Inception Report

Master Plan for Sewerage System of Delhi for 2031

June 2010
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Acknowledgement

We gratefully acknowledge the guidance and cooperation provided by all officials of DJB in the timely start of the project. We are also thankful to the staff of DJB for making available in time data and reports as requested by us. We appreciate the time and efforts put forward by the JE/AE/EE/SE of the DJB looking after this project.

We, in particular, acknowledge the guidance and cooperation extended by the Chief Engineer and Ad. CEO/CEO. Without their cooperation and valuable efforts, we perhaps, would not have been able to produce this report in time.
**Abbreviations**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AS</td>
<td>Activated Sludge</td>
</tr>
<tr>
<td>Avg</td>
<td>Average</td>
</tr>
<tr>
<td>BIS</td>
<td>Bureau of Indian Standards</td>
</tr>
<tr>
<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
</tr>
<tr>
<td>CETP</td>
<td>Combined Effluent Treatment Plant (industrial)</td>
</tr>
<tr>
<td>CI</td>
<td>Cast Iron</td>
</tr>
<tr>
<td>CO₂</td>
<td>Carbon Dioxide</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>CPCB</td>
<td>Central Pollution Control Board</td>
</tr>
<tr>
<td>CWR</td>
<td>Clear Water Reservoir</td>
</tr>
<tr>
<td>DO</td>
<td>Dissolved Oxygen</td>
</tr>
<tr>
<td>DPRs</td>
<td>Detailed Project Reports</td>
</tr>
<tr>
<td>EPA</td>
<td>Environmental Protection Act (1986 and amendments)</td>
</tr>
<tr>
<td>ETP</td>
<td>Effluent Treatment Plant (industrial)</td>
</tr>
<tr>
<td>FAB</td>
<td>Engineering Technology Transfer (programme)</td>
</tr>
<tr>
<td>FAB</td>
<td>Fluidized Aerated Bioreactor</td>
</tr>
<tr>
<td>FS</td>
<td>Feasibility Study</td>
</tr>
<tr>
<td>WTP</td>
<td>Water Treatment Plant</td>
</tr>
<tr>
<td>YAP</td>
<td>Yamuna Action Plan</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information System</td>
</tr>
<tr>
<td>GOI</td>
<td>Government of India</td>
</tr>
<tr>
<td>HDPE</td>
<td>High–Density Polyethylene</td>
</tr>
<tr>
<td>JBIC</td>
<td>Japanese Bank for International Cooperation</td>
</tr>
<tr>
<td>Km</td>
<td>Kilometre</td>
</tr>
<tr>
<td>KVA</td>
<td>Kilo Volta Ampere</td>
</tr>
<tr>
<td>lpcd</td>
<td>Litres per capita per day</td>
</tr>
<tr>
<td>lpm</td>
<td>Litres per minute</td>
</tr>
<tr>
<td>lps</td>
<td>Litres per second</td>
</tr>
<tr>
<td>mg/l</td>
<td>milligrams per litre</td>
</tr>
<tr>
<td>MGD</td>
<td>Million gallons per day</td>
</tr>
<tr>
<td>MLSS</td>
<td>Mixed Liquor Suspended Solids</td>
</tr>
<tr>
<td>MPN</td>
<td>Most Probable Number per 100ml</td>
</tr>
<tr>
<td>MoEF</td>
<td>Ministry of Environment &amp; Forests</td>
</tr>
<tr>
<td>NRCD</td>
<td>National River Conservation Directorate</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operation &amp; Maintenance</td>
</tr>
<tr>
<td>PS</td>
<td>Pumping Station</td>
</tr>
<tr>
<td>PVC</td>
<td>Polyvinyl Chloride</td>
</tr>
<tr>
<td>SPS</td>
<td>Sewage Pumping Station</td>
</tr>
<tr>
<td>SS</td>
<td>Suspended Solids</td>
</tr>
<tr>
<td>STP</td>
<td>Sewage Treatment Plant</td>
</tr>
<tr>
<td>TDS</td>
<td>Total Dissolved Solids</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>UASB</td>
<td>Upflow Anaerobic Sludge Blanket</td>
</tr>
<tr>
<td>UFW</td>
<td>Unaccounted For Water</td>
</tr>
<tr>
<td>ULB</td>
<td>Urban Local body</td>
</tr>
<tr>
<td>UV</td>
<td>Ultra Violet</td>
</tr>
</tbody>
</table>
Terminology

Aerated Lagoons: Like Waster Stabilisation Pond (WSP), but with mechanical aeration. Oxygen requirement mostly from aeration and hence more complicated and higher O&M costs require less land than WSP.

Activated Sludge Process: It is 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.

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

Average Daily Flow: The total flow past 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°C.

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

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

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

Coliform System: In wastewater, a system of conduits, generally underground pipes, that receives and convey 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.

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.
**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 or 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.

**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, services 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 $\text{CH}_4$.

**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 prepares wastewater influent for further treatment.

Pump Station: See Lift Station.

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 conditions 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 solids 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.


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 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 treat 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 particular 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 and 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 poor quality effluent than processes such as ASP (NOTE: other anaerobic processes exist, but UASB is the most common at present).

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

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

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

**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 main sewers.

**Pumping Main:** Pumping mains are used to convey wastewater from pumping stations to treatment plants at higher elevations. They are also referred as rising mains or force mains.
1. **INTRODUCTION**

1.1 **Background of the study**

Delhi, the focus of the socio-economic and political life of India, a symbol of ancient values and aspirations and capital of the largest democracy is assuming increasing eminence among the great cities of the world. Delhi is situated in the northern part of India and is the capital of the Union of India.

Table 1-1 *Project Background Details*

<table>
<thead>
<tr>
<th>Delhi</th>
<th>The capital of India is the third largest city of the world, exceeded in size by Calcutta and Mumbai. It is situated in north central India and stands on the west and east banks of Yamuna River. It is bounded on the east by the state of Uttar Pradesh and on the north, west and south by Haryana. Delhi is situated on the banks of river Yamuna in the northern part of India. Once a part of the Avarallis, today Delhi has only the Ridge area to tell the story of the greenery this place once had. Himalayas are in the North of Delhi.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Situation</td>
<td>Latitude – 28° 35 N; Longitude - 77° 12 E</td>
</tr>
<tr>
<td>Weather</td>
<td>The capital of India is a land locked city. The distance from the sea gives Delhi an extreme type of continental climate. The summers in Delhi are very hot and winters very cold. The temperature range varies from 45°C in summers to 4°C in winters. The winters are marked by mist and fog in the mornings and often sun is seen in the afternoons. The cold wave from the Himalayan region makes winters very chilly. In summers the heat wave is immense in the afternoons.</td>
</tr>
<tr>
<td>Rainfall</td>
<td>The rainfall season is from July to September averaged at 550 mm pa.</td>
</tr>
<tr>
<td>Ground Water</td>
<td>The water table in most parts of the city has gone down to 30 meters. The quality of the ground water is generally brackish, polluted and unacceptable.</td>
</tr>
<tr>
<td>Diplomatic Hub</td>
<td>Being the capital it houses the Embassies and High Commissions of all countries of the world and helps them in the discharge of their functions.</td>
</tr>
<tr>
<td>Delhi Jal Board (DJB)</td>
<td>DJB was constituted through an Act of Delhi Legislative Assembly on 6th April 1998. It has been meeting the needs of potable water in the National Capital Territory of Delhi for more than five decades. DJB has been able to supply pure and wholesome filtered water to the capital city of India which has grown phenomenally to the present population of about 180 lakhs. DJB is committed for the augmentation of water supply in Delhi and has taken many steps in this direction. DJB has ensured availability of the filtered water through an efficient network of water treatment plants, booster pumping stations and about 9000 km of water mains and distribution system. It has also been responsible for collection, treatment and safe disposal of wastewater from the entire territory of Delhi except NDMC and cantonment areas from where it collects the wastewater in bulk for treatment and ultimate disposal.</td>
</tr>
</tbody>
</table>
The NCT of Delhi as per MPD-2021 has been divided into 15 Zones from A to P out of which 8 Zones are in urban area, one in River bed and the remaining 6 in rural area. So far, Zonal Plans in respect of 7 zones have been notified by the Government of India, whereas for others, which also include Urban Extension areas like Dwarka, Rohini and Narela, the complete Zonal Plans remain to be notified. The process of planning and development has been carried out through change of land use etc., in terms of specific development plans that may be prepared for specific areas within these zones.

The territory of Delhi is stretched over an area of 1483 square kilometres and is located between the mountain ranges of the Great Himalayas and Avarallis. The river Yamuna, the source and sink for the city run by the eastern part of the Delhi for a total length of 22 km. The city lies around 250 meters above the sea level.

The topography of Delhi can be divided into three different parts, the plains, the Yamuna flood plain and the ridge. As per the topography, Delhi is located on the western fringes of the Gangetic Plains. The low altitude Yamuna flood plains provides an excellent scope for disposal towards the river, as it is covered with the fertile alluvium brought by the river Yamuna which deposited here during frequent floods.
1.1.1 Delhi Water Supply

Delhi is situated on either sides of the bank of river Yamuna. Yet, it faces a shortage of raw water, especially in summer. This is primarily because the entire flow of the river is diverted into Eastern and Western Yamuna canals upstream of Tajewala (Hathini Kund Barrage) leaving the river high and dry downstream. To run the existing water treatment plants at Wazrabad (120 MGD) and Chandrawal (90 MGD), releases have to be arranged from the canals.

As a result of water agreements with governments of Haryana and UP, Delhi is able to operate the water purification plants at Haiderpur (200 MGD). Through yet other agreements, it is able to run 140 MGD water purification plant at Sonia Vihar plants at Sonia Vihar and 100 MGD Water purification plant at Bhagirathi in trans-Yamuna area. The Figure 1.1 below shows the Location of Water Treatment Plants in Delhi.
It may be noted that in spite of an Inter State agreement signed amongst the Basin States, the river Yamuna does not have a minimum flow of 200 cumecs thereby seriously affecting the dilution, especially in the reach between Wazirabad to Okhla. This is the most polluted stretch.

As a long term solution for shortage of water, three storage dams namely Renuka, Kishau and Lakhwar Vijasi, have been agreed for construction by the Basin States. The work at these storages is however yet to start.

1.1.2 Delhi Sewerage

The existing sewerage system in Delhi is grossly inadequate, as only about 55% of the population is covered under organized conventional sewerage system and about 15% under on-site sanitation systems. The rest of the population does not have proper access to sanitation facilities. The increasing pollution in the river Yamuna is also a major indicator of lack of sewerage treatment facilities. By the year 2021 the whole of Delhi should be served by a regular sewerage system implemented in a phased manner according to Delhi Master Plan 2021.

As stated in the RFP there are approximately 40 unauthorised / regularised colonies, 27 urban villages, 150 rural villages and 1575 unauthorised colonies yet to be provided with sewerage facilities.

Common Effluent Treatment Plants

It is estimated that about 50 MGD of industrial effluents are generated in the city. DSIDC has planned 15 Common Effluent Treatment Plants (CETPs) in industrial area of Delhi as per directions of the Hon' Supreme Court of India for treating these effluents in CETP and discharging them in the drains after treatment. Figure 1.2 shows the Location of Common Effluent Treatment Plants in Delhi.

Five of the 15 CETPs are reported to be not ready:

1) Okhla Industrial Estate
2) Mohan Corporative Industrial Area
3) Anand Pravat Industrial Area
4) Nagafgarh Industrial Area
5) Naraina Industrial Area

The locations of the existing and the planned sewage treatment plants can be found in the figure 1.3 below.
1.1.3 River Pollution

The current water quality parameters in the river Yamuna far exceed the permissible levels of BOD; coli form count and dissolved oxygen.

The most polluted stretch from Wazirabad barrage to Okhla receives water from 18 major drains which carry both treated and untreated effluent besides solid waste, industrial effluent and other pollutants. There are also similar pollution problems in the Najafgarh drain, the supplementary drain along with the Shahdara drain, the Delhi Gate drain and Dr. Sen Nursing Home drain.

Against the installed capacity of 512 MGD of all STP only about 350 - 360 MGD of sewage is treated. The remaining quantities of untreated waste along with treated wastewater find its way into 19 major storm drains and ultimately into the river.

In addition, Delhi receives treated / untreated wastewaters from Haryana Territory into Najafgarh drain. It also receives untreated wastewater from UP Territory into the Shahdara drains which ultimately finds way into the River Yamuna. The study of the same is not in the scope of this assignment.

There are also connections of storm water drains into the sewerage system which results in:
• Overloading of pumping stations and sewage treatment plants
• Unnecessary additional costs of pumping and treatment of sewage
• Siltation of sewers which in turn leads to overflows, and blockages causing impact on the sewage collection operation and efficiency

**Trolley Pumps**

DJB has installed trolley pumps to lift sewage / sullage and pump into the downstream end of the network / drains to divert flow from non functional sewers. The flow from such sites normally goes to the river causing further deterioration of river water quality.

### 1.2 Objectives of the study

The main objective of the SMP is to develop a comprehensive, technically viable plan for the implementation of sewerage works within the NCT of Delhi with support by a Wastewater Management Information System. According to the Terms of Reference, the key activities of the study are as follows:

• To forecast population for the Year 2031 along with the consideration of “Delhi Master Plan 2021” and “Master Plan for Water Sector for Year 2021”;
• To develop a hydraulic model with GIS platform for the future sewerage system integrating with the proposed sewerage system for the unsewered areas and the interceptor sewers along Najafgarh, Supplementary and Shahdara drains;
• To carry out a performance audit of the 17 existing Sewage Treatment Plants (STP) (Excluding E & M components) and evaluate the existing technology vis-à-vis the latest adopted worldwide and suggest upgrades and modifications;
• To identify and evaluate treatment technologies for potential re-use of secondary effluent;
• To formulate a well integrated sewerage master plan for Delhi for the Year 2031, covering the unsewered areas such as un-authorized colonies/urban villages/rural villages/resettlement colonies/JJ Clusters etc; and sewered areas thus reducing pollution to River Yamuna;
• To formulate a world class management information system master plan for Delhi for efficient management of the sewerage system;
• To develop a sewerage and sludge management plan; and
• To estimate the costs (Capital and O&M) and draw up a prioritized works implementation schedule.
Table 1-2 Objectives of the Study

It is envisage that upon completion of the study, the opportunity to take advantage of following benefits will result:

i. Rapid implementation to deliver the project on a fast track schedule.
ii. Significant improvements in protection of human health.
iii. Protection and enhancement of the overall ecological environment.
iv. Improvement in quality of life by ensuring availability of organized and flexible schemes and plans for implementing short-term and long-term sewerage infrastructure improvements suitable for future development within each unsewered area.
v. Opportunities for improvements in institutional and organizational capacity for sustainable solutions, with possible full cost recovery and coordination among various institutions for cost-effective capital improvements and operation and maintenance activities.
vi. Acceptance and support of stakeholders for good governance.
1.3 Scope of the study

1.3.1 Planning horizon

The study requires for the planning horizon to be 2031. Currently, only the 2021 planning dataset is available and the data beyond 2021 from the developments for the 2 inter related projects namely the “Master Plan for Water Sector for Year 2021” and “Delhi Master Plan 2021” is yet to be made available. The population projection will be based on the 2021 dataset in the beginning and adjustment and refinement will be required when the 2031 dataset is released by the town planning board/authority for use in this study.

1.3.2 General Scope

In addition to the detailed scope of individual tasks, activities and reports required for completion of the study as described in the following sections of this report, the scope of this study generally covers:

- Data collection and collation of as-builts of the existing sewerage systems, STPs and SPSs together with GIS data / maps acquired from the various government departments/agencies for setting up the network model. Population figures and Land Use Plans will be obtained and population will be projected to year 2031. This will be used in the hydraulic model to establish total average and peak estimated wastewater generation for each existing and proposed sewer zone.

- Review of DPR prepared for YAP III for the existing sewerage system. To carry out Condition Assessment Survey and formulation of the project components under YAP-III, Preparation and Facilitation of DPRs for Loan Assistance under JICA scheme under YAP-III.

- Sewered Area - Performance Audit of 17 STP and propose necessary modification work for optimum operation including:
  - Capacity review of all SPS to cater for future flow and propose optimum operation mode.
  - Capacity assessment of the peripheral and trunk sewers with diameter above 500mm.
  - Recommendations for up gradation of STPs and allied works.

- Unsewered Area - provision of sewerage plan for unsewered areas such as unauthorized colonies, rural villages, urban villages, extended abadi, Lal dora resettlement colonies. There are also approximately 40 unauthorised / regularized colonies, 27 urban villages, 150 rural villages and 1575 unauthorised colonies (CHECK) are yet to be provided with sewerage facilities.

- Field investigation including Manhole survey (500 manholes), topographical survey and Geotechnical Survey covering approximately 200 boreholes, demographic surveys for 1600 colonies, flow and water quality for 50 locations and wastewater sampling for 17 STP locations.

- Preparation of an integrated sewerage master plan for the Year 2031 for the entire NCT of Delhi utilizing hydraulic network modelling software and GIS including update of the existing GIS sewerage networks.
• Identification of opportunities for the development of recycle and reuse plants for direct non potable application of treated wastewater
• Development of a sewerage and sludge management plan
• Preparation of feasibility study, DPRs, suggested cost for the identified projects for the unsewered areas.

1.4 Project Management and Delivery

1.4.1 Project Delivery Phase

Mobilisation

Since the execution of the agreement with DJB, we have mobilised the project team as per Project Activity Schedule. Procurement of software (Bentley’s Sanitary Sewer GEMS for optimised design and hydraulic modelling), in place together with the GIS Arc Info Tool.

The project team will submit the agreed number of copies of the deliverables to DJB according to the TOR. The Project Team is organised efficiently and coherently in a simple structure with clear lines of responsibility. The team members’ work will be verified and endorsed by in-house specialist advisers to provide independent insights and to ensure that work complies with our high standards.

1.5 Proposed Work Schedule

A work flow diagram encompasses the following tasks within the 36-month consultancy period covering the following tasks can be found at the end of this section:

• Data collection and analysis
• Review previous studies, reports by client and other consultants
• Review and Revise DPRs for three Drainage Zones Sewage treatment plants namely Okhla, Rithala and Kondli, to carry the preparatory survey, Condition Assessment Survey and formulate the project components for JICA Loan Assistance under YAP-III.
• Review Guidelines adopted by Delhi Jal Board and formulate standards in line with DJB and as per practise in line with relevant codes for Sewerage Services
• Sub-Zoning of the scope area
• Develop technology options
• Options evaluation / prioritisation strategies
• Workshop
• Identification of project components
• Preparation of Strategic master plan
• Prioritization and cost benefit analysis of project components
• Preliminary design of short to medium term mitigation works
• Cost estimation
• Implementation schedule
• Submissions as per TOR

1.6 Project Organisation and Staffing

Table below presents the full list of the International and domestic staffing committed to the project and the figure showing the deployment schedule can be found at the end of this section.

Table 1-3 Team Composition of Proposed Professional Staff

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<tr>
<th>Staff No.</th>
<th>Staff Name</th>
<th>Proposed Position</th>
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<td>01.</td>
<td>Luk Kin Choi, Ken</td>
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<td>02.</td>
<td>Chan Wai Tong, Tommy</td>
<td>Project Manager</td>
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Table 1-4 Organisation Chart
## TIME SCHEDULE FOR PROPOSED PERSONNEL

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2. Study Approach

2.1 General

Our responsibility to DJB and other stakeholders is to develop a world class master plan for unsewered areas besides the development of a management information system with hydraulic modelling, preparation of feasibility report and documents etc. An approach has been formulated that is responsive to project objectives and can meet the tight timeframe without compromising quality of work. The key issues are:

i. Use of technical memoranda to seek concurrence and decision from DJB and other stakeholders regarding critical issues before proceeding to subsequent activities that will rely on decisions

ii. A comprehensive and pro-active Public Participation and Awareness (PP&A) programme

iii. Integration of institutional, environmental, social and financial considerations into the evaluation and selection of alternative solutions

iv. Consideration of innovative alternative technologies for collection, pumping, and treatment of wastewater, including sludge handling and reuse of effluent

2.1.1 Technical Memorandum

The tight project schedule for completion of master plan, feasibility studies, and detailed project reports (project completion report) dictates that all work must be accomplished efficiently. To comply with schedule requirements, frequent and meaningful discussions between stakeholder agencies and the Project Team are essential to obtain and document stakeholder input and agreements at each step in the planning process. To facilitate meaningful dialogue and decision-making, the Project Team will prepare and deliver draft technical memoranda. We will suggest that meetings be conducted to discuss and review comments from stakeholder agencies within 7 calendar days after distribution of each draft technical memorandum.

The purpose of the draft technical memorandum is to share information and analysis with stakeholders, encourage discussion and understanding of issue and project approaches, for agreements at each step of the Project. Any modifications to the approaches, data, and/or conclusions presented in the draft technical memoranda based on input from stakeholder agencies will be reflected in the draft master plans, studies, and reports.

We consider the following draft technical memorandum for review and comment:

i. **Evaluation and Design Criteria:** for wastewater collection, pump station, and wastewater treatment master planning purposes, it is important to establish a design criteria that will be used consistently to evaluate existing systems and to develop conceptual designs of alternative and proposed systems. To ensure smooth and efficient progress of the Project, it is important that the entire project team (consultants and stakeholders) agree to accept the design criteria early in the project. Therefore, a draft **Technical Memorandum (TM)** containing recommended
general evaluation and design criteria will be circulated for renewal and comments. The agreed design criteria will be adopted finally.

ii. **Treatment Process Evaluation Methodology** – Because of the wide range of available wastewater treatment process technologies, it is important to establish a rigorous and consistent methodology to evaluate alternative processes. A TM will be prepared and delivered to stakeholders for review and comment regarding the proposed evaluation methodology.

iii. **Population Projections** – A TM will be prepared to present information regarding existing population, distribution of population, historical population growth trends, and recommended population projections for the 2011, 2021, and 2031. The TM will also identify the source and basis for existing and projected populations. A series of workshops will be conducted with project stakeholders to discuss the estimated population projections.

iv. **Wastewater Generation Factors** – A separate TM will be prepared to present an evaluation of historical and estimate future water use, wastewater generation, effluent quality, and sludge generation.

### 2.1.2 Public Participation and Awareness (PP& A) Programme

For the success of the project it is proposed to follow a participatory approach through the inclusion of identified agencies and members of the public in the process. Agency stakeholders are expected to provide valuable inputs to various project activities. The participation of the main stakeholder agencies are NDMC, Cantt, MCD, DDA, CPCB, Delhi etc.

Effective involvement of the general public will be achieved through citizen groups, local committees, village panchayats and the eminent local residents and professionals. All PP&A activities will be planned, implemented, and documented to ensure no duplication in effort. The project team will make an effort to ensure that a response is provided to all questions, comments, and suggestions from public and agency stakeholders. We consider that valuable prompt, professional, responses are essential to demonstrate that stakeholder input is welcome and meaningful.

Through a structured random sample survey, information will be gathered from all sections of society in the project area, with special focus on the slum and poor communities, informal and un-regularized developments. Workshops shall be organized to explain the objective and benefits of the program, the importance of treatment of wastewater before disposal, reuse options, and the role of different stakeholders, especially the public, in the success of the program. This will be more focused in dealing with rural areas. Key elements of the program such as overall system plan including collection system and treatment system, selection of treatment plant locations, disposal of waste, and reuse of treated effluent will be discussed. The workshops and public interaction program will be designed in a manner to facilitate participation of all sections of the stakeholders including women and vulnerable groups. Open dialogue and crucial inputs from NGOs, donors, and other stakeholders will be encouraged. Their views and suggestions will be considered during formulation of plans and reports.

We propose to prepare and distribute information including land use and population projection analysis, wastewater generation analysis, descriptions of alternatives, summary conclusions regarding potential alternatives, and summaries of other issues where agency stakeholder consent is critical to proceeding. When appropriate, meetings will be conducted
with the agency stakeholders to discuss and resolve issues. DPRs also will be distributed for review and comment as approved by DJB.

2.1.3 Environmental and Social Consideration

The environmental assessment process is an essential tool in the promotion of sustainable development. It provides a systematic approach for identifying, assessing, and predicting the potential environmental effects of a project, on both the biophysical setting and the human population, determining means of reducing or eliminating these effects, enhancing environmental and social benefits and, addressing public concerns. Integrating these considerations as early as possible in the planning stages of the project will help to avoid downstream costs and delays arising from unforeseen environmental impacts and public resistance to implementation and will ensure environmentally sound development.

This project will include screening and categorization of potential environmental and social impacts.

Under this project, the Project Team will address environmental and social considerations at the master-planning stage. These considerations will influence the decision matrix and development of alternatives for consideration. These considerations will be further detailed out during the feasibility study stage wherein EIAs and SIAs will be conducted, when necessary, with specific attention to proposed project action under the identified alternatives.

Development of the Rapid Environmental and Social Impact Assessment (RE&SIA) and EMP will address the regulatory requirements of GoI (Govt. of India) as well as the concerns of JICA Environmental and Social Guidelines. Environmental clearance and approval of the RE&SIA, and associated documents, are not anticipated to be required from any regulatory agency associated with this project.
2.1.4 Economic Evaluation Criteria

Economic evaluation will be accomplished by calculating the lifecycle cost (Present Value of all costs including initial capital of all components, cost of land, and recurring (O& M) costs) of each alternative.

The design life of most sewerage works is usually more than 30 years. However, because the planning and design target year is 2031 an assumed design life of 30 years will be used for developing lifecycle costs with replacement of some mechanical and electrical equipment at pumping stations and STPs every 15 years. Estimated land costs for pumping and treatment facilities, plus recurring costs over a 30-year period will be developed and factored into the lifecycle cost. Estimated costs that will be incurred during the project lifecycle for the majority of the system components will be discounted at an assumed interest rate of 5 percent to calculate the present value of each alternative for comparison purpose. For PVC and HDPE pipe, FRP/GRP, and precast manholes, the design life will be assumed to be 50 years.

2.2 Alternative Technologies

2.2.1 Introduction

Within the field of wastewater management, there are numerous alternative materials and processes that could be considered for use on any given project. In the interest of providing stakeholders with reliable, durable, and cost-effective sewerage systems, several alternative and innovative material, construction, and process technologies will be considered during identification evaluation, and design of alternatives. The detailed design criteria and evaluation of alternatives for wastewater collection system, pumping station and sewerage treatment plant will be addressed in relevant Technical Memoranda.

2.2.2 Wastewater Collection Systems

Pipe Material

Typical pipe materials that will be considered for new and replacement sewer collection systems include:

i. Reinforced Cement Concrete (RCC)
ii. Polyvinyl Chloride (PVC)
iii. High Destiny Polyethylene (HDPE)

The key factors which will determine their use will be:

i. Suitability for conditions
ii. Easy availability
iii. Cost
iv. Ease in laying
v. Water tightness of the joint
Material for manholes construction will be decided

i. Brickwork
ii. RCC
iii. Pre-manufactured HDPE

**Sewer Protection**

It is getting common to protect the sewer structure by lining or coating against H₂S attack. The protective coating used should possess the following qualities:

i. It should be resistant to acid attack.
ii. It should bond securely to the concrete.
iii. It should be economical and durable.
iv. It should be resistant to abrasive action.
v. It should be thin enough to fill all pores and irregularities in the surface.
vi. It should be continuous with no pin holes or other breaks.
vii. It should be able to form impervious membrane.

**2.2.3 Sewage Treatment Plants**

**Technical Design**

The important criterion of a wastewater treatment system design is its suitability to the local conditions. There are many aspects that must be considered when designing wastewater treatment facilities to ensure that the design will not only meet the treatment standards, but that it will also be able to work within the local technical and economic, environment. The wastewater treatment design hinges around the influent and effluent criteria. It is between these two data points that the design must be developed. The design regarding effluent criteria should consider the reuse options and goals. The influent quality design criteria is important and must be established with due diligence.

The dependability of performance of a process lies in spite of fluctuations in influent quality and quantity. The process must ensure a stable effluent quality. Similarly, ability to withstand power and operational failure is a consideration in the final choice of process. The more sophisticated process the more sensitive is its operation. Some process like digesters, lagoons, and ponds are sensitive to temperature. Wastewater treatment processes that typically will be considered are described below.
**Secondary Treatment System Option**

The secondary treatment system is in use in most sewage treatment facilities. There are several secondary treatment options that could be used in local conditions. Each option has a unique set of advantages and disadvantages that must be considered in relation to each individual site. Various factors affecting selection of secondary treatment processes include:

i. Land
ii. Power supply availability and dependability
iii. Operating (and control) equipment and its indigenous availability
iv. Skilled staff
v. Nature of maintenance problems
vi. Extent of sludge production and disposal requirements
vii. Loss of head through plant in relation to available head (to avoid/ minimize pumping as far as possible)
viii. Ease of strategic expansion of plant capacity over time

A detailed list of possible secondary treatment options is provided in Table below:

**Table 2-1 Secondary Treatment Options**

<table>
<thead>
<tr>
<th>Process</th>
<th>Operation Details</th>
<th>Performance</th>
<th>Land Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facultative Lagoon</td>
<td>Simple to operate and maintain</td>
<td>Poor effluent quality, not suitable for large flows, high odour potential</td>
<td>Highest</td>
</tr>
<tr>
<td>Aerated Lagoon</td>
<td>Smaller than Facultative Lagoon</td>
<td>Power required as compared to Facultative Lagoon</td>
<td>High</td>
</tr>
<tr>
<td>Wetland</td>
<td>Simple to operate and maintain, adequate disinfection</td>
<td></td>
<td>High</td>
</tr>
<tr>
<td>Extended Aeration</td>
<td>Robust and good quality effluent</td>
<td>High power cost</td>
<td>Medium</td>
</tr>
<tr>
<td>Sequencing Batch Reactors</td>
<td>Automated, no secondary clarifiers</td>
<td>Higher maintenance, difficulties with foam and scum control</td>
<td>Medium</td>
</tr>
<tr>
<td>Conventional Activated Sludge (CAS)</td>
<td>Flexible, proven technology, low power usage</td>
<td>Requires good operations staff</td>
<td>Medium</td>
</tr>
<tr>
<td>High Purity Oxygen Activated Sludge (HPO)</td>
<td>Compact</td>
<td>Technically complex, high operating costs</td>
<td>Medium</td>
</tr>
<tr>
<td>Trickling Filters</td>
<td>Mechanically simple</td>
<td>Trickling filter tower heights may be visually obtrusive</td>
<td>Medium</td>
</tr>
<tr>
<td>Process</td>
<td>Operation Details</td>
<td>Performance</td>
<td>Land Requirement</td>
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<tr>
<td>----------------------------------------------</td>
<td>-------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Rotating Biological Contactors</td>
<td>Current design criteria require high energy input</td>
<td>Trickling filter tower heights may be visually obstructive. Add-on nitrification process would be costly</td>
<td>Medium</td>
</tr>
<tr>
<td>Trickling Filter-Solids Contact Process</td>
<td>High Quality effluent</td>
<td>Trickling filter tower heights may be visually obstructive. Add-on nitrification process would be costly</td>
<td>Medium</td>
</tr>
<tr>
<td>UASB + Polishing Lagoon</td>
<td>Low energy usage produces usable methane</td>
<td>Poor quality effluent, high odour potential</td>
<td>High</td>
</tr>
<tr>
<td>UASB + Conventional Activated Sludge</td>
<td>Low energy usage (but higher than polishing lagoon option high quality effluent)</td>
<td>Mechanically complex, high odour potential</td>
<td>Medium</td>
</tr>
<tr>
<td>Biological Aerated Filters (BAF)</td>
<td>High quality effluent</td>
<td>Mechanically complex and difficult to operate</td>
<td>Low</td>
</tr>
<tr>
<td>Membrane Bioreactor</td>
<td>High quality effluent suitable for reuse. Automated</td>
<td>Imported membranes, mechanically complex</td>
<td>Lowest</td>
</tr>
<tr>
<td>Physical/Chemical Treatment</td>
<td>Easy operation</td>
<td>High chemical cost. High sludge production. High operational costs</td>
<td>Low</td>
</tr>
</tbody>
</table>

Of the options listed in the above table the most promising options, as a minimum, that will be considered for further examination for this project include:
Integration of Conventional Activated Sludge with:

i. Extended Aeration
ii. Sequencing Batch Reactor (SBR)
iii. Mixed Bed Bioreactors
iv. Membrane Bioreactors

For Decentralised system and/or for JJ Clusters, an option of UASB may be evaluated as per site condition/s.

For reuse of effluent, disinfection by UV and chlorination will be considered.

The table below gives progressive removal of impurities in the sewage treatment process:
**Table 2-2 Percentage removal of impurities in the sewage treatment process**

<table>
<thead>
<tr>
<th>Option</th>
<th>Process</th>
<th>B.O.D</th>
<th>Phosphates</th>
<th>Nitrogen</th>
<th>ABS*</th>
<th>Suspended Solids</th>
<th>T.D.S</th>
<th>Coliforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Conventional Sewage Treatment</td>
<td>90</td>
<td>40-50</td>
<td>40-50</td>
<td>50</td>
<td>90</td>
<td>5</td>
<td>95-99</td>
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<tr>
<td>2.</td>
<td>Conventional Sewage Treatment + lime – alum coagulation, settling filtration</td>
<td>93-95</td>
<td>95</td>
<td>50</td>
<td>50-55</td>
<td>99</td>
<td>10</td>
<td>99-99.9</td>
</tr>
<tr>
<td>3.</td>
<td>2 above + absorption on activated carbon</td>
<td>99</td>
<td>95</td>
<td>50-55</td>
<td>95</td>
<td>99</td>
<td>15</td>
<td>99-99.9</td>
</tr>
<tr>
<td>4.</td>
<td>3 above + demineralization or Reverse Osmosis</td>
<td>99</td>
<td>97</td>
<td>75</td>
<td>98</td>
<td>80 Further removed by demineralization</td>
<td>99.9-100</td>
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*ABS = Alkyl Benzene Sulphonate

The cost of disinfection is directly related to the quality of effluent discharged from a process. For example, disinfection for the UASB plus Polishing Pond option will have very high costs as a result of high TSS value typically found in UASB effluent, but the MBR effluent will normally be less 100 cfu/100ml without any disinfection. Liquid sodium hypochlorite has been found to be the lowest cost of the most commonly used systems. However, solar disinfection also relatively has very low cost, but requires larger land areas that may not always be available.

Odours from secondary treatment can be controlled in a number of manners. The importance of odour control must first be evaluated and is important UASBs are not a good option because they inherently produce higher odour levels than other treatment technologies. Facultative lagoons also are susceptible to odour generation problems. The more conventional activated sludge systems, such as SBRs, MBRs, Extended Aeration, and conventional activated sludge generally do not produce significant odours. Of some note, the sludge produced by an extended aeration facility is relatively stable and will therefore minimize the chance of significant odour generation.
**Bio solids Generation, Treatment, and Reuse**

All wastewater treatment facilities produce bio solids that must be disposed off in a manner that protect the public health and, if possible, provide benefit to the local economy or people. There is a wide option for handling bio solids. The quantity of sludge that will need to be disposed of will be based on future population projections and wastewater generation factors. Disposal and reuse of sludge is dependent on the selection of sludge treatment levels that will be applied.

We will consider whether the best option is to include primary clarification or not. The inclusion of primary clarification generally reduces secondary treatment sizes, but also result in primary sludge, which is very objectionable, and can cause added difficult in treatment. If primary clarifiers are not included, the resultant bio solids will include some degree of biomass, whether it is from a UASB system or from a conventional secondary treatment facility, these bio solids are biologically active and normally are not suitable for disposal, except for disposal in a landfill that accepts such materials. Landfill disposal of bio solids normally is an expensive option.

The objective of solid treatment is to reduce the volume and mass of bio solids and to reduce the volatility of the bio solids so that they may be handled without issue of odour and public health. Depending on a number of factors, bio solids treatment could range from as complex as thickening, anaerobic (or aerobic) digestion, and then mechanical dewatering, or as simple as disposal in facultative sludge lagoons that are intermittently cleaned out, or sludge drying bed. The correct answer for a particular facility will depend on the available land area, the volume of solids to be treated, and the quantity of bio solids that need to be produced for the various disposal/reuse options.

Basic qualities of sludge that may be produced by a facility are:

i. Raw sludge which is hazardous to human health and can be safety disposed of only in an appropriate landfill.

ii. Fully digested sludge (aerobic or anaerobic) that can be applied to crop land as fertilizer under appropriately controlled conditions. This sludge needs to contain metals and toxics at levels beneath the levels that would accumulate in the environment.

iii. The highest quality of sludge is a fully digested and disinfected sludge that can be handled by the public for unrestricted use.

This level of sludge treatment normally requires either step-wise digestion technologies, or high temperature digestion to achieve the needed disinfection. There have been a number of technologies introduced to the market that can significantly reduce the amount of solids produced by a wastewater treatment facility. In some cases these technologies will eliminate the need for a complicated solids handling and treatment system. The appropriateness of these technologies for local conditions will be evaluated on a case by case basis.

**Sludge Digestion**

The main purpose of sludge digestion is to reduce its putrescibility i.e. odour and pathogenic contents. This can be achieved through the following biological processes:

i. Anaerobic Digestion
ii. Aerobic Digestion

Anaerobic Digestion is the biological degradation of organic matter in the absence of free oxygen. During this process, much of the organic matter is converted to methane, carbon dioxide and water. This is achieved in a closed container called sludge digester. The main advantages of anaerobic digestion are:

i. Recovery of methane: a useful source of energy, as a by-product. The process is a net energy producer, since the energy content of the digester gas is more than the energy demand for mixing and heating of the digester contents.
ii. Anaerobically digested sludge contains nutrients and organic matter that can improve the fertility and texture of soils
iii. Pathogens in the sludge die off during the relatively long detention periods used in anaerobic digestion.

Aerobic Digestion is done in the presence of oxygen. These are used for small treatment plants and have the following advantages:

i. Lower BOD concentration in digester supernatant;
ii. Production of odourless and easily dewaterable biologically stable digested sludge;
iii. Recovery of more basic fertilizer value in the digested sludge;
iv. Lower capital cost; and
v. Fewer operational problems.

Sludge Dewatering

Sludge dewatering is achieved by any of the following methods:

i. Vacuum filters
ii. Centrifugation
iii. Air flotation

We will examine the alternatives on merits case by case.

Effluent Disposal and Utilisation

The effluent from sewage treatment plants can be disposed of in several ways. It can be discharged:

i. In receiving waters such as lakes, streams, rivers etc.
ii. Disposal on land.
iii. Artificial recharge of aquifers.
iv. Reuse for irrigation, horticulture, cooling and other Industrial uses.
The Ministry of Environment and Forest (MOEF) of Government of India has laid norms for discharge and reuse of effluents. The nature and degree of treatment given to the sewage is dependent upon the regulations imposed by MOEF.

We will be studying case by case the various technical, economic and environmental aspects for efficient and sustainable disposal arrangement in line with regulations imposed by Government.

2.3 Rural Areas Low Cost Appropriate Technologies

2.3.1 Duckweed based wastewater system

The system may be used for treatment of low strength wastewater and availability of land is not a constraint. As this system does not require any power for operation, the system is ideal for rural areas where availability of power is sometimes an issue.

i. Low strength wastewaters - The suspended solids (SS) get settled at the bottom of the duckweed pond and get decomposed in the anaerobic conditions. The SS are no hindrance in the growth of the duckweed.

ii. Municipal Sewage - A pre-sedimentation tank for treatment of waste having suspended solids will be required if the duckweed pond is used as the main treatment system. The main duckweed pond will be handling lower organic load efficiently.

iii. Polishing of treated wastewaters – Duckweed ponds are sometimes used for nutrient removal from the secondary treated effluents and are added in series. These are sometimes further used as a fish pond.

Functioning of Duckweed Ponds

These function basically as anaerobic tanks except in the top layers where they function in aerobic conditions.

Apart from physical sedimentation and adsorption, the pollutants get removed by microbial metabolism and duckweed support the right environment.

Duckweed creates a barrier to travel of light thereby restricting photo synthesis and ensuring anaerobic conditions below the top layers. The duckweed rots provides a support medium for growth of bacteria for filtration and adsorption down and adsorption. The end result is removal of nitrogen, Phosphorus, Sulphur and even heavy metals.

Advantages of Duckweed system include:

i. The plants growth is less sensitive to low temperatures, high nutrients levels, pH variations and grows rapidly

ii. It absorbs heavy metals effectively

iii. It does not encourage the development of mosquitoes unlike water hyacinth rather it decreases the growth of mosquitoes

iv. It helps in odour control
v. Harvesting of duckweed from the ponds is far easier than the harvesting of water hyacinth  
vi. Due to its high protein content, it is suitable as a high quality cattle feed

### 2.3.2 Wetlands

Natural wetlands exist all over the world. They play an important role in maintaining natural ecosystems rich in plant and animal (fish) life. They have saturated soil conditions and rooted vegetation. These can be integrated with wastewater treatment system.

**Constructed Wetlands**

These are man-made either for treatment of wastewater or for specific value to wildlife. These wetlands have been used for treating effluents from septic tanks and also to provide tertiary treatment to meet the desired standard of BOD and suspended solids (SS).

These are generally of horizontal flow type and include “reed beds” and Root Zone treatment methods. The beds can serve flows from 1m$^3$/per day or more. They require (2 - 5m$^2$/per person) the beds, maybe in 3:1 (rectangular length: width) ratio, isolated with ground water by lying it with clay or/ and polythene sheets to prevent contamination of ground water. Sealing of bottom is done by using natural clay with bentonite.

It is desirable to maintain sub surface flow to prevent mosquito breeding and odour formation.

**Performance**

The performance of the constructed wetlands can be determined on the basis of removal of BOD/COD, TSS, nitrogen, phosphorus and coli forms.

As reed beds, these have been used as polishing of effluents and the systems can be considered for reuse of wastewater, ground water recharge and flushing of toilets. Wastewater from the kitchens (grey water) has been treated using reed beds and successfully used for toilet flushing.

### 2.3.3 Development of treated effluent reuse plan

With increasing pressure on water as a result of limited availability, increasing urbanization and deterioration of water quality of surface as well as ground water, primarily due to pollution of sources of supplies, water recycling is becoming an established way of moving towards sustainable management of our water resources and environment. Faced with perennial shortages of fresh water, and to discourage the use of potable water for industrial uses, the municipal bodies have raised the industrial tariffs considerably. In most cases the tariff for industrial water is pitched high than the cost of reclaimed water.

Water recycling adopts the concept of using water that is “fit for purpose”. In practice this means using high quality water for potable uses and non-potable water for recharge of ground, water for flushing of toilets, gardening, crop irrigation, fire fighting and various industrial use particularly air conditioning, cooling, power generation (cooling and boilers), paper industry, steel industry etc.
The Benefits of Recycle

- Helps conserve vast volumes of water while protecting the environment and reducing pollution
- Assured availability of water
- Less requirement for fresh water, hence low water costs
- Additional savings through product recovery
- Compliance with pollution control regulations and clean environment through reduced effluent discharge
- In new projects, incorporation of recycle considerably reduces capital investment on water treatment

There have been significant developments over the world in respect of reuse of water. These initiatives are mainly driven by shortage of fresh water. Presently many cities around the world are using reclaimed water to reduce their water demands.

With the available technology it is possible to treat the sewage to drinking water standards. However, the cost of such treatment far exceeds the cost of potable water. Besides that there is a psychological barrier against the use of reclaimed water for drinking purposes. The treatment for such water involves conventional wastewater treatment followed by tertiary treatment like microfiltration / ultra-filtration including, UV disinfection and chlorination.

The level of tertiary treatment to be provided is decided based on the possible uses to which the recycled sewage is to be put to. The available treatment options to be evaluated would include:

i. Conventional Activated Sludge Process
ii. Sequencing Batch Reactor
iii. Moving Media Bioreactor
iv. Hybrid Biological Treatment
v. Membrane Bioreactor

The reuse of water for toilet flushing or for industrial processes can result in significant reduction of the fresh water demand. The water, after reuse of this nature comes back into the system, often with an added quantum of dissolved solids of inorganic nature. For example, water used for toilet flushing will return to the system with about 8 to 10g of salt added. The treatment processes other than reverse osmosis do not remove the dissolved inorganic matters. Therefore, the possible uses of sewage, which has received tertiary treatment, are:

i. Cooling water for HVAC systems where substantial quantity of water would be lost by evaporation
ii. Gardening, roadside arboriculture and green belts
iii. Aquifer recharge
iv. Landscaped water bodies with fountains
v. Washing of roads, vehicles etc
vi. Various industrial processes
Several precautions have to be taken to protect the water quality of aquifer against contamination while using reclaimed waters. These include the following:

i. Locating the points of recharge a safe distance away from the existing sources of ground water.

ii. The safe distance would be determined by the flow paths taken by the water with an aquifer, the permeability and the travel time of water to reach the ground water.

iii. Ensuring sufficient treatment to the sewage to minimize the BOD, pesticides and other undesirable contaminants in conformity with the standard laid down.

iv. Elaborate precautions will have to be observed for toilet flushing to avoid chances of connections with filtered water lines, which may lead to outbreak of diseases. Such precautions include:

   o Colour coding of conveyance pipes for filtered water, reclaimed water.
   o Using different materials of pipes for conveyance of filtered water and reclaimed water.
   o Keeping safe distance between such conveyances.
   o Exerting strict control on plumbing of these conveyances.
   o Minimizing the differentials of tariffs of supply of these waters.
   o Imparting colour to reclaimed water.
   o The treated effluent must meet the U.S.E.P.A guidelines for use of water for toilet flushing.

In India, reclaimed water is extensively being used for cooling for HVAC systems, boilers, industries, manufacturing paper, automobiles, steel and steel products and even in refineries, apart from horticulture. A beginning has also been made using reclaimed water for flushing of toilets.
3. Sewerage Master Plan

3.1 Introduction

3.1.1 Master Planning Process

The planning and implementation of a major sewerage master plan project must go through an iterative process of evaluating options against a number of performance indicators or criteria for measuring success. For a city like Delhi, there are many possible ways to address the sewerage problems; hence the goal of the master planning process is to match the most applicable and trouble free system of conveyance and treatment technology to suit the specific treatment needs for the city.

3.2 Data Collection and Review of Available Information

3.2.1 General Data

The first task of the study is to obtain and review all readily available existing information regarding the sewerage and associated water supply and storm water systems, including those studies carried out for Delhi by DJB and other agencies, for developing the SMP. Typical documents that will be obtained, if available, include:

- Population data/census data for projection of population for 2031;
- Previous studies for Sewerage system/ Sewage Treatment/Sewage Pumping Station/trolley Sewage Pumping Station;
- Sewage Quality reports of the existing Sewage Treatment Plants;
- Information of Drains that discharge Treated/ Untreated Wastewater/ Effluent into River Yamuna;
- Reports on Interception Sewers and Dry Weather Flow Interceptors;
- Report pertaining to Storm Water System;
- Topographic maps by Survey of India/any other agency;
- Geological and soil maps;
- Verdicts and affidavits by Honourable Supreme Court of India;
- GIS maps for existing sewerage system;
- Development plans and land use maps;
- Reports prepared under YAP-II;
- DPR/Feasibility Study of Up gradation / Augmentation of Sewage Treatment/Sewerage network rehabilitation, if any that are under implementation;
• Typically managers, operators, and maintenance staff have significant and important personal knowledge of the existing system operations and maintenance. These key staff will be interviewed to acquire knowledge of the system that attribute to the successful implementation of the SMP for Delhi for 2031; and

• Review of existing DPRs.

The International and National experts on sewerage and sewage treatment will be undertaking the review of the Detailed Project Reports (DPRs) proposed by DJB for Kondli, Okhla and Rithala catchments and their STPs and SPSs and suggest modification and improvements as may be necessary to be acceptable to the JICA. Field visits of STPs and SPSs will the undertaken to get first-hand knowledge of the existing systems and associated constraints.

We shall recommend new technology to be adopted which is suitable to the local conditions and can be used in tandem with the existing facilities thus eliminating additional load of tertiary treatment process and the treated effluent from the secondary process can be used for non-portable usages.

3.2.2 Study of Delhi Master Plan 2021

To review and project the anticipated growth of population within the study area and the subsequent sewage flow data after thorough surveys, field investigations and data analysis. We require the following Planning data:

• Population and growth data.
• Trends and projections on flow monitoring activities.
• Policy for housing squatters and dwellers.
• Migration from rural areas and other movements.
• Changing land use patterns and constraints imposed by the existing infrastructure.
• Any large-scale schemes being proposed /implemented by government agencies or institutions.
• Limitations owing to other infrastructure services.
• Proposals for sanitation improvements in unsewered pockets.

Our in house town planner expert will study all relevant data and information on planning, developments, land uses as well as the existing and planned population of the relevant planning documents including development zoning plans, departmental plans and private and public development proposals. Findings of the latest relevant planning studies and projects at the territorial and sub-regional levels will also be taken into account. With assistance from DJB, we will closely liaise with Planning Authority to agree on the design population for 2031, the land use permitted under development zoning plans, population statistics and forecasts based on the most updated data set. We will also review the most up dated development programme of unsewered areas, and new or proposed development/expansion area. Close liaison with the Land Authority will be necessary.
Our Town Planning Team is experienced in gathering relevant baseline planning information to form a GIS database suitable for future planning analysis. Relevant data including development data of the existing and planned public/private developments, existing and planned population and employment distribution within the Study Area, will be collected and analyzed with the aid of GIS so as to facilitate the development of GIS or equivalent models for the sewerage systems.

Based on the latest population projection and land use data from the Planning Authority, we will preliminarily estimate the design flows from each sub-catchment using the unit flow rates and peaking factors as set out in the latest DJB Guidelines (and modified by the flow monitoring results where necessary). Once these criteria are established, catchment plans can be prepared as required.

The compatibility of the proposed options for sewerage provision with its surrounding land uses will be assessed taking into account the latest public and private development and planning proposals within the Study Area. Possible land use implications on the land uses adjacent to the proposed sewerage provision will be investigated. In addition, statutory planning requirements including amendments to the Development Zoning Plan and/or planning application will be examined to facilitate the implementation of the recommended sewerage master plan.

3.2.3 Demographic survey for un-authorized colonies, urban/rural villages etc

**Sources of Information**

Keeping in view the objective / scope of the assignment, the information would be collected with the active involvement of the householders and key stakeholders at different levels.

The information would be collected from both sources, i.e. primary as well as secondary. The primary sources of information would be the stakeholders including rural / urban masses and representatives of the NGOs and other implementing agencies. Similarly, secondary sources of information would be the published / unpublished reports / documents available with various organizations / departments of the Delhi Government.

**Tools**

As already mentioned the main tools to be used for data collection from primary sources would be the “Household Interview Schedule”. Interview Schedules would be used for collection of information from individual households while focused group discussions would be held with the groups of people by using checklist developed for smooth discussions. Both the tools would consist of different variables / indicators status of livelihood of the people and developing future strategies for the development of the same.

To collect information from secondary sources, checklists consisting of different variables / indicators would also be developed as per the requirement of the assignment. Separate checklists would be used to collect information from different departments of the Delhi Government. Each checklist would be helpful in
assessing the preset status of physical / financial coverage under the particular sector / activity.

The tools to be used for data collection would consist of the following variables / indicators:

- Economic and Poverty Indicators
- Equity
- Employment generation
- Environmental Indicators
- Land Use Diversification
- Water quality
- Water availability
- Sanitation facilities
- Solid Waste Disposal
- Hygiene
- Human/Social Indicators
- Participation in local policy decision making
- Human Capital
- Social Capital
- Quality of Life Indicators

**Sampling**

During the canvassing of the interview schedules, all the social groups including SC, OBC and General would be covered. Besides, in each of the sampled pockets, focused group discussions (FGDs) would be organized by the trained field staff of the Project Team.

**Data Collection**

The filled-in interview schedules and focused group discussions would become helpful in assessing the Human Capital, Physical Capital Social, Capital, Natural Capital and Financial Capital and thus, the participatory approach would lead to increase in the opportunity available to individuals / groups / community for the improvement and scaling up of the assets for sustainable improvement of their livelihood. Typical Sample Demographic Format is attached as Annexure No. 1. However, the same needs to be reframed as per design data requirement.
Sustainable Livelihoods Framework

After developing the formats, information would be gathered from different sources mainly from primary sources and subsequently from secondary sources by the enumerators under the direct guidance of field supervisors. The team of experts involved from time to time would conduct overall supervision of data collection work. The enumerators/supervisors would be inducted locally, who will be well conversant with the local customs, traditions and culture. They will be trained by explaining each and every aspect covered in the formats and details of checklist developed for conducting focused group discussions on the present socio economic status, means of livelihood, and possible alternatives to increase their income, present skill available with them and its upgradation, issues relating to the women and child development etc.

The outcome of the data collected would be used to develop multiple programs and strategies to influence the Government, and the NGOs, for wider uptake and to disseminate the study learning with a measure of success.

Thus, the reports would be generated by analyzing the tables created through these statistical techniques. Before finalizing draft reports, findings would be discussed with the local masses as well as representatives of DJB. At the same time, finding of the study would be disseminated at a larger audience consisting of representatives of different departments and NGOs. At every stage of assignment local people, i.e. the target population and other stakeholders including different Government departments / agencies and some of the leading NGOs would be involved.

The outcome of the study would cover the detailed information on all aspects, more specifically on the followings:

- Employment opportunities for the families
- Quality of Education and Higher Education
- Economic Development
- Health & Hygiene
- Housing
- Migration
- Safe drinking water
3.2.4 Desktop Study

In undertaking the desktop study, the general design criteria will be examined and determined as follows.

**Design Year**

Design Year is considered to be 2031.

**Design Flow**

The design flow is based on the wastewater expected to be generated in 2031. It would include wastewater from domestic use in residential, commercial, industrial and institutional areas. The wastewater from large industrial areas, after suitable treatment, will be discharged to surface bodies to conform to relevant standards as defined by regulatory authorities.

Design flows are essentially peak dry weather flows. Peak dry weather flows would comprise peak domestic wastewater and infiltration.

**Population Projection**

The Central Public Health and Environmental Engineering Organisation (CPHEEO) in its manual on Sewerage and Sewage Treatment has listed a number of methods which can be described as follows:

*Arithmetic Increase Method* – This method is generally applicable to large and old cities. In this method the average increase of population per decade is calculated from the past records and added to the present population to find out population in the next decade. This method gives a low value and is suited for well settled and established communities.

\[ P_n = P_o + (N \times X) \]

Where,

- \( P_n \) = Projected population to be calculated
- \( P_o \) = Population of Base Year (2001)
- \( N \) = Number of Decades
- \( X \) = Average of Decadal Variation

*Incremental Increase Method* – In this method the increment in arithmetical increase is determined from the past decades and the average of that increment is added to the average increase. This method increases the figures obtained by the arithmetic increase method.
\[ P_n = P_o + N \times X + N(N+1) \times Y/2 \]

Where,
- \( P_n \) = Projected population to be calculated
- \( P_o \) = Population of Base Year (2001)
- \( N \) = Number of Decades
- \( X \) = Average of Decadal Variation
- \( Y \) = Average of Incremental Increase

**Geometrical Increase/ Exponential Method** – In this method percentage increase is assumed to be the rate of growth and the average of the percentage increase is used to find out future increment in population. This method gives much higher value and is mostly applicable for growing towns and cities having vast scope for expansion.

\[ P_n = P_o (1+R/100)^N \]

Where,
- \( P_n \) = Projected population to be calculated
- \( P_o \) = Population of Base Year (2001)
- \( R \) = Average percentage of Growth
- \( N \) = Number of Decades

Master Plan for Delhi-2021 shall also be reviewed in perspective of Projected Population as a whole scenario.

**Per Capital wastewater flows**

After allowing for losses in treated water transmission, distribution, etc an agreed percentage of the gross water supplied will be considered as reaching the consumer. The wastewater generated is expected to be 80 percent of the water consumed.

In addition to the water supplied by DJB, non-drinking water from private wells and hand pumps is used by the consumer in some areas amounting to some, 25 to 30% of water used. This appears to be high and is expected to reduce when the quantum of treated water supply increases and the per capita water improves. The higher level of satisfaction from DJB’s supply will reduce the quantum of water abstracted from this source. Thus, provision of 10% will be made for water from this source in 2031.

**Rate of Infiltration**

Infiltration into the wastewater systems occurs through sewers, manholes, etc. The rate of infiltration into sewers also depends upon the ground water table and permeability of the surrounding soil. Though strict quality control and good workmanship will ensure minimum infiltration as the system condition deteriorates with age the possibility of infiltration increases.

In the hydraulic design of sewers, an allowance for infiltration for the project area is proposed to be considered uniformly at 10% of the average domestic wastewater.
**Peak Factors**

The peak factors with respect to contributing population for domestic sewage as per CPHEEO manual (1993) is furnished in the table below. The peak factors are applied to the projected population for the design considering an average per wastewater flow based on allocation.

<table>
<thead>
<tr>
<th>Contribution Population</th>
<th>Peak Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 20,000</td>
<td>3.00</td>
</tr>
<tr>
<td>20,000 to 50,000</td>
<td>2.50</td>
</tr>
<tr>
<td>50,000 to 750,000</td>
<td>2.25</td>
</tr>
<tr>
<td>Above 750,000</td>
<td>2.00</td>
</tr>
</tbody>
</table>

*Table 3-1 Recommended Peak Factors*

For the sewerage collection system, the various design criteria are discussed as follows.

**Design formula**

Manning’s formula is adopted for design of gravity sewers.

\[ Q_f = A \times V_f \]

\[ V_f = \frac{1}{n} \times R^{2/3} \times S^{1/2} \]

Where,

- \( Q_f \) = Flow rate pipe flows full in cumecs
- \( V_f \) = Velocity when pipe flows full in mps
- \( n \) = Manning’s roughness coefficient when pipe flows full
- \( R \) = Hydraulic radius in m
- \( S \) = Slope of energy gradient
- \( A \) = Cross sectional area of pipe in sq.m

**Coefficient of Roughness**

As pipes deteriorate with age, a roughness coefficient is considered for the design period assuming fair condition in sewers.

The roughness coefficient \( N \) is considered the same for all diameters when flowing full and as follows for fair condition. RCC Pipes - 0.015  
Glass coated reinforced / HDPE Pipes – 0.011, which anticipate increasing the carrying capacity of proposed sewer/s. However the final recommendation for material shall be in accordance with cost-benefit analysis.

The value of \( n/N \) however varies with \( d/D \)
Design Capacity of Sewers

Sewers are designed to carry estimated peak flows generated in the design years and will run 80% full at ultimate peak flow as per Page 49, clause 3.4.2.6 of CPHEEO Manual. This is to ensure proper ventilation and prevent septicity.

Self Cleansing Velocities

To ensure that deposition of suspended solids does not take place, self cleansing velocities using Shield’s formula is considered in the design of sewers. The formula indicates that velocity required to transport material in sewers is mainly dependent on the particle size and specific weight and slightly dependent on conduit shape and depth of flow.

Limiting velocities for particles varying in specific gravity form 1.01 to 2.65 were studied during earlier studies. The specific gravity of grit was usually in the range of 2.4 to 2.65. As per the above formula, for a minimum velocity of 0.5 mps, all particles of specific gravity 2.685 and size less than 1.0 mm will remain in suspension. Similarly, particles of specific gravity 1.01 and size less than 160 mm will be in suspension. Hence, a minimum velocity of 0.5 mps should be adequate to prevent siltation in sewers during minimum flow conditions.

When considering typical values of particle size and specific gravity, minimum partial flow velocities of 0.6 mps at present peak flows and 0.8 mps at ultimate peak flows are considered desirable, provided depth of sewers do not necessitate provision of too many pumping stations.

The minimum velocity of 2.50 mps is considered adequate to prevent scouring, where topography permits steep slopes. This is only a limit which has been defined to prevent scouring.

Minimum Size of Sewers

The minimum diameter of proposed trunk sewers is 900 mm as per the scope of this study.

Depth of Cover

To facilitate connection of house sewers to branch sewers and to provide protection to sewers form external loads, the minimum depth of covers to be provided over the top of pipe at the start of the trunk sewers is 2 metres or as per actual invert level of branch sewers.

As per current practice, the maximum allowable depth of sewer is considered as ranging from 6 m to 8 m depending on the area and considering soil strata and water table levels.

Pipe Material

In underground sewerage systems mainly pipes are used for collection system and transmission lines. For collection systems stoneware pipes, RCC Pipes, CI pipes, DI pipes etc. are being used. For transmission systems under pressure, normally CI pipes, DI pipes, PSC pipes etc. are being used. As sewage consists of acidic and corrosive substances, the pipe material used should be corrosion resistant. The usage of new pipes such as DI pipes, HDPE and PVC pipes shall be resorted to than the conventional pipes now being used. For transmission mains DI pipe is preferable up to 1000mm dia.

We plan to analyse High Density index pipes with low roughness coefficient, eg HDPE, GRP, Vitrified Clay pipes etc. The same shall be considered after carrying cost-benefit analysis as per site constraints.
However, RCC pipes shall be considered as per IS 458:1998 (reaffirmed in 2001) and bedding shall be considered as per requirement. NP2 class pipes are not advised for depths greater than 3.0 m and pipes greater than 400 mm dia from structural point of view. NP3 pipes with medium duty are applicable for medium, traffic and for depths up to 6m. Pipes other than RCC will be considered case by case in consultation with DJB.

Due to the comparatively higher cost, larger space requirement, ground water table and slow progress of work, bricks sewers are not recommended in developed areas of Delhi.

Sewer lining shall be recommended for specific sites and will be considered as constraint with cost option.

**Pipe Bedding**

If recommendation comes for HDPE and/or Glass reinforced pipes, we need not to take care of the Pipe bedding. However in case to case basis if RCC pipes (coated with Epoxy lining), the bedding of the pipes will be considered on the factors as listed below:

a) Soil strata  
b) Supreme imposed load  
c) Depth of backfill  
d) Three edge test of the pipe
<table>
<thead>
<tr>
<th>Bedding Factor</th>
<th>Type of Bedding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 1.9</td>
<td>Granular (GRB)</td>
</tr>
<tr>
<td>&gt; 1.9 &amp; up to 2.8</td>
<td>Plain Concrete cradle (PCCB)</td>
</tr>
<tr>
<td>&gt; 2.8 &amp; up to 3.4</td>
<td>Reinforced Concrete cradle (RCCB)</td>
</tr>
<tr>
<td>&gt; 3.4</td>
<td>Complete Concrete Encasement (CCE)</td>
</tr>
</tbody>
</table>

**Table 3-2 Bedding Factors**

**Manholes**

1. **Ordinary Manhole** – Circular manholes are preferred over rectangular manholes. The centre to centre distance of manholes may be adopted as 30 m even for large diameter sewers for ease of maintenance of sewers. The manhole frame and cover shall be of Steel Reinforced Concrete (SFRC) capable of withstanding heavy duty loads, conforming to the relevant IS codes. Construction of manholes may be done using sewer bricks conforming to IS 4885.

2. **Scraper Manholes** – For sewers of 600 mm diameter and above, scraper (service) manholes are proposed to be provided at a spacing of 120 m centre to centre. They will be of circular shape as per DJB’s current practice. However, rectangular manhole can also be provided without offset as practiced in other metros.

3. **Junction Manhole** – Junction manholes are to be provided at all junctions of sewers.

4. **Vent shafts** – Vent shafts are normally provided at the beginning of each sewer at junctions and along straight stretches of sewer at a spacing of 180 m for ventilation. This will require discussion with DJB.

**For the conveyance system, the following design criteria will be considered.**

**Rising Mains Design Formula**

Hazen-William’s formula is adopted for design of rising mains

\[
V = 0.849 \times C \times R^{0.63} \times S^{0.54}
\]

\[
Q = A \times V
\]

Where,

\[
\begin{align*}
Q &= \text{Discharge in cumecs} \\
V &= \text{Velocity in mps} \\
R &= \text{Hydraulic radius in m} \\
S &= \text{Slope of hydraulic gradient}
\end{align*}
\]
\[ C = \text{Hazen Williams coefficient} \]

Depending on pipe material, the following C values are adopted for design of rising main.

<table>
<thead>
<tr>
<th>Material</th>
<th>C Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cast Iron</td>
<td>100</td>
</tr>
<tr>
<td>Ductile Iron</td>
<td>120</td>
</tr>
</tbody>
</table>

**Pumping Station**

*Civil Aspects* – The civil structure of pumping stations (PS) is designed for the ultimate design year; whereas electrical and mechanical components are planned for an intermediate period as the life of pumping machinery is generally 15 years.

While designing the wastewater system, efforts shall be made to ensure that minimum numbers of pumping stations are required and that most of the wastewater generated will be conveyed by gravity.

*Hydraulic Aspects* – The following hydraulic criteria are adopted for the design of pumping stations:

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Peak Factor</td>
<td>2 to 3.5</td>
</tr>
<tr>
<td>b) Maximum retention time of sewage in the suction well/wet well</td>
<td>Upper limit of 30 minutes</td>
</tr>
<tr>
<td>(in order to prevent sewage turning septic)</td>
<td></td>
</tr>
<tr>
<td>c) Minimum permissible velocity in the pumping main/rising main</td>
<td>0.75 m/s (or for one pump operation 0.6 m/s if 1.0 m/s is also achievable for part of day)</td>
</tr>
<tr>
<td>d) Maximum level of sewage in the wet well (to avoid surcharging of the sewer)</td>
<td>300 mm below maximum level in incoming sewer</td>
</tr>
<tr>
<td>e) Maximum velocity in pumping main (from consideration of erosion)</td>
<td>2.5 m/s</td>
</tr>
<tr>
<td>f) Maximum no. of starts per hour (for manual operation)</td>
<td>2</td>
</tr>
<tr>
<td>g) Priming of pumps</td>
<td>By positive suction</td>
</tr>
<tr>
<td>h) Minimum level different between two starts/ tops</td>
<td>300 mm</td>
</tr>
</tbody>
</table>

The above will be placed before DJB as Technical Memoranda for consideration including detailed design criteria for electrical and mechanical equipments, illumination levels, earthing design and BIS codes.
3.3 Engineering Surveys and Investigations (Task 2, TOR 6.2)

3.3.1 Introduction

In order to supplement the desktop study, further information would be collected through various field investigations:

- Topographical Survey
- Geotechnical Survey
- Flow Measurement in existing trunk mains at 50 locations within the city
- Differential Global Positioning System (DGPS)/ Total Station Survey for Ground points if required for GIS integration
- Performance Audit of Existing 17 Nos. of Sewage Treatment Plant
- Performance Audit of Existing Sewage Pumping Stations
- Wastewater quality analysis
- Manhole Investigation on existing trunk and peripheral sewerage system of the city

Time for completing the field survey and investigation is extremely short. We will mobilize sufficient number of well experienced and well trained teams to undertake the surveys each headed by a team leader.

3.3.2 Topographical Survey

Master planning of the sewerage system requires data such as contours, spot levels, etc. However, carrying out such survey for the entire city would consume time and significant quantum of resource. Thus, we propose to use the Survey Maps of India and overlay with GIS based base maps as a first step to find out the spot levels. We will carry out fieldwork to confirm levels that could not be obtain from GIS.

Topographical Survey of identified areas within NCT of Delhi is by electronic Total Station on the longitudinal alignment of the road corridor of 30m width or up to build up lines whichever is the less and all road intersections. Survey of existing objects includes buildings, trees, river, bridge, electric & telephone lines, utility services (only over ground) etc. available in the area and taking spot levels at 30m intervals or as per site condition.

Survey Control – Where possible, stations are generally set-out using PK-type nails in hard standing surfaces. A sufficient number of stations are left outside the development areas allowing for consistent future electronic control and reference.

A copy of format proposed to be used is attached as Annexure No. 2.
Topographic Details – Street furniture, kerbs, wall faces and tops, fences and types, top & bottom of banks, services covers, street ironwork, building footprints, tree trunks and canopies on and near site, neighbouring building locations and heights and overhead services. Contouring is generally set at 0.5m intervals in elevation or as topography allows. Drainage alignment and invert levels where possible, including tree heights and species will be at 30m interval. The cross section of existing drains and sewer lines at 30m interval is required.

A copy of format proposed to be used is attached as Annexure No. 2.

Drawings Submission – Drawings are generally drafted to scales of 1/200 or 1/500 and produced in AutoCAD together with cross sections in every 30m intervals. The client may request drawings in varying combinations and versions of electronic or hard copy paper formats, as standard, and unless otherwise requested, model space 2-D format drawings are dimensioned in millimetres. One soft copy of the drawings will be submitted in AutoCAD format together with 1 printout copy.

3.3.3 Geotechnical Survey

The Geotechnical investigations will include preliminary geotechnical and sub-surface investigations to identify the sub-ground conditions and identify possible locations for the proposed structures, such as for new treatment facilities if required, for pipe supports etc. The data of particular importance for the design of structures include:

- soil profile;
- foundation stratum;
- Strength characteristics;
- safe bearing capacity; and
- Rock stratum.

Geotechnical investigations will be conducted to obtain the subsurface stratifications in the proposed project areas and to collect soil and ground water samples for laboratory testing to arrive at the foundation design parameters. Laboratory testing will be done as per testing procedures given in the relevant parts of IS: 2720. Geotechnical investigations will be conducted at all proposed pumping station and treatment plant locations where such information is not available. Details are given in Annexure No. 3.

The investigation work will include the following:

- 10m to 15m deep bore holes 200 no.
- Standard penetration test and collection of disturbed and undisturbed soil samples from bore
holes

- Recording of existing ground water table
- Laboratory tests on soil samples collected
- Conducting electrical resistivity test at decided locations and submission of results
- Submission of reports in 2 No. of copies

3.3.4 Flow Measurement

We will collect the available flow details of the pipe/nullah/drain from DJB. In terms of timing of monitoring it will be necessary to carry out the flow and rainfall monitoring survey in the wet season in order to capture the contribution of storm water flow to the sewerage systems well as dry weather flows.

3.3.5 GPS Survey

Differential Global Positioning System (DGPS) / Total Station Survey for Ground points is required for GIS integration. As per our past experience, there are likely discrepancies between existing data and the hydraulic model data. The previous module will be changed against the latest sewerage records plan and updated accordingly.

The design criteria, hydraulic modelling approach and GIS requirements will be established at the start of the assignment and circulated in a working paper for comment and agreement. This will include the approach for construction, calibration and verification of the models. Reference will be made to the International Standards for Sewer Network Hydraulic Model- Build and Verification.
3.3.6 Manhole Survey

At the master plan level we plan to carry out manhole surveys for the existing trunk and peripheral sewers. We envision that the manholes are a prime source for infiltration and silt intrusion as they are the point of connection to the main system. In all we propose to investigate 500 manholes to facilitate desalting and to check the existing situation to obtain real time data on the depth, size and slope of the trunk and peripheral system. Any manhole cover defects found will be informed to DJB for carrying out the maintenance immediately. We shall use all safety precautions like safety boots, gas masks, self breathing apparatus etc while entering the manhole, as H₂S may be present in the system due to poor ventilation or non-availability of sufficient flow. A copy of the format is attached as Annexure No. 4.

3.3.7 Performance Audit of Existing Sewage Treatment Plants

The overall performance of a wastewater treatment works, in which each individual treatment train is designed to remove one class of contaminants, is significantly influenced by the quality of the incoming raw sewage and susceptible to deterioration in the presence of other contaminants out of design consideration, such as from industrial effluents. In particular, oil, heavy metals, ammonia, sulphide and toxic constituents may damage sewers (e.g. by corrosion) and reduce treatment plant performance. The individual performance of each treatment facilities and ambient environmental factors such as temperature can also influence the overall performance of a wastewater treatment works.

We will develop a water quality monitoring programme that comprises process monitoring and compliance monitoring. This will be implemented in a systematic and cost effective manner following the Water Quality Sampling and Monitoring Plan (SAMP). With consideration of the available track records, site specific conditions, and strategic analysis approach and given resources, we will formulate the SAMP and agree with DJB targeting testing parameters and methods and sampling methods, time, locations and frequency. The process-monitoring programme will not only examine laboratory testing data of the water in treatment process but on-line measured data at various strategic locations of the treatment trains is also taken into account as a real time information to assess the each treatment train with the relevant specification. The process-monitoring programme will also focus to identify the location of inadequacy in the whole treatment trains. The water quality compliance monitoring programme is provided to assess the effluent quality against the discharge criteria specified by DJB to assess overall treatment performance.

Our survey of the existing treatment plants shall include:

1. Capacity assessment with respect to designed capacity and present flow
2. Hydraulic and Organic load capacity with respect to the designed and present flow characteristics
3. **Assessment of civil structures mainly water retaining**

4. **Performance of secondary units with respect to the performance of aeration tank, dissolved oxygen, secondary, short circuiting, bulking of sludge etc.**

5. **Power consumption from the available data like payments of energy bill**

6. **Sludge dewatering and digestion**

7. **Potential for modernization in the plant**

Formats have been designed for this purpose and a copy of the same is annexed (ATTACH THE FORMAT OF CAS YAP-III Works).

**3.4 Review of DPRs prepared by DJB**

Over a period of time due to fast urbanization, the water quality of the river Yamuna has undergone severe deterioration having impact on the health and well being of millions of people. To address this problem, YAP (Yamuna Action Plans) have been conceived under the National River Conservation Directorate (NRCD) Ministry of Environment and Forest (MOEF), Govt. of India. The YAP 1 was completed in Feb, 2007. The programmes have been further designed under YAP–II which are under implementation.

Under YAP III, DJB has formulated DPRs for the catchments of Okhla, Rithala and Kondli comprising rehabilitation of STP, SPS and trunk sewers with a view to significantly improve the water quality of the river.

We have collected the copies of these DPR’s and are currently reviewing them. We will make suggestions in consultation with DJB to address the concerns of JICA and will put them in an acceptable frame. We will, in particular, address social considerations and issues of financial viability and sustainability.

**3.5 Assessment of Existing Sewerage Facilities**

**3.5.1 Condition Assessment of Existing Trunk Sewers**

The assessment of the physical conditions of trunk sewers and main sewers will be based on observations during manhole and outfall inspections and information obtained during interviews with DJB staff. Field investigations to assess the conditions of existing sewer trunk lines will be accomplished. CCTV surveys are not in the scope of the present study, however, stretches showing where CCTV surveys need to be conducted can be provided.

**3.5.2 Hydraulic Evaluation of Existing Sewers**

Urban systems involve many complex and interdependent processes, such as wastewater generation, urban hydrology, and various structural elements designed to convey hydraulic flows. The Bentley’s Sewer GEMS steady state and dynamic hydraulic model is proposed. Results of the hydraulic evaluation will include identification of trunk sewer locations where the capacity of existing pipes currently is adequate, where the capacity is inadequate, where flow velocities are inadequate for self-cleaning, and where the hydraulic profile indicates
surcharging and potential overflow. Assessment of pump station hydraulic will be based on hydraulics and pump efficiency testing results.

After the base maps, field survey, existing land use data wastewater generation factors, and peaking factors are finalized, Sewer GEMS or equivalent hydraulic models of the existing trunk sewers will be developed. The initial analysis will be based on wastewater generation peak flow factors. The initial analysis also will assume that the existing pipes are in good conditions, and do not have any silting or choking, do not have any overflow discharges and do not have any storm water contributions. This will simulate the assumed “as designed” conditions. Key parameters that will be calculated and evaluated are flow velocity, depth of flow, total flow in cubic metres per second (cms), and hydraulic profile.

3.5.3 Rehabilitation Measure for Pumping Stations

Requirements for pumping station rehabilitation and modification will be based on information obtained from pumping station inspections, testing, and interviews with staff. Some typical pump station work may include modification to inlet chambers, screens, and/ or grinders; replacement of pumps, valves, and other equipment that have failed or are not working properly; improvement or addition to emergency power supply systems; improvements to pump station monitoring and control system; installing or repair of pump and motor removal and replacement systems; and additional or modification of odour control systems.

Physical inspection of the rising mains is not practical at the master planning phase. However, the hydraulic adequacy and existing condition of the rising mains will be evaluated. The hydraulic adequacy of the rising mains will be assessed based on estimated existing and projected peak flows. Assessment of existing conditions of rising main will be based on information related to the age, type of pipe material and repair history of the mains. Based on these assessments, recommendations regarding replacement, enlargement, or supplemental parallel relief mains will be developed.

Modifications to the existing pumping stations to accommodate future development will be evaluated to determine the expected date if and when additional hydraulic capacity will be required. This analysis will be used to establish priorities for increasing the hydraulic capacity of existing systems.

3.5.4 New Pumping Stations

Alternative locations for new pumping station will be identified based on alternative STP locations, alternative trunk sewer locations, potential availability of land, and access conditions for O&M. Conceptual pumping station capacities will be based on average and peak wastewater flows for the upstream catchments area for each alternative pumping station location. Additionally, alternative pumping station configurations and alternative technologies as described in this report will be evaluated. Each potential new station also will be evaluated for potential phasing of pumping station capacity increases.

3.5.5 Other Potential Improvements

Information obtained prior to preparing this Inception Report revealed that much of the sewer pipe choking is caused by uncontrolled disposal of solid waste into the sewage collection and storm drain systems. The Public Participation and Acceptance Programme for this Project will
include discussion awareness of the impacts of placing solid waste into the sewer system. Although the long term solution to solid waste and control and disposal is beyond the scope of the Project, issues related to solid waste management that affect proper functioning of sewage collection and drainage system will be addressed in the master plan.

The primary goal of YAP is improvement of water quality in the river Yamuna. Also the primary focus of this Project is improvement to the sewage facilities to reduce pollution from raw sewage. Although the scope of the Project does not intend to cover development of comprehensive non-point source pollution control mater plans, non-point sources of pollution should not be ignored. Therefore, if possible, well defined non-point sources of pollution will be identified and potential solutions will be identified and discussed in general, qualitative terms.

3.6 Interceptor Sewers and their Integration

The current water quality parameters in river Yamuna far exceed the permissible levels. As against a desirable BOD level of 3 mg/l, the present level is around 41 mg/l. The total coliform count ought to be less than 5000 per 100 ml as against this; the total coliform count is around 24,000,000 per 100 ml. Similarly, the levels of dissolved oxygen which ought to be 4 mg/l or more were understood to be almost non-existent.

The most polluted stretch is the 22 km length from Wazirabad barrage to Okhla and that the major cause of pollution is the emptying of 18 major drains in the stretch. These drains carry both treated and untreated effluent besides solid waste, industrial effluent and other pollutants.

It is learnt that the Najafgarh drain and the Supplementary drain along with the Shahdara drain account for around 60% of the pollution and 70% of the total discharge. If we include the Delhi Gate drain and Dr. Sen Nursing Home drain as well, it would imply that almost 75% of the pollution in terms of BOD is through these five drains and 80% of the total discharge as well.

Some of the existing STPs do not receive sewage to their optimal capacity because some peripheral/trunk sewers are either silted or settled. As a result, the existing treatment capacity of STPs is only 350 MGD even though the installed treatment capacity of the STPs is 512 MGD.

DJB plans to increase the sewage treatment capacity from 512 MGD to 612 MGD by adding smaller plants at Yamuna Vihar, Okhla and Kondli STPs as these are getting water from Sonia Vihar Water Treatment Plant.

The interceptor sewer has the following broad features: -

- Laying of interceptor sewers along three major drains of Irrigation & Flood Control Department (i.e. Najafgarh, Supplementary and Shahdara).
- Augmentation of the existing capacity of Sewage Treatment Plants at Delhi Gate drain and Dr. Sen Nursing Home Drain.
- Intercepting 13 small drains into Bela Road and Ring Road Trunk sewer after rehabilitation.
• Construction of additional Sewerage Treatment Plants after utilization of full capacity of existing plants.

The above concept, seeks to take care of the 18 drains emptying into the 22 km of the most polluted stretch of river Yamuna.

We will, at length, examine and evaluate the concept with a view to integrate with Master Planning of the sewered and unsewered areas of Delhi – 2031. A Technical Memorandum will be prepared and circulated to elicit comments and views of all stakeholders.

3.7 Provision of Sewerage Systems in un-sewered areas

Taking into consideration the future flows, proximity of existing of sewerage systems and topography of the unsewered areas, a new catchment area for each of the existing STPs will be formed. Where those unsewered areas cannot be connected to the existing STP catchment, a decentralized approach for a small treatment works serving each of the unsewered areas or for a group of unsewered area may be a viable option subject to site selection, availability and land acquisition costs. In general, it is easier to manage the operation and maintenance of smaller facilities. However, this process will also include a detailed evaluation of decentralized sewerage system along with combined conventional centralized sewer collection and treatment facilities.

The TOR also requires the consultant to address is the Slum Sanitation. We understand that it would be difficult to adopt a decentralized approach at the slum level due to various reasons such as land availability, convenience of sewerage etc, therefore in such circumstances appropriate strategy such as a nearby communal toilet and bath complex would be studied.

3.8 Approach to Developing Technology Options

3.8.1 Approach

There are many aspects that must be considered when designing treatment facilities to ensure that the design will not only meet the treatment standards, but that it will also be able to work within the local technical, economic and social conditions. Any solutions that we propose must be cost effective and sustainable and generally acceptable to community.

We will bring international world class experience to the Project that will be applied to the local conditions. With AECOM's strong local and global knowledge, we have the technical tools and business practices needed to work with project stakeholders to ensure that the optimum design will be developed from technical, economic, environmental and social aspects.

For wastewater treatment design, the first criteria that must be known, or developed, are the influent and effluent criteria. It is between these two data points that the design must be developed. While it is often relatively simple to determine the target effluent criteria, the development of the influent criteria is often significantly more difficult. The dependability of performance of a process in spite of fluctuations in influent quality and quantity are very useful attributes in ensuring a stable effluent quality. Similarly, ability to withstand power and operational failures also form important considerations in the final choice of options.
There are several treatment options that could be appropriate for local conditions. Each option has a unique set of advantages and disadvantages that must be considered in relation to each individual site. Various factors affecting selection of the most appropriate treatment option include:

- Availability of Land
- Geographical and geological conditions
- Robust to handle shock hydraulic and organic loads
- Density of households
- Power supply availability and dependability
- Nature of maintenance problems
- Extent of sludge production and disposal requirements
- Ease of strategic expansion of treatment capacity over time
- Options to augment the plant to meet future requirements
- Fully Automated with SCADA with real time analysis of the plant and pumping

The approach in developing the options shall consider the social and environmental aspects given below.

3.8.2 Public Health

Many countries and eminent cities across the globe have failed to invest in the “unseen” infrastructure to support the rapid development of the urban environment. The consequences in some of these countries/cities have been very expensive, serious and non-reversible. Therefore, while preparing the Sewerage Master Plan, focus will be given on improving the public health, as a whole and efforts shall be made to the best possible extent to provide sewerage services to each and every stakeholder.

3.8.3 Water Conservation/Re-use/Recycle

By assessing the demand for reuse of treated effluent, strategies will be formulated for treatment of sewage to meet the end demand. Our intention is to develop a perfect water balance to the extent possible with zero discharge.

We intend to utilise this unique situation by appropriately reusing the treated wastewater for a variety of non-potable applications. However, additional treatment may be required for some of the applications due to better water quality requirements, but recycle / reuse could still be an effective solution to mitigate the water deficit problems. The reuse option can be implemented immediately and
could also be cheaper than developing new and distance water sources for the same non-potable applications.

Success of wastewater recycles and reuse depends upon identifying or generating demand for recycled water. The demand assessment helps to identify following key issues:

- **Step 1**: Various possible end-uses for recycled water in the vicinity of the plant
- **Step 2**: Desired qualities of recycled water
- **Step 3**: Possible consumption of recycled water
- **Step 4**: Revenue generation potential by sale of the recycled water (willingness-to-pay by various end-users)

Suitable treatment technologies can be identified once demand, quality and cost effectiveness of recycled water is established. Treatment technologies are now available that can treat sewage to the most stringent requirements. However, end-user’s acceptance of the recycled water and their ‘willingness-to-pay’ for the recycled water are essential for a viable recycle/reuse project.

### 3.8.4 User Pay Policy

New developments must proceed in a planned manner; similarly, facilities should be extended to planned communities. In keeping with the user pay principle, it should be made mandatory for developers, whether private or government to share the cost of sewers and treatment plant. We will evaluate the “user pay principle” for implementation of master plan. This would also result in Self Sustainable Operation and Management, thus making the utility financially self-sufficient along with customer eccentric which is the most essential attribute for a successful utility in the world. During the site visits in the proposal stage, some residents in the unsewered areas expressed that they would be willing to pay for the construction of the sewerage work.

### 3.8.5 Whole Life Costs

Our assessments shall be made on the basis of Internal Rate of Return (IRR), NPV calculations embracing both capital expenditure, CAPEX and operating expenditure, OPEX in line with other advanced utility operators of the world.

### 3.8.6 Improving Power Supply

Pumping stations and treatment plants must be provided with a reliable and continuous power supply. This is very essential as quality power is required for efficient performance of the machinery; therefore these facilities must be designated as essential services and should be given top priority for service by the electrical utility.

However, in case of any failure, 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. The SMP will review the possible options for improving the power supply.
3.8.7 **Sludge Generation, Treatment, and Reuse**

The objective of solids treatment is two-fold.

- First, the volume and mass of bio-solids to be disposed will be reduced.
- Second, the volatility of the bio-solids will be reduced so that they may be handled without issues of odour and public health.

Depending on a number of factors, bio-solids treatment could range from as complex as thickening, anaerobic (or aerobic) digestion, and then mechanical dewatering, or as simple as disposal in facultative sludge lagoons that are intermittently cleaned out, or sludge drying bed. The correct answer for a particular facility will depend on the available land area, the volume of solids to be treated, and the quality of bio-solids that need to be produced for the various disposal/reuse options.

We will not only assess the performance of the existing sludge treatment in the STPs and recommend improvement to the existing facilities in term of energy consumption and treated sludge quality, but also study various prevailing and mature technologies with proven track records for sludge technologies including incineration, composting and stabilization to formulate a feasible and cost effective comprehensive strategy for sludge management suitable for local specific conditions of the STPs.

3.8.8 **Review of Current Mature Sewage Sludge Treatment Technologies**

We will identify overseas technologies such as composting, incineration and alkaline stabilization currently being used for the treatment of sewage sludge, with particular attention to the design parameters, process considerations and environmental concerns. In addition we will provide up-to-date information concerning other sludge recycling options. The key issues associated with the various composting technologies are organic decomposition efficiency, capital and operation cost, environmental aspects including odour generation, leachate production, compost quality, operation effectiveness and ease of maintenance.

3.8.9 **Assessment of Sewage Sludge Treatment Technologies**

We will assess the applicability of appropriate sludge treatment technologies in regard to local condition and site specific constraints in order to identify merits and demerits of individual technology. The local specific conditions to be considered include sludge characteristics such as contaminants, chemicals added during the sewage treatment process including polymer and ferric chloride; land availability; and the proximity to sensitive receivers in regard to odour, bio aerosols and health risk. We will also conduct a review of the management approach for organic wastes to evaluate the competitiveness of recycled sludge against other organic waste recycle products.
3.8.10 Identification of Potential Local Applications

As applicable sludge technologies identified from the review in Task 1, we will also identify other sludge recycling technologies (e.g. heat drying, patented “sludge fertilizer” technology modified from N-viro process, a lime stabilization technology) that have been widely used for on-site applications. Further review will be carried out on the identified recycling technologies to obtain information for the assessment of their merits and demerits under local conditions. The approach of the review will be similar to that for Task 1. The applicability of the identified on-site sludge treatment / recycling technologies will be evaluated based on local specific conditions mentioned in Task 2. A marking scheme will be developed to provide a semi-quantitative evaluation framework to determine the relative applicability of each identified technology.

3.8.11 Recommendation on Way Forward

Upon the information gathered above, we will study the following aspect further to prepare the way for detailed investigation for sustainable development of sludge treatment:

- Assessment of site conditions such as site topography, drainage and space available
- Brief assessment of infrastructure present and needed, including water, sewage and power supply
- Type of odour system that may be required
- Possible approach to increase the land-to-waste ratio of the facilities, in order to save space in the STPs

3.8.12 Social Consideration

Locations of existing and proposed sewage treatment facilities may have several social impacts. Typically, these facilities may reduce the value of property adjacent to the selected sites. Other typical issues related to facility locations include potentially undesirable visual and odour conditions. Therefore, the Project Team is committed to mitigating these potential negative issues of the new technologies through appropriate planning and design of facility architecture, landscaping, and odour control systems.

On the other hand, some potential positive social impacts include:

- New employment opportunities during and after construction
- Elimination of unpleasant sewage flows that expose humans and animals to potential health hazards
- Reduction in potential contamination of drinking water supplies
- Improvement in surface water quality will allow safer contact with the surface water
- Improved ecological health will result in improved quality of life for all residents
- A vision, plan, and direction for the future
3.9 Review and Determine Appropriate Technologies for Application

3.9.1 Introduction

Based on our extensive international experience, we have identified the following appropriate technologies which may be suitable for the Project. We will critically study these options and if found suitable will recommendation to DJB for further consideration.

3.9.2 Pumping Station

The ultimate aim of the pumping station rehabilitation is to meet the present and future needs with performance enhancement. However, the level of protection had to be cognizant of the economic cost to the public, which would be the theme for review of the financial aspects of the proposed pumping station Rehabilitation. The developed criteria will enable the Project Team to assess all financial aspects of the pumping station rehabilitation plan. The Project Team shall carry techno-economical evaluation selection of automated pumps to cope with the hydraulic flow variations. Figure shows the schematic diagram of the pumping Station.

The Project Team will assess the hydraulic efficiency of the existing pumping mode by examining pumping head of operating pumps with derived head loss of given size and the configuration of relevant force mains correspondence with various flow rate under various pumping heads. The pumping mode shall also be assessed in conjunction with the control philosophy of the whole treatment stream in terms of cost effectiveness and pump efficiencies.

3.9.3 Advanced Energy Monitoring System (AEMS)

AEMS in UK has invented a very accurate way of measuring pump efficiencies called Yatesmeter. The technology uses the thermodynamic method of measurement which does not measure the flow rate (usually with a large margin of error) but rather the changes in fluid temperature of the pumped fluid.
Using the same technology, AEMS has developed the Fixed Yatesmeter System which monitors the pump efficiency on a continuous basis. The main benefit of such a system is that, apart from observing the rate of pump efficiency deterioration, the system would choose the best combination of pumps to maximize the pump efficiencies, thereby reducing the pump energy cost. (As the efficiency of the pumps will only be checked every 6 - 12 months, no up-to-date information is available for the operators to make this informed decision.) This technology will further enhance the pumping energy efficiency programme. This innovative technology will be very relevant to this Project because of the huge volume of water that has to be pumped daily.

3.9.4 New Sewage Treatment Plants

The degree of sewage treatment required will mainly depend on the raw sewage characteristics and quality of treated water required for its usage for different purposes (viz. Gardening, irrigation, industries or recharge of ground water table) or its safe disposal into inland water body.

Based on the degree of treatment required various sewage treatment schemes can be derived from various combination of primary, secondary and tertiary sewage treatment processes. Some of the sewage treatment technologies available for the treatment of sewage are:

**Primary Treatment**

- Screening (Coarse and Fine)
- Grit Removal
- Primary Settling Tank, with high rate of settling, low footprint area Physico-chemical Process (Chemical addition, Coagulation, Flocculation followed by Clarification)

**Secondary Treatment**

The Secondary Treatment can be divided into two parts namely aerobic and anaerobic treatments. Mainly for domestic sewage with typical domestic characteristics of BOD and SS, normally anaerobic schemes are not preferred as they require high COD for performance
results. Therefore the aerobic treatment is further divided into suspended and attached growth. With developments in suspended growth have grown popular we shall lay stress on the same for various alternatives.

Various aerobic suspended processes are

- Conventional Activated Sludge Process
- Low Load / Extended Activated Sludge Process
- Membrane Bio-Reactor with submerged membranes
- Moving Bed Bio Reactor (MBBR)
- Fluidized Aerobic Bed Reactor
- Sequential Batch Reactor

*Tertiary Treatment*

- Membrane Treatment
- Filtration /Dual Bed Filtration
- Disinfection

We shall prepare alternative wastewater treatment schemes in different combinations using proven wastewater treatment technologies achieving desired quality of treated water for different reuse purpose. We will also carry out techno-economical evaluation of the different options available for the wastewater treatment for the selection of most suitable treatment technology for the project. Reuse plan of treated water and sludge, if appropriate shall also be
Some opportunities in Treatment Plant Energy Efficiency are:

- Bio-fuel Reuse
- Micro-turbines using digester gas
- Plant effluent source heating/cooling
- Hydro power using plant effluent flow
- Solar photovoltaic
- Solar water/air heating

### 3.9.5 Automation and upgrade of STP

To upgrade the existing STP for automation, the Project Team will examine relevant existing Process & Instrumentation Drawings (P&IDs), operating and maintenance track records and relevant documents such as control philosophy with site inspection to assess the current automatic level of instrumentation, control and monitoring and conduct risk analysis and develop an appropriate upgrading strategy for each of STP with respect to their site specific condition. In general, upgrading of the manual operated system in current state may pose lesser risk than semi- or full-automatic system in terms of consistence and reliability.

Often, instead of a “snapshot” approach to process control, the real-time automatic monitoring and control of costly resources can routinely achieve significant savings in energy and chemical consumption without sacrificing effluent quality. Because of the nature and variety of sewage treatment facilities, the processes are usually spread over a large area. Instrumentation and automation can centralize reporting of data and issue of control commands.

The Project Team will propose approach for upgrading with automation of the process control and monitoring in order to provide for consistent control and monitoring of performance of the treatment processes and the plant shall be capable of fully automatic operation, without operator attendance. Data logging of treatment performance and remote monitoring of processes for fault detection will also be necessary. All operating data for each process unit are to be captured and stored in a manner that will allow easy assessment of the overall performance of each process unit and the plant as a whole. The treatment trains in an automatic plant is also designed to have a process control, monitoring and instrumentation system which enables each of the process units to perform its individual assigned functions and to operate with the other components of the plant as an integrated whole. The process control, monitoring and instrumentation systems include wastewater quality monitoring and
recording devices and process controllers. On-line, continuous water quality monitors are required for the automatic operation of the process units, and to measure and record the performance of each process unit and treatment barrier.

3.9.6 Integration of Hydraulic Model/GIS

We will develop a comprehensive hydraulic modelling with computer software Sewer GEMS supplied by Bentley and integrated with Web based ESRI Arc GIS as an effective spatial data management approach managing data of sewerage and sewage treatment facilities such as pipeline dataset, field survey data, on-line flow monitoring data from DJB and especially useful for processing territory-wide spatial and attribute data such as population distribution and type. The Sewer GEMS / GIS modelling can be coupled with the other township data in the spatial database of GIS for generating enhanced display, searching, mapping and printing for analysis, verification and validation. We will also study its capability to couple Sewer GEMS sewerage model and any existing drainage models via ODBC connections for assessing any impact of any potential risk of overflow from river to sewerage system through existing combined sewer overflow system (CSO).

The GPS module is to facilitate formation of sewerage works, design and verify information in available records in the course of site inspection at remote location. It provides accurate geographical information, a rugged design for outdoor environment and digital data like slope feature boundary, topographic data or lot boundary etc. for location referencing during site inspection. The system has field data inputting and retrieving interfaces. Track logging function can dynamically display the walking path on screen for verifying feature extent and such logged information can be stored for post-processing.

3.10 Environmental and social Impacts

3.10.1 Introduction

Environmental and social assessments of all the upgrading works and new works will be conducted in accordance with specification and guidelines provided by both JBIC (International Standards) and MoEF/ CPCB (National Standard).

Through the course of the project, different levels of effort and detail will be required at the master planning stage, the feasibility study stage, and the detailed project report approach for each stage of the project.
3.10.2 Workshops

In the course of the Study, workshops will be organized to keep DJB and the stakeholders informed of the outcome of the studies and to finally obtain comments and views. The participants would include concern stakeholders/representatives as follows:

- NRCD, MoEF
- Central Pollution Control Board, MoEF
- Ministry of Water Resource
- DDA/NDMC/MCD
- Department of Urban Development, Ministry of Urban Development and Poverty Alleviation
- Government of Delhi

3.10.3 Major Issues

To review and understand the existing and future environment and social conditions, an inventory study will be conducted based on existing data and records. Discussion below elaborates the issues identified at this stage.

Pollution related issues

The pollution related issues include:

1. Offensive odour from a sewage treatment plants,
2. Soil following the felling of trees, etc., as a result of facility construction, and consequent deterioration of water quality downstream,
3. Noise from an operating sewage treatment plants, and
4. Disposal of sludge produced at a sewage treatment plant.

Natural Environment issue

There are natural environment issues such as:

1. Effect of construction of the facility on the ecology,
2. Effect on landscape, and
3. Effect of construction of the facility on the historical and cultural heritage will be dealt with during the IEEE & EIA and mitigation measures will be proposed in the Environment Management Plan (EPM).

Social acceptability

During the Master Planning Stage, Qualitative and Quantitative Surveys would be conducted for social impacts particularly in terms of people’s acceptance of the sewer system and their involvement to take house connections.
The scope of work identified for the Feasibility Study is to address the issues concerning social environment that would have a bearing on living and livelihoods of the affected communities.

**Social Impact Assessment**

Report that shall be submitted with Detailed Project Report (DPR) will adequately address the land, assets, structures, park / community property resources, livelihood, occupation and associated issues of project affected people if any. It will also incorporate principles and procedures for catering to entitlement, and provision of required resources to deliver the compensation and assistance to PAPs and PAHs. Entitlement matrix would be prepared to outline the provision for the same.

A major emphasis has been on reducing the potential direct negative impacts of the project on people. The social component would carefully address in the project design, along with technical, environmental and economic considerations. The major concerns include not only minimizing negative impacts especially displacement but also extending and enhancing positive impacts on the affected communities.

**Resettlement**

Issues related to involuntary resettlement if any would be identified. Adequate explanation shall be given to the affected people on the location and compensation offered to them prior to resettlement.

**R and R Issues**

Proper packages would be developed to deal with the rehabilitation and relocation of families if any due to the proposed project activity.

All the sewerage projects namely; construction of new pumping stations, mini treatment plant with sewerage system, rehabilitation of existing treatment plant, rehabilitation of pumping station and pumping main, desilting of sewers, desilting of secondary and internal sewer, rehabilitation of trunk sewers, reconstruction of settled sewers, new sewers, automation of pumping station have been initially screened to identify social issue and further investigated for social assessment.

**Living and Livelihood**

The income and livelihood, gender, culture heritage, litigation and other allied issues associated with development projects will be identified. A careful assessment would be made for any demonstration, damage, dislocation, displacement. Resettlement, rehabilitation that may take place due to the proposed projects.

**Economic and Financial Analysis**

Suggestions/ assistance/ guidance will be provided to DJB for structuring of tariff. In addition we would carry out the financial analysis giving the FIRR and B/C ration of the project using the discounted cash flow method. A projected cash flow also will be prepared. The economic impact of the project would also be studied and analysed. The information for the economic benefit will be extracted from the result of the social survey. The financial costs will be converted into economic cost using the conversion factor and will be used for the purpose of carrying out the EIRR, EB/EC ratios. Finally a conclusion will be made on the viability of the project based on the financial and economic analysis.
3.10.4 Methodology

**Scoping:** An exhaustive list of all likely impacts drawing information from as many sources as possible is prepared. The next step is to select a manageable number of attributes, which are likely to be affected as a result of the proposed project. The various criteria applied for selection of the important impacts are as follows:
- magnitude
- extent
- significance
- special sensitivity.

The Scoping Matrix proposed to be adopted for the study is given in Table-1.

### Table-1: Scoping Checklist for the Environmental Assessment study for the proposed project

<table>
<thead>
<tr>
<th>No.</th>
<th>Environmental Items</th>
<th>Evaluation</th>
<th>Reason</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Socio-Economic Environment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>Resettlement</td>
<td>D</td>
<td>Land acquisition is necessary but human settlement is possibly avoidable by selecting no-settlement land</td>
</tr>
<tr>
<td>2.</td>
<td>Economic Activities</td>
<td>B</td>
<td>Adversary affects of the living conditions of inhabitants by changes in land use due to the project. Positive impact is also expected such as increase of employment in construction phase.</td>
</tr>
<tr>
<td>3.</td>
<td>Traffic/public facilities</td>
<td>B</td>
<td>Traffic jam during construction phase may be expected</td>
</tr>
<tr>
<td>4.</td>
<td>Split of Communities</td>
<td>D</td>
<td>Since no large-scale construction will be undertaken, the separation of the communities may not occur</td>
</tr>
<tr>
<td>5.</td>
<td>Cultural Property</td>
<td>B</td>
<td>No cultural properties are identified in and around the project area</td>
</tr>
<tr>
<td>6.</td>
<td>Water rights/Rights of common</td>
<td>D</td>
<td>Water rights problem is not expected</td>
</tr>
<tr>
<td>7.</td>
<td>Public health condition</td>
<td>D</td>
<td>Positive impact is expected</td>
</tr>
<tr>
<td>8.</td>
<td>Waste</td>
<td>B</td>
<td>The sewerage sludge from treatment plant will be generated. It will be ecologically re-used as a</td>
</tr>
<tr>
<td></td>
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</tr>
</tbody>
</table>
| 9 | Hazard | D | No significant impact.  
Scale of facilities is small |
| 10 | Topography & Geology | D | No significant impact. |
| 11 | Soil Erosion | B | No significant impact.  
Proposed facilities are situated in flat land area |
| 12 | Groundwater | D | No significant impact is expected. |
| 13 | Hydrological situation | D | Treated effluent will be discharged into the nearest drains/river Yamuna. No significant impact pollution loading is low in treated sewage. |
| 14 | Flora and fauna | C | No endangered species or conservation areas are reported |
| 15 | Meteorology | D | No significant impact |
| 16 | Air pollution | D | No significant impact |
| 17 | Water Pollution | B | Treated sewage will be discharged into the nearest drain/river Yamuna after appropriate treatment. |
| 18 | Soil contamination | D | No impact is expected. |
| 19 | Noise and vibration | B | Some noise and vibration during construction period is expected. |
| 20 | Land subsidence | D | Since groundwater will not be used for the Project, the land subsidence with the project would not occur. |
| 21 | Offensive odor | B | Some smell anticipated from the treatment plants. But suitable treatment method will minimize this impact to a large extent |
Note: A.: Significant impact anticipated  
B.: Slight impact anticipated  
C.: Unknown,  
D.: Almost no impact anticipated

The relevant environmental impacts out of the entire gamut of issues are outlined in the Scoping Matrix shall be identified. For these impacts or aspects, environmental baseline data shall be collected from secondary as well as primary data sources.

**Baseline study:** Before the start of the project, it is essential to ascertain the baseline levels of appropriate environmental parameters, which could be significantly affected during various stages of project implementation. The planning of baseline survey shall emanate from short-listing of impacts prepared during identification. The baseline study involves both fieldwork and review of existing documents, which is necessary for identification of data, which may already have been collected for other purposes.

**Impact prediction:** is essentially a process to forecast the future environmental conditions of the project area that might be expected to occur during various stages of the proposed project implementation. An attempt shall generally be made to forecast future environmental conditions quantitatively to the extent possible. But for certain parameters which cannot be quantified, the general approach shall be to discuss such intangible impacts in qualitative terms so that planners and decision makers are aware of their existence as well as their possible implications.

**Environmental Management Plan:** The approach for formulation of an Environmental Management Plan (EMP) is to maximize the positive environmental impacts and minimize the negative ones. The steps taken generally consist of modifications of plans, engineering designs, construction schedules and techniques, as well as operational and management practices. After selection of suitable environmental mitigation measures, the cost required for implementation of various management measures is also estimated, to have an idea of their cost-effectiveness.

**Environmental monitoring programme:** An environmental monitoring programme shall be suggested to oversee the environmental safeguards, to ascertain the agreement between prediction and reality and to suggest remedial measures not foreseen during the planning stage but arising during operation and to generate data for further use. The monitoring programme shall cover both project construction as well as operation phases.

6. **ENVIRONMENTAL BASELINE STATUS**

The data is proposed to be collected through literature review, and interaction with concerned departments. The methodology for data collection is given in the following sections.

6.1 **Demography**

As per Census 2001, Delhi had a population of 137.83 lakhs as on March, 2001. The number of households has increased from 18.62 lakhs in March, 1991 to about 27.57 lakhs in March 2001. Also as per the Delhi Master Plan, the 2021 population for Delhi is projected to be 23 Million.

The present population Delhi is about 180 million, residing in planned areas in core Delhi, 189 rural villages, 44 resettlement colonies, 1623 unauthorized colonies, 135 Urban villages and 567 regularized colonies. Delhi’s decadal population growth rate is 47% per decade which is
made than double of national average of 21%. The decadal population growth in NCT Delhi is given in Table-2.

Table-2- Decadal population growth in NCT Delhi

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (million)</th>
<th>Growth Rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961</td>
<td>2.66</td>
<td>52.5</td>
</tr>
<tr>
<td>1971</td>
<td>4.07</td>
<td>52.9</td>
</tr>
<tr>
<td>1981</td>
<td>6.22</td>
<td>53.0</td>
</tr>
<tr>
<td>1991</td>
<td>9.42</td>
<td>51.5</td>
</tr>
<tr>
<td>2001</td>
<td>13.78</td>
<td>46.3</td>
</tr>
<tr>
<td>2011</td>
<td>19.00</td>
<td>46.0</td>
</tr>
</tbody>
</table>

The socio-economic characteristics of the study area shall be described based on the available secondary data. The information on population, caste profile, literacy rate, occupational profile, etc. will be collected.

6.2 Surface Water Quality

The 22-km stretch of the Yamuna, which is barely 2 per cent of the length of the river basin, continues to contribute over 80 per cent of the pollution load in the entire stretch of the river. There is also no water in the river for virtually nine months.

- As far as River Yamuna is concerned Delhi takes water from the river, upstream of Wazirabad, and returns only sewage to it. Between the two barrages — Wazirabad, when the river enters Delhi till Okhla, where it exits Delhi — there is no water.
- Delhi’s upstream neighbors are reluctant to release water and each drop that is released as its share is used for meeting domestic water requirements. Due to non availability of water in the 22 Km stretch, waste disposed cannot be diluted. The river is then reduced to a drain for the filth and waste of the city’s inhabitants.

As a part of the study, information on ground and surface water quality as available from various secondary data sources will be collected. The data as available with Central Pollution Control Board, Delhi Pollution Control Committee, etc. shall be utilized for this purpose.

6.3 Ground water Quality

Ground water is one of the major sources for water supply in many parts of the country. In Delhi too ground water contributes to substantial quantity of supply. Especially in new development areas ground water is largely being utilised as a drinking water resource, mainly because of the insufficiency of the Yamuna water share for Delhi. The quality of ground water in Delhi is neutral to alkaline with pH ranging from 7.1 to 9.2, chloride content ranges between 21 and 1380 ppm. In south Delhi, average chloride content is 250 ppm while in Najafgarh area it is around 1000 ppm rendering the water saline. The ground water study done by the NEERI for MoEF revealed high nitrate and fluoride concentrations. High metallic content, particularly manganese and iron have also been observed. With over-development of ground water resources in the district, more and more areas are becoming brackish.

As a part of the study, information on ground water quality as available from various secondary data sources will be collected. The data as available with Central Pollution Control
6.4 Meteorology
The project area has a semi-arid climate with large variations in temperature. The climate of the project area can be divided into four seasons. The winter season lasts from November to February, which is followed by summer season upto June. The area receives rainfall under the influence of south-west monsoons from July to mid-September. The period from mid-September to October is the post-monsoon season.

Rainfall: The average rainfall in the project area is 797.3 mm. About 77% of annual rainfall is received under the influence of south-west monsoons. On an average, there are 29 rainy days in a year.

Temperature: The temperature in the study area rises rapidly after March. The months of May and June are hottest month with mean daily maximum temperature being 39.6°C. The mean daily minimum temperatures in the months of May and June are 25.9°C and 28.3°C respectively. The temperature drops with the advancement of south-west monsoons by mid-July. The withdrawal of monsoons in the latter half of September leads to a slight increase in the day temperature but there is a decrease in the night temperature. From November there is a sudden decrease in the day and night temperatures. The month of January is generally the coolest month of the year with mean daily minimum and maximum temperatures being 7.3°C and 21.1°C respectively.

Humidity: The humidity in the area is generally low throughout the year except during monsoon months. The summer months are the driest with relative humidity being as low as 20%.

Special weather phenomena: The study area experiences thunder alongwith the rainfall. On an average, thunder is observed for about 17 days in a year. Fog is observed for about 17 days in a year mainly during winter months. Likewise dust-storm is reported on an average for about 8 days in a year, mainly during summer season. The monthly data on various meteorological parameters is summarized in Table3.
### TABLE-3: Average meteorological conditions in the project area district

<table>
<thead>
<tr>
<th>Month</th>
<th>Temperature (°C)</th>
<th>Rainfall (mm)</th>
<th>Relative humidity (%)</th>
<th>Wind velocity (km/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Maximum</td>
<td>Minimum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>January</td>
<td>21.1</td>
<td>7.3</td>
<td>20.3</td>
<td>8.3</td>
</tr>
<tr>
<td>February</td>
<td>24.2</td>
<td>10.1</td>
<td>15.0</td>
<td>10.1</td>
</tr>
<tr>
<td>March</td>
<td>30.0</td>
<td>15.4</td>
<td>15.8</td>
<td>10.7</td>
</tr>
<tr>
<td>April</td>
<td>36.2</td>
<td>21.5</td>
<td>6.7</td>
<td>11.2</td>
</tr>
<tr>
<td>May</td>
<td>39.6</td>
<td>25.9</td>
<td>17.5</td>
<td>12.8</td>
</tr>
<tr>
<td>June</td>
<td>39.3</td>
<td>28.3</td>
<td>54.9</td>
<td>13.7</td>
</tr>
<tr>
<td>July</td>
<td>35.1</td>
<td>26.8</td>
<td>231.5</td>
<td>9.9</td>
</tr>
<tr>
<td>August</td>
<td>33.3</td>
<td>25.9</td>
<td>258.7</td>
<td>8.3</td>
</tr>
<tr>
<td>September</td>
<td>33.9</td>
<td>24.4</td>
<td>127.8</td>
<td>8.9</td>
</tr>
<tr>
<td>October</td>
<td>32.9</td>
<td>19.5</td>
<td>36.3</td>
<td>6.1</td>
</tr>
<tr>
<td>November</td>
<td>28.3</td>
<td>12.8</td>
<td>5.0</td>
<td>6.1</td>
</tr>
<tr>
<td>December</td>
<td>23.0</td>
<td>8.2</td>
<td>7.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Average</td>
<td>31.4</td>
<td>18.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>797.3</td>
<td></td>
</tr>
</tbody>
</table>

**Source:** IMD

### 6.5 Ambient Air Quality

The information on ambient air quality as available from various secondary data sources will be collected. Data shall be mainly collected from Central Pollution Control Board and Delhi Pollution Control Committee.

### 6.6 Ecology

- The vegetation of Delhi is thorny scrub which are found in arid and semi arid Zone. The main forest i.e., Ridge Forest fall in the forest type as per classification of Champion and Seth (1968) in the category of 'Tropical thorn forest' and more especially as 'semi arid open scrub'. The total geographical area of NCR of Delhi is 1483 sq.km. of which recorded forest area is 85 km². Thus, the forest area accounts for about 5.7% of the total area of NCT of Delhi. However, within the project or the study area, no forest land is observed. This is expected as the study area lies within an urban area, with high population. Mainly tree plantation along roads, and open ground, park, etc. are observed.

The list of commonly observed tree species observed in the study area is given in Table-4.
### TABLE 4 - Commonly observed tree species in the study area

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Botanical Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eucalyptus</td>
<td>Eucalyptus teretecornis</td>
</tr>
<tr>
<td>Kikar</td>
<td>Acacia Arabica</td>
</tr>
<tr>
<td>Pipl</td>
<td>Ficus religiosa</td>
</tr>
<tr>
<td>Siras</td>
<td>Albizia procera</td>
</tr>
<tr>
<td>Babool</td>
<td>Acacia nilotica</td>
</tr>
<tr>
<td>Ruijha</td>
<td>Acacia leucocephlea</td>
</tr>
<tr>
<td>Amaltas</td>
<td>Cassia fistula</td>
</tr>
<tr>
<td>Gulmohar</td>
<td>Delonix regia</td>
</tr>
<tr>
<td>Shahtoot</td>
<td>Morus alba</td>
</tr>
</tbody>
</table>

As a part of the study, Inventory of major species of trees, herbs, shrubs, etc. in the project area will be prepared. Likewise, inventory of major wildlife species including mammal, reptiles, birds, etc. will also be prepared.

### 6.7 Noise

The information on ambient noise levels as available from various secondary data sources will be collected. Data shall be mainly collected from Central Pollution Control Board and Delhi Pollution Control Committee.

### 7. Prediction of Impacts

Based on the project details and the baseline environmental status, potential impacts as a result of the construction and operation of various works under sewage Master Plan shall be identified. The key impacts to be covered as a part of the study area are listed in following sections:

#### 7.1 Detailed Engineering phase

1. **Route Selection for Trunk Sewers and Transmission Mains**
   - Land acquisition leading to resettlement with unrealistic compensation
   - Improper right of way selection temporarily affecting telecommunication/electricity
   - Reckless felling of avenue trees

2. **Corrosion of Sewers/Transmission Mains**
   - Reduction in life of trunk mains
   - Corrosion can lead to public health problems due to leakage of untreated sewage

3. **Safety of sewers/Transmission Mains**

4. **Misuse of Sewers for Storm water**
   - Leads to blockages of the sewers and overflows
   - Leading to potential public health problems and causing general nuisance
7.2 Construction phase

(i) Soil Quality
- Due to excavation and earthwork soil erosion, loss of top soil, silting and blocking of drainage/nallahs, which can cause slush; damage to existing structures
- Due to compacting; loss of original quality, reduction in fertility
- Impacts due to disposal of bituminous waste
- Improper handling of excess soil

(ii) Air Quality
- Localised increase in dust due to excavation & earthwork
- Impacts due to fugitive emissions on account of entrainment of dust from waste soil and imported sand
- Temporary increase in the levels of SO$_2$/NOx from construction equipment and vehicles

(iii) Noise
- Increase in noise levels due to operation of construction equipment
- Increase in noise levels due to increase in vehicular traffic

(iv) Water Quality/Drainage
- Increase in turbidity affecting surface water quality
- Pollution due to increase in organic and hydraulic loading
- Collection of rain water in stagnant pools

(v) Traffic
- Traffic jams, bottlenecks, delays and inconvenience to general public
- Serious disruptions of vehicular traffic, pedestrian access and commerce

(vi) Endangering lives of people/workers during construction due to inadequate safety measures

(vii) Visually unaesthetic conditions due to cluttering of waste and spoils, dug up roads and pavements

(viii) Land Acquisition
- Inadequate compensation
- Inadequate utilities in the rehabilitation area
- Relocation trauma and infections and other diseases in the new location

(ix) Construction Camp
- Prevalence of unsanitary conditions and practices like open air defecation
- Possibilities of public health problems
- Pilling of garbage from workers
- Adverse health of workers due to unsanitary practices and spreading of diseases from vectors

(x) Impacts due to utility shifting
(xi) Inconvenience to public during sewer laying along thick commercial areas and narrow streets, or where public facilities are located.

(xii) Impacts on buildings due to vibration during construction activities could affect some of the buildings in the nearby areas.

### 7.3 Operation Phase

(i) Odour problems from sewage treatment plant

(ii) Water Quality

- Overflow of sewers and breakdowns of treatment plant leading to failure in meeting the requisite standards
- Poor performance will affect the proposed reuse and also the receiving water body

(iii) Improper treatment of sludge could lead to putrefaction and other related problems such as bad odour, health effects, etc.

(iv) Public Health

- Mixing of sewage with drinking water
- Outbreak of waterborne diseases
- Unhealthy conditions, mosquito breeding oversludge drying beds, etc.

(v) Worker’s Health and Safety

- Workers may be inflicted by endemic & other diseases such as malaria or respiratory ailments
- Accidents and loss of lives may occur during sewer cleaning & maintenance
- Non-availability of emergency medical facilities at all times during day & night

### 8. ENVIRONMENTAL MANAGEMENT PLAN

Based on the environmental baseline conditions, planned project activities and impacts assessed earlier, an Environmental Management Plan (EMP) enumerating set of measures to be adopted to minimize the adverse impacts shall be suggested. The key impacts to be covered are listed as below:

- Prevention of groundwater contamination
- Control of odour nuisance to neighbors
- Reduction in inconvenience during construction phase
- Impacts on buildings
- Noise Control Measures
- Control of noise from DG sets
- Control of pollution from stockpiles
- Disposal of bituminous waste
- Handling of excess soil
- Collection of rain water in stagnant pools
- Control of pollution from fuels and Lubricants
- Risk Management
• Safety measures for the workers at the STP site during Operation Phase
• Prevention of mixing of Industrial Waste water with sewage
• Control measure to avoid overflowing/choking of sewers
• Sludge management plan
• Greenbelt development plan

9. ENVIRONMENTAL MONITORING PROGRAMME

Monitoring becomes essential to ensure that the mitigation measures planned by way of environmental protection, function effectively. Moreover, changes external to the project site may at any future stage endanger environmental conditions rendering the existing mitigation measures inadequate. Hence, the necessity of remaining vigilant through a well planned and meticulously implemented environmental monitoring programme.

The list of parameters to be monitored are listed as below:

9.1 Design/ Location stage
• All designs of components include proper consideration of environment (i.e., water, sludge management
• Design of occupational safety measures
• Gas monitoring for sewage pipes – Adequate monitoring of gas may not be possible due to distant manhole spacing.

9.2 Construction Stage
• Monitoring of water quality of the stream flowing adjacent to the STP site
• Construction site management plan to control the dust and noise nuisance, road blocks and provide access to businesses while pipe laying
• Implementation of construction site management plan dust and noise nuisance at site and traffic maintenance.
• Ambient air Quality at major construction sites
• Noise monitoring at various sites
• Waste soil removal as soon as it is excavated
• Avoidance of narrow local roads when transporting soil
• Avoidance of transporting soil during peak traffic periods
• Coverage or damping down stockpiled soil in dry weather
• Location of water and sewer pipes on opposite sides of roads
• Consultation with authorities, custodians of buildings, communities to address key issues and avoid working at sensitive times
• Ensuring that workers wear Personal Protective Equipment
• Provision for Health and Safety training for all personnel

9.3 Operation Stage Monitoring
• Check for contamination of groundwater due to infiltration from STP
• Clogging of drains
• Potential for gas explosion in Pipes – gas monitoring
• Odor emission control at STP and Sewerage System
• Treated wastewater quality at outlet discharge point of STP
• Implementation of the Sludge Management plan
• Preparation and operation of Health and Safety plan to protect workers and citizens
• Bacteriological surveys of dried STP sludge
• Monitoring of sewage inflow and outflow at various STPs

3.11 Evaluation of Alternatives

Evaluation of alternatives will be an iterative process accomplished in consultation with DJB and other project stakeholders. Evaluation procedures to identity optimal solutions and to select the preferred alternative will be conducted. Each alternative will be rigorously examined from the standpoint of cost, environmental, institutional, social, and O&M factors. It is expected that the final selected alternative for each case will be cost-effective, environmentally and socially sensitive, sustainable through the year 2031, acceptable to the stakeholders, and can be implemented by the DJB.

3.12 Master Plan Report

3.12.1 Preparation and Delivery

Interim, draft and final master plans will be prepared. It is assumed that stakeholder agencies will be able to review the interim and draft master plan within two weeks after delivery. After review of interim and draft master plan by stakeholder agencies, consultation meetings will be conducted with stakeholder agencies to summarize the planning process results and alternative opportunities, and to resolve stakeholder review comments. The expected outcome of these meetings is identification of preferred alternatives and priorities for implementation.

Based on stakeholder review comments regarding the interim and draft master plans, final master plan will be prepared. Final master plan will be delivered in accordance with the project schedule.

3.12.2 Report Contents

The master plan will be organized according to the following annotated outline:

1. Executive Summary (Summary of project purpose and goals, overview of the master plan, short-term and log-term recommended project, schedule, and cost estimates along with a summary of significant issued that will require further consideration, and selection of priority project for feasibility study)
2. Introduction (Existing wastewater systems, review of existing information)
3. City Planning and Population Projects (Discussion of past and existing population and land use, catalysts for future growth, basis and estimates of population growth, basis and estimates of population growth projections, and population distribution projections)
4. Water Supply Systems (water supply systems, quantity of water supplied and consumed, interrelationship of water supply and development of sewerage facilities, and available information regarding existing water supply master plans)

5. Sewerage Planning Framework (Planning horizons, planning capacity, sewerage development strategy, water consumptions and wastewater generation factors, and design criteria)

6. Assessment of Existing Sewerage Systems (Condition assessment, hydraulic assessment, treatment effectiveness assessment, and O&M assessment)

7. Evaluation of Alternatives (Summary, descriptions of alternatives, evaluations, and conclusions)

8. Proposed Master Plan (Wastewater systems and descriptions of proposed systems – SPS, STPs)

9. Implementation Strategy and Phasing (Overall strategy, timing for implementation of each component, and priority projects)

10. Cost Estimates (Capital costs for each component, O&M costs including staffing, and cost schedule)

11. Initial Environmental Examination (IEE) Study (Objective of study, methodology of study, survey area, project/programs for the IEE study, existing environmental conditions, evaluation, and conclusions)

12. Appendices
   a) Appendix A – Cost Comparison of Alternatives
   b) Preliminary Design Drawings
4. GIS and Hydraulic Modelling

4.1 Introduction of Approach

This Section describes Task 5, Terms of Reference 6.5. Our goal is to recommend an approach involving combined application of remote sensing, GIS and Sewerage Management System that can be effectively used by DJB as the graphic, mapping and analysis capabilities of GIS are strong tools for conveying information.

For this purpose an approach involving combined application of remote sensing and GIS is described below.

4.1.1 Stage 1: Project Planning and Input Data Collection

This stage can be divided into various activities:

- Collection of requisite maps, available data like GIS of existing sewerage network (soft copy), Maps of existing sewerage network in dwg file and satellite images for the study area from DJB and/or other concerned department.
- Collection of Ground Control Points (GCPs) using DGPS or Total Station survey to achieve desired accuracy.
- Geo-referenced high resolution satellite image with spatial resolution of 0.6m (60 cm) or better and the same shall be used for mapping un-sewered areas of Delhi city.

4.1.2 Stage 2: Satellite Image Processing and GIS Data Preparation

This stage can be divided into following activities:

- Geo-referencing of satellite image by using DGPS/total station points for unsewered areas, if required
- Base map creation at 1:2000 scale based on NUIS standards for unsewered areas
- Integrating the existing network to the proposed one, along with positioning of existing STP, SPS and later marking area for proposed STP and allied SPS, major drains on the digitized base map

4.2 Base Map Creation of Un-sewered Areas

Base map consisting of roads, rail network, metro rail, location of disposal and treatment facilities, water bodies, and other important and other necessary land base features which are interpretable using satellite images, will be prepared for the unsewered areas of Delhi. Attributes will be assigned to these spatial features. The base map of the unsewered areas will be updated based on the ground truth verification/reconnaissance. Figure 1 shows example of base map. Figure 2 shows the approach for base map creation.
### Table 4-1 Example of Base Map

![Base Map](image1)

### Table 4-2 GIS Map Creation

![GIS Map Creation](image2)
4.3 Integration of Existing Sewerage Network with Proposed Sewerage Network of Unsewered Areas

The maps of the existing sewerage networks shall be integrated with the proposed maps for the unsewered areas which shall duly portray the location of all Sewage Treatment Plants, existing and proposed, along with Sewage Pumping Stations, and finally the drains into which the treated effluent is discharged in River Yamuna.

All the primary parameters identified in NUIS design standard document including National Spatial Framework, Image Registration accuracy, Projection for Maps, Datum for image products, Position (planimetric) Accuracy, Minimum Mappable Unit (MMU), Accuracy of Classification and Map Formats will be strictly followed while preparing the spatial database.

NUIS Scheme Standards of Quality Certification (QC) and Quality Assurance (QA) at the individual process level and total product level will be performed before delivering the product to the user. NUIS Metadata standard prescribed would be part of Quality Assurance and Certification parameters. Though based on local requirements, the standards can be modified in consultation with the client and other department.

4.4 Hydraulic Modelling

The first step in the hydraulic design of sewerage is to prepare a map showing locations of all sewers, measure the contributory area to each point and the population of contributing the sewage flow. Critical levels such as basements of low lying houses and other buildings, levels of existing to be intercepted high water levels in trunk sewers or disposal point have to be noted. Head loss incurred by various special sewer configurations such as relief sewer, small bore sewer, shallow sewer and sewer appurtenances such as flow control devices including flow regulator, overflow devices, flap gates and manhole and inverted siphon.
A key parallel activity in the early part of the Assignment is hydraulic modelling and setting up of the GIS. The modelling work will incorporate into the models existing and planned works not already in the existing models.

The design criteria, hydraulic modelling approach and GIS requirements will be established at the start of the assignment and circulated in a working paper for comment and agreement. This will include the approach for construction, calibration and verification of the models. Reference will be made to the International Standards for Sewer Network Hydraulic Model-Build and Verification.

The latest sewerage records will be assembled and will form the basis for analysis under this assignment. The hydraulic models developed will form the basis for the development of the GIS models. Three main hydraulic models will be set up:

- Existing model – incorporating the existing sewerage networks and used for calibration purposes,
- Planned model – incorporating the existing and the planned sewerage networks for analysis of the build of flow and assessment of sewerage impacts, and
- Future model – which will include all existing, planned and proposed sewerage, works under this Study.
As per our past experiences, there are deemed to have discrepancies between the record database and the hydraulic model data. Hence the previous models will need to be reviewed and checked against the latest sewerage record plans and updated accordingly.

Reference will also be made to the findings of previous studies regarding unit flow factors, storm water inflow, etc. The unit flow factors will be established and the percentage contribution of storm water and infiltration. The calibrated data will be extended for use in modelling the planned and future sewerage networks, subject to agreement with DJB. The ultimate model will be analyzed with the 2011, 2016, 2021, 2026 and 2031 population projections.

4.5 GIS and Hydraulic Modelling Integration Approach Report

4.5.1 Preparation and Delivery

The GIS and Hydraulic Modelling Integration Approach (GIS) Report will be prepared. Prior to delivery of the GIS report, consultation meetings will be conducted with stakeholder agencies to summarize the modelling results and the recommended approaches. The purpose of these meetings is to obtain tentative stakeholder acceptance of proposed approaches and project findings.

Based on input received from the stakeholder agency consultation meetings, the GIS report will be prepared and delivered for review. It is assumed that stakeholder agencies will review the GIS report within 2 weeks after delivery. After review of the report by stakeholder agencies, a comment discussion and resolution meeting will be conducted.

Based on stakeholder review comments regarding the GIS report, the finalised details will be prepared for incorporation into the Feasibility Report. The GIS report will be delivered in accordance with the project schedule.

4.5.2 Report Contents

The GIS Report will be organized according to the following annotated outline:

1. Existing GIS data format, e.g. land use, contours, spatial
2. Collected site survey information, including wastewater facilities such as sewers, SPSs and STPs
3. Satellite Imagery attributes
4. Existing DJB GIS system information
5. Sewer network hydraulic data format for sewered areas
6. Sewer network hydraulic data format for unsewered areas
7. Proposed approach in integrating all data into a unified GIS platform
8. Proposed GIS metadata attributes
9. Proposed extension for DJB GIS system, in particular for online flow monitoring of STPs and SPSs
10. Proposed thematic maps
11. Sample GIS Base Maps
12. Sample GIS Integrated Maps
5. Feasibility Study

5.1 Introduction

This section describes Task 6 of Terms of Reference 6.6.

The feasibility study reports are meant to provide the initial basis for fund allocations for each project. For this reason, a feasibility study requires intensive analysis and more reliable information than preparation of master plans. Supplemental data collection and analysis are required to confirm that the project is feasible in all respects. Each project must be demonstrated to be socially, economically, technically, financially, environmentally and institutionally feasible.

At the feasibility study phase, two separate, but competing, project options might appear to be equally attractive for implementation. In such cases, both projects would be assessed up to the point where one project is evaluated to be superior, at which time preparation of the superior project continues. Major activities that will be required during the feasibility studies are summarized as follows:

1. Field surveys to examine topography for sewers pumping station and STP sites for hindrances.
2. Analysis of project alternatives, if any
3. Preliminary design of the preferred alternative
4. Financial analysis of the preferred alternative (including administrative, capital, operation and maintenance (O&M), and loan repayment costs as well as potential fees, cess, and income for users and reuse systems)
5. Conduct a limited Environmental and Social Impact Assessment
6. Analysis of the current institutional and O&M arrangements, and recommendations to address the future requirements

The following information provides the broad methodology and approach that would be adopted during the Feasibility Study Phase.

5.2 Planning Basis

The feasibility studies will be based on the following information collected and analysed during the Master Planning Phase:

1. Immediate Priority Works
2. Project phasing
3. Sewerage Zones/Districts
4. Total population, population projections, and future spatial distribution of population
5. Service coverage and standards considered for sewerage services
6. Quantification of future demands for services
7. Design flows for sewers and pumping stations
8. Treatment technology options selected as most suitable to the project sites
9. Design capacity requirements for STPs
10. Raw sewage characteristics
11. Effluent discharge, disposal, and reuse criteria
12. Sludge disposal and reuse criteria

5.3 Field Investigations

If necessary, field investigations to be conducted for the feasibility study will be more intensive in specific locations than those conducted in the Master Planning phase. These would include:

1. Topography Surveys – L-Sections and area surveys
2. Condition Assessment Survey for STPs and allied works
3. Condition Assessment of Sewers
4. Geotechnical Investigations
5. Wastewater Influent and Effluent Sampling

5.4 Evaluation of Alternatives

5.4.1 Evaluation of Alternatives

Preparation of a sewerage master plan for a 5 years interval up to Year 2031 for the study area including unsewered areas through hydraulic modelling will be prepared. The master planning process is expected to identify numerous technical, operation and maintenance, implementation schedule, and physical alternatives for sewage collection and treatment systems, effluent disposal and reuse, and sludge disposal and reuse. Each alternative will be rigorously evaluated. After elimination of non-viable alternatives through the screening process, the remaining viable alternatives will be subjected to a complete optimisation evaluation. Selection of the optimum solutions requires evaluation of alternatives based on several factors. Major factors to be considered in evaluating alternatives include:

- Improvement of water quality in the river Yamuna
- General improvement to local quality of life and ecological health
- Stakeholder goals and objectives
- Social and environmental considerations
- Alternative schedules for construction of proposed sewerage system improvements
- Flexibility for future strategic expansion/modification
- Initial capital cost to build or modify sewage collection and treatment systems.
- Availability and cost of land for treatment and disposal facilities
• Operation and maintenance cost for sewage collection and treatment systems.
• Estimated income from sale of treated effluent to potential clients like power plants etc and reused sludge
• Estimated cost savings from avoidance of developing and treating new water supplies in the future due to re-use/use of treated effluent

The master plans for future sewerage system improvements will depend on evaluating all the above factors. Costs and estimated income/savings from Treated Effluent Re-use and Sludge reuse will be evaluated on a life-cycle basis of Internal Rate of Return (IRR), NPV calculations embracing both capital expenditure, CAPEX and operating expenditure, OPEX in line with other advanced utility operators of the world. The master plan will recommend implementation of the alternatives that best balance improvements to water quality of the river Yamuna, quality of life, and ecological health goals to identify the option that provides the best economic and non-economic outcomes.

5.4.2 Option Evaluation and Value Management (VM) Workshop

An important element of this Assignment is to determine the implementation priority of the proposed works. Based on the degree and extent of pollution that can be reduced, the estimated cost and the population served, it is possible to set up key performance indicators (KPI) so that the proposed works can be in the order of immediate, intermediate and long term needs.

A further consideration in this assignment is the need to tie in with the proposed sewerage programme within the area. The following three groups of sewers shall be identified:

• Existing sewers
• Sewers planned for completion by 2011
• Sewers planned without a completion date

There will be cases that the proposed works will definitely reduce the pollution level but its success will depend on the availability of trunk sewers to transfer the collected sewage to designed STP for treatment. If these works are on the priority list requiring urgent attention, then either the trunk sewer programmes have to be advanced to pace in with the proposed works, or local communal treatment facilities have to be proposed as interim measures. This will add cost to the proposed works. The VM Workshop is a suitable forum for discussion of these options.

The draft and final master plan will be prepared and delivered according to the schedule for comments and review. It is assumed that stakeholder agencies will be able to review the draft master plan within 2 weeks after delivery. Based on stakeholder review comments regarding the Draft Master Plan, the Final Master Plan will be prepared and delivered in accordance with the required Project schedule.
5.4.3 Sewage Collection Systems

The proposed layout plans for separation of sewage and drainage flows, and hydraulics of gravity pipe line will be refined based on additional field surveys. The estimated capital and O&M costs for the preferred alternatives identified in the master plan will be updated by obtaining quotations from domestic supplier and contractors.

5.4.4 Pumping Stations

The feasibility of pumping station locations selected in the master planning stage will be reviewed to confirm that the lands are available and that they will be compatible with the estimated flows and STP locations. Additional evaluation of alternative pumping station components will be performed to ensure that the components identified in the master plans are the most suitable specific conditions. The estimated capital and O&M costs for the preferred alternatives identified in the master plan will be updated by obtaining quotations from domestic suppliers and contractors wherever possible and needed.

5.4.5 Wastewater Treatment

Preferred treatment option identified in the master plan will be reviewed for each identified short-term project particularly the following:

1. Complexity of operation
2. Ability to comply with effluent and odour standards
3. Institutional and capacity building requirements for O&M
4. Capital, O&M, life-cycle, and other costs
5. Potential income from fees, cess, and/or sale of effluent and sludge
6. Availability of land at identified alternative sites
7. Effluent re-use potential
8. Social and environmental impacts
9. Other strategic issues

5.4.6 Conclusions

Completion of the evaluation of alternatives will result in identification of projects and project components that are considered feasible. A summary of the valuation processes, considerations, and conclusions will be presented to DJB for discussion. This summary will include specific information regarding how the recommended projects and project components will achieve the overall project objectives for improvement of water quality, ecological health, and public health.
5.5 Preliminary Design

5.5.1 Introduction

Design criteria will have been established during the Master Planning Stage. Some criteria may need additional evaluation during the feasibility studies for site-specific conditions.

Preliminary design for each selected sewerage facility will include descriptions, and appropriate maps and drawings, of:

1. Role, location, design criteria, number, type, and capacity of each component.
2. Performance specifications, technical description (functional requirements, material, etc.), and method of construction of each component.
3. Design methodology, summary of design results, and degree of preparation of each component (e.g. maps and descriptions will be provided for the existing and proposed sewage collection patterns).

5.5.2 Rehabilitation of Existing Sewers

Details or proposals for replacement /de-silting/ rehabilitation of each sewer (trunk) segment based on limited information available will be identified based on the following considerations:

1. Discharge capacity and requirements of each segment
2. Lengths of sewer for which existing slope/discharge capacity is inadequate
3. General structural conditions of the sewer
4. Replacement costs v/s rehabilitation costs

5.5.3 Rehabilitation of Existing Pumping Stations

Design information regarding existing pump station rehabilitation projects will include description of work to be done showing specific locations of proposed improvement. Appropriate design factors, criteria, calculations and assumptions also will be provided.

5.5.4 Rehabilitation of Existing STPs

Design information regarding rehabilitation projects for existing STPs will include descriptions of work to be completed and plans and sketches sufficient to show specific locations of proposed improvements. Sketches will include one-line diagrams of piping, electrical, and control modifications. Appropriate design factors, criteria, calculations and assumptions also will be provided.

5.5.5 Sewage Collection Systems in Unsewered Areas

Design and hydraulic analysis of proposed new sewers will be performed using the hydraulic modelling software such as SewerGEMS or equivalent model. Dynamic analysis for rising mains, if required, will use the KY PIPE 2000 or equivalent model as developed by the University of Kentucky. A table of design criteria, assumptions, and design results similar to
that shown for existing sewer will be provided in the feasibility study report. Proposed pipe and manhole materials and construction technologies will be described. GIS maps will be provided to show sewer zones and proposed horizontal locations of new sewage collection piping and pump stations.

5.5.6 Pumping Stations for Unsewered Areas (CROSS CHECK FROM RFP / TOR)

Civil, structural, electrical, and mechanical design of proposed Pumping Stations will be developed based on relevant Indian codes and international best accepted practices. The design outcomes, such as wet well size, critical elevations, pump capacity requirement, pump operation plans, emergency power systems, odour control, and piping and valve sizes will provided. To assist understanding of the proposed pump station designs, the following drawings/sketches also will be provided:

1. Site Layouts
2. Pumping Station floor plan drawing and building sections
3. Hydraulic Flow Diagram
4. Single Line Electrical, and Control Diagrams

5.5.7 Sewage Treatment Plants (STPs) for Unsewered Areas

For each proposed STP, major factors that will be evaluated include:

1. Alternative locations, if any
2. Alternative treatment technologies – by carrying out a life cycle cost – benefit analysis

Civil, structural, electrical and mechanical design of proposed STPs will be developed based on relevant Indian codes. The design outcomes, such as treatment processes and sizes, estimated effluent quality, estimated sludge production, potential wastewater reuse systems, critical elevations, emergency power systems, odour control will be provided. To assist understanding of the proposed STP designs, the following drawings/sketches will be provided:

1. Site Layouts
2. STP floor plan drawing and building sections
3. Hydraulic and Process Flow Diagrams
4. Mass Balance Diagram
5. Flow Balance Diagram
6. Single Line Piping, Electrical, and Control Diagrams

5.6 Implementation Plan

After selection and preliminary design of recommended alternatives, a proposed project implementation plan will be prepared. The proposed implementation plan will be prepared in consultation with DJB and will address the following major factors.
1. Summary descriptions of each recommended project
2. Estimated total project capital costs
3. Estimated annual O&M costs
4. Estimated fees/cess
5. Estimated income/savings that may be expected from reuse of effluent and sludge
6. Recommended total financial plan, including any existing debt and repayment programmes.
7. Identification of agencies and their roles during each future phase of project implementation, including identification of agency / legislative approvals or other actions required for implementation
8. Recommended capacity building programme for future sewerage system management, administration, planning, operation, and maintenance.
9. PP&A programme will be conducted during all the phases of the project as indicated in the Project Schedule
10. Procurement procedures
11. Special procurement procedure that may be required or proposed for project implementation
12. Identification of materials to be imported and any special procedures required to acquire them and delivery periods (if any)
13. Preliminary implementation schedule

Major activities for the implementation schedule will be planned using Microsoft Project scheduling software or equivalent. These activities will be logically connected and “critical path” activities will be identified.

5.6.1 Conclusions and Recommendation

Full justification of the project with justification, cost effectiveness, affordability and willingness of the beneficiaries to accept the services will be given. We will also consider the effect of not proceeding with the project according to the followings:

- Issues which may affect the implementation and operation of the project will be considered and remedial measures will be suggested.
- The changes in the assumptions made for developing the project, project implementation period, benefits, tariff cost and demand with impacts shall be outlined.
- Action to be taken by various agencies in a time bound manner will be recommended pending approval and financing of the project.
5.7 Feasibility Study Report

5.7.1 Preparation and Delivery

Interim, draft and final feasibility study (FS) reports will be prepared. Prior to delivery of the interim and draft FS reports, consultation meetings will be conducted with stakeholder agencies to summarize the planning process results and recommended projects and project components. The purpose of these meetings is to obtain tentative stakeholder acceptance of proposed projects and project components.

Based on input received from the stakeholder agency consultation meetings, interim and draft FS reports will be prepared and delivered for review. It is assumed that stakeholder agencies will review the interim and draft FS reports within 2 weeks after delivery. After review of draft master plan by stakeholder agencies, a comment discussion and resolution meeting will be conducted for the study area.

Based on stakeholder review comments regarding the interim and draft FS reports, final FS report will be prepared. Final FS report will be delivered in accordance with the project schedule.

5.7.2 Report Contents

The FS report will be organized according to the following annotated outline:

1. Executive Summary (Summary of all recommended projects and project components, recommendations for proceeding with preparation of DPRs for the highest priority projects, summary schedule of major implementation activities, summary of cost estimates and proposes financial plan, and a summary of significant issues that will require further consideration during preparation of DPRs.)

2. Existing Wastewater Management Scenarios

3. Summary of Master Plan Information Regarding:
   (a) Existing and Future Population and Land Use
   (b) Wastewater Generation Factors
   (c) Evaluation and Design Criteria
   (d) Description of Short-term Project Recommended for Feasibility Studies
   (e) Summary of Issues to be Future Investigated during the Feasibility Studies.

5. Evaluation of Alternatives
   (a) Sewage Collection Systems (sewerage pipe, sewerage improvements, pumps, and rising mains)
   (b) Wastewater Treatment Systems (treatment and reuse)
   (c) Conclusions and Recommendations

6. Preliminary Design
   (a) Rehabilitation of Existing Sewer Systems
   (b) Rehabilitation of Existing Pump Stations
(c) Rehabilitation of Existing STPs
(d) New Sewer Systems
(e) New Pump Stations
(f) New STPs

7. Implementation Plan

5.8 Integration of Feasibility Study Information into Project Database

The project database is being created in the geo database (Arc GIS) based on a data model. The objective of creating a data model is to provide a practical template for implementing GIS projects. With the help of the data model, data generated at various stages of the project can easily be incorporated into GIS outputs.

At the present stage, the data model consists of details shown on the base maps. During the subsequent stages of Master Planning and Feasibility Study, land use and urban sprawl will be incorporated. Additionally, the data model will have the separate subsets of sewerage data, including information related to treatment facilities, pumping stations, and trunk sewers.

As a parallel activity, metadata will be created for the GIS database. Metadata are data or properties that describe the data. The data descriptions ensure validity of the data in the future by tracking the purpose of the data and how it was created. By adding information like keywords and author’s names, it is will be possible for other to locate their data.

Listed below is the information that will be provided in the metadata.

1. Description
2. Keywords
3. Citation/Source
4. Extent
5. Time Period of content
6. Status
7. Access and use constraints
8. Metadata contact
9. Entity descriptions
10. Attribute description and values

Benefits of having the data model and metadata as components of the GIS database will accrue in the form of a strong platform of which DJB and other agencies will be able to expand the database in the future.

The GIS will provide the Project Team with a documentation of the location of sewerage systems, appended to database will be the engineering information. The GIS team will also be developing the database of available contour information from Survey of India maps that can be used to develop catchment within the project study areas. The satellite imagery based
analysis using Quick Bird data will provide land use/land cover information for the entire project area.
6. Project Completion Report (Detailed Project Report)

6.1 Introduction

The feasibility studies will identify feasible sewerage infrastructure improvement projects, recommended priorities for each project, project design parameters, and sufficient project details to allow funding allocations to individual projects with reasonable accuracy. During the Detailed Project Report (DPR) phase, the design will be further developed and the project cost estimates will be refined through more detailed quantity calculations and by obtaining additional quotations from suppliers and vendors whoever possible and needed.

DPRs will be prepared for projects requiring immediate construction. In the DPRs, the project planning and design will be advanced to the point the implementation can begin as soon as funding is available. The DPRs will carry the project implementation forward to a stage that preparation of detailed design and tender document for each scheme for traditional/EPC/DBO tenders are the next logical step for major project works. The guidelines for preparation of DPR for ‘Conservation of river and lake’ and the checklist for consideration of DPRs in respect of ‘National River Conservation Plan’ framed by NRCD will also be referred to during DPR stage.

6.2 Relationship to Master Plan and Feasibility Studies

DPRs will be based on the following information finalized during the master planning and feasibility study stages:

1. Scope of Work, with details such as
   (a) Length, material of construction tentative alignment and diameters of new sewers to be laid
   (b) Segments of sewers which require immediate cleaning / rehabilitation /replacement
   (c) Required drainage system improvements
   (d) Pumping station augmentations/capacities of new pumping station, civil, mechanical and electrical rehabilitation works to be carried out in the existing pumping stations and STPs
   (e) Alignment, material and diameters of new rising mains
   (f) STP treatment processes, effluent and sludge reuse facilities, and rehabilitation of existing sewerage facilities as approved by the stakeholder agencies

2. Locations – Sites of various project components as finalized during the feasibility study phase. Site specific data for each site, whether collected during the feasibility study or during the DPR phase, will be included in the DPR.

3. Capacities – Pipe, pump, and STP design capacities as finalized during feasibility study.

4. Design Criteria – Design criteria finalized during the master planning and feasibility study phases will be used to advance design to the level required for the preparation of the DPRs.
6.3 Field Investigations

The field investigations carried out during the feasibility stage will be supplemented with additional surveys like plane table surveys for increased areas at proposed pumping stations and STP sites, long-section surveys for additional length of sewers, geotechnical investigations consisting of additional number and increased depth of boreholes at sites with loose/week soil, boreholes of depth > 6m along sewer alignments where depth of sewers exceeds 6m etc. However, no additional wastewater sampling and flow measurement surveys are envisaged during the DPR stage.

6.4 Design and Drawings

The DPRs will include detailed process and hydraulic designs for all sewerage system components, as these are process-oriented units. The Detailed Project Report will include the following:

1. Design of New Sewers – Hydraulic analysis and design will be accomplished using SewerGEMS or other equivalent design and hydraulic modelling software. Detailed L-Section drawings will be produced showing invert elevations, sewer diameters, and locations of appurtenances. Locations and details regarding special/innovative construction methods also will be provided.

2. Hydraulic Design of Rising Mains – Hydraulic analysis will be performed, where appropriate.

3. Preliminary mechanicals and electrical design for pumping installations

4. Design of Appurtenances – Typical designs, sections, and drawings for appurtenant works for gravity sewers and rising mains, e.g. manholes, valve pits, thrust blocks, culverts, box culverts, small bridges, etc will be produced. However, production of construction drawings with detailed reinforced drawings is not envisaged at DPR stage and not included in the scope.

5. Design of Sewer Rehabilitation Projects for Existing Sewers – Potential rehabilitation projects may range from sewer cleaning activities to sewer replacement projects. Hydraulic analyses and location and detail drawings/sketch will be developed as needed. In particular, details of designs to disconnect storm drains from the sewer systems, and required storm drainpipe extensions/rerouting will be provided.

6. Designs for New Pumping Stations and STPs – Civil design for pumping station and treatment plant units would be carried out in sufficient details so that tender preparation for these works can be carried out expeditiously. Production of construction drawings with reinforcement details and tender documents is not envisaged at the DPR stage. Also various processes, mechanical and electrical equipment would be identified and selected at this stage. As a minimum, the following intermediate design products will be included in the DPRs for new pumping stations and STPs:

   (a) Site layouts with dimensions showing building and other structure locations, proposed year-piping and utilities, access roads, and landscaping.
   
   (b) Hydraulic and process flow diagrams
   
   (c) Mass balance diagram
   
   (d) Preliminary design of mechanical equipment
(e) Single line electrical and control diagrams

(f) General arrangement drawings and typical sections of proposed buildings and other structures showing preliminary horizontal and vertical dimensions, equipment/process types and locations, electrical and control equipment locations, provisions for emergency power, and any special equipment required for operation and maintenance.

7. Designs for Existing Pumping Stations and STP Rehabilitation Projects – Recommendations for rehabilitation of existing pumping stations and STPs will be developed wherever feasible. Benefits of rehabilitation can be realized immediately by improvements in the operating regime of the system or by small capital improvement works. Wherever appropriate, intermediate rehabilitation designs presented in the DPRs may include:

(a) Site layouts with dimensions showing rehabilitation project locations and facility improvements.

(b) General arrangement drawings and typical sections showing preliminary horizontal and vertical dimensions of improvements, equipment/process types and locations, pipes and valves modifications, electrical and control equipment modifications, emergency power modifications, and any special equipment required for operation and maintenance.

(c) Hydraulic and process flow diagram

(d) Mass balance diagram

(e) Single line electrical and control diagrams

6.5 Specifications

The specification followed for arriving at the project cost as calculated in the DPRs will be clearly presented in the DPRs. The basis for project specifications will be the local model specifications typically used for infrastructure projects, plus typical international practices and specifications where local specifications are not available, or where alternative specifications will provide a more cost-effective solution. All special specifications, which are likely to have a cost impact, will be clearly identified. The specifications will include a list of equivalent International Standard Codes/Indian Standard Codes to be used for the project.

In additions to general specifications, project component specifications will be provided to define component-specific material, size, capacity, and performance requirements. For example, pump specifications will include the type of pumps, total suction and discharge dynamic heads, discharge flow for the overall pump system, automatic controls, and spare parts. The total specifications package will be sufficient to develop construction cost estimates with reasonable accuracy for the proposed projects. The project-specific specifications also will include appropriate environmental and social impact.

6.6 Bill of Quantities (BOQ) and Costing

Based on the design detailed lists of quantities of project materials and equipment will be included in the DPRs. These will include civil and electro-mechanical BOQs. The civil BOQ will be prepared as per the format in the Delhi Schedule of Rates, with estimated quantities for
excavation, backfilling/disposal, PCC, RCC, steel, shuttering etc. being estimated for main process and building units.

Electro-mechanical and instrumentation BOQ will follow the preliminary design of electro-mechanical components of pumping stations/STPs. Any requirement of items to be imported would be identified separately.

The Schedule of Rates to be used for costing of sewerage works will be taken from the latest / Delhi Schedule of Rates with a cost index applied to arrive at current prices. However, in view of the recent rapid increase in steel and cement prices, DJB will be consulted on the prices at which recent tenders have been awarded. The Schedule of Rates to be used for estimates needs to be aligned with the market rates. A judicious mix of rates from the Schedule of Rates and market rates will be adopted to arrive at a realistic and optimum project cost. Rates for electro-mechanical items will be obtained from vendor quotations, to the extent possible considering, the limited time available to complete the project.

6.7 Implementation Plan

6.7.1 General

DPRs will include detailed implementation plans to be undertaken at the end of this consultancy work. These plans will include descriptions of activities required for financial planning, continuing PP&A activities, final design, the tendering process, award of construction contracts, construction, institutional capacity building, and operation and maintenance. A schedule of required activities will be included in the implementation plans. However preparation of detailed construction drawings, specifications and other tender documents are not included in the scope of the DPRs.

6.7.2 Sewer Cleaning / Rehabilitation

This type of work generally requires specialty contractors and hence, a national/international procurement contract may be a preferred alternative. Rehabilitation of existing sewers is expected to be assigned a high priority. Depending on the type(s) of rehabilitation work to be performed, one or more tenders may be appropriate to cover the different types of work. To the extent practical, similar work may be included in a single tendering package attract good domestic potential international bidders.

6.7.3 Pumping Station and STP Rehabilitation

These projects could range from relatively small, such as replacing a grit screen at a pumping station, to relatively large, such as a major process addition at a STP. To the extent practical, it may be appropriate to include several small value projects in a single tender offer. There is wide range of project delivery options for large projects. These options range from the traditional approach (final design, bid, and construct with operation by local agencies to Design-Build-Operate contracts with some establish operational period. A major consideration is to ensure that the project value and the selected project delivery process will attract reputable and experienced contractors in sufficient numbers. Selection of the appropriate project delivery options will be defined through consultation with the stakeholder.
6.7.4 New Pump Station and STP Projects

There is a wide range of project delivery options. These options may range from the traditional approach (separate contracts for final design and construction with operation by local agencies) to Design-Build-Operate contracts with some established operational period. A major consideration is to ensure that the project value and the selected project delivery process will attract reputable and experienced contractors for the scope of work included in the tender offers. Selection of the appropriate project delivery options will be defined through consultation with DJB.

6.7.5 New Sewer Construction Works

DJB is following the practice of percentage tender and same may be followed.
ANNEXURE I

FORMAT OF DEMOGRAPHIC SURVEY
1.0 Identification

1.1 House No.:
1.2 Name of Village/ JJ Cluster/ Un-authorized colony/ Locality:
1.3 Name of District/Tehsil:
1.4 Name of the Zone:
1.5 Pin Code:

2.0 General

2.1 Name of the Respondent:
2.2 Name of the Head of the Household
2.3 Relationship of the respondent
   With the Head of the Household:

2.4 Religion of the Household:
   1. Christian (   )
   2. Hindu (   )
   3. Muslim (   )
   4. Buddhist (   )
   5. Others (   )

2.5 Caste of Household:
   1. General (   )
   2. Other Backward Class (OBC) (   )
   3. Schedule Caste (SC) (   )
   4. Schedule Tribe (ST) (   )
### 3.0 Family Details

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Name of Family Member</th>
<th>Age (complete years)</th>
<th>Sex M/F</th>
<th>Marital Status</th>
<th>Relationship with head of HH</th>
<th>Upto which class educated</th>
<th>Whether continuing education</th>
<th>Main occupation</th>
<th>Whether living in or out of Delhi</th>
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</thead>
<tbody>
<tr>
<td>1</td>
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<td>3</td>
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</table>

**Note: How to Fill-in this Table**

- **Column 3** - Age of each family member should be in complete years
- **Column 4** – Sex of the Individual should be either (1) for male or (2) for female
- **Column 6** – Relationship 1. Head of Household = Self; 2. Wife (1) meaning wife of S.No. 1
  3. Son (1,2) Meaning Son of S.No. 1 and 2
  4. Wife (3) Meaning wife of S.No. 3
  5. Daughter (1,2) Meaning Daughter of S.No. 1 and 2
  6. Daughter (3,4) meaning daughter of S.No. 3 and 4 (or Grand Daughter of 1 and 2)
  7. Son (3,4) Meaning son of S.No. 3 and 4 (and 4 (Or Grand son of 1 and 2)
- **Column 7** - Write down the last completed class/standard at School/College/Institution
- **Column 8** - Whether continuing education – 1, Yes and 2 = No
- **Column 9** - Main occupation of each member
### 3.1 For those member who live outside

<table>
<thead>
<tr>
<th>Name of the Member</th>
<th>Place presently residing</th>
<th>Reason for Migrating</th>
<th>Whether gone permanently/temporarily</th>
<th>Since when gone (year)</th>
<th>How many times do you they come Home</th>
<th>Do they send money home and how much</th>
</tr>
</thead>
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</tbody>
</table>

Note: The names and S.No. of the members should correspond with the name in Table-3.0

### 4.0 Housing Details

#### 5.1 Ownership of homestead

1. Self Owned  
2. Tenant  
3. Others

#### 5.2 Housing Details

<table>
<thead>
<tr>
<th></th>
<th>No. of Floors</th>
<th>No. of Rooms</th>
<th>Provision of Electricity Yes/No</th>
<th>What are the walls made of</th>
<th>What is the Roof made of</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
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<tr>
<td>Cattle Shed</td>
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<tr>
<td>Store Room</td>
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<tr>
<td>Lavatory</td>
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<tr>
<td>Others</td>
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</table>

Investigators are to kindly estimate the Rough area of the Housing Plot and other homestead structures and note them here:

### 4.1 Sources of Water for various purposes

- Access to drinking water facility
  - Private tap connection ( )
  - Community Outpost ( )
  - Pond/ well ( )
  - DJB tankers ( )
  - Others ( )

- Access to water for cleaning and washing
  - Private tap connection ( )
- Community Outpost ( )
- Pond/ well ( )
- DJB tankers ( )
- Others ( )

- Availability of water
  - Once a day ( )
  - Twice a day ( )
  - Few days in a week ( )
  - Once a week ( )

- How is the quality of water (clean and odorless)
  - Very good ( )
  - Good ( )
  - Okay ( )
  - Fair ( )
  - Bad ( )

Tick(√) The relevant option. In case, for any use, the source of water is “Others”.

4.2 Sanitation Facilities

- Do you have access to lavatory facility
  - Private lavatory: ( )
  - Public lavatory ( )
  - Open defecation ( )

- Do you have access to bathroom facility
  - Private bathroom ( )
  - Community bathroom ( )
  - Open ( )

- Where is the domestic waste water discharged
  - Drains (covered) ( )
  - Drains (un-covered) ( )
  - In the open ( )

- Where do you discard solid waste
  - In designated places ( )
  - In the open ( )

- Where do you discard domestic waste
  - In designated places ( )
  - In the open ( )

- How often is the garbage collected from you locality
  - Once a day ( )
- Once a week (  )
- Once a month (  )
- Once in several months (  )

➢ How often are the drains in your locality cleaned
- Once a day (  )
- Once a week (  )
- Once a month (  )
- Once in several months (  )

Tick (√) The relevant option. In case, for any use, the source of water is “Others”,

5.0 Family wellbeing indicators

<table>
<thead>
<tr>
<th>Material Assets</th>
<th>Numbers</th>
<th>Material Assets</th>
<th>Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Television Set</td>
<td></td>
<td>6. Cycle</td>
<td></td>
</tr>
<tr>
<td>2. Tape-Recorder</td>
<td></td>
<td>7. Two Wheeler</td>
<td></td>
</tr>
<tr>
<td>3. Transistor Radio</td>
<td></td>
<td>8. Four Wheeler</td>
<td></td>
</tr>
<tr>
<td>4. Modern Furniture</td>
<td></td>
<td>9. LPG Cylinder</td>
<td></td>
</tr>
<tr>
<td>5. Refrigerator</td>
<td></td>
<td>10. Others</td>
<td></td>
</tr>
</tbody>
</table>

Investigators signature:

Supervisor’s signature:
ANNEXURE II

SAMPLE AND FORMAT OF SURVEY
CONTROL AND TOPOGRAPHIC
SURVEY
Area Classification

- OPEN LAND
- RESIDENTIAL
- COMMERCIAL
- EDUCATIONAL
- RELIGIOUS
- ELECTRIC SUB-STATION

Legend

- Elevation, Point
- 0.5 Meter, Contour
- Bore Well
- Hand Pump
- Manhole
- TBM
- Telephone Pole
- Transmission Pole
- Trees

Total road length surveyed = 6.2 Km

Note: -

Levels taken are at 30m c/c all along the road. However, all levels are not shown in printout for clarity.

All levels are w.r.t. m.s.l and are in meters.
ANNEXURE III

FORMAT OF GEOTECHNICAL-SURVEY
<table>
<thead>
<tr>
<th>Elevation Feet</th>
<th>Depth Feet</th>
<th>Graphic Log</th>
<th>Attitudes</th>
<th>Sample No.</th>
<th>Blows Per Foot</th>
<th>Dry Density, pcf</th>
<th>Moisture Content %</th>
<th>Soil Class. (U.S.C.S.)</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>N</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Asphaltic concrete</td>
</tr>
<tr>
<td></td>
<td>S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Portland cement concrete</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td>CL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>CH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inorganic silt; clayey silt with low plasticity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>OL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Inorganic silt; diatomaceous fine sandy or silty soils; elastic silt</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ML-CL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clayey silt to silty clay</td>
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<tr>
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<td></td>
<td></td>
<td>GW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Well-graded gravel; gravel-sand mixture, little or no fines</td>
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<td></td>
<td></td>
<td></td>
<td>GP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Poorly graded gravel; gravel-sand mixture, little or no fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Clayey gravel; gravel-sand-clay mixture</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Well-graded sand; gravelly sand, little or no fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Poorly graded sand; gravelly sand, little or no fines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SP</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Silty sand; poorly graded sand-silt mixture</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SM</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Bedrock</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SC</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ground water encountered at time of drilling</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SAMPLE TYPES:</th>
<th>TYPE OF TESTS:</th>
</tr>
</thead>
<tbody>
<tr>
<td>S SPLIT SPOON</td>
<td>DS DIRECT SHEAR</td>
</tr>
<tr>
<td>R RING SAMPLE</td>
<td>MO MAXIMUM DENSITY</td>
</tr>
<tr>
<td>B BULK SAMPLE</td>
<td>CN CONSOLIDATION</td>
</tr>
<tr>
<td>T TUBE SAMPLE</td>
<td>CR CORROSION</td>
</tr>
<tr>
<td>G GRAB SAMPLE</td>
<td>SA SIEVE ANALYSIS</td>
</tr>
<tr>
<td>SH SHELBY TUBE</td>
<td>AT ATTERBURG LIMITS</td>
</tr>
<tr>
<td></td>
<td>EI EXPANSION INDEX</td>
</tr>
<tr>
<td></td>
<td>RV R-VALUE</td>
</tr>
</tbody>
</table>

LEIGHTON
ANNEXURE IV

FORMAT OF MAN-HOLE SURVEY
The final data is required to be projected to a co-ordinate system using UTM-WGS-84-43N on GIS platform using Arcinfo version 9.3 or equivalent. Manhole Shape file will be point type with the following fields and attributes.

- **Label (Text)**: Unique ID for each Manhole e.g. (MH- xyz) xyz depict unique Id.
- **Level(Float)**: Capture from survey with minimum three number of decimal places.
- **X_Co (Double)**: Generate X co-ordinate in the form of Meter (m).
- **Y_Co (Double)**: Generate Y co-ordinate in the form of Meter (m).
- **Layer (Text)**: Utilities
- **Feature_Type (Text)**: Type will be ‘MANHOLE’.