 24 | |
| 10 | Lakhanpur | Existing | 16 | 27 | |
| 11 | Panki | Proposed | 80 | 126 | |
| 12 | Ruman | Proposed | 79 | 133 | |
| 13 | Kathonagar | Proposed | - | - | |

| No. | Treatment Plant inflow | | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Jajmau | Domestic | 134 | 159 | |
| | | Tannery | 13 | 13 | Previous M/P 9mld |
| | | Total | 147 | 172 | |
| 2 | Karankhera | | 89 | 151 | |
| 3 | Bingawan | | 291 | 364 | |
| 4 | Panka | | 116 | 199 | |
| 5 | Kathonagar | | - | - | |

| No. | Treatment Plant capacity | | Status | Capacity (mld) 2015 | Capacity (mld) 2030 | Remark |
|---|---|---|---|---|---|---|
| 1 | Jajmau | UASB1 | Existing | 5 | 5 | For domestic |
| | | UASB2 | Existing | 36 | 36 | For tannery |
| | | ASP1 | Existing | 130 | 130 | For domestic |
| | | | Sub Total | 171 | 171 | |
| | | UASB1 | Augument | - | - | |
| | | UASB2 | Augument | 16 | 16 | For tannery 4 + domestic 12 |
| | | ASP1 | Augument | | | 130 mld x 1/3 |
| | | ASP2 | Augument | | | |
| | | | Sub Total | 16 | 16 | |
| | | | Total | 187 | 187 | |
| 2 | Karankhera | | Proposed | 90 | 155 | |
| 3 | Bingawan | | Proposed | 295 | 365 | |
| 4 | Panka | | Proposed | 120 | 200 | |
| 5 | Kathonagar | | Proposed | - | - | |
| | Total | | | 692 | 907 | |

**Figure 6.1 Sewer Layout (Alternative I)**




ALTERNATIVE - II

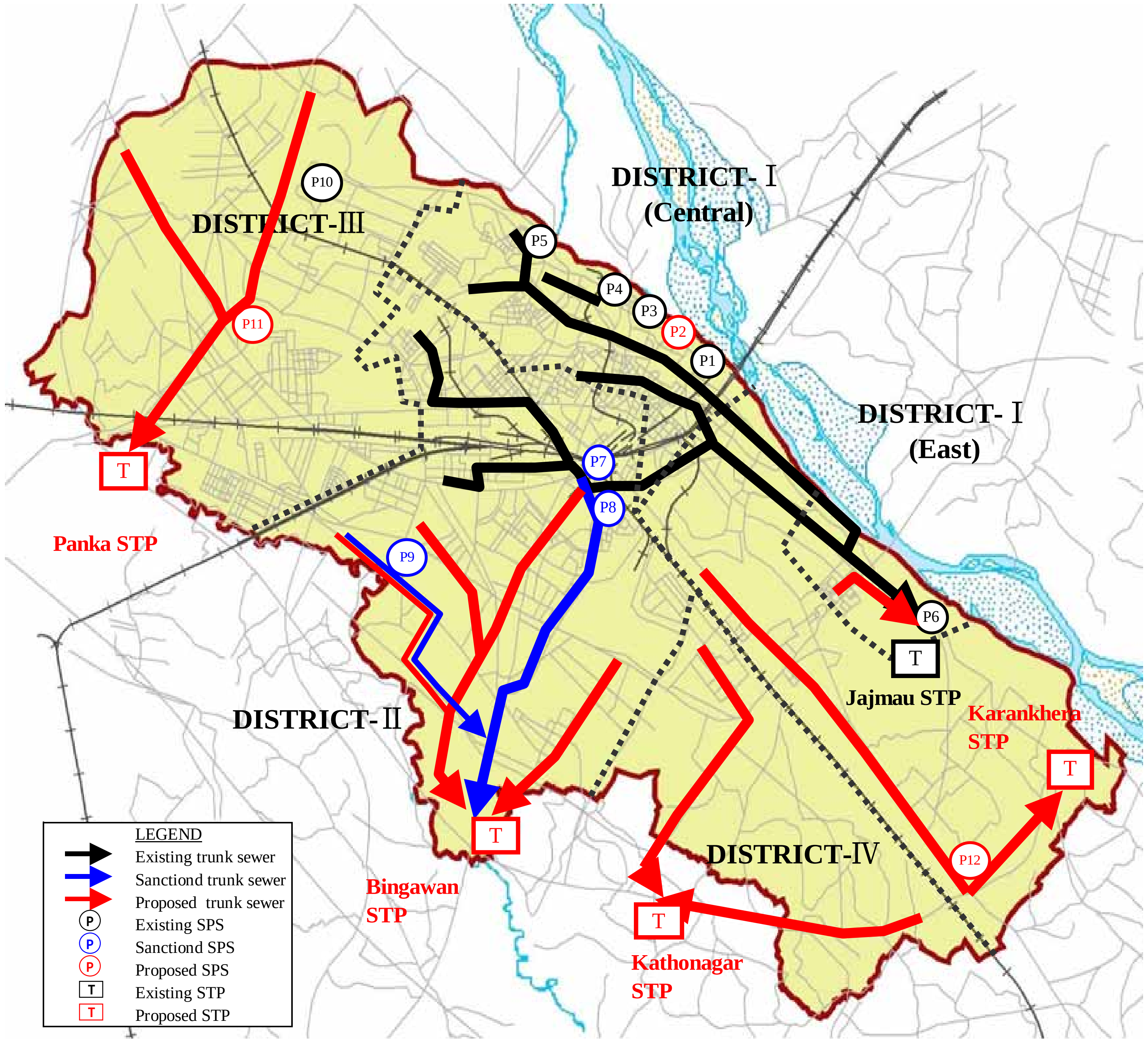
| DISTRICT | | Population 2003 | Population 2015 | Population 2030 | Wastewater Generation (mld) 2003 | Wastewater Generation (mld) 2015 | Wastewater Generation (mld) 2030 |
|---|---|---|---|---|---|---|---|
| DISTRICT- Ⅰ | Central | 694,517 | 802,336 | 869,853 | 97 | 116 | 135 |
| DISTRICT- Ⅰ | Tannety | 77,885 | 122,910 | 152,075 | 11 | 18 | 24 |
| DISTRICT- Ⅰ | East | 232,464 | 338,808 | 433,093 | 33 | 49 | 67 |
| DISTRICT- Ⅱ | Central | 843,469 | 1,072,781 | 1,172,659 | 118 | 156 | 182 |
| DISTRICT- Ⅱ | South | 547,771 | 934,330 | 1,172,711 | 77 | 135 | 182 |
| DISTRICT-Ⅲ | | 335,790 | 801,640 | 1,283,484 | 47 | 116 | 199 |
| DISTRICT-Ⅳ | SA | 56,345 | 201,106 | 428,512 | 8 | 30 | 66 |
| | NSA | 31,586 | 68,120 | 116,694 | 4 | 10 | 18 |
| Total | | 2,819,827 | 4,342,031 | 5,629,081 | 395 | 630 | 873 |
| Tannery industrial wastewater | | | | | 13 | 13 | 13 |
| Total | | | | | 408 | 643 | 886 |

| No. | Pumping Station | Status | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Guptar | Existing | 4 | 4 | |
| 2 | Bhagwatdas ghat nala | Proposed | 8 | 8 | |
| 3 | Muirmill | Existing | 4 | 5 | |
| 4 | Parmat | Existing | 54 | 54 | |
| 5 | Nawabganj | Existing | 6 | 8 | |
| 6 | Jajmau | Existing | 165 | 202 | |
| | Jajmau | Existing | 18 | 24 | For tannery area domestic |
| 7 | Rahkimandi | Sanctioned | 86 | 99 | |
| 8 | Munshipurwa | Sanctioned | 70 | 82 | |
| 9 | Ganda nala | Sanctioned | 19 | 24 | |
| 10 | Lakhanpur | Existing | 16 | 27 | |
| 11 | Panki | Proposed | 80 | 126 | |
| 12 | Ruman | Proposed | 29 | 66 | |
| 13 | Kathonagar | Proposed | - | - | |

| No. | Treatment Plant inflow | | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Jajmau | Domestic | 183 | 226 | |
| | | Tannery | 13 | 13 | Previous M/P 9mld |
| | | Total | 196 | 239 | |
| 2 | Karankhera | | 39 | 84 | |
| 3 | Bingawan | | 291 | 364 | |
| 4 | Panka | | 116 | 199 | |
| 5 | Kathonagar | | - | - | |

| No. | Treatment Plant capacity | | Status | Capacity (mld) 2015 | Capacity (mld) 2030 | Remark |
|---|---|---|---|---|---|---|
| 1 | Jajmau | UASB1 | Existing | 5 | 5 | For domestic |
| | | UASB2 | Existing | 36 | 36 | For tannery |
| | | ASP1 | Existing | 130 | 130 | For domestic |
| | | | Sub Total | 171 | 171 | |
| | | UASB1 | Augument | - | - | |
| | | UASB2 | Augument | 16 | 16 | For tannery 4 + domestic 12 |
| | | ASP1 | Augument | 43 | 43 | 130 mld x 1/3 |
| | | ASP2 | Augument | | 10 | |
| | | | Sub Total | 59 | 69 | |
| | | | Total | 230 | 240 | |
| 2 | Karankhera | | Proposed | 40 | 85 | |
| 3 | Bingawan | | Proposed | 295 | 365 | |
| 4 | Panka | | Proposed | 120 | 200 | |
| 5 | Kathonagar | | Proposed | - | - | |
| | Total | | | 685 | 890 | |

**Figure 6.2 Sewer Layout (Alternative II)**




## ALTERNATIVE - Ⅲ

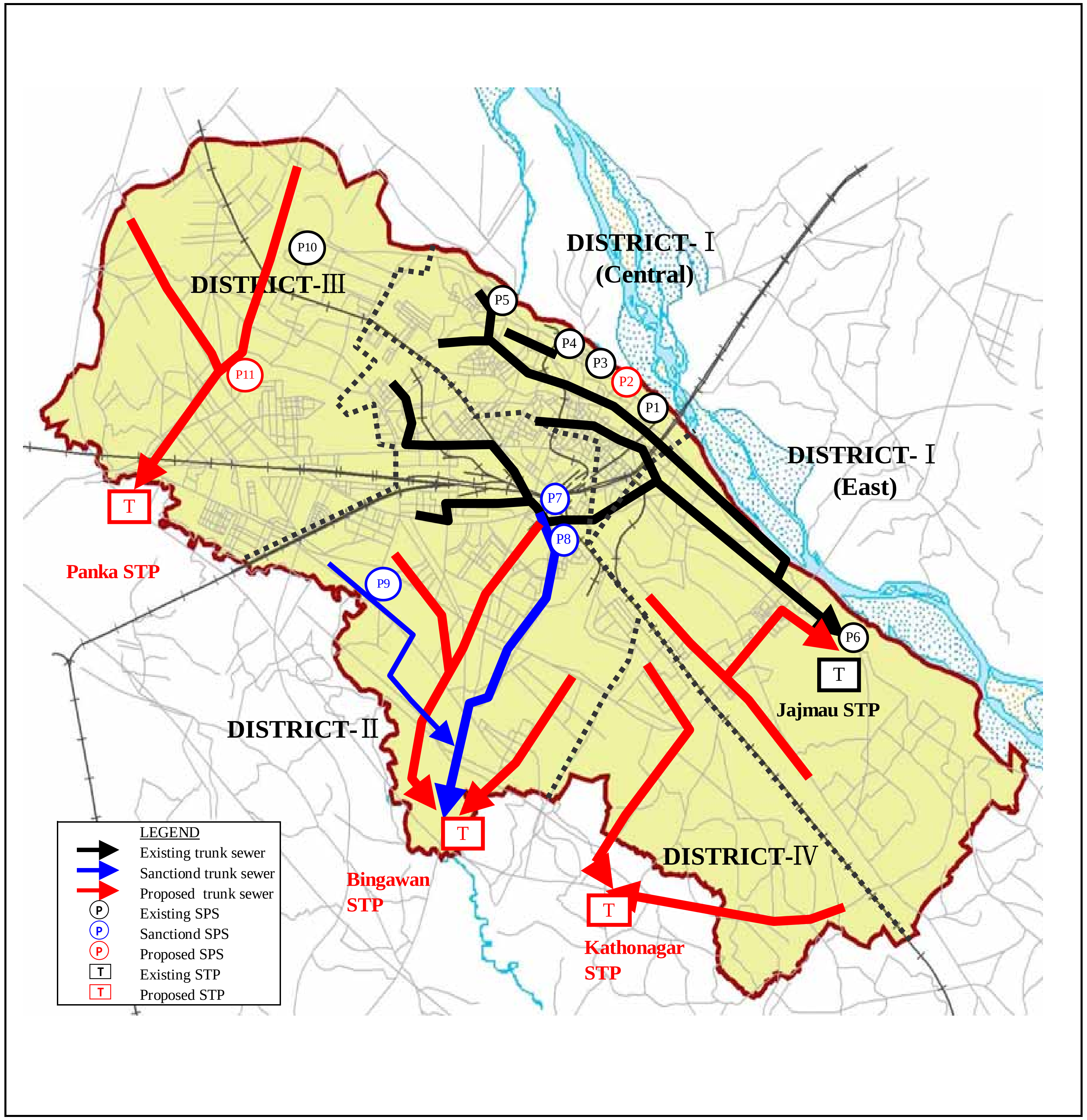
| DISTRICT | | | Population 2003 | Population 2015 | Population 2030 | Wastewater Generation (mld) 2003 | Wastewater Generation (mld) 2015 | Wastewater Generation (mld) 2030 |
|---|---|---|---|---|---|---|---|---|
| DISTRICT- Ⅰ | Central | | 694,517 | 802,336 | 869,853 | 97 | 116 | 135 |
| DISTRICT- Ⅰ | Tannery | | 77,885 | 122,910 | 152,075 | 11 | 18 | 24 |
| DISTRICT- Ⅱ | Central | | 843,469 | 1,072,781 | 1,172,659 | 118 | 156 | 182 |
| DISTRICT- Ⅱ | South | | 547,771 | 934,330 | 1,172,711 | 77 | 135 | 182 |
| DISTRICT- Ⅲ | | | 335,790 | 801,640 | 1,283,484 | 47 | 116 | 199 |
| DISTRICT- Ⅳ | C.east(exclude Jajmau) | | 232,464 | 338,808 | 433,093 | 33 | 49 | 67 |
| DISTRICT- Ⅳ | East | SA | 56,345 | 201,106 | 428,512 | 8 | 30 | 66 |
| | C.east | NSA | 31,586 | 68,120 | 116,694 | 4 | 10 | 18 |
| Total | | | 2,819,827 | 4,342,031 | 5,629,081 | 395 | 630 | 873 |
| Tannery industrial wastewater | | | | | | 13 | 13 | 13 |
| Total | | | | | | 408 | 643 | 886 |

| No. | Pumping Station | Status | Inflow (mld) 2003 | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|---|
| 1 | Guptar | Existing | | 4 | 4 | |
| 2 | Bhagwatdas ghat nala | Proposed | | 8 | 8 | |
| 3 | Muirmill | Existing | | 4 | 5 | |
| 4 | Parmat | Existing | | 54 | 54 | |
| 5 | Nawabganj | Existing | | 6 | 8 | |
| 6 | Jajmau | Existing | | 116 | 135 | |
| | Jajmau | Existing | | 18 | 24 | For tannery area domestic |
| 7 | Rahkimandi | Sanctioned | | 86 | 99 | |
| 8 | Munshipurwa | Sanctioned | | 70 | 82 | |
| 9 | Ganda nala | Sanctioned | | 19 | 24 | |
| 10 | Lakhanpur | Existing | | 16 | 27 | |
| 11 | Panki | Proposed | | 80 | 126 | |
| 12 | Ruman | Proposed | | 49 | 67 | |
| 13 | Kathonagar | Proposed | | - | - | |

| No. | Treatment Plant inflow | | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Jajmau | Domestic | 134 | 159 | |
| | | Tannery | 13 | 13 | Previous M/P 9mld |
| | | Total | 147 | 172 | |
| 2 | Karankhera | | 59 | 85 | |
| 3 | Bingawan | | 291 | 364 | |
| 4 | Panka | | 116 | 199 | |
| 5 | Kathonagar | | 30 | 66 | |

| No. | Treatment Plant capacity | | Status | Capacity (mld) 2015 | Capacity (mld) 2030 | Remark |
|---|---|---|---|---|---|---|
| 1 | Jajmau | UASB1 | Existing | 5 | 5 | For domestic |
| | | UASB2 | Existing | 36 | 36 | For tannery |
| | | ASP1 | Existing | 130 | 130 | For domestic |
| | | | Sub Total | 171 | 171 | |
| | | UASB1 | Augument | - | - | |
| | | UASB2 | Augument | 16 | 16 | For tannery 4 + domestic 12 |
| | | ASP1 | Augument | | | 130 mld x 1/3 |
| | | ASP2 | Augument | | | |
| | | | Sub Total | 16 | 16 | |
| | | | Total | 187 | 187 | |
| 2 | Karankhera | | Proposed | 60 | 85 | |
| 3 | Bingawan | | Proposed | 295 | 365 | |
| 4 | Panka | | Proposed | 120 | 200 | |
| 5 | Kathonagar | | Proposed | 30 | 70 | |
| | Total | | | 692 | 907 | |

**Figure 6.3 Sewer Layout (Alternative III)**




## ALTERNATIVE - IV

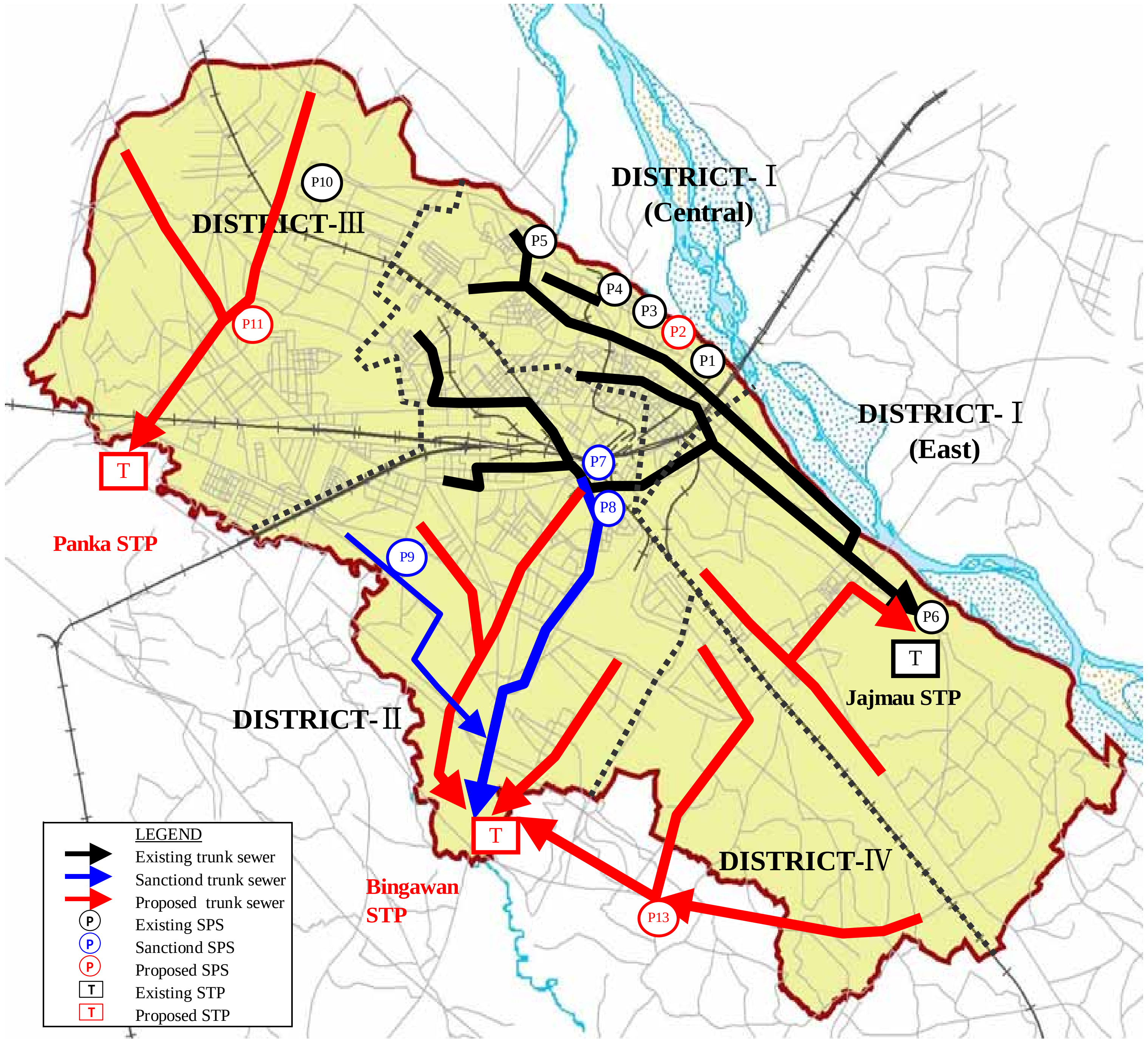
| DISTRICT | | Population 2003 | Population 2015 | Population 2030 | Wastewater Generation (mld) 2003 | Wastewater Generation (mld) 2015 | Wastewater Generation (mld) 2030 |
|---|---|---|---|---|---|---|---|
| DISTRICT- Ⅰ | Central | 694,517 | 802,336 | 869,853 | 97 | 116 | 135 |
| DISTRICT- Ⅰ | Tannety | 77,885 | 122,910 | 152,075 | 11 | 18 | 24 |
| DISTRICT- Ⅰ | C.east(exclude Jajmau) | 232,464 | 338,808 | 433,093 | 33 | 49 | 67 |
| DISTRICT- Ⅰ | NSA | 31,586 | 68,120 | 116,694 | 4 | 10 | 18 |
| DISTRICT- Ⅱ | Central | 843,469 | 1,072,781 | 1,172,659 | 118 | 156 | 182 |
| DISTRICT- Ⅱ | South | 547,771 | 934,330 | 1,172,711 | 77 | 135 | 182 |
| DISTRICT-Ⅲ | | 335,790 | 801,640 | 1,283,484 | 47 | 116 | 199 |
| DISTRICT-Ⅳ | | 56,345 | 201,106 | 428,512 | 8 | 30 | 66 |
| Total | | 2,819,827 | 4,342,031 | 5,629,081 | 395 | 630 | 873 |
| Tannery industrial wastewater | | | | | 13 | 13 | 13 |
| Total | | | | | 408 | 643 | 886 |

| No. | Pumping Station | Status | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Guptar | Existing | 4 | 4 | |
| 2 | Bhagwatdas ghat nala | Proposed | 8 | 8 | |
| 3 | Muirmill | Existing | 4 | 5 | |
| 4 | Parmat | Existing | 54 | 54 | |
| 5 | Nawabganj | Existing | 6 | 8 | |
| 6 | Jajmau | Existing | 175 | 220 | |
| | Jajmau | Existing | 18 | 24 | For tannery area domestic |
| 7 | Rahkimandi | Sanctioned | 86 | 99 | |
| 8 | Munshipurwa | Sanctioned | 70 | 82 | |
| 9 | Ganda nala | Sanctioned | 19 | 24 | |
| 10 | Lakhanpur | Existing | 16 | 27 | |
| 11 | Panki | Proposed | 80 | 126 | |
| 12 | Ruman | Proposed | - | - | |
| 13 | Kathonagar | Proposed | - | - | |

| No. | Treatment Plant inflow | | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Jajmau | Domestic | 193 | 244 | |
| | | Tannery | 13 | 13 | Previous M/P 9mld |
| | | Total | 206 | 257 | |
| 2 | Karankhera | | - | - | |
| 3 | Bingawan | | 291 | 364 | |
| 4 | Panka | | 116 | 199 | |
| 5 | Kathonagar | | 30 | 66 | |

| No. | Treatment Plant capacity | | Status | Capacity (mld) 2015 | Capacity (mld) 2030 | Remark |
|---|---|---|---|---|---|---|
| 1 | Jajmau | UASB1 | Existing | 5 | 5 | For domestic |
| | | UASB2 | Existing | 36 | 36 | For tannery |
| | | ASP1 | Existing | 130 | 130 | For domestic |
| | | | Sub Total | 171 | 171 | |
| | | UASB1 | Augument | - | - | |
| | | UASB2 | Augument | 16 | 16 | For tannery 4 + domestic 12 |
| | | ASP1 | Augument | 43 | 43 | 130 mld x 1/3 |
| | | ASP2 | Augument | | 30 | |
| | | | Sub Total | 59 | 89 | |
| | | | Total | 230 | 260 | |
| 2 | Karankhera | | Proposed | - | - | |
| 3 | Bingawan | | Proposed | 295 | 365 | |
| 4 | Panka | | Proposed | 120 | 200 | |
| 5 | Kathonagar | | Proposed | 30 | 70 | |
| | Total | | | 675 | 895 | |

**Figure 6.4 Sewer Layout (Alternative IV)**




## ALTERNATIVE - V

| DISTRICT | | Population 2003 | Population 2015 | Population 2030 | Wastewater Generation (mld) 2003 | Wastewater Generation (mld) 2015 | Wastewater Generation (mld) 2030 |
|---|---|---|---|---|---|---|---|
| DISTRICT- Ⅰ | Central | 694,517 | 802,336 | 869,853 | 97 | 116 | 135 |
| DISTRICT- Ⅰ | Tannety | 77,885 | 122,910 | 152,075 | 11 | 18 | 24 |
| DISTRICT- Ⅰ | C.east(exclude Jajmau) | 232,464 | 338,808 | 433,093 | 33 | 49 | 67 |
| DISTRICT- Ⅰ | NSA | 31,586 | 68,120 | 116,694 | 4 | 10 | 18 |
| DISTRICT-Ⅱ | Central | 843,469 | 1,072,781 | 1,172,659 | 118 | 156 | 182 |
| DISTRICT-Ⅱ | South | 547,771 | 934,330 | 1,172,711 | 77 | 135 | 182 |
| DISTRICT-Ⅲ | | 335,790 | 801,640 | 1,283,484 | 47 | 116 | 199 |
| DISTRICT-Ⅳ | | 56,345 | 201,106 | 428,512 | 8 | 30 | 66 |
| Total | | 2,819,827 | 4,342,031 | 5,629,081 | 395 | 630 | 873 |
| Tannery industrial wastewater | | | | | 13 | 13 | 13 |
| Total | | | | | 408 | 643 | 886 |

| No. | Pumping Station | Status | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Guptar | Existing | 4 | 4 | |
| 2 | Bhagwatdas ghat nala | Proposed | 8 | 8 | |
| 3 | Muirmill | Existing | 4 | 5 | |
| 4 | Parmat | Existing | 54 | 54 | |
| 5 | Nawabganj | Existing | 6 | 8 | |
| 6 | Jajmau | Existing | 175 | 220 | |
| | Jajmau | Existing | 18 | 24 | For tannery area domestic |
| 7 | Rahkimandi | Sanctioned | 86 | 99 | |
| 8 | Munshipurwa | Sanctioned | 70 | 82 | |
| 9 | Ganda nala | Sanctioned | 19 | 24 | |
| 10 | Lakhanpur | Existing | 16 | 27 | |
| 11 | Panki | Proposed | 80 | 126 | |
| 12 | Ruman | Proposed | - | - | |
| 13 | Kathonagar | Proposed | 30 | 66 | |

| No. | Treatment Plant inflow | | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Jajmau | Domestic | 193 | 244 | |
| | | Tannery | 13 | 13 | Previous M/P 9mld |
| | | Total | 206 | 257 | |
| 2 | Karankhera | | - | - | |
| 3 | Bingawan | | 321 | 430 | |
| 4 | Panka | | 116 | 199 | |
| 5 | Kathonagar | | 30 | 66 | |

| No. | Treatment Plant capacity | | Status | Capacity (mld) 2015 | Capacity (mld) 2030 | Remark |
|---|---|---|---|---|---|---|
| 1 | Jajmau | UASB1 | Existing | 5 | 5 | For domestic |
| | | UASB2 | Existing | 36 | 36 | For tannery |
| | | ASP1 | Existing | 130 | 130 | For domestic |
| | | | Sub Total | 171 | 171 | |
| | | UASB1 | Augument | - | - | |
| | | UASB2 | Augument | 16 | 16 | For tannery 4 + domestic 12 |
| | | ASP1 | Augument | 43 | 43 | 130 mld x 1/3 |
| | | ASP2 | Augument | | 30 | |
| | | | Sub Total | 59 | 89 | |
| | | | Total | 230 | 260 | |
| 2 | Karankhera | | Proposed | - | - | |
| 3 | Bingawan | | Proposed | 325 | 430 | |
| 4 | Panka | | Proposed | 120 | 200 | |
| 5 | Kathonagar | | Proposed | - | - | |
| | Total | | | 675 | 890 | |

**Figure 6.5 Sewer Layout (Alternative V)**

# CHAPTER 7

## PROPOSED MASTER PLAN

# CHAPTER 7 PROPOSED MASTER PLAN

## 7.1 SUMMARY

This chapter describes the collection and treatment components of the future sewerage system based on the recommended Alternative II selected in the Chapter 6. In addition, this section of the Master Plan evaluates current capacity, and existing deficiencies and identifies capacity of each component to handle projected wastewater flows over the planning horizon.

District wise delineation of the sewerage scheme is presented in Figure 7.1 for 2015 and Figure 7.2 for 2030. The overall sewerage scheme will consists of 4 separate sewerage Districts each with its own treatment plant:

- District I: City center, and areas surrounding Jajmau conveying 239 mld of sewage to 2 treatment plants at Jajmau
- District II: South of City district, conveying 364 mld sewage to a sanctioned UASB treatment plant near Bingawan village. Approximately 182 mld is diverted from the City District to relieve flows in the 90" outfall to Jajmau.
- District III: West of City and South districts, conveying 199 mld of sewage to a proposed aerated lagoon near Panka village. This district includes areas north of GT road identified in former master plan as north/west district
- District IV: East of South district conveying 84 mld of sewage to a proposed aerated lagoon near Karankhera village.

Populations, and wastewater generated by sewerage district are presented in Planning Framework Chapter 5 Table 5.6. Sewage generation quantities have been computed considering tributary areas proposed under the Master Plan. These tributaries areas are presented in Table 5.6 and are also shown on layout drawings in Appendix B. Peak sewage generation volumes at various phase years have been computed on peak factors as per design criteria identified in Chapter 5.

Hydraulic calculations for evaluating capacity of existing trunk sewers and replacement sewer are presented in Table 7.1. Calculations for sizing proposed trunk sewers are presented in Table 7.2.

Existing pumping station data is presented in Table 7.4. Evaluation of pumping station capacity for present and future wastewater loads is presented in Table 7.5.

## 7.2 STORM WATER DRAINS

Locations of existing drains are shown in Figure. 7.3. Kanpur city has 23 drains that carry significant amounts of wastewater to Ganga and Pandu rivers. These drains are also a significant source of pollution during wet weather when cow dung and human waste that accumulates during the dry season are flushed away by runoff.

Flow measurements, taken in 2003 are presented in Table 7.6 and these indicate a total wastewater flow of 360 mld. Out of the 23 nalas, 20 nalas were found to carry 150.91 mld of wastewater to Ganga river, while 3 nalas carry 62.34 mld of wastewater to Pandu river.

Under GAP-I, pumping stations and relief sewers were implemented to divert 160 mld of sewage through the 90" outfall sewer to two treatment plants at Jajmau. However, the combined average inflow at both treatment plants is only 79 mld and this indicates that most of the wastewater is not reaching the treatment plant, i.e., the collection system is not operating properly.

Nala-tapping arrangements are essential for intercepting wastewater during dry weather and reducing pollution loads, however the present tapping arrangements are inadequate:

- They allow a substantial quantity of silt and debris into the sewer system which is detrimental to its life and proper functioning.
- They allow large quantities of storm water into the sewerage system which causes flooding and hydraulic overloads at treatment plants

Such nala tapping arrangements are considered as interim measures only and should be phased out gradually with the improvement in sewerage coverage into all urban areas, i.e., implementation of the Master Plan. However, house connection targets for 2030 are at most 80% therefore there will always be some flow in the nalas. It is recommended that each tapping point be provided with screening and grit removal facilities to protect the collection system. Furthermore, each tapping point should have a means of automatically regulating the inflow during wet weather.

## 7.3 GENERAL ASSESSMENT: PHYSICAL CONDITION OF TRUNK SEWERS

A detailed survey of the trunk sewers was beyond the scope of the present Master Plan study. However the JICA team did carry out a visual survey of the trunk sewers at random locations to get an appreciation for potential problems. The visual surveys were supplemented by discussions with Jal Sansthan and Jal Nigam.

### 7.3.1 Current Deficiencies

1) Poor maintenance: The majority of the branch sewerage system is at any time either completely blocked or its capacity is severely reduced by silt and solid waste. Sewer maintenance is restricted to emergency clearing of blockages and is given low priority.

2) Silting and Surcharging: Visual surveys by JICA study team indicates that sections of the trunk sewers are heavily silted. Reduced capacity from silting results in sewage overflows from manholes to surface drains during peak flow periods. Problems may also be caused by structural damage in some sections.

3) Ageing infrastructure: The existing trunk sewer system is over 75 years old and has been allowed to deteriorate to the point where rehabilitation or replacement is necessary. Many of the sewers have not been inspected.

4) Poor record keeping and inadequate information for planning: The limited availability of records relating to pumping stations and the sewerage system makes planning for extending services and assessing the amount of sewage presently flowing into the sewer system difficult. This also prevents effective maintenance and corrective actions.

5) Storm water and solid waste ingress to sewers: Damaged manholes, sewer defects particularly around the nala and connections of nala to the sewerage system have led to the increased risk of solid waste entering and blocking the system.

### 7.3.2 Current Capital Needs

Trunk sewers and branch sewers in the city need to be cleaned. Sewers that have been diverted to drains as a temporary relief from chronic blockage or surcharging should be re-instated and connected to the sewage collection system.

Drains that have been diverted directly into sewers must be rerouted to formal tapping points. These tapping points must be constructed with proper screening and grit removal facilities. Tapping points will also require some physical means of by-passing large storm water flows. The present solution of manual gates is inadequate and creates operational difficulties.

## 7.4 SEWERAGE DISTRICT I (CITY DRAINAGE): JAJMAU STP

### 7.4.1 General Description

This sewerage district is bounded by the Ganga river to the North, H.B.T.I. and roadways workshop to the West, Armapur Estate, Dada nagar, Kidwai nagar and COD in the South. The area extends along the east axis of the city taking in the area north of Delhi Calcutta track beyond COD gate up to the master planning boundary in the East.

This area includes the old city core with an old sewerage network dating back to as early as 1910 and the tannery district located east of the cantonment lands. Wastewater from District I is conveyed to Jajmau pumping station via a 90" trunk sewer with maximum carrying capacity of 3,878 lps peak flow (168 mld average flow). At Jajmau, domestic wastewater is pumped to the 130 mld activated sludge treatment plant and a 5 mld UASB pilot plant.

A separate network of open drains and pumping stations collects about 13 mld of tannery wastewater in the Jajmau area and pumps it to the 36 mld UASB treatment works

The total wastewater load for the City district exceeds the carrying capacity of the outfall sewer. The existing sewerage network in City district must therefore be reconfigured to provide a smaller catchment area population of 8.7 lakhs in 2030 to generate no more than 168 mld (estimated carrying capacity for the 90" trunk). It is therefore proposed to divert flow from the Central district (182 mld equivalent to a population of 11.7 lakhs) to a new outfall and treatment plant south of the city.

Both treatment plants at Jajmau will need to be augmented to cope with increased domestic flows:

- By 2015,
    - the domestic activated sludge (AS) treatment plant will be augmented from 130 mld to 173 mld.
    - the UASB plant will need an additional 16 mld capacity
    - Post treatment processes should be added to the UASB plant
- By 2030,
    - the AS plant will need an additional 10 mld capacity.

### 7.4.2 Jajmau Tannery Wastewater Treatment Facility

(1) General

This section includes information pertaining to the city's existing 36 mld tannery wastewater treatment plant at Jajmau. Process control data for the facility is unavailable and plant performance data provided to the study team is limited to monthly average, max and min, for influent and effluent parameters such as BOD, COD and SS.

Detailed analysis of plant process is beyond the scope of the present study. Nevertheless, a brief review of available data is useful for identifying the potential problem areas and solutions that should be investigated in more detail in subsequent studies.

(2) Facility Overview

The site plan presented in Drawing B1 provides actual layout and location of the various process units. This STP is operated and maintained by a contractor under the supervision of UP Jal Nigam.

The process consists of 2 x 18 mld UASB reactors giving a total capacity of 36 mld. The plant is designed to treat 9 mld of wastewater from 175 tanneries in the Jajmau cluster diluted with 27 mld of domestic wastewater (mixing ratio of 1:3). At present, the average monthly inflow to the STP is only 25 mld of which approximately 13 mld is tannery wastewater, the balance being domestic wastewater.

Average monthly data made available to the study team for the period of Nov 2002 to Oct 2003 is presented in Table 7.7 and Figure7.4. In general, the data shows that actual strength of the incoming wastewater exceeds the design parameters. This is not surprising since tannery wastewater is not being diluted in the ratio that was intended.

**Table 7.8 Design Parameters versus Actual**

| **Parameters** | | **Design value** | **Actual** |
|---|---|---|---|
| Flow | Peak ($m^3$/min) | n.a. | n.a. |
| | Average ($m^3$/day) | 36,000 | 25,000 |
| | Minimum ($m^3$/min) | n.a. | n.a. |
| Wastewater quality | $BOD_5$ (mg/l) | 775 | 119 to 1,228 |
| | TSS (mg/l) | 1,625 | 215 to 1,835 |
| | COD (mg/l) | 1,875 | 540 to 4,170 |
| | Chromium (mg/l) | 30 | 84.9 |
| | Sulphates (mg/l) | 738 | 532 |
| Effluent quality | $BOD_5$ (mg/l) | 175 | 82 to 382 |
| | TSS (mg/l) | 570 | 170 to 940 |
| | COD | 600 | 245 to 1,046 |
| | Chromium (mg/l) | 4.3 | 12 |
| | Sulphates (mg/l) | 120 | 543 |

Influent values are after mixing with domestic sewage
Actual values for BOD, COD and TSS are monthly minimum and maximum from Nov-02 to Oct-03 as reported by UPJN Kanpur.
Actual values for Chromium and Sulphates taken by JICA Study Team, from two day composite samples, June 16, 17 2003.

The plant was not designed to meet present NRCD effluent criteria. In fact, effluent from the plant is worse than anticipated by the design. Again, this is probably because tannery wastewater is not being sufficiently diluted with domestic sewage as originally intended. Chromium levels in the treated effluent exceed NRCD discharge standards.

The following recommendations should be investigated in more detail in subsequent studies:

- The influent should be diluted to respect design parameters
- The post treatment process should be improved to reduce BOD and sulphides to acceptable limits. Options include adding aerated lagoons, trickling filters or forced aeration of the final polishing pond.
- Effluent must be disinfected either by chlorination or preferably by maturation ponds if land is available.

(3) Master Plan Provisions

Tannery wastewater flows have already increased from 9 mld to 13 mld. Furthermore, additional flows will be diverted to the UASB by the Project to isolate the collection system in Jajmau tannery district.

In order to achieve the correct dilution factor of 1:3 the treatment plant should be augmented from 36 mld to 52 mld. The revised design flows are as follows:

- 2015: 13 mld (tannery) + 39 mld (domestic) 52 mld @ 1: 3 dilution ratio

### 7.4.3 Jajmau Domestic Wastewater Treatment Facility

(1) General

This section includes information pertaining to the existing 130 mld domestic wastewater treatment plant at Jajmau. Process control data for the facility is unavailable and plant performance data provided to the team is limited to monthly average, max and min, for influent and effluent parameters such as BOD, COD and SS.

Detailed analysis of plant processes to identify potential improvements for optimizing performance of the present treatment plant is beyond the scope of the present Master Planning study. Nevertheless ,a brief review of available data is provided to identify the potential problem areas and solutions that should be investigated in more detail in subsequent studies.

(2) Facility Overview

The site plan presented in Drawing B1 provides the actual layout and location of the various process units.

The treatment plant was commissioned in January 1999. The process was designed with 3 parallel liquid streams giving a total capacity of 130mld. There is provision for adding a fourth 43 mld module. This STP is operated and maintained by a contractor under the supervision of UP Jal Nigam.

At present the average monthly inflow is 49 mld with a seasonal fluctuation ranging from 40 mld to 56 mld. Under the proposed Master Plan the treatment capacity would eventually be augmented to 183 mld to accommodate projected sewage flows from the City District I.

(3) Liquid Process Units

The present wastewater treatment process consists of two stages: primary treatment and secondary treatment. Each phase of treatment acts as a removal mechanism for targeted pollutants in the influent wastewater stream.

The wastewater flow enters the inlet collection chamber and preliminary treatment is carried out in the subsequent grit chamber. The flow is measured at the Parshall flume.

The flow is divided into three equal streams and enters circular primary clarifier. In the primary clarifier, not only some settleable solids but also some settleable organic load is removed from the bottom and conveyed to solids handling process with the sludge generated from secondary clarifiers.

Secondary treatment accomplishes the conversion of soluble organic material into settleable biomass by utilizing metabolic mechanism of micro-organisms. The biomass is settled in final secondary clarifiers. At Jajmau STP, secondary treatment is accomplished with the conventional activated sludge process in three aeration tanks using surface aerators. The settled sludge in the secondary clarifier is drawn off the bottom and pumped back to the head of the aeration tank to maintain MLSS concentrations.

Treated effluent is pumped through a 1500 mm dia. rising main to an effluent channel used for irrigation. A by-pass arrangement is also available to discharge effluent to a nearby drain when pumps at the lift station fail or when irrigation water is not required.

Table 7.9 contains an itemized list of major plant components related to liquid process. The various components are listed by treatment stage. The condition of each component could not be assessed and will need to be evaluated in subsequent study. Furthermore some of the dimensional data required for process calculations is unavailable.

**Table 7.9 Major Liquid Process Components**

| Level | Process | Component | Condition |
|---|---|---|---|
| Headworks | Inlet collection chamber | 1 – 6.4m x 6.4m x 5.0m(D) | n.a. |
| | Grid chamber | 3 – 9.3m x 9.3m x 1.22m(D) | n.a. |
| | Flow measurement | 1 – Parshall flume TW= 2.134m | n.a. |
| Primary Treatment | Primary clarifier | 3– 44.0m diameter, SWD= 4.1m | n.a. |
| Secondary Treatment | Aeration tank | 3 – 52.5m x34.5m x , SWD= 4.032 m | n.a. |
| | Secondary clarifiers | 3 – 48.0m diameter, SWD= 3.802 m | n.a. |

n.a. = not available

(4) Solids Handling Units

Table 7.10 provides an inventory of solids handling process. Sludge consists of primary clarifier sedimentation and biological sludge from secondary clarifier ,that is conversion of organic materials into cellular mass.

Biological sludge from the secondary clarifiers is recirculated to the head of aeration tank and to the primary clarifiers. The combined sludge settled in the bottom of the primary clarifiers is pumped to the 2 sludge thickeners. Thickened sludge is then pumped to two primary sludge digesters. Sludge entering the digester is stabilized anaerobically where volatile fraction of the sludge is converted by bacteria into methane and water. Digested sludge from primary digesters is sent by gravity to secondary sludge digesters. Finally, digested sludge is pumped to 4 centrifuges where it is dewatered and then air-dried. The gas containing methane and $CO_2$ is utilized for the production of electricity.

**Table 7.10 Major Solids Handling Components**

| Process | Component | Condition |
|---|---|---|
| Sludge Thickener | 2– 28.0m diameter, SWD= 3.485m | n.a. |
| Digesters | Primary digesters: 2 – 29.0m diameter, SWD= 9.1 m<br>Secondary digesters: 2 – 25.0m diameter, SWD= 9.7 m | n.a. |
| Sludge Drying Beds | n.a. | n.a. |

n.a. = not available

(5) Evaluation

The treatment plant was designed to treat 130 mld of domestic wastewater with a BOD strength of 300mg/l.

Average monthly data made available to the study team for the period of Nov 2002 to Oct 2003 are presented in Table 7.7. In general, the data shows that actual strength of the incoming wastewater exceeds the design parameters. Relatively high average monthly COD values and high sulphates indicate that a large amount of industrial wastewater is present in the domestic wastewater stream. The average TSS values are also relatively high and are indicative that tannery wastewater is present.

**Table 7.11 Influent and Effluent Design Parameters versus Actual**

| Parameters | | Design value | Actual |
|---|---|---|---|
| Flow | Peak ($m^3$/min) | n.a. | n.a. |
| | Average ($m^3$/day) | 130,000 | 49,000 |
| | Minimum ($m^3$/min) | n.a. | n.a. |
| Wastewater quality | $BOD_5$ (mg/l) | 300 | 269 to 360 |
| | TSS (mg/l) | 600 | 751 to 1205 |
| | COD (mg/l) | 180 | n.a. |
| | Chromium (mg/l) | 420 | n.a. |
| | Sulphates (mg/l) | 450-550 | 768 to 1468 |
| | $BOD_5$ (mg/l) | | 79.5 |
| | TSS (mg/l) | | 262 |
| Effluent quality | COD | 30 | 25 to 52 |
| | Chromium (mg/l) | 50 | 102 to 128 |
| | Sulphates (mg/l) | | 0.04 |
| | Peak ($m^3$/min) | | 176 |

Actual values are monthly averages from Nov-02 to Oct-03 reported by UPJN Kanpur

Effluent generally does not meet the requirements set out in NRCD standards for discharge to water bodies or used for agricultural irrigation. The treatment plant is not hydraulically overloaded. However BOD removal efficiency ranging from 61% to 83% is lower than the norm for activated sludge plants. Poor performance of the treatment plant is no doubt caused by the high strength of the wastewater. It could also be caused by frequent power failures or discharge of toxic pollutants from industry.

The following recommendations should be investigated in more detail in subsequent studies:

- Tannery wastewater should be separated from the domestic wastewater stream. This can be achieved by implementing a separate collection system for the tannery district and conveying all sewage from the area to the UASB plant.
- The domestic wastewater collection system in the City district must be improved to increase the amount of wastewater conveyed to the treatment plant.
- The activated sludge process should be protected from shock loads by providing a roughing filter before the aeration tanks. This might be achieved by installing trickling filters.
- Effluent must be disinfected either by chlorination or preferably by maturation ponds if land is available.

(6) Master plan Provisions

Projected domestic wastewater flows in District I are as follows:

- 2015: 183 mld
- 2030: 226 mld

The activated sludge treatment plant can be expanded by adding a third stream to treat up to 183 mld. The remaining balance of domestic wastewater (43 mld) will be treated as follows:

- 5 mld at the pilot plant

- 39 mld for dilution with tannery waste at the UASB

### 7.4.4 Tannery District Wastewater Collection System

The tannery district is served by two collection systems.

A separate network of shallow open drains, implemented under the Indo-Dutch assistance program, collects tannery wastewater at four intermediate pumping stations designated as IPS 1 to 4. These pumping stations convey tannery wastewater through a common rising main directly to the UASB treatment plant where it is supposed to be diluted in a ratio of 1:3 with domestic wastewater (i.e. 9 mld tannery wastewater to 27 mld domestic wastewater) before passing through the treatment process.

A conventional network of branch and lateral sewers collects domestic wastewater from households in a part of the tannery area. These sewers are connected to the 90” outfall sewer and conveyed to the main pumping station at Jajmau and from there to the activated sludge treatment plant.

The activated sludge treatment plant is at present experiencing operational difficulties because the BOD, COD and SS loads are quite high. The presence of high chromium levels in the influent is an indication that tannery wastewater is still finding its way into the domestic wastewater stream. The reason tannery waste is reaching the activated sludge plant can be attributed to the following factors:

- Not all tanneries are disposing wastewater to the special collection system
- Solid wastes from the tannery process is frequently dumped into manholes of the domestic collection system
- Existing branch sewers installed in the north side area of 150m road are discharging tannery industrial wastewater to 90 inch sewer.
- According to UPJN, the UASB treatment plant frequently overflows, and the overflow pipes are connected to the 90” outfall. The result is that overflows from UASB are subsequently pumped to the activated sludge treatment plant.

The following solutions are proposed as possible countermeasures.:

- Domestic wastewater from the tannery district should be collected separately and conveyed directly to the UASB. The estimated domestic wastewater load is 24 mld. Existing branch and lateral sewers should be disconnected from the 90” outfall sewer and reconnected to a new service pipe dedicated to the tannery district. The service pipe would be terminated at a low lift pumping station located near the UASB plant.
- Manhole covers on the 90” trunk sewer, in the tannery district, should be redesigned so that they can only be opened by authorized maintenance personnel.
- Overflow pipes from the UASB plant should be disconnected from the 90” trunk sewer and redirected to the drain east of the site, discharging to Ganga river.
- According to the monitoring study carried out by IIT Kanpur, the quantity of tannery industrial wastewater is estimated to be 13 mld. Therefore, existing 36 mld UASB reactor needs additional 16 mld capacity in order to treat tannery industrial wastewater at the mixing ratio 1:3 (tannery 13mld : domestic 39mld).

A schematic of the tannery collection system and proposed solutions is presented in Drawing B2.

### 7.4.5 Domestic Wastewater Collection System

The city district has an existing network of sewers. The carrying capacity of this network is evaluated in Table 7.1. The carrying capacity of the existing sewers is computed in accordance with Manning’s formula with value of ‘n’ = 0.015 for concrete pipes and 0.017 for brick sewers. Sewage quantities are peak flows that the collection system has to sustain.

From the hydraulic analysis it is evident that most existing trunk sewers will not have sufficient carrying capacity even after flows have been diverted to the South District. Table 7.2 identifies a total of 30.8 km of sewer pipe that will need to be replaced before 2015. Considering the congested situation of streets in the area the new sewers will probably have to be laid along the same alignment as old sewers. Maps and data on existing sewer alignments is either unavailable or extremely unreliable. It will therefore be necessary to confirm the location and condition of existing sewers, as well as the feasibility of replacement by carrying out detailed site surveys in subsequent studies.

Tentative alignment and sizing of proposed sewers is presented in Drawing B4.

### 7.4.6 Muir Mill Pumping Station

A pumping station was implemented under the Ganga Action Plan (GAP-I) to intercept wastewater from Muir mill nala.

Pumping station data is presented in Table 7.4. And evaluations of pumping station capacities is presented in Table 7.5.

Wastewater is pumped through a 735 m long rising main with diameter of 400 mm. A total of 3 x 2,800 lpm pumps are installed. The allowable discharge with 50% reserve is 93 lps. The flow measured by the study team in 2003 was 3.13 mld (4.54 mld was reported by UPJN in 1997). Assuming the higher of the two values the peak flow is 105 lps which slightly exceeds the allowable discharge capacity.

Assuming that sewerage will be improved, the peak sullage flows are expected to decrease, however it is difficult to predict when or how much less the flows will be. If sewerage schemes are not implemented the flow could even increase, therefore a program of on-going flow monitoring is essential.

The 168 $m^3$ sump provides ample storage capacity. Excessively long holding time can result in septic wastewater and should be avoided by operating the pumps at least 4 to 5 starts per hour.

### 7.4.7 Guptar Ghat Pumping Station

A pumping station was implemented under the Ganga Action Plan (GAP-I) to intercept wastewater from Guptar ghat nala.

Pumping station data is presented in Table 7.4 and an evaluation of pumping station capacities are presented in Table 7.5.

Wastewater is pumped through a 300 m long rising main with diameter of 150 mm. A total of 3 x 1,000 lpm pumps are installed. The allowable discharge with 50% reserve is 33 lps. The flow measured by the study team in 2003 was 2.29 mld while a flow of 13.74 mld was reported by UPJN in 1997. Assuming the higher of the two values, the peak flow is 318 lps which greatly exceeds the allowable discharge capacity and the total installed capacity of the pumping station. If the lower value is adopted the pumping station would have enough capacity. The flow in the nala should be confirmed before determining the capacity that will be required. Several measurements should be taken for two or three days over a period of months.

Assuming that sewerage will be improved, the peak sullage flows are expected to decrease, however it is difficult to predict when or how much less the flows will be. If sewerage schemes are not implemented the flow could even increase, therefore a program of on-going flow monitoring is essential.

The 118m$^3$ sump provides sufficient capacity at peak flow even when using the higher of the two flow measurements. Therefore expansion, if required, would be limited to providing additional pumping capacity.

### 7.4.8 Bhagwatdas Ghat Nala Pumping Station

Bhagwatdas ghat nala is located near Guptar ghat nala and has not been tapped yet. Although the flow measured by UPJN is not available, projected flows based on populations in future service area are as follows:

- 2015 Average: 8 mld Peak: 185 lps
- 2030 Average: 8 mld Peak: 185 lps

### 7.4.9 Parmat Pumping Station

A pumping station was implemented under the Ganga Action Plan (GAP-I) to intercept wastewater from the following nalas: Tafco nala, Parmat ghat nala, Police lines nala, and Jail nala. The pumping station also collects wastewater from local sewers. Under the Ganga Action Plan (GAP-II), Sisamau nala, the largest nala in Kanpur city (measured flow 138 mld) will be diverted to treatment. Out of 138 mld, 80-100 mld will be tapped upstream and diverted to Bingawan STP. The remaining 30-50 mld will be tapped down stream at Parmat pumping station and diverted to Jajmau STP.

Pumping station data is presented in Table 7.4 and an evaluation of pumping station capacities is presented in Table 7.5.

The wastewater flow estimated on the basis of population in the contributing catchment area is as follows:

- 2015 Average: 17 mld Peak: 394 lps
- 2030 Average: 20 mld Peak: 463 lps

However the design flow should be based on amount of tapping Sisamau nala. According to Table 7.4, capacity of existing pumping facility is estimated 54 mld (average), which is enough for 30-50 mld tapping. Therefore, the design wastewater flow for Parmat SPS is selected as follows;

- 2015 Average: 54 mld Peak: 1,250 lps
- 2030 Average: 54 mld Peak: 1,250 lps

There is no data regarding the amount of wastewater being conveyed to the pumping station by the sewer system and there is no flow meter on the rising main. Therefore it is impossible to assess capacity against existing conditions. The 310 m$^3$ sump provides ample storage capacity. Excessively long holding time can result in septic wastewater and should be avoided by operating the pumps at least 4 to 5 starts per hour. Alternatively, the wet well can be divided into two compartments to reduce holding time.

### 7.4.10 Nawab Ganj Pumping Station

A pumping station was implemented under the Ganga Action Plan (GAP-I) to intercept wastewater from the following nalas: Kesa colony nala, Roadways colony nala, Jageswar nala, Jewra nala, Nawabganj nala, and Rani ghat nala. The pumping station also collects wastewater from local sewers. There is no data regarding the amount of wastewater being conveyed to the pumping station by the sewer system and there is no flow meter on the rising main therefore it is impossible to assess capacity against existing conditions.

The flow measured in the contributing nalas by the study team in 2003 was 4.2 mld while a flow of 12.9 mld was reported by UPJN in 1997. The wastewater flow estimated on the basis of populations in the contributing catchment area is as follows:

- 2015 Average: 6 mld Peak: 139 lps
- 2030 Average: 8 mld Peak: 185 lps

Pumping station data is presented in Table 7.4 and an evaluation of pumping station capacities is presented in Tables 7.5.

The allowable discharge with a 50% reserve is 234 lps. Assuming that sewerage will be improved, the pumping station should have sufficient capacity for the future peak flows. If sewerage schemes are not implemented the flow in nalas can be expected to increase, therefore a program of on-going flow monitoring is essential.

The 288 $m^3$ sump provides ample storage capacity. Excessively long holding time can result in septic wastewater and should be avoided by operating the pumps at least 4 to 5 starts per hour.

## 7.5 SEWERAGE DISTRICT II: BINGAWAN STP

### 7.5.1 General Description

This sewerage district is bounded by the City district to the North, Kanpur Jhansi railway line to the West and Pandu river to the South. The Eastern boundary has been arbitrarily drawn to the east of Hamirpur road to include those areas that are already more heavily populated.

Some areas of this district just south of the canal and along Hamirpur road are already developed. Several housing schemes sponsored by the Kanpur Development Authority also lie in this district. However, quite a large area of this district is yet undeveloped. Total population for the year 2030 is 1.17 million.

At present UPJN is implementing a scheme to divert sewage from the City district to a proposed 200 mld UASB treatment plant. The catchment area that will be diverted from the City district is depicted in drawing B5. Diversion is required to relieve flows in the 90” outfall to Jajmau. The scheme, which is at present under construction includes relieving sewers in the City district, pumping stations at Munshi purwa and Rakhi mandi, a 2.2 m diameter outfall sewer to Bingawan and a gravity sewer for tapping Ganda nala and Halawakanda nala. The scheme also includes intercepting COD nala.

Projected flows based on populations in future service area are as follows:

| Contributing catchment | 2015 | | 2030 | |
|---|---|---|---|---|
| | Population | Flow (mld) | Population | Flow (mld) |
| Diverted from District I | 1,072,781 | 156 | 1,172,659 | 182 |
| District II | 934,330 | 135 | 1,172,711 | 182 |
| Total | 2,007,111 | 291 | 2,345,370 | 364 |

The projected wastewater flows clearly exceed the scope of the sanctioned treatment plant project. Additional collection and treatment capacity will be required before 2015.

### 7.5.2 Sewers

Details of the diversion scheme are presented in Drawing B6. The size of sanctioned trunk sewers presently under construction is taken from DPR documents provided by UPJN.

The carrying capacity of existing and proposed trunk sewers have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to used concrete pipes with allowance for build up of sediment. Sewage quantities in Table 7.3 are peak flows that the collection system has to sustain for the year 2015 and 2030. The hydraulic analysis indicates that the 2.2 m dia outfall sewer has a carrying capacity of approximately 300 mld at 80% full depth. This should be sufficient up to the year 2015. Additional outfall sewers will be required after 2015.

Tentative alignment and size of the future sewer network are shown in Drawing B7. Some of the sewer alignments shown in this area are along roads that do not yet exist or roads that have been proposed in the City Master Plan. Therefore the sewerage scheme will need to be revised when the detailed project is taken up.

### 7.5.3 Rakhi Mandi Pumping Station

This pumping station is at present being constructed under the Indo-Dutch project to divert sewage flows from existing sewers in the City district. The pumping station has been designed for the following flows:

- 2007 Average: 96 mld Peak: 2,109 lps
- 2020 Average: 99 mld Peak: 2,197 lps

Revised wastewater flows estimated on the basis of population in the contributing catchment area is as follows:

- 2015 Average: 86 mld Peak: 1,990 lps
- 2030 Average: 99 mld Peak: 2,292 lps

The allowable discharge with a 50% reserve is 2,667 lps and is sufficient for the ultimate projected sewage load. Pumping station data is presented in Table 7.4 and an evaluation of pumping station capacities is presented in Table 7.5.

The 568 $m^3$ sump provides only 4.1 minutes of storage at peak flow, which is slightly less than the standard requirement of 5 minutes.

### 7.5.4 Munshi Purwa Pumping Station

This pumping station is at present being constructed under the Indo-Dutch project to divert sewage flows from existing sewers in the City district. The pumping station has been designed for the following flows:

- 2007 Average: 76 mld Peak: 1,980 lps
- 2020 Average: 82 mld Peak: 2,138 lps

The revised wastewater flow estimated on the basis of population in the contributing catchment area is as follows:

- 2015 Average: 70 mld Peak: 1,620 lps
- 2030 Average: 82 mld Peak: 1,898 lps

The installed capacity is 2,400 lps but the allowable discharge with a 50% reserve is only 1,600 lps and is sufficient for projected sewage load up to the year 2015. Additional pumps would be required to meet the ultimate projected sewage load. Pumping station data is presented in Table 7.4 and an evaluation of pumping station capacities is presented in Tables 7.5. The 606 $m^3$ sump provides 5.3 minutes of storage at peak flow, which is adequate.

### 7.5.5 Ganda Nala Pumping Station

This pumping station is sanctioned and is designed to tap wastewater from Ganda nala (design flow 22.72 mld). The wastewater flow estimated on the basis of population in the contributing catchment area is as follows:

- 2015 Average: 19 mld Peak: 439 lps
- 2030 Average: 24 mld Peak: 556 lps

The installed capacity is 725 lps and the allowable discharge with a 50% reserve is 483 lps and is sufficient for projected sewage load up to the year 2015. Additional pumps would be required to meet the ultimate projected sewage load. Pumping station data is presented in Table 7.4 and an evaluation of pumping station capacities is presented in Tables 7.5. The 130.4 $m^3$ sump provides 3.9 minutes of storage at peak flow.

### 7.5.6 Bingawan STP

A 200 mld UASB treatment plant with 1 day final polishing pond discharging to Pandu River has been identified under the Indo-Dutch project. The STP and land acquisition for 56 ha is in the process of being sanctioned. The site plan presented in Drawing B3 indicates provision for future expansion by adding additional UASB modules and polishing ponds. The site could potentially accommodate up to 365 mld if additional post treatment units are not added.

Although total wastewater generation in District II including diverted flow from the City District would amount to 291 mld in year 2015, incoming wastewater to the treatment plant will be estimated under the sanctioned capacity 200 mld because of slow implementation of wastewater collection system in newly developed colonies. So the treatment plant may be expanded in Stage II (after year 2015). Furthermore, the process should be modified with appropriate post aeration to improve effluent quality. Additional study is needed to identify land requirements and feasibility of expansion.

## 7.6 SEWERAGE DISTRICT III: PANKA STP

### 7.6.1 General Description

The district is bounded by the Pandu river to the South, development master plan boundaries to the West and North and the Kanpur-Jhansi railway line to the East. City and South sewerage districts are its adjoining neighbours on the eastern flank. Important localities included in this district include:

- To the South of GT road, the Fertilizer Factory, Armapur Estate, Panki Power Generating Station, Indian Institute of Technology are located in this district
- To the North of GT Road, Lakhanpur area, Kanpur University, HBTI

To the North of GT Road the Lakhanpur area has some sewerage system. A temporary outfall has been provided to the North along Kalyanpur road to Naubasta village. As proposed under the previous master plan, sewage from this area should ultimately be diverted south to the Panka outfall and STP.

Projected flows based on population in future service area are as follows:

- Year: 2015 Population: 801,640 Sewage load: 116 mld
- Year: 2030 Population: 1,283,484 Sewage load: 199 mld

### 7.6.2 Sewers

Tentative alignment and size of the future sewer network is shown in Drawing B8. Some of the sewer alignments shown in this area are along roads that do not yet exist or roads that have been proposed in the City Master Plan. Therefore, the sewerage scheme will need to be revised when the detailed project is taken up. Carrying capacity of the new trunk sewers have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to old concrete pipe. Sewage quantities in Table 7.3 are peak flows that the collection system has to sustain.

Two outfall sewers will convey sewage from below the Pandu river to a main pumping station located at the treatment plant. The outfall sewers will have an invert level of about 8 m at the STP and it should be possible to cross the Pandu river depending on the scour depth of the river during flood season. Locating the pumping station at the treatment plant will improve operational reliability, facilitate maintenance by treatment staff, and reduce the cost of providing transmission lines for electrical services. Further detailed investigation is required in subsequent studies. If crossing under the river is not feasible then the scheme can easily be modified by locating the pumping station and screening facilities on the north side of the river, conveying flows under pressure directly to the STP.

### 7.6.3 Panki Pumping Station

Panki Pumping Station will be on the north side of the Kanpur Branch of the Ganga Canal. A rising main will carry sewage under the canal to a gravity sewer starting immediately on the south side of the Canal. Details of the required capacities of pumps, rising mains and sumps are presented in Table 7.12.

The pumping station will cater to the following design flows from the northern part of the West district:

- 2015 Average: 80 mld Peak: 1,852 lps
- 2030 Average: 126 mld Peak: 2,916 lps

The new pumping station would have the following characteristics:

| | 2015 | 2030 |
|---|---|---|
| Pumps | : 6 x 260 lps | : 8 x 370 lps |
| Rising main | : 1 x 1600 mm dia. | : 1 x 1600 mm dia. |
| Sump | : 888 $m^3$ - (10 minutes at peak flow) | : 888 $m^3$ - (5 minutes at peak flow) |

Both rising mains should be installed under the canal during Stage I to minimize disruption in the future. Pipes will be installed by jacking method therefore dual rising mains are recommended to reduce the overall diameter to simplify construction. Dual rising mains will also provide more operating flexibility in the event of repairs or maintenance.

### 7.6.4 Lakhanpur Pumping Station

This pumping station was commissioned in 1982, however, is not working now. Therefore the pumping station needs to be rehabilitated. The pumping station should collect flow from a colony developed on the north side of the GT road. At present, wastewater from this colony discharges via natural drains to the Ganga river. The Master Plan proposes to rehabilitate this station. Sewage will be pumped to a new trunk sewer and conveyed to proposed Panka STP .

Pumping station data is presented in Table 7.4. and an evaluation of pumping station capacities is presented in Table 7.5.

Projected flows based on population in future service area are as follows:

- 2015 Average: 16 mld Peak: 370 lps
- 2030 Average: 27 mld Peak: 625 lps

### 7.6.5 Panka STP

The ultimate capacity of the treatment plant proposed for the year 2030 is 200 mld. A detailed comparison of various treatment process options is presented in Appendix A and summarized in Table 7.13.

**Table 7.13 Panka STP: Preliminary Cost Comparison of Process Alternatives**

| Cost (Rs. million) | WSP | AL | AL+ | AS | AS+ | FAB | UASB ++ |
|---|---|---|---|---|---|---|---|
| 200 mld | | | | | | | |
| Land area for treatment process (ha) | 250 | 70 | 150 | 40 | 120 | 12 | 70 |
| Land cost | 1,000 | 280 | 600 | 160 | 480 | 48 | 280 |
| Capital cost | 320 | 500 | 640 | 540 | 680 | 920 | 600 |
| Annual O&M | 12 | 60 | 64 | 72 | 76 | 118 | 26 |
| Total present value (including land cost) | 1,508 | 1,750 | 2,272 | 1,911 | 2,432 | 3,047 | 1,366 |

The comparison indicates that Waste Stabilization Ponds offer the lowest O&M cost. However the land requirement is excessive. The next most attractive option would be UASB plus post treatment with aerated lagoons because it is simple to operate and maintain, and has a low running cost compared to other options. The addition of maturation ponds to reduce faecal coliform counts would significantly increase the land requirement therefore it is proposed to use disinfection with chlorine.

A potential site has been identified near Panka Bahadur Nagar village and UPJN has confirmed that land could be acquired. Final site location and the potential for effluent re-use should be investigated in more detail at the feasibility study stage.

## 7.7 SEWERAGE DISTRICT IV: KARANKHERA STP

### 7.7.1 General Description

This district is bounded by the Delhi Calcutta railway line to the North, Pandu river to the South, and the City Master Plan boundary in the East. It is sparsely populated and has no sewerage system at present.

The district also includes a small pocket north of the railway line to the east of the Jajmau STP which has been designated as a non-sewered area since population densities will remain below 120 persons per hectare over the planning horizon.

Projected flows based on populations in future service area are as follows:

| Areas | 2015 | | 2030 | |
|---|---|---|---|---|
| | Population | Sewage load (mld) | Population | Sewage load (mld) |
| Sewer service area | 201,106 | 29 | 428,512 | 66 |
| Non sewer area | 68,120 | 11 | 116,694 | 18 |
| Total | 269,226 | 40 | 545,206 | 84 |

### 7.7.2 Sewers

Tentative alignment and size of the future sewer network is shown in Drawing B9. Most of the sewer alignments shown in this area are along roads that do not yet exist or roads that have been proposed in the City Master Plan and have yet to be built. Therefore the sewerage scheme will need to be revised when the detailed project is taken up. Carrying capacity of the new trunk sewers have been computed in accordance with Manning's formula with value of 'n' = 0.015 corresponding to old concrete pipes. Sewage quantities in Table 7.3 are peak flows that the collection system has to sustain.

The main trunk sewer will convey sewage to a pumping station located at Ruman village just on the north side of the railway line. The pumping station will convey sewage directly to the head of the treatment plant.

### 7.7.3 Ruman Pumping Station

Ruman pumping station will be on the north side of the Delhi Kolkatta railway line. A rising main will carry sewage from Ruman SPS directly to the sewage treatment plant at Karankhera. The pumping station will be implemented some time after 2015 along with the treatment plant and trunk sewers for the East District. Details of the required capacities of pumps, rising mains and sumps are presented in Tables 7.14.

The pumping station will cater to the following design flows from the East district:

- 2030 Average: 66 mld Peak: 1,600 lps

The new pumping station would have the following characteristics:

| | |
|---|---|
| Pumps | : 6 x 260 lps |
| Rising main | : 1 x 1200 mm dia. |
| Sump | : 468 $m^3$ (5 minutes at peak flow) |

### 7.7.4 Karankhera STP

The ultimate capacity of the treatment plant proposed for the year 2030 is 84 mld. The cost comparison of treatment options indicates that UASB++ is the most cost effective process. UPJN has reported that a suitable site is available near Karankhera Village. The effluent can be discharged directly to Ganga river or can be used for irrigation. There may also be enough land available for maturation ponds to reduce faecal coliform counts instead of using chlorine. Final site location and the potential for effluent re-use, including polishing using wetlands, should be investigated in more detail at the feasibility study stage.

## 7.8 SUMMARY

The Master Plan in this study is summarized in Table 7.15.

# Table 7.15 Summary of Master Plan

| DISTRICT | | Population 2003 | Population 2015 | Population 2030 | Wastewater Generation (mld) 2003 | Wastewater Generation (mld) 2015 | Wastewater Generation (mld) 2030 |
|---|---|---|---|---|---|---|---|
| DISTRICT- Ⅰ | Central | 694,517 | 802,336 | 869,853 | 97 | 116 | 135 |
| DISTRICT- Ⅰ | Tannety | 77,885 | 122,910 | 152,075 | 11 | 18 | 24 |
| DISTRICT- Ⅰ | East | 232,464 | 338,808 | 433,093 | 33 | 49 | 67 |
| DISTRICT-Ⅱ | Central | 843,469 | 1,072,781 | 1,172,659 | 118 | 156 | 182 |
| DISTRICT-Ⅱ | South | 547,771 | 934,330 | 1,172,711 | 77 | 135 | 182 |
| DISTRICT-Ⅲ | | 335,790 | 801,640 | 1,283,484 | 47 | 116 | 199 |
| DISTRICT-Ⅳ | SA | 56,345 | 201,106 | 428,512 | 8 | 30 | 66 |
| | NSA | 31,586 | 68,120 | 116,694 | 4 | 10 | 18 |
| Total | | 2,819,827 | 4,342,031 | 5,629,081 | 395 | 630 | 873 |
| Tannery industrial wastewater | | | | | 13 | 13 | 13 |
| Total | | | | | 408 | 643 | 886 |

| No. | Pumping Station | Status | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Guptar | Existing | 4 | 4 | |
| 2 | Bhagwatdas nala | Proposed | 8 | 8 | |
| 3 | Muirmill | Existing | 4 | 5 | |
| 4 | Parmat | Existing | 54 | 54 | |
| 5 | Nawabganj | Existing | 6 | 8 | |
| 6 | Jajmau | Existing | 165 | 202 | |
| | Jajmau | Existing | 18 | 24 | For tannery area domestic |
| 7 | Rahkimandi | Sanctioned | 86 | 99 | |
| 8 | Munshipurwa | Sanctioned | 70 | 82 | |
| 9 | Ganda nala | Sanctioned | 19 | 24 | |
| 10 | Lakhanpur | Existing | 16 | 27 | |
| 11 | Panki | Proposed | 80 | 126 | |
| 12 | Ruman | Proposed | 29 | 66 | |

| No. | Treatment Plant inflow | | Inflow (mld) 2015 | Inflow (mld) 2030 | Remark |
|---|---|---|---|---|---|
| 1 | Jajmau | Domestic | 183 | 226 | |
| | | Tannery | 13 | 13 | Previous M/P 9mld |
| | | Total | 196 | 239 | |
| 2 | Karankhera | | 39 | 84 | |
| 3 | Bingawan | | 175 | 364 | District II (central)+ Ganda Nala in 2015 |
| 4 | Panka | | 116 | 199 | |

| No. | Treatment Plant capacity | | Status | Capacity (mld) 2015 | Capacity (mld) 2030 | Remark |
|---|---|---|---|---|---|---|
| 1 | Jajmau | UASB1 | Existing | 5 | 5 | For domestic |
| | | UASB2 | Existing | 36 | 36 | For tannery |
| | | ASP1 | Existing | 130 | 130 | For domestic |
| | | | Sub Total | 171 | 171 | |
| | | UASB1 | Augument | - | - | |
| | | UASB2 | Augument | 16 | 16 | For tannery 4 + domestic 12 |
| | | ASP1 | Augument | 43 | 43 | 130 mld x 1/3 |
| | | ASP2 | Augument | | 10 | |
| | | | Sub Total | 59 | 69 | |
| | | | Total | 230 | 240 | |
| 2 | Karankhera | | Proposed | 40 | 85 | |
| 3 | Bingawan | | Proposed | 295 | 365 | |
| 4 | Bhaunti | | Proposed | 120 | 200 | |
| | Total | | | 685 | 890 | |

**Table 7.1 Existing Trunk Sewer: Hydraulic Capacity Analysis (DISTRICT I) (1/2)**

| Node | | Contributory Population | | Design Flow (lps) | Shape | Size (inch) | Size (mm) | Length (m) | Gradient | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Design Flow(l/s) / Design capacity(l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | | | PreviousM/P | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| Parbati Bagla Rd Low Level Sewer | | | | | | | | | | | | | | | | | | | | | | |
| I3-1 | I3 | 5,295 | 5,295 | 27 | Circle | 12 | 305 | 1,150 | 303 | 300 | 122.060 | 118.260 | 126.500 | 125.220 | 4.14 | 6.65 | 0.690 | 50 | 0.80 | 0.787 | 48 | 1.78 |
| | | | | | | | | | | | | | | | | | | | | | | |
| I3 | H2-2 | 22,300 | 22,300 | 100 | Circle | 36 | 914 | 900 | 300 | 300 | 118.260 | 115.260 | 125.230 | 126.000 | 6.06 | 9.83 | 1.440 | 945 | 0.80 | 1.642 | 915 | 9.15 |
| H2-2 | H2-1 | 16,088 | 38,388 | 173 | Circle | 36 | 914 | 500 | 1,263 | 480 | 115.130 | 114.734 | 126.600 | 118.855 | 10.56 | 3.21 | 0.702 | 461 | 0.80 | 0.800 | 446 | 2.58 |
| H2-1 | H2 | 16,088 | 54,476 | 221 | Circle | 36 | 914 | 750 | 550 | 550 | 114.614 | 113.250 | 118.855 | 116.000 | 3.33 | 1.84 | 1.064 | 698 | 0.80 | 1.213 | 676 | 3.06 |
| H2 | H1 | 36,712 | 91,188 | 369 | Circle | 36 | 914 | 1,200 | 1,395 | 1,000 | 112.250 | 111.390 | 116.000 | 116.500 | 2.84 | 4.20 | 0.668 | 438 | 0.80 | 0.762 | 424 | 1.15 |
| | | 0 | 0 | 0 | Circle | 24 | 610 | 1,200 | 851 | 1,000 | 112.250 | 110.840 | 116.000 | 116.500 | 3.14 | 5.05 | 0.653 | 191 | 0.80 | 0.744 | 185 | - |
| | | | 250,000 | 1,008 | Circle | | 1,400 | 1,200 | 1,395 | | 112.250 | 111.390 | 116.000 | 116.500 | 2.35 | 3.71 | 0.887 | 1,365 | 0.80 | 1.011 | 1,321 | 1.31 (Proposed) |
| | Go to H | through Rising Main | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| H1(a) | H1 | 31,315 | 31,315 | 140 | Circle | 24 | 610 | 1,200 | 759 | 1,000 | 110.840 | 109.260 | 118.000 | 116.500 | 6.55 | 6.63 | 0.691 | 202 | 0.80 | 0.788 | 196 | 1.40 |
| | Go to H | through Rising Main | | | | | | | | | | | | | | | | | | | | |
| | | | | | | | 1,650 | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | |
| C1 | D | 20,112 | 20,112 | 90 | Rectangle | 20x 30 | | 845 | 1,018 | 1,000 | 117.380 | 116.550 | 126.820 | 124.200 | | | | | | 0.586 | 181 | 2.01 |
| | | | | | | | | | | | | | | | | | | | | | | |
| E | D | 97,490 | 137,490 | 556 | Rectangle | 28x 42 | | 1,600 | 1,032 | 1,000 | 118.580 | 117.030 | 122.860 | 124.100 | | | | | | 0.729 | 442 | **0.79** |
| | | | | | | | | | | | | | | | | | | | | | | |
| D | C | 44,902 | 202,504 | 817 | Rectangle | 32x 48 | | 720 | 1,200 | 1,200 | 117.030 | 116.430 | 124.100 | 124.200 | | | | | | 0.739 | 586 | **0.72** |
| C | C'-B(b) | 64,148 | 266,652 | 1,076 | Rectangle | 36x 54 | | 1,200 | 1,500 | 1,500 | 116.200 | 115.400 | 124.200 | 124.340 | | | | | | 0.715 | 717 | **0.67** |
| | | | | | | | | | | | | | | | | | | | | | | |
| Trunk Sewer No.1 | | | | | | | | | | | | | | | | | | | | | | |
| Nawabganj SPS | | | | | | | | | | | | | | | | | | | | | | |
| I4 | I3 | 52,314 | 52,314 | 212 | Circle | 24 | 610 | 1,150 | 852 | 850 | 121.920 | 120.570 | 126.570 | 125.220 | 4.04 | 4.04 | 0.653 | 191 | 0.80 | 0.744 | 185 | **0.87** |
| | | | | | | | | | | | | | | | | | | | | | | |
| I3(a) | I3 | 86,726 | 86,726 | 351 | Circle | 18 | 457 | 1,036 | 500 | 500 | 122.790 | 120.720 | 125.500 | 125.220 | 2.25 | 4.04 | 0.703 | 115 | 0.80 | 0.801 | 111 | **0.32** |
| | | | | | | | | | | | | | | | | | | | | | | |
| I3 | I2 | 26,441 | 170,776 | 689 | Circle | 24 | 610 | 400 | 851 | 850 | 120.570 | 120.100 | 125.220 | 124.750 | 4.04 | 4.04 | 0.653 | 191 | 0.80 | 0.744 | 185 | **0.27** |
| I2 | I1 | 71,491 | 242,267 | 979 | Circle | 30 | 762 | 880 | 1,000 | 1,000 | 119.950 | 119.070 | 124.750 | 124.500 | 4.04 | 4.67 | 0.699 | 319 | 0.80 | 0.797 | 309 | **0.32** |
| I1 | I | 19,753 | 262,020 | 1,058 | Circle | 48 | 1,219 | 600 | 1,714 | 1,700 | 118.620 | 118.270 | 124.000 | 123.000 | 4.16 | 3.51 | 0.730 | 852 | 0.80 | 0.832 | 825 | **0.78** |
| I | H | 40,377 | 302,397 | 1,220 | Circle | 48 | 1,219 | 800 | 1,111 | 1,700 | 118.270 | 117.550 | 123.000 | 124.710 | 3.51 | 5.94 | 0.906 | 1,057 | 0.80 | 1.033 | 1,023 | **0.84** |

**Table 7.1 Existing Trunk Sewer: Hydraulic Capacity Analysis (DISTRICT I) (2/2)**

| Node | | Contributory Population | | Design Flow (lps) | Shape | Size (inch) | Size (mm) | Length (m) | Gradient | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Design Flow(l/s) / Design capacity(l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | | | PreviousM /P | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| Parmat SPS | | | | | | | | | | | | | | | | | | | | | | |
| Rising Main(To H) | | | | 0 | Circle | | 600 | 1,000 | | | 113.820 | 122.030 | 116.500 | 124.710 | 2.00 | 2.00 | 0.00 | 0 | | | | - |
| Rising Main(To B') | | | 122,503 | 440 | Circle | | 700 | 1,000 | | | 113.720 | 121.930 | 116.500 | 124.710 | 2.00 | 2.00 | 1.14 | 440 | | | | Proposed |
| H | G | 11,899 | 218,400 | 882 | Circle | 60 | 1,524 | 1,274 | 2,404 | 2,400 | 116.950 | 116.420 | 124.710 | 120.820 | 6.24 | 2.88 | 0.715 | 1,304 | 0.80 | 0.815 | 1,262 | 1.43 |
| | | | 218,400 | 882 | Circle | | 1,600 | 1,274 | 2,404 | 2,400 | 116.950 | 116.420 | 124.710 | 120.820 | 6.16 | 2.80 | 0.739 | 1,486 | 0.80 | 0.842 | 1,438 | 1.63 (Proposed) |
| G | B' | 81,695 | 259,247 | 1,046 | Circle | 60 | 1,524 | 1,200 | 2,927 | 2,900 | 116.120 | 115.710 | 120.820 | 124.390 | 3.18 | 7.16 | 0.648 | 1,182 | 0.80 | 0.739 | 1,144 | 1.09 |
| | | | 259,247 | 1,046 | Circle | | 1,600 | 1,200 | 2,927 | 2,900 | 116.120 | 115.710 | 120.820 | 124.390 | 3.10 | 7.08 | 0.669 | 1,345 | 0.80 | 0.763 | 1,302 | 1.24 (Proposed) |
| B' | B-A | 12,001 | 271,248 | 1,096 | Circle | 60 | 1,524 | 7,123 | 2,400 | 2,400 | 115.448 | 112.480 | 124.390 | 115.250 | 7.42 | 1.25 | 0.716 | 1,306 | 0.80 | 0.816 | 1,264 | 1.15 |
| B' | B'(b)-A' | 72,706 | 119,721 | 484 | Rectangle | 36x 54 | | 1,810 | 3,017 | 3,000 | 114.940 | 114.340 | 124.390 | 124.400 | | | | | | 0.504 | 506 | 1.05 |
| | | | 478,884 | 1,933 | Circle | 78 | 2,000 | 1,810 | 3,017 | 3,000 | 114.940 | 114.340 | 124.390 | 124.400 | 7.45 | 8.06 | 0.765 | 2,403 | 0.80 | 0.872 | 2,326 | 1.20 (Proposed) |
| A''' | A'' | 0 | 0 | 0 | Circle | 72 | 1,829 | 2,255 | 3,351 | 3,350 | 115.600 | 114.927 | 126.335 | 125.520 | 8.91 | 8.76 | 0.684 | 1,797 | 0.80 | 0.780 | 1,739 | - |
| A'' | A' | 163,097 | 163,097 | 659 | Circle | 78 | 1,981 | 1,905 | 3,521 | 3,350 | 114.912 | 114.371 | 125.520 | 124.400 | 8.63 | 8.05 | 0.704 | 2,170 | 0.80 | 0.803 | 2,101 | 3.19 |
| A' | A | 0 | 761,702 | 2,732 | Circle | 84 | 2,134 | 3,434 | 1,561 | 1,700 | 114.190 | 111.990 | 124.400 | 115.250 | 8.08 | 1.13 | 1.110 | 3,970 | 0.80 | 1.265 | 3,843 | 1.41 |
| A | K | 0 | 1,032,950 | 3,706 | Circle | 90 | 2,286 | 340 | 2,267 | 2,200 | 111.730 | 111.580 | 115.250 | 120.625 | 1.23 | 6.76 | 0.965 | 3,961 | 0.80 | 1.100 | 3,834 | 1.03 |
| K | PS (J) | 0 | 1,032,950 | 3,706 | Circle | 90 | 2,286 | 5,140 | 2,216 | 2,200 | 111.580 | 109.260 | 120.625 | 114.510 | 6.76 | 2.96 | 0.976 | 4,006 | 0.80 | 1.113 | 3,878 | 1.05 |

## Table 7.1 Existing Trunk Sewer: Hydraulic Capacity Analysis (DISTRICT II) (1/2)

| Node | | Contributory Population | | Design Flow (lps) | Shape | Size (inch) | Size (mm) | Length (m) | Gradient | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Design Flow(l/s) / Design capacity(l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | | | PreviousM/P | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| GT Rd Trunk Sewer No.2 | | | | | | | | | | | | | | | | | | | | | | |
| X12 | X11 | 24,077 | 24,077 | 108 | Circle | 24 | 610 | 535 | 849 | 850 | 123.200 | 122.570 | 126.360 | 126.650 | 2.55 | 3.47 | 0.654 | 191 | 0.80 | 0.746 | 185 | 1.71 |
| X11 | X10 | 84,177 | 108,254 | 437 | Circle | 30 | 762 | 1,040 | 1,000 | 1,000 | 122.470 | 121.430 | 126.650 | 127.300 | 3.42 | 5.11 | 0.699 | 319 | 0.80 | 0.797 | 309 | 0.71 |
| X10 | X9 | 17,382 | 125,636 | 506 | Circle | 30 | 762 | 1,040 | 1,000 | 1,000 | 121.430 | 120.390 | 127.300 | 125.200 | 5.11 | 4.05 | 0.699 | 319 | 0.80 | 0.797 | 309 | 0.61 |
| X9 | X8 | 30,871 | 156,507 | 632 | Circle | 30 | 762 | 400 | 1,000 | 1,000 | 120.390 | 119.990 | 125.200 | 125.000 | 4.05 | 4.25 | 0.699 | 319 | 0.80 | 0.797 | 309 | 0.49 |
| X8 | X7 | 15,645 | 172,152 | 695 | Circle | 36 | 914 | 95 | 1,357 | 1,400 | 119.840 | 119.770 | 125.000 | 124.740 | 4.25 | 4.06 | 0.677 | 444 | 0.80 | 0.772 | 430 | 0.62 |
| X7 | X6 | 139,649 | 311,801 | 1,258 | Circle | 42 | 1,067 | 2,060 | 1,807 | 1,800 | 119.620 | 118.480 | 124.740 | 127.435 | 4.05 | 7.89 | 0.650 | 581 | 0.80 | 0.741 | 562 | 0.45 |
| X6 | X4 | 39,770 | 351,571 | 1,420 | Circle | 54 | 1,372 | 1,650 | 2,463 | 2,500 | 117.760 | 117.090 | 127.435 | 126.610 | 8.30 | 8.15 | 0.659 | 974 | 0.80 | 0.751 | 943 | 0.66 |
| From X4 | | | | | | | | | | | | | | | | | | | | | | |
| to | South | | 351,571 | | | | | | | | | | | | | | | | | | | |
| to | X3 | | 0 | | | | | | | | | | | | | | | | | | | |
| Diverted to south | | | | | | | | | | | | | | | | | | | | | | |
| from | X4 | | 351,571 | | | | | | | | | | | | | | | | | | | |
| from | X5-2 | 289,276 | | | | | | | | | | | | | | | | | | | | |
| Total | | | 640,847 | 2,588 | | | | | | | | | | | | | | | | | | |
| X4 | X3 | 9,425 | 9,425 | 51 | Circle | 66 | 1,676 | 360 | 3,000 | 2,900 | 116.770 | 116.650 | 126.610 | 121.065 | 8.16 | 2.74 | 0.682 | 1,505 | 0.80 | 0.777 | 1,457 | 28.57 |
| Y3 | Y2 | 44,401 | 44,401 | 200 | Circle | 33 | 838 | 1,120 | 1,493 | 1,500 | 120.450 | 119.700 | 125.580 | 125.585 | 4.29 | 5.05 | 0.609 | 336 | 0.80 | 0.694 | 325 | 1.63 |
| Y2→Y1 | X3 | 0 | 44,401 | 200 | Circle | 33 | 838 | 2,900 | 1,503 | 1,500 | 119.680 | 117.750 | 125.850 | 121.065 | 5.33 | 2.48 | 0.607 | 335 | 0.80 | 0.692 | 324 | 1.62 |
| X3 | X2 | 13,887 | 67,713 | 272 | Circle | 66 | 1,676 | 1,015 | 2,900 | 2,900 | 116.500 | 116.150 | 121.065 | 120.235 | 2.89 | 2.41 | 0.694 | 1,531 | 0.80 | 0.791 | 1,482 | 5.45 |

**Table 7.1 Existing Trunk Sewer: Hydraulic Capacity Analysis (DISTRICT II) (2/2)**

| Node | | Contributory Population | | Design Flow (lps) | Shape | Size (inch) | Size (mm) | Length (m) | Gradient | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Design Flow(l/s) / Design capacity(l/s) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | | | PreviousM /P | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| Z2 | Z2' | 26,381 | 26,381 | 118 | Circle | 24 | 610 | 1,850 | 849 | 850 | 120.850 | 118.670 | 124.500 | 126.210 | 3.04 | 6.93 | 0.654 | 191 | 0.80 | 0.746 | 185 | 1.57 |
| Z1.1 | Z | 18,285 | 18,285 | 99 | Circle | 24 | 610 | 990 | 1,904 | 550 | 119.490 | 118.970 | 124.130 | 125.160 | 4.03 | 5.58 | 0.437 | 128 | 0.80 | 0.498 | 124 | 1.25 |
| Z | X1 | 12,546 | 257,863 | 1,042 | Circle | 36 | 914 | 450 | 1,406 | 1,400 | 116.870 | 116.550 | 125.160 | 125.980 | 7.38 | 8.52 | 0.665 | 436 | 0.80 | 0.758 | 422 | **0.40** |
| Z5 | Z4 | 12,123 | 12,123 | 66 | Circle | 24 | 610 | 1,120 | 473 | 850 | 121.460 | 119.090 | 125.500 | 123.940 | 3.43 | 4.24 | 0.876 | 256 | 0.80 | 0.999 | 248 | 3.76 |
| Z4 | Z3 | 28,237 | 40,360 | 180 | Circle | 30 | 762 | 430 | 1,000 | 1,000 | 118.750 | 118.320 | 123.940 | 124.190 | 4.43 | 5.11 | 0.699 | 319 | 0.80 | 0.797 | 309 | 1.72 |
| Z3.1 | Z3 | 32,999 | 32,999 | 148 | Circle | 24 | 610 | 900 | 849 | 850 | 119.790 | 118.730 | 125.770 | 124.990 | 5.37 | 5.65 | 0.654 | 191 | 0.80 | 0.746 | 185 | 1.25 |
| Z3 | X1 | 24,186 | 97,545 | 394 | Circle | 36 | 914 | 711 | 1,394 | 1,400 | 118.170 | 117.660 | 124.190 | 125.980 | 5.11 | 7.41 | 0.668 | 438 | 0.80 | 0.762 | 424 | 1.08 |
| X1 | X2 | 17,076 | 372,484 | 1,503 | Circle | 36 | 914 | 640 | 386 | ? | 117.660 | 116.000 | 125.980 | 120.235 | 7.41 | 3.32 | 1.270 | 833 | 0.80 | 1.448 | 806 | **0.54** |
| X2 | A''' | 24,186 | 464,382 | 1,874 | Circle | 72 | 1,829 | 1,340 | 2,978 | 3,000 | 116.000 | 115.550 | 120.235 | 126.335 | 2.41 | 8.96 | 0.725 | 1,905 | 0.80 | 0.827 | 1,844 | **0.98** |
| From Y2 | | | 67,430 | | | | | | | | | | | | | | | | | | | |
| From X2 | | | | | | | | | | | | | | | | | | | | | | |
| to | South | | 531,812 | 2,147 | | | | | | | | | | | | | | | | | | |
| to | A''' | | 0 | | | | | | | | | | | | | | | | | | | |
| South Total | | | 1,172,659 | 4,208 | | | | | | | | | | | | | | | | | | |
| to | Relief | | 750,659 | 2,694 | | | | | | | | | | | | | | | | | | |
| to | E11 | | 422,000 | 1,703 | | | | | | | | | | | | | | | | | | |

**Table 7-2(1/3) Trunk Sewer Replacement Schedule**

| | Node | | Existing | Existing pipe size | | Replacement | | Length | Target year | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pipe shape | | | Pipe diameter | | | 2010 | 2015 | 2030 |
| | From | To | | (inch) | (mm) | (mm) | (inch) | (m) | | | |
| DISTRICT I | E | D | Rectangle | 28 x42 | 711 x1,067 | 1,000 | 39 | 1,600 | | | ○ |
| | D | C | Rectangle | 32 x48 | 813 x1,219 | 1,200 | 47 | 720 | | | ○ |
| | C | C'-B(b) | Rectangle | 36 x54 | 914 x1,372 | 1,400 | 55 | 1,200 | | | ○ |
| | H2 | H1 | Circle | 24 | 610 | 1,400 | 55 | 1,200 | ○ | | |
| | I4 | I3 | Circle | 24 | 610 | 700 | 28 | 1,150 | | | ○ |
| | I3(a) | I3 | Circle | 18 | 457 | 800 | 31 | 1,036 | ○ | | |
| | I3 | I2 | Circle | 24 | 610 | 1,200 | 47 | 400 | ○ | | |
| | I2 | I1 | Circle | 30 | 762 | 1,200 | 47 | 880 | ○ | | |
| | I1 | I | Circle | 48 | 1,219 | 1,600 | 63 | 600 | | | ○ |
| | I | H | Circle | 48 | 1,219 | 1,400 | 55 | 800 | | | ○ |
| | Total | | | | | | | 9,586 | | | |
| | | | | | | | | | | | |
| DISTRICT II | X11 | X10 | Circle | 30 | 762 | 900 | 35 | 1,040 | | | ○ |
| | X10 | X9 | Circle | 30 | 762 | 1,000 | 39 | 1,040 | | | ○ |
| | X9 | X8 | Circle | 30 | 762 | 1,000 | 39 | 400 | | | ○ |
| | X8 | X7 | Circle | 36 | 914 | 1,600 | 63 | 95 | | | ○ |
| | X7 | X6 | Circle | 42 | 1,067 | 1,600 | 63 | 2,060 | | | ○ |
| | X6 | X4 | Circle | 54 | 1,372 | 1,600 | 63 | 1,650 | | | ○ |
| | Z | X1 | Circle | 36 | 914 | 1,400 | 55 | 450 | | ○ | |
| | X1 | X2 | Circle | 36 | 914 | 1,200 | 47 | 640 | | ○ | |
| | X2 | A''' | Circle | 72 | 1,829 | 2,200 | 87 | 1,340 | | | ○ |
| | Total | | | | | | | 8,715 | | | |

**Table 7-2(2/3) Relief Sewer Installation Schedule**

| | Node | | Existing | Existing pipe size | | Relief sewer | | Length | Target year | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Pipe shape | | | Pipe diameter | | | 2010 | 2015 | 2030 |
| | From | To | | (inch) | (mm) | (mm) | (inch) | (m) | | | |
| DISTRICT I | H | G | Circle | 60 | 1,524 | 1,600 | 63 | 1,274 | ○ | | |
| | G | B' | Circle | 60 | 1,524 | 1,600 | 63 | 1,200 | ○ | | |
| | B' | B'(b)-A' | Rectangle | 36 x54 | 914 x1,372 | 2,000 | 79 | 1,810 | ○ | | |
| | Total | | | | | | | 4,284 | | | |

**Table 7-2(3/3) Rising Main Installation Schedule**

| | Inflow | | | Diameter | Velocity | Length | Target year | | |
|---|---|---|---|---|---|---|---|---|---|
| | (avg;mld) | (peak;mld) | (peak;lps) | (mm) | (m/s) | (m) | 2010 | 2015 | 2030 |
| Parmat SPS | 54 | 108 | 1,250 | 1,000 | 1.59 | 1,000 | ○ | | |
| Bhagwatdas nala SPS | 8 | 16 | 185 | 400 | 1.47 | 1,000 | ○ | | |

**Table 7.3 Proposed Trunk Sewers: Hydraulic Capacity Analysis (DISTRICT- I East)**

| Node | | Contributory Population | | Design Flow (lps) | Size (mm) | Length (m) | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| CE1 | CE2 | 89,500 | 89,500 | 362 | 900 | 1,800 | 1,500 | 121.40 | 120.20 | 124.40 | 124.00 | 2.00 | 2.80 | 0.64 | 405 | 0.80 | 0.726 | 392 | 1.08 |
| CE2 | CE4 | 49,143 | 138,643 | 560 | 1,200 | 2,050 | 2,000 | 119.90 | 118.88 | 124.00 | 125.10 | 2.78 | 4.91 | 0.67 | 757 | 0.80 | 0.763 | 733 | 1.31 |
| CE3 | CE4 | 39,978 | 39,978 | 180 | 700 | 2,000 | 1,000 | 123.12 | 121.12 | 125.90 | 125.10 | 2.00 | 3.20 | 0.66 | 254 | 0.80 | 0.752 | 246 | 1.37 |
| CE4 | CE6 | 10,863 | 189,484 | 765 | 1,400 | 750 | 2,200 | 118.68 | 118.34 | 125.10 | 124.10 | 4.88 | 4.22 | 0.71 | 1,087 | 0.80 | 0.805 | 1,052 | 1.38 |
| CE5 | CE6 | 69,649 | 69,649 | 281 | 800 | 2,450 | 1,000 | 122.11 | 119.66 | 125.00 | 124.10 | 2.00 | 3.55 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.25 |
| CE6 | CE7 | 10,863 | 269,996 | 1,089 | 1,600 | 700 | 2,500 | 118.14 | 117.86 | 124.10 | 124.10 | 4.22 | 4.50 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.29 |
| CE7 | CE8 | 0 | 269,996 | 1,089 | 1,600 | 1,000 | 2,500 | 117.26 | 116.86 | 124.10 | 120.60 | 5.10 | 2.00 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.29 |
| CE8 | CE9(SPS) | 0 | 269,996 | 1,089 | 1,600 | 750 | 2,500 | 114.16 | 113.86 | 120.60 | 117.60 | 4.70 | 2.00 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.29 |
| | | | | 1,089 | 1,600 | 750 | 2,500 | 111.06 | 110.76 | 117.60 | 114.50 | 4.80 | 2.00 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.29 |
| Domestic lateral sewer in Tannery area | | | | | | | | | | | | | | | | | | | |
| Tannery-1 | Tannery-2 | 81,236 | 81,236 | 329 | 800 | 1,100 | 1,000 | 118.81 | 117.71 | 124.10 | 120.60 | 4.40 | 2.00 | 0.72 | 363 | 0.80 | 0.560 | 351 | 1.07 |
| Tannery-2 | Tannery-3 | 70,839 | 152,075 | 614 | 1,200 | 750 | 2,000 | 114.61 | 114.24 | 120.60 | 117.60 | 4.67 | 2.05 | 0.67 | 757 | 0.80 | 0.763 | 733 | 1.19 |
| | | | | 614 | 1,200 | 750 | 2,000 | 111.54 | 111.17 | 117.60 | 114.50 | 4.75 | 2.02 | 0.67 | 757 | 0.80 | 0.763 | 733 | 1.19 |

**Table 7.3 Proposed and Sanctioned Trunk Sewers: Hydraulic Capacity Analysis (DISTRICT-II)**

| Node | | Contributory Population | | Design Flow (lps) | Size (mm) | Length (m) | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| F2 | X5-2 | 105,941 | 105,941 | 428 | 1,000 | 1,800 | 1,500 | 121.50 | 120.30 | 125.30 | 126.30 | 2.70 | 4.90 | 0.68 | 537 | 0.80 | 0.780 | 520 | Proposed |
| D1 | ER | 5,199 | 5,199 | 27 | 600 | 240 | 900 | 120.22 | 119.95 | 124.81 | 121.77 | 3.91 | 1.14 | 0.63 | 178 | 0.80 | 0.716 | 172 | Sanctioned |
| ER | ER1 | 10,398 | 15,597 | 84 | 1,200 | 210 | 3,000 | 118.50 | 118.43 | 121.77 | 123.95 | 1.95 | 4.20 | 0.55 | 618 | 0.80 | 0.622 | 598 | Sanctioned |
| ER1 | ER2 | 10,398 | 25,995 | 118 | 1,200 | 650 | 2,400 | 118.43 | 118.16 | 123.95 | 124.85 | 4.20 | 5.37 | 0.61 | 690 | 0.80 | 0.695 | 668 | Sanctioned |
| ER2 | ER3 | 10,398 | 36,393 | 163 | 1,400 | 490 | 3,000 | 117.96 | 117.80 | 124.85 | 126.14 | 5.35 | 6.81 | 0.61 | 931 | 0.80 | 0.690 | 901 | Sanctioned |
| ER3 | ER4 | 15,597 | 51,990 | 209 | 1,400 | 270 | 3,000 | 117.80 | 117.71 | 126.14 | 126.28 | 6.81 | 7.04 | 0.61 | 931 | 0.80 | 0.690 | 901 | Sanctioned |
| ER4 | CR | 12,123 | 64,113 | 259 | 1,600 | 240 | 4,000 | 117.51 | 117.45 | 126.28 | 126.05 | 7.03 | 6.86 | 0.57 | 1,152 | 0.80 | 0.653 | 1,115 | Sanctioned |
| C1 | C2 | 12,169 | 12,169 | 66 | 600 | 110 | 800 | 120.50 | 120.36 | 124.55 | 124.45 | 3.37 | 3.40 | 0.67 | 188 | 0.80 | 0.759 | 182 | Sanctioned |
| C2 | C3 | 32,553 | 44,722 | 200 | 800 | 490 | 1,000 | 120.16 | 119.67 | 124.45 | 126.84 | 3.39 | 6.27 | 0.72 | 363 | 0.80 | 0.823 | 351 | Sanctioned |
| C3 | CR | 20,384 | 65,106 | 263 | 900 | 240 | 1,300 | 119.57 | 119.39 | 126.84 | 126.05 | 6.26 | 5.66 | 0.69 | 436 | 0.80 | 0.781 | 422 | Sanctioned |
| CR | X5-2 | 40,768 | 169,986 | 686 | 1,600 | 630 | 2,800 | 117.45 | 117.23 | 126.05 | 126.30 | 6.86 | 7.34 | 0.68 | 1,375 | 0.80 | 0.780 | 1,331 | Sanctioned |
| X5-2 | X4 | 13,349 | 289,276 | 1,168 | 1,800 | 810 | 3,600 | 117.03 | 116.80 | 126.30 | 126.36 | 7.32 | 7.61 | 0.65 | 1,662 | 0.80 | 0.744 | 1,609 | Sanctioned |
| Z2' | Z1 | 15,548 | 15,548 | 84 | 600 | 60 | 3,000 | 119.15 | 119.13 | 126.65 | 126.32 | 6.82 | 6.51 | 0.34 | 97 | 0.80 | 0.392 | 94 | Sanctioned |
| - | - | 77,164 | 92,711 | 374 | 900 | 744 | 1,000 | 120.33 | 119.58 | 126.32 | 126.58 | 4.99 | 6.00 | 0.78 | 497 | 0.80 | 0.890 | 481 | Sanctioned |
| - | - | 16,736 | 109,447 | 441 | 900 | 527 | 1,000 | 119.58 | 119.05 | 126.58 | 125.57 | 6.00 | 5.52 | 0.78 | 497 | 0.80 | 0.890 | 481 | Sanctioned |
| - | Z | 0 | 109,447 | 441 | 900 | 772 | 1,000 | 119.05 | 118.25 | 125.57 | 125.53 | 5.52 | 6.28 | 0.78 | 497 | 0.80 | 0.890 | 481 | Sanctioned |
| Z2' | Z | 91,204 | 117,585 | 475 | 1,200 | 2,103 | 2,337 | 119.15 | 118.25 | 126.65 | 125.53 | 6.19 | 5.96 | 0.62 | 700 | 0.80 | 0.706 | 678 | Proposed |
| Y2 | - | 38,817 | 38,817 | 175 | 900 | 1,170 | 1,500 | 119.68 | 118.70 | 125.60 | 126.49 | 4.92 | 6.79 | 0.64 | 405 | 0.80 | 0.726 | 392 | Sanctioned |
| - | - | | 38,817 | 175 | 900 | 360 | 1,500 | 118.70 | 118.54 | 125.58 | 126.49 | 5.88 | 6.95 | 0.64 | 405 | 0.80 | 0.726 | 392 | Sanctioned |
| - | - | 28,613 | 67,430 | 272 | 900 | 70 | 1,500 | 118.54 | 118.01 | 126.49 | 126.25 | 6.95 | 7.24 | 0.64 | 405 | 0.80 | 0.726 | 392 | Sanctioned |
| - | - | | 67,430 | 272 | 1,000 | 1,480 | 2,500 | 117.91 | 117.32 | 126.25 | 126.55 | 7.24 | 8.13 | 0.53 | 416 | 0.80 | 0.604 | 403 | Sanctioned |
| - | SPS | | 67,430 | 272 | 1,200 | 155 | 1,900 | 117.12 | 117.04 | 126.55 | 126.65 | 8.11 | 8.30 | 0.69 | 776 | 0.80 | 0.782 | 751 | Sanctioned |
| | Munsi puruwa | | | | | | | | | | | | | | | | | | |

## Table 7.3 Proposed Trunk Sewers: Hydraulic Capacity Analysis (DISTRICT-Ⅱ)

| Node | | Contributory Population | | Design Flow (lps) | Size (mm) | Length (m) | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| | | | | | | | | | | | | | | | | | | | |
| S1 | S3 | 104,951 | 104,951 | 423 | 1,000 | 1,850 | 1,500 | 120.90 | 119.67 | 124.00 | 123.80 | 2.00 | 3.03 | 0.68 | 537 | 0.80 | 0.780 | 520 | |
| | | | | | | | | | | | | | | | | | | | |
| S2 | S3 | 34,858 | 34,858 | 158 | 600 | 450 | 900 | 121.32 | 120.82 | 124.00 | 123.80 | 2.00 | 2.30 | 0.63 | 178 | 0.80 | 0.716 | 172 | |
| S3 | S4(SPS) | 13,272 | 153,081 | 619 | 1,200 | 980 | 2,000 | 119.47 | 118.98 | 123.80 | 124.00 | 3.02 | 3.71 | 0.67 | 757 | 0.80 | 0.763 | 733 | |
| | | | | | | | | | | | | | | | | | | | |
| S4(SPS) | S9 | 15,459 | 168,540 | 680 | 1,000 | 1,080 | 2,101 | 119.80 | 119.29 | 122.00 | 126.38 | 1.10 | 5.99 | 0.58 | 454 | 0.80 | 0.659 | 439 | Sanctioned |
| S4(SPS) | S5 | | 0 | 0 | 400 | 1,200 | 600 | 119.52 | 117.52 | 122.00 | 124.20 | 2.00 | 6.20 | 0.59 | 74 | 0.80 | 0.669 | 72 | |
| | | | | | | | | | | | | | | | | | | | |
| S5 | S6 | 49,834 | 49,834 | 223 | 1,000 | 690 | 1,583 | 119.29 | 118.85 | 126.38 | 125.58 | 5.99 | 5.63 | 0.67 | 523 | 0.80 | 0.759 | 506 | Sanctioned |
| S6 | S7 | 39,354 | 89,188 | 360 | 1,100 | 1,260 | 2,000 | 118.75 | 118.12 | 125.58 | 125.51 | 5.63 | 6.18 | 0.63 | 600 | 0.80 | 0.719 | 581 | Sanctioned |
| S7 | S20 | 52,240 | 141,428 | 572 | 1,200 | 2,640 | 2,198 | 118.02 | 116.82 | 125.55 | 123.35 | 6.21 | 5.22 | 0.64 | 722 | 0.80 | 0.727 | 699 | Sanctioned |
| S20 | R5 | 23,736 | 165,164 | 666 | 1,400 | 1,305 | 3,000 | 116.62 | 116.18 | 123.35 | 122.92 | 5.20 | 5.20 | 0.61 | 931 | 0.80 | 0.690 | 901 | Sanctioned |
| | | | | | | | | | | | | | | | | | | | |
| S8 | S9 | 83,298 | 83,298 | 335 | 800 | 1,300 | 1,000 | 121.11 | 119.81 | 124.00 | 124.20 | 2.00 | 3.50 | 0.72 | 363 | 0.80 | 0.823 | 351 | |
| S9 | S10 | 76,998 | 328,836 | 1,328 | 1,600 | 1,000 | 2,500 | 116.32 | 115.92 | 124.20 | 125.00 | 6.14 | 7.34 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | |
| S10 | S11 | 66,545 | 395,381 | 1,595 | 1,800 | 2,500 | 2,500 | 115.72 | 114.72 | 125.00 | 125.00 | 7.33 | 8.33 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | |
| S11 | S19 | 5,825 | 401,206 | 1,620 | 1,800 | 450 | 2,500 | 114.72 | 114.54 | 125.00 | 125.00 | 8.33 | 8.51 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | |
| | | | | | | | | | | | | | | | | | | | |
| From City District | | | 422,000 | | | | | | | | | | | | | | | | |
| S12 | S13 | 0 | 422,000 | 1,703 | 1,800 | 2,900 | 2,500 | 121.71 | 120.55 | 125.90 | 124.50 | 2.24 | 2.00 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | |
| S13 | S14 | 0 | 422,000 | 1,703 | 1,800 | 1,000 | 2,500 | 120.45 | 120.05 | 124.50 | 124.00 | 2.10 | 2.00 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | |
| S14 | S16 | 13,034 | 435,034 | 1,755 | 1,800 | 400 | 2,500 | 120.05 | 119.89 | 124.00 | 124.00 | 2.00 | 2.16 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | |
| | | | | | | | | | | | | | | | | | | | |
| S15 | S16 | 21,475 | 21,475 | 98 | 500 | 1,400 | 700 | 121.52 | 119.52 | 124.10 | 124.00 | 2.00 | 3.90 | 0.63 | 124 | 0.80 | 0.719 | 120 | |
| S16 | S17 | 37,250 | 493,759 | 1,994 | 2,000 | 1,400 | 2,500 | 118.02 | 117.46 | 124.00 | 124.50 | 3.81 | 4.87 | 0.84 | 2,639 | 0.80 | 0.958 | 2,555 | |
| S17 | S19 | 8,044 | 501,803 | 2,025 | 2,000 | 700 | 2,500 | 117.46 | 117.18 | 124.50 | 125.00 | 4.87 | 5.65 | 0.84 | 2,639 | 0.80 | 0.958 | 2,555 | |
| | | | | | | | | | | | | | | | | | | | |
| S18 | S19 | 17,388 | 17,388 | 93 | 500 | 650 | 700 | 122.42 | 121.49 | 125.00 | 125.00 | 2.00 | 2.93 | 0.63 | 124 | 0.80 | 0.719 | 120 | |
| S19 | S20 | 8,699 | 929,096 | 3,334 | 2,200 | 1,000 | 2,200 | 114.14 | 113.69 | 125.00 | 123.35 | 8.46 | 7.26 | 0.96 | 3,630 | 0.80 | 1.089 | 3,514 | |

# Table 7.3 Proposed Trunk Sewers: Hydraulic Capacity Analysis (DISTRICT-Ⅱ)

| Node | | Contributory Population | | Design Flow (lps) | Size (mm) | Length (m) | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| S20 | S21 | 32,131 | 961,227 | 3,448 | 2,200 | 1,700 | 2,200 | 113.69 | 112.92 | 123.35 | 123.00 | 7.26 | 7.68 | 0.96 | 3,630 | 0.80 | 1.089 | 3,514 | |
| S21 | S22 | 29,329 | 990,556 | 3,554 | 2,200 | 950 | 2,000 | 112.92 | 112.45 | 123.00 | 122.00 | 7.68 | 7.15 | 1.00 | 3,805 | 0.80 | 1.141 | 3,683 | |
| S22 | S23(STP) | 20,908 | 1,011,464 | 3,630 | 2,200 | 900 | 2,000 | 112.45 | 112.00 | 122.00 | 122.40 | 7.15 | 8.00 | 1.00 | 3,805 | 0.80 | 1.141 | 3,683 | |
| S24 | S26 | 69,779 | 69,779 | 281 | 800 | 950 | 1,000 | 122.91 | 121.96 | 125.80 | 125.50 | 2.00 | 2.65 | 0.72 | 363 | 0.80 | 0.823 | 351 | |
| S25 | S26 | 49,029 | 49,029 | 220 | 700 | 950 | 1,000 | 122.22 | 121.27 | 125.00 | 125.50 | 2.00 | 3.45 | 0.66 | 254 | 0.80 | 0.752 | 246 | |
| S26 | S29 | 31,769 | 150,577 | 608 | 1,200 | 1,100 | 2,000 | 120.77 | 120.22 | 125.50 | 124.50 | 3.42 | 2.97 | 0.67 | 757 | 0.80 | 0.763 | 733 | |
| S27 | S29 | 10,129 | 10,129 | 54 | 400 | 750 | 600 | 120.92 | 119.67 | 123.40 | 124.50 | 2.00 | 4.35 | 0.59 | 74 | 0.80 | 0.669 | 72 | |
| S28 | S29 | 27,959 | 27,959 | 125 | 600 | 850 | 900 | 122.32 | 121.38 | 125.00 | 124.50 | 2.00 | 2.44 | 0.63 | 178 | 0.80 | 0.716 | 172 | |
| S29 | S32 | 14,090 | 202,755 | 819 | 1,400 | 1,000 | 2,200 | 118.67 | 118.22 | 124.50 | 125.50 | 4.30 | 5.75 | 0.71 | 1,087 | 0.80 | 0.805 | 1,052 | |
| S30 | S32 | 14,050 | 14,050 | 75 | 500 | 1,000 | 700 | 120.92 | 119.49 | 123.50 | 125.50 | 2.00 | 5.43 | 0.63 | 124 | 0.80 | 0.719 | 120 | |
| S31 | S32 | 19,992 | 19,992 | 108 | 500 | 900 | 700 | 123.42 | 122.13 | 126.00 | 125.50 | 2.00 | 2.79 | 0.63 | 124 | 0.80 | 0.719 | 120 | |
| S32 | S35 | 12,337 | 249,134 | 1,006 | 1,400 | 1,150 | 2,200 | 118.22 | 117.70 | 125.50 | 126.00 | 5.75 | 6.77 | 0.71 | 1,087 | 0.80 | 0.805 | 1,052 | |
| S33 | S35 | 25,374 | 25,374 | 115 | 500 | 1,200 | 700 | 123.42 | 121.71 | 126.00 | 126.00 | 2.00 | 3.71 | 0.63 | 124 | 0.80 | 0.719 | 120 | |
| S34 | S35 | 27,028 | 27,028 | 120 | 600 | 900 | 900 | 123.32 | 122.32 | 126.00 | 126.00 | 2.00 | 3.00 | 0.63 | 178 | 0.80 | 0.716 | 172 | |
| S35 | S36 | 5,989 | 307,525 | 1,242 | 1,600 | 700 | 2,500 | 117.50 | 117.22 | 126.00 | 126.00 | 6.76 | 7.04 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | |
| S36 | S38 | 10,209 | 317,734 | 1,283 | 1,600 | 350 | 2,500 | 117.22 | 117.08 | 126.00 | 125.40 | 7.04 | 6.58 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | |
| S37 | S38 | 15,684 | 15,684 | 84 | 500 | 750 | 700 | 121.42 | 120.35 | 124.00 | 125.40 | 2.00 | 4.47 | 0.63 | 124 | 0.80 | 0.719 | 120 | |
| S38 | S39 | 14,549 | 347,967 | 1,404 | 1,600 | 1,050 | 2,500 | 117.08 | 116.66 | 125.40 | 125.00 | 6.58 | 6.60 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | |
| S39 | S23(STP) | 20,141 | 368,108 | 1,485 | 1,800 | 1,750 | 2,500 | 116.46 | 115.76 | 125.00 | 122.40 | 6.59 | 4.69 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | |
| From City District | | | 750,659 | 2,694 | | | | | | | | | | | | | | | |
| R1 | R2 | 0 | 750,659 | 2,694 | 2,000 | 2,820 | 1,600 | 121.80 | 120.00 | 125.94 | 124.01 | 1.97 | 1.84 | 1.05 | 3,299 | 0.80 | 1.197 | 3,193 | Sanctioned |
| R2 | R3 | 14,549 | 765,208 | 2,746 | 2,000 | 900 | 1,400 | 120.00 | 119.40 | 124.01 | 123.62 | 1.84 | 2.04 | 1.12 | 3,528 | 0.80 | 1.280 | 3,415 | Sanctioned |
| R3 | R4 | 19,960 | 785,168 | 2,818 | 2,000 | 1,920 | 1,300 | 119.40 | 117.90 | 123.62 | 125.10 | 2.04 | 5.02 | 1.17 | 3,660 | 0.80 | 1.328 | 3,543 | Sanctioned |
| R4 | R5 | 7,141 | 957,473 | 3,436 | 2,000 | 1,410 | 1,200 | 117.90 | 115.90 | 125.10 | 122.92 | 5.02 | 4.85 | 1.21 | 3,811 | 0.80 | 1.383 | 3,689 | Sanctioned |
| R5 | R6(STP) | 8,325 | 965,798 | 3,466 | 2,200 | 1,710 | 1,400 | 115.30 | 114.10 | 122.92 | 117.35 | 5.22 | 0.85 | 1.20 | 4,550 | 0.80 | 1.365 | 4,404 | Sanctioned |

**Table 7.3 Proposed Trunk Sewers: Hydraulic Capacity Analysis (DISTRICT-Ⅲ)**

| Node | | Contributory Population | | Design Flow (lps) | Size (mm) | Length (m) | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| W1 | W2(SPS) | 99,236 | 99,236 | 401 | 1,000 | 1,700 | 1,500 | 122.90 | 121.77 | 127.00 | 127.00 | 3.00 | 4.13 | 0.68 | 537 | 0.80 | 0.780 | 520 | 1.30 |
| Lakhanpur SPS | | | | | | | | | | | | | | | | | | | |
| W2(SPS) | W4 | 74,789 | 174,025 | 702 | 1,200 | 600 | 2,000 | 123.69 | 123.39 | 127.00 | 127.00 | 2.00 | 2.30 | 0.67 | 757 | 0.80 | 0.763 | 733 | 1.04 |
| W3 | W4 | 71,103 | 71,103 | 288 | 800 | 1,500 | 1,000 | 124.61 | 123.11 | 127.50 | 127.00 | 2.00 | 3.00 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.22 |
| W4 | W12 | 17,776 | 262,904 | 1,062 | 1,600 | 1,250 | 2,500 | 122.31 | 121.81 | 127.00 | 127.60 | 2.95 | 4.05 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.33 |
| W5 | W6 | 30,832 | 30,832 | 138 | 600 | 850 | 900 | 125.82 | 124.88 | 128.50 | 128.00 | 2.00 | 2.44 | 0.63 | 178 | 0.80 | 0.716 | 172 | 1.25 |
| W6 | W12 | 18,490 | 49,322 | 220 | 700 | 1,850 | 1,000 | 124.78 | 122.93 | 128.00 | 127.60 | 2.44 | 3.89 | 0.66 | 254 | 0.80 | 0.752 | 246 | 1.12 |
| W7 | W9 | 19,199 | 19,199 | 102 | 500 | 1,500 | 700 | 124.22 | 122.08 | 126.80 | 126.70 | 2.00 | 4.04 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.18 |
| W8 | W9 | 43,015 | 43,015 | 193 | 700 | 1,000 | 1,000 | 123.72 | 122.72 | 126.50 | 126.70 | 2.00 | 3.20 | 0.66 | 254 | 0.80 | 0.752 | 246 | 1.27 |
| W9 | W11 | 24,407 | 86,621 | 349 | 800 | 1,000 | 1,000 | 121.78 | 120.78 | 126.70 | 127.00 | 4.03 | 5.33 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.01 |
| W10 | W11 | 30,628 | 30,628 | 138 | 600 | 1,150 | 900 | 124.82 | 123.54 | 127.50 | 127.00 | 2.00 | 2.78 | 0.63 | 178 | 0.80 | 0.716 | 172 | 1.25 |
| W11 | W12 | 29,185 | 146,434 | 592 | 1,200 | 1,150 | 2,000 | 120.38 | 119.81 | 127.00 | 127.60 | 5.31 | 6.47 | 0.67 | 757 | 0.80 | 0.763 | 733 | 1.24 |
| W12 | W13 | 16,384 | 475,043 | 1,917 | 1,800 | 700 | 2,500 | 119.21 | 118.93 | 127.60 | 127.50 | 6.44 | 6.62 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.01 |
| W13 | W15 | 36,203 | 511,246 | 2,063 | 2,000 | 1,300 | 2,500 | 118.73 | 118.21 | 127.50 | 127.30 | 6.60 | 6.92 | 0.84 | 2,639 | 0.80 | 0.958 | 2,555 | 1.24 |
| W14 | W15 | 120,621 | 120,621 | 486 | 1,000 | 3,300 | 1,500 | 125.40 | 123.20 | 128.50 | 127.30 | 2.00 | 3.00 | 0.68 | 537 | 0.80 | 0.780 | 520 | 1.07 |
| W15 | W22(SPS) | 30,734 | 662,601 | 2,675 | 2,200 | 950 | 2,500 | 118.01 | 117.63 | 127.30 | 128.00 | 6.89 | 7.97 | 0.90 | 3,402 | 0.80 | 1.020 | 3,293 | 1.23 |
| W16 | W17 | 9,784 | 9,784 | 54 | 400 | 1,400 | 600 | 125.02 | 122.69 | 127.50 | 128.50 | 2.00 | 5.33 | 0.59 | 74 | 0.80 | 0.669 | 72 | 1.33 |
| W17 | W19 | 9,837 | 19,621 | 105 | 500 | 1,050 | 700 | 122.59 | 121.09 | 128.50 | 129.00 | 5.33 | 7.33 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.14 |
| W18 | W19 | 23,602 | 23,602 | 105 | 500 | 650 | 700 | 125.42 | 124.49 | 128.00 | 129.00 | 2.00 | 3.93 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.14 |
| W19 | W22(SPS) | 17,358 | 60,581 | 245 | 700 | 2,000 | 1,000 | 120.89 | 118.89 | 129.00 | 128.00 | 7.33 | 8.33 | 0.66 | 254 | 0.80 | 0.752 | 246 | 1.00 |

**Table 7.3 Proposed Trunk Sewers: Hydraulic Capacity Analysis (DISTRICT-Ⅲ)**

| Node | | Contributory Population | | Design Flow (lps) | Size (mm) | Length (m) | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| | | | | | | | | | | | | | | | | | | | |
| W20 | W21 | 73,295 | 73,295 | 295 | 800 | 1,500 | 1,000 | 122.11 | 120.61 | 125.00 | 127.50 | 2.00 | 6.00 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.19 |
| W21 | W22(SPS) | 16,361 | 89,656 | 362 | 900 | 4,000 | 1,500 | 120.51 | 117.84 | 127.50 | 128.00 | 5.99 | 9.16 | 0.64 | 405 | 0.80 | 0.726 | 392 | 1.08 |
| SPS | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| W22(SPS) | W24 | 14,544 | 413,691 | 1,484 | 1,800 | 1,000 | 2,500 | 124.05 | 123.65 | 128.00 | 127.60 | 2.00 | 2.00 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.30 |
| | | | 413,691 | 1,484 | 1,800 | 1,000 | 2,500 | 124.05 | 123.65 | 128.00 | 127.60 | 2.00 | 2.00 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.30 |
| | | | | | | | | | | | | | | | | | | | |
| W23 | W24 | 31,206 | 31,206 | 140 | 600 | 1,500 | 900 | 125.82 | 124.15 | 128.50 | 127.60 | 2.00 | 2.77 | 0.63 | 178 | 0.80 | 0.716 | 172 | 1.23 |
| | | | | | | | | | | | | | | | | | | | |
| W24 | W30 | 15,043 | 436,816 | 1,568 | 1,800 | 1,250 | 2,500 | 122.95 | 122.45 | 127.60 | 127.00 | 2.70 | 2.60 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.23 |
| | | | 436,816 | 1,568 | 1,800 | 1,250 | 2,500 | 122.95 | 122.45 | 127.60 | 127.00 | 2.70 | 2.60 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.23 |
| | | | | | | | | | | | | | | | | | | | |
| W25 | W26 | 21,251 | 21,251 | 95 | 500 | 1,100 | 700 | 124.92 | 123.35 | 127.50 | 127.70 | 2.00 | 3.77 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.26 |
| W26 | W27 | 15,160 | 36,411 | 163 | 600 | 1,000 | 900 | 123.25 | 122.14 | 127.70 | 128.00 | 3.77 | 5.18 | 0.63 | 178 | 0.80 | 0.716 | 172 | 1.06 |
| W27 | W28 | 25,380 | 61,791 | 250 | 800 | 1,750 | 1,000 | 121.94 | 120.19 | 128.00 | 128.00 | 5.17 | 6.92 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.40 |
| W28 | W29 | 56,498 | 118,289 | 477 | 1,000 | 1,100 | 1,500 | 119.99 | 119.26 | 128.00 | 127.50 | 6.91 | 7.14 | 0.68 | 537 | 0.80 | 0.780 | 520 | 1.09 |
| W29 | W30 | 10,141 | 128,430 | 518 | 1,000 | 1,300 | 1,500 | 119.26 | 118.39 | 127.50 | 127.00 | 7.14 | 7.51 | 0.68 | 537 | 0.80 | 0.780 | 520 | 1.00 |
| | | | | | | | | | | | | | | | | | | | |
| W30 | W33 | 9,736 | 505,899 | 1,816 | 1,800 | 700 | 2,500 | 117.59 | 117.31 | 127.00 | 126.00 | 7.46 | 6.74 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.06 |
| | | | 505,899 | 1,816 | 1,800 | 700 | 2,500 | 117.59 | 117.31 | 127.00 | 126.00 | 7.46 | 6.74 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.06 |
| | | | | | | | | | | | | | | | | | | | |
| W31 | W32 | 24,703 | 24,703 | 110 | 500 | 1,850 | 700 | 126.02 | 123.38 | 128.60 | 127.00 | 2.00 | 3.04 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.09 |
| W32 | W33 | 41,546 | 66,249 | 268 | 800 | 1,300 | 1,000 | 123.08 | 121.78 | 127.00 | 126.00 | 3.03 | 3.33 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.31 |
| | | | | | | | | | | | | | | | | | | | |
| W33 | W37 | 18,505 | 548,276 | 1,968 | 2,000 | 300 | 2,500 | 117.11 | 116.99 | 126.00 | 126.00 | 6.72 | 6.84 | 0.84 | 2,639 | 0.80 | 0.958 | 2,555 | 1.30 |
| | | | 548,276 | 1,968 | 2,000 | 300 | 2,500 | 117.11 | 116.99 | 126.00 | 126.00 | 6.72 | 6.84 | 0.84 | 2,639 | 0.80 | 0.958 | 2,555 | 1.30 |
| | | | | | | | | | | | | | | | | | | | |
| W34 | W36 | 121,510 | 121,510 | 491 | 1,000 | 2,500 | 1,500 | 120.90 | 119.23 | 124.00 | 127.00 | 2.00 | 6.67 | 0.68 | 537 | 0.80 | 0.780 | 520 | 1.06 |
| | | | | | | | | | | | | | | | | | | | |
| W35 | W36 | 35,133 | 35,133 | 158 | 600 | 2,150 | 900 | 125.32 | 122.93 | 128.00 | 127.00 | 2.00 | 3.39 | 0.63 | 178 | 0.80 | 0.716 | 172 | 1.09 |
| W36 | W37 | 30,290 | 186,933 | 754 | 1,400 | 1,750 | 2,200 | 118.83 | 118.03 | 127.00 | 126.00 | 6.64 | 6.44 | 0.71 | 1,087 | 0.80 | 0.805 | 1,052 | 1.40 |
| W37 | W38(STP) | 0 | 641,742 | 2,302 | 2,000 | 300 | 2,500 | 116.99 | 116.87 | 126.00 | 126.00 | 6.84 | 6.96 | 0.84 | 2,639 | 0.80 | 0.958 | 2,555 | 1.11 |
| | | | 641,742 | 2,302 | 2,000 | 300 | 2,500 | 116.99 | 116.87 | 126.00 | 126.00 | 6.84 | 6.96 | 0.84 | 2,639 | 0.80 | 0.958 | 2,555 | 1.11 |
| | | | | | | | | | | | | | | | | | | | |

## Table 7.3 Proposed trunk sewers: Hydraulic capacity analysis (DISTRICT-IV)

| Node | | Contributory Population | | Design Flow (lps) | Stage A;2010 B;2015 C;2030 | Size (mm) | Length (m) | Gradient | Invert level (m) | | Ground level (m) | | Covering (m) | | Full pipe capacity | | Design capacity | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| From | To | Each | Cumulative | | | | | | u/s | d/s | u/s | d/s | u/s | d/s | Velocity (m/s) | Discharge (l/s) | Depth ratio d/df | Velocity (m/s) | Discharge (l/s) | |
| E1 | E2 | 50,600 | 50,600 | 205 | C | 700 | 1,800 | 1,000 | 122.22 | 120.42 | 125.00 | 124.00 | 2.00 | 2.80 | 0.66 | 254 | 0.80 | 0.752 | 246 | 1.20 |
| E2 | E4 | 36,031 | 86,631 | 349 | C | 800 | 350 | 1,000 | 120.32 | 119.97 | 124.00 | 124.50 | 2.79 | 3.64 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.01 |
| E3 | E4 | 31,570 | 31,570 | 143 | C | 600 | 2,200 | 900 | 122.32 | 119.88 | 125.00 | 124.50 | 2.00 | 3.94 | 0.63 | 178 | 0.80 | 0.716 | 172 | 1.20 |
| E4 | E8 | 3,023 | 121,224 | 488 | C | 1,000 | 650 | 1,500 | 119.48 | 119.05 | 124.50 | 124.80 | 3.92 | 4.65 | 0.68 | 537 | 0.80 | 0.780 | 520 | 1.07 |
| E5 | E7 | 33,907 | 33,907 | 153 | C | 600 | 1,750 | 900 | 123.32 | 121.38 | 126.00 | 125.00 | 2.00 | 2.94 | 0.63 | 178 | 0.80 | 0.716 | 172 | 1.12 |
| E6 | E7 | 15,114 | 15,114 | 81 | C | 500 | 500 | 700 | 122.32 | 121.61 | 124.90 | 125.00 | 2.00 | 2.81 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.48 |
| E7 | E8 | 18,963 | 67,984 | 275 | C | 800 | 1,800 | 1,000 | 121.18 | 119.38 | 125.00 | 124.80 | 2.93 | 4.53 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.28 |
| E8 | E10 | 8,662 | 197,870 | 799 | C | 1,400 | 1,000 | 2,200 | 118.65 | 118.20 | 124.80 | 124.70 | 4.61 | 4.97 | 0.71 | 1,087 | 0.80 | 0.805 | 1,052 | 1.32 |
| E9 | E10 | 26,459 | 26,459 | 118 | C | 500 | 1,550 | 700 | 121.42 | 119.21 | 124.00 | 124.70 | 2.00 | 4.91 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.02 |
| E10 | E11 | 56,266 | 280,595 | 1,132 | C | 1,600 | 2,550 | 2,500 | 118.00 | 116.98 | 124.70 | 124.50 | 4.96 | 5.78 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.24 |
| E11 | E12 | 8,178 | 288,773 | 1,166 | C | 1,600 | 600 | 2,500 | 116.98 | 116.74 | 124.50 | 124.50 | 5.78 | 6.02 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.21 |
| E12 | E16 | 15,194 | 303,967 | 1,226 | C | 1,600 | 1,300 | 2,500 | 116.74 | 116.22 | 124.50 | 124.50 | 6.02 | 6.54 | 0.72 | 1,456 | 0.80 | 0.825 | 1,409 | 1.15 |
| E13 | E14 | 21,939 | 21,939 | 98 | C | 500 | 2,150 | 700 | 121.42 | 118.35 | 124.00 | 125.00 | 2.00 | 6.07 | 0.63 | 124 | 0.80 | 0.719 | 120 | 1.22 |
| E14 | E15 | 20,448 | 42,387 | 190 | C | 700 | 250 | 1,000 | 118.15 | 117.90 | 125.00 | 125.00 | 6.07 | 6.32 | 0.66 | 254 | 0.80 | 0.752 | 246 | 1.29 |
| E15 | E16 | 42,723 | 85,110 | 344 | C | 800 | 900 | 1,000 | 117.80 | 116.90 | 125.00 | 124.50 | 6.31 | 6.71 | 0.72 | 363 | 0.80 | 0.823 | 351 | 1.02 |
| E16 | E17 | 7,036 | 396,113 | 1,600 | C | 1,800 | 1,050 | 2,500 | 115.90 | 115.48 | 124.50 | 124.50 | 6.65 | 7.07 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.21 |
| E17 | E18(SPS) | 32,399 | 428,512 | 1,730 | C | 1,800 | 2,350 | 2,500 | 115.48 | 114.54 | 124.50 | 124.50 | 7.07 | 8.01 | 0.78 | 1,992 | 0.80 | 0.893 | 1,928 | 1.11 |
| E18(SPS) | E19(STP) | 0 | 428,512 | 1,730 | C | 1,200 | 4,200 | | 121.19 | 120.69 | 124.50 | 124.00 | 2.00 | 2.00 | 1.53 | 1,730 | | | | 1.00 |

## Table 7.4 Kanpur Pump Stations: Existing and Sanctioned

| Pump station | Status | Exisiting pumps | | | | | Allowable discharge [1] | | Sump capacity | Exisiting rising mains | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | No. | lpm | lps | Head (m) | Total installed (lps) | PK (lps) | AVG (mld) | m3 | dia (mm) | Length (m) | Static Head (m) |
| Muir Mill | E | 3 | 2,800 | 47 | | 140 | 93.33 | 4.03 | 168.0 | 400 | 735 | 15.0 |
| Guptar Ghat | E | 3 | 1,000 | 17 | | 50 | 33.33 | 1.44 | 118.0 | 150 | 300 | 15.0 |
| ISPS No.1 | E | 3 | 2,580 | 43 | 27.5 | 129 | 86.00 | 3.72 | 10.0 | 300 | 1,232 | 1.5 |
| ISPS No.2 | E | 4 | 4,560 | 76 | 25.0 | 304 | 202.67 | 8.76 | 18.0 | 500 | 545 | 25.0 |
| | | | | | | | | | | 600 | 1,950 | |
| ISPS No.3 | E | 3 | 3,450 | 58 | 20.0 | 173 | 115.00 | 4.97 | 14.0 | 300 | 35 | 17.7 |
| | | | | | | | | | | 700 | 794 | |
| ISPS No.4 | E | 2 | 1,766 | 29 | 20.0 | 59 | 39.24 | 1.70 | 7.0 | 300 | 765 | 20.0 |
| Nawab ganj | E | 2 | 4,950 | 83 | | 350 | 233.47 | 10.09 | 288.6 | 450 | 1,500 | 10.0 |
| | | 2 | 2,475 | 41 | | | | | | | | |
| | | 1 | 6,162 | 103 | | | | | | | | |
| Parma Ghat | E | 3 | 22,000 | 367 | | 1,883 | 1,255.56 | 54.24 | 310.4 | 600 | 1,000 | 10.0 |
| | | 2 | 15,000 | 250 | | | | | | 250 | 1,000 | |
| | | 2 | 8,500 | 142 | | | | | | | | |
| Rakhi Mandi | S | 3 | 60,000 | 1,000 | 23.0 | 4,000 | 2,666.67 | 115.20 | 568.0 | 1,300 | 2,310 | 20.0 |
| | | 2 | 30,000 | 500 | | | | | | | | |
| Munshi purwa | S | 6 | 24,000 | 400 | 20.0 | 2,400 | 1,600.00 | 69.12 | 606.0 | 1,200 | 450 | 27.0 |
| Jajmau MPS | E | 7 | 36,000 | 600 | | 4,200 | 2,800.00 | 120.96 | 360.0 | 1,500 | 1,500 | |
| Jajmau MPS | E | 4 | 8,700 | 145 | | 580 | 386.67 | 16.70 | | 700 | 200 | 20.0 |
| Ganda nala PS | S | 5 | 8,700 | 145 | | 725 | 483.33 | 20.88 | 130.4 | 700 | 30 | 8.0 |
| Lakhanpur | E | 1 | 2,250 | 38 | | 171 | 113.89 | 4.92 | | 700 | 1,600 | 17.5 |
| | E | 2 | 4,000 | 67 | | | | | | | | |

(1) Assuming 50% spare capacity

**Table 7.5 (1/3) Pump Sation Design**

| | |
|---|---|
| Peak (pk) | 2 |
| Average (avg) | 1 |
| Non-peak (npk) | 0.5 |

| Pump stations | Status | Installed capacity (lps) | Design discharge (lps) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 2015 | | | | 2030 | | | |
| | | | pk x 1.5 | pk | avg | npk | pk x 1.5 | pk | avg | npk |
| Muir Mill | E | 93 | 157.6 | 105 | 53 | 26 | 157.6 | 105 | 53 | 26 |
| Guptar Ghat | E | 33 | 477.1 | 318 | 159 | 80 | 477.1 | 318 | 159 | 80 |
| Nawab ganj | E | 233 | 208.3 | 139 | 69 | 35 | 277.8 | 185 | 93 | 46 |
| Parma Ghat | E | 1,256 | 1,875.0 | 1,250 | 625 | 313 | 1,875.0 | 1,250 | 625 | 313 |
| Lakhanpur | E | | 555.6 | 370 | 185 | 93 | 937.5 | 625 | 313 | 156 |
| Bagwatdas nala | P | | 277.8 | 185 | 93 | 46 | 277.8 | 185 | 93 | 46 |
| Jajmau new or expanded | P | | 625.0 | 417 | 208 | 104 | 833.3 | 556 | 278 | 139 |
| Ruman | P | | - | - | - | - | 2,291.7 | 1,528 | 764 | 382 |
| Panki | P | | 2,777.8 | 1,852 | 926 | 463 | 4,375.0 | 2,917 | 1,458 | 729 |

**Table 7.5 (2/3) Pump station design**

| Pump stations | Proposed pumps | | | | | | | | | | | | Proposed rising main | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2015 | | | | | | 2030 | | | | | | dia. | length |
| | Pk (lps) | Pk * 1.5 | No. | lps | lpm | total (lps) | Pk (lps) | Pk * 1.5 | No. | lps | lpm | total (lps) | mm | m |
| Muir Mill | - | - | 3 | 60 | 3,600 | 180 | - | - | 3 | 60 | 3,600 | 180 | existing | |
| Guptar Ghat | - | - | 3 | 110 | 6,600 | 490 | - | - | 3 | 110 | 6,600 | 490 | 1x400 | 300 |
| | | | 2 | 80 | 4,800 | | | | 2 | 80 | 4,800 | | | |
| Nawab ganj | - | - | 3 | 70 | 4,200 | 310 | - | - | 3 | 70 | 4,200 | 310 | existing | |
| | | | 2 | 50 | 3,000 | | | | 2 | 50 | 3,000 | | | |
| Parma Ghat | - | - | 2 | 200 | 12,000 | 600 | - | - | 2 | 240 | 14,400 | 720 | existing | |
| | | | 2 | 100 | 6,000 | | | | 2 | 120 | 7,200 | | | |
| Lakhanpur | - | - | 3 | 200 | 12,000 | 600 | - | - | 2 | 250 | 15,000 | 500 | | |
| Bagwatdas nala | - | - | 3 | 100 | 6,000 | 300 | - | - | 3 | 100 | 6,000 | 300 | | |
| Jajmau augmented | - | - | 5 | 150 | 9,000 | 750 | - | - | 6 | 150 | 9,000 | 900 | 1x700 | 1,500 |
| Ruman | - | - | | | | | - | - | 8 | 200 | 12,000 | 1,600 | 1x1200 | 4,200 |
| Panki | - | - | 12 | 240 | 14,400 | 2,880 | - | - | 12 | 370 | 22,200 | 4,440 | 1x1600 | 30 |

Required installed capacity is 1.5 x projected peak flow

**Table 7.5 (3/3) Pump Sation Design**

| Pump station | | Peak flows (lps) | | Exisiting/ Sanctioned sump | Exisiting Sump Holding Time | | Design Holding Time | Required sump capacity | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | 2030 | m3 | 2015 | 2030 | (min) | 2015 | 2030 |
| Muir Mill | E | - | - | 0 | 26.64 | 26.64 | 5.0 | - | - |
| Guptar Ghat | E | - | - | 0 | 6.18 | 6.18 | 5.0 | - | - |
| Nawab ganj | E | - | - | 0 | 34.63 | 25.97 | 5.0 | - | - |
| Parmat Ghat | E | - | - | 0 | 4.14 | 4.14 | 5.0 | - | - |
| Lakhanpur | E | - | - | - | - | - | 5.0 | - | - |

**Table 7.6 Nalas Measured Flows**

(mld)

| No. | Name of Nala | Flow |
|---|---|---|
| 1 | Jadeshwar Nala | 0.92 |
| 2 | Jewra Nala | 0.79 |
| 3 | Ranighat Nala | 0.32 |
| 4 | Tafco Nala | 0.43 |
| 5 | Permatghat Nala | 1.78 |
| 6 | Muir Mill Nala | 3.13 |
| 7 | Police Line Nala | 0.79 |
| 8 | Jail Nala | 1.22 |
| 9 | Golf Club Nala -I | 1.26 |
| 10 | Golf Club Nala -II | 0.40 |
| 11 | KESA Colony Nala | 0.16 |
| 12 | Roadway Colony Nala | 0.40 |
| 13 | Kheora Nala | 0.14 |
| 14 | Nawabganj Nala | 1.66 |
| 15 | Sisamau Nala | 138.33 |
| 16 | Guptarghat Nala | 2.29 |
| 17 | Dubka Nala | |
| 18 | Buriaghat Nala | |
| 19 | Wazidpur Nala | |
| 20 | Bangalighat Nala | |
| 21 | Halwa Khanda Nala | 11.44 |
| 22 | COD Nala | 8.81 |
| 23 | Ganda Nala | 55.09 |
| | Sub Total | 229.36 |
| | Discharge of sewage channel | 129.50 |
| | Total | 358.86 |
| | Say | 360.00 |

## Table7.7 Jajmau STP: Average Monthly Inflow and Effluent Characteristics

Inflow

| | | Nov-02 | Dec-02 | Jan-03 | Feb-03 | Mar-03 | Apr-03 | May-03 | Jun-03 | Jul-03 | Aug-03 | Sep-03 | Oct-03 | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| STP | 5MLD | 4.5 | 4.0 | 4.3 | 4.6 | 4.6 | 4.5 | 4.5 | 4.7 | 0.0 | 4.6 | 4.2 | 4.1 | 4.1 |
| | 36MLD | - | - | - | - | - | - | 29 | 31 | 30 | - | 15 | 21 | 25 |
| | 130MLD | 47 | 45 | 50 | 51 | 46 | 40 | 56 | 49 | 40 | 52 | 54 | 56 | 49 |
| | Total | 52 | 49 | 54 | 56 | 51 | 45 | 90 | 85 | 70 | 57 | 73 | 81 | 63 |

5MLD STP

| | | Nov-02 | Dec-02 | Jan-03 | Feb-03 | Mar-03 | Apr-03 | May-03 | Jun-03 | Jul-03 | Aug-03 | Sep-03 | Oct-03 | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOD | influent | 268 | 271 | 312 | 307 | 296 | 365 | 361 | 312 | 288 | 271 | 251 | 320 | 302 |
| | effluent | 147 | 123 | 128 | 129 | 141 | 180 | 151 | 178 | 161 | 136 | 131 | 205 | 151 |
| | polishing | 67 | 60 | 55 | 72 | 57 | 87 | 97 | 104 | 84 | 92 | 87 | 113 | 81 |
| BOD filtered | influent | 118 | 115 | 130 | 130 | 114 | 129 | 130 | 116 | 118 | 120 | 100 | 145 | 122 |
| | effluent | 56 | 56 | 60 | 66 | 65 | 85 | 89 | 64 | 74 | 86 | 56 | 75 | 69 |
| | polishing | 35 | 27 | 38 | 36 | 30 | 59 | 61 | 46 | 35 | 28 | 39 | 54 | 41 |
| COD | influent | 778 | 779 | 933 | 858 | 839 | 1,004 | 996 | 1,147 | 1,171 | 1,070 | 991 | 1,371 | 995 |
| | effluent | 340 | 300 | 316 | 341 | 345 | 459 | 468 | 448 | 366 | 394 | 360 | 519 | 388 |
| | polishing | 190 | 180 | 196 | 198 | 174 | 231 | 285 | 247 | 155 | 149 | 143 | 234 | 199 |
| TSS | influent | 785 | 793 | 894 | 845 | 860 | 1,057 | 962 | 1,009 | 968 | 999 | 891 | 1,110 | 931 |
| | effluent | 312 | 300 | 312 | 356 | 280 | 356 | 474 | 399 | 252 | 274 | 304 | 347 | 331 |
| | polishing | 125 | 117 | 131 | 151 | 116 | 108 | 123 | 124 | 114 | 123 | 122 | 147 | 125 |
| VSS | influent | 271 | 314 | 334 | 315 | 287 | 346 | 342 | 426 | 341 | 312 | 266 | 299 | 321 |
| | effluent | 194 | 117 | 139 | 187 | 148 | 210 | 206 | 180 | 159 | 174 | 194 | 196 | 175 |
| | polishing | 100 | 89 | 101 | 108 | 91 | 82 | 96 | 96 | 84 | 90 | 97 | 119 | 96 |

36MLD STP

| | | Nov-02 | Dec-02 | Jan-03 | Feb-03 | Mar-03 | Apr-03 | May-03 | Jun-03 | Jul-03 | Aug-03 | Sep-03 | Oct-03 | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOD | influent | 498 | 445 | 298 | 391 | 395 | 447 | 439 | 470 | 416 | | 331 | 495 | 420 |
| | effluent | 247 | 251 | 194 | 313 | 353 | 256 | 243 | 272 | 240 | | 198 | 280 | 259 |
| | polishing | 161 | 172 | 173 | 224 | 267 | 201 | 199 | 220 | 185 | | 138 | 213 | 196 |
| BOD filtered | influent | 183 | 172 | 108 | 198 | 204 | 180 | 170 | 193 | 194 | | 138 | 194 | 176 |
| | effluent | 125 | 97 | 82 | 158 | 161 | 139 | 116 | 134 | 130 | | 104 | 108 | 123 |
| | polishing | 99 | 78 | 62 | 122 | 133 | 111 | 97 | 116 | 106 | | 123 | 86 | 103 |
| COD | influent | 1,465 | 1,504 | 885 | 1,212 | 1,119 | 1,396 | 1,281 | 1,478 | 1,378 | | 1,079 | 1,369 | 1,288 |
| | effluent | 656 | 659 | 599 | 838 | 983 | 745 | 592 | 647 | 445 | | 409 | 586 | 651 |
| | polishing | 414 | 392 | 400 | 432 | 633 | 556 | 471 | 509 | 341 | | 303 | 392 | 440 |
| TSS | influent | 1,342 | 1,272 | 892 | 1,247 | 1,147 | 1,412 | 1,251 | 1,306 | 1,156 | | 933 | 1,198 | 1,196 |
| | effluent | 559 | 491 | 444 | 816 | 974 | 716 | 536 | 521 | 409 | | 306 | 517 | 572 |
| | polishing | 283 | 317 | 281 | 406 | 577 | 419 | 377 | 352 | 218 | | 230 | 240 | 336 |
| VSS | influent | 467 | 410 | 286 | 424 | 368 | 395 | 402 | 472 | 361 | | 296 | 399 | 389 |
| | effluent | 286 | 204 | 191 | 322 | 236 | 235 | 243 | 211 | 227 | | 187 | 213 | 232 |
| | polishing | 201 | 131 | 125 | 214 | 185 | 179 | 167 | 131 | 159 | | 171 | 120 | 162 |

130MLD STP

| | | Nov-02 | Dec-02 | Jan-03 | Feb-03 | Mar-03 | Apr-03 | May-03 | Jun-03 | Jul-03 | Aug-03 | Sep-03 | Oct-03 | AVG |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BOD | influent | 269 | 274 | 308 | 310 | 298 | 323 | 308 | 313 | 288 | 287 | 269 | 360 | 301 |
| | effluent | 38 | 29 | 52 | 28 | 32 | 37 | 39 | 29 | 29 | 25 | 31 | 25 | 33 |
| | polishing | | | | | | | | | | | | | |
| BOD filtered | influent | 118 | 120 | 132 | 127 | 119 | 129 | 131 | 118 | 117 | 123 | 105 | 150 | 124 |
| | effluent | 23 | 20 | 27 | 18 | 21 | 24 | 26 | 17 | 13 | 15 | 21 | 17 | 20 |
| | polishing | | | | | | | | | | | | | |
| COD | influent | 768 | 779 | 899 | 845 | 830 | 938 | 975 | 1,160 | 1,204 | 1,115 | 1,007 | 1,466 | 999 |
| | effluent | 144 | 133 | 170 | 135 | 133 | 140 | 142 | 129 | 137 | 119 | 126 | 143 | 138 |
| | polishing | | | | | | | | | | | | | |
| TSS | influent | 751 | 799 | 901 | 869 | 862 | 1,035 | 1,009 | 1,030 | 1,006 | 1,092 | 936 | 1,205 | 958 |
| | effluent | 109 | 113 | 128 | 112 | 108 | 102 | 126 | 115 | 113 | 107 | 115 | 108 | 113 |
| | polishing | | | | | | | | | | | | | |
| VSS | influent | 257 | 279 | 303 | 299 | 295 | 302 | 334 | 310 | 311 | 352 | 343 | 329 | 310 |
| | effluent | 77 | 92 | 70 | 81 | 88 | 82 | 98 | 84 | 87 | 84 | 95 | 80 | 85 |
| | polishing | | | | | | | | | | | | | |

**Table 7.12 Panki Pumping Station (1/4)**

**Average flow** 126 mld

| | Condition | Flow factor | Hours | Total flow m3 | no. of pumps | Calculated discharge lps | Proposed discharge | actual hours of pumping |
|---|---|---|---|---|---|---|---|---|
| 1 | peak | 2 | 4 | 42000 | 8 | 370 | 370 | 3.94 |
| 2 | Average | 1 | 12 | 63000 | 4 | 370 | 370 | 11.82 |
| 3 | non-peak | 0.5 | 8 | 21000 | 2 | 370 | 370 | 7.88 |
| | | | 24 | 126000 | | | | 23.65 |

**Table 7.12 Panki Pumping Station (2/4)**

| | | | | | | |
|---|---|---|---|---|---|---|
| Length of rising main | 30 | m | | | | |
| Friction factor C | 110 | | $Hf = 10.7\ Q^{1.85} L / C^{1.85}\ D^{4.87}$ | | | |
| minor losses | 10% | | | | | |
| Static head | 13 | m | | | | |
| Peak flow | 2.960 | m3/s | sump volume | 888 | m3 |
| Average flow | 1.48 | m3/s | diameter | 14.00 | |
| non-peak flow | 0.74 | m3/s | depth | 5.77 | |

| | Dia of rising main | flow condition | Head loss in rising main | Velocity | minor losses | static head | total head |
|---|---|---|---|---|---|---|---|
| | mm | | m | m/s | m | m | m |
| 1 | 1200 | peak | 0.16 | 2.62 | 0.02 | 12.67 | 12.85 |
| | 1200 | average | 0.05 | 1.31 | 0.00 | 12.67 | 12.72 |
| | 1200 | non-peak | 0.01 | 0.65 | 0.00 | 12.67 | 12.68 |
| 2 | 1400 | peak | 0.08 | 1.92 | 0.01 | 12.67 | 12.75 |
| | 1400 | average | 0.02 | 0.96 | 0.00 | 12.67 | 12.69 |
| | 1400 | non-peak | 0.01 | 0.48 | 0.00 | 12.67 | 12.68 |
| 3 | 1600 | peak | 0.04 | 1.47 | 0.00 | 12.67 | 12.71 |
| | 1600 | average | 0.01 | 0.74 | 0.00 | 12.67 | 12.68 |
| | 1600 | non-peak | 0.00 | 0.37 | 0.00 | 12.67 | 12.67 |

**Table 7.12 Panki Pumping Station (3/4)**

| | | |
|---|---|---|
| Pump efficiency | 0.82 | |
| Motor efficiency | 0.91 | |
| Cost of electricity | 3.1 | Rs/kwH |

| | Dia of rising main mm | flow condition | Actual pumping hours | Total head m | Flow m3/s | Power required by each pump kw | Power required by motor kw | Total power consummed per day kwh | Daily energy cost Rs | Annual Energy Cost Rs |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1200 | peak | 3.94 | 12.85 | 2.96 | 56.88 | 62.50 | 1,971 | 6,110 | |
| | 1200 | average | 11.82 | 12.72 | 1.48 | 56.30 | 61.87 | 2,926 | 9,071 | |
| | 1200 | non-peak | 7.88 | 12.68 | 0.74 | 56.14 | 61.69 | 973 | 3,015 | |
| | | | | | | | | | 18,196 | 6,641,421 |
| 2 | 1400 | peak | 3.94 | 12.75 | 2.96 | 56.46 | 62.04 | 1,956 | 6,064 | |
| | 1400 | average | 11.82 | 12.69 | 1.48 | 56.18 | 61.74 | 2,920 | 9,052 | |
| | 1400 | non-peak | 7.88 | 12.68 | 0.74 | 56.11 | 61.65 | 972 | 3,013 | |
| | | | | | | | | | 18,130 | 6,617,302 |
| 3 | 1600 | peak | 3.94 | 12.71 | 2.96 | 56.27 | 61.84 | 1,950 | 6,045 | |
| | 1600 | average | 11.82 | 12.68 | 1.48 | 56.13 | 61.68 | 2,917 | 9,044 | |
| | 1600 | non-peak | 7.88 | 12.67 | 0.74 | 56.09 | 61.64 | 972 | 3,013 | |
| | | | | | | | | | 18,101 | 6,606,992 |

**Table 7.12 Panki Pumping Station (4/4)**

| | | |
|---|---|---|
| Length of rising main | 30 | m |
| Pump cost | 36000 | Rs/Kw |
| Pump design period | 15 | years |
| Pipeline Design period | 30 | years |
| Pipeline Maintenance cost | 0.25% | |
| Pump Maintenance cost | 3% | |
| Capital discount factor | 5% | |

| | Diameter mm | Cost of pumps | Cost of pipe | Annual Pipeline maintenance | Pump maintenance | Energy charges | Total | Present Value of annual recurring cost | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1200 | 31,351,527 | 551,952 | 1,380 | 940,546 | 6,641,421 | 7,583,346 | 78,712,542 | 110,616,021 |
| 2 | 1400 | 31,196,539 | 668,716 | 1,672 | 935,896 | 6,617,302 | 7,554,870 | 78,416,965 | 110,282,220 |
| 3 | 1600 | 31,130,289 | 804,537 | 2,011 | 933,909 | 6,606,992 | 7,542,912 | 78,292,850 | 110,227,675 |

assume PSC pipe

## Table 7.14 Ruman Pumping Station (1/4)

**Average flow** 66 mld

| | Condition | Flow factor | Hours | Total flow m3 | no. of pumps | Calculated discharge lps | Proposed discharge | actual hours of pumping |
|---|---|---|---|---|---|---|---|---|
| 1 | peak | 2 | 4 | 22000 | 8 | 200 | 200 | 3.82 |
| 2 | Average | 1 | 12 | 33000 | 4 | 200 | 200 | 11.46 |
| 3 | non-peak | 0.5 | 8 | 11000 | 2 | 200 | 200 | 7.64 |
| | | | 24 | 66000 | | | | 22.92 |

## Table 7.14 Ruman Pumping Station (2/4)

| | | | | | | |
|---|---|---|---|---|---|---|
| Length of rising main | 4200 | m | | | | |
| Friction factor C | 110 | | $Hf = 10.7\ Q^{1.85} L / C^{1.85}\ D^{4.87}$ | | | |
| minor losses | 10% | | | | | |
| Static head | 16 | m | | | | |
| Peak flow | 1.600 | m3/s | sump volume | 480 | m3 |
| Average flow | 0.8 | m3/s | diameter | 14.00 | |
| non-peak flow | 0.4 | m3/s | depth | 3.12 | |

| | Dia of rising main | flow condition | Head loss in rising main | Velocity | minor losses | static head | total head |
|---|---|---|---|---|---|---|---|
| | mm | | m | m/s | m | m | m |
| 1 | 1000 | peak | 17.93 | 2.04 | 1.79 | 15.62 | 35.35 |
| | 1000 | average | 4.97 | 1.02 | 0.50 | 15.62 | 21.09 |
| | 1000 | non-peak | 1.38 | 0.51 | 0.14 | 15.62 | 17.14 |
| 2 | 1200 | peak | 7.38 | 1.41 | 0.74 | 15.62 | 23.74 |
| | 1200 | average | 2.05 | 0.71 | 0.20 | 15.62 | 17.87 |
| | 1200 | non-peak | 0.57 | 0.35 | 0.06 | 15.62 | 16.24 |
| 3 | 1400 | peak | 3.48 | 1.04 | 0.35 | 15.62 | 19.45 |
| | 1400 | average | 0.97 | 0.52 | 0.10 | 15.62 | 16.68 |
| | 1400 | non-peak | 0.27 | 0.26 | 0.03 | 15.62 | 15.91 |

**Table 7.14 Ruman Pumping Station (3/4)**

| | | |
|---|---|---|
| Pump efficiency | 0.82 | |
| Motor efficiency | 0.91 | |
| Cost of electricit | 3.1 | Rs/kwH |

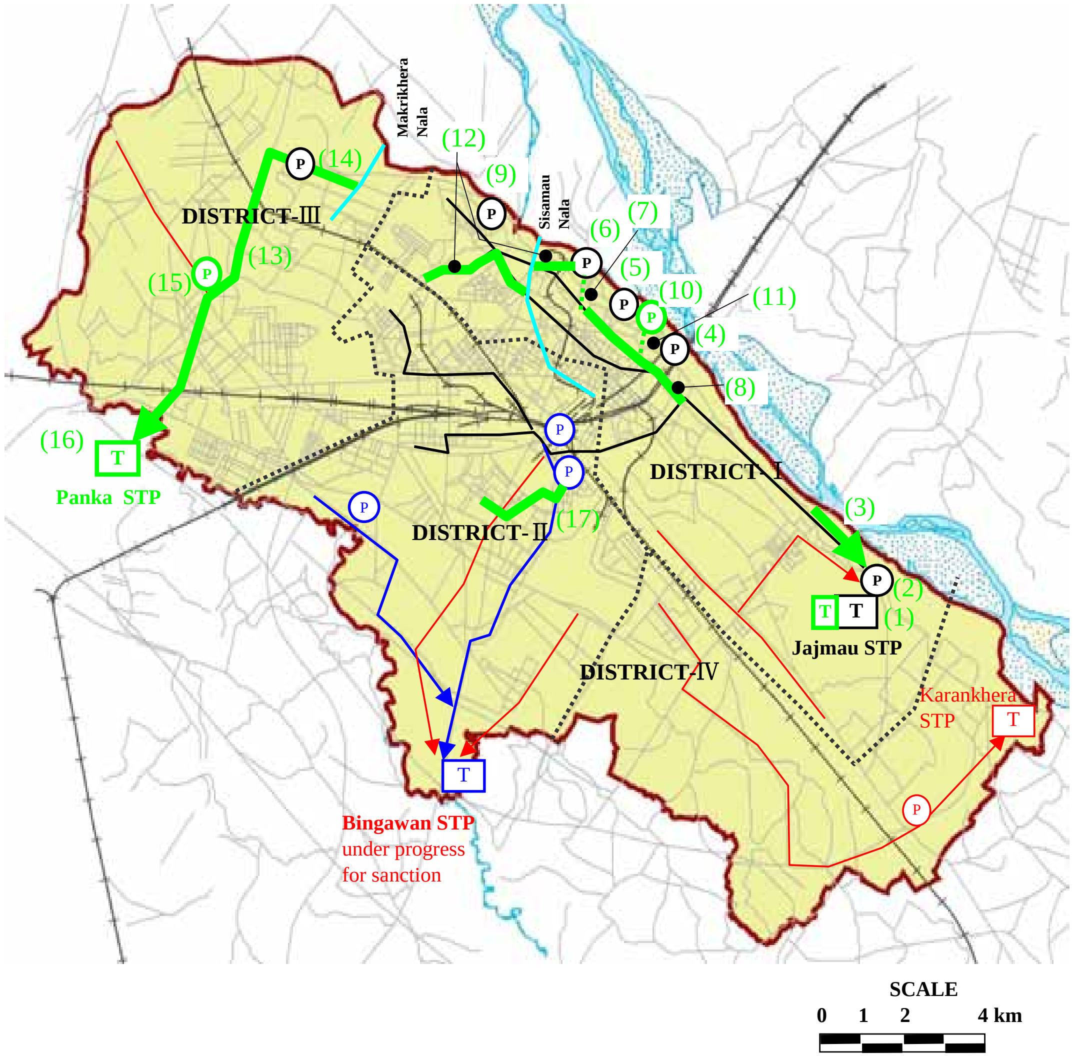
| | Dia of rising main mm | flow condition | Actual pumping hours | Total head m | Flow m3/s | Power required by each pump kw | Power required by motor kw | Total power consummed per day kwh | Daily energy cost Rs | Annual Energy Cost Rs |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1000 | peak | 3.82 | 35.35 | 1.60 | 84.57 | 92.93 | 2,840 | 8,803 | |
| | 1000 | average | 11.46 | 21.09 | 0.80 | 50.46 | 55.45 | 2,542 | 7,879 | |
| | 1000 | non-peak | 7.64 | 17.14 | 0.40 | 41.00 | 45.06 | 688 | 2,134 | |
| | | | | | | | | | 18,816 | 6,867,814 |
| 2 | 1200 | peak | 3.82 | 23.74 | 1.60 | 56.79 | 62.41 | 1,907 | 5,912 | |
| | 1200 | average | 11.46 | 17.87 | 0.80 | 42.76 | 46.99 | 2,154 | 6,676 | |
| | 1200 | non-peak | 7.64 | 16.24 | 0.40 | 38.86 | 42.71 | 652 | 2,023 | |
| | | | | | | | | | 14,610 | 5,332,751 |
| 3 | 1400 | peak | 3.82 | 19.45 | 1.60 | 46.54 | 51.14 | 1,563 | 4,844 | |
| | 1400 | average | 11.46 | 16.68 | 0.80 | 39.91 | 43.86 | 2,010 | 6,232 | |
| | 1400 | non-peak | 7.64 | 15.91 | 0.40 | 38.07 | 41.84 | 639 | 1,982 | |
| | | | | | | | | | 13,058 | 4,766,005 |

**Table 7.14 Ruman Pumping Station (4/4)**

| | | |
|---|---|---|
| Length of rising main | 4200 | m |
| Pump cost | 36000 | Rs/Kw |
| Pump design period | 15 | years |
| Pipeline Design period | 30 | years |
| Pipeline Maintenance cost | 0.25% | |
| Pump Maintenance cost | 3% | |
| Capital discount factor | 5% | |

| | Diameter mm | Cost of pumps | Cost of pipe | Annual Pipeline maintenance | Pump maintenance | Energy charges | Total | Present Value of annual recurring cost | Total Cost |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1000 | 37,994,616 | 58,522,996 | 146,307 | 1,139,838 | 6,867,814 | 8,153,960 | 84,635,318 | 181,152,929 |
| 2 | 1200 | 27,815,147 | 77,273,328 | 193,183 | 834,454 | 5,332,751 | 6,360,389 | 66,018,663 | 171,107,138 |
| 3 | 1400 | 24,056,878 | 93,620,274 | 234,051 | 721,706 | 4,766,005 | 5,721,762 | 59,389,930 | 177,067,082 |

assume PSC pipe




## Priority Project

| No. | Item | Description | |
|---|---|---|---|
| DISTRICT I | | | |
| (1) | Jajmau STP | Renovat/Augmen | ASP unit, 43.3 mld augmentation |
| (2) | Jajmau SPS | Rehab/Renovat. | |
| (3) | Domestic lateral sewer in Jajmau tannery area | New | Approximately 3.0 km |
| (4) | Guptar ghat SPS | Rehab. | |
| (5) | Muir mill SPS | Rehab. | |
| (6) | Parmat SPS | Rehab. | |
| (7) | Rising main | New | Approximately 1.0 km |
| (8) | Relief sewer | New | Approximately 4.5 km |
| (9) | Nawabganj SPS | Rehab. | |
| (10) | Bhagwatdas ghat nala SPS | New | Capacity 8 mld (avg) |
| (11) | Rising main | New | Approximately 1.0 km |
| (12) | Trunk sewer | Replacment | Approximately 3.5 km |
| DISTRICT III | | | |
| (13) | Trunk sewer | New | Approximately 10.0 km |
| (14) | Lakhanpur SPS | Reconstruction | |
| (15) | Panki SPS | New | Capacity (50 - 80) mld (avg) |
| (16) | Panka STP | New | Capacity (60 - 120) mld (avg) |
| DISTRICT II | | | |
| (17) | Trunk sewer | Replacment | Approximately 5.0 km |

LEGEND

- Municipal boundary
- District boundary
- Sewer
- Rising main
- P Pumping station
- T Treatment Plant

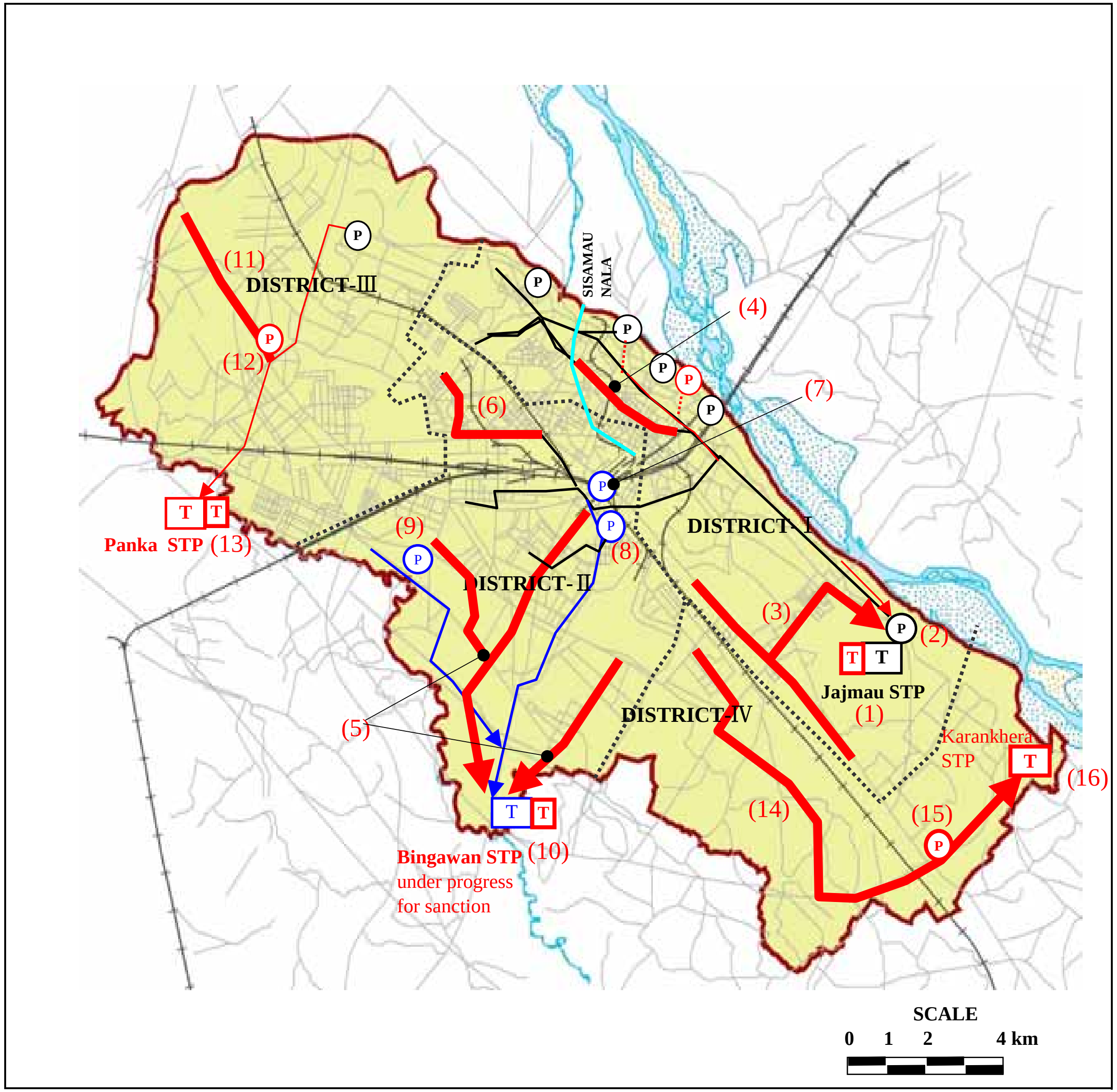
NOTE:

- P T : Existing Facility
- P T : Sanctioned Facility
- P T : Proposed Facility
- P T : F/S Components Proposed Facility

**SEWERAGE MASTER PLAN IN KANPUR CITY**

**FIGURE 7.1**

**Proposed Collection & Treatment capacity (2015)**




## Projects

| No. | Item | | Description |
|---|---|---|---|
| DISTRICT I | | | |
| (1) | Jajmau STP | Upgrde/Augment | UASB 16 mld and ASP 10 |
| (2) | Jajmau SPS | Upgrde/Augment | |
| (3) | Trunk sewer | New | |
| (4) | Trunk sewer | Replacmnt | |
| DISTRICT II | | | |
| (5) | Trunk sewer | New | |
| (6) | Trunk sewer | Replacment | |
| (7) | Rahkimandi SPS | Upgrde/Augment | |
| (8) | Munshipurwa SPS | Upgrde/Augment | |
| (9) | Ganda nala SPS | Upgrde/Augment | |
| (10) | Bingawan STP | Augment | Capacity 165 mld (avg) |
| DISTRICT III | | | |
| (11) | Trunk sewer | New | |
| (12) | Panki SPS | Augment | |
| (13) | Panka STP | Augment | Capacity 80 mld (avg) |
| DISTRICT IV | | | |
| (14) | Trunk sewer | New | |
| (15) | Ruman SPS | New | |
| (16) | Karankhera STP | New | Capacity 85 mld (avg) |

LEGEND

- Municipal boundary
- District boundary
- Sewer
- Rising main
- P Pumping station
- T Treatment Plant

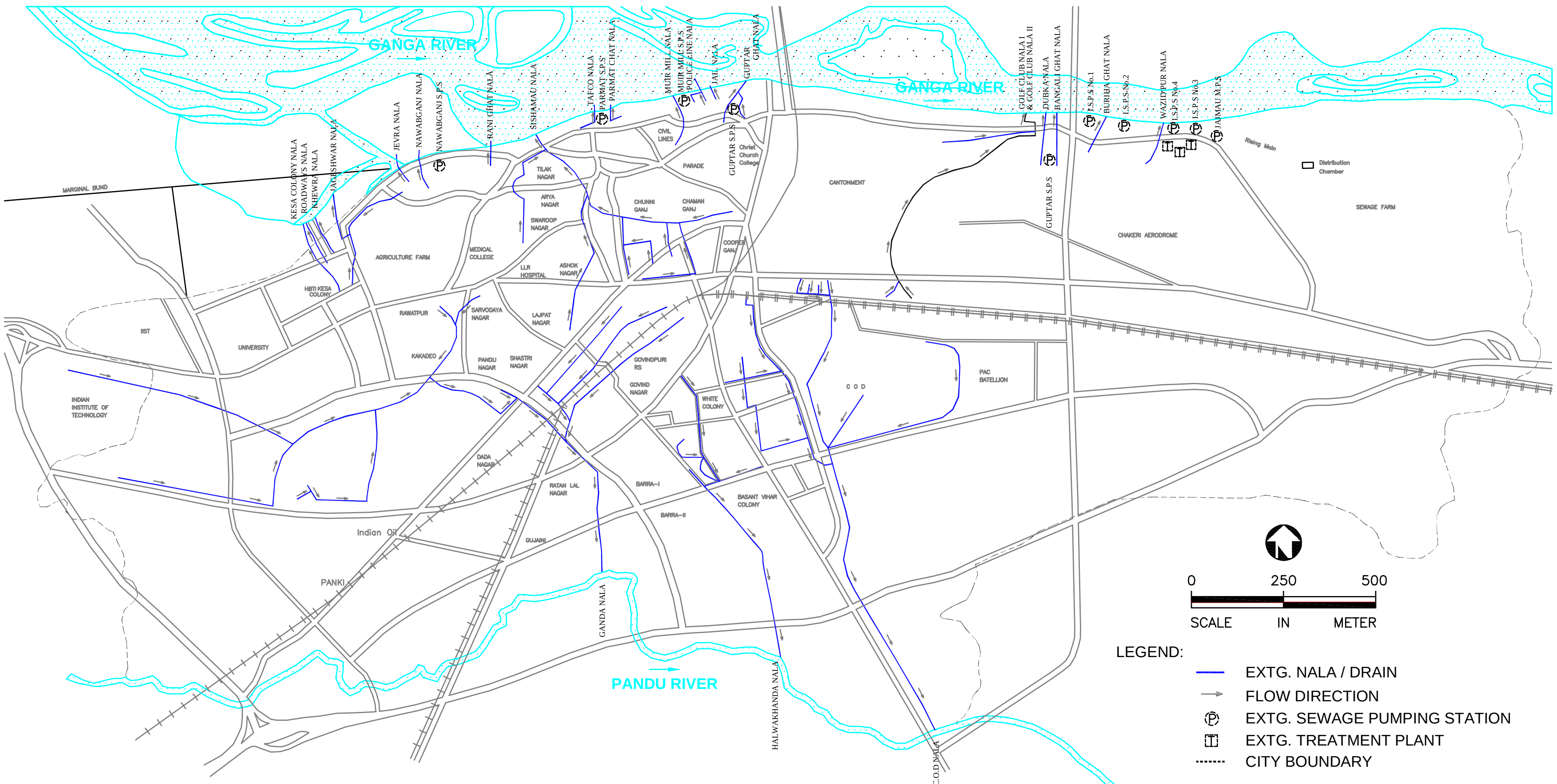
NOTE:

- P T : Existing Facility
- P T : Sanctioned Facility
- P T : Proposed Facility

**SEWERAGE MASTER PLAN IN KANPUR CITY**

**FIGURE 7.2**

**Proposed Collection & Treatment capacity (2030)**




| No. | NAME OF NALA | DISCHARGE (MLD) | LENGTH (KM) | REMARK |
|---|---|---|---|---|
| 1. | KESA COLONY NALA | 0.16 | 3.00 | Tapped through sewer to Nawabganj S.P.S |
| 2. | ROADWAYS COLONY NALA | 0.40 | - | Tapped through sewer to Nawabganj S.P.S |
| 3. | KHEORA NALA | 0.14 | 2.00 | Tapped into Septic Tank |
| 4. | JAGESHWAR NALA | 0.92 | 0.70 | Tapped through sewer to Nawabganj S.P.S |
| 5. | JEWRA NALA | 0.79 | 1.50 | Tapped through sewer to Nawabganj S.P.S |
| 6. | NAWABGANJ NALA | 1.66 | - | Tapped through sewer to Nawabganj S.P.S |
| 7. | RANIGHAT NALA | 0.43 | 1.40 | Tapped through sewer to Nawabganj S.P.S |
| 8. | SISAMAU NALA | 138.33 | 6.30 | Proposed to be tapped under GAP-II |
| 9. | TAFCO NALA | 0.43 | 1.80 | Tapped through sewer to Parmat S.P.S |
| 10. | PARMATGHAT NALA | 1.78 | 21.80 | Tapped through sewer to Parmat S.P.S |
| 11. | MUIR MILL NALA | 3.13 | - | Tapped into Muir Mill sewage pumping station |
| 12. | POLICE LINE NALA | 0.79 | - | Tapped through sewer to Parmat S.P.S |

NOTE: Date of Discharge Measurement 9/10.5.2003

| No. | NAME OF NALA | DISCHARGE (MLD) | LENGTH (KM) | REMARK |
|---|---|---|---|---|
| 13. | JAIL NALA | 1.22 | 0.60 | Tapped through sewer to Parmat S.P.S |
| 14. | GUPTARGHAT NALA | 2.29 | 1.30 | Tapped through sewer to Guptar S.P.S |
| 15. | GOLF CLUB NALA I | 1.26 | - | Tapped through sewer to Jajmau S.P.S |
| 16. | GOLF CLUB NALA II | 0.40 | 2.00 | Tapped through sewer to Jajmau S.P.S |
| 17. | DUBKA NALA | - | 0.93 | Tapped into Intermediate pumping station No.1 under GAP Ph-I. |
| 18. | BANGALIGHAT NALA | - | 3.60 | Tapped into Intermediate pumping station No.2 under GAP Ph-I. |
| 19. | BURIAHGHAT NALA | - | 0.70 | Tapped into Intermediate pumping station No.3 under GAP Ph-I. |
| 20. | WAZIDPUR NALA | - | 2.90 | Tapped into Intermediate pumping station No.4 under GAP Ph-I. |
| 21. | GANDA NALA | 55.09 | 13.50 | Proposed to be tapped under GAP-II |
| 22. | HALWA KHANDA NALA | 11.44 | 6.60 | Proposed to be tapped under GAP-II |
| 23. | COD NALA | 8.81 | 6.20 | Proposed to be tapped under GAP-II |

NOTE: Date of Discharge Measurement 9/10.5.2003

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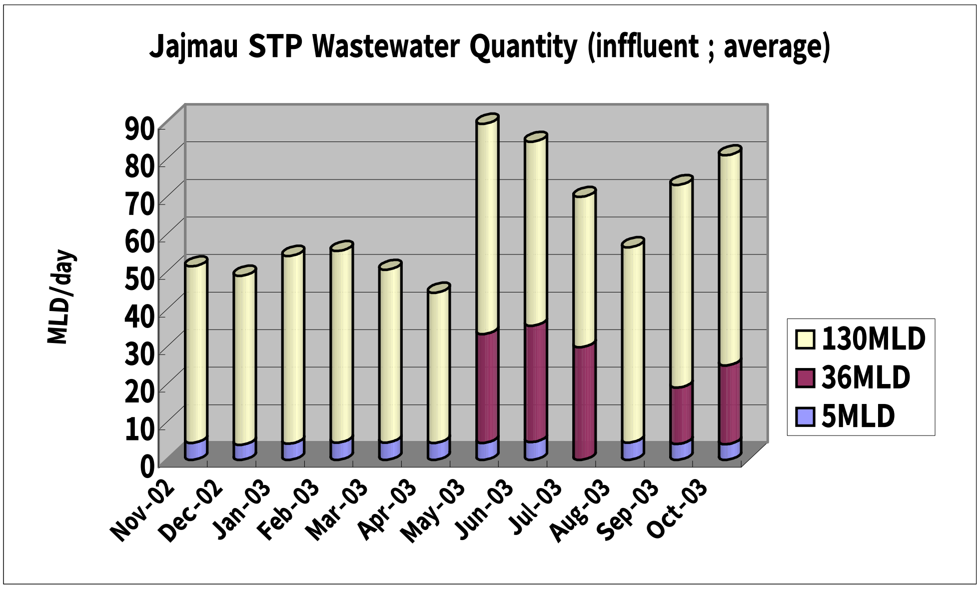
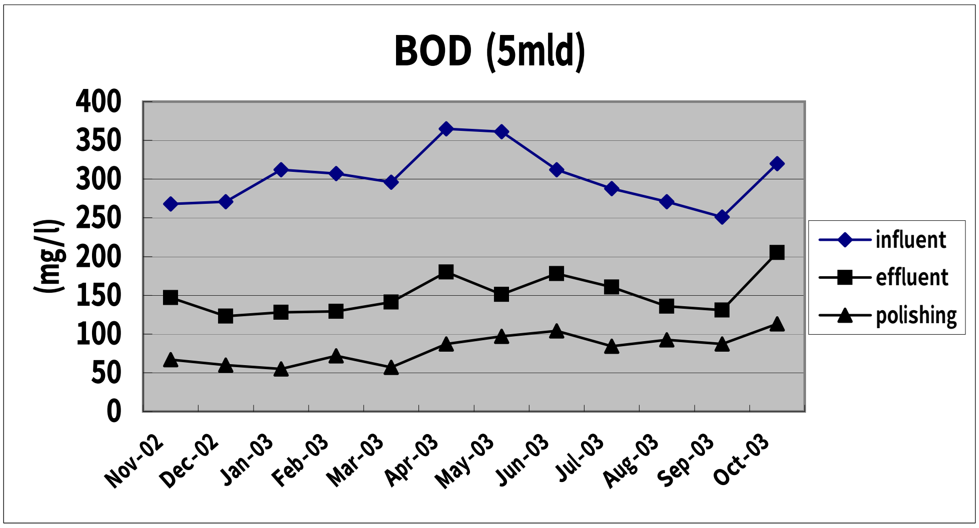
CTI ENGINEERING INTERNATIONAL CO., LTD.

| PROJECT | LOCATION | FIGURE 7.3 |
|---|---|---|
| THE STUDY ON WATER QUALITY MANAGEMENT PLAN FOR GANGA RIVER IN THE REPUBLIC OF INDIA | KANPUR CITY | LOCATION MAP FOR NALA |



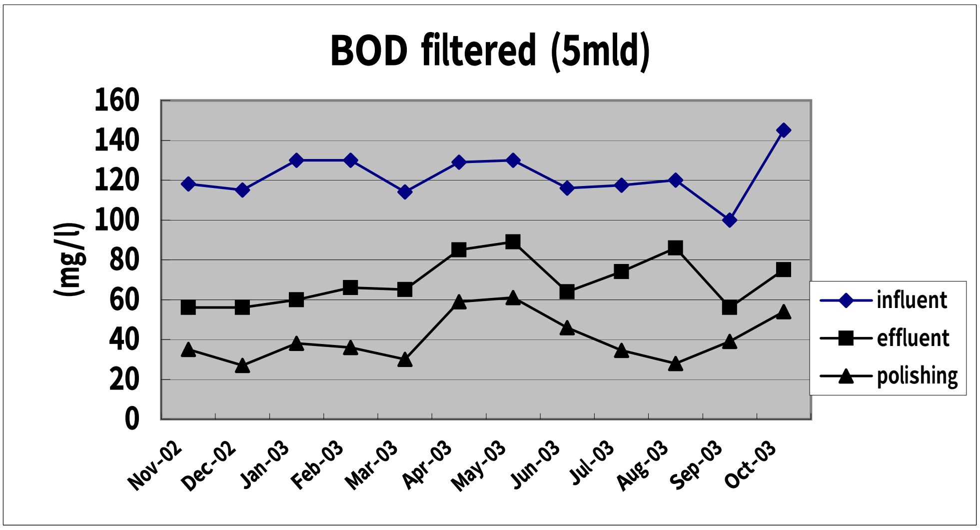
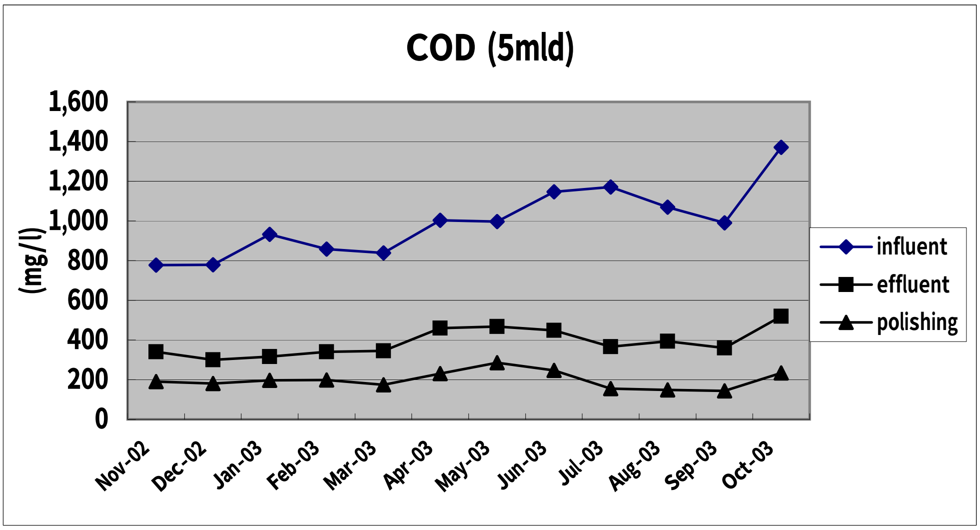
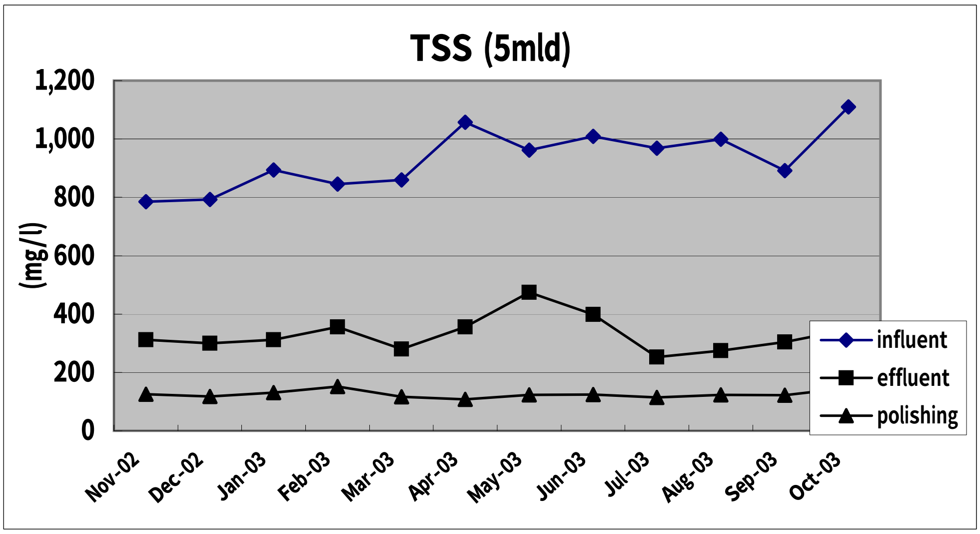




**Figure 7.4 Jajmau STP: Average Monthly Inflow and Effluent Characteristics(1/6)**



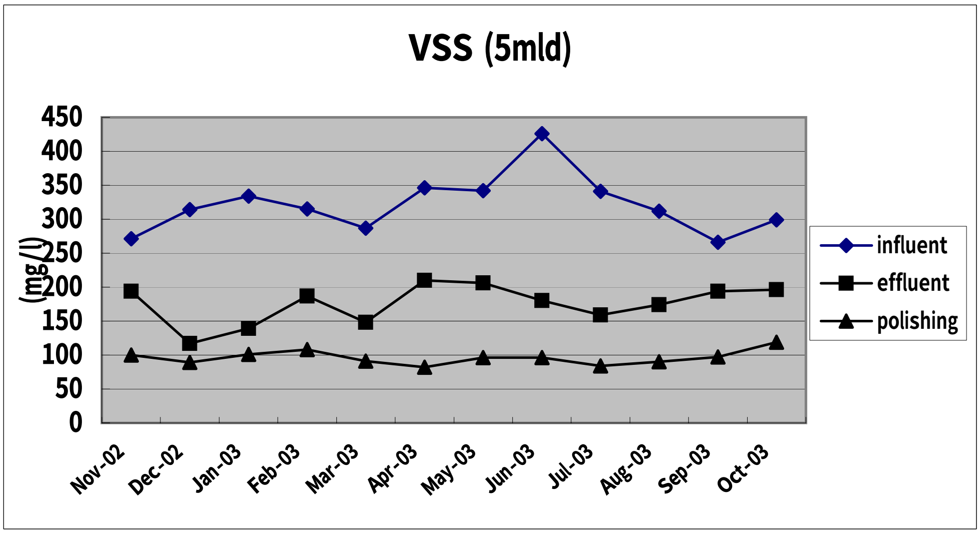
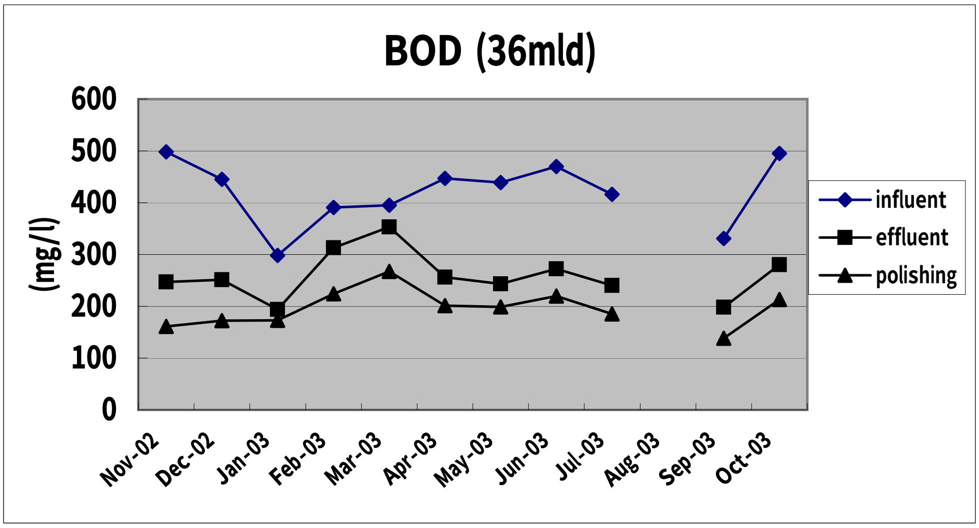
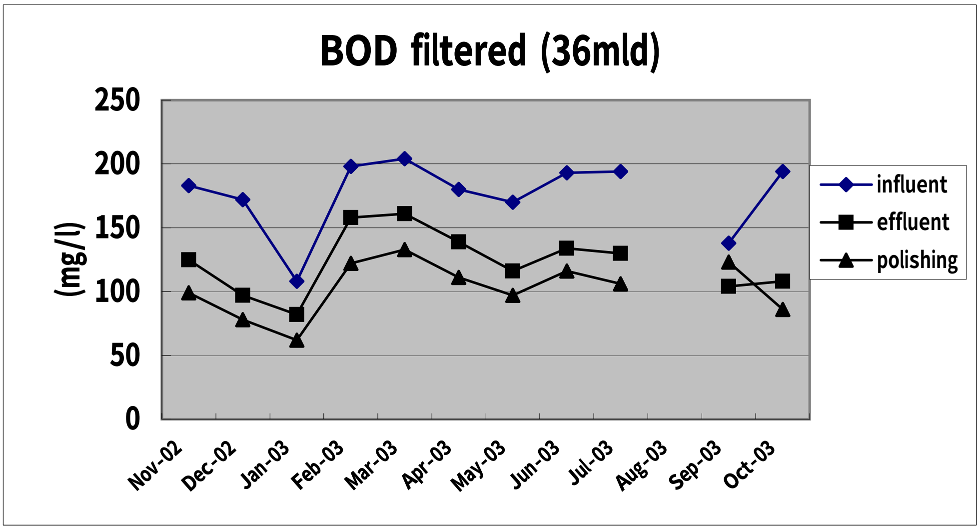




**Figure 7.4 Jajmau STP: Average Monthly Inflow and Effluent Characteristics(2/6)**



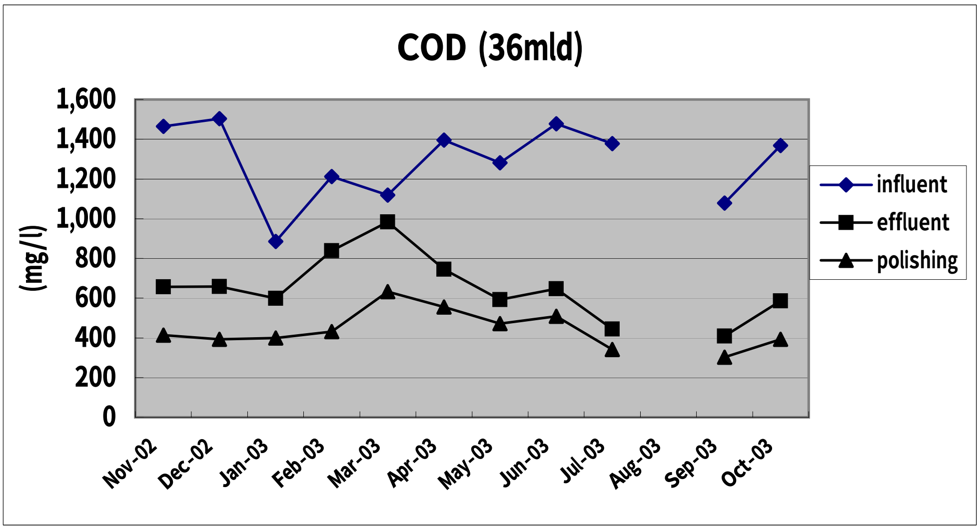
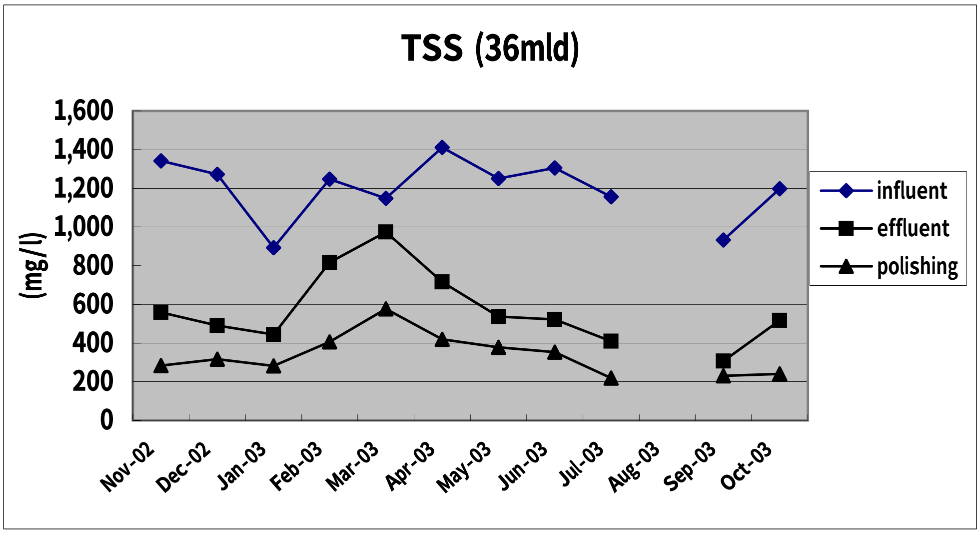




**Figure 7.4 Jajmau STP: Average Monthly Inflow and Effluent Characteristics(3/6)**



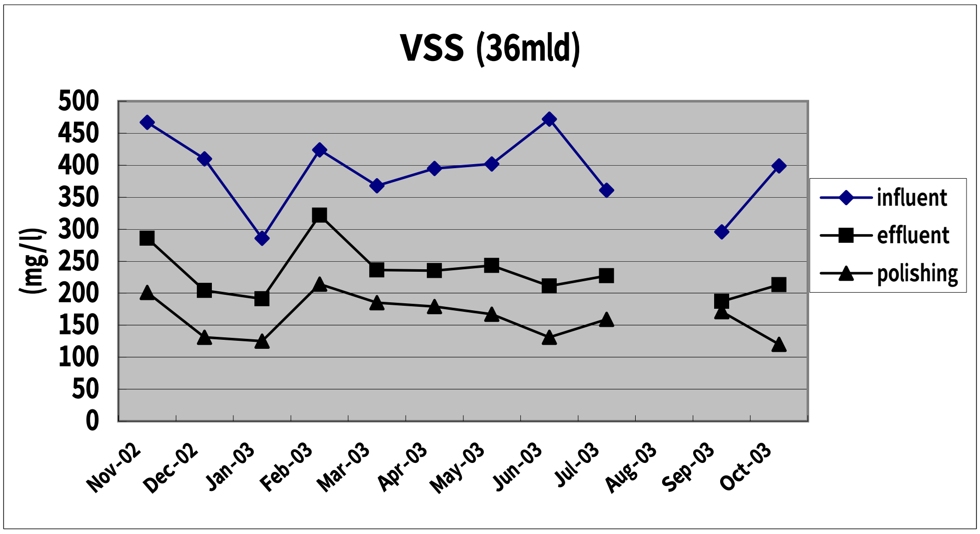
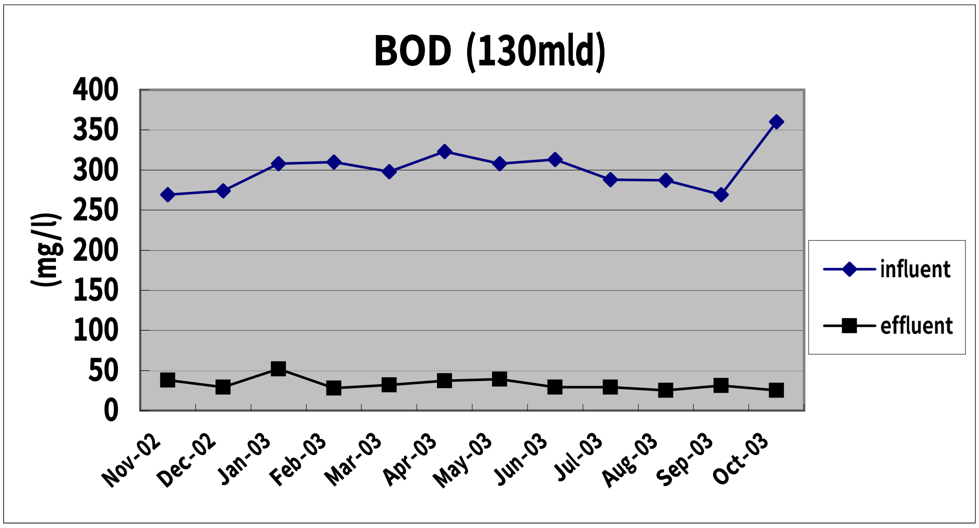
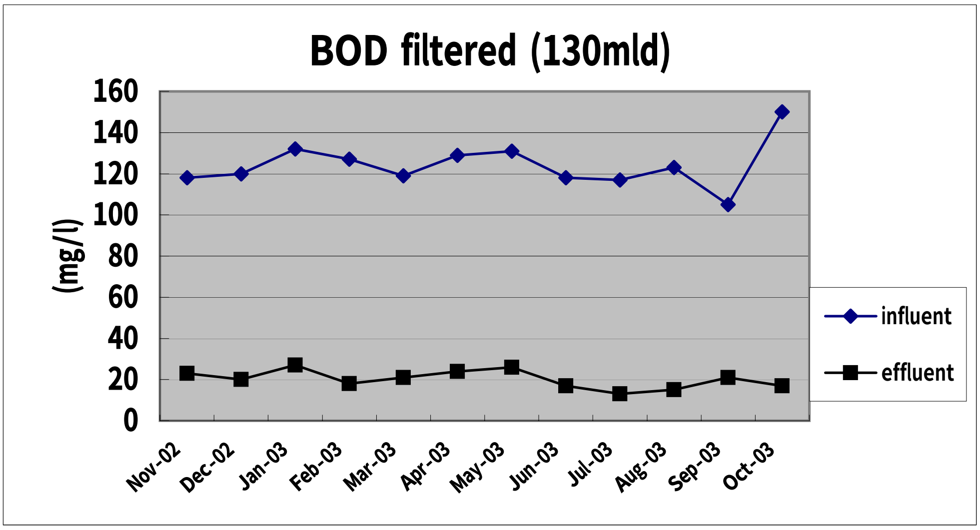




**Figure 7.4 Jajmau STP: Average Monthly Inflow and Effluent Characteristics(4/6)**



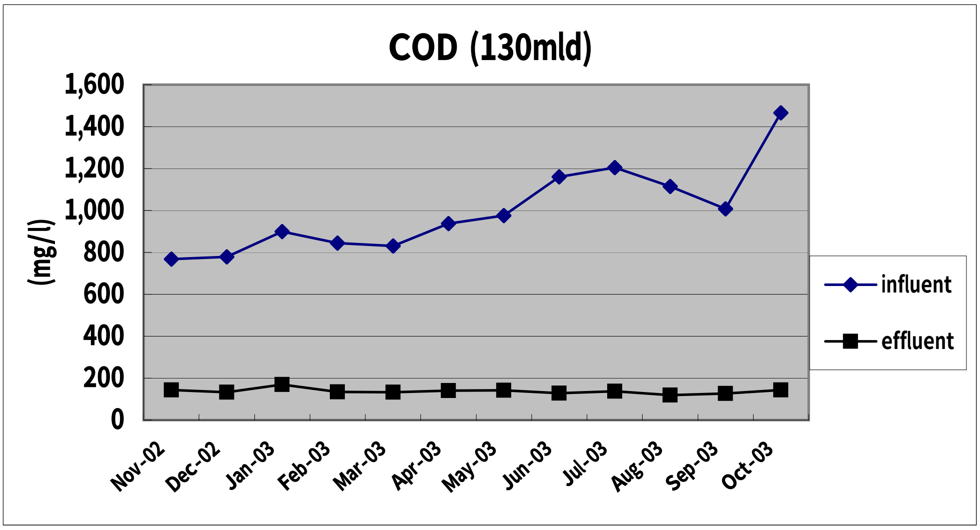
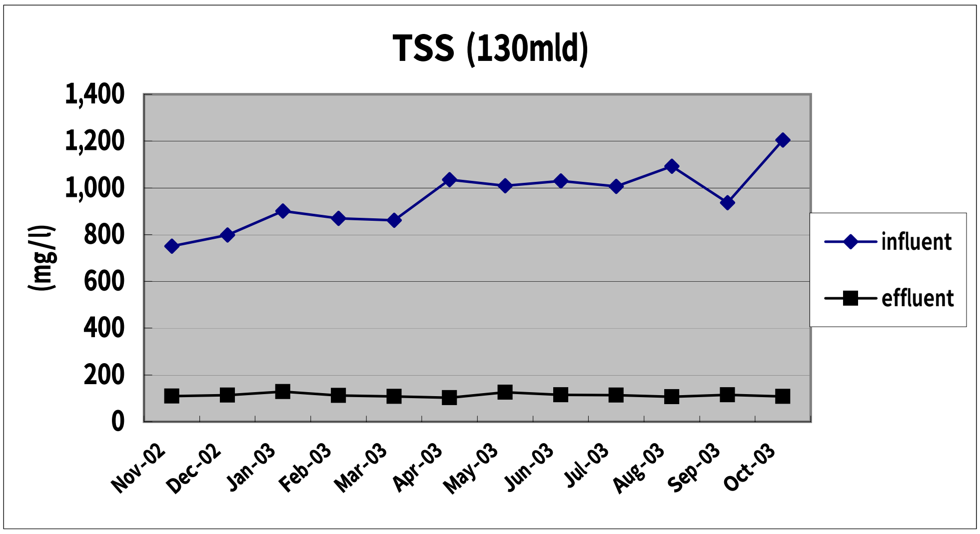




**Figure 7.4 Jajmau STP: Average Monthly Inflow and Effluent Characteristics(5/6)**



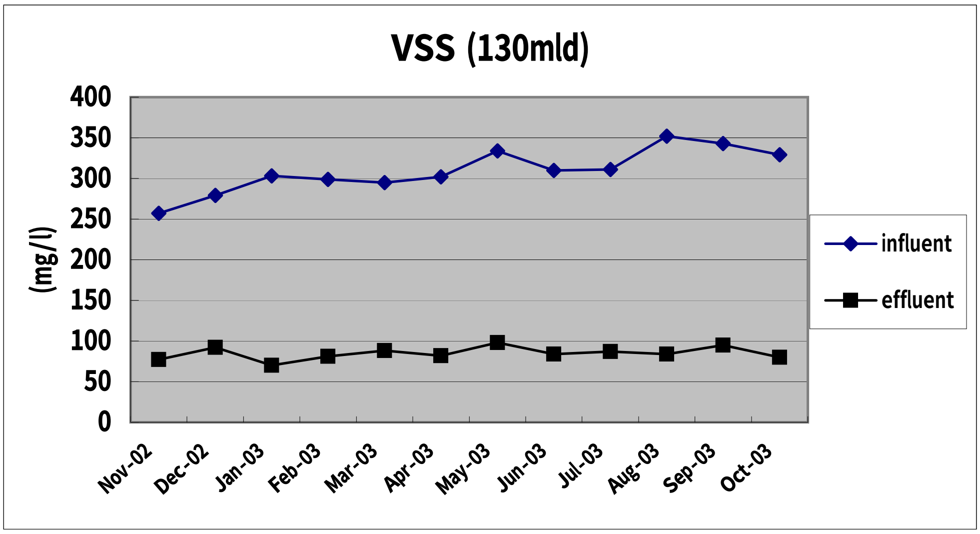




**Figure 7.4 Jajmau STP: Average Monthly Inflow and Effluent Characteristics(6/6)**

# CHAPTER 8

## IMPLEMENTATION STRATEGY AND PHASING

# CHAPTER 8 IMPLEMENTATION STRATEGY AND PHASING

A number of options were evaluated in Chapter 6 leading to the selection of a recommended plan. The details of the sewerage infrastructure, location, capacity, and type of treatment process were determined in Chapter 7. This section of the Master Plan identifies the implementation strategy and recommends priorities. It also identifies the required infrastructure components, along with implementation phases.

## 8.1 OVERALL STRATEGY

Sewerage will be developed gradually, with a series of interventions implemented in a phased approach. Although the time line to full build out cannot be predicted with any certainty, and may not happen within the 2030 planning horizon, it is assumed that all the improvements will take place within the planning horizon. The implementation of sewerage over the planning horizon has been divided into two stages:

- Stage I: immediate interventions required by 2015
- Stage II: continuing long-term development of sewerage 2016 to 2030

### 8.1.1 Stage I

The following projects have been identified as critical needs and should be implemented within one to five years following the adoption of the Master Plan:

- Augmentation of existing treatment works
- Construction of new treatment plants
- Interception of all drains and diversion to treatment
- Major trunk sewers and pumping stations required to service densely populated areas and convey sewage to treatment works.
- Cleaning and rehabilitation of existing sewers
- Capacity building for project implementation organization
- Capacity building of O&M organizations for sewers and treatment plants

The second phase of improvements will be the development of sewerage as a foundation for long-term growth. Projects are aimed at extending trunk sewer facilities and increasing sewer connection rates to improve health, sanitation and living environment.

Projects in the second part of Stage I are considered a priority and should be implemented between 2011 and 2015. Projects will generally consist of:

- Reorganization of existing trunk sewers to divert sewage to new treatment works
- The extension of trunk sewers in all areas of the city that do not have adequate sewerage infrastructure
- Improving branch sewers in existing sewered areas
- Development of branch sewers in formerly unserviced areas
- An on-going program of house connections to increase amount of wastewater collected and treated
- Removing informal connections of storm drains to the sewer system
- Disconnecting informal connections of branch sewers to storm drains.
- On-going capacity building for O&M organizations

### 8.1.2 Stage II

Stage II projects implemented beyond 2015 are required to service population growth in new areas. These projects will generally include:

- Additional trunk sewers in new growth areas
- Replacement pumping equipment and/or augmentation of pumping capacity
- Augmentation of capacity at treatment plants to handle increased flows over the planning horizon.
- On-going program for development of branch sewers and improving house connections ratios.

## 8.2 TIMING FOR IMPLEMENTATION OF SEWERAGE COMPONENTS

District wise delineation of the sewerage scheme is presented in Chapter 7 Figure 7.1 for 2015 and Figure 7.2 for 2030. The overall scheme will consist of 4 separate sewerage districts each with its own treatment plant.

### 8.2.1 Treatment Plants

Treatment plants for each district have been selected on the basis of cost comparisons and technology options for meeting required effluent standards. Capacities are for full build out conditions in 2030.

**Table 8.1 Phase wise Implementation of Treatment Plant Capacity**

(mld)

| STP | District | Status | 2003 | 2015 | 2030 |
|---|---|---|---|---|---|
| Jajmau tannery | I | E/A | 36 | 52 | 52 |
| Jajmau domestic | I | E /A | 130+5 | 173+5 | 183+5 |
| Bingawan STP | II | S /A | - | 200 | 365 |
| Panka STP | III | P | - | 120 | 200 |
| Karankhera STP | IV | P | - | 0 | 85 |
| Total | | | 171 | 550 | 890 |

| STP | District | Process | Effluent discharge | Disinfection |
|---|---|---|---|---|
| Jajmau tannery | I | UASB | Irrigation and Ganga River | |
| Jajmau Domestic | I | AS, UASB(Pilot) | Irrigation and Ganga River | Add chlorination or maturation ponds |
| Bingawan STP | II | UASB++ | Irrigation or Pandu River | Chlorination |
| Panka STP | III | UASB++ | Irrigation or Pandu River | Chlorination |
| Karankhera STP | IV | UASB++ | Irrigation or Ganga River | Chlorination or maturation ponds |

++ indicates the addition of post treatment by aeration.

### 8.2.2 Collection System Components

Proposed trunk sewers, pumping stations and preliminary alignments are presented in layout drawings B4 to B9 Appendix B. The drawings also identify tributary areas used to calculate hydraulic capacity of trunk sewers. A phase wise summary for implementation of sewerage system infrastructure improvements is presented in Table 8.2.

**Table 8.2 Phase wise Implementation of Collection System Improvements**

| Implementation period | Pumping stations | Trunk sewers/ Rising mains | Lateral and branch sewers |
|---|---|---|---|
| Stage I ( - 2015) | Upgrade equipment and augment capacity:<br>▪ Jajmau Main PS<br>▪ Parmat PS<br>▪ Nawab ganj SPS<br>▪ Muir mill SPS<br>▪ Guptar ghat PS<br>▪ Lakhanpur SPS<br><br>New pumping station:<br>▪ Bhagwatdas ghat nala SPS<br>▪ PankiSPS | Rehabilitate and replace:<br>▪ Old trunk sewers in District I, city center<br><br>New trunk sewers:<br>▪ District III | District I<br>District III |
| Stage II ( - 2030) | New pumping station<br>▪ Ruman SPS<br><br>Upgrade equipment and augment capacity:<br>▪ Jajmau Main SPS<br>▪ Panki SPS<br>▪ Ganda nala SPS<br>▪ Rakhi Mandi SPS<br>▪ Munshi Purwa SPS | New trunk sewers<br>▪ Districts II, IV | On-going III<br>District II, IV |

### 8.2.3 Discussion

(1) District I

Most of the existing trunk sewers in the city center are overloaded and do not have sufficient carrying capacity for future populations. These sewers can either be paralleled or replaced by larger pipes in areas that are congested. Furthermore, many sewers are probably in poor condition and in need of cleaning or repairs.

The existing treatment plants in Jajmau are at present not receiving sufficient domestic wastewater flow that is slightly less than 50% of their design flow. The collection system should be improved in order to fully utilize the existing treatment capacity.

Tannery wastewater flows have already increased from 9 mld to 13 mld. Furthermore, additional flows will be diverted to the UASB by the Project to isolate the collection system in Jajmau tannery district. In order to achieve the correct dilution factor of 1:3 the treatment plant should be augmented from 36 mld to 52 mld. Augmentation of the UASB treatment plant is included for Stage I.

Expansion of the activated sludge treatment plant is included during Stage I. The existing capacity of 130 mld is insufficient to handle projected domestic wastewater flows from the city center well beyond 2015. The timing for expanding the activated sludge treatment plant will depend on how much growth, if any, will take place in the area around Jajmau.

The catchment area for the 90” outfall sewer is at present being reconfigured (reduced in size) to limit the ultimate flow to 168 mld, thereby matching the maximum carrying capacity. The outfall pipe need not be replaced. However its condition should be confirmed and if necessary it should be cleaned and repaired.

Existing pumping stations are more than 20 years old and the mechanical/electrical equipment should be replaced. Other improvements may also be necessary and should be identified and planned in more detail during subsequent studies.

(2) District II

Many improvements are already being implemented by UPJN under Indo-Dutch assistance program. Sewage projections indicate that the treatment plant will need to be augmented in Stage II (after year 2015) assuming that most of the wastewater will not be intercepted by sewer because of slow implementation of wastewater collection system in this district. The outfall pipe being constructed at present has a carrying capacity of 300 mld. It will be able to convey projected wastewater loads after year 2015, but additional trunk sewers will be required to service the South District and convey sewage directly to the treatment plant before year 2030.

(3) District III

Sewerage in District III is urgently required because UPJN is at present providing water supply infrastructure that will add an extra 200 mld. Combined with rapid population growth in this area, the amount of wastewater is expected to increase significantly. Therefore the treatment plant, main north south trunk sewer and pumping station should be implemented as early as possible.

(4) District IV

Sewerage in District IV is less urgent. Except for a few colonies, population density in the area is less than 120 persons per hectare. Trunk sewers and the treatment plant at Karankhera can be implemented sometime after 2015. The exact timing will depend on growth trends.

## 8.3 PRIORITY PROJECTS

The sewerage system is required to improve sanitary conditions in the city with the goal of removing wastewater from open drains and improving water quality in water bodies. In the beginning, priority should be given to developing sewerage in areas upstream of water supply intake.

Development of sewerage should then follow in the downstream direction with priority given to diverting sewage away from the rivers and improving services in the most densely populated areas. Finally sewerage should be implemented in new growth areas.

The timing of any sewerage development will depend on actual population growth and growth patterns. It is also essential that sewerage development be integrated with development of water supply. Installation of sewers in areas where water distribution is inadequate will lead to failure of the system. Delayed installation of sewers in areas that have adequate water supplies will lead to discharge of sewage to drains and pollution of the environment.

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.

*Priority projects* (listed in order of priority):

1) Develop a plan and identify the cost for inspection of existing trunk sewers and the 90" outfall sewer to Jajmau.

2) Feasibility study to isolate the domestic wastewater collection system in the Jajmau tannery area and treat it at the UASB along with industrial wastewater (to protect the activated sludge process).

3) Feasibility of augmenting the treatment capacity at Jajmau activated sludge treatment plant.

4) Field surveys to confirm alignment, and invert levels of trunk sewers that need to be replaced. Determine the feasibility of installing a parallel pipe or develop a plan for replacement in the same alignment.

5) Field surveys for the following existing pumping stations:
   - Nawab ganj
   - Muir mill
   - Parmat
   - Guptar ghat
   - Jajmau
   - Lakhanpur

6) Determine physical condition of existing mechanical, electrical equipments, rising mains and sumps. Identify repair or replacement needs. Confirm catchment areas (existing and future). Determine future flows, required size of replacement pumps and rising mains if required.

7) Field surveys for new pumping station to intercept and divert Bhagwatdas ghat Nala in Central District, confirm catchment areas (existing and future). Determine future flows, required size of civil structures, pumping plants and rising mains.

8) Feasibility of Panka treatment plant for West District. Confirm and survey site, method of treatment, method of disposal for effluent and sludge. Develop preliminary design for STP including influent pumping station.

9) Feasibility of Panka outfall sewer, Panki pumping station and main North-South trunk sewers. Confirm and survey proposed alignments, confirm size of pipes, develop profile drawings. Determine feasibility of crossing under Pandu river with gravity sewer; identify river cross section, flood levels and scouring depth. If necessary adjust conceptual trunk sewer layout based on topographic surveys. Develop preliminary designs for proposed pumping stations.

# CHAPTER 9

## COST ESTIMATES

# CHAPTER 9 COST ESTIMATES

## 9.1 CAPITAL COST ESTIMATE

### 9.1.1 General

The total estimated direct construction costs including a 20% physical contingency for planning level estimates and land acquisition are as follows:

(Crores)

| Item | Stage I | Stage II | Total |
|---|---|---|---|
| Direct Cost | 317.9 | 1,259.6 | 1,577.6 |
| Physical Contingency (20%) | 63.6 | 251.9 | 315.5 |
| Land Acquisition | 28.8 | 41.9 | 70.7 |
| Total | 410.3 | 1,553.4 | 1,963.8 |

Direct cost does not include house connection cost

Summary of preliminary direct cost is presented phase wise in Table 9.1 and the breakdown of component costs is represented in the form of a pie chart in Figure 9.1.

All costs are with 2003 base prices, in Indian Rupees. Taxes and duties vary depending on the equipment or material supplied therefore these are included in the unit costs.

The estimate of investment costs has been worked out based on a phase wise implementation plan that corresponds to priorities and timeframes discussed in the report. The following costs have been included in estimated costs for project evaluation:

| Item | Capital | O&M | Replacement |
|---|---|---|---|
| Existing facilities and Sanctioned projects (GAP-II) | X | O | O |
| Augmenting existing pumping stations and treatment plants or replacing outdated equipment | O | O | O |
| Proposed master plan projects | O | O | O |

X = not included     O = included in cost estimate

The investment costs for Stage II (2015 to 2030) include an estimate of replacement costs for mechanical/electrical equipment installed during the first phase that will have reached the end of their useful life after 15 years.

Total costs for the facilities identified in the master plan are comprised of the following items:

- Direct construction cost based on preliminary design of facilities (based on unit costs including taxes and duties) plus 10% for contractor’s profit.
- Land acquisition cost
- Engineering cost: Add 15% of direct construction cost for design and construction supervision
- Administrative costs: Add 10% of direct construction cost for centage fees related to project preparation and supervision (refer Indo-Dutch project 4% preparation + 6% admin. during construction)
- Physical contingency: add 20% to the sum of direct construction cost

### 9.1.2 Capital Costs for Trunk Sewers and Manholes

The cost estimate for laying trunk sewers and laterals has been prepared on the basis of preliminary design for Master Plan.

The estimated costs include ancillary items like excavation, reinstatement of road surfaces, provision of protection works, closed timbering, and cost of bedding. The cost per linear meter of pipe includes the cost of manholes. The cost of new trunk sewers and laterals is presented in Table 9.2. Total length of trunk sewers and laterals is approximately 133 km. The cost of trunk sewers and laterals is estimated at Rs. 4,483 million.

### 9.1.3 Capital Costs for Branch Sewers

The capital cost of branch sewers has been worked out on the basis of cost per unit length of 1,000 Rs/m (Jal Sansthan Allahabad) assuming 250mm diameter concrete pipe. The average length of branch sewer per hectare is 385 m/ha which has been worked out from a review of sewer drawings for typical colonies and urban areas.

The estimated cost of branch sewers includes cost of manholes, road reinstatement and other ancillary works. The estimated cost of branch sewers is presented in Table 9.3. The total cost of branch sewers is worked out to be Rs. 7,349 million.

### 9.1.4 Capital Costs for House Connections

The number of house connections to be made during various project years have been assessed on the basis of number of dwellings calculated from census population and family size. The number of houses connected to the wastewater collection system will reach up to 80% by the end of phase 2. The connection ratios at each phase have been identified in Section 5 “Planning Framework”.

The unit cost of house connections is taken as 7,750 Rs./connection. This unit cost is obtained from discussions with Jal Sansthan Allahabad and costs identified in Allahabad sewerage master plan adjusted to 2003 cost base using wholesale price index. Costs for household connections are estimated for each District in Table 9.4.

### 9.1.5 Capital Costs for Sewage Pumping Stations

The total capital cost of pumping stations has two major components: civil works and electro-mechanical works. The cost of each component has been worked out separately as shown in Table 9.5

The costs are worked out on the basis of cost per mld developed from a review of recent UPJN tenders and DPR cost estimates. The following formulae and costs are applied depending on the type of pumping station:

Cost : Rs. $10^6$ /mld

| | Civil works | Electro-mechanical | Electrical service |
|---|---|---|---|
| Submersible < 6 mld | y = 0.1073x + 2.7675 | 1.0 | 0.8 |
| Submersible > 6 mld | y = 0.1679x + 1.3616 | 0.3 | 0.8 |
| Centrifugal | y = 26.958Ln(x) - 80.598 | Y = 0.2462x + 5.0009 | 25.0 |

The electro-mechanical costs include the cost of diesel generators. The cost of electrical service entrance assumes 11 kV, and includes an average transmission line length of 5 km.

The cost of new pumping stations and upgrades to existing is estimated at Rs. 1,994 million.

### 9.1.6 Capital Costs for Rising Mains

The size and other details of rising mains have been worked out on the basis of preliminary design. All rising mains are estimated on the basis of unit cost per length for pre-stressed concrete pipe. Costs include installation, jointing, and testing, and connection to outfall sewer.

Cost details are provided in Table 9.6. The total length of new rising mains is 6.2 km and the estimated cost is Rs. 97 million.

### 9.1.7 Capital Costs for Treatment Plants

Capital costs of treatment plants have been worked out in Section 6 "Evaluation" for comparison and selection of treatment processes. Capital costs per unit mld are based on a review of treatment plants constructed under GAP and YAP presented in Supporting Report (Vol. III-11). The estimated cost of treatment works is presented in Table 9.7. The total cost is Rs. 1,554 million. The estimated cost includes treatment units along with piping, pumping, cost of laboratory, administrative building, electrical sub-station, site development and boundary walls. The cost of dual fuel engine generators is included for treatment processes that produce methane. Costs of land acquisition have been identified separately in Table 9.8.

## 9.2 ANNUAL O&M COSTS

Effective operation and maintenance is essential for the success of any sewerage system. Operation and maintenance involves the following major components:

- Operation, maintenance and monitoring personnel
- Parts, equipment and machinery
- Energy costs

Total O&M costs are summarized in Table9.10.

Annual repair and maintenance costs for pumping stations are estimated as a percentage of capital costs using the following factors as adopted by UPJN:

**Table 9.11 Unit Operation and Maintenance Costs**

| Sl. | Description of items | Economic life (years) | Annual repair and maintenance cost as % of capital cost |
|---|---|---|---|
| 1 | Civil structures | 30 | 1.5 |
| 2 | Pumps | 15 | 3.0 |
| 3 | Pipelines | 30 | 0.25 |
| 4 | Electrical | 15 | 3.0 |
| 5 | Diesel generators | 15 | 3.0 |

Source: UPJN Detailed Project Reports, Allahabad and Lucknow

Energy costs for pumping stations are calculated on the basis of electricity required to operate the pumps as calculated from the discharge and pumping head. The cost of electricity is taken as Rs 3.1 per kwh from the rate schedule issued by U.P. Power Corporation, August 2003. Recurring costs (excluding staff) for pumping stations are presented in Table 9.12.

Energy costs for treatment plants is worked out on the basis of unit consumption rates per mld identified in Supporting Report “Case Study of Sewage Treatment Plants”. Recurring costs for treatment plants are identified in Table 9.13.

Proposals regarding staffing are described in the following sub-sections.

### 9.2.1 Staff

The number of staff required for carrying out regular operational, preventive and corrective maintenance activities can be grouped into the following categories:

- Personnel for sewer maintenance
- Personnel for sewage pumping stations
- Personnel for operation and maintenance of sewage treatment works
- Personnel for process control

Staff requirements for pumping stations and treatment plants are in accordance with directives issued for GAP projects by UP Ministry for Urban Development Annual recurring costs on staffing is based on the manpower required and salaries that have been given by UPJN Allahabad for 2002, and increased by 10% to bring them to 2003 base.

(1) Sewer Maintenance

Sewer maintenance generally involves regular inspection of all sewers, sewer cleaning operations, both preventive and corrective, and occasional repairs to manholes. Category and extent of personnel required for these activities have been worked out on the basis of quantity of work. Recommended personnel requirements for this component are presented in Table 9.14. A total of 6 gangs are recommended for Stage I, and 14 gangs for Stage II.

(2) Sewage Pumping Stations

The personnel requirement for operation and maintenance of sewage pumping stations varies depending on the size of the station. Staff requirements for pumping stations are presented in Table 9.15 in accordance with directives issued for GAP projects by UP Ministry for Urban Development.

(3) Sewage Treatment Plants

The personnel requirement for operation and maintenance of treatment plants varies depending on the size of the station. Staff requirements for GAP projects are determined by UP Ministry for Urban Development and presented in Table 9.16 and Table 9.20.

## 9.3 COST SCHEDULE

The annual investment costs and recurring costs for implementing the Sewerage Master Plan are presented for each district in Table 9.21. The schedule of costs is based on a preliminary implementation plan and priorities discussed in previous sections. The cost breakdown of projects identified for implementation during Stage I is listed in order of priority in Table 9.22.

## Table 9.1 Preliminary Capital Cost Estimate: Summary

Base year : 2003
City: Kanpur

**Total**

| Item | Cost (Rs. million) | | |
|---|---|---|---|
| | Stage I -2015 | Stage II 2016-2030 | Total |
| Trunk sewers (including manholes) | 873.96 | 3,609.19 | 4,483.15 |
| Branch sewers | 695.48 | 6,653.07 | 7,348.55 |
| Pumping stations | 1,100.80 | 893.50 | 1,994.30 |
| Rising mains | 20.17 | 76.47 | 96.64 |
| Treatment plants | 489.00 | 1,065.00 | 1,554.00 |
| Replacement of M/E assets | 0.00 | 299.06 | 299.06 |
| Sub-total | 3,179.41 | 12,596.29 | 15,775.70 |
| Physical Contingency (20%) | 635.88 | 2,519.26 | 3,155.14 |
| Cost of detailed engineering (15%) | 476.91 | 1,889.43 | 2,366.35 |
| Cost of project administration (10%) (1) | 317.94 | 1,259.63 | 1,577.57 |
| Land acquisition | 288.00 | 419.20 | 707.20 |
| Sub-total | 1,718.73 | 6,087.52 | 7,806.26 |
| Grand total | 4,898.14 | 18,683.81 | 23,581.96 |

| | | | |
|---|---|---|---|
| Direct Cost (including land acquisition) | 3,467.41 | 13,015.49 | 16,482.90 |
| House connections | 830.00 | 2,840.28 | 3,670.28 |

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Kanpur

**District I (City Central)**

| Item | Cost (Rs. million) | | |
|---|---|---|---|
| | Stage I -2015 | Stage II 2016-2030 | Total |
| Trunk sewers (including manholes) | 328.57 | 313.05 | 641.62 |
| Branch sewers | 113.25 | 264.25 | 377.50 |
| Pumping stations | 34.30 | 25.80 | 60.10 |
| Rising mains | 20.17 | 0.00 | 20.17 |
| Treatment plants | 0.00 | 0.00 | 0.00 |
| Replacement of M/E assets | 0.00 | 0.00 | 0.00 |
| Sub-total | 496.29 | 603.10 | 1,099.39 |
| Physical Contingency (20%) | 99.26 | 120.62 | 219.88 |
| Cost of detailed engineering (15%) | 74.44 | 90.46 | 164.91 |
| Cost of project administration (10%) (1) | 49.63 | 60.31 | 109.94 |
| Land acquisition | 4.00 | 0.00 | 4.00 |
| Sub-total | 227.33 | 271.39 | 498.73 |
| Grand total | 723.62 | 874.49 | 1,598.12 |

| | | | |
|---|---|---|---|
| House connections | 197.96 | 308.31 | 506.27 |

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Kanpur

**District I (City East)**

| Item | Cost (Rs. million) | | |
|---|---|---|---|
| | Stage I -2015 | Stage II 2016-2030 | Total |
| Trunk sewers (including manholes) | 58.25 | 347.17 | 405.42 |
| Branch sewers | 282.12 | 705.32 | 987.44 |
| Pumping stations | 0.30 | 27.00 | 27.30 |
| Rising mains | 0.00 | 0.00 | 0.00 |
| Treatment plants | 129.00 | 75.00 | 204.00 |
| Replacement of M/E assets | 0.00 | 227.01 | 227.01 |
| Sub-total | 469.67 | 1,381.50 | 1,851.17 |
| Physical Contingency (20%) | 93.93 | 276.30 | 370.23 |
| Cost of detailed engineering (15%) | 70.45 | 207.22 | 277.68 |
| Cost of project administration (10%) (1) | 46.97 | 138.15 | 185.12 |
| Land acquisition | 0.00 | 8.00 | 8.00 |
| Sub-total | 211.35 | 629.67 | 841.02 |
| Grand total | 681.02 | 2,011.17 | 2,692.19 |
| House connections | 148.48 | 130.67 | 279.15 |

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Kanpur

**District II (South)**

| Item | Cost (Rs. million) | | |
|---|---|---|---|
| | Stage I -2015 | Stage II 2016-2030 | Total |
| Trunk sewers (including manholes) | 64.05 | 923.11 | 987.16 |
| Branch sewers | 156.27 | 2,002.43 | 2,158.70 |
| Pumping stations | 0.00 | 520.80 | 520.80 |
| Rising mains | 0.00 | 0.00 | 0.00 |
| Treatment plants | 0.00 | 495.00 | 495.00 |
| Replacement of M/E assets | 0.00 | 72.05 | 72.05 |
| Sub-total | 220.32 | 4,013.39 | 4,233.71 |
| Physical Contingency (20%) | 44.06 | 802.68 | 846.74 |
| Cost of detailed engineering (15%) | 33.05 | 602.01 | 635.06 |
| Cost of project administration (10%) (1) | 22.03 | 401.34 | 423.37 |
| Land acquisition | 0.00 | 288.00 | 288.00 |
| Sub-total | 99.14 | 2,094.03 | 2,193.17 |
| Grand total | 319.46 | 6,107.42 | 6,426.88 |
| House connections | 305.93 | 1,149.73 | 1,455.66 |

Note (1): 4% preparation + 6% administration during construction

Base year : 2003
City: Kanpur

**District III (West)**

| Item | Cost (Rs. million) | | |
|---|---|---|---|
| | Stage I -2015 | Stage II 2016-2030 | Total |
| Trunk sewers (including manholes) | 423.09 | 1,270.59 | 1,693.68 |
| Branch sewers | 143.84 | 2,357.05 | 2,500.89 |
| Pumping stations | 1,066.20 | 98.10 | 1,164.30 |
| Rising mains | 0.00 | 0.00 | 0.00 |
| Treatment plants | 360.00 | 240.00 | 600.00 |
| Replacement of M/E assets | 0.00 | 0.00 | 0.00 |
| Sub-total | 1,993.13 | 3,965.74 | 5,958.87 |
| Physical Contingency (20%) | 398.63 | 793.15 | 1,191.77 |
| Cost of detailed engineering (15%) | 298.97 | 594.86 | 893.83 |
| Cost of project administration (10%) (1) | 199.31 | 396.57 | 595.89 |
| Land acquisition | 284.00 | 0.00 | 284.00 |
| Sub-total | 1,180.91 | 1,784.58 | 2,965.49 |
| Grand total | 3,174.04 | 5,750.32 | 8,924.36 |

| | | | |
|---|---|---|---|
| House connections | 177.63 | 992.12 | 1,169.75 |

Note (1): 4% preparation + 6% administration during construction

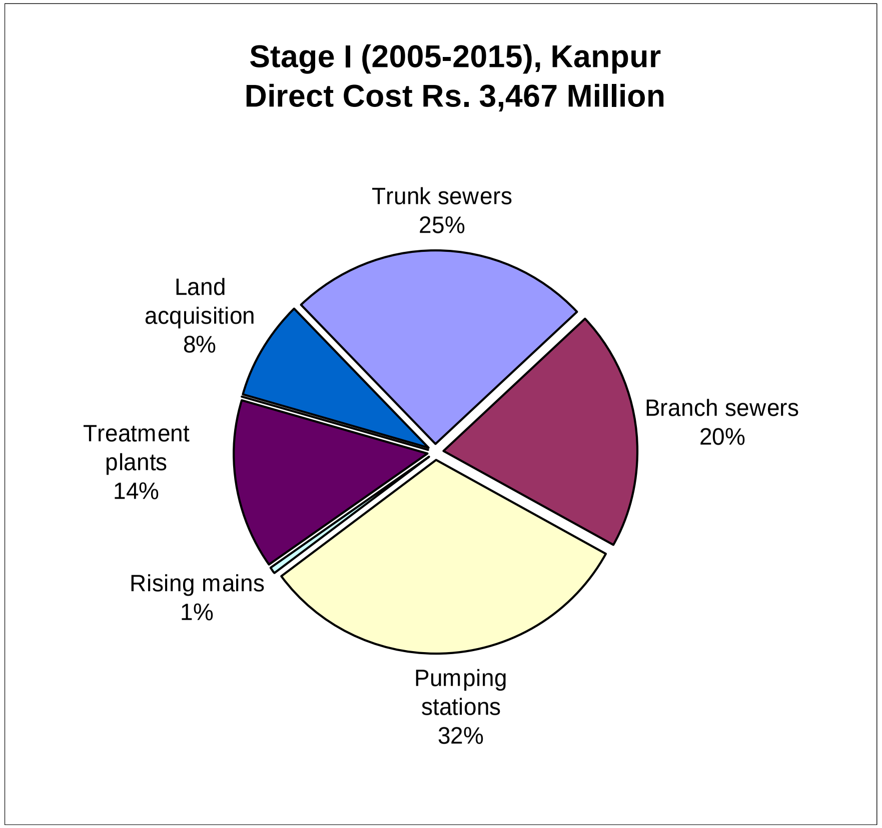
Base year : 2003
City: Kanpur

**District IV (East)**

| Item | Cost (Rs. million) | | |
|---|---|---|---|
| | Stage I -2015 | Stage II 2016-2030 | Total |
| Trunk sewers (including manholes) | 0.00 | 755.27 | 755.27 |
| Branch sewers | 0.00 | 1,324.02 | 1,324.02 |
| Pumping stations | 0.00 | 221.80 | 221.80 |
| Rising mains | 0.00 | 76.47 | 76.47 |
| Treatment plants | 0.00 | 255.00 | 255.00 |
| Replacement of M/E assets | 0.00 | 0.00 | 0.00 |
| Sub-total | 0.00 | 2,632.56 | 2,632.56 |
| Physical Contingency (20%) | 0.00 | 526.51 | 526.51 |
| Cost of detailed engineering (15%) | 0.00 | 394.88 | 394.88 |
| Cost of project administration (10%) (1) | 0.00 | 263.26 | 263.26 |
| Land acquisition | 0.00 | 123.20 | 123.20 |
| Sub-total | 0.00 | 1,307.85 | 1,307.85 |
| Grand total | 0.00 | 3,940.41 | 3,940.41 |

| | | | |
|---|---|---|---|
| Cost of house connections | 0.00 | 259.45 | 259.45 |

Note (1): 4% preparation + 6% administration during construction



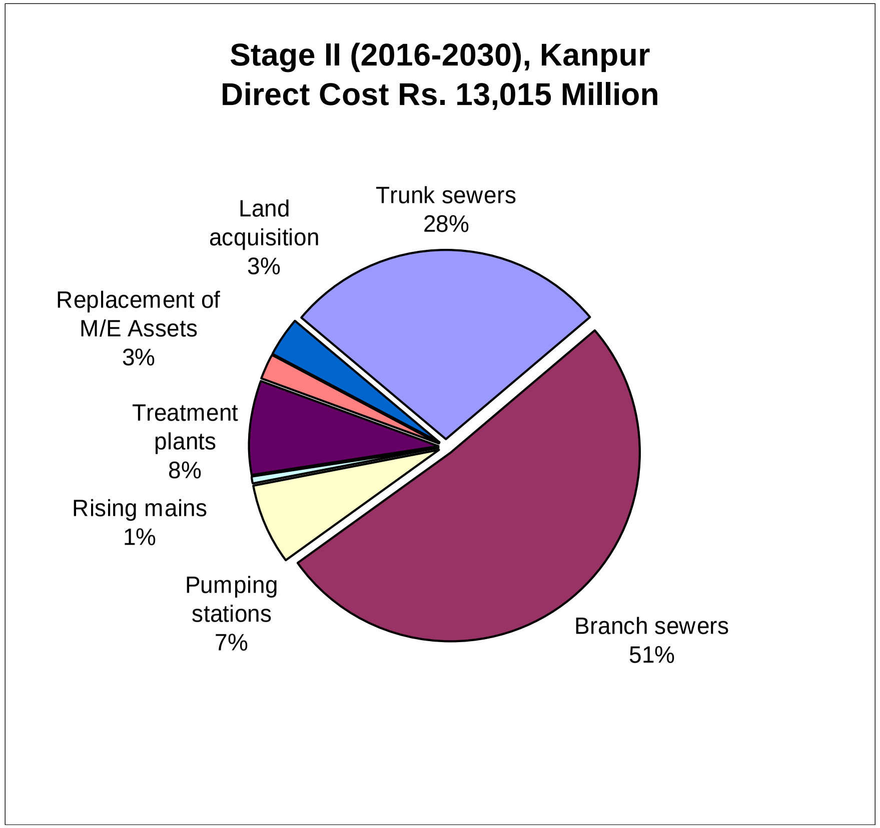




**Figure 9.1 Estimated Cost of Sewerage, Breakdown of Direct Construction Cost**

**Table 9.2 Preliminary Capital Cost Estimate: Trunk Sewers and Laterals (Page 1 of 3)**

Base year : 2003
City: Kanpur

| District | Node | | Diameter (mm) | Depth | Length (m) | Unit Cost (Rs./m) | Cost (Rs. million) | | |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | Stage I -2015 | Stage II 2016-2030 | Total |
| **District I (City Central)** | | | | | | | | | |
| **Replace Old Sewer (150% of construct cost)** | | | | | | | | | |
| | E | D | 1,000 | E | 1,600 | 46,940 | | 75.10 | |
| | D | C | 1,200 | E | 720 | 51,434 | | 37.03 | |
| | C | B' | 1,400 | F | 1,200 | 69,180 | | 83.02 | |
| | H2 | H1 | 1,400 | F | 1,200 | 69,180 | 83.02 | | |
| | I4 | I3 | 700 | D | 1,200 | 36,548 | | 43.86 | |
| | I3(a) | I3 | 800 | C | 1,036 | 30,812 | 31.92 | | |
| | I3 | I2 | 1,200 | D | 400 | 42,918 | 17.17 | | |
| | I2 | I1 | 1,200 | D | 880 | 42,918 | 37.77 | | |
| | I1 | I | 1,600 | D | 600 | 55,997 | | 33.60 | |
| | I | H | 1,400 | D | 800 | 50,555 | | 40.44 | |
| | | | **Sub-Total** | | 9,636 | | 169.88 | 313.05 | 482.93 |
| **New** | | | | | | | | | |
| | H | G | 1,600 | D | 1,000 | 37,331 | 37.33 | | |
| | G | B' | 1,600 | E | 1,600 | 43,425 | 69.48 | | |
| | B' | B'(b)-A7 | 2,000 | G | 700 | 74,109 | 51.88 | | |
| | | | **Sub-Total** | | 3,300 | | 158.69 | 0.00 | 158.69 |
| | | | | | **Total** | | 328.57 | 313.05 | 641.62 |
| **District I (City East)** | | | | | | | | | |
| | CE1 | CE2 | 900 | C | 1,800 | 19,986 | | 35.97 | |
| | CE2 | CE4 | 1,200 | D | 2,050 | 28,612 | | 58.65 | |
| | CE3 | CE4 | 700 | D | 2,000 | 24,365 | | 48.73 | |
| | CE4 | CE6 | 1,400 | E | 750 | 39,685 | | 29.76 | |
| | CE5 | CE6 | 800 | C | 2,450 | 20,541 | | 50.33 | |
| | CE6 | CE7 | 1,600 | E | 700 | 43,425 | | 30.40 | |
| | CE7 | CE8 | 1,600 | D | 1,000 | 37,331 | | 37.33 | |
| | CE8 | SPS | 1,600 | D | 1,500 | 37,331 | | 56.00 | |
| | Tan-1 | Tan-2 | 800 | C | 1,100 | 20,541 | 22.60 | | |
| | Tan-2 | Tan-3 | 1,200 | C | 1,500 | 23,768 | 35.65 | | |
| | | | **Sub-Total** | | 14,850 | | 58.25 | 347.17 | 405.42 |
| | | | | | **Total** | | 58.25 | 347.17 | 405.42 |
| **District II (South)** | | | | | | | | | |
| **Replace Old Sewer (150% of construct cost)** | | | | | | | | | |
| | X11 | X10 | 900 | D | 1,040 | 37,046 | | 38.53 | |
| | X10 | X9 | 1,000 | D | 1,040 | 38,621 | | 40.17 | |
| | X9 | X8 | 1,000 | D | 400 | 38,621 | | 15.45 | |
| | X8 | X7 | 1,600 | D | 95 | 55,997 | | 5.32 | |
| | X7 | X6 | 1,600 | E | 2,060 | 65,138 | | 134.18 | |
| | X6 | X4 | 1,600 | G | 1,650 | 87,933 | | 145.09 | |
| | Z | X1 | 1,400 | F | 450 | 69,180 | 31.13 | | |
| | X1 | X2 | 1,200 | E | 640 | 51,434 | 32.92 | | |
| | X2 | A''' | 2,200 | E | 1,340 | 93,702 | | 125.56 | |
| | | | **Sub-Total** | | 8,715 | | 64.05 | 504.30 | 568.35 |

Depth

| Symbol | Range |
|---|---|
| A | -1.5 m |
| B | 1.5 - 3.0 m |
| C | 3.0 - 4.5 m |
| D | 4.5 -6.0 m |
| E | 6.0 - 7.5 m |
| F | 7.5 - 9.0 m |
| G | 9.0 - 10.5m |
| H | 10.5 - 12.0 m |

**Table 9.2 Preliminary Capital Cost Estimate: Trunk Sewers and Laterals (Page 2 of 3)**

Base year : 2003
City: Kanpur

| District | Node | | Diameter (mm) | Depth | Length (m) | Unit Cost (Rs./m) | Cost (Rs. million) | | |
|---|---|---|---|---|---|---|---|---|---|
| | From | To | | | | | Stage I -2015 | Stage II 2016-2030 | Total |
| **New** | | | | | | | | | |
| | F2 | X5-2 | 1,000 | D | 1,800 | 25,747 | | 46.34 | |
| | S1 | S3 | 1,000 | C | 1,850 | 20,996 | | 38.84 | |
| | S2 | S3 | 600 | B | 450 | 13,718 | | 6.17 | |
| | S3 | SPS | 1,200 | D | 980 | 28,612 | | 28.04 | |
| | crossing Ganda nala | | 1,200 | H | 20 | 55,620 | | 1.11 | |
| | SPS | S8 | 1,000 | D | 1,080 | 25,747 | Sanctioned | | |
| | SPS | S8 | 1,000 | D | 1,080 | 25,747 | | 27.81 | |
| | S5 | S7 | 800 | C | 1,300 | 20,541 | | 26.70 | |
| | S6 | S7 | 700 | B | 700 | 14,483 | | 10.14 | |
| | S7 | S8 | 1,200 | D | 1,000 | 28,612 | | 28.61 | |
| | S8 | S9 | 1,000 | E | 690 | 31,293 | Sanctioned | | |
| | S8 | S9 | 1,400 | E | 690 | 39,685 | | 27.38 | |
| | S9 | S10 | 1,100 | E | 1,260 | 51,899 | Sanctioned | | |
| | S9 | S10 | 1,600 | F | 1,260 | 50,021 | | 63.03 | |
| | S10 | S21 | 1,200 | E | 2,640 | 34,289 | Sanctioned | | |
| | S10 | S21 | 1,600 | E | 2,640 | 43,425 | | 114.64 | |
| | | | **Sub-Total** | | 19,440 | | 0.00 | 418.81 | 418.81 |
| | | | | | **Total** | | 64.05 | 923.11 | 987.16 |
| **District III (West)** | | | | | | | | | |
| | W1 | W2 | 1,000 | D | 1,700 | 25,747 | 43.77 | | |
| | W2 | W4 | 1,200 | C | 600 | 23,768 | 14.26 | | |
| | W3 | W4 | 800 | C | 1,500 | 20,541 | | 30.81 | |
| | W4 | W12 | 1,600 | D | 1,250 | 37,331 | | 46.66 | |
| | W5 | W6 | 600 | B | 850 | 13,718 | | 11.66 | |
| | W6 | W12 | 800 | C | 1,850 | 20,541 | | 38.00 | |
| | W7 | W9 | 500 | C | 1,500 | 17,162 | | 25.74 | |
| | W8 | W9 | 700 | C | 1,000 | 19,352 | | 19.35 | |
| | W9 | W11 | 800 | D | 1,000 | 25,594 | | 25.59 | |
| | W10 | W11 | 600 | B | 1,150 | 13,718 | | 15.78 | |
| | W11 | W12 | 1,200 | E | 1,150 | 34,289 | | 39.43 | |
| | W12 | W13 | 1,800 | F | 700 | 57,045 | 39.93 | | |
| | W13 | W15 | 2,000 | F | 1,300 | 64,190 | 83.45 | | |
| | W14 | W15 | 1,000 | C | 3,300 | 20,996 | | 69.29 | |
| | W15 | SPS | 2,200 | G | 950 | 80,749 | 76.71 | | |
| | W16 | W17 | 400 | C | 1,400 | 17,162 | | 24.03 | |
| | W17 | W19 | 500 | E | 1,050 | 27,720 | | 29.11 | |
| | W18 | W19 | 500 | C | 650 | 17,162 | | 11.16 | |
| | W19 | SPS | 700 | G | 2,000 | 43,754 | | 87.51 | |
| | W20 | W21 | 800 | D | 1,500 | 25,594 | | 38.39 | |
| | W21 | SPS | 900 | F | 4,000 | 35,991 | | 143.96 | |
| | SPS | W24 | 1,800 | C | 1,000 | 38,454 | 38.45 | | |
| | SPS | W24 | 1,800 | C | 1,000 | 38,454 | | 38.45 | |
| | W23 | W24 | 600 | B | 1,500 | 13,718 | | 20.58 | |
| | W24 | W30 | 1,800 | C | 1,250 | 38,454 | 48.07 | | |
| | W24 | W30 | 1,800 | C | 1,250 | 38,454 | | 48.07 | |
| | W25 | W26 | 500 | C | 1,100 | 17,162 | | 18.88 | |
| | W26 | W27 | 500 | D | 1,000 | 22,083 | | 22.08 | |
| | W27 | W28 | 800 | E | 1,750 | 31,420 | | 54.99 | |
| | W28 | W29 | 1,000 | F | 1,100 | 37,162 | | 40.88 | |
| | W29 | W30 | 1,000 | F | 1,300 | 37,162 | | 48.31 | |
| | W30 | W33 | 1,800 | F | 700 | 57,045 | 39.93 | | |
| | W30 | W33 | 1,800 | F | 700 | 57,045 | | 39.93 | |
| | W31 | W32 | 500 | C | 1,850 | 17,162 | | 31.75 | |
| | W32 | W33 | 800 | C | 1,300 | 20,541 | | 26.70 | |
| | W33 | W37 | 2,000 | F | 300 | 64,190 | 19.26 | | |
| | W33 | W37 | 2,000 | F | 300 | 64,190 | | 19.26 | |
| | W34 | W36 | 1,000 | D | 2,500 | 25,747 | | 64.37 | |
| | W35 | W36 | 600 | C | 2,150 | 18,557 | | 39.90 | |
| | W36 | W37 | 1,400 | F | 1,750 | 46,120 | | 80.71 | |
| | W37 | STP | 2,000 | F | 300 | 64,190 | 19.26 | | |
| | W37 | STP | 2,000 | F | 300 | 64,190 | | 19.26 | |
| | | | **Sub-Total** | | 54,800 | | 423.09 | 1,270.59 | 1,693.68 |
| | | | | | **Total** | | 423.09 | 1,270.59 | 1,693.68 |

**Table 9.2 Preliminary Capital Cost Estimate: Trunk Sewers and Laterals (Page 3 of 3)**

Base year : 2003
City: Kanpur

| District | Node | | Diameter (mm) | Depth | Length (m) | Unit Cost (Rs./m) | Cost (Rs. million) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Stage I | Stage II | Total |
| | From | To | | | | | -2015 | 2016-2030 | |
| **District IV (East)** | | | | | | | | | |
| | E1 | E2 | 700 | C | 1,800 | 19,352 | | 34.83 | |
| | E2 | E4 | 800 | C | 350 | 20,541 | | 7.19 | |
| | E3 | E4 | 600 | C | 2,200 | 18,557 | | 40.83 | |
| | E4 | E8 | 1,000 | D | 650 | 25,747 | | 16.74 | |
| | E5 | E7 | 600 | C | 1,750 | 18,557 | | 32.47 | |
| | E6 | E7 | 500 | B | 500 | 12,368 | | 6.18 | |
| | E7 | E8 | 800 | D | 1,800 | 25,594 | | 46.07 | |
| | E8 | E10 | 1,400 | E | 1,000 | 39,685 | | 39.69 | |
| | E9 | E10 | 500 | C | 1,550 | 17,162 | | 26.60 | |
| | E10 | E11 | 1,600 | E | 2,550 | 43,425 | | 110.73 | |
| | E11 | E12 | 1,600 | F | 600 | 50,021 | | 30.01 | |
| | E12 | E16 | 1,600 | F | 1,300 | 50,021 | | 65.03 | |
| | E13 | E14 | 500 | D | 2,150 | 22,083 | | 47.48 | |
| | E14 | E15 | 700 | E | 250 | 30,132 | | 7.53 | |
| | E15 | E16 | 800 | E | 900 | 31,420 | | 28.28 | |
| | E16 | E17 | 1,800 | F | 1,050 | 57,045 | | 59.90 | |
| | E17 | SPS | 1,800 | G | 2,350 | 66,261 | | 155.71 | |
| | | | **Sub-Total** | | 22,750 | | 0.00 | 755.27 | 755.27 |
| | | | | | **Total** | | 0.00 | 755.27 | 755.27 |

## Table 9.3 Preliminary Capital Cost Estimate: Branch Sewers

Base year : 2003
City: Kanpur

| District/Zone | Area (ha) | Length (m) | | Cost (Rs million) | | |
|---|---|---|---|---|---|---|
| | | Stage I | Stage II | Stage I | Stage II | Total |
| | | -2015 | 2016-2030 | -2015 | 2016-2030 | |
| **District I (City Cen.)** | | | | | | |
| | 1,961 | 113,248 | 264,245 | 113.25 | 264.25 | 377.50 |
| Sub-Total | 1,961 | | | 113.25 | 264.25 | 377.50 |
| **District I (City East)** | | | | | | |
| | 3,664 | 282,128.00 | 705,320 | 282.12 | 705.32 | 987.44 |
| Sub-Total | 3,664 | | | 282.12 | 705.32 | 987.44 |
| **District II (South)** | | | | | | |
| Central | 2,706 | 156,272 | 364,634 | 156.27 | 364.63 | 520.90 |
| South-Central | 240 | 0 | 92,400 | - | 92.40 | 92.40 |
| South-West | 2,469 | 0 | 950,565 | - | 950.57 | 950.57 |
| South-East | 1,545 | 0 | 594,825 | - | 594.83 | 594.83 |
| Sub-Total | 6,960 | | | 156.27 | 2,002.43 | 2,158.70 |
| **District III (West)** | | | | | | |
| West-1 | 1,868 | 143,836 | 287,672 | 143.84 | 287.67 | 431.51 |
| West-2 | 5,375 | 0 | 2,069,375 | - | 2,069.38 | 2,069.38 |
| Sub-Total | 7,243 | | | 143.84 | 2,357.05 | 2,500.89 |
| **District IV (East)** | | | | | | |
| | 3,439 | 0 | 1,324,015 | 0 | 1,324.02 | 1,324.02 |
| (NSA) | 2,543 | | | | | |
| Sub-Total | 5,982 | | | 0 | 1,324.02 | 1,324.02 |
| Total | 25,810 | | | | 6,653.07 | 6,653.07 |

1. Average length of branch sewer per hectare taken as 385 m / ha.
2. A factor of increment in connection target in each Phase, has been used for calculation of lengths of branch sewers.
Branch sewer length = 385 x Area (ha) x Increment in connection target (%)
3. Cost per unit length taken as Rs. 1000 / m (Jal Sansthan, Allahabad) assuming 250 mm diameter concrete pipe.

**Existing and proposed branch sewer coverage**

| | Year | | | |
|---|---|---|---|---|
| | 2003 | 2010 | 2015 | 2030 |
| **District I (City Cen.)** | | | | |
| | 50% | 55% | 65% | 100% |
| **District I (City East)** | | | | |
| | 30% | 40% | 50% | 100% |
| **District II (South)** | | | | |
| Central | 50% | 55% | 65% | 100% |
| South-Central | 0% | 0% | 0% | 100% |
| South-West | 0% | 0% | 0% | 100% |
| South-East | 0% | 0% | 0% | 100% |
| **District III (West)** | | | | |
| West-1 | 40% | 50% | 60% | 100% |
| West-2 | 0% | 0% | 0% | 100% |
| **District IV (East)** | | | | |
| | 0% | 0% | 0% | 100% |

### Table 9.4 Preliminary Capital Cost Estimate: House Connections

Base year : 2003
City: Kanpur

| District/Zone | No. of households with connection | | | | Cost (Rs. Million) | | |
|---|---|---|---|---|---|---|---|
| | 2003 | 2010 | 2015 | 2030 | Stage I -2015 | Stage II 2016-2030 | Total |
| **District I (City Cen.)** | | | | | | | |
| | 43,407 | 53,256 | 68,950 | 108,732 | 197.96 | 308.31 | 506.27 |
| Sub-Total | | | | | 197.96 | 308.31 | 506.27 |
| **District I (City East)** | | | | | | | |
| | 9,698 | 18,687 | 28,857 | 45,717 | 148.48 | 130.67 | 279.15 |
| Sub-Total | | | | | 148.48 | 130.67 | 279.15 |
| **District II (South)** | | | | | | | |
| Central | 52,717 | 68,712 | 92,192 | 146,582 | 305.93 | 421.52 | 727.45 |
| South-Central | 0 | 0 | 0 | 6,247 | 0.00 | 48.41 | 48.41 |
| South-West | 0 | 0 | 0 | 58,956 | 0.00 | 456.91 | 456.91 |
| South-East | 0 | 0 | 0 | 28,759 | 0.00 | 222.88 | 222.88 |
| Sub-Total | | | | | 305.93 | 1,149.73 | 1,455.66 |
| **District III (West)** | | | | | | | |
| West-1 | 8,374 | 19,256 | 31,294 | 75,468 | 177.63 | 342.35 | 519.98 |
| West-2 | 0 | 0 | 0 | 83,842 | 0.00 | 649.78 | 649.78 |
| Sub-Total | | | | | 177.63 | 992.12 | 1,169.75 |
| **District IV (East)** | | | | | | | |
| | 0 | 0 | 0 | 33,478 | 0.00 | 259.45 | 259.45 |
| Sub-Total | | | | | 0.00 | 259.45 | 259.45 |
| Total | | | | | | 2,840.28 | 3,670.28 |

1. Unit cost per connection taken as Rs. 7750
2. Existing and proposed connection targets (%) have been used to calculate the Number of households with connection.
Cost = Rs. 7750 x Increase in Number of households with connection.

**Population and number of households**

| Zone | No. of persons per household | 2003 | | Stage I | | | | StageII | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Before 2010 | | 2011-2015 | | 2016-2030 | |
| | | Population | Total Households | Population | Total Households | Population | Total Households | Population | Total Households |
| District I (City Cen.) | | | | | | | | | |
| | 6.4 | 694,517 | 108,518 | 757,412 | 118,346 | 802,326 | 125,363 | 869,853 | 135,915 |
| District I (City East) | | | | | | | | | |
| | 6.4 | 310,349 | 48,492 | 398,648 | 62,289 | 461,718 | 72,143 | 585,168 | 91,433 |
| District II (South) | | | | | | | | | |
| Central | 6.4 | 843,469 | 131,792 | 977,234 | 152,693 | 1,072,781 | 167,622 | 1,172,659 | 183,228 |
| South-Central | 6.4 | 20,578 | 3,215 | 31,283 | 4,888 | 38,929 | 6,083 | 49,975 | 7,809 |
| South-West | 6.4 | 369,346 | 57,710 | 508,639 | 79,475 | 608,134 | 95,021 | 754,628 | 117,911 |
| South-East | 6.4 | 157,847 | 24,664 | 233,342 | 36,460 | 287,267 | 44,885 | 368,108 | 57,517 |
| District III (West) | | | | | | | | | |
| West-1 | 6.4 | 178,645 | 27,913 | 308,091 | 48,139 | 400,555 | 62,587 | 603,746 | 94,335 |
| West-2 | 6.4 | 157,146 | 24,554 | 299,445 | 46,788 | 401,086 | 62,670 | 670,739 | 104,803 |
| District IV (East) | | | | | | | | | |
| | 6.4 | 56,345 | 8,804 | 140,789 | 21,998 | 201,106 | 31,423 | 428,512 | 66,955 |

1. No. of persons per household, for the city of Kanpur has been taken as 6.4.
2. Population considered here is the total population.

**Existing and proposed household connection targets**

| District/Zone | Year | | | |
|---|---|---|---|---|
| | 2003 | 2010 | 2015 | 2030 |
| District I (City Cen.) | | | | |
| | 40% | 45% | 55% | 80% |
| District I (City East) | | | | |
| | 20% | 30% | 40% | 50% |
| District II (South) | | | | |
| Central | 40% | 45% | 55% | 80% |
| South-Central | 0% | 0% | 0% | 80% |
| South-West | 0% | 0% | 0% | 50% |
| South-East | 0% | 0% | 0% | 50% |
| District III (West) | | | | |
| West-1 | 30% | 40% | 50% | 80% |
| West-2 | 0% | 0% | 0% | 80% |
| District IV (East) | | | | |
| | 0% | 0% | 0% | 50% |

## Table 9.5 Preliminary Capital Cost Estimate: Pumping Stations

Base year : 2003
City: Kanpur

| Name | District | Status | Type of Pump | Design capacity Average flow (mld) | | Cost (Rs. million) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Stage I | Stage II | Electrical service | M&E (Stage I) | M&E (Stage II) | Civil works | Misc. Road, wall, staff quarters | Total capital cost | | |
| | | | | | | | | | | | Stage I | Stage II | Total |
| | | | | -2015 | 2016-2030 | | | | | 10% of civil | -2015 | 2016-2030 | |
| Guptar SPS | I(CC) | E/R | Submersible | 4.0 | 4.0 | | 1.2 | 1.2 | | | 1.2 | 1.2 | 2.4 |
| Bhagwatdas Nala SPS | I(CC) | P | Submersible | 8.0 | 8.0 | 6.4 | 2.4 | 2.4 | 2.7 | 0.3 | 11.8 | 2.4 | 14.2 |
| Muirmill SPS | I(CC) | E/R | Submersible | 4.0 | 5.0 | | 1.2 | 1.5 | | | 1.2 | 1.5 | 2.7 |
| Parmat SPS | I(CC) | E/R | Centrifugal | 54.0 | 54.0 | | 18.3 | 18.3 | | | 18.3 | 18.3 | 36.6 |
| Nawabganj SPS | I(CC) | E/R | Submersible | 6.0 | 8.0 | | 1.8 | 2.4 | | | 1.8 | 2.4 | 4.2 |
| Jajmau SPS (ASP) | I(CE) | E | Centrifugal | 121.0 | 121.0 | | | | | | (Existing) | | 0.0 |
| | | A | Centrifugal | 44.0 | 81.0 | | | 24.9 | | | | 24.9 | 24.9 |
| Jaimau SPS (UASB) | I(CE) | E | Centrifugal | 17.0 | 17.0 | | | | | | (Existing) | | 0.0 |
| | | A | Centrifugal | 1.0 | 7.0 | | 0.3 | 2.1 | | | 0.3 | 2.1 | 2.4 |
| Rahkimanj SPS | II | S | Centrifugal | 86.0 | 99.0 | | | | | | (Sanctioned) | | 0.0 |
| Mushipurwa SPS | II | S | Centrifugal | 70.0 | 82.0 | | | | | | (Sanctioned) | | 0.0 |
| Ganda Nala SPS | II | S | Centrifugal | 45.0 | 45.0 | | | | | | (Sanctioned) | | 0.0 |
| Lakhanpur SPS | III | E/R | Centrifugal | 16.0 | 27.0 | 67.5 | 4.8 | 8.1 | | | 72.3 | 8.1 | 80.4 |
| Panki SPS | III | P | Centrifugal | 80.0 | 126.0 | 315.0 | 24.7 | 36.0 | 49.8 | 5.0 | 394.5 | 36.0 | 430.5 |
| Ruman SPS | IV | P | Centrifugal | 0.0 | 66.0 | 165.0 | | 21.3 | 32.3 | 3.2 | 0.0 | 221.8 | 221.8 |
| MPS at Bingawan STP | II | S | Centrifugal | 200.0 | 200.0 | | | 54.2 | | | (Sanctioned) | | 0.0 |
| | | P | Centrifugal | | 165.0 | 412.5 | | 45.6 | 57.0 | 5.7 | | 520.8 | 520.8 |
| MPS at Panka STP | III | P | Centrifugal | 116.0 | 199.0 | 497.5 | 33.6 | 54.0 | 62.1 | 6.2 | 599.4 | 54.0 | 653.4 |
| **Sanctioned facilities** | | | | | | | | | | | | | |
| Rahkimanj SPS | II | S | Centrifugal | 86.0 | 99.0 | 247.5 | 29.4 | | | | 276.9 | | |
| Mushipurwa SPS | II | S | Centrifugal | 70.0 | 82.0 | 205.0 | 25.2 | | | | 230.2 | | |
| Ganda Nala SPS | II | S | Centrifugal | 45.0 | 45.0 | 112.5 | 16.1 | | | | 128.6 | | |
| MPS at Bingawan STP | II | S | Centrifugal | 200.0 | 200.0 | 500.0 | 54.2 | | | | 554.2 | | |

| Type of pump | Costs (Rs. million) | | |
|---|---|---|---|
| | M&E | Civil | Electrical Service |
| Centrifugal (>=30mld) | Y = 0.2462x + 5.0009 | Y=26.958Ln(x) - 80.598 | Y= 2.5x |
| Submersible (<30mld) | Y = 0.3x | y = 0.1679x + 1.3616 | Y = 0.8x |

| | Stage I | Stage II | Total |
|---|---|---|---|
| | -2015 | 2016-2030 | |
| District I (City Central) | 34.3 | 25.8 | 60.1 |
| District I (City East) | 0.3 | 27.0 | 27.3 |
| District II | 0.0 | 520.8 | 520.8 |
| District III | 1,066.2 | 98.1 | 1,164.3 |
| District IV | 0.0 | 221.8 | 221.8 |
| Total | 1,100.8 | 893.5 | 1,994.3 |

## Table 9.6 Preliminary Capital Cost Estimate: Rising Mains

Base year : 2003
City: Kanpur

| Pump station | Status | Diameter (mm) | Length (m) | Type of material | Unit Cost (Rs./m) | Cost (Rs. million) | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Stage I -2015 | Stage II 2016-2030 | Total |
| **District I (City Center)** | | | | | | | | |
| Parmat SPS | P | 1,000 | 1,000 | PSC | 13,806 | 13.81 | | 13.81 |
| Bhagwantdas Nala SPS | P | 400 | 1,000 | DIP | 6,362 | 6.36 | | 6.36 |
| Sub-Total | | | | | | 20.17 | 0.00 | 20.17 |
| **District IV (East)** | | | | | | | | |
| Ruman SPS | P | 1,200 | 4,200 | PSC | 18,208 | 0.00 | 76.47 | 76.47 |
| **Total** | | | | | | 20.17 | 76.47 | 96.64 |

## Table 9.7 Preliminary Capital Cost Estimate: Treatment Plants

Base year : 2003
City: Kanpur

| | District | Process | Unit Cost Rs.$10^6$/mld | Status | Incremental Capacity (mld) | | Civil Cost (Rs. million) | | M&E Cost (Rs. million) | | Total Cost (Rs. million) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stage I -2015 | Stage II 2016-2030 | Stage I -2015 | Stage II 2016-2030 | Stage I -2015 | Stage II 2016-2030 | Stage I -2015 | Stage II 2016-2030 | Total |
| Jajmau STP (UASB) | I (CE) | UASB++ | 3.0 | A | | 16.0 | | 28.8 | | 19.2 | | 48.0 | 48.0 |
| Jajmau STP (ASP) | I (CE) | ASP | 2.7 | A | 43.0 | 10.0 | 77.4 | 16.2 | 51.6 | 10.8 | 129.0 | 27.0 | 156.0 |
| Bingawan STP | II | UASB++ | 3.0 | S | 200.0 | | | | | | Sanctioned | | 0.0 |
| | | | | P | | 165.0 | | 346.5 | | 148.5 | | 495.0 | 495.0 |
| Panka STP | III | UASB++ | 3.0 | P | 120.0 | 80.0 | 252.0 | 168.0 | 108.0 | 72.0 | 360.0 | 240.0 | 600.0 |
| Karankher STP | IV | UASB++ | 3.0 | P | | 85.0 | | 178.5 | | 76.5 | | 255.0 | 255.0 |
| Total | | | | | | | 329.4 | 738.0 | 159.6 | 327.0 | 489.0 | 1,065.0 | 1,554.0 |

**Sanctioned facility** **(Replace)**

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bingawan STP | II | UASB++ | 3.0 | S | 200.0 | | 420.0 | | 180.0 | | 600.0 | | |

| | Stage I -2015 | Stage II 2016-2030 | Total |
|---|---|---|---|
| District I (CE) | 129.0 | 75.0 | 204.0 |
| District II | 0.0 | 495.0 | 495.0 |
| District III | 360.0 | 240.0 | 600.0 |
| District IV | 0.0 | 255.0 | 255.0 |
| Total | 489.0 | 1,065.0 | 1,554.0 |

## Table 9.8 Preliminary Capital Cost Estimate: Land Acquisition

Base year : 2003
City: Kanpur

**(1) Treatment Plant**

| | District | Process | Land Req. (ha/mld) | Status | Ultimate Capacity (mld) | | Land Requirement (ha) | | Cost (Rs. million) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Stage I | Stage II | Stage I | Stage II | Stage I | Stage II | Total |
| | | | | | -2015 | 2016-2030 | -2015 | 2016-2030 | -2015 | 2016-2030 | |
| Jajmau STP (APS) | I (CE) | ASP | 0.20 | E/A | | 10.0 | | 2.0 | | 8.0 | 8.0 |
| Bingawan STP [1] | II | UASB++ | 0.35 | S/A | | 365.0 | | 72.0 | | 288.0 | 288.0 |
| Panka STP | III | UASB++ | 0.35 | P | 200.0 | | 70.0 | | 280.0 | | 280.0 |
| Karankher STP | IV | UASB++ | 0.35 | P | | 85.0 | | 29.8 | | 119.2 | 119.2 |
| Total | | | | | | | 70.0 | 103.8 | 280.0 | 415.2 | 695.2 |

**(2) Pumping Station**

| | District | Status | Land Requirement (ha) | | Cost (Rs. million) | | |
|---|---|---|---|---|---|---|---|
| | | | Stage I | Stage II | Stage I | Stage II | Total |
| | | | -2015 | 2016-2030 | -2015 | 2016-2030 | |
| Bhagwantdas Nala SPS | I(CC) | P | 1.0 | | 4.0 | | 4.0 |
| Panki SPS | III | P | 1.0 | | 4.0 | | 4.0 |
| Ruman SPS | IV | P | | 1.0 | | 4.0 | 4.0 |
| Total | | | 2.0 | 1.0 | 8.0 | 4.0 | 12.0 |

Note (1): Land requirement 72.0 ha=0.35x365MLD-56.0, 56.0ha sanctioned

| | Stage I | Stage II | Total |
|---|---|---|---|
| | -2015 | 2016-2030 | |
| District I (City Central) | 4.0 | 0.0 | 4.0 |
| District I (City East) | 0.0 | 8.0 | 8.0 |
| District II (South) | 0.0 | 288.0 | 288.0 |
| District III (West) | 284.0 | 0.0 | 284.0 |
| District IV (East) | 0.0 | 123.2 | 123.2 |
| Total | 288.0 | 419.2 | 707.2 |

## Table 9.9 Replacement Cost of Existing Assets

**(1) Pumping Stations**

| | District | Capacity (MLD) | Type | Capital cost Rs x $10^6$ | |
|---|---|---|---|---|---|
| | | | | Civil | M/E |
| ISPS No.1 | I(CE) | 3.7 | S | 2.18 | 1.11 |
| ISPS No.2 | I(CE) | 8.8 | S | 3.11 | 2.63 |
| ISPS No.3 | I(CE) | 5.0 | S | 2.42 | 1.49 |
| ISPS No.4 | I(CE) | 1.7 | S | 1.81 | 0.51 |
| Sub Total | | | | | 5.74 |
| Jajmau MPS | I(CE) | 121.0 | C | 53.55 | 34.78 |
| Jajmau MPS | I(CE) | 17.0 | C | 4.64 | 9.19 |
| Sub-Total | | | | | 43.97 |
| Rakhi Mandi SPS | II | 115.2 | C | 52.10 | 33.36 |
| Munshi purwa SPS | II | 82.0 | C | 42.02 | 25.19 |
| Ganda Nala SPS | II | 45.0 | C | 9.81 | 13.50 |
| Sub-Total | | | | | 72.05 |

**(2) Treatment Plant**

| | District | Capacity (MLD) | Type | Capital cost Rs x $10^6$ | |
|---|---|---|---|---|---|
| | | | | Civil | M/E |
| Jajmau STP (Pilot) | I(CE) | 5 | UASB++ | 10.50 | 4.50 |
| Jajmau STP (UASB) | I(CE) | 36 | UASB++ | 75.60 | 32.40 |
| Jajmau STP (ASP) | I(CE) | 130 | ASP | 210.60 | 140.40 |
| Sub-Total | | | | | 177.30 |

## Table 9.10 Annual Operation and Maintenance Costs: Summary

(Rs. million)

| | Status | District | Stage I | | | | Stage II | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Maintenance | Staff | Energy | Total | Maintenance | Staff | Energy | Total |
| **Sewer Maintenance** | | | | | | | | | | |
| District I (City Central) | | | 8.19 | 0.60 | - | 8.79 | 13.97 | 0.60 | - | 14.57 |
| District I (City East) | | | 7.64 | - | - | 7.64 | 18.16 | 0.60 | - | 18.76 |
| District II (South) | | | 11.58 | 0.60 | - | 12.18 | 36.67 | 1.20 | - | 37.87 |
| District III (West) | | | 19.49 | 0.60 | - | 20.09 | 44.82 | 1.20 | - | 46.02 |
| District IV (East) | | | - | - | - | - | 20.79 | 0.60 | - | 21.39 |
| Sub-total Sewers | | | 46.90 | 1.80 | - | 48.70 | 134.41 | 4.20 | - | 138.61 |
| **Pump stations** | | | | | | | | | | |
| Guptar Ghat | E | I(CC) | 0.07 | 0.47 | 0.55 | 1.09 | 0.07 | 0.47 | 0.55 | 1.09 |
| Bhagwatdas Nala SPS | P | I(CC) | 0.13 | 0.47 | 0.40 | 1.00 | 0.13 | 0.47 | 0.40 | 1.00 |
| Muir Mill | E | I(CC) | 0.07 | 0.47 | 0.21 | 0.75 | 0.08 | 0.47 | 0.21 | 0.76 |
| Parma Ghat | E | I(CC) | 0.99 | 0.67 | 0.55 | 2.21 | 0.99 | 0.67 | 0.83 | 2.49 |
| Nawabganj | E | I(CC) | 0.09 | 0.47 | 0.23 | 0.80 | 0.11 | 0.47 | 0.40 | 0.99 |
| Jajmau MPS (ASP) | E | I(CE) | 1.77 | 0.83 | 4.38 | 6.99 | 2.03 | 0.83 | 6.61 | 9.46 |
| Jajmau MPS (UASB) | E | I(CE) | 0.50 | 0.67 | 0.47 | 1.64 | 0.54 | 0.67 | 0.81 | 2.02 |
| ISPS No.1 | E | I(CE) | 0.05 | 0.47 | 0.08 | 0.60 | 0.05 | 0.47 | 0.08 | 0.60 |
| ISPS No.2 | E | I(CE) | 0.09 | 0.47 | 0.20 | 0.77 | 0.09 | 0.47 | 0.20 | 0.77 |
| ISPS No.3 | E | I(CE) | 0.06 | 0.47 | 0.11 | 0.64 | 0.06 | 0.47 | 0.11 | 0.64 |
| ISPS No.4 | E | I(CE) | 0.03 | 0.47 | 0.04 | 0.54 | 0.03 | 0.47 | 0.04 | 0.54 |
| Rakhi Mandi | E | II | 1.43 | 0.83 | 3.02 | 5.28 | 1.53 | 0.83 | 4.31 | 6.67 |
| Munshi Purwa | E | II | 1.24 | 0.83 | 2.00 | 4.07 | 1.33 | 0.83 | 2.79 | 4.95 |
| Ganda Nala SPS | P | II | 0.81 | 0.47 | 0.49 | 1.78 | 0.81 | 0.47 | 0.80 | 2.08 |
| MPS at Bingawan STP | P | II | 3.57 | - | 7.88 | 11.45 | 4.78 | - | 11.70 | 16.49 |
| Lakhanpur SPS | E | III | 0.42 | 0.02 | 0.12 | 0.56 | 0.50 | 0.98 | 0.98 | 2.45 |
| Panki SPS | P | III | 1.49 | 0.98 | 1.84 | 4.31 | 1.83 | 0.98 | 4.07 | 6.88 |
| MPS at Panka STP | P | III | 1.94 | - | 2.76 | 4.70 | 2.55 | - | 6.40 | 8.95 |
| Ruman SPS | P | IV | - | 0.83 | - | 0.83 | 1.31 | 0.83 | 3.13 | 5.26 |
| Sub-total Pumping Station | | | 14.74 | 9.90 | 25.37 | 50.01 | 18.82 | 10.85 | 44.43 | 74.10 |
| **Treatment Plants** | | | | | | | | | | |
| Jajmau Tannery STP (Pilot) | E | I(CE) | 0.29 | - | 0.42 | 0.71 | 0.29 | - | 0.42 | 0.71 |
| Jajmau Tannery STP (UASB) | E | I(CE) | 2.11 | 8.76 | 3.01 | 13.88 | 3.04 | 8.76 | 4.35 | 16.16 |
| Jajmau STP (ASP) | E | I(CE) | 7.37 | 8.76 | 29.42 | 45.55 | 17.68 | 8.76 | 41.41 | 67.85 |
| Bingawan STP | S/A | II | 11.70 | 8.76 | 25.12 | 45.58 | 21.35 | 8.76 | 30.56 | 60.68 |
| Panka STP | P | III | 7.02 | 4.83 | 10.05 | 21.89 | 11.70 | 4.83 | 16.75 | 33.27 |
| Karankhera STP | P | IV | | | | | 4.97 | 2.99 | 7.12 | 15.08 |
| Sub-total of Treatment Plants | | | 28.49 | 31.11 | 68.02 | 127.62 | 59.04 | 34.10 | 100.61 | 193.75 |
| **Total** | | | 90.13 | 42.81 | 93.39 | 226.33 | 212.26 | 49.15 | 145.04 | 406.46 |

## Table 9.12 Annual Operation and Maintenance: Pumping Stations

(Rs. million)

| | Status | District | Stage I | | | | | | Stage II | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annual Repairs | | | Staff | Energy | Total | Annual Repairs | | | Staff | Energy | Total |
| | | | M&E | Rising Main | Civil works | | | | M&E | Rising Main | Civil works | | | |
| | | | 3% | 0.25% | 1.5% | | | | 3% | 0.25% | 1.5% | | | |
| **New pumping stations** | | | | | | | | | | | | | | |
| Bhagwatdas Nala SPS | P | I(CC) | 0.07 | 0.02 | 0.04 | 0.47 | 0.40 | 1.00 | 0.07 | 0.02 | 0.04 | 0.47 | 0.40 | 1.00 |
| Ganda Nala SPS | P | II | 0.48 | - | 0.33 | 0.47 | 0.49 | 1.78 | 0.48 | - | 0.33 | 0.47 | 0.80 | 2.08 |
| MPS at Bingawan STP | S | II | 1.78 | - | 1.79 | - | 7.88 | 11.45 | 3.00 | - | 1.79 | - | 11.70 | 16.49 |
| Panki SPS | P | III | 0.74 | - | 0.75 | 0.98 | 1.84 | 4.31 | 1.08 | - | 0.75 | 0.98 | 4.07 | 6.88 |
| MPS at Panka STP | P | III | 1.01 | - | 0.93 | - | 2.76 | 4.70 | 1.62 | - | 0.93 | - | 6.40 | 8.95 |
| Ruman SPS | P | IV | - | - | - | 0.83 | - | 0.83 | 0.64 | 0.19 | 0.48 | 0.83 | 3.13 | 5.26 |
| **Existing pumping station** | | | | | | | | | | | | | | |
| Guptar Ghat SPS | E | I(CC) | 0.04 | - | 0.03 | 0.47 | 0.55 | 1.09 | 0.04 | - | 0.03 | 0.47 | 0.55 | 1.09 |
| Muir Mill SPS | E | I(CC) | 0.04 | - | 0.03 | 0.47 | 0.21 | 0.75 | 0.05 | - | 0.03 | 0.47 | 0.21 | 0.76 |
| Parma Ghat SPS | E | I(CC) | 0.55 | 0.03 | 0.40 | 0.67 | 0.55 | 2.21 | 0.55 | 0.03 | 0.40 | 0.67 | 0.83 | 2.49 |
| Nawabganj SPS | E | I(CC) | 0.05 | - | 0.04 | 0.47 | 0.23 | 0.80 | 0.07 | - | 0.04 | 0.47 | 0.40 | 0.99 |
| Jajmau MPS (ASP) | E | I(CE) | 1.04 | - | 0.73 | 0.83 | 4.38 | 6.99 | 1.30 | - | 0.73 | 0.83 | 6.61 | 9.46 |
| Jajmau MPS (UASB) | E | I(CE) | 0.43 | - | 0.06 | 0.67 | 0.47 | 1.64 | 0.48 | - | 0.06 | 0.67 | 0.81 | 2.02 |
| ISPS No.1 | E | I(CE) | 0.02 | - | 0.03 | 0.47 | 0.08 | 0.60 | 0.02 | - | 0.03 | 0.47 | 0.08 | 0.60 |
| ISPS No.2 | E | I(CE) | 0.05 | - | 0.04 | 0.47 | 0.20 | 0.77 | 0.05 | - | 0.04 | 0.47 | 0.20 | 0.77 |
| ISPS No.3 | E | I(CE) | 0.03 | - | 0.03 | 0.47 | 0.11 | 0.64 | 0.03 | - | 0.03 | 0.47 | 0.11 | 0.64 |
| ISPS No.4 | E | I(CE) | 0.01 | - | 0.02 | 0.47 | 0.04 | 0.54 | 0.01 | - | 0.02 | 0.47 | 0.04 | 0.54 |
| Rakhi Mandi SPS | E | II | 0.79 | - | 0.65 | 0.83 | 3.02 | 5.28 | 0.88 | - | 0.65 | 0.83 | 4.31 | 6.67 |
| Munshi Purwa SPS | E | II | 0.67 | - | 0.57 | 0.83 | 2.00 | 4.07 | 0.76 | - | 0.57 | 0.83 | 2.79 | 4.95 |
| Lakhanpur SPS | E | III | 0.27 | 0.02 | 0.12 | 0.98 | 0.33 | 1.72 | 0.35 | 0.02 | 0.12 | 0.98 | 0.98 | 2.45 |
| **Total** | | | 8.07 | 0.07 | 6.60 | 10.85 | 25.57 | 51.17 | 11.47 | 0.27 | 7.08 | 10.85 | 44.43 | 74.10 |

## Table 9.13 Annual Operation and Maintenance: Treatment Plants

(Rs. million)

| | District | Process | Stage I | | | | | Stage II | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Annual Repairs | | Staff | Energy | Total | Annual Repairs | | Staff | Energy | Total |
| | | | M&E 3% | Civil works 1.5% | | | | M&E 3% | Civil works 1.5% | | | |
| Jajmau Tannery STP (Pilot) | I | UASB++ | 0.14 | 0.16 | - | 0.42 | 0.71 | 0.14 | 0.16 | - | 0.42 | 0.71 |
| Jajmau Tannery STP (UASB) | I | UASB++ | 0.97 | 1.13 | 8.76 | 3.01 | 13.88 | 1.40 | 1.64 | 8.76 | 4.35 | 16.16 |
| Jajmau STP (ASP) | I | ASP | 4.21 | 3.16 | 8.76 | 29.42 | 45.55 | 10.10 | 7.58 | 8.76 | 41.41 | 67.85 |
| Bingawan STP | II | UASB++ | 5.40 | 6.30 | 8.76 | 25.12 | 45.58 | 9.86 | 11.50 | 8.76 | 30.56 | 60.68 |
| Panka STP | III | UASB++ | 3.24 | 3.78 | 4.83 | 10.05 | 21.89 | 5.40 | 6.30 | 4.83 | 16.75 | 33.27 |
| Karankhera STP | IV | UASB++ | - | - | | - | - | 2.30 | 2.68 | 2.99 | 7.12 | 15.08 |
| Total | | | 13.96 | 14.53 | 31.10844 | 68.02 | 127.62 | 29.19 | 29.85 | 34.10 | 100.61 | 193.75 |

**Energy Cost**

| | District | Process | kWhr/mld | Stage I | | Stage II | |
|---|---|---|---|---|---|---|---|
| | | | | mld | kWhr/day | mld | kwhr/day |
| Jajmau Tannery STP (Pilot) | I | UASB++ | 74 | 5 | 370 | 5 | 370 |
| Jajmau Tannery STP (UASB) | I | UASB++ | 74 | 36 | 2,664 | 52 | 3,848 |
| Jajmau STP (ASP) | I | ASP | 200 | 130 | 26,000 | 183 | 36,600 |
| Bingawan STP | II | UASB++ | 74 | 300 | 22,200 | 365 | 27,010 |
| Panka STP | III | UASB++ | 74 | 120 | 8,880 | 200 | 14,800 |
| Karankhera STP | IV | UASB++ | 74 | 0 | 0 | 85 | 6,290 |

| Cost of electricity (Rs./kWhr): | 3.1 |
|---|---|

**Initial Cost for Calculating Maintenance Cost**

| | District | Process | Unit Cost Rs $10^6$/mld | Capacity (mld) | | Civil Cost | | M&E Cost | | Total Cost | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Stage I -2015 | Stage II 2016-2030 | Stage I -2015 | Stage II 2016-2030 | Stage I -2015 | Stage II 2016-2030 | Stage I -2015 | Stage II 2016-2030 |
| Jajmau Tannery STP (Pilot) | I | UASB++ | 3.0 | 5 | 5 | 10.5 | 10.5 | 4.5 | 4.5 | 15.0 | 15.0 |
| Jajmau Tannery STP (UASB) | I | UASB++ | 3.0 | 36 | 52 | 75.6 | 109.2 | 32.4 | 46.8 | 108.0 | 156.0 |
| Jajmau STP (ASP) | I | ASP | 2.7 | 130 | 183 | 210.6 | 505.1 | 140.4 | 336.7 | 351.0 | 841.8 |
| Bingawan STP | II | UASB++ | 3.0 | 200 | 365 | 420.0 | 766.5 | 180.0 | 328.5 | 600.0 | 1,095.0 |
| Panka STP | III | UASB++ | 3.0 | 120 | 200 | 252.0 | 420.0 | 108.0 | 180.0 | 360.0 | 600.0 |
| Karankhera STP | IV | UASB++ | 3.0 | - | 85 | | 178.5 | - | 76.5 | 0.0 | 255.0 |
| Total | | | | | | 968.7 | 1,989.8 | 465.3 | 973.0 | 1,434.0 | 2,962.8 |

**Table 9.14 Staff Requirement per Sewer Cleaning Crew**

| Staff | No. Required | Unit Salaries/Month | Stage I | | Stage II | |
|---|---|---|---|---|---|---|
| | | | Number of Crews | Annual Cost (Rs.) | Number of Crews | Annual Cost (Rs.) |
| Supervisor | 1 | 5,500 | 6 | 396,000 | 14 | 924,000 |
| Sewer inspector | 1 | 4,500 | 6 | 324,000 | 14 | 756,000 |
| Machine Operator | 2 | 3,600 | 6 | 259,200 | 14 | 604,800 |
| Helper | 2 | 2,700 | 6 | 194,400 | 14 | 453,600 |
| Sweeper | 1 | 2,700 | 6 | 194,400 | 14 | 453,600 |
| Unskilled laborer | 3 | 2,700 | 6 | 194,400 | 14 | 453,600 |
| Mason | 1 | 3,300 | 6 | 237,600 | 14 | 554,400 |
| Total | | | | 1,800,000 | | 4,200,000 |

**Staff Cost**

| | No. of Crews | | Staff Cost | |
|---|---|---|---|---|
| | Stage I | Stage II | Stage I | Stage II |
| District I (City Central) | 2 | 2 | 600,000 | 600,000 |
| District I (City East) | 0 | 2 | 0 | 600,000 |
| District II (South) | 2 | 4 | 600,000 | 1,200,000 |
| District III (West) | 2 | 4 | 600,000 | 1,200,000 |
| District IV (East) | 0 | 2 | 0 | 600,000 |
| | 6 | 14 | 1,800,000 | 4,200,000 |

**Capital Cost of Trunk Sewer**

| | Staff Cost | |
|---|---|---|
| | Stage I | Stage II |
| District I (City Central) | 328.57 | 641.62 |
| District I (City East) | 58.25 | 405.42 |
| District II (South) | 64.05 | 987.16 |
| District III (West) | 423.09 | 1,693.68 |
| District IV (East) | 0.00 | 755.27 |
| | 873.96 | 4,483.15 |

**Capital Cost of Branch Sewer** (Rs. million)

| | Area (ha) | Branch Cover Area (ha) | | Length per ha (m/ha) | Branch Length (m) | | Capital Cost | |
|---|---|---|---|---|---|---|---|---|
| | | Stage I | Stage II | | Stage I | Stage II | Stage I | Stage II |
| District I (City Central) | 1,961 | 1,275 | 1,961 | 385 | 490,875 | 754,985 | 490.88 | 754.99 |
| District I (City East) | 3,664 | 1,832 | 3,664 | 385 | 705,320 | 1,410,640 | 705.32 | 1,410.64 |
| District II (South) | 6,960 | 2,842 | 6,960 | 385 | 1,094,170 | 2,679,600 | 1094.17 | 2,679.60 |
| District III (West) | 7,243 | 3,963 | 7,243 | 385 | 1,525,755 | 2,788,555 | 1525.76 | 2,788.56 |
| District IV (East) | 3,439 | 0 | 3,439 | 385 | 0 | 1,324,015 | 0.00 | 1,324.02 |
| Total | 23,267 | 9,912 | 23,267 | | 3,816,120 | 8,957,795 | 3816.12 | 8,957.80 |

| | Maintenance Cost | |
|---|---|---|
| | Stage I | Stage II |
| District I (City Central) | 8.19 | 13.97 |
| District I (City East) | 7.64 | 18.16 |
| District II (South) | 11.58 | 36.67 |
| District III (West) | 19.49 | 44.82 |
| District IV (East) | 0.00 | 20.79 |
| Total | 46.90 | 134.41 |

Maintenance Cost = 1.0% of Initial Cost

**Table 9.15 Operation and maintenance staff: Requirements at Pumping Stations**

**Required Staff**

| S. No. | Post | Shifts | Muir Mill | Bhagwatdas Nala | Guptar Ghat | ISPS No.1 to 4 | Nawabganj | Parma Ghat | Rakhimandi | Munshipurwa | Jajmau | Jajmau (New) | Ruman | Panki | Ganda Nala | Rahkanpur |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Junior Engineer | 1 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.5 | 0.5 | 0.5 | 1 | 0.5 | 0.5 | 1 | 0.25 | 1 |
| 2 | Electician | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.5 | 1 | 1 | 1.5 | 1 | 1.5 |
| 3 | Mech. cum fitter | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1.5 | 1 | 2 | 2.5 | 1 | 2.5 |
| 4 | Pump Operator | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 5 | Screen Operator | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 6 | Gen Set Operator | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 7 | Beldar | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 8 | Sweeper | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 4 | 4 | 1 | 1 | 4 | 4 | 1 | 4 |

**Annual Staffing Costs (in Rs.)**

| S. No. | Post | Muir Mill | Bhagwatdas Nala | Guptar Ghat | ISPS No.1 to 4 | Nawabganj | Parma Ghat | Rakhimandi | Munshipurwa | Jajmau | Jajmau (New) | Ruman | Panki | Ganda Nala | Rahkanpur |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Junior Engineer | 56,100 | 56,100 | 56,100 | 56,100 | 56,100 | 112,200 | 112,200 | 112,200 | 224,400 | 112,200 | 112,200 | 224,400 | 56,100 | 224,400 |
| 2 | electrician | 47,520 | 47,520 | 47,520 | 47,520 | 47,520 | 47,520 | 47,520 | 47,520 | 71,280 | 47,520 | 47,520 | 71,280 | 47,520 | 71,280 |
| 3 | Mech. cum fitter | 47,520 | 47,520 | 47,520 | 47,520 | 47,520 | 47,520 | 95,040 | 95,040 | 71,280 | 47,520 | 95,040 | 118,800 | 47,520 | 118,800 |
| 4 | Pump Operator | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 | 213,840 |
| 5 | Screen Operator | - | - | - | - | - | 106,920 | 106,920 | 106,920 | 106,920 | 106,920 | 106,920 | 106,920 | - | 106,920 |
| 6 | Gen Set Operator | - | - | - | - | - | 35,640 | 35,640 | 35,640 | 35,640 | 35,640 | 35,640 | 35,640 | - | 35,640 |
| 7 | Beldar | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 | 71,280 |
| 8 | Sweeper | 35,640 | 35,640 | 35,640 | 35,640 | 35,640 | 35,640 | 142,560 | 142,560 | 35,640 | 35,640 | 142,560 | 142,560 | 35,640 | 142,560 |
| | TOTAL | 471,900 | 471,900 | 471,900 | 471,900 | 471,900 | 670,560 | 825,000 | 825,000 | 830,280 | 670,560 | 825,000 | 984,720 | 471,900 | 984,720 |

### Table 9.16 Operation and Maintenance Staff: Requirements for JajmauSTP (ASP)

**Activated sludge**

| S. No. | Designation | Staff Requirement | | Monthly Salary in Rs. | Annual wages in Rs. | |
|---|---|---|---|---|---|---|
| | | Stage I | Stage II | | Stage I | Stage II |
| 1 | Executive Engineer (Project Manager) | 1 | 1 | 27,500 | 330,000 | 330,000 |
| 2 | Assistant Engineer (E&M) (Asstt. Manager) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 3 | Assistant Engineer (Civil) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 4 | Junior Engineer (E&M) (Junior Manager) | 6 | 6 | 19,800 | 1,425,600 | 1,425,600 |
| 5 | Junior Engineer (Civil) (Junior Manager) | 2 | 2 | 19,800 | 475,200 | 475,200 |
| 6 | Fitter (Mech.) I Class | 2 | 2 | 3,960 | 95,040 | 95,040 |
| 7 | Electrician I Class | 3 | 3 | 3,960 | 142,560 | 142,560 |
| 8 | Fitter II Class | 1 | 1 | 3,630 | 43,560 | 43,560 |
| 9 | Electrician II Class | 2 | 2 | 3,630 | 87,120 | 87,120 |
| 10 | Gardener | 2 | 2 | 3,080 | 73,920 | 73,920 |
| 11 | Driver | 1 | 1 | 7,700 | 92,400 | 92,400 |
| 12 | Cleaner | 1 | 1 | 3,080 | 36,960 | 36,960 |
| 13 | Junior Accountant | 1 | 1 | 11,550 | 138,600 | 138,600 |
| 14 | UDC (Senior Assistant) | 2 | 2 | 9,570 | 229,680 | 229,680 |
| 15 | LDC/Typist (Junior Assistant) | 3 | 3 | 8,360 | 300,960 | 300,960 |
| 16 | Peon | 3 | 3 | 6,050 | 217,800 | 217,800 |
| 17 | Junior Stenographer | 1 | 1 | 9,570 | 114,840 | 114,840 |
| 18 | Chemist | 1 | 1 | 7,700 | 92,400 | 92,400 |
| 19 | Assistant Chemist | 1 | 1 | 6,600 | 79,200 | 79,200 |
| 20 | Lab Assistant | 1 | 1 | 4,950 | 59,400 | 59,400 |
| 21 | Lab Attendant | 2 | 2 | 3,080 | 73,920 | 73,920 |
| 22 | Sweeper | 2 | 2 | 2,970 | 71,280 | 71,280 |
| 23 | Weldar-cum-black smith | 1 | 1 | 3,630 | 43,560 | 43,560 |
| 24 | Operator | 19 | 19 | 5,940 | 1,354,320 | 1,354,320 |
| 25 | Labour (Beldar) | 73 | 73 | 2,970 | 2,601,720 | 2,601,720 |
| | TOTAL | 133 | 133 | | 8,760,840 | 8,760,840 |

**Table 9.17 Operation and Maintenance Staff: Requirements for JajmauSTP**

**UASB**

| S. No. | Designation | Staff Requirement | | Monthly Salary in Rs. | Annual wages in Rs. | |
|---|---|---|---|---|---|---|
| | | Stage I | Stage II | | Stage I | Stage II |
| 1 | Executive Engineer (Project Manager) | 1 | 1 | 27,500 | 330,000 | 330,000 |
| 2 | Assistant Engineer (E&M) (Asstt. Manager) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 3 | Assistant Engineer (Civil) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 4 | Junior Engineer (E&M) (Junior Manager) | 6 | 6 | 19,800 | 1,425,600 | 1,425,600 |
| 5 | Junior Engineer (Civil) (Junior Manager) | 2 | 2 | 19,800 | 475,200 | 475,200 |
| 6 | Fitter (Mech.) I Class | 2 | 2 | 3,960 | 95,040 | 95,040 |
| 7 | Electrician I Class | 3 | 3 | 3,960 | 142,560 | 142,560 |
| 8 | Fitter II Class | 1 | 1 | 3,630 | 43,560 | 43,560 |
| 9 | Electrician II Class | 2 | 2 | 3,630 | 87,120 | 87,120 |
| 10 | Gardener | 2 | 2 | 3,080 | 73,920 | 73,920 |
| 11 | Driver | 1 | 1 | 7,700 | 92,400 | 92,400 |
| 12 | Cleaner | 1 | 1 | 3,080 | 36,960 | 36,960 |
| 13 | Junior Accountant | 1 | 1 | 11,550 | 138,600 | 138,600 |
| 14 | UDC (Senior Assistant) | 2 | 2 | 9,570 | 229,680 | 229,680 |
| 15 | LDC/Typist (Junior Assistant) | 3 | 3 | 8,360 | 300,960 | 300,960 |
| 16 | Peon | 3 | 3 | 6,050 | 217,800 | 217,800 |
| 17 | Junior Stenographer | 1 | 1 | 9,570 | 114,840 | 114,840 |
| 18 | Chemist | 1 | 1 | 7,700 | 92,400 | 92,400 |
| 19 | Assistant Chemist | 1 | 1 | 6,600 | 79,200 | 79,200 |
| 20 | Lab Assistant | 1 | 1 | 4,950 | 59,400 | 59,400 |
| 21 | Lab Attendant | 2 | 2 | 3,080 | 73,920 | 73,920 |
| 22 | Sweeper | 2 | 2 | 2,970 | 71,280 | 71,280 |
| 23 | Weldar-cum-black smith | 1 | 1 | 3,630 | 43,560 | 43,560 |
| 24 | Operator | 19 | 19 | 5,940 | 1,354,320 | 1,354,320 |
| 25 | Labour (Beldar) | 73 | 73 | 2,970 | 2,601,720 | 2,601,720 |
| | TOTAL | 133 | 133 | | 8,760,840 | 8,760,840 |

**Table 9.18 Operation and Maintenance Staff: Requirements for Bingawan STP**

**UASB**

| S. No. | Designation | Staff Requirement | | Monthly Salary in Rs. | Annual wages in Rs. | |
|---|---|---|---|---|---|---|
| | | Stage I | Stage II | | Stage I | Stage II |
| 1 | Executive Engineer (Project Manager) | 1 | 1 | 27,500 | 330,000 | 330,000 |
| 2 | Assistant Engineer (E&M) (Asstt. Manager) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 3 | Assistant Engineer (Civil) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 4 | Junior Engineer (E&M) (Junior Manager) | 6 | 6 | 19,800 | 1,425,600 | 1,425,600 |
| 5 | Junior Engineer (Civil) (Junior Manager) | 2 | 2 | 19,800 | 475,200 | 475,200 |
| 6 | Fitter (Mech.) I Class | 3 | 3 | 3,960 | 142,560 | 142,560 |
| 7 | Electrician I Class | 2 | 2 | 3,960 | 95,040 | 95,040 |
| 8 | Fitter II Class | 2 | 2 | 3,630 | 87,120 | 87,120 |
| 9 | Electrician II Class | 1 | 1 | 3,630 | 43,560 | 43,560 |
| 10 | Gardener | 2 | 2 | 3,080 | 73,920 | 73,920 |
| 11 | Driver | 1 | 1 | 7,700 | 92,400 | 92,400 |
| 12 | Cleaner | 1 | 1 | 3,080 | 36,960 | 36,960 |
| 13 | Junior Accountant | 1 | 1 | 11,550 | 138,600 | 138,600 |
| 14 | UDC (Senior Assistant) | 2 | 2 | 9,570 | 229,680 | 229,680 |
| 15 | LDC/Typist (Junior Assistant) | 3 | 3 | 8,360 | 300,960 | 300,960 |
| 16 | Peon | 3 | 3 | 6,050 | 217,800 | 217,800 |
| 17 | Junior Stenographer | 1 | 1 | 9,570 | 114,840 | 114,840 |
| 18 | Chemist | 1 | 1 | 7,700 | 92,400 | 92,400 |
| 19 | Assistant Chemist | 1 | 1 | 6,600 | 79,200 | 79,200 |
| 20 | Lab Assistant | 1 | 1 | 4,950 | 59,400 | 59,400 |
| 21 | Lab Attendant | 2 | 2 | 3,080 | 73,920 | 73,920 |
| 22 | Sweeper | 2 | 2 | 2,970 | 71,280 | 71,280 |
| 23 | Weldar-cum-black smith | 1 | 1 | 3,630 | 43,560 | 43,560 |
| 24 | Operator | 19 | 19 | 5,940 | 1,354,320 | 1,354,320 |
| 25 | Labour (Beldar) | 73 | 73 | 2,970 | 2,601,720 | 2,601,720 |
| | TOTAL | 133 | 133 | | 8,760,840 | 8,760,840 |

**Table 9.19 Operation and Maintenance Staff: Requirements for Panka STP**

**UASB**

| S. No. | Designation | Staff Requirement | | Monthly Salary in Rs. | Annual wages in Rs. | |
|---|---|---|---|---|---|---|
| | | Stage I | Stage II | | Stage I | Stage II |
| 1 | Executive Engineer (Project Manager) | 0 | 0 | 27,500 | 0 | 0 |
| 2 | Assistant Engineer (E&M) (Asstt. Manager) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 3 | Assistant Engineer (Civil) | 1 | 1 | 24,200 | 290,400 | 290,400 |
| 4 | Junior Engineer (E&M) (Junior Manager) | 4 | 4 | 19,800 | 950,400 | 950,400 |
| 5 | Junior Engineer (Civil) (Junior Manager) | 2 | 2 | 19,800 | 475,200 | 475,200 |
| 6 | Fitter (Mech.) I Class | 1 | 1 | 3,960 | 47,520 | 47,520 |
| 7 | Electrician I Class | 2 | 2 | 3,960 | 95,040 | 95,040 |
| 8 | Fitter II Class | 1 | 1 | 3,630 | 43,560 | 43,560 |
| 9 | Electrician II Class | 2 | 2 | 3,630 | 87,120 | 87,120 |
| 10 | Gardener | 2 | 2 | 3,080 | 73,920 | 73,920 |
| 11 | Driver | 1 | 1 | 7,700 | 92,400 | 92,400 |
| 12 | Cleaner | 1 | 1 | 3,080 | 36,960 | 36,960 |
| 13 | Junior Accountant | 1 | 1 | 11,550 | 138,600 | 138,600 |
| 14 | UDC (Senior Assistant) | 1 | 1 | 9,570 | 114,840 | 114,840 |
| 15 | LDC/Typist (Junior Assistant) | 2 | 2 | 8,360 | 200,640 | 200,640 |
| 16 | Peon | 2 | 2 | 6,050 | 145,200 | 145,200 |
| 17 | Junior Stenographer | 0 | 0 | 9,570 | 0 | 0 |
| 18 | Chemist | 0 | 0 | 7,700 | 0 | 0 |
| 19 | Assistant Chemist | 1 | 1 | 6,600 | 79,200 | 79,200 |
| 20 | Lab Assistant | 1 | 1 | 4,950 | 59,400 | 59,400 |
| 21 | Lab Attendant | 1 | 1 | 3,080 | 36,960 | 36,960 |
| 22 | Sweeper | 2 | 2 | 2,970 | 71,280 | 71,280 |
| 23 | Weldar-cum-black smith | 0 | 0 | 3,630 | 0 | 0 |
| 24 | Operator | 4 | 4 | 5,940 | 285,120 | 285,120 |
| 25 | Labour (Beldar) | 34 | 34 | 2,970 | 1,211,760 | 1,211,760 |
| | TOTAL | 67 | 67 | | 4,825,920 | 4,825,920 |

**Table 9.20 Operation and Maintenance Staff: Requirements for Karankhera STP**

**UASB**

| S. No. | Designation | Staff Requirement | | Monthly Salary in Rs. | Annual wages in Rs. | |
|---|---|---|---|---|---|---|
| | | Stage I | Stage II | | Stage I | Stage II |
| 1 | Executive Engineer (Project Manager) | | 0 | 27,500 | 0 | 0 |
| 2 | Assistant Engineer (E&M) (Asstt. Manager) | | 1 | 24,200 | 0 | 290,400 |
| 3 | Assistant Engineer (Civil) | | 0 | 24,200 | 0 | 0 |
| 4 | Junior Engineer (E&M) (Junior Manager) | | 4 | 19,800 | 0 | 950,400 |
| 5 | Junior Engineer (Civil) (Junior Manager) | | 1 | 19,800 | 0 | 237,600 |
| 6 | Fitter (Mech.) I Class | | 0 | 3,960 | 0 | 0 |
| 7 | Electrician I Class | | 1 | 3,960 | 0 | 47,520 |
| 8 | Fitter II Class | | 1 | 3,630 | 0 | 43,560 |
| 9 | Electrician II Class | | 1 | 3,630 | 0 | 43,560 |
| 10 | Gardener | | 1 | 3,080 | 0 | 36,960 |
| 11 | Driver | | 0 | 7,700 | 0 | 0 |
| 12 | Cleaner | | 0 | 3,080 | 0 | 0 |
| 13 | Junior Accountant | | 1 | 11,550 | 0 | 138,600 |
| 14 | UDC (Senior Assistant) | | 1 | 9,570 | 0 | 114,840 |
| 15 | LDC/Typist (Junior Assistant) | | 1 | 8,360 | 0 | 100,320 |
| 16 | Peon | | 1 | 6,050 | 0 | 72,600 |
| 17 | Junior Stenographer | | 0 | 9,570 | 0 | 0 |
| 18 | Chemist | | 0 | 7,700 | 0 | 0 |
| 19 | Assistant Chemist | | 0 | 6,600 | 0 | 0 |
| 20 | Lab Assistant | | 1 | 4,950 | 0 | 59,400 |
| 21 | Lab Attendant | | 1 | 3,080 | 0 | 36,960 |
| 22 | Sweeper | | 1 | 2,970 | 0 | 35,640 |
| 23 | Weldar-cum-black smith | | 0 | 3,630 | 0 | 0 |
| 24 | Operator | | 4 | 5,940 | 0 | 285,120 |
| 25 | Labour (Beldar) | | 14 | 2,970 | 0 | 498,960 |
| | TOTAL | 0 | 35 | | 0 | 2,992,440 |

**Table 9.21.1 Implementation/Investment Schedule, District I (City Central) (page1 of 2)**

| | Stage I | | | | | | | | | | | Stage II | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| **Direct Construction Cost** | | | | | | | | | | | | | | | | | | | |
| Trunk Sewer | | | | 65.7 | 65.7 | 65.7 | 65.7 | 65.8 | | | | 62.6 | 62.6 | 62.6 | 62.6 | 62.6 | | | |
| Rising Main | | | | 20.2 | | | | | | | | | | | | | | | |
| Branch Sewer | | | | 14.1 | 14.1 | 14.1 | 14.2 | 14.2 | 14.2 | 14.2 | 14.2 | 17.6 | 17.6 | 17.6 | 17.6 | 17.6 | 17.6 | 17.6 | 17.6 |
| Bhagwatdas Nala SPS | | | | 3.9 | 7.9 | | | | | | | | | | | | | | 2.4 |
| Guptar SPS | | | | 1.2 | | | | | | | | | | | | | | | 1.2 |
| Muir Mill SPS | | | | 1.2 | | | | | | | | | | | | | | | 1.5 |
| Parmat SPS | | | | 18.3 | | | | | | | | | | | | | | | 18.3 |
| Nawabganj SPS | | | | 1.8 | | | | | | | | | | | | | | | 2.4 |
| **Sub Total of Direct Cost** | | | | 126.4 | 87.7 | 79.8 | 79.9 | 80.0 | 14.2 | 14.2 | 14.2 | 80.2 | 80.2 | 80.2 | 80.2 | 80.2 | 17.6 | 17.6 | 43.4 |
| **O/M Cost** | | | | | | | | | | | | | | | | | | | |
| Sewers | | | | 8.8 | 8.8 | 8.8 | 8.8 | 8.8 | 8.8 | 8.8 | 8.8 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 |
| Bhagwatdas Nala SPS | | | | | | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| Guptar SPS | | | | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 |
| Muir Mill SPS | | | | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Parmat SPS | | | | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.2 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Nawabganj SPS | | | | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| **Sub Total of O/M Cost** | | | | 13.7 | 12.9 | 13.9 | 13.9 | 13.9 | 13.9 | 13.9 | 13.9 | 21.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 |
| **Sum of Direct Cost and O/M Cost** | | | | 140.1 | 100.6 | 93.7 | 93.8 | 93.9 | 28.1 | 28.1 | 28.1 | 101.2 | 100.2 | 100.2 | 100.2 | 100.2 | 37.6 | 37.6 | 63.4 |
| **House Connection** | | | | | | | | | | | | | | | | | | | |
| **City Central** | | | | 24.7 | 24.7 | 24.7 | 24.7 | 24.8 | 24.8 | 24.8 | 24.8 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.6 |
| **Sub Total of Houseconnection Cost** | | | | 24.7 | 24.7 | 24.7 | 24.7 | 24.8 | 24.8 | 24.8 | 24.8 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.5 | 20.6 |
| **Land Acquisition** | | | | | | | | | | | | | | | | | | | |
| Bhagwatdas Nala SPS | | | | 4.0 | | | | | | | | | | | | | | | |
| **Sub Total of Land Acquisition** | | | | 4.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Cost** | | | | 168.8 | 125.3 | 118.4 | 118.5 | 118.7 | 52.9 | 52.9 | 52.9 | 121.7 | 120.7 | 120.7 | 120.7 | 120.7 | 58.1 | 58.1 | 84.0 |

**Table 9.21.1 Implementation/Investment Schedule, District I (City Central) (page2 of 2)**

| | Stage II | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| **Direct Construction Cost** | | | | | | | | |
| Trunk Sewer | | | | | | | | 641.6 |
| Rising Main | | | | | | | | 20.2 |
| Branch Sewer | 17.6 | 17.6 | 17.6 | 17.6 | 17.6 | 17.7 | 17.7 | 377.5 |
| Bhagwatdas Nala SPS | | | | | | | | 14.2 |
| Guptar SPS | | | | | | | | 2.4 |
| Muir Mill SPS | | | | | | | | 2.7 |
| Parmat SPS | | | | | | | | 36.6 |
| Nawabganj SPS | | | | | | | | 4.2 |
| **Sub Total of Direct Cost** | 17.6 | 17.6 | 17.6 | 17.6 | 17.6 | 17.7 | 17.7 | 1,099.4 |
| **O/M Cost** | | | | | | | | |
| Sewers | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 289.4 |
| Bhagwatdas Nala SPS | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 21.0 |
| Guptar SPS | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 1.1 | 25.3 |
| Muir Mill SPS | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 18.4 |
| Parmat SPS | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 55.1 |
| Nawabganj SPS | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 21.4 |
| **Sub Total of O/M Cost** | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 20.0 | 411.0 |
| **Sum of Direct Cost and O/M Cost** | 37.6 | 37.6 | 37.6 | 37.6 | 37.6 | 37.7 | 37.7 | 1,510.4 |
| **House Connection** | | | | | | | | |
| **City Central** | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 506.3 |
| **Sub Total of Houseconnection Cost** | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 20.6 | 506.3 |
| **Land Acquisition** | | | | | | | | |
| Bhagwatdas Nala SPS | | | | | | | | |
| **Sub Total of Land Acquisition** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 4.0 |
| **Total Cost** | 58.2 | 58.2 | 58.2 | 58.2 | 58.2 | 58.3 | 58.3 | 2,020.7 |

**Table 9.21.2 Implementation/Investment Schedule, District I (City East) (Page 1 of 2)**

| | Stage I | | | | | | | | | | | Stage II | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| **Direct Construction Cost** | | | | | | | | | | | | | | | | | | | |
| Trunk Sewer | | | | 19.4 | 19.4 | 19.5 | | | | | | 69.4 | 69.4 | 69.4 | 69.4 | 69.5 | | | |
| Rising Main | | | | | | | | | | | | | | | | | | | |
| Branch Sewer | | | | 35.2 | 35.2 | 35.2 | 35.3 | 35.3 | 35.3 | 35.3 | 35.3 | 47.0 | 47.0 | 47.0 | 47.0 | 47.0 | 47.0 | 47.0 | 47.0 |
| Jajmau SPS (ASP) | | | | | | | | | | | | 24.9 | | | | | | | 34.8 |
| Jajmau SPS (UASB) | | | | | | | | | | | | 2.4 | | | | | | | 9.2 |
| ISPS No.1 - No.4 | | | | | | | | | | | | | | | | | | | 5.7 |
| Jajmau STP (ASP) | | | | | | | | | | | | 48.0 | | | | | | | 140.4 |
| Jajmau STP (UASB) | | | | 43.0 | 86.0 | | | | | | | 27.0 | | | | | | | 36.9 |
| **Sub Total of Direct Cost** | 0.0 | 0.0 | 0.0 | 97.6 | 140.6 | 54.7 | 35.3 | 35.3 | 35.3 | 35.3 | 35.3 | 218.7 | 116.4 | 116.4 | 116.4 | 116.5 | 47.0 | 47.0 | 274.0 |
| **O/M Cost** | | | | | | | | | | | | | | | | | | | |
| Sewers | | | | 7.6 | 7.6 | 7.6 | 7.6 | 7.6 | 7.6 | 7.6 | 7.6 | 18.8 | 18.8 | 18.8 | 18.8 | 18.8 | 18.8 | 18.8 | 18.8 |
| Jajmau SPS (ASP+UASB) | | | | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 8.6 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 |
| ISPS No.1 - No.4 | | | | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 |
| Jajmau STP (Pilot) | | | | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 |
| Jajmau STP (ASP) | | | | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 67.9 | 67.9 | 67.9 | 67.9 | 67.9 | 67.9 | 67.9 | 67.9 |
| Jajmau STP (UASB) | | | | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 14.6 | 16.2 | 16.2 | 16.2 | 16.2 | 16.2 | 16.2 | 16.2 | 16.2 |
| **Sub Total of O/M Cost** | | | | 79.7 | 79.7 | 79.7 | 79.7 | 79.7 | 79.7 | 79.7 | 79.7 | 117.7 | 117.7 | 117.7 | 117.7 | 117.7 | 117.7 | 117.7 | 117.7 |
| **Sum of Direct Cost and O/M Cost** | 0.0 | 0.0 | 0.0 | 177.3 | 220.3 | 134.4 | 115.0 | 115.0 | 115.0 | 115.0 | 115.0 | 336.4 | 234.1 | 234.1 | 234.1 | 234.2 | 164.7 | 164.7 | 391.7 |
| **House Connection** | | | | | | | | | | | | | | | | | | | |
| City East | | | | 18.5 | 18.5 | 18.5 | 18.5 | 18.6 | 18.6 | 18.6 | 18.6 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 |
| **Sub Total of Houseconnection Cost** | 0.0 | 0.0 | 0.0 | 18.5 | 18.5 | 18.5 | 18.5 | 18.6 | 18.6 | 18.6 | 18.6 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 | 8.7 |
| **Land Acquisition** | | | | | | | | | | | | | | | | | | | |
| Jajmau STP (ASP) | | | | | | | | | | | | 8.0 | | | | | | | |
| **Sub Total of Land Acquisition** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Cost** | 0.0 | 0.0 | 0.0 | 195.8 | 238.8 | 152.9 | 133.5 | 133.6 | 133.6 | 133.6 | 133.6 | 353.1 | 242.8 | 242.8 | 242.8 | 242.9 | 173.4 | 173.4 | 400.4 |

**Table 9.21.2 Implementation/Investment Schedule, District I (City East) (Page 2 of 2)**

| | Stage II | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| **Direct Construction Cost** | | | | | | | | |
| Trunk Sewer | | | | | | | | 405.4 |
| Rising Main | | | | | | | | 0.0 |
| Branch Sewer | 47.0 | 47.0 | 47.0 | 47.0 | 47.1 | 47.1 | 47.1 | 987.4 |
| Jajmau SPS (ASP) | | | | | | | | 59.7 |
| Jajmau SPS (UASB) | | | | | | | | 11.6 |
| ISPS No.1 - No.4 | | | | | | | | 5.7 |
| Jajmau STP (ASP) | | | | | | | | 188.4 |
| Jajmau STP (UASB) | | | | | | | | 192.9 |
| **Sub Total of Direct Cost** | 47.0 | 47.0 | 47.0 | 47.0 | 47.1 | 47.1 | 47.1 | 1,851.1 |
| **O/M Cost** | | | | | | | | |
| Sewers | 18.8 | 18.8 | 18.8 | 18.8 | 18.8 | 18.8 | 18.8 | 342.8 |
| Jajmau SPS (ASP+UASB) | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 241.3 |
| ISPS No.1 - No.4 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 59.8 |
| Jajmau STP (Pilot) | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 16.1 |
| Jajmau STP (ASP) | 67.9 | 67.9 | 67.9 | 67.9 | 67.9 | 67.9 | 67.9 | 1,383.3 |
| Jajmau STP (UASB) | 16.2 | 16.2 | 16.2 | 16.2 | 16.2 | 16.2 | 16.2 | 359.8 |
| **Sub Total of O/M Cost** | 117.7 | 117.7 | 117.7 | 117.7 | 117.7 | 117.7 | 117.7 | 2,403.1 |
| **Sum of Direct Cost and O/M Cost** | 164.7 | 164.7 | 164.7 | 164.7 | 164.8 | 164.8 | 164.8 | 4,254.2 |
| **House Connection** | | | | | | | | |
| City East | 8.7 | 8.7 | 8.7 | 8.7 | 8.8 | 8.8 | 8.8 | 279.2 |
| **Sub Total of Houseconnection Cost** | 8.7 | 8.7 | 8.7 | 8.7 | 8.8 | 8.8 | 8.8 | 279.2 |
| **Land Acquisition** | | | | | | | | |
| Jajmau STP (ASP) | | | | | | | | 8.0 |
| **Sub Total of Land Acquisition** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 8.0 |
| **Total Cost** | 173.4 | 173.4 | 173.4 | 173.4 | 173.6 | 173.6 | 173.6 | 4,541.4 |

**Table 9.21.3 Implementation/Investment Schedule, District II (Page 1 of 2)**

| | Stage I | | | | | | | | | | | Stage II | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| **Direct Construction Cost** | | | | | | | | | | | | | | | | | | | |
| Trunk Sewer | | | | 64.1 | | | | | | | | 184.6 | 184.6 | 184.6 | 184.6 | 184.7 | | | |
| Rising Main | | | | | | | | | | | | | | | | | | | |
| Branch Sewer | | | | 71.6 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 105.6 | 105.6 | 105.6 | 105.7 | 105.7 | 105.7 | 105.7 | 105.7 |
| MPS at Bingawan STP | | | | | | | | | | | | 104.2 | 208.3 | 208.3 | | | | | |
| Rakhi Mandi SPS (Sanctioned) | | | | | | | | | | | | | | | | | | | 276.9 |
| Mushi Purwa SPS (Sanctioned) | | | | | | | | | | | | | | | | | | | 230.2 |
| Ganda Nala SPS (Sanctioned) | | | | | | | | | | | | | | | | | | | 128.6 |
| Bingawan STP | | | | | | | | | | | | 99.0 | 198.0 | 198.0 | | | | | |
| **Sub Total of Direct Cost** | | | | 135.7 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 71.7 | 493.4 | 696.5 | 696.5 | 290.3 | 290.4 | 105.7 | 105.7 | 741.4 |
| **O/M Cost** | | | | | | | | | | | | | | | | | | | |
| Sewers | | | | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 12.2 | 37.9 | 37.9 | 37.9 | 37.9 | 37.9 | 37.9 | 37.9 | 37.9 |
| Rakhi Mandi SPS | | | | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 |
| Mushi Purwa SPS | | | | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 4.1 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 |
| Ganda Nala SPS | | | | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 |
| MPS at Bingawan STP | | | | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 |
| Bingawan STP | | | | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 45.6 | 60.7 | 60.7 | 60.7 | 60.7 | 60.7 | 60.7 | 60.7 | 60.7 |
| **Sub Total of O/M Cost** | | | | 80.5 | 80.5 | 80.5 | 80.5 | 80.5 | 80.5 | 80.5 | 80.5 | 128.9 | 128.9 | 128.9 | 128.9 | 128.9 | 128.9 | 128.9 | 128.9 |
| **Sum of Direct Cost and O/M Cost** | | | | 216.2 | 152.2 | 152.2 | 152.2 | 152.2 | 152.2 | 152.2 | 152.2 | 622.3 | 825.4 | 825.4 | 419.2 | 419.3 | 234.6 | 234.6 | 870.3 |
| **House Connection** | | | | | | | | | | | | | | | | | | | |
| South | | | | 52.0 | 52.0 | 52.0 | 52.0 | 52.1 | 52.1 | 52.1 | 52.1 | 69.2 | 69.2 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 |
| **Sub Total of Houseconnection Cost** | | | | 52.0 | 52.0 | 52.0 | 52.0 | 52.1 | 52.1 | 52.1 | 52.1 | 69.2 | 69.2 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 |
| **Land Acquisition** | | | | | | | | | | | | | | | | | | | |
| Bingawan STP | | | | 288.0 | | | | | | | | | | | | | | | |
| **Sub Total of Land Acquisition** | 0.0 | 0.0 | 0.0 | 288.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Cost** | 0.0 | 0.0 | 0.0 | 556.2 | 204.2 | 204.2 | 204.2 | 204.3 | 204.3 | 204.3 | 204.3 | 691.5 | 894.6 | 894.7 | 488.5 | 488.6 | 303.9 | 303.9 | 939.6 |

**Table 9.21.3 Implementation/Investment Schedule, District II (Page 2 of 2)**

| | Stage II | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| **Direct Construction Cost** | | | | | | | | |
| Trunk Sewer | | | | | | | | 987.2 |
| Rising Main | | | | | | | | 0.0 |
| Branch Sewer | 105.7 | 105.7 | 105.7 | 105.7 | 105.7 | 105.7 | 105.7 | 2,158.7 |
| MPS at Bingawan STP | | | | | | | | 520.8 |
| Rakhi Mandi SPS (Sanctioned) | | | | | | | | 276.9 |
| Mushi Purwa SPS (Sanctioned) | | | | | | | | 230.2 |
| Ganda Nala SPS (Sanctioned) | | | | | | | | 128.6 |
| Bingawan STP | | | | | | | | 495.0 |
| **Sub Total of Direct Cost** | 105.7 | 105.7 | 105.7 | 105.7 | 105.7 | 105.7 | 105.7 | 4,797.4 |
| **O/M Cost** | | | | | | | | |
| Sewers | 37.9 | 37.9 | 37.9 | 37.9 | 37.9 | 37.9 | 37.9 | 666.1 |
| Rakhi Mandi SPS | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 6.7 | 142.9 |
| Mushi Purwa SPS | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 5.0 | 107.8 |
| Ganda Nala SPS | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 45.9 |
| MPS at Bingawan STP | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 16.5 | 339.5 |
| Bingawan STP | 60.7 | 60.7 | 60.7 | 60.7 | 60.7 | 60.7 | 60.7 | 1,275.3 |
| **Sub Total of O/M Cost** | 128.9 | 128.9 | 128.9 | 128.9 | 128.9 | 128.9 | 128.9 | 2,577.5 |
| **Sum of Direct Cost and O/M Cost** | 234.6 | 234.6 | 234.6 | 234.6 | 234.6 | 234.6 | 234.6 | 7,374.9 |
| **House Connection** | | | | | | | | |
| South | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 1,455.7 |
| **Sub Total of Houseconnection Cost** | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 69.3 | 1,455.7 |
| **Land Acquisition** | | | | | | | | |
| Bingawan STP | | | | | | | | 288.0 |
| **Sub Total of Land Acquisition** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 288.0 |
| **Total Cost** | 303.9 | 303.9 | 303.9 | 303.9 | 303.9 | 303.9 | 303.9 | 9,118.6 |

**Table 9.21.4 Implementation/Investment Schedule, District III (Page1 of 2)**

| | | | Stage I | | | | | | | | | | | Stage II | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| **Direct Construction Cost** | | | | | | | | | | | | | | | | | | | | | |
| Trunk Sewer | | | | | | 84.6 | 84.6 | 84.6 | 84.6 | 84.7 | | | | 254.1 | 254.1 | 254.1 | 254.1 | 254.2 | | | |
| Rising Main | | | | | | | | | | | | | | | | | | | | | |
| Branch Sewer | | | | | | 17.9 | 17.9 | 18.0 | 18.0 | 18.0 | 18.0 | 18.0 | 18.1 | 157.1 | 157.1 | 157.1 | 157.1 | 157.1 | 157.1 | 157.1 | 157.1 |
| Lakhanpur SPS | | | | | | | 24.1 | 48.2 | | | | | | | | | | | | | |
| Panki SPS | | | | | | | 131.5 | 263.0 | | | | | | | | | | | | | |
| MPS at Panka STP | | | | | | 119.9 | 239.8 | 239.8 | | | | | | 54.0 | | | | | | | |
| Panka STP | | | | | | 72.0 | 144.0 | 144.0 | | | | | | 240.0 | | | | | | | |
| **Sub Total of Direct Cost** | | | | | | 294.4 | 641.9 | 797.6 | 102.6 | 102.7 | 18.0 | 18.0 | 18.1 | 705.2 | 411.2 | 411.2 | 411.2 | 411.3 | 157.1 | 157.1 | 157.1 |
| **O/M Cost** | | | | | | | | | | | | | | | | | | | | | |
| Sewers | | | | | | 20.1 | 20.1 | 20.1 | 20.1 | 20.1 | 20.1 | 20.1 | 20.1 | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 |
| Lakhanpur SPS | | | | | | | | | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 |
| Panki SPS | | | | | | | | | 4.3 | 4.3 | 4.3 | 4.3 | 4.3 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 |
| MPS at Panka STP | | | | | | | | | 5.1 | 5.1 | 5.1 | 5.1 | 5.1 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 |
| Panka STP | | | | | | | | | 21.9 | 21.9 | 21.9 | 21.9 | 21.9 | 33.3 | 33.3 | 33.3 | 33.3 | 33.3 | 33.3 | 33.3 | 33.3 |
| **Sub Total of O/M Cost** | | | | | | 20.1 | 20.1 | 20.1 | 52.0 | 52.0 | 52.0 | 52.0 | 52.0 | 98.2 | 98.2 | 98.2 | 98.2 | 98.2 | 98.2 | 98.2 | 98.2 |
| **Sum of Direct Cost and O/M Cost** | | | 0.0 | 0.0 | 0.0 | 314.5 | 662.0 | 817.7 | 154.6 | 154.7 | 70.0 | 70.0 | 70.1 | 803.4 | 509.4 | 509.4 | 509.4 | 509.5 | 255.3 | 255.3 | 255.3 |
| **House Connection** | | | | | | | | | | | | | | | | | | | | | |
| West | | | | | | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 |
| **Sub Total of Houseconnection Cost** | | | | | | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 22.2 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 |
| **Land Acquisition** | | | | | | | | | | | | | | | | | | | | | |
| Panki SPS | | | | | | 4.0 | | | | | | | | | | | | | | | |
| Panka STP | | | | | | 280.0 | | | | | | | | | | | | | | | |
| **Sub Total of Land Acquisition** | | | 0.0 | 0.0 | 0.0 | 284.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Cost** | | | | | | 620.7 | 684.2 | 839.9 | 176.8 | 176.9 | 92.2 | 92.2 | 92.3 | 869.5 | 575.5 | 575.5 | 575.5 | 575.6 | 321.4 | 321.4 | 321.4 |

**Table 9.21.4 Implementation/Investment Schedule, District III (Page2 of 2)**

| | Stage II | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| **Direct Construction Cost** | | | | | | | | |
| Trunk Sewer | | | | | | | | 1,693.7 |
| Rising Main | | | | | | | | 0.0 |
| Branch Sewer | 157.1 | 157.1 | 157.2 | 157.2 | 157.2 | 157.2 | 157.2 | 2,500.9 |
| Lakhanpur SPS | | 8.1 | | | | | | 80.4 |
| Panki SPS | | 36.0 | | | | | | 430.5 |
| MPS at Panka STP | | | | | | | | 653.5 |
| Panka STP | | | | | | | | 600.0 |
| **Sub Total of Direct Cost** | 157.1 | 201.2 | 157.2 | 157.2 | 157.2 | 157.2 | 157.2 | 5,959.0 |
| **O/M Cost** | | | | | | | | |
| Sewers | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 | 46.0 | 850.8 |
| Lakhanpur SPS | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 2.5 | 40.5 |
| Panki SPS | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 | 6.9 | 125.0 |
| MPS at Panka STP | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 9.5 | 168.0 |
| Panka STP | 33.3 | 33.3 | 33.3 | 33.3 | 33.3 | 33.3 | 33.3 | 609.0 |
| **Sub Total of O/M Cost** | 98.2 | 98.2 | 98.2 | 98.2 | 98.2 | 98.2 | 98.2 | 1,793.3 |
| **Sum of Direct Cost and O/M Cost** | 255.3 | 299.4 | 255.4 | 255.4 | 255.4 | 255.4 | 255.4 | 7,752.3 |
| **House Connection** | | | | | | | | |
| West | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 1,169.1 |
| **Sub Total of Houseconnection Cost** | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 66.1 | 1,169.1 |
| **Land Acquisition** | | | | | | | | |
| Panki SPS | | | | | | | | 4.0 |
| Panka STP | | | | | | | | 280.0 |
| **Sub Total of Land Acquisition** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 284.0 |
| **Total Cost** | 321.4 | 365.5 | 321.5 | 321.5 | 321.5 | 321.5 | 321.5 | 9,205.4 |

**Table 9.21.5 Implementation/Investment Schedule, District IV (Page 1 of 2)**

| | Stage I | | | | | | | | | | | Stage II | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
| **Direct Construction Cost** | | | | | | | | | | | | | | | | | | | |
| Trunk Sewer | | | | | | | | | | | | 151.0 | 151.0 | 151.1 | 151.1 | 151.1 | | | |
| Rising Main | | | | | | | | | | | | | | 76.5 | | | | | |
| Branch Sewer | | | | | | | | | | | | 88.2 | 88.2 | 88.2 | 88.2 | 88.2 | 88.3 | 88.3 | 88.3 |
| Ruman SPS | | | | | | | | | | | | | 73.9 | 147.9 | | | | | |
| Karankher STP | | | | | | | | | | | | 51.0 | 102.0 | 102.0 | | | | | |
| **Sub Total of Direct Cost** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 290.2 | 415.1 | 565.7 | 239.3 | 239.3 | 88.3 | 88.3 | 88.3 |
| **O/M Cost** | | | | | | | | | | | | | | | | | | | |
| Sewers | | | | | | | | | | | | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 |
| Ruman SPS | | | | | | | | | | | | | | | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 |
| Karankher STP | | | | | | | | | | | | | | | 15.1 | 15.1 | 15.1 | 15.1 | 15.1 |
| **Sub Total of O/M Cost** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 21.4 | 21.4 | 21.4 | 41.8 | 41.8 | 41.8 | 41.8 | 41.8 |
| **Sum of Direct Cost and O/M Cost** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 311.6 | 436.5 | 587.1 | 281.1 | 281.1 | 130.1 | 130.1 | 130.1 |
| **House Connection** | | | | | | | | | | | | | | | | | | | |
| East | | | | | | | | | | | | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 |
| **Sub Total of Houseconnection Cost** | | | | | | | | | | | | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 |
| **Land Acquisition** | | | | | | | | | | | | | | | | | | | |
| Ruman SPS | | | | | | | | | | | | 4.0 | | | | | | | |
| Karankher STP | | | | | | | | | | | | 119.2 | | | | | | | |
| **Sub Total of Land Acquisition** | | | | | | | | | | | | 123.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total Cost** | | | | | | | | | | | | 452.1 | 453.8 | 604.4 | 298.4 | 298.4 | 147.4 | 147.4 | 147.4 |

**Table 9.21.5 Implementation/Investment Schedule, District IV (Page 2 of 2)**

| | Stage II | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | |
| **Direct Construction Cost** | | | | | | | | |
| Trunk Sewer | | | | | | | | 755.3 |
| Rising Main | | | | | | | | 76.5 |
| Branch Sewer | 88.3 | 88.3 | 88.3 | 88.3 | 88.3 | 88.3 | 88.3 | 1,324.0 |
| Ruman SPS | | | | | | | | 221.8 |
| Karankher STP | | | | | | | | 255.0 |
| **Sub Total of Direct Cost** | 88.3 | 88.3 | 88.3 | 88.3 | 88.3 | 88.3 | 88.3 | 2,632.6 |
| **O/M Cost** | | | | | | | | |
| Sewers | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 21.4 | 321.0 |
| Ruman SPS | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 | 5.3 | 63.6 |
| Karankher STP | 15.1 | 15.1 | 15.1 | 15.1 | 15.1 | 15.1 | 15.1 | 181.2 |
| **Sub Total of O/M Cost** | 41.8 | 41.8 | 41.8 | 41.8 | 41.8 | 41.8 | 41.8 | 565.8 |
| **Sum of Direct Cost and O/M Cost** | 130.1 | 130.1 | 130.1 | 130.1 | 130.1 | 130.1 | 130.1 | 3,198.4 |
| **House Connection** | | | | | | | | |
| East | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 259.5 |
| **Sub Total of Houseconnection Cost** | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 17.3 | 259.5 |
| **Land Acquisition** | | | | | | | | |
| Ruman SPS | | | | | | | | 4.0 |
| Karankher STP | | | | | | | | 119.2 |
| **Sub Total of Land Acquisition** | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 123.2 |
| **Total Cost** | 147.4 | 147.4 | 147.4 | 147.4 | 147.4 | 147.4 | 147.4 | 3,581.1 |

## Table 9.22 Stage I Project - Implementation Cost

(Million Rs.)

| Project | Estimated Cost | +Physical Contingency | Cumulative Cost |
|---|---|---|---|
| **1. District I (City Central)** | | | |
| (a) Replacing existing trunk sewers | 169.9 | 203.9 | |
| (b) New Trunk Sewers | 158.7 | 190.4 | |
| (c) Nala tapping pumping stations and rising mains | 54.5 | 65.4 | |
| (d) Branch Sewer | 113.3 | 135.9 | |
| (e) Land acquisition for new pumping station | 4.0 | 4.0 | |
| Sub Total | 500.3 | 599.6 | 599.6 |
| **2. District I (City East)** | | | |
| (a) New Trunk Sewers | 58.3 | 69.9 | |
| (b) Upgrade treatment plant | 129.0 | 154.8 | |
| (c) Upgrade pumping station | 0.3 | 0.4 | |
| (d) Branch Sewer | 282.1 | 338.5 | |
| Sub Total | 469.7 | 563.6 | 1,163.2 |
| **3. District II** | | | |
| (a) New Trunk Sewers | 64.1 | 76.9 | |
| (b) Branch Sewer | 156.3 | 187.5 | |
| Sub Total | 220.3 | 264.4 | 1,427.6 |
| **4. District III** | | | |
| (a) New Trunk Sewers | 423.1 | 507.7 | |
| (b) New treatment plant | 360.0 | 432.0 | |
| (c) New pumping station | 1,066.2 | 1,279.4 | |
| (d) Branch Sewer | 143.8 | 172.6 | |
| (e) Land acquisition for STP and SPS | 284.0 | 284.0 | |
| Sub Total | 2,277.1 | 2,675.7 | 4,103.3 |
| **Total** | 3,467.4 | 4,103.3 | 4,103.3 |

# CHAPTER 10

## INITIAL ENVIRONMENTAL EXAMINATION (IEE) STUDY FOR KANPUR

# CHAPTER 10 INITIAL ENVIRONMENTAL EXAMINATION (IEE) STUDY FOR KANPUR

## 10.1 OBJECTIVE OF THE IEE STUDY

IEE is a very important and useful planning tool for development projects/programs at early stage. Original formulation of any projects/programs may be modified, if significant negative impact is predicted by the IEE. According to the JICA Environmental Guidelines, IEE is defined as "an examination undertaken at the outset of the development project planning stage to determine the environmental impacts that may be created by the particular project based on existing information and data."

The IEE has the following two objectives:

(1) To evaluate whether EIA is necessary for the project and, if so, to define its contents, and (2) to examine from an environmental viewpoint, the measures for mitigating the impacts of the project, which require environmental considerations but not a full-scale environmental impact assessment.

For the above objectives, the study on IEE was investigated (1) knowing the existing social and natural environmental conditions of the Study area, (2) identifying constraints and problems for the master plan projects/programs on the water quality management for Ganga River.

## 10.2 METHODOLOGY OF THE IEE STUDY

### 10.2.1 Procedure

There are three steps for the IEE as follows.

(a) Identification of master plan projects/programs for the IEE,
(b) Survey evaluation of environmental impact at the construction or rehabilitation and the operation stage by using an environmental impact checklist, and
(c) Output of evaluation.

### 10.2.2 Evaluation of Environmental Elements

An environmental impact matrix is used as a checklist of environmental effects. Environmental elements of impact matrix are based on JICA Guideline including JBIC Guideline. The major components are social issues, demographic issues, economic activity, institutional and custom related issues, health and sanitary issues, and cultural asset issues as social environment, and biological and ecological issues, soil resources, land resources, hydrology, water quality and temperature, pollution and landscape as natural environment.

## 10.3 SURVEY AREA

The survey area is four (4) cities of Lucknow, Kanpur, Allahabad and Varanasi. This part of the Report focuses on Kanpur.

## 10.4 PROJECTS/PROGRAMS FOR THE IEE STUDY

**(a) District I**

(1) Renovation and augmentation of Jajmau STP
(2) Renovation and augmentation of Jajmau SPS
(3) Rehabilitation of ghat area SPSs
(4) Installation of trunk sewer, rising main

(5) Installation of trunk and lateral sewers in Jajmau tannery area
(6) Construction of Bigwandas ghat nala SPS

**(b) District II**

(7) Augmentation of Rakimandi SPS and Munshipurwa SPS
(8) Augmentation of Ganda nala SPS
(9) Augmentation of Bingawan STP
(10) Installing and replacement of trunk sewers

**(c) District III**

(11) Reconstruction of Lakhanpur SPS
(12) Installation of trunk sewer
(13) Construction of Panki SPS
(14) Construction of Panka STP

**(d) District IV**

(15) Installation of trunk sewer
(16) Construction of Kathonagar SPS
(17) Construction of Karankhera STP

## 10.5 EXISTING ENVIRONMENTAL CONDITION

Kanpur is the eighth largest metropolis in India and it is one of the important industrial cities. It is situated on the right bank of river Ganga at 125.6 m above MSL. It is located at $26^0 28'$ N latitude and $80^0 21'$ E longitude, at a distance of 93 Km south west of Lucknow, 435 Km south east of Delhi, 192 Km north west of Allahabad.

The topography is generally flat with minimum level of nearly 125.6 m and the maximum of about 126.8 m above MSL. The city is located within alluvial Gangetic plains. The area is under laid with sediments deposited in successive stages. The bed of clay, fine sand, mixed with kankar and stone bajri is found in layers. The deep tube well have been bored successfully in Panki, Moti jheel, Phool bagh and Jajmau area of Kanpur city.

The climate of the area is extreme type, i.e., very hot summer and severe winter. During November to March the weather is cold and from March the temperature gradually rises and becomes very hot during May and June.

Bulk of the rainfall occurs from southwest monsoon, which lasts from middle June to September, and maximum rainfall takes place during July and August. The average annual rainfall is approximately 800 mm and temperature varies between 35 °C to 12 °C, and humidity varies from 15 % to 25 % during the year.

The major existing environmental conditions are as following.

(1) Pollution of River Ganga

The pollution of river Ganga in Kanpur is more due to the following main reasons:

- Due to chocking of sewers, the sewage flows into different storm water drains leading towards river Ganga.
- Low capacity utilisation of sewage treatment plant at Jajmau, which is treating only 40-50 mld of sewage which is applied to sewage farm and balance waste water finds its way to river Ganga.
- 354 tanneries at Jajmau produce about 13mld of highly toxic waste water which finds its way to river Ganga after partial treatment only.
- Burning of dead bodies along river ghats.
- Pollution due to settlement of people along the river banks.

(2) Drainage

The river Ganga enters the town from western side and flows out in eastern direction whereas the river Pandu enters the city from western side and joins the river Ganga at a distance of about 25 Km down stream of Kanpur. The city is thus surrounded by the river Ganga on one side (north) and the river Pandu on the other side (south).

There are 23 nalas identified to be carrying wastewater that pollute the Ganga and Pandu rivers. Among them, 20 nalas drain into the Ganga river and three into the Pandu river.

(3) Sewage Treatment Facility

There are three Sewage Treatment Plants (STP) named as 5 mld Pilot STP, 36 mld UASB STP and 130 mld STP.

(4) Wastewater Irrigation

In India, the oldest sewage farm was established around 1895, and even today one of principal modes of final disposal of wastewater is on land. It is preferred that wastewaters from even large cities be used in this manner. Presently, there are over 150 farms covering over 12,000 hectare (ha) and utilizing over $5 \times 10^8$ $m^3$ of sewage annually.

In Kanpur, there is a big sewage farm area getting discharge from Jajmau treatment plant in south-east part of Kanpur city. It was informed by UP Jal Nigam that treated effluent is being used for irrigating 3,000 hectares of land of private farmers. Digested sludge after drying is converted to manure. It is very good fertilizer for high yield because including Nitrogen, Phosphate, Potassium minerals, 1.45-1.60, 1.12-1.15, and 1.04-1.06 mg/Kg respectively. At the present, farmers are cultivating wheat, paddy rice, vegetables, and flower.

(5) Industrial Scenario

Kanpur is one of the India's earliest industrial cities. It is an important centre of Textile industries and tanneries. After independence, a large fertilizer factory and several arms factories were established. Besides this many small-scale industries such as steel re-rolling, casting, chemicals, paints, varnish and other miscellaneous industries have come up in the city.

At present, in Kanpur district, there are many kinds of industrial units. Especially, cluster of Jajmau tanneries and ordinance factories are discharging much effluent with high BOD load every day. Effluent from these units is treated at Jajmau STP.

Some industrial wastes are unfit for land disposal as they contain hazardous components such as tannery wastes containing heavy metals which accumulate in the food chain or migrate in the soils and pollute ground waters. Regular monitoring of heavy metals present in treated water is important.

(6) National Standards (MINAS) for Tannerie's Effluents

The parameters of relevance for wastewater quality in tannery industry are BOD, total chromium, sulphides, total suspended solids, total dissolved solids, chloride, sulphate, oil and grease, etc. National standards for tannery effluents are as following.

| Parameter | Limits not to Exceed |
|---|---|
| 1. pH | 6.5 – 9.0 |
| 2. $BOD_5$ at $20^o$ C (mg/l) | 100* |
| 3. Total Suspended Solids (mg/l) | 100 |
| 4. Sulphides (mg/l) | 2 |
| 5. Total Chromium (mg/l) | 2 |
| 6. Oil and Grease (mg/l) | 10 |

Note: *For effluent discharged into inland surface waters, BOD limit is stricter to 30 mg/litre.
Source: Central Pollution Control Board, 1991-1992

(7) Sanitation

On account of rapid growth of population, the development of unplanned colonies has come up in outskirts and surroundings of city area. These colonies are facing so many problems such as lack of proper roads, drainage and sewerage, etc.

(8) Open Space

Open spaces with recreational facilities are Allen Park with zoo, Company Bagh Park, and Green Park.

## 10.6 EVALUATION AND CONCLUSION OF THE IEE STUDY

The Ministry of Environment and Forests (MoEF) enforced the notification in January 1994 and amended it in May 1997, April 1997, January 2000, December 2000, August 2001 and November 2001 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 30 categories. The appraisal committees comprising experts, Governmental official and non-government organisations (NGOs) were set up by the MoEF to scrutinise various EIAs 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. Sewerage project is not included in these industries and does not require EIA study according to the Notification.

An Initial Environmental Examination (IEE) for the proposed project components in the Master Plan for the four cities was carried out by JICA Study Team based on a JICA guideline, to briefly identify the impacts of the facilities proposed in the Sewerage Master Plans on natural and social environment. The important environmental issues are identified and the impacts are ranked as (A) strong impact, (B) medium impact, (C) not fully known, and (blank) no major impact during the construction and operation stage.

The results of the IEE to Master Plan Projects that have been planned for Kanpur city are shown in Table 10.1. The major impacts identified for the proposed facilities are related to construction and operation of sewage treatment plants as given in table below.

| Impact items | Phase | Spatial range | Time range | Range/ affected people |
|---|---|---|---|---|
| 1. Land acquisition for construction of STP | Construction | Agricultural field | Long term | Farmers |
| 2. Income loss of agriculture due to construction of STP in agricultural field | Construction | (Social issue) | Long term | Farmers |
| 3. Landscape and land use change | Construction | Agricultural field | Long term | Nearby villagers |
| 4. Sludge disposal from STP | Operation | Disposal sites | Long term | Disposal sites |
| 5. Contamination of surface water and groundwater by discharging treated effluent and seepage from STP | Operation | River, irrigation canal and groundwater | Long term | Nearby villagers |
| 6. Contamination of soil through application of treated water and dried sludge | Operation | Agricultural field | Long term | Farmers |

The proposed projects are, however, in general, environmental mitigation projects by providing sewerage system to properly dispose of municipal sewage. Therefore, the projects themselves have preferable environmental impacts on the water environment and the public health of the residents.

## Table 10.1 Possible Environmental Impact Matrix for IEE

| 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 | Odour |
| Sewage Treatment Plant | **C** | B/C | B/C | C | | | | | C | | | | | | | | | B/C | | | | C | | |
| | **O** | | | | | | | C | C | | | | B/C | C | | | | | | B/C | B/C | C | | C |
| Pumping Station | **C** | C | | C | | | | | | | | | | | | | | | | | | C | | |
| | **O** | | | | | | | C | C | | | | | | | | | | | | | C | | |
| Installation of Main Trunk Sewer | **C** | | C | C | | | | | | | | | | | | | | | | | | C | | |
| | **O** | | | | | | | | | | | | | | | | | | | | | | | |
| Rehabilitation of Existing Trunk sewer | **C** | | C | C | | | | C | | | | | | | | | | | | C | | C | | C |
| | **O** | | | | | | | | | | | | | | | | | | | | | | | |

**Remarks:**

**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 that the development scheme is foreseen to have minor impact on the environmental element

Balnk: indicates no impact

# *Appendix A*

## Cost Comparison, Kanpur

## A. Initial Cost

### (1) Treatment Plant

**1) Capacity Required (incremental)**

| Name | Process | Status | Incremental Capacity (MLD) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Option-1 | Option-2 | Option-3 | Option-4 | Option-5 |
| Jajmau No.1 | UASB | E | | | | | |
| Jajmau No.2 | UASB | E | | | | | |
| Jajmau No.3 | ASP | E | 0 | 52 | 0 | 70 | 70 |
| Karankhera | UASB | P | 151 | 84 | 85 | 0 | 0 |
| Kathonagar | UASB | P | 0 | 0 | 66 | 66 | 0 |
| Bingawan (Inclemental) | UASB | S/A | 0 | 0 | 0 | 0 | 66 |

**2) Initial Cost (incremental)**

| Name | Process | Unit Cost Rs.Million/MLD | Initial Cost (Rs.Million) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Option-1 | Option-2 | Option-3 | Option-4 | Option-5 |
| Jajmau No.1 | UASB | | | | | | |
| Jajmau No.2 | UASB | | | | | | |
| Jajmau No.3 | ASP | 2.7 | 0.0 | 140.4 | 0.0 | 189.0 | 189.0 |
| Karankhera | UASB | 3.0 | 453.0 | 252.0 | 255.0 | 0.0 | 0.0 |
| Kathonagar | UASB | 3.0 | 0.0 | 0.0 | 198.0 | 198.0 | 0.0 |
| Bingawan (Inclemental) | UASB | 3.0 | | | | | 198.0 |
| Total | | | 453.0 | 392.4 | 453.0 | 387.0 | 387.0 |

### (2) Pumping Station

**1) Capacity Required**

| Name | Type | Status | Incremental Capacity | | | | |
|---|---|---|---|---|---|---|---|
| | | | Option-1 | Option-2 | Option-3 | Option-4 | Option-5 |
| Jajmau SPS | Centrifugal | E | 0 | 64 | 0 | 82 | 82 |
| Ruman SPS | Centrifugal | P | 151 | 84 | 85 | 0 | 0 |
| PS in Kathonagar STP | Centrifugal | P | 0 | 0 | 66 | 66 | 66 |
| PS in Bingawan STP (incremental) | Centrifugal | P | | | | | 66 |

**2) Initial Cost**

| Name | | | Initial Cost (Rs.Million) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Option-1 | Option-2 | Option-3 | Option-4 | Option-5 |
| Jajmau SPS | | | | 212.3 | | 268.4 | 268.4 |
| Ruman SPS | | | 474.3 | 274.5 | 277.6 | | |
| PS in Kathonagar STP | | | | | 218.6 | 218.6 | 218.6 |
| Total | | | 474.3 | 486.8 | 496.2 | 487.0 | 487.0 |

**(3) Land Acquisition**

**1) Land Required**

| Name | Process | Land Required ha/MLD | Land Required (ha) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Option-1 | Option-2 | Option-3 | Option-4 | Option-5 |
| **Treatment Plant** | | | | | | | |
| Jajmau No.1 | UASB | - | | | | | |
| Jajmau No.2 | UASB | - | | | | | |
| Jajmau No.3 | ASP | 0.20 | 0.0 | 2.0 | 0.0 | 5.0 | 5.0 |
| Karankhera | UASB | 0.35 | 53.0 | 29.0 | 30.0 | 0.0 | 0.0 |
| Kathonagar | UASB | 0.35 | 0.0 | 0.0 | 23.0 | 23.0 | 0.0 |
| Bingawan (Inclemental) | UASB | 0.35 | | | | | 23.0 |
| **Pumping Station** | | | | | | | |
| Jajmau SPS | | | | 0.5 | | 0.5 | 0.5 |
| Ruman SPS | | | 0.5 | 0.5 | 0.5 | | |
| PS in Kathonagar STP | | | | | | | 0.5 |
| Total | | | 53.5 | 32.0 | 53.5 | 28.5 | 29.0 |

Note(1): Land for Augmentation is already prepared at Jajmau No.1 and No.2 STP
Note(2): Land for 43MLD-Augmentation is already prepared at Jajmau No.3 STP

**2) Land Acquisition Cost**

| | Initial Cost (Rs.Million) | | | | |
|---|---|---|---|---|---|
| | Option-1 | Option-2 | Option-3 | Option-4 | Ootion-5 |
| Land Acquisition Cost (Rs.Million) | 214.0 | 128.0 | 214.0 | 114.0 | 116.0 |

**(4) Trunk Sewer/Rising Main**

| | Initial Cost (Rs.Million) | | | | |
|---|---|---|---|---|---|
| | Option-1 | Option-2 | Option-3 | Option-4 | Ootion-5 |
| District I (city east) | 715.8 | 515.9 | 667.7 | 511.1 | 511.1 |
| District IV | 755.2 | 755.2 | 754.9 | 754.9 | 754.9 |
| Rising Main from District IV(East) to II(South) | | | | | 72.1 |
| Total (Rs.Million) | 1,471.0 | 1,271.1 | 1,422.6 | 1,266.0 | 1,338.1 |

**(5) Total Initial Cost**

| | | | Initial Cost (Rs.Million) | | | | |
|---|---|---|---|---|---|---|---|
| | | | Option-1 | Option-2 | Option-3 | Option-4 | Ootion-5 |
| Treatment Plant | | | 453 | 392 | 453 | 387 | 387 |
| Pumping Station | | | 474 | 487 | 496 | 487 | 487 |
| Land Acquisition | | | 214 | 128 | 214 | 114 | 116 |
| Trunk Sewer | | | 1,471 | 1,271 | 1,423 | 1,266 | 1,338 |
| Total | | | 2,612 | 2,278 | 2,586 | 2,254 | 2,328 |

**(6) Treatment Plant O&M**

| | | Unit cost | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|---|---|
| Treatment Plant Name | Process | Rs/mld | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Jajmau No.1 | UASB | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jajmau No.2 | UASB | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Jajmau No.3 | AS | 0.36 | 0.00 | 18.72 | 0.00 | 25.20 | 25.20 |
| Karankhera | UASB | 0.13 | 19.63 | 10.92 | 11.05 | 0.00 | 0.00 |
| Bingawan (Inclemental) | UASB | 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 8.58 |
| Kathonagar | UASB | 0.13 | 0.00 | 0.00 | 8.58 | 8.58 | 0.00 |
| | | Total | 19.63 | 29.64 | 19.63 | 33.78 | 33.78 |

**(7) Pump station O&M**

**1) Energy requirements**

| | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|
| Pump station name | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Jajmau SPS - new | 1.30 | 4.84 | 1.30 | 6.47 | 6.47 |
| Ruman SPS | 14.68 | 6.67 | 7.24 | 0.00 | 0.00 |
| PS at Kathonagar STP | | | | | 9.77 |
| PS at Karankhera STP | 0.00 | 0.00 | 7.98 | 7.98 | |
| Total | 15.99 | 11.51 | 16.53 | 14.45 | 16.24 |

**2) Rising main maintenance**

| | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|
| Pump station name | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Jajmau SPS - new | 0.06 | 0.08 | 0.06 | 0.08 | 0.08 |
| Ruman SPS | 0.28 | 0.23 | 0.23 | 0.00 | |
| PS at Kathonagar STP | | | | | 0.18 |
| PS at Karankhera STP | 0.00 | 0.00 | 0.00 | 0.001 | |
| Total | 0.34 | 0.32 | 0.29 | 0.08 | 0.27 |

**3) mechanical maintenance**

| | | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|---|
| Pump station name | 3% | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Jajmau SPS - new | | 0.33 | 0.81 | 0.33 | 0.94 | 0.94 |
| Ruman SPS | | 1.27 | 0.77 | 0.78 | 0.00 | |
| PS at Kathonagar STP | | | | | | 0.64 |
| PS at Karankhera STP | | 0.00 | 0.00 | 0.64 | 0.64 | |
| Total | | 1.60 | 1.58 | 1.75 | 1.58 | 1.58 |

**4)Civil maintenance**

| | 1.5% | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|---|
| Pump station name | | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Jajmau SPS - new | | 0.09 | 0.61 | 0.09 | 0.68 | 0.68 |
| Ruman SPS | | 0.82 | 0.58 | 0.59 | 0.00 | |
| PS at Kathonagar STP | | | | | | 0.49 |
| PS at Karankhera STP | | 0.00 | 0.00 | 0.49 | 0.49 | |
| Total | | 0.91 | 1.19 | 1.17 | 1.17 | 1.17 |

**5)Staffing**

| | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|
| Pump station name | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Jajmau SPS - new | 0.47 | 0.67 | 0.47 | 0.67 | 0.67 |
| Ruman SPS | 0.74 | 0.83 | 0.83 | 0.00 | |
| PS at Kathonagar STP | | | | | 0.83 |
| PS at Karankhera STP | 0.00 | 0.00 | 0.83 | 0.83 | |
| Total | 1.21 | 1.50 | 2.12 | 1.50 | 1.50 |

**(8) Total Annual O&M**

| | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|
| | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Trunk sewers | 14.71 | 12.71 | 14.23 | 12.66 | 12.66 |
| Treatment plants | 19.63 | 29.64 | 19.63 | 33.78 | 33.78 |
| Pump stations | 20.04 | 16.09 | 21.86 | 18.78 | 20.74 |
| Total | 54.38 | 58.44 | 55.72 | 65.22 | 67.18 |

**(9) Total life cycle cost**

| | Cost (Rs. million) | | | | |
|---|---|---|---|---|---|
| | Option -1 | Option -2 | Option -3 | Option -4 | Option-5 |
| Total initial cost | 2,612 | 2,278 | 2,586 | 2,254 | 2,328 |
| Net present value of O&M & equipment replacement | 907 | 986 | 930 | 1,095 | 1,175 |
| Total | 3,520 | 3,264 | 3,516 | 3,349 | 3,503 |

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**A2. Karankhera STP: Comparison of cost for various treatment methods ALT I**

| | | |
|---|---|---|
| Land cost | Rs. million | 4 |
| Interest | | 5% |
| Project life | years | 30 |
| Capacity | mld | 155 |

| **Unit rates** | WSP | AL | AL+ | AS | AS + | FAB | UASB++ |
|---|---|---|---|---|---|---|---|
| Land area Ha/mld | 1.25 | 0.35 | 0.75 | 0.20 | 0.60 | 0.06 | 0.35 |
| Capital costs (Rs.million/mld) | 1.60 | 2.5 | 3.2 | 2.7 | 3.4 | 4.6 | 3.0 |
| M&E cost (% of total) | 2% | 20% | 20% | 40% | 40% | 60% | 30% |
| Annual O&M (Rs.million/mld) | 0.06 | 0.30 | 0.32 | 0.36 | 0.38 | 0.59 | 0.13 |
| **Capital Cost Component** | | | | | | | Cost (Rs. million) |
| Land area for treatment process Ha | 194 | 54 | 116 | 31 | 93 | 9 | 54 |
| Land | **775** | **217** | **465** | **124** | **372** | **37** | **217** |
| Capital costs | **248** | **388** | **496** | **419** | **527** | **713** | **465** |
| **Recurring Cost Component** | | | | | | | Cost (Rs. million) |
| Replace M&E every 15 years | 5 | 78 | 78 | 167 | 167 | 428 | 140 |
| Annual O&M Cost (1) | 9 | 47 | 50 | 56 | 59 | 91 | 20 |
| Present value recurring cost | **145** | **752** | **800** | **938** | **986** | **1,612** | **377** |
| **Total present value** (2) | **1,168** | **1,357** | **1,761** | **1,481** | **1,885** | **2,362** | **1,059** |

(1) includes energy costs
(2) includes land costs

WSP= waste stabilization pond
AL= aerated lagoon

AS=activated sludge
+ indicates maturation ponds

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**A3. Karankhera STP: Comparison of cost for various treatment methods ALT II&III**

| | | |
|---|---|---|
| Land cost | Rs. million | 4 |
| Interest | | 5% |
| Project life | years | 30 |
| Capacity | mld | 90 |

| **Unit rates** | WSP | AL | AL+ | AS | AS + | FAB | UASB |
|---|---|---|---|---|---|---|---|
| Land area Ha/mld | 1.25 | 0.35 | 0.75 | 0.20 | 0.60 | 0.06 | 0.35 |
| Capital costs (Rs.million/mld) | 1.60 | 2.5 | 3.2 | 2.7 | 3.4 | 4.6 | 3.0 |
| M&E cost (% of total) | 2% | 20% | 20% | 40% | 40% | 60% | 30% |
| Annual O&M (Rs.million/mld) | 0.06 | 0.30 | 0.32 | 0.36 | 0.38 | 0.59 | 0.13 |
| **Capital Cost Component** | | | | | | | Cost (Rs. million) |
| Land area for treatment process Ha | 113 | 32 | 68 | 18 | 54 | 5 | 32 |
| Land | **450** | **126** | **270** | **72** | **216** | **22** | **126** |
| Capital costs | **144** | **225** | **288** | **243** | **306** | **414** | **270** |
| **Recurring Cost Component** | | | | | | | Cost (Rs. million) |
| Replace M&E every 15 years | 3 | 45 | 45 | 97 | 97 | 248 | 81 |
| Annual O&M Cost (1) | 5 | 27 | 29 | 32 | 34 | 53 | 12 |
| Present value recurring cost | **84** | **437** | **464** | **545** | **572** | **936** | **219** |
| **Total present value** (2) | **678** | **788** | **1,022** | **860** | **1,094** | **1,371** | **615** |

(1) includes energy costs
(2) includes land costs

WSP= waste stabilization pond
AL= aerated lagoon

AS=activated sludge
+ indicates maturation ponds

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**A4. Kathonagar STP: Comparison of cost for various treatment methods ALT III&IV**

| | | |
|---|---|---|
| Land cost | Rs. million | 4 |
| Interest | | 5% |
| Project life | years | 30 |
| Capacity | mld | 70 |

| **Unit rates** | WSP | AL | AL+ | AS | AS + | FAB | UASB |
|---|---|---|---|---|---|---|---|
| Land area Ha/mld | 1.25 | 0.35 | 0.75 | 0.20 | 0.60 | 0.06 | 0.35 |
| Capital costs (Rs.million/mld) | 1.60 | 2.5 | 3.2 | 2.7 | 3.4 | 4.6 | 3.0 |
| M&E cost (% of total) | 2% | 20% | 20% | 40% | 40% | 60% | 30% |
| Annual O&M (Rs.million/mld) | 0.06 | 0.30 | 0.32 | 0.36 | 0.38 | 0.59 | 0.13 |
| **Capital Cost Component** | | | | | | | Cost (Rs. million) |
| Land area for treatment process Ha | 88 | 25 | 53 | 14 | 42 | 4 | 25 |
| Land | **350** | **98** | **210** | **56** | **168** | **17** | **98** |
| Capital costs | **112** | **175** | **224** | **189** | **238** | **322** | **210** |
| **Recurring Cost Component** | | | | | | | Cost (Rs. million) |
| Replace M&E every 15 years | 2 | 35 | 35 | 76 | 76 | 193 | 63 |
| Annual O&M Cost (1) | 4 | 21 | 22 | 25 | 27 | 41 | 9 |
| Present value recurring cost | **66** | **340** | **361** | **424** | **445** | **728** | **170** |
| **Total present value** (2) | **528** | **613** | **795** | **669** | **851** | **1,067** | **478** |

(1) includes energy costs
(2) includes land costs

WSP= waste stabilization pond
AL= aerated lagoon

AS=activated sludge
+ indicates maturation ponds

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**A5. Panka STP: Comparison of cost for various treatment methods**

| | | |
|---|---|---|
| Land cost | Rs. million | 4 |
| Interest | | 5% |
| Project life | years | 30 |
| Capacity | mld | 200 |

| **Unit rates** | WSP | AL | AL+ | AS | AS + | FAB | UASB++ |
|---|---|---|---|---|---|---|---|
| Land area Ha/mld | 1.25 | 0.35 | 0.75 | 0.20 | 0.60 | 0.06 | 0.35 |
| Capital costs (Rs.million/mld) | 1.60 | 2.5 | 3.2 | 2.7 | 3.4 | 4.6 | 3.0 |
| M&E cost (% of total) | 2% | 20% | 20% | 40% | 40% | 60% | 30% |
| Annual O&M (Rs.million/mld) | 0.06 | 0.30 | 0.32 | 0.36 | 0.38 | 0.59 | 0.13 |
| **Capital Cost Component** | | | | | | | Cost (Rs. million) |
| Land area for treatment process Ha | 250 | 70 | 150 | 40 | 120 | 12 | 70 |
| Land | **1,000** | **280** | **600** | **160** | **480** | **48** | **280** |
| Capital costs | **320** | **500** | **640** | **540** | **680** | **920** | **600** |
| **Recurring Cost Component** | | | | | | | Cost (Rs. million) |
| Replace M&E every 15 years | 6 | 100 | 100 | 216 | 216 | 552 | 180 |
| Annual O&M Cost (1) | 12 | 60 | 64 | 72 | 76 | 118 | 26 |
| Present value recurring cost | **188** | **970** | **1,032** | **1,211** | **1,272** | **2,079** | **486** |
| **Total present value** (2) | **1,508** | **1,750** | **2,272** | **1,911** | **2,432** | **3,047** | **1,366** |

(1) includes energy costs
(2) includes land costs

WSP= waste stabilization pond
AL= aerated lagoon

AS=activated sludge
+ indicates maturation ponds

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**A6. Bingawa STP: Comparison of cost for various treatment methods**

| | | |
|---|---|---|
| Land cost | Rs. million | 4 |
| Interest | | 5% |
| Project life | years | 30 |
| Capacity | mld | 365 |

| **Unit rates** | WSP | AL | AL+ | AS | AS + | FAB | UASB++ |
|---|---|---|---|---|---|---|---|
| Land area Ha/mld | 1.25 | 0.35 | 0.75 | 0.20 | 0.60 | 0.06 | 0.35 |
| Capital costs (Rs.million/mld) | 1.60 | 2.5 | 3.2 | 2.7 | 3.4 | 4.6 | 3.0 |
| M&E cost (% of total) | 2% | 20% | 20% | 40% | 40% | 60% | 30% |
| Annual O&M (Rs.million/mld) | 0.06 | 0.30 | 0.32 | 0.36 | 0.38 | 0.59 | 0.13 |
| | | | | | | | |
| **Capital Cost Component** | | | | | | | Cost (Rs. million) |
| Land area for treatment process Ha | 456 | 128 | 274 | 73 | 219 | 22 | 128 |
| Land | **1,825** | **511** | **1,095** | **292** | **876** | **88** | **511** |
| Capital costs | **584** | **913** | **1,168** | **986** | **1,241** | **1,679** | **1,095** |
| | | | | | | | |
| **Recurring Cost Component** | | | | | | | Cost (Rs. million) |
| Replace M&E every 15 years | 12 | 183 | 183 | 394 | 394 | 1,007 | 329 |
| Annual O&M Cost (1) | 22 | 110 | 117 | 131 | 139 | 215 | 47 |
| Present value recurring cost | **342** | **1,771** | **1,883** | **2,210** | **2,322** | **3,795** | **887** |
| | | | | | | | |
| **Total present value** (2) | **2,751** | **3,195** | **4,146** | **3,487** | **4,439** | **5,562** | **2,493** |

(1) includes energy costs
(2) includes land costs

WSP= waste stabilization pond
AL= aerated lagoon

AS=activated sludge
+ indicates maturation ponds

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**A7. Bingawa STP: Comparison of cost for various treatment methods**

| | | |
|---|---|---|
| Land cost | Rs. million | 4 |
| Interest | | 5% |
| Project life | years | 30 |
| Capacity | mld | 430 |

| **Unit rates** | WSP | AL | AL+ | AS | AS + | UASB++ | FAB |
|---|---|---|---|---|---|---|---|
| Land area Ha/mld | 1.25 | 0.35 | 0.75 | 0.20 | 0.60 | 0.35 | 0.06 |
| Capital costs (Rs.million/mld) | 1.60 | 2.5 | 3.2 | 2.7 | 3.4 | 3.0 | 4.6 |
| M&E cost (% of total) | 2% | 20% | 20% | 40% | 40% | 30% | 60% |
| Annual O&M (Rs.million/mld) | 0.06 | 0.30 | 0.32 | 0.36 | 0.38 | 0.13 | 0.59 |
| **Capital Cost Component** | | | | | Cost (Rs. million) | | |
| Land area for treatment process Ha | 538 | 151 | 323 | 86 | 258 | 151 | 26 |
| Land | **2,150** | **602** | **1,290** | **344** | **1,032** | **602** | **103** |
| Capital costs | **688** | **1,075** | **1,376** | **1,161** | **1,462** | **1,290** | **1,978** |
| **Recurring Cost Component** | | | | | Cost (Rs. million) | | |
| Replace M&E every 15 years | 14 | 215 | 215 | 464 | 464 | 387 | 1,187 |
| Annual O&M Cost (1) | 26 | 129 | 138 | 155 | 163 | 56 | 254 |
| Present value recurring cost | **403** | **2,086** | **2,219** | **2,603** | **2,735** | **1,045** | **4,471** |
| **Total present value** (2) | **3,241** | **3,763** | **4,885** | **4,108** | **5,229** | **2,937** | **6,552** |

(1) includes energy costs
(2) includes land costs

WSP= waste stabilization pond
AL= aerated lagoon

AS=activated sludge
+ indicates maturation ponds