NCR Planning Board
Asian Development Bank

Capacity Development of the National Capital Region Planning Board (NCRPB) – Component B

(TA No. 7055-IND)

Water Supply Master Plan of Panipat

January 2009

Abbreviations

AD/MM	:	Average Day/Max month
ADF	:	Average Daily Flow
ADWF	:	Average Dry Weather Flow
AIWSP	:	Average Integrated Wastewater Stabilization Ponds
AL	:	Aerated Lagoon
AS	:	Activated Sludge
ASR	:	Aquifer Storage & Recovery System
Avg	:	Average
AWT	:	Advanced Wastewater Treatment
BIS	:	Bureau of Indian Standards
BOD	:	Biochemical Oxygen Demand
CETP	:	Combined Effluent Treatment Plant (industrial)
CI	:	Cast Iron
DI	:	Ductile iron
cms	:	Cubic Metres per Second
CO2	:	Carbon Dioxide
COD	:	Chemical Oxygen Demand
CDM	:	Clean Development Mechanism
CPCB	:	Central Pollution Control Board
CWR	:	Clear Water Reservoir
DHS	:	Downflow Hanging Sponge
DLW	:	Diesel Locomotive Work
DO	:	Dissolved Oxygen
DPRs	:	Detailed Project Reports
EPA	:	Environmental Protection Act (1986 and amendments)
ES	:	Equalization Storage
ETP	:	Effluent Treatment Plant (industrial)
ETT	:	Engineering Technology Transfer (programme)
FAB	:	Fluidized Aerated Bioreactor
FS	:	Feasibility Study
FSA	:	Future Service Area
GIS	:	Geographical Information System
gpd	:	Grams per day
GoI	:	Government of India
GWI	:	Groundwater Infiltration
HDPE	:	High-Density Polyethylene
HDR	:	High-Density Residential
HSIDC	:	Haryana State Industrial Development Corporation
HP	:	Horse Power
HSPCB	:	Haryana State Pollution Control Board
HUDA	:	Haryana Urban Development Authority
I/I	:	Infiltration/Inflow
I&D	:	Inception and Diversion
IPS	:	Intermediate Pumping Station
ISC	:	Indian Standard Code
Km	:	Kilometer
KVA	:	Kilo Volt Ampere
LDR	:	Low-Density Residential
lpcd	:	Litres per capita per day
lpm	:	Litres per minute
lps	:	Litres per second

MC	:	Municipal Committee
MCG	:	Municipal Corporation Ghaziabad
MDR	:	Medium-Density Residential
mg/l	:	Milligrams per litre
ML	:	Million Litres
MLD	:	Million Litres per day
MLSS	:	Mixed liquor Suspended Solids
MP	:	Maturation Pond/Master Plan
MPN	:	Most Probable Number per 100 ml
MPS	:	Main Pumping Station
MUD	:	Ministry of Urban Development
MoEF	:	Ministry of Environment & Forests
N/A	:	Not Available
NH3-N	:	Ammonia as Nitrogen
NCR	:	National Capital Region
NRCD	:	National River Conservation Directorate
NSA	:	Non-sewerage Area
O&M	:	Operation & Maintenance
PDWF	:	Peak Dry Weather Flow
PFR	:	Project Feasibility Report
PHED	:	Public Health and Engineering Department
PIA	:	Project Implementing Agency
PMC	:	Project Management Consultants
PS	:	Pumping Station
PSC	:	Pre-Stressed Concrete
PVC	:	Polyvinyl Chloride
PWD	:	Public Works Department
RAP	:	Reform Action Plan
RAS	:	Return Activated Sludge
RPM	:	Relative Particulate Matter (air quality)
SPM	:	Suspended Particulate Matter (air quality)
SPS	:	Sewage Pumping Station
SS	:	Suspended Solids
SSO	:	Sanitary Sewer Overflow
STP	:	Sewage Treatment Plant
TDS	:	Total Dissolved Solids
TKN	:	Total Kjeldahl Nitrogen
TMDL	:	Total Maximum Daily Load
TN	:	Total Nitrogen
TP	:	Total Phosphorus
TPS	:	Temporary Pumping Station
TSS	:	Total Suspended Solids
UASB	:	Upflow Anaerobic Sludge Blanket
UFW	:	Unaccounted For Water
ULB	:	Urban Local Body
UV	:	Ultra Violet
VCP	:	Vitrified Clay Pipe
WAS	:	Waste Activated Sludge
WHO	:	World Health Organization
WRF	:	Water Reclamation Facility
WSP	:	Waste Stabilization Pond
WTP	:	Water Treatment Plant

Glossary of Terms

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

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

Biological Process: The process by which the metabolic activities of bacteria and other microorganisms 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.

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

Digester: A tank or vessel used for sludge digestion.

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

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

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

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

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

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.

Head works: The initial structure and devices located at the receiving end of a water or sewage treatment plant.

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

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

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

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

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

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.

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.

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

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

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

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

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

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

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

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

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

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I. INTRODUCTION

A. Background

1. The National Capital Region Planning Board, constituted in 1985 under the provisions of NCRPB Act, 1985, is a statutory body functioning under the Ministry of Urban Development, Government of India. NCRPB has a mandate to systematically develop the National Capital Region (NCR) of India. It is one of the functions of the Board to arrange and oversee the financing of selected development projects in the NCR through Central and State Plan funds and other sources of revenue.

2. On Government of India's request, Asian Development Bank (ADB) has formulated the technical assistance (TA) to enhance the capacities of National Capital Region Planning Board and its associated implementing agencies. The TA has been designed in three components: Component A relates to improving the business processes in NCRPB; Component B relates to improving the capacity of the implementing agencies in project identification, feasibility studies and preparing detailed engineering design; and Component C relates to urban planning and other activities.

3. ADB has appointed M/s Wilbur Smith Associates to perform consultancy services envisaged under Component B. In the context of this contract, the first deliverable – Inception Report, was submitted in October 2008.

4. This is the Interim Report prepared for the TA Component B, and is the second deliverable under the Contract. This was prepared by the WSA Team between October 2008 and January 2009.

B. Overview of this ADB TA

5. *Objectives*. The objective of this Technical Assistance (TA) is to strengthen the capacity at NCRPB, state-level NCR cells, and other implementing agencies in the area of planning for urban infrastructure and to impart necessary skills to conceive, design, develop, appraise and implement good quality infrastructure projects for planned development of NCR. The increased institutional capacity of the NCRPB and the implementing agencies will lead to effective and time scaling-up of urban infrastructure to (i) improve quality of basic urban services in the NCR; (ii) develop counter magnet towns; (iii) reduce in migration into Delhi and orderly development of NCR; and (iv) accelerate economic growth in the NCR.

6. The TA – Capacity Development of the NCRPB, Component B focuses on strengthening the capacities of NCRPB and implementing agencies relating to project feasibility studies and preparation, and detailed engineering design in the implementing agencies. Specifically this component B of the TA will support the project preparation efforts of the

implementing agencies by preparing demonstration feasibility studies that include all due diligence documentation required for processing of the project in accordance with best practices, including ADB's policies and guidelines.

7. *Scope of Work*. According to the terms of reference of the TA assignment, the following activities are envisaged in component B of the TA:

(i) Conduct technical, institutional, economic and financial feasibility analysis of identified subprojects in the six sample implementing agencies;
(ii) Conduct safeguards due diligence on the subprojects, including environmental assessment report and resettlement plan for all subprojects covered in the sample implementing agencies;
(iii) Prepare environmental assessment framework and resettlement framework; and
(iv) Develop a capacity building and policy reform program for the implementing agencies, including governance strengthening, institutional development and financial management.

8. Besides, this component of the TA will also:

(i) help in assessing the current practices and procedures of project identification and preparation of detailed project reports including technical, financial, economic and social safeguard due diligence;
(ii) support preparation of standard procedure manuals for project identification and preparation of detailed project reports including technical, financial, economic and social safeguard due diligence;
(iii) train the implementing agencies in the preparation of detailed project reports by using the sample subprojects, reports on deficiency of current practices and standard protocol manuals; and
(iv) help in developing a user-friendly web-page where different manuals and guidelines for preparation of DPRs will be made available for the implementing agencies.

C. About the Interim Report

9. The Interim Report is the second report/deliverable under the TA Component B, and was prepared between October 15, 2008 and January 16, 2009. During the Inception Stage, ADB/NCRPB in consultation with the implementing agencies and WSA Team has identified and finalized the sample implementing agencies and subprojects for preparation under this TA. Accordingly, it is proposed to produce model Detail Project Reports (DPR) in the following sectors: (i) Water Supply; (ii) Sewerage; (iii) Storm Water Drainage; (iv) Solid Waste Management, and (v) Traffic Planning

10. These model DPRs are proposed to be made available to the implementing agencies of the state governments so that they may replicate the methodology/approach in the future DPRs being prepared by them for obtaining finances from financial institutions including NCRPB. It is also proposed to develop appropriate tool kits for each of these sectors to facilitate preparation of DPRs.

11. It is proposed to produce DPR for water supply for Panipat town, Sewerage for Hapur town, Storm Water Drainage for Hapur and Sonipat towns, Solid Waste Management for Ghaziabad town and Traffic Planning for Ghaziabad town.

12. Following the approach developed for the TA assignment as presented in the Inception Report, the Team at this stage focused on preparation of Master Plan as a base for preparation of sample DPRs. These Plans are prepared keeping in view of the long terms requirements of the sample towns. The existing infrastructure systems have been studied assessed and issues in service delivery have been identified. A long term plan has been developed with the projected service demands and targets to be achieved; and various interventions and subprojects required to achieve the sector plan targets have been identified. In the next phase of this study, DPRs will be prepared for selected subproject components from the above long-term plans.

13. The Interim Report is organized in Four Volumes:

Volume I is the main Interim Report; summarizes the entire output produced till date under the TA Component B; provides a brief of all Sector Master Plans;

Volume II. Infrastructure Master Plans: this is compiled in five parts, each dealing with a separate sector, as given below:

A – Water Supply Master Plan of Panipat
B – Sewerage Master Plan of Hapur
C – Drainage Master Plan of Hapur
D – Solid Waste Management Master Plan of Ghaziabad
E – Existing Traffic & Transport Analysis of Ghaziabad

Volume III presents the results of the socio-economic base line survey conducted in three sample towns in three parts:

A – Ghaziabad
B – Panipat
C – Hapur

Volume IV. The proceedings of the Introductory Workshop organized on December 10, 2008, as part of training/workshop component of the TA is presented in this Volume.

14. This is **Volume II A: Water Supply Master Plan of Panipat,** of the Interim Report. This report is the first step in the direction of producing DPR for water supply in Panipat Town. This report is organized into following ten (10) sections including this introductory section:

Section II elucidates the methodology followed and tasks performed for preparation of this Master Plan;

Section III presents profile of Panipat Town;

Section IV assesses the existing water supply and wastewater systems in Panipat;

Section V establishes the design criteria followed in preparation of the Master Plan;

Section VI reviews the growth trends of Panipat and presents population projections for the Design Year;

Section VII presents planning and designing of proposed water system of Panipat, including the measures to improve the existing system;

Section VIII provides proposed UFW reduction strategies and water safety plan;

Section IX provides proposed operation and maintenance (O&M) plan; and

Section X provides cost estimates of the proposed Water Supply Master Plan

II. METHODOLOGY

A. Overview

15. The following tasks have been performed during the preparation of the water supply master plan:

- Data Collection and Field visits
- Population Projection and Water Demand
- Study of Existing Water Supply System
- Water Resource Study for Identification of Source of Water
- Design of Proposed Water Supply System
- Calculation of Capital Cost
- Operation & Maintenance Plan
- Institutional Arrangement

B. Methodology

16. *Data Collection, Field Visits, Collection of Information of Existing Water Supply System (Task 1).*This task involved collection and analysis of data of existing water supply system and mapping the components in a Base map of Panipat. A thorough field reconnaissance and subsequent visits have been performed to gain a better understanding of the project area, existing water supply system and related issues that confront the present water supply system. The objective of such surveys was to obtain information on the water supply system components, general topography, soil characteristics, routing/alignment of feeder mains, area available for construction of Water Treatment Plant & Pumping Stations, high-density areas for population projection and related information. The following basic details were collected for preparing the proposed Water Supply Master Plan;

- Census Population
- Present population and ward-wise distribution
- Town Map showing ward boundaries and reduced levels
- Source details
- Details of the existing pump stations, storage reservoirs, duration of water supply
- Details of distribution system network
- Details of existing tube wells, their lithology, assembly details etc.
- City Master Plan for 2021
- Sewerage Master Plan prepared under Yamuna Action Plan II
- Status of ground water exploitation in Hayana state and specifically of Panipat district
- Other relevant details

- Also, topographical details of Panipat City are collected. The details have been used for Preparation of a contour map
- Marking of important features like bridges, culverts, ponds, streams, lakes etc in the contour map.
- Secondary data relating to Geo-technical investigation in the city will be collected later during detailed engineering.The data will assist in deciding locations of proposed structures.

17. *Population Projection and Water Demand (Task 2).* This task involved study of present service area and future expansions.

- Estimation of present population in the service area and water demand
- Population projection, estimation of future demand in the city and in different distribution zones/ centers based on Population projections
- Study of presently unserved area and future water demand analysis.

18. A critical factor in the design of a water supply system is the present population and its expected rate of growth. The design horizon year for master plan is 2041. Population projection has been done for the year 2041 using alternative methods. The overall population has been distributed among various wards using expected growth rates in different wards. These numbers form the basis for estimating water demand and have been used for design of various components of the water supply system. Conventional population projection methods such as Numerical (Arithmetic, Incremental & Geometric Increase) methods have been used in projecting the future population of Panipat City. Appropriate population projection method has been selected for Panipat City. The population projections have been compared with those adopted for Sewerage Master so that there is major variation in population adopted. The population projections have also been compared with those projected in Regional Plan 2021 approved by NCR Planning Board and also in City Master Plan approved by the state government.

19. *Study of Existing Water Supply System (Task 3).* The existing water Supply system consists of tube wells, distribution pipes, valves, rising mains from the bore wells, ground reservoir and boosting station etc. The study mainly involved:

(i) Evaluation of supply pattern and identifying the gap in demand and supply, system performance of storage reservoirs, distribution system and tube wells etc. Suggestions for remedial measures to rectify the deficiencies of the present water supply system.

(ii) The evaluation of existing ground water source for its sustainability on long term basis and study of alternative sources for water supply. Assessment has been made regarding discharge from the tube wells, water level depletion, deterioration in ground water quality and failure of tube wells.

(iii) Evaluation of Existing Distribution System: Detailed distribution network work has been got completed with the help of PHED staff and evaluated. Based on the above study and also as per discussions held with PHED staffs, necessary proposals for rezoning of the system have been carried out. Hydraulic analysis of water

distribution network will be carried out using available computer software during the process of preparation of DPR.

20. *Water Resource Study for Identification of Sources (Task 4).* Identification of sustainable sources of water for supply to the city of Panipat is an important component of the master plan. Tapping of source is generally either through abstraction of water from ground aquifer or through surface source. Sustainable water source have been identified for water supply augmentation in the city.

21. *Design of Proposed Water Supply System (Task 5).* The design of the proposed water supply system includes a Concept Plan to meet future water demand in the years 2026 and 2041. The proposed water supply system includes proposed sources, intake works, raw water and clear pumping stations, water treatment plant, proposed distribution zones, boosting station and overhead tanks, proposed feeder mains to the new distribution centers and improvement and extension of existing distribution system.

    The city does not have a well designed distribution network and zoning. The existing distribution system has to be rezoned to ensure that equitable distribution of water at minimum residual pressure (12.00 m) is provided based on the ultimate stage water demand (2041). Hydraulic design of proposed modifications to the distribution network is being done as per CPHEEO norms.

22. *Reduction of UFW and Water safety Plan (Task 6).* As there is no metering, either on production or on consumer end, it is difficult to make a realistic assessment of Un accounted For Water (UFW). It has therefore been proposed to provide Bulk meters for water produced, reaching each Zonal reservoir and consumer meters. In any case as per past experience in other similar cities, the UFW is likely to be in excess of 40%. It has therefore been attempted to prepare District Metering Areas for actual assessment of leakages and plugging the same for reducing UFW to the desired levels.

    Water quality safety is the most important part of a water supply system. The water safety plan requirements will be examined and appropriate suggestions will be made.

23. *Calculation of Capital Cost (Task 7).* Capital cost for each component of the proposed water supply improvement scheme will be derived based on the current Standard Schedule of Rates (SOR). Additionally, prevailing market rates will be adopted in the event pertinent data was unavailable in the schedules and for rates of specialized items.

24. *Operation & Maintenance Plan (Task 8).* At present, PHED is taking care of the maintenance of water supply scheme in Panipat city. It is felt that much more attention is necessary for proper maintenance. Hence, it is proposed to provide an operation & maintenance plan with proper restructuring of PHED so as to ensure proper maintenance. In addition, it is felt that there have been no training facilities inbuilt in the system both for the field staff as well as for the Engineering wing. It is felt that the training is essential tool for proper O & M facilities.

Similarly there is lot of scope for considering introduction of Public Private Partnership (PPP) in O&M of the system. The new production system can form a unit for privatizing to obtain better efficiency, lower operational cost and dependable sustainable production.

Haryana state PHED has already taken up fully automated water treatment and raw water pumping. It would be worthwhile to go for a full scale SCADA for Panipat city water supply system.

25. *Institutional Arrangement (Task 9)*. Existing institutional arrangement for delivery of water supply services in the city has been analysed. Present institutional deficiencies have been identified.

III. PROFILE OF PANIPAT

A. Introduction

26. Panipat enjoys a pride place in the long and chequered history of India. It has witnessed the three famous Battles of Panipat in the years 1526, 1556 and 1761. In 1805, British soldiers captured and took over the town while establishing the cantonment at Karnal. The municipal committee for Panipat was formed in the year 1886.

27. The existing town of Panipat is situated on National Highway No.1 (Delhi-Amritsar GT Road) and is at about 85 km from Delhi, 34 km from Karnal (**Map 1**). It is situated between 76º 38'- 77º 09' west longitudes and 29º 10'-29º 31' north latitudes. Panipat is the headquarter of Panipat District in Haryana State. The town is the point of convergence of roads from Delhi, Gohana, Karnal, and Assandh, in Haryana and Kairana from Uttar Pradesh. It is also a Railway Junction; the Delhi- Ambala Railway line, which runs parallel to the G.T. Road, divides it into two parts. On the western side, across the railway line is the Industrial area and the Model Town. The old town of Panipat lies on the eastern side.

28. Panipat is popularly known as 'the city of handloom' because the industrial activities in this town primarily consist of textiles with handloom. Textiles produced at Panipat have a very good domestic as well as international market. Internationally known Pachranga Pickle is produced here. The National Fertilizers Limited and Panipat Thermal Power Plant represent the heavy industry segment of Panipat. The scenario will change radically as soon as Indian Oil Refinery at Baholi Village, in close proximity to the town, goes to full production. This prestigious project of national importance is likely to further boost the economy and size of the town.

B. Demographic Characteristics

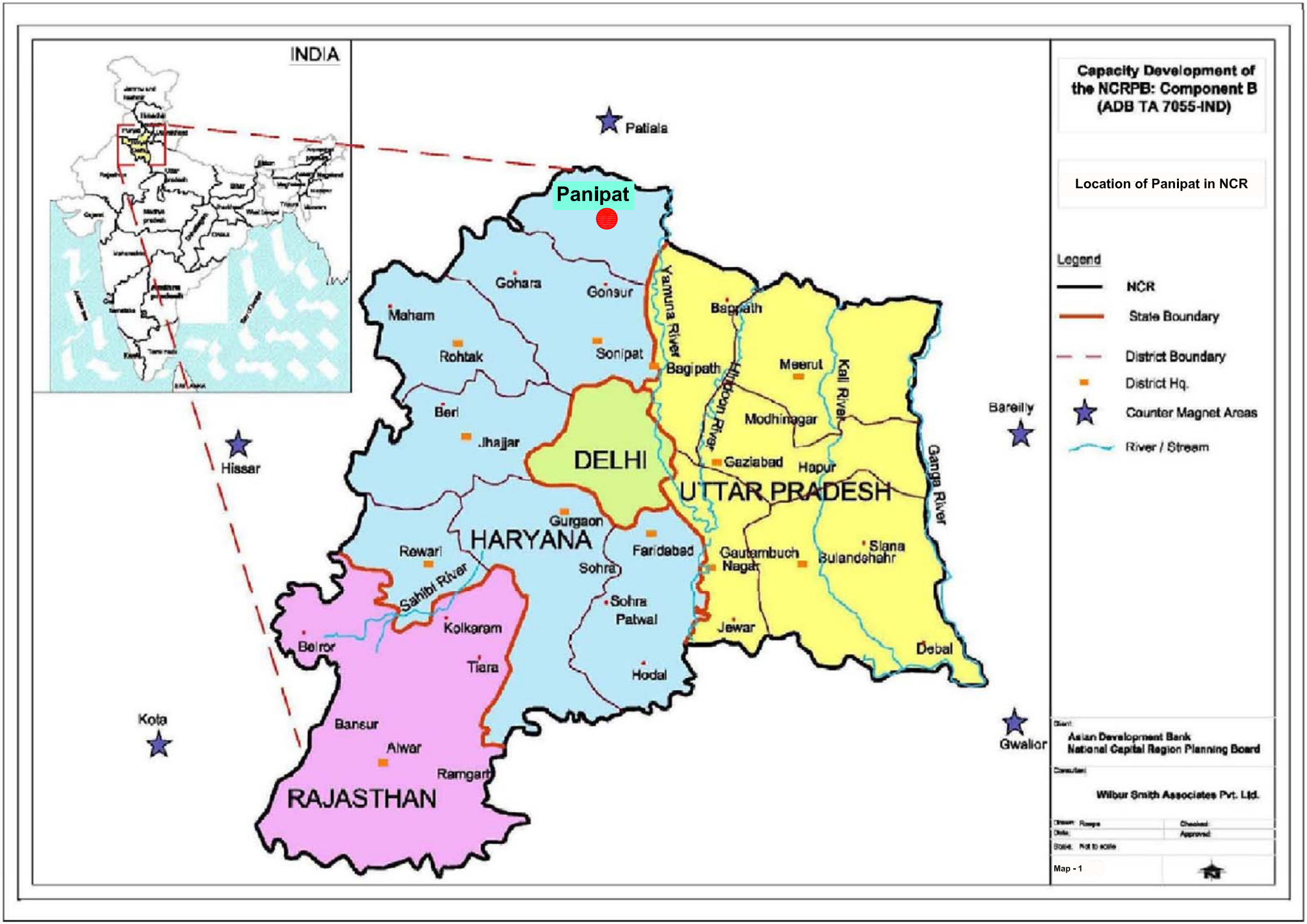
1. Population Growth

29. The population of Panipat town was 38,000 in 1941 and increased to 54,981 in 1951 due to large scale immigration of displaced persons at the time of country partition in 1947.

Table 1: Population Growth of Panipat

Year	Population	Decadal Growth Rate (%)
1941	38,000	-
1951	54,981	44.73
1961	67,026	21.81
1971	87,981	31.34
1981	137,927	56.82
1991	191,000	38.41
2001	261,740	27.00

Source: Census


INDIA
Capacity Development of the NCRPB: Component B (ADB TA 7055-IND)
Location of Panipat in NCR
Panipat
Patiala
Hissar
Kota
Bareilly
Gwalior
Legend
NCR
State Boundary
District Boundary
District Hq.
Counter Magnet Areas
River / Stream
DELHI
HARYANA
UTTAR PRADESH
RAJASTHAN
Gohara
Gonsur
Maham
Rohtak
Sonipat
Baghpath
Meerut
Modhinagar
Gaziabad
Hapur
Beri
Jhajjar
Gurgaon
Rewari
Faridabad
Sohra
Sohra Patwal
Sahibi River
Kolkaram
Behror
Tiara
Hodal
Jewar
Gautambuch Nagar
Siana
Bulandshahr
Debal
Ganga River
Yamuna River
Hindon River
Kali River
Bansur
Alwar
Ramgarh
Asian Development Bank
National Capital Region Planning Board
Wilbur Smith Associates Pvt. Ltd.
Not to scale
Map - 1

30. In the period of 50 years (1941-1991) the average decadal growth rate has been 38.6%. In the Regional Plan, 2001 of National Capital Region, the assigned population for the town for the year 2001 was 500,000. However, it achieved a population of only 261,740 in Panipat municipal limits (as per census 2001) and 354,148 in urban agglomerate which include villages in the fringe of the town. Growth rate during 1991-2001 is 27 percent.. However, there has been sharp growth of population in the fringe villages during last decade. Due to slump in the market and closure of certain Spinning Mills, it may not be possible to achieve the same growth rate during the current decade. The revised draft development plan has anticipated a population of 700,000 up to the year 2021. It has been assumed that the growth rate during the next decades will be around 40 percent.

2. Occupation structure

31. The occupational structure of town as per Census 2001 is presented in the table given below. Workforce is predominantly engaged in industrial sector, followed by trade and commerce and service sectors.

Table 2: Occupational Structure of Panipat

Occupational Sector	**1971**	**1981**	**1991**	**2001**
	%	*%*	*%*	*%*
Primary Sector	9.78	7.37	5.30	4.00
Industry	32.79	36.39	39.70	40.00
Construction	2.55	2.89	3.10	4.00
Trade and commerce	25.95	25.14	24.60	20.00
Transport and communication	5.95	5.36	4.80	12.00
Other services	22.98	22.85	22.50	20.00
Percentage to total population	**26.80**	**30.40**	**30.00**	**32.0**

Source: Census

C. Land Use and Growth Trends

1. Existing Land Use

32. The existing town of Panipat has expanded on both sides of GT Road. The old settlement is on an elevated tract of land, which once upon a time was a fortified town. The features of historical importance of the town are Lodhi Tomb, Devi Mandir and Tomb of Saint Qualendar. River Yamuna flows at a distance at about 16 km from the town in the east.

33. The wholesale grain market named Gaushala Mandi and Gandhi Mandi are situated on G.T. Road. A temporary wholesale fruit and vegetable market is situated on Sanoli Road, whereas a new vegetable market with modern amenities has already been constructed by the Urban Improvement Trust, Panipat on the same road to meet with the future needs of the town. A new grain-market with World Bank assistance stands developed over an area of 42 hectares on G.T. Road.

34. Recently Hali Park, a recreational complex named after the famous Urdu Poet "Khawaja Altaf Hussain Hali" has been developed on an area of 11.6 hectares near the industrial area. This complex consists of a children park, a rose garden, fountain, streams and a lake with boating and fishing facilities. Besides this, a stadium has also been constructed on an area of 2.8 Hectares in the Model Town. A tourist complex in an area of 2 Hectares has been constructed by the Tourism Department in a triangular tract on G.T. Road, towards the north of Civil Hospital.

35. Panipat Thermal Power Plant with a capacity of 660 MW constructed on Assandh Road is one of the biggest thermal plants in the country. In addition to above, Panipat is the main distribution centre of electricity produced at Bhakra Nangal Project. Hence the town is likely to attract more projects of national importance in future.

36. The Haryana Urban Development Authority (HUDA) has acquired approximately 1230 hectares of land for development of residential and industrial areas. The development works are under progress. A well-planned Transport Nagar on G.T. Road is a redeeming feature, which has eased the parking congestion in the town to some extent and will provide the facilities at one place once all workshops of the town are shifted to the Transport Nagar. The living environment of the town is likely to improve considerably after the development of industrial sector–29 Part II, as it has the capacity to accommodate all the fibre-dying units scattered presently in and around the town including its residential areas.

37. In order to channelise the development in planned manner and to control the sprawling haphazard piecemeal growth, the state government declared 6740 hectares area around municipal limits of the town in year 1971 as controlled area and 22800 hectares area as additional controlled areas– II and III in the year 1982 under section 4 (I) (a) of the Punjab Scheduled Roads and Controlled areas Restriction of Unregulated Development Act-1963 (Punjab Act 41 of 1963), vide Notification No. 10165-VDP-71/3884, dated the 10th September, 1971 and 10 DP-82/3163, dated the 23rd February 1982 published in the Haryana Government Gazette dated the 24th January 1984 vide Notification No.3591-2TCP/83 dated the 26th October 1983.

2. Development Concept

38. Since Panipat is to be seen as a regional centre for Haryana sub-region of National Capital Region, therefore, there is a need to intensify the development efforts by providing sufficient regional level infrastructural facilities so that it can not only hold back the out-migration but also capture the Delhi-bound migration. Efforts for the same have already been started with the help of public-sector development agencies.

39. Although Panipat has been growing along National Highway-I on a linear pattern, there is a marked twist in favour of East and marginally on the West. Therefore, the axis for development is likely to be in line with natural axis of growth i.e. eastward. The new town is to be developed not as an urban extension of the existing town but as a separate entity in

itself. Predominant wind direction i.e Northwest to Southeast direction and availability of transportation network are the guiding factors for location of major land uses i.e. industry and whole sale trade etc.

40. The municipal limits (old) of the town cover an area of about 1056 hectares. The planning within the existing town is conspicuously absent, except few residential colonies like Model Town, Housing Board colony, and a few pockets developed under town-planning-schemes and planned industrial area.

41. According to the development plan prepared for the town by the state Town Planning Department, estimated population of about 1.75 lacs would be adjusted within old municipal limits. The final development plan provides for the remaining 5.25 lacs(for 2021) to be accommodated in the extended municipal area and controlled area. The town density has been taken as 115 persons per hectare in the final development plan.

42. Since the town is situated on both sides of the Grand Trunk Road, it will generate high criss-cross traffic. The road system has been so proposed in the final development plan that the eastern V-2 Road, along with the inner spine V-2 road can serve as a through high-speed traffic road. V-2 road in the east can serve as an outer ring road. The city centre has been proposed along the inner V-2 road in view of its central location. Further keeping in view the prevailing wind direction the area for industrial use has been proposed mainly towards south duly separated by sufficient wide green buffer from residential area except for some area in west for expansion of the existing industrial area contiguous to the existing town. The land use proposed in the final development plan is given below:

Table 3: Proposed Land Use of Panipat 2021

Land use	**Area within municipal limits**	**Area within extended municipal limits**	**Area within controlled area**	**Total area**	**%age of total area**
	ha	*ha*	*ha*	*ha*	*%*
Residential	400	300	2282	2982	42.53
Commercial	115	50	97	262	3.74
Industrial	262	293	1135	1690	24.10
Transport and Communication	42	-	475	517	7.37
Public utilities	44	--	173	217	3.10
Public and semi public	105	8	180	293	4.18
Open Spaces	88	-	485	573	8.18
Special Zone			477	477	6.80
Total	**1056**	**651**	**5304**	**7011**	**100.00**

Source: Development Plan 2021

43. The phasing of development has been proposed as follows in the Final development plan:

Table 4: Phasing of Development as per Final Development Plan

S.No.	Period	Sector to be Developed	Departmental Activities to be taken up
1	2001-05	(i) Industrial Sector 29-II	
		(ii) Shifting of Dairies	Milk Dairies will be shifted to the site identified at Jatal Road, Panipat.
2	2005-11	(i) Residential Sectors 19, 36, 37, 38, 39 & 40.	(i) Construction of V-2 Road (Eastern Peripheral Road.
		(ii) Industrial Sectors-28 & 30	(ii) Construction of Canal based Water Supply System by P.W.D, Public Health Department.
		(iii) District Center in Sector-13 and 38	(iii) Construction of Common Effluent Treatment Plant.
3	2011-16	(i) Residential Sectors 19-A, 23, 27 & 31	(i) Construction of V-1 Road (Western Peripheral Road)
		(ii) Commercial Sector 22	
		(iii) Public & Semi Public Sector 20 & 21.	
		(iv) Industrial Sectors 32, 33 & 34	
4	2016-21	Rest of the proposal in the development plan	
S.No.	Period	Sector to be Developed	Departmental Activities to be taken up

Source: Development Plan 2021

IV. ASSESSMENT OF EXISTING WATER SUPPLY SYSTEM

A. Introduction

44. This Chapter gives a summary of the existing water supply & sewerage systems. Based on the records and discussions with the Public Works Department – Water Supply and Sanitation Department (PWD-WSS) officials, an analysis of water supply and sewerage systems has been done and is presented here.

B. Existing Water Supply System

1. General

45. There are two water and wastewater service providers in Panipat area for non-industrial users. These are the Public Works Department (Water Supply and Sanitation department) (PWD-WSSD) and the Haryana Urban Development Authority (HUDA). These agencies provide all the basic services pertaining to water supply and sewerage facilities in Panipat town. PWD-WSSD is a state government body and is primarily responsible for providing water supply and sewerage services within the municipal boundaries. Their responsibilities include providing piped water supply and sewerage facilities to the residents of the area.

46. The PWD-WSSD has informed approximately 27,303 water connections in their service area. There are smaller but undetermined number of unauthorized connections. Using an average of six persons per connection, the population officially connected to the water supply system is approximately 163,818. The population in the PWDWSSD service area was documented at 282,714 in 2006. This implies that 58 percent of the population is connected legally to the water supply system. However, a number of consumers located on the outskirts of the PWD-WSSD service area have been reported to be using hand pumps as their main source because of low residual pressure in distribution system at those locations. Due to an unequal distribution of water, per capita water supply in some areas could be less as compared to the targeted per capita rate. It is not unusual for people in wealthier areas to use personal tube wells as a supplemental source of water, especially to meet non-potable needs for cattle bathing, filling coolers, washing vehicles, gardening etc.

47. HUDA is an autonomous government body and functions as the land developer in Haryana. HUDA is the second largest service provider in Panipat and is responsible for providing services only to areas developed by it. The areas under HUDA are divided into “Sectors”. HUDA has separate water works and a wastewater collection system. However, wastewater from HUDA areas is currently being discharged into PWD-WSSD sewers and treated at the existing 35 MLD Sewage Treatment Plant (STP) in Panipat. HUDA has released about 4818 water connections in the HUDA service area.

48. Existing water supply system of Panipat is shown in **Map 2**.

Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Existing Water Supply Distribution System

Legend

- Municipal Boundary
- Ward Boundary
- 20 Ward Number
- Major Roads
- Other Roads
- Railway Line
- Cart Track
- House settlement
- Tube Well
- Temple
- Water Course

Overlay Legend

- Existing Pipe Line
- 4" Pipe Size

Source:
PHED Panipat, Haryana

Client:
Asian Development Bank
National Capital Region Planning Board

Consultant:
Wilbur Smith Associates Pvt Ltd

Drawn: SK	Checked: OPG
Date: Jan.2009	Approved: NSS
Scale: NTS	

Map. 2

49. Tube wells have traditionally been the main source of water in Panipat. However, there is now an attempt to tap the surface water sources. The existing tube wells are demonstrating a marked decrease in yield and deteriorating water quality according to PWD-WSSD and the Ground Water cell of the state Agriculture Department. At few places the ground water quality has become unpotable. Accordingly, the existing water sources are unable to meet the peak summer season demand of the residents. Extensive ground water usage for domestic as well as commercial & Industrial use was observed to be a common phenomenon in the town. The level of the water table is reported to be sharply depleting during last 5 years, resulting in declining yield from existing tube wells. The main water supply sources in the town are listed in Table below. **Error! Reference source not found.** shows the location of existing Tube Wells.

Table 5: Main Water Supply Sources of Panipat

S. No	Existing water works	No, of Tube Wells	Location	O&M By	Water Production
1	Tube Wells in PWDWSSD (Within Municipal area)	115	Various locations	PWD-WSSD	56.31 MLD
2	Tube Wells in HUDA Sectors	41	Various locations	HUDA	15.66 MLD
3	Tube Wells in PWD WSSD areas around Panipat (outside Municipal area)	39	Various locations	PWD-WSSD	9.07 MLD
	Total installed Water Works Capacity	195			81.05 MLD

HUDA – Haryana Urban Development Authority; PWD WSSD – Public Works Department – Water Supply & Sanitation Department
Source: PWD WSSD

50. The total estimated quantity of water delivered to the distribution system of PWD-WSSD and HUDA by this tube well based supply is 81.05 MLD. Allowances have been made for groundwater usage and leakage to estimate the quantity of potable water used by consumers in the area. A leakage factor of 40% has also been applied to the total quantity of water delivered into the distribution system. Thus, the total estimated quantity of water used by consumers is 48.63 MLD. This gives a service level of around 100 lpcd for the present estimated population of 4.86 lacs. Industries are estimated to be using 40MLD water from their own bore wells to meet their requirement.

51. A statement giving particulars of tube wells in municipal area belonging to PWD (WSSD) is given below:

Table 6: Details of Tube Wells inside Municipal Boundary

S. No	Name of Location	Location Code	Pump details			
			Pump Discharge	Head	BHP of Motor	Operating Time
			LPM	*m*	*HP*	*hr/day*
1	Old Housing Board I	TW001	800	70	25	22
2	Old Housing Board II	TW002	600	70	20	22
3	Slaughter House	TW003	800	60	20	22
4	Quila W/Works-I	TW004	750	70	25	22
5	Quila W/Works-II	TW005	750	70	25	22
6	Quila W/Works-III	TW006	750	90	30	22
7	Quila 1000ft new	TW007	1200	60	30	22
8	Sukhdev Nagar-I	TW008	600	70	20	10
9	Sukhdev Nagar-II	TW009	600	60	15	10
10	Rajiv Colony	TW010	600	60	15	10
11	Mangewala Ward 11	TW011	600	60	15	20
12	Mohinderwala Ward 11	TW012	450	70	15	20
13	Chandni Bagh	TW013	600	60	15	10
14	Saini Colony	TW014	600	60	15	18
15	SalarganjGate (Devimurthy Colony)	TW015	750	70	25	22
16	Near Lal Maszid Ward 8	TW016	600	60	15	8
17	Green Park	TW017	600	70	20	10
18	Nehru Nagar	TW018	600	70	20	10
19	Ram nagar-I(Melaram Park)	TW019	600	70	20	10
20	Ram nagar-II(Ranjan Park)	TW020	600	60	15	10
21	Jai Dalal Colny(Fatehpuri Chawk)	TW021	600	70	20	10
22	Ashok Nagar (Tehsil camp)	TW022	800	60	20	12
23	Ramesh Nagar (Tehsil camp)	TW023	800	60	20	12
24	Ramesh Nagar-II (Tehsil camp)	TW024	750	60	20	10
25	Sudhir Nagar	TW025	800	70	25	16
26	Preet Vihar colony	TW026	600	70	20	10
27	Patel nagar	TW027	750	48	15	8
28	Bhagat nagar	TW028	600	70	20	10
29	Vet.Hospital-I	TW029	600	60	15	10
30	Vet-Hospital-II	TW030	750	70	25	10
31	Durgamandir Krishanpura	TW031	600	90	25	12
32	Sarai Mohalla	TW032	800	60	20	22
33	Geetha Colony	TW033	600	60	15	10
34	Kataria Colony	TW034	600	90	25	22
35	Netaji colony	TW035	450	70	15	22
36	Bishan Sarup Colony I	TW036	600	70	20	10
37	Bishan Sarup Colony II	TW037	600	70	20	10
38	Sabji Mandi-I	TW038	600	60	15	22
39	Sabji Mandi-II	TW039	600	60	15	22
40	Mahavir Colony-I Mandir	TW040	600	60	15	8
41	Mahavir Colony-II Mal Godown Road	TW041	600	70	20	10
42	Mahavir Colony-III Paliwal Factory	TW042	800	60	20	10
43	Khatican Basti-I	TW043	600	60	15	10
44	Khatican Basti-II	TW044	600	60	15	10
45	Khatican Basti-III	TW045	300	60	7.5	6
46	Bank Colony	TW046	600	60	15	10

S. No	Name of Location	Location Code	Pump details			
			Pump Discharge	Head	BHP of Motor	Operating Time
			LPM	*m*	*HP*	*hr/day*
47	I B School	TW047	800	70	25	16
48	Khadi Ashram	TW048	600	70	20	14
49	Deha Basti	TW049	600	60	15	8
50	Balmiki Basti Jattal Road	TW050	600	70	20	10
51	Shiv Nagar-1 (Advt.Wala)	TW051	600	60	15	8
52	Shiv Nagar-2 (Peer Wala)	TW052	600	70	20	8
53	Shiv Nagar-3 (Gali no.2)	TW053	600	60	15	8
54	Krishanpura 1 (Tankiwala)	TW054	600	60	15	8
55	Krishanpura 2 (Sanjaypark)	TW055	600	70	20	22
56	Krishanpura 3 (Govt.school)	TW056	600	60	15	20
57	Krishanpura 4 (Fatakwala)	TW057	600	60	15	16
58	Booster Ward no.10	TW058	800	60	20	18
59	Sant Nagar	TW059	600	60	15	8
60	Pachranga Bazar	TW060	600	70	20	16
61	Chawla colony	TW061	600	70	20	22
62	Amar Bhavan Chowk	TW062	750	48	15	16
63	Raj Colony Ward 10	TW063	600	60	15	16
64	Khadi Ashram 1000'new	TW064	1200	60	30	16
65	Idgah Colony	TW065	600	60	17.5	14
66	Sadanand Park	TW066	400	90	20	14
67	Lal Tanki	TW067	600	60	15	14
68	Hero Ground	TW068	400	60	12.5	12
69	Stadium	TW069	400	70	17.5	12
70	Gurutegbahadur Colony	TW070	600	70	20	12
71	Gole Market Old	TW071	400	60		14
72	Gole Market New	TW072	800	60	20	14
73	Bosa Ram Chowk	TW073	400	70	17.5	12
74	National Park	TW074	600	70	20	12
75	Rotary Club	TW075	600	70	20	12
76	Kamalia Bhawan Old	TW076	400	70	15	12
77	Kamalia Bhavan New	TW077	600	60	17.5	12
78	New Model Town	TW078	600	70	20	14
79	Virat Nagar Old	TW079	600	70	20	12
80	Virat Nagar New	TW080	600	60	17.5	12
81	Agrasian Colony II	TW081	400	70	17.5	12
82	Shanti Nagar	TW082	600	70	20	14
83	8-Marla Behind Mandir	TW083	400	90	20	14
84	8-Marla Park II	TW084	600	90	25	12
85	8-Marla -III New	TW085	600	90	25	14
86	Dhanak Basti	TW086	400	90	20	14
87	Sat Kartar Colony	TW087	400	70	15	14
88	Deswal Colony	TW088	400	70	17.5	14
89	Azad Nagar Old	TW089	400	90	20	14
90	Azad Nagar New	TW090	600	90	25	14
91	Raj Nagar New	TW091	600	90	25	12
92	Raj Nagar Shiv Chowk	TW092	600	70	20	12
93	Sanjay Colony Old	TW093	400	70	17.5	12
94	Sanjay Colony New	TW094	600	90	25	14

S. No	Name of Location	Location Code	Pump details			
			Pump Discharge	Head	BHP of Motor	Operating Time
			LPM	*m*	*HP*	*hr/day*
95	Weavers colony	TW095	600	70	20	12
96	Adarsh Nagar New	TW096	600	60	17.5	12
97	Hali Park	TW097	400	60	12.5	12
98	Narain Singh Park	TW098	400	70	17.5	14
99	Catering Institute	TW099	400	60	12.5	12
100	Court Complex	TW100	600	70	20	14
101	Bhatia Colony-I	TW101	400	110	25	12
102	Bhatia Colony-II New	TW102	600	70	20	12
103	Hari Bagh Colony Old	TW103	400	60	12.5	12
104	Hari Bagh Colony New	TW104	400	60	12.5	12
105	New Diwan Nagar	TW105	600	70	20	12
106	Katcha Camp School	TW106	400	70	17.5	12
107	Katcha Camp Opp. Shivamandi	TW107	600	60	17.5	14
108	Batra Colony New	TW108	600	90	25	14
109	Labour colony	TW109	600	90	25	14
110	Gandhi Colony	TW110	400	70	15	8
111	Purewal colony	TW111	600	60	17.5	12
112	Gautam nagar	TW112	600	60	15	12
113	Basant Nagar	TW113	600	60	15	12
114	RK Puram	TW114	600	60	15	12
115	Friends Colony	TW115	400	70	15	12

hr/day – Hours per day; HP – Horse Power; LPM – liters per minute; m - meter

Source: PWD - WSSD

52. A statement giving particulars of tube wells in Panipat urban agglomerate but out side municipal limits belonging to PWD (WSSD) is given below:

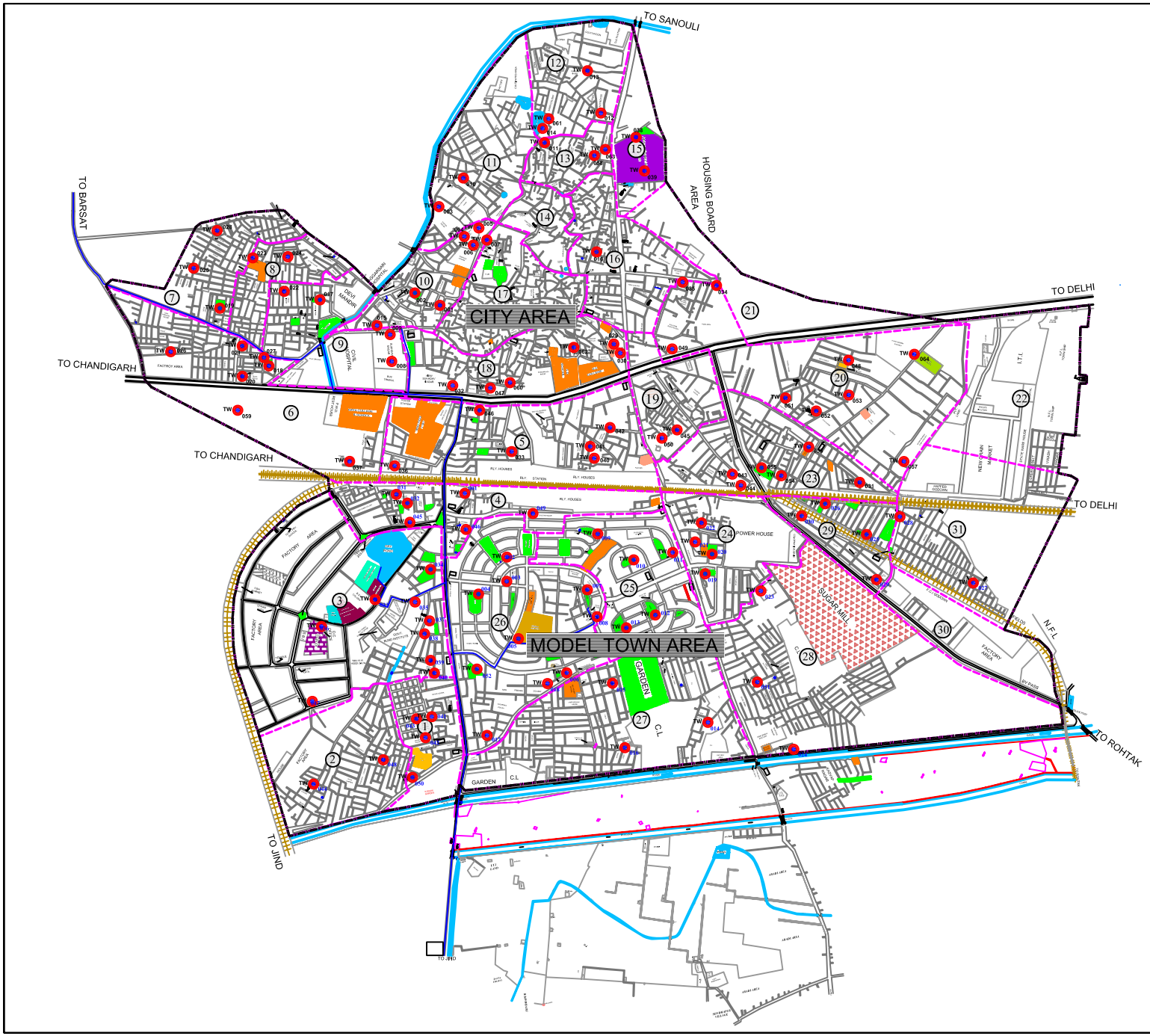
Table 7: Details of Tube Wells in HUDA Area, Panita

S. No	Name of Tube Well	Location Code	Pump details			
			Pump Discharge	Head	BHP of Motor	Operating Time
			LPM	*m*	*HP*	*Hours/day*
1	Sector.6T/W No.01	301	600	45	20	10
2	Sector.6T/W No.02	302	600	45	20	10
3	Sector.7T/W No.01	303	600	45	20	10
4	Sector.11T/W No.01	304	380	45	20	10
5	Sector.11T/W No.02	305	380	45	15	10
6	Sector.11T/W No.03	306	380	45	20	10
7	Sector.11T/W No.04	307	380	45	20	10
8	Sector.11T/W No.05	308	530	45	20	10
9	Sector.11T/W No.06	309	530	45	20	10
10	Sector.11T/W No.07	310	760	45	20	10
11	Sector.11T/W No.11	311	250	45	10	10
12	Sector.12T/W No.08	312	760	70	15	20

S. No	Name of Tube Well	Location Code	Pump details			
			Pump Discharge	Head	BHP of Motor	Operating Time
			LPM	*m*	*HP*	*Hours/day*
13	Sector.12T/W No.10	313	760	70	15	10
14	Sector.12T/W No.12	314	700	60	15	10
15	Sector.12T/W No.13	315	700	60	15	20
16	Sector.12T/W No.14	316	760	70	20	10
17	Sector.12T/W No.15	317	700	60	15	20
18	Sector.12T/W No.16	318	700	60	20	10
19	Sector.12T/W No.17	319	760	70	20	10
20	Sector.12T/W No.18	320	760	70	20	10
21	Sector.13-17T/W No.01	321	600	45	15	10
22	Sector.13-17T/W No.02	322	150	45	20	10
23	Sector.13-17T/W No.03	323	600	45	20	10
24	Sector.13-17T/W No.05	324	600	45	20	10
25	Sector.13-17T/W No.06	325	600	45	20	10
26	Sector.13-17T/W No.07	326	600	45	20	10
27	Sector.18T/W No.12	327	600	45	20	10
28	Sector.18T/W No.13	328	600	45	20	10
29	Sector.24T/W No.01	329	760	45	15	10
30	Sector.24T/W No.02	330	760	45	15	10
31	Sector.25-I T/W No.01	331	380	45	20	10
32	Sector.25-I T/W No.02	332	760	45	20	10
33	Sector.25-II T/W No.02	333	760	60	15	10
34	Sector.25-II T/W No.03	334	760	60	15	10
35	Sector.25-II T/W No.04	335	760	60	15	10
36	Sector.29-I T/W No.01	336	760	60	15	10
37	Sector.29-I T/W No.02	337	760	70	20	10
38	Sector.29-II T/W No.01	338	600	60	20	8
39	Sector.29-II T/W No.05	339	600	60	20	8
40	Sector.40 T/W No.01	340	600	45	20	2
41	Govt.Land T/W No.01	341	230	45	10	3

hr/day – Hours per day; HP – Horse Power; LPM – liters per minute; m - meter

Source: PWD - WSSD



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Location of Tubewells (Municipal Area)

Legend

- Municipal Boundary
- Ward Boundary
- 20 Ward Number
- Major Roads
- Other Roads
- Railway Line
- Cart Track
- House settlement
- Temple
- Water Course

Overlay Legend

- Tube Well
- 050 Tube Well Number for City Portion
- 050 Tube Well Number for Model Town

Source:
PHED Panipat, Haryana

Client

Asian Development Bank
National Capital Region Planning Board

Consultant

Wilbur Smith Associates Pvt Ltd

Drawn: SK	Checked: OPG
Date: Jan. 2009	Approved: NSS
Scale: NTS	

Map. 3

53. PWD-WSSD supplies water directly from the tube wells into the distribution network. Dis-infection of water is done on-line by using a new compound named ‘Twin-Oxide’. The tube wells are operated for 8 to 12 hours daily. However, the consumer end pressures are generally low. In the old city area, which is thickly populated, water from the tube wells is first collected in a ground level reservoir and then pumped into the distribution network. Water is then supplied to consumers by making zones, zone wise for 2 hours daily. There are 115 tube wells of PWD(WSSD) in the municipal area and 39 tube wells in the surrounding areas of municipal area in the urban agglomerate being served by PWD(WSSD) as per list placed given above. Details of some of tube wells constructed regarding lithology, well assembly, initial capacity and draw down etc. is placed at **Annexure 1**. Condition of few tube wells is depicted below:

54. HUDA has a sectoral approach. It has constructed a set of tube wells in each sector. Water is collected in a CWR in each sector and then boosted into the distribution network after dis-infection. HUDA has also constructed few OHSRs but the same are defunct and the general practice is to boost water directly to distribution system. As population in HUDA area is quite less compared to projected population, there is generally no pressure problem, but as load increases, the system will get into strain. There are in all 41 tube wells in HUDA area as per list given above.

55. HUDA is executing a project to supply raw water to Industries from the WJC canal through a dedicated pipeline. This is likely to take care of the projected water demand of industries in HUDA industrial sectors.

56. There is no metering system for water produced or for water supplied. Domestic water connections are all on flat rate basis. Recently metered connections have been started for commercial consumers. In absence of metering of production and distribution water, there is no system of estimating losses in distribution system. However, it has been reported that there are large number of un-authorised water connections. The general pattern of leakage losses in other water supply projects of similar nature and size has been reported to be around 40% and accordingly distribution losses have been assumed to be around 40% for Panipat town.

57. The status of water connections as on November 1, 2008, was as follows:

Domestic Flat rate (15mm)	27,083
Commercial Metered (25mm)	220

58. The department charges a connection fee of Rs1000 for each new connection. The present tariff is Rs.25 per month for single tap connections and Rs.48 per month for two tap connections. The revenue collected during last three years in Panipat Town is as follows:

Table 8: Revenue Collected

Year	**Assessment**		**Collection**	
	Water Supply	**Sewerage**	**Water Supply**	**Sewerage**
	Rs. million			
2005-06	12.88	0.37	5.79	0.14
2006-07	15.96	0.42	8.32	0.63
2007-08	18.40	0.76	11.03	0.91
2008-09(Up to Oct 2008)	NA	NA	2.05	09.40

Source: PWD – WSSD

2. .Industrial Water Supply:

59. The old industrial area is located in Sewerage Zone I and receives water supply from PWD-WSSD. The industrial area in Panipat is maintained by HSIDC and HUDA. Major Industries in Panipat are weaving and dyeing units. Textile dyeing is the main Industry in Panipat. There are 451 small scale and large dyeing units scattered all over town. Some industries distributed spatially across the town use PWD-WSSD water supply, others use unregulated bore wells for their process water requirements. PWD (WSSD) estimated that Industries are using 40MLD water from their own tube wells to meet their requirement. Most of these industries are discharging their effluent into public sewers and drains. Data obtained from the local PCB office show the wastewater discharge of these industries is 34 MLD. The modes of disposal of industrial effluent are land application, PWD-WSSD sewers and septic tanks and at times in ground through deep bore wells without any treatment. Following photographs depict condition of drains on account of industrial effluents:

60. It has been proposed that dyeing units shall be relocated to Sector 29 Part II, and a CETP of 42 MLD shall be constructed in two phases of 21 MLD each. The treated effluent from CETP shall be taken to Panipat Drain. This under-construction CETP will reduce the load on existing sewerage scheme.

C. Water Supply Analysis

61. *Use of groundwater for domestic / commercial / industrial purposes*. The water supply system of Panipat town has not been given any comprehensive look for improvement during past. The approach seams to have been mostly ad-hoc. Construction of additional tube wells to meet increased demand or construction of new tube wells as replacement against failed tube wells has been the practice. Similarly extension of pipe lines in new developed areas has been done. There is no defined zoning of distribution system. Whenever there is any complaint of low pressure, laying additional pipe line or a new pipe line of bigger size seems to be the practice.

62. In addition to this, there has been sharp growth of population on the fringe of municipal boundary. As there is no check on this growth in rural area, on urban pattern due non development in formal urban area and fast economic growth in the municipal township, PWD(WSSD) has provided partial water supply in such areas by constructing tube wells and laying skeleton distribution system. This was good from the point of view of providing immediate relief but has resulted in creating proper system for water distribution, release of regular water connections and putting the required sewage network in place.

63. As ground water is available at reasonable depth and tube well construction is not a problem, industrial water demand is mostly met through privately owned tube wells. This however, creates a problem on sewerage front because effluent discharge from the industries is either put into the sewers or in open drains. The discharge of open drains is also connected to sewers at many places. Thus there is excess flow into the sewers on one hand and quality of sewage also become worst as the industries discharge their effluent untreated. This is putting excessive load on the STPs resulting in poor quality of effluent being discharged into the Panipat drain from the treatment plants.

64. The water supply system of Panipat is facing several problems at present. A low level of service in terms of low per capita water supply rate, short hours of supply, insufficient terminal pressure in the outlying areas, and non-uniform spatial supply rate are among these problems. Most of the unauthorized colonies do not receive municipal water supply. These problems affect the water consumption patterns in the following ways:

(i) These colonies not receiving municipal water supply use ground water extensively to meet drinking and non-drinking needs of water.

(ii) Areas connected to the municipal water supply system but located at the service end use ground water to supplement the municipal supply due to low rate of supply and low terminal pressure.

(iii) Small household industries and commercial enterprises (dying, dairies, hotels, nursing homes, and hospitals) continue to rely heavily on ground water to meet their demands.

65. The water being supplied by PWD-WSSD and HUDA in Panipat is 81.05 MLD. Industries are using 40 MLD water to meet their requirement from their own ground water sources. Most industries have bore wells for their water requirement. Therefore the net quantity of water being used for industrial and non-industrial uses works out to be around 121.05 MLD. With a return rate of 0.8, this should generate 96.8 MLD of waste water. Drain flow measurements were carried out during preparation of Sewerage Master Plan under Yamuna Action Plan II to ascertain the net quantity of wastewater being generated in the town. The measurements were made using V-notch for relatively narrower (upto 2.5m water way) channels and current cup type flow meters for wider drains. It was estimated that approximately 79.63 MLD wastewater is being disposed of outside the town.

66. The flow measurement of drains was carried out at three locations, and the results are tabulated below:

Table 9: Flow Measurement of Wastewater Drains

Flow Measurement Location and Date	**Time**	**Flow**	**Average Flow**
		MLD	*MLD*
Site 1: 35 MLD STP disposal Drain			
May 29, 2007	11:30 AM.	77.34	
	3:30 PM.	81.79	78.09
	6:00 PM.	75.14	
Site 2: Nohra Drain (after 10 MLD STP disposal)			
May 29, 2007	9:30 AM.	15.05	
	2:30 PM.	14.34	13.86
	5.00PM.	12.19	
Site 3: Near Kabri Road Panipat Drain			
May 29, 2007	10:30 AM.	11.44	
	1:30 PM.	9.62	10. 31
	7:00 PM	9.87	

Source: Sewerage Master Plan of Panipat
MLD – million liters per day

67. There is evidence that a significant amount of wastewater is being discharged to open drains leading to river Yamuna. If this undetermined quantity of wastewater is added to the volume of wastewater being pumped through the PWD-WSSD and HUDA MPS, the total volume of wastewater would exceed the volume of wastewater that would have been produced corresponding to the municipal water supply figure. The volume of water which is being used over and above the municipal supply is difficult to assess but definitely is a significant amount.

D. Assessment of Existing Wastewater Facilities

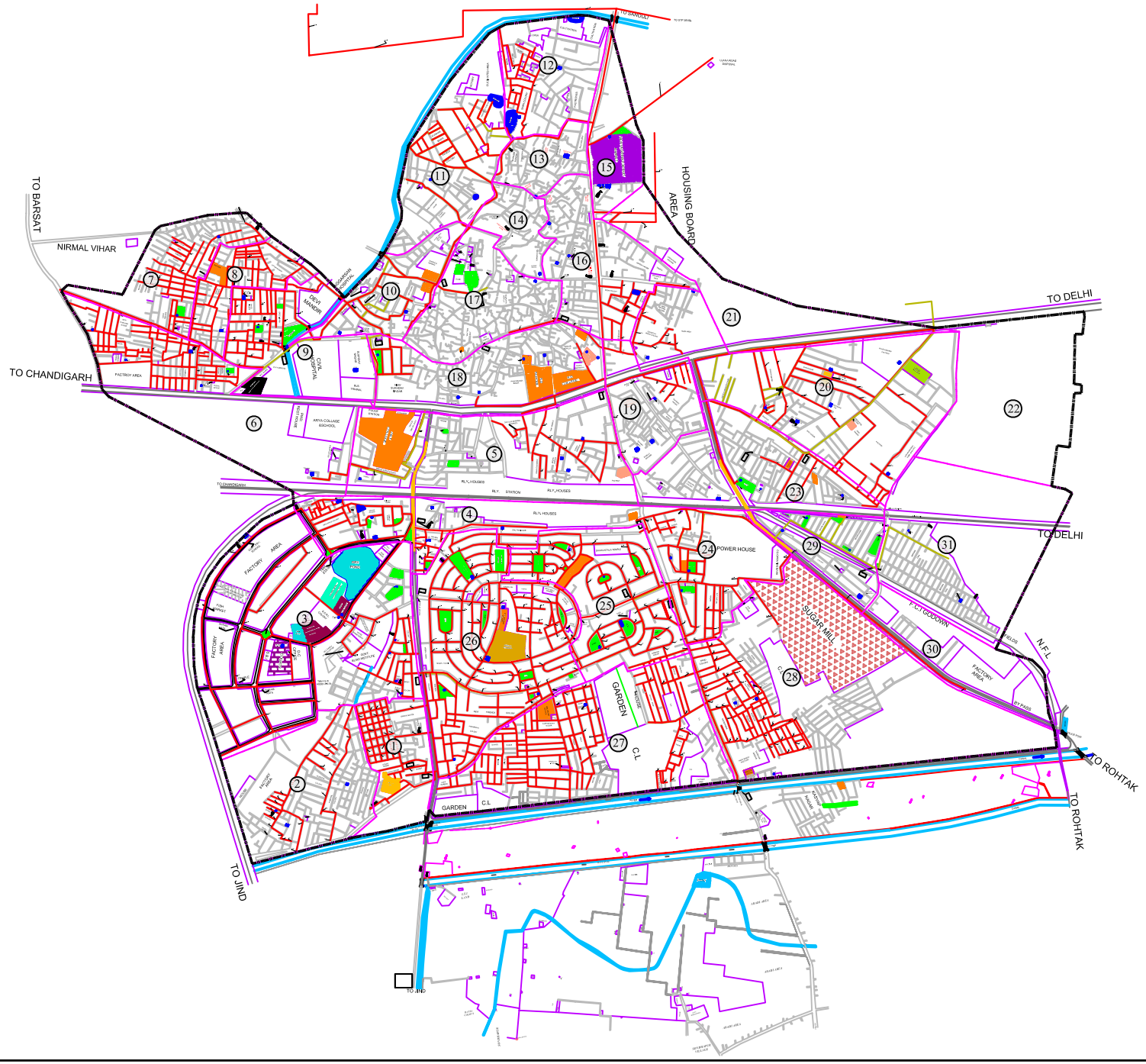
1. General

68. More than 197 km of sewers varying in sizes from 150 mm to 1800 mm are being operated and maintained by PWD (WSSD) and HUDA in Panipat town. There are around 3729 sewerage connections in the town, which indicates that not even 10% population is connected to the sewerage system. Most of this network was layed under Yamuna Action Plan I. There are 2 sewage main pumping stations and one intermediate pumping station which pump sewage into two STPs of 10 and 35MLD capacities. The effluent from the treatment plants is discharged into Panipat drain, which ultimately meats river Yamuna. In addition to this, sewerage system has been provided by HUDA in its own colonies called sectors. However, HUDA has not constructed any STPs so far and is thus discharging its sewage into the STPs of PWD (WSSD).**Map 4** and **Map 5** respectively show existing sewerage zones and the existing sewerage system.

69. Each element of the existing sewerage infrastructure has been evaluated while preparing Sewerage Master Plan under Yamuna Action Plan II during 2006. **Map 6** shows Sewerage Master Plan of Panipat.

2. Storm water Drainage Issues

70. **Map 7** shows the approximate locations and sources of storm water being discharged into the sewers, locations of sewer overflows into storm water drains, and locations of sewer bypasses in storm water drains. The storm water of Panipat is discharged into Panipat Drain. Industrial discharge from the Industrial area in Ward 1, 2, 3 and Sector 25 also finds its way to Panipat Drain. Surface drains have been observed along some roads and streets. Separate storm water drains are available for some parts of the town. Unsewered areas of Quila area, Chandni Bagh, Saini Colony are discharging raw wastewater into Panipat Drain.



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Existing Sewerage System

Legend

- Municipal Boundary
- Ward Boundary
- 20 Ward Number
- Major Roads
- Other Roads
- Railway Line
- Cart Track
- House settlement
- Tube Well
- Temple
- Water Course

Overlay Legend

- Existing Sewer Line
- 20" Size of the Pipe

Source:
PHED Panipat, Haryana

Client:
Asian Development Bank
National Capital Region Planning Board

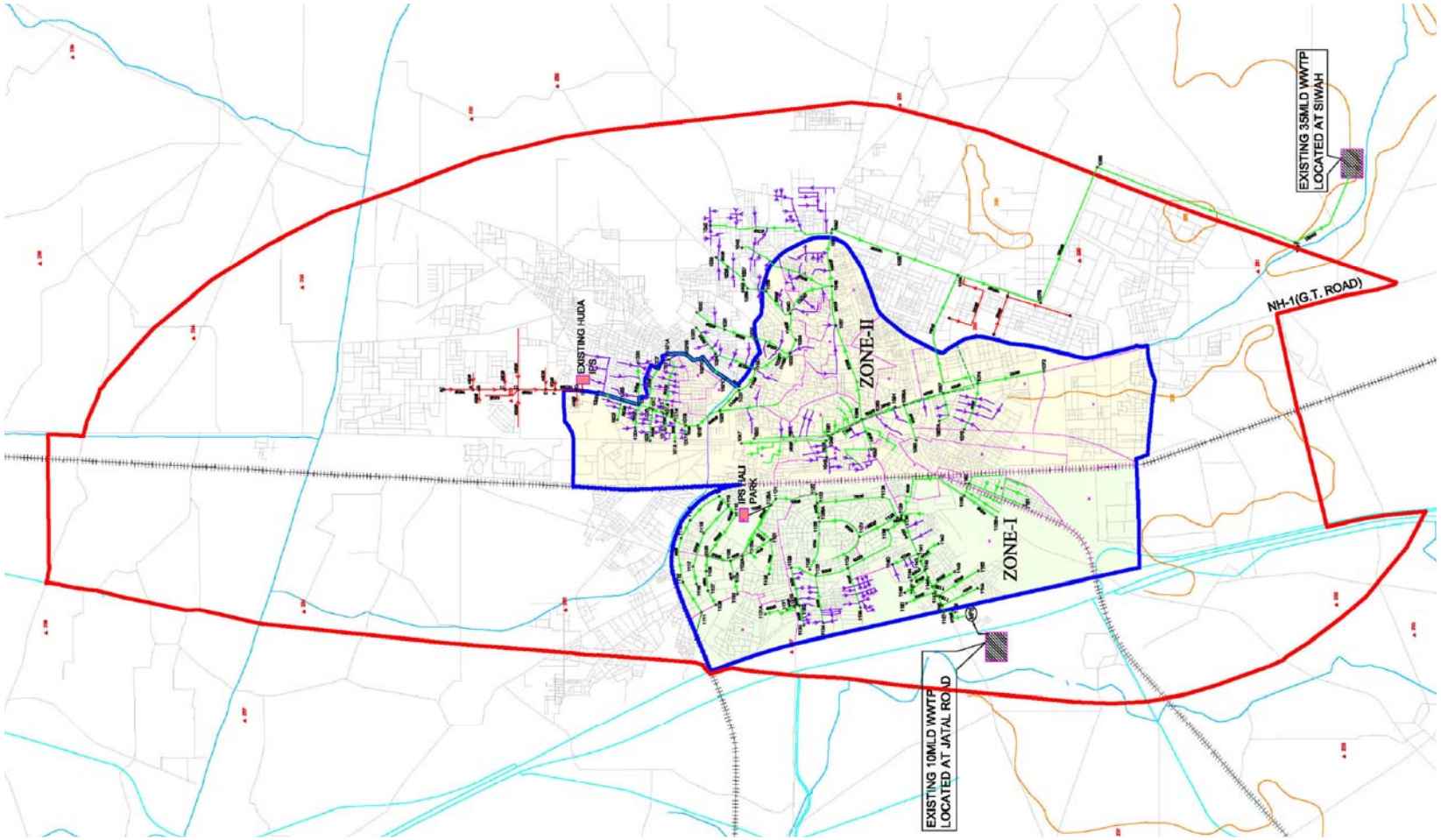
Consultant:
Wilbur Smith Associates Pvt Ltd

Drawn: SK	Checked: OPG
Date: Jan. 2009	Approved: NSS
Scale: NTS	

Map. 5

Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Existing sewerage Zone in Urban Extent Area



LEGEND:-

1. PWD-WSSD SEWERS
2. PWD-WSSD LATERALS
3. RISING MAIN
4. EXISTING HUDA SEWERS
5. STORM WATER DRAIN
6. MUNICIPAL AREA
7. ROAD
8. DRAIN
9. CANAL
10. WARDS
11. WARD NO. 21
12. RAILWAY LINE
13. SEWERS DIA FOR EX. 300mmØ
14. NODE NO. 1079
15. CONTOURS 235
16. SPOT HEIGHT ▲ 231
17. EXISTING MPS LOCATION
18. EXISTING WWTP & MPS LOCATIONS
19. ZONE-I
20. ZONE-II
21. STUDY AREA
22. EXISTING IPS

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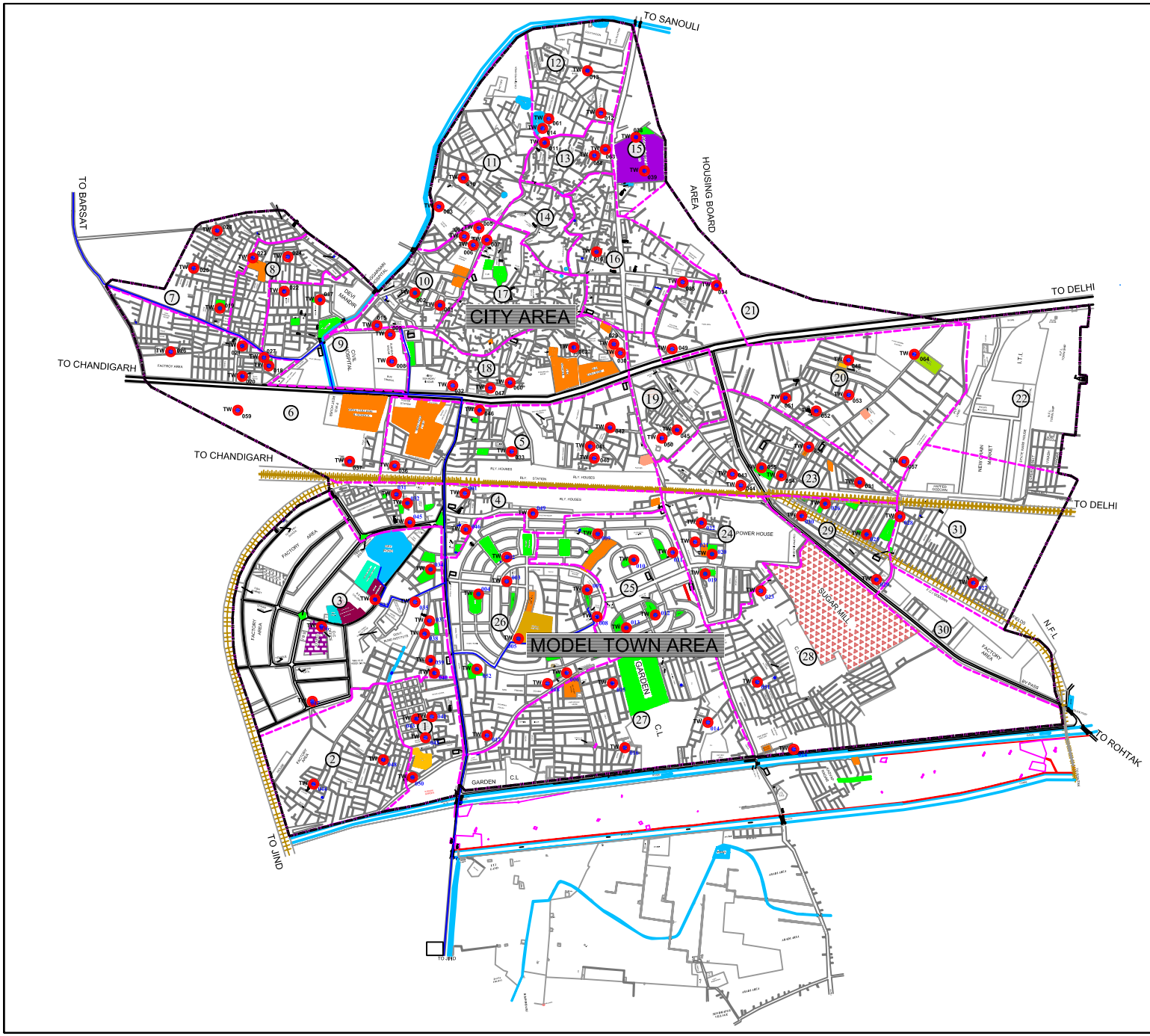
Map. 4



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Location of Tubewells (Municipal Area)

Legend

- Municipal Boundary
- Ward Boundary
- 20 Ward Number
- Major Roads
- Other Roads
- Railway Line
- Cart Track
- House settlement
- Temple
- Water Course

Overlay Legend

- Tube Well
- 050 Tube Well Number for City Portion
- 050 Tube Well Number for Model Town

Source:
PHED Panipat, Haryana

Client

Asian Development Bank
National Capital Region Planning Board

Consultant

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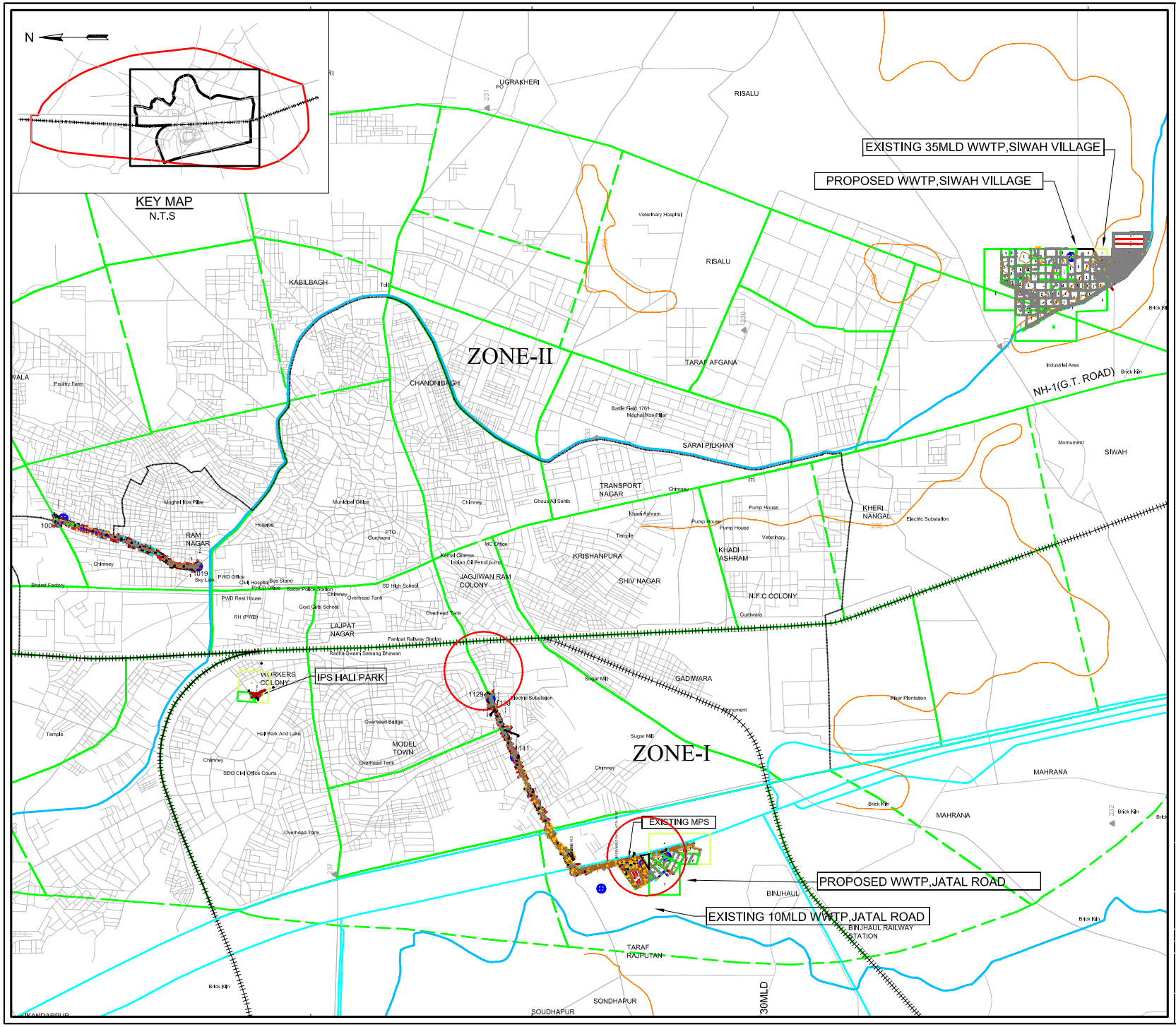
Map. 3



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Sewerage Master Plan

Legend

- Municipal Limit
- Road
- Railway Line
- Canal
- Drain
- Sector

Overlay Legend

- Pumping Station
- Waste Water Treatment Plant
- Sewer
- Rising Main
- Bore Hole

Client:
Asian Development Bank
National Capital Region Planning Board

Prepared By:
Wilbur Smith Associates Pvt Ltd

Drawn: SK	Checked: OPG
Date : Jan. 2009	Approved:NSS

Scale: 0 0.5 1 Km

Map. 6

3. Assessment of Existing Sewage Pumping Stations

71. The town is divided into 2 sewerage zones for wastewater management. It has been observed that pressure gauges are not working for almost all the pumping stations. Lifting devices, automation and level switches also require repairs. Mechanical screens are not working. Manual screens are inadequate and allow plastics and other floating material to enter the wet wells. Table below is a comparison of the estimated maximum capacity of each pumping station with estimated peak flows, including estimated infiltration but not including potential storm water inflow, for 2011 population estimates.

Table 10: Comparison of Existing Pumping Capacity and Total Estimated Flow

Pumping Station Name	**Estimated Peaked Capacity (Present)**	**Estimated 2011 Peak Flow**
	MLD	*MLD*
Master Pumping Station for 10 MLD STP,Zone I	20	31
Master Pumping Station at 35 MLD STP, Zone II	70	77
Intermediate Pumping Station Hali Park, Zone I	9.6	8

Source: Analysis
MLD – million liters per day; STP – Sewage Treatment Plan

4. Assessment of Existing Sewage Treatment Plants

72. Table below is a comparison of the estimated maximum capacity of each STP with estimated average flows, not including potential storm water inflow, for 2011 population estimates.

Table 11: Comparison of Existing STP Capacity and Total Estimated Flow

Pumping Station Name	**Estimated Peaked Capacity(Present)**	**Estimated 2011 Peak Flow***
	MLD	*MLD*
Master Pumping Station for 10 MLD STP,Zone I	20	31
Master Pumping Station at 35 MLD STP, Zone II	70	77
Intermediate Pumping Station Hali Park, Zone I	9.6	8

*Estimated average flows (without industrial wastewater). However, industrial waste finding its way to the treatment plant is substantial and causing overloading of the same resulting in poor quality of effluent coming out from Sewage Treatment Plants.

73. *35 MLD STP*. The 35 MLD capacity STP, based on UASB technology, is located at Village Siwah and was constructed under YAP I. The treated wastewater is discharged into Panipat Drain which eventually meets the river Yamuna. The main treatment units of the plant are an inlet chamber with mechanically cleaned bar screens, grit channels, the UASB reactor and the final polishing unit (FPU). A biogas holder is also provided for collection of biogas which can be either flared or utilized in a dual fuel engine. The sludge from the UASB reactor goes to the sludge dewatering beds for drying before it is sold as agricultural manure. A summary of the observations are given below:

(i) The wastewater coming to the STP is of different colours at different times of the day indicating a very high presence of influents from the dyeing industry.

(ii) The average incoming flow to the plant has reached 31 MLD. It is in excess of the design flow of 35 MLD during some parts of the year.

(iii) The removal of pollutants in the UASB is as follows: These are lower than what was assumed in the DPR.

- COD: 34%
- BOD: 63%
- TSS: 71%

(iv) The removal of pollutants in the FPU seems to be overstated especially for a one day pond. In fact, the FPU is operating more like an anaerobic/facultative pond rather than as an oxidation pond.

(v) Poor performance of the screening facilities, especially the mechanical screens, is one of basic reason for the poor performance of the plant.

(vi) The FPU, as a secondary treatment facility after the UASB, seems to be inadequate to achieve the desired treatment standards.

74. *10 MLD STP*. The 10 MLD STP, based on UASB technology, located on Jatal Road near the Western Jamuna Canal, was commissioned in 2001, under YAP I. The treated wastewater is discharged into the Nohra drain. The main treatment units of the plant are an inlet chamber with mechanically cleaned bar screens, grit channels, the UASB reactor and the final polishing unit (FPU). A biogas holder is also provided for collection of biogas which can be either flared or utilized in a dual fuel engine. The sludge from the UASB reactor goes to the sludge dewatering beds for drying before it is sold as agricultural manure. Main observations are:

(i) The removal of pollutants in the UASB are reported to be:

- COD 35%
- BOD 64%
- TSS 76%

(ii) The maintenance of electrical and mechanical equipment is minimal.

(iii) The laboratory testing facilities at the site need to be improved.

(iv) The FPU, as a secondary treatment facility after the UASB, is inadequately sized to deliver the expected treatment standards.

E. Existing O & M Considerations

75. PWD-WSSD has following sewer cleaning equipment/practices available in Panipat.

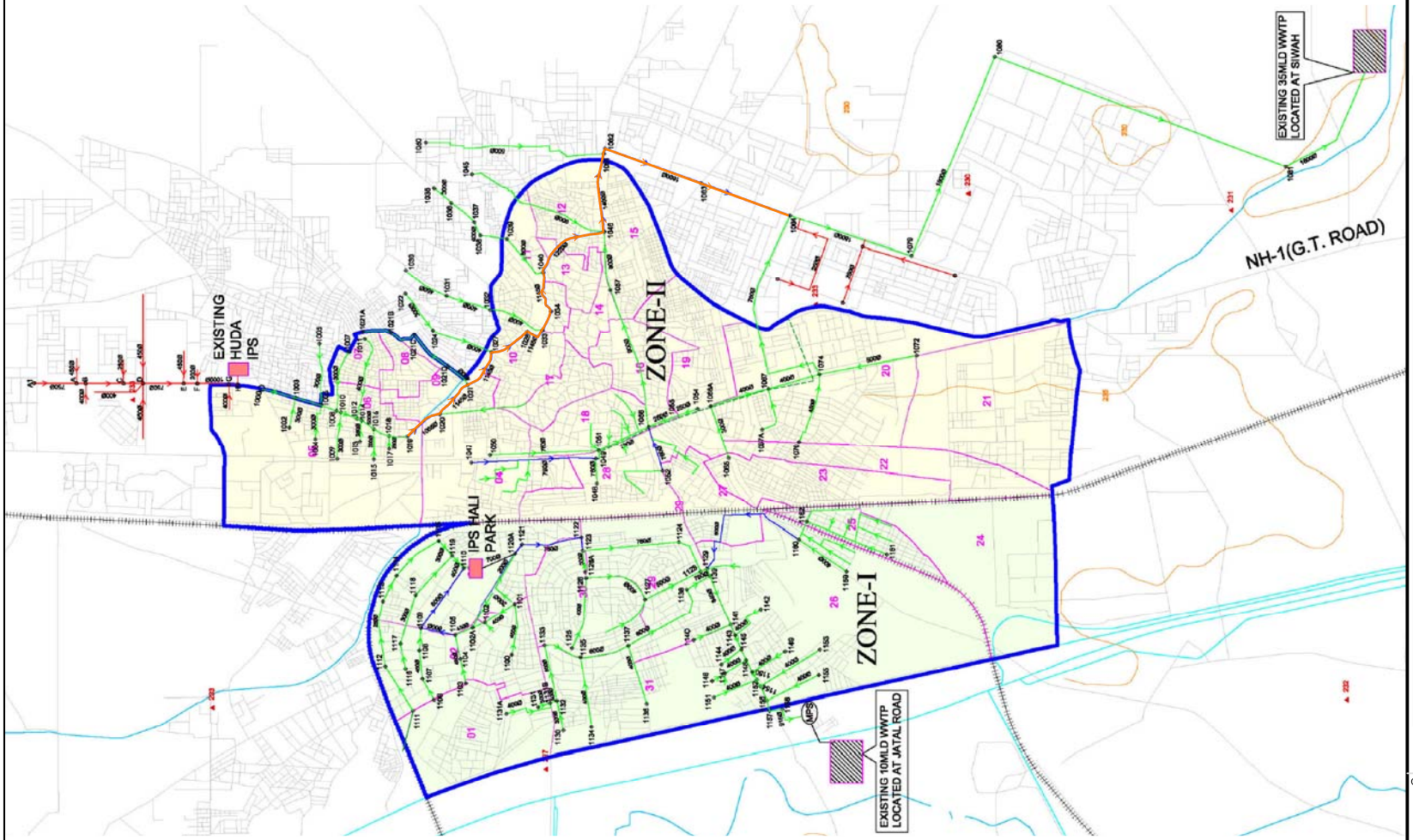
(i) D. G. Sets (3 no.s)

(ii) Jetting Machine: The machine is utilized for cleaning major blockages in the trunk mains. Trunks are generally cleaned with this machine. The machine is suitable for wide roads only and has limited uses in the town.

(iii) Rope and bucket machines (2 no.s): This machine is used for cleaning mains and sub-mains in the town and has relatively higher usage.

iv) Bamboo Sticks: This is the most widely used technique in the town. It provides immediate relief to the households and is quite efficient in cleaning of smaller laterals. Twenty-five sewer personnel are available as permanent staff for regular maintenance of the sewerage system in the town. Extra laborers are used on contract basis if needed. The most common bottleneck observed in the system is due to unauthorized connections.

76. It was observed that sewage/industrial effluent flowing in open drains has been diverted into the sewage man-holes at several places. This results in lot of silt and foreign material getting into the sewers causing choking of sewers and overflowing of man-holes. The condition of sewers has also been adversely affected on account of industrial untreated waste from textile mills getting into the sewers. The Master Plan prepared for Sewerage system for 2040 under Yamuna Action Plan II has recommended for a detailed survey of sewers through CCTV for their detailed condition assessment. **Map 8** shows the sewers identified for CCTV surveys and desilting.



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Sewers Identified for CCTV Survey and Desilting

LEGEND:-

1. PWD-WSSD SEWERS
2. SEWERS IDENTIFIED FOR CCTV INSPECTION + DE-SILTATION
3. RISING MAIN
4. HUDA EXISTING SEWERS
5. STORM WATER DRAIN
6. MUNICIPAL AREA
7. ROAD
8. DRAIN
9. CANAL
10. WARDS
11. WARD NO. 21
12. RAILWAY LINE
13. SEWERS DIA FOR EX. 300mm
14. NODE NO. 1079
15. CONTOURS
16. SPOT HEIGHT ▲ 231
17. EXISTING MPS LOCATION
18. EXISTING WWTP & MPS LOCATIONS
19. ZONE-I
20. ZONE-II
21. EXISTING IPS

Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates Pvt Ltd

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Map. 8

V. DESIGN CRITERIA

A. Introduction

77. The objective of a public protected water supply system is to supply safe and clean water in adequate quantity, conveniently and as economically as possible on sustainable basis. Engineering decisions are required to specify the area and population to be served, the design period, the per capita rate of water supply, other water needs in the area, the nature and location of facilities to be provided, the utilization of centralized or multiple points of treatment facilities and points of water supply intake and waste water disposal. Optimization may call for planning for a number of phases relating to plant capacity and the degree of treatment to be provided by determining the capacities for several units, working out capital cost required, interest charges, and period of repayment of loan, water tax and water rate. The assumptions/guide lines adopted mainly relate to Per capita water supply, design period, population forecast, measurement of flow, water treatment, specifications of materials, water quality standards etc. The main design criteria adopted are described in below sections.:

B. Population Forecast

78. The design population will be estimated with due regard to all factors governing future growth and development of the project area in the industrial, commercial, educational, social and administrative spheres. Special factors causing sudden emigration or influx of population shall also be foreseen to the extent possible. A judgment based on these factors would help in selecting the most suitable method of deriving the probable trend of the population growth in the areas of the project town from out of the following mathematical methods.

(i) Arithmetical Increase Method

(ii) Incremental Increase Method

(iii) Geometric Increase Method

79. In addition to above, population has been assigned in the Regional Plan for 2021 approved by the National Capital Region Planning Board for Panipat and also assessment for population increase has been made in the development plan approved by the state government for the year 2021. These forecasts will also influence our population projections for the design year. The design period for the project will be 30 years. Taking base year as 2011, the master plan is proposed to be designed for 2041. Population forecast will be made for 2041 with interpolation for mid year 2026 and decadal years of 2011, 2021 and 2031.

C. Per Capita Water Supply

80. Piped water supplies for communities should provide adequately for the following as applicable:

(i) Domestic needs such as drinking, cooking, bathing, washing, flushing of toilets, gardening and individual air conditioning.

(ii) Institutional needs.

(iii) Public purposes such as street washing or street watering, flushing of sewers, watering of public parks.

(iv) Industrial and commercial uses including central air conditioning.

(v) Fire fighting

(vi) Requirement for livestock; and

(vii) Minimum possible UFW

81. Looking to the size and type of the township with sewerage system, CPHEEO manual recommends a per capita supply of 135 lpcd. This is exclusive of Unaccounted For Water (UFW) and supply to major Industrial, commercial and Institutional establishments which may require bulk supplies. As ground water is easily available at reasonable depths in adequate quantity for local requirements and also the fact that a major canal is passing through the town, it is assumed that any bulk requirement of water for major industry/commercial/institutional establishment will be met by the establishment it self and no provision for the same is being made. As has been mentioned earlier, in absence of metering of bulk water production and water supplied to consumers, it is not possible to realistically estimate UFW in the system. Looking to present status of the distribution system and previous experience it is presumed that present level of UFW is around 40%. The CPHEEO manual on water supply recommends a maximum of 15% as UFW in water supply system. In view of the proposals envisage taking appropriate action to reduce the UFW and bring down the same to the level of 15%.

82. The Regional Plan 2021 approved by NCRPB provides for a water supply rate of 225 lpcd in the urban areas of NCR. This includes the requirement of water of major industries/commercial/institutional establishments.

83. Looking to the recommendations of CPHEEO and the provisions of Regional Plan 2021, it is assumed that water supply at consumer end will be 135lpcd with UFW as 15%. Thus water supply shall be designed for 160 lpcd. Water requirement of major industries, commercial establishments and institutions with bulk requirement will be met by themselves.

D. Terminal Pressure Requirement

84. CPHEEO manual on water supply recommends that piped water supplies should be designed on continuous 24 hours basis to distribute water to consumers at adequate pressure at all points. The terminal pressure at ferrule point is specified as 7m for direct supply, 12m for 2 storeyed buildings and 17m for 3 storeyed buildings in the above manual. Continuous 24 hours water supply is ideal on following grounds amongst others:

(i) It provides the most economical project design and best utilization of resources.

(ii) It ensures that there is no intrusion of pollution in the distribution system thus ensuring quality of water distributed.

(iii) It provides high level of consumer satisfaction.

(iv) It saves from substantial indirect costs on local storages and purification/disinfections equipments to be provided at consumer end by the consumers.

85. In view of above it is assumed that continuous 24 hours water supply shall be provided with a minimum terminal pressure of 12m as buildings are mostly single story and 2 storied.

E. Design Period for different elements of Water Supply system:

86. Based on the recommendations in the CPHEEO Manual on water supply, following design periods have been adopted:

(i)	Water Treatment Plant	15 years
(ii)	Canal Outlet	30 years
(iii)	Raw and Clear Water main pipe lines	30 years
(iv)	Distribution system	30 years
(v)	Clear water ground/over-head tanks	15 years
(vi)	Pump house buildings	30 years
(vii)	Pumping equipment (E&M)	15 years

F. Water Quality Standards:

87. The water quality standards specified in the CPHEEO Manual on water supply for Physical, chemical and Bacteriological quality will be followed. As recommended in the manual Filtration with disinfection will be proposed as the new source of water is proposed to be canal water. Water quality standards given in the CPHEEO manual are placed at **Annexure 2**.

G. Power Supply

88. It is proposed to take power supply for the main raw and clear water pumping stations on 33kv directly from the 132 kv GSS. In view of this it is assumed that power will be available on continuous 24 hours. The raw water pumping and clear water pumping in the trunk main is therefore assumed to be 23.5 hours daily.

VI. TOWN PLANNING AND POPULATION PROJECTIONS

A. Introduction

89. This chapter presents the population projections for the Water Supply Master Plan. These projections are focused on the estimation of population that is expected to be achieved within the area for which land use has been defined as per the current Town Development Plan. Panipat is located on National Highway No. 1, 85 km north of Delhi and 34 km south of Karnal. The town is the headquarters of Panipat district and has converging roads from Delhi; Gohana, Karnal and Assandh in Haryana and Meerut from Uttar Pradesh. It is a major railway junction on the Delhi - Ambala rail route. The railway line and the National Highway divide the town into two parts. On the western side across the railway line are the industrial area and the model town. The older, historical part of the town is on the eastern side of National Highway No 1. As per the 2001 census records, the town had a population of 261740 with 31 municipal wards, comprising of an area of 1986.7 hectares and a population of 354148 for the urban agglomerate which include surrounding villages within the master plan area.

90. Panipat is popularly known as the “City of Handlooms” or “Weaver’s City” due to a high concentration of textile and handloom units. These units are primarily located in wards 2, 3, 20 and 26. Heavy industries like National Fertilizers Limited in ward 24 and Panipat Oil Refinery northwest of the town are prominent industrial units. The town also has small scale and household industrial units specializing in pickle-making and carpet making.

91. The character of the old town has remained much the same over time. However, the planned sectors developed by Haryana Urban Development Authority (HUDA) have grown and gained importance. The HUDA areas have grown substantially and now represent almost 26 percent of the overall urban population.

92. At the town level, these population projections have been developed for the project target year 2041, and the interim-planning horizon 2021 & 2031. The projections were made with an eye on the past as well as current demographic data, the 2021 Town Development Plan, and the 2021 NCR Regional Development Plan.

93. The population projections have also been developed for the wards within the municipal area and areas for which land use has been defined as per the current Town Development Plan. These detailed area-wise projections have been correlated with the overall town level projections and together they serve the purpose of developing population suitable for the Water Supply Master Plan.

B. Study Area

94. The study area for the Water Supply Master Plan is as shown on Map 3.1 Within this study area is the urbanisable area (area for which land use has been defined as per the current

Town Development Plan) for which population projections were developed for the year 2041. This study area, covering approximately 8065 hectares, is comprised of (a) the municipal area, and (b) the sectors outside the municipal area as per the Town Development Plan. As the land use pattern of area out side the development plan has not been defined , the same has not been considered for the master plan. This is also in consonance with the area adopted in the Master Plan prepared for Sewerage for Panipat under Yamuna Action Plan II.

C. Past Population and Demographic Growth

95. The analysis of the past population data provides an understanding of the growth rates of the town. While census data for the municipal level is readily available, clear documentation of the urban extents and their area in 1991 and 2001 is not available. The demographic analysis at the municipal level is focused on the growth rates, population density, and their correlation if any. At the town level, the growth rates have been examined in the context of state, district, and other project towns.

Table 12: Past Population and Growth Rates for Municipal Extents

Year	**Population**	**Area (ha)**	**Density (ppha)**	**Growth Rate**
		ha	*Persons/ha*	*%*
1951	54981	770	71	-
1961	67026	770	87	21.9
1971	87981	770	114	31.3
1981	137927	1987	69	56.8
1991	191000	1987	96	38.5
2001	261740	1987	132	37.0

D. Review of Development Plans

96. The Development Plan of the town of Panipat and the NCR Regional Plan -2021 are a few of the critical drivers for developing the growth projections for the Water Supply Master Plan. The key highlights of these guiding documents are outlined below:

1. Development Plan-2021

97. The Development Plan of a town is a vision document of the town prepared by the urban planning department of the state government. The key highlights of this guiding document are:

(i) The projections are based on “induced growth” estimations and no mathematical method has been used for establishing population projections.

(ii) At a growth rate of 43 percent and 40 percent, the Development Plan projects a population of 506,866 for the year 2011 and 709,612 for the year 2021.

(iii) The planned development density in the residential pockets is in the range of 125 to 300 ppha.

(iv) An average planned development density for the town is 115 person per ha across the entire Panipat town development area.

(v) The Plan focuses on developing the town as an industrial hub, with the provision of 25.1 % of total area to be developed as Industrial land use and with 42% of the total workforce engaged in industrial activities by 2021.

(vi) The expected direction for development of the town is towards north and northeast.

(vii) The Plan proposes 40 sectors in and around existing Panipat town to be developed per designated land use.

2. Regional Plan – 2021

98. The Regional Plan has been prepared by the National Capital Region Planning Board to bring about balanced and organized growth in the National Capital Region and to reduce pressure on Delhi.

(i) At a growth rate of 41% and 40%, the Regional Plan projects a population of 500,000 (in the year 2011) and 700,000 (in the year 2021).

(ii) The town is a designated as "Regional Center", marked by specialized secondary and tertiary sector activities.

(iii) The Plan proposes strengthening and widening of the Rohtak-Gohana-Panipat National Highway No.71A.

(iv) The Plan proposes construction of a Rapid Rail Transit System between Sonepat-Panipat during 2011 – 2021.

E. Population Projections

99. Population projections for decennial intervals were developed using mathematical methods using the past data available from census data. Other inputs into the projections were the 2021 Town Development Plan and the 2021 NCR Regional Development Plan. The mathematical methods were used as the basis for establishing a best fit with the published town development plans, with the intent of selecting a method which is appropriate to compute future decennial projections.

100. The population projections for the project area were then finalized in consultation with key town planners, experienced professionals, representatives of Urban Local Bodies (ULB) , District Town Planning Office, PWD(WSS) and NCR Planning Board and rationalized using the growth rate method to arrive at the final recommendations of population projections. Having finalized the projected populations by decadal intervals based on census years, estimates were interpolated for the intermediate decadal Years – 2021, 2031 and 2041. Field verifications were done to understand the current development scenario on the ground and examine relative growth between the last census in 2001 and the current development scenario (in 2008). A better appreciation of the accelerated rate of growth and the spatial pattern of urbanization was obtained from this dataset.

1. Overall Population Projections

101. Different mathematical methods were used to ascertain the possible population growths and assess indicative population projections for the town by using these methods (arithmetical, incremental and exponential). Considering the prospects of expansion of the economic base of the town due to the industrial activity and the growth driven by the increasing industrial base of the town, the incremental growth were assessed to mathematically best fit the population growth established by the town development plan and the NCR Regional Development Plan, using 2001 census data as the base.

Table 13: Population Projections based on Growth Models

Year	Development Plan-2021	Arthem-tic increase	Increme-ntal increase	Exponen-ial Method	Growth Rate by Incremental Method	Growth Rate Allocated$ (%)	Computed Population
2001	3,54,148*						
2011	5,06,866 (43%)	4,42,864	4,99,438	566,637	41.0 %	41.34 %	500,543
2021	7,09,612 (40%)	5,31,580	7,01,302	906,619	40.4 %	42.87 %	715,105
2031	-	6,20,296	9,59,740	1,450,590	36.9 %	33.33 %	953,484
2041	-	7,09,012	12,74,752	2,320,944	32.8 %	28.33 %	1,270,597

* Census 2001
Note: The data represented in the parentheses represents the revised projection as per the Development Plan Notification dated February 14, 2006
$ Growth rates have been marginally adjusted as adopted in Sewerage Master Plan, Panipat
Source: Census of India, Regional Plan-2021, National Capital Region and Development Plan – 2021

102. Based on interactions with local officials, field reconnaissance, assessment of current population, and the infrastructure development in Panipat Town, it was perceived that the growth rate over the past 7 years (from 2001 to 2008) had been perceptibly higher than the estimated 40+%. Given this ground reality, the growth rates assessed by incremental growth method appeared to be on the lower side and Panipat was estimated to have the growth potential to grow at a rate marginally higher than that estimated by the NCR Plan and the Town Development Plan. With the increasing urban densities and patterns of surrounding urbanization, the growth rates for subsequent decadal intervals, 2031 and 2041, are anticipated to decline and lower growth rates were forecast using guidance from the mathematical models as well as the induced growth rate analysis.

103. Subsequent to projecting the population for the town and its distribution within the sectors, and wards, the aggregated totals were re-computed to fine tune the growth rates of the town, resulting in the final overall population projections for Panipat. These projections form the basis of the distribution within the currently defined wards and sectors, which have a limited capacity to accommodate the increasing population.

2. Population Projections within Municipal Limits

104. The municipal limits of Panipat are comprised of 31 wards. Assessed based on the 2001 census demographics, the development density of these wards varies from about 36 ppha to 542 ppha. In this broad range the higher densities are associated with the older parts of the town which have densified over the decades. In the absence of spatial information correlating ward geographies between the past and present it becomes impracticable to assess the relative growth differentials and create an explicit relationship between increasing density and declining growth rates. However assessed as a whole, the data from 1981 to 2001, a time period with unchanged municipal extents, reflects an inversely proportional reduction in the growth rate (from 56% to 37%) as population densities increased (from 69 ppha to 132 ppha). Other factors that are an influence are evidently the increasing development outside of the municipal limits that become evident in Panipat from field work, indicating growth directions shifting from municipal to other HUDA sectors and private developers. While part of the municipal area is encompassed by the sectors which have planned development, a substantive part of the municipal extent is reflective of an urban development landscape that is relatively unplanned with organic growth of small lots and old building stock. The building bylaws for the town do not provide for any significant direction of increased development density in such unplanned areas permitting increased densification within the municipal limits while regulating only the planned sectoral developments.

105. As compared to other towns, the extensive industrial activity in the town, especially in the informal sector, has resulted in a high population density on average across the municipal limits. The population density for the decadal interval ending 2001 is consequently at about 132 ppha. Preparing estimates of population within municipal areas based on field reconnaissance, information provided by officials from PWD WSSD, municipal officials etc. has already exceeded the average planned development density for Panipat anticipated at 115 ppha, the municipal area in 2001 and 2008 has already exceeded these population density levels. Although it is not possible to specify a saturation level for the municipal extent, the unplanned residential areas can be expected to achieve densities upward of 300 ppha, and those of planned areas within the municipal limits being between 150 and 300 ppha. Considering the pressures for affordable housing, the slum clusters within the town (generating high base densities in some wards at over 500 ppha) the average development density of Panipat can be anticipated to be upwards of 200 ppha, trending

3. Population Projections in Sectors outside Municipal Limits but within Study Area

106. The development extent of 6,078 ha outside of the municipal limits represents an area of about 3 times that of the municipal extent itself, distributed over 40 sectors. As per current assessments, this area already has a base population of 185,862 persons, with an average density of 31 ppha.

107. The development plan proposes an increase in the industrial land use, an increased residential development density (ranging from 150 – 300 ppha) and the active participation of the private sector in developing the residential areas. The average development density of this area, as per the development plan, is expected to be about 115 ppha.

F. Population Distribution

108. The town has been studied with respect to its administrative divisions, wards and sectors, for the purpose of allocation and distribution of the population. The 31 wards form part of the municipal area. The area outside the municipal limits form part of the planned urban development is categorized into sectors. The portion of sectors that are part of wards, or fall within the municipal limits have been addressed for the projection purpose under the category of wards. The area of the sectors outside of the municipal limits has been addressed under the sectors category.

1. Determinants of Population Distribution

109. Growth drivers are the parameters which act as a catalyst to the growth of the city. These are the phenomenon that attract or repel the population to a particular area, thereby resulting the spread and growth of an urban area in a particular direction. Growth catalysts influencing Panipat are:

(i) Panipat as a Regional Centre: Designated as a regional centre under the Regional Plan-2021 of National Capital Region (NCR Plan), marked by highly specialized secondary and tertiary sector activities. As a Regional Centre, the town will be developed for advanced industrial and other economic activities. These are expected to exert an increasingly dynamic influence on attraction of investment and creation of healthy living and working environment. The industrial impetus coupled with the improvement of infrastructure will generate employment opportunities and is expected to be a major driver for population growth.

(ii) Transport catalyst: The proposals for improvement and development of the road network between Panipat and other important towns of the region like Gohana, Rohtak and Sonepat will provide development impetus to Panipat. A Rapid Rail Corridor has also been proposed to be developed between Panipat-Sonepat. Wider roads in the ‘to-be developed’ town and reduced congestion of the inner town will also enhance the town’s development.

(iii) Employment catalyst: Industrial development being carried out in and around an urban area functions as catalyst to the population growth of the town. Industrial activity generates employment, further attracting an influx of population. This is likely to be among the key drivers for growth in Panipat. Over 1722 hectares of land area (25%) has been allocated for industrial development.

110. Growth Deterrents influencing Panipat are:

(i) Man-Made Barriers: Panipat drain, which crosses the town, has limited the growth towards the east and inhibits development to some extent. The canal on the west also acts as a deterrent.

(ii) Property Barriers: The National Fertilizer Ltd. Township and Thermal Power Plant act as deterrents to the development of the town in the southern side.

2. Field Information

111. As a result of the limitations of not being able to specifically ascribe a growth rate to each ward based on ward-specific past data, it was necessary to assess the development potential of each municipal ward, and build up its potential increase in population through careful analysis of the available data and field-based review of the urban morphology of the municipal extents.

112. Panipat has a complex mix of residential, informal industries, slums, and planned development. The municipal limits are well inhabited, with some areas having very high population densities, the areas under the urban extent have also been growing very rapidly. The areas along the highways and the existing municipal limits has grown rapidly, however areas set further back and relatively less accessible from NH-1 are now beginning to gather development momentum.

113. In the old town areas, commercial activity and daily use shopping is interspersed within the urban fabric with the frontage of buildings conventionally being used for such activity. Added to this, industrial activity seems to be generally pervasive through a large extent of Panipat and current efforts to move textile dyeing units to a specific industrial area are meeting with limited success as the smaller, informal units are difficult to close down and move to this designated area.

3. Assessment of Existing Land Use

114. Land use and development density patterns were identified using the visual interpretation technique and further classified into twelve categories to reflect varying densities. The land use as defined in the Development Plan has been the basis for the allocation and distribution of the population in the urban sectors. The proposed phased development of the sectors was also a consideration in the distribution of the population. The area under residential use, mainly in the Municipal limits was further classified based on the existing density patterns as built up– sparse, built up–low, built up–medium, built up-high and informal colonies. Areas under mixed land use, bodies of water, large institutions and industries were identified.

Table 14: Existing & Proposed Land Use in Panipat Municipal Limits

Land Use Classification	**Existing Land Use**		**Proposed Land Use**	
	Area	**% of total area**	**Area**	**% of total Area**
	ha	*%*	*Ha*	*%*
Residential	1040	52.3	980	49.3
Commercial	28	1.4	165	8.3
Industrial	427	21.5	555	27.9
Public & Semi-Public	95	4.8	113	5.7
Transport & Communication	33	1.7	42	2.1
Public Utility			44	2.2
Open Spaces	252	12.7	88	4.4

Land Use Classification	Existing Land Use		Proposed Land Use	
	Area	% of total area	Area	% of total Area
Special Zone	-	-	-	-
Agricultural Zone*	77	3.9	-	-
Mixed Land Use**	35	1.8	-	-

* Agricultural Zone as a land use type is not defined in the Development Plan Document. However, the supporting Plan drawing depicts large areas entitled Agricultural Zone.
** The Development Plan does not define any development where mixed land is planned. However, on field verification, approximately 1 percent of the Municipal Area has been identified as having Mixed land use, i.e. residential and commercial activities on the same land.
Source: Development Plan

G. Population Computation for Project Specific Years

115. Consequent to the allocation of the population for the decennial years, 2011, 2021, 2031 and 2041, population has been interpolated for the Project Horizon year 2026. The summation of the project populations computed for the municipal area and the planned urban development area represent our project service area population. A summary of these numbers is presented in Table below.

Table 15: Population Projections for Horizon Years

Year	Population in Municipal Area	Population in Urban Areas	Population In the Master Plan	Average Population Density
	No,s	*No,s*	*No,s*	*Persons/ha*
2011	308,574	191,969	500,543	62
2026	374,649	430,390	805,039	100
2041	500,017	717,488	1,270,597	151

Source: Analysis

116. From this information and available area statistics, it may be summarized that the water supply Master plan extent as limited to the municipal area and area outside municipal area for which land use has been defined in the town development plan, as indicated in their currently available town development plan (as per October 2006 documentation).

H. Conclusion

117. The population projections for Panipat have been developed using documented information collected by the Project Team. Projected population has been rationally examined in the context of the growth drivers and is considered reasonable and achievable, given the development characteristics of the town. The projections developed in this document must be viewed as indicative planning numbers and not be considered to be absolute, fixed numbers. The Project Team is working toward development of a Water Supply Master Plan. This chapter addresses the development of estimated growth projections for the purposes of developing a Water Supply Master Plan.

118. It is not our intention to develop a comprehensive urban development plan. This Master Plan is not to be confused with an urban development plan. The projections by Town Planning department and National Capital Regional Planning Board have been the basis of projections made in this study. Allocation of population is made in a scientific manner considering the growth catalysts proposed in Development Plan and Regional Plan, NCR. The population distribution is in consonance with those adopted in Sewerage Master Plan except in some wards where faster growth has taken place than anticipated in the Sewerage Master Plan during last two years as pointed out by the local PWD (WSSD) and based on actual field visits. Although mixed land use forms a minor part of the town area, it has been considered in the review and growth projections of individual wards/ sectors. Having broadly established the projected population by decadal intervals up to the year 2041, the project exercise has been focused on ascertaining the service population that is expected to grow within the municipal and planned urban development area. The balance population growth anticipated would be expected to be accommodated in additional urban development areas that are adjacent, yet outside of the present sectors defined in the Town Development Plan extent. Future updates to the town development plans are expected to make clear such additional Urbanisable Areas and their development guidelines.

VII. WATER SUPPLY PLANNING AND DESIGNING

A. Introduction

119. Asian Development Bank under their Technical Assistance program is providing Technical assistance to National Capital Region Planning Board for Capacity Building in development of Infrastructure projects. It is proposed to produce model Detail Project Reports (DPR) in the following sectors: (i) Water Supply; (ii) Sewerage; (iii) Storm Water Drainage; (iv) Solid Waste Management, and (v) Traffic Planning

120. These model DPRs are proposed to be made available to the implementing agencies of the state governments so that they may replicate the methodology/approach in the future DPRs being prepared by them for obtaining finances from financial institutions including NCRPB. It is also proposed to develop appropriate tool kits for each of these sectors to facilitate preparation of DPRS.

121. It is proposed to produce DPR for water supply for Panipat town, Sewerage for Hapur town, Storm Water Drainage for Hapur and Sonipat towns, Solid Waste Management for Ghaziabad town and Traffic Planning for Ghaziabad town. The present report is the first step in the direction of producing DPR for water supply to Panipat town.

122. The matter regarding preparation of DPR was discussed during the inception meeting with NCRPB. It was thought appropriate that in the first instance a Master Plan may be prepared for the town for 30 years design period and then work for preparation of DPR for one part of the master plan may be taken up. Accordingly Master Plan for water supply to Panipat town has been prepared with design year 2041.

B. Water Supply Analysis

123. Water supply to Panipat town is presently based totally on ground water. PWD(WSSD) through its 115 tube wells in municipal area and 39 tube wells in area out side municipal limits but within urban agglomerate and HUDA through its 41 tube wells in sectors provide water supply to all domestic and commercial consumers. Industries and many private individuals have large number of private tube wells to meet their water requirement. There is no survey data available to allow assess the actual number of such private tube wells in the town. Details of drilling data and well assembly data of departmental tube wells are placed at **Annexure 3**.

124. Panipat district has very good ground water potential. The area is occupied by quaternary alluvium-sand, silt, kankar and gravel which constitute potential water bearing zones. Physiographically, the district is characterized by two distinct features, the upland plain and the flood plain of river Yamuna. The depth to water table varies from 2 m to 33 m. The water table depth is shallow in the southwestern parts of the district and in the flood plain areas of river Yamuna. Deeper water table condition occurs in northern, eastern, central and southern area, where, in general, depth to water table is in between 10 m to 20

m. The water table has declined during the past decades all over the district. When compared with the 10 years depth to water table average (May 93 – May 2003), the water table has declined by 0 – 2 m all over the district.

125. In alluvium, potential fresh water aquifer zones exist down to 460 m depth. Shallow tube wells tapping aquifer zones within 20 m to 40 m depth yield 500 LPM to 900 LPM for moderate draw down. A number of cavity wells also exist in the district. Detailed test drilling has established occurrence of three distinct aquifer groups down to 450 m depth in Upper Yamuna basin which largely includes Panipat District.

126. Aquifer group-I, which occurs under unconfined conditions, extends from water table to 50 m – 150 m depth. Tubewells tapping this aquifer group yield 2100 LPM to 2660 LPM for 5 m to 6 m of drawdown. Transmissivity (T) values of 1850 m2/day and 1950 m2/day, Lateral Hydraulic Conductivity (k) values of 17 m/day and 40 m/day and Specific Yield (Sy) values of 7% and 24% characteristics of this aquifer group-I.

127. Aquifer group-II occurs under semi-confined / confined conditions and in the depth range of 160 m to 250 m. A test well located at Chhajpur tapping this aquifer group in the depth range of 163 m to 252 m yielded 1740 LPM for about 15 m of drawdown. The aquifer characteristics determined are as under:

Table 16: Aquifer Group II Properties

S. No	Aquifer Properties	Value
1	Tranmissivity (T)	350 m2/day
2	Permeability (K)	3.95 m/day
3	Storativity (S)	1.0×10^{-3}
4	Vertical Hydraulic Conductivity	3.10×10^{-3} m/day

Source: Groundwater Cell, Agricultural Department, GoH

128. Aquifer group-III occurs in the depth range of 286 m to 366 m at Dadlana site and is under confined conditions. A test well tapping this aquifer group yielded 600 LPM for about 20 m of drawdown Aquifer characteristics determined are as under :

Table 17: Aquifer Group III Properties

S. No	Aquifer Properties	Value
1	Tranmissivity (T)	390 m2/day
2	Permeability (K)	4.90 m/day

Source: Groundwater Cell, Agricultural Department, GoH

129. The flood plains of river Yamuna are underlain by highly potential freshwater un-confined aquifer group down to 150 m depth. It is, further, underlain by fresh water semi-confined and confined aquifer groups down to 450 m depth It is considered feasible to dewater and refill the unconfined aquifer group underlying the Yamuna flood plain. Keeping in view that large quantity of surface water flows out of the district through river Yamuna, recharging the dewatered flood plain aquifer system can be attempted. However, it

requires enormous efforts in land acquisition for artificial recharge and enforcement of proper water management.

130. The status of ground water recharge and withdrawal in Haryana state, district wise is given in the table placed at **Annexure 4**. The status of ground water in different blocks of Panipat district is given in the following table.

Table 18: Status of ground water development in Panipat District

District/Assessment Unit	**Stage of Ground Water Development**	**Is there a significant decline of pre-monsoon water table levels**	**Is there a significant decline of post-monsoon water table levels**	**Categorization for future ground water development**
	(%)	*(Yes/No)*	*(Yes/ No)*	*safe/ semi-critical/ critical/ over-exploited*
Bapoli	1.86	Yes	Yes	Over-Exploited
Israna	1.60	Yes	Yes	Over-Exploited
Madlauda	1.28	Yes	Yes	Over-Exploited
Panipat	1.37	Yes	Yes	Over-Exploited
Samalkha	1.81	Yes	Yes	Over-Exploited
Total	**1.56**	**-**	**-**	**-**

Source: Groundwater Cell, Agricultural Department, GoH

131. The following shows the fluctuation of water level from June 1974 to June 2007 in different blocks of Panipat district as recorded by the ground water cell of the state Agricultural Department. Detailed water level data is presented in **Table 18**.

Figure 1: Fluctuations in Groundwater Level (1974-2007) in Panipat District

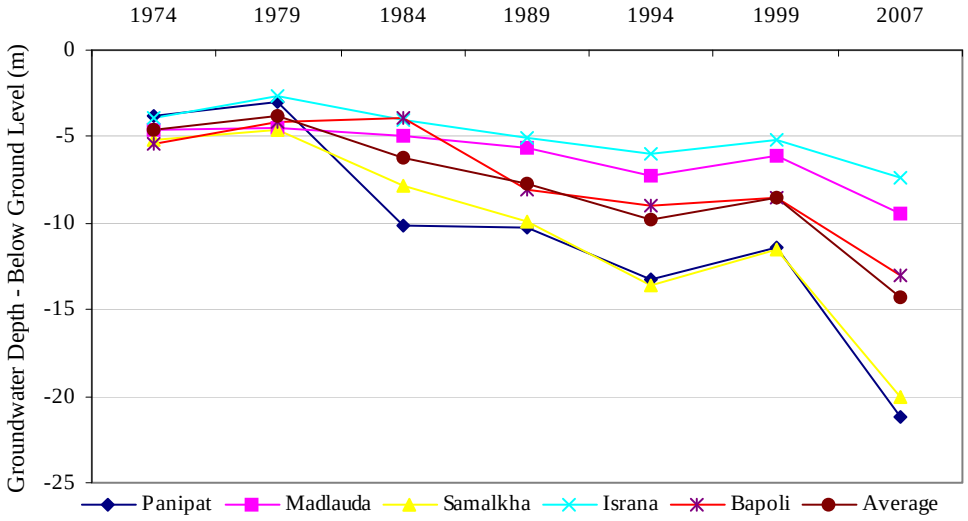


Table 19: Fluctuations in Groundwater Level (1974-2007) in Panipat District

Year	Panipat		Madlauda		Samalkha		Israna		Bapoli		Average	
	Level	fluct	Level	fluct	Level	Fluct	Level	fluct	Level	fluct	Level	fluct
	M											
June 1974	3.81	-	4.57	-	5.16	-	3.87	-	5.39	-	4.56	-
June 1979	3.04	0.77	4.45	0.12	4.66	0.5	2.64	1.23	4.14	1.25	3.79	0.77
June 1984	10.18	-6.37	4.99	-0.42	7.79	-2.63	4.04	-0.17	3.95	1.44	6.19	-1.63
June 1989	10.2	-6.39	5.59	-1.02	9.86	-4.7	5.08	-1.21	8.02	-2.63	7.75	-3.19
June 1994	13.29	-9.48	7.25	-2.68	13.55	-8.39	6.04	-2.17	9.03	-3.64	9.83	-5.27
June 1999	11.35	-7.54	6.09	-1.52	11.49	-6.33	5.19	-1.32	8.53	-3.14	8.53	-3.97
June 2007	21.2	-17.39	9.49	-4.92	20.09	-14.93	7.43	-3.56	13.01	-7.62	14.24	-9.68
Avg fluct/yr	-	-0.52	-	-0.15	-	-0.45	-	0.11	-	-0.23	0	-0.29

Avg fluct/yr – Average yearly fluctuation in water level between 1974-2007; fluct – fluctuation in groundwater level considering 1974 as base year; negative (-) sign indicates decline
Source: Groundwater Cell, Agricultural Department, Government of Haryana

132. It is evident from the table above that there is an average depletion in ground water table of 9.68m for the Panipat district as a whole and 17.39m for Panipat block during the period under reference. The situation of ground water depletion is still worse in and around Panipat town. The table also reveals that during the period 1999 to 2007, drop in water table in Panipat block on an average is 9.85m. The PWD(WSSD), which operates more than 150 tube wells in and around Panipat town has reported a drop of more than 5m in water table during last 5 years. It has also been reported by the department that rate of failure of tube wells and reduction in their discharge is becoming alarming. A statement showing results of water quality analysis of various tube wells from time to time is placed at **Annexure 5** (refer Annexure 2 for water quality standards prescribed by CPHEEO manual).

133. Central Ground Water Board, which has been appointed as designated authority for regulation of ground water by the Hon'ble Supreme court, has recommended to the Chief Secretary, GOH that "In order to preserve and protect the ground water resources from further depletion, it is considered necessary to regulate the indiscriminate construction of of bore-wells and over development of ground water in "Bapoli, Isarna, Madlauda and Panipat Blocks of Panipat district" vide letter dated 5th March 2007. This letter has been issued in terms of mandate given to CGWA constituted by GOI under section 3(3) of the Environment (Protection) Act 1986. This is based on the assessment made by CGWB that the above blocks have become over exploited.

C. Water Source Selection:

134. The above discussion reveals that the ground water status in and around Panipat town is over exploited and in critical stage. There is little control on ground water exploitation. The present rate of over exploitation is likely to result in permanent damage to the aquifer.

It is also evident that ground water use for drinking purposes can not be relied upon on long term basis with out effective and substantial recharge of ground water. The rate of failure of existing tube wells and reduction in their yield is resulting in continuous requirement of additional annual investment in construction of new tube wells and keeping the operational and supervising staff in a panic state. In addition to this there is deterioration in ground water quality also on account of over drawl of water and also pollution due to untreated effluent from textile industries. The untreated industrial effluent normally flows in open drains/nalahs percolating into ground and at times some industries pump the effluent directly into ground through abandoned bore wells. It would therefore be appropriate to reduce dependence on ground water for drinking water requirement gradually and switch over to some alternative source.

135. There are following two alternative sources available for water supply: (i) Yamuna river flowing 19 km from Panipat; and (ii) Delhi Carrier Link Channel Canal (Also popularly called WJC Canal) passing through the town Panipat along with the 'Delhi parallel Canal'. The feasibility of these two sources is discussed below:

1. Yamuna River

136. Yamuna River passes from a point which is about 19 km from Panipat towards Haridwar. This is the only river which is passes through Panipat district. The flow into the river during rainy season is substantial which recharges the banks. However, Panipat drain, which carries sullage water, effluent from the Sewage Treatment Plants and other waste water including industrial waste ultimately discharges into Yamuna River.

137. The banks of River Yamuna has very good ground water potential and provides an opportunity to meet drinking water requirement of Panipat town on sustainable basis looking to the average flood discharge passing by constructing a battery of tube wells on the river bank. However, bringing water from Yamuna River will involve pumping of water through additional pumping head (bed level of Yamuna River near Saloni-Karana bridge is 226m and general ground level in Panipat town is 237m). This is on account of static lift as well as frictional losses in pumping main of approximately 19 km in length. The other disadvantages are with regard to threat to battery of tube wells during floods, non availability of water from the well field during flood period due to approach problem and creating a new operational point which will be 19 km away which will require additional logistics and man power.

2. Delhi Carrier Link Channel

138. Delhi Carrier Link Channel and Delhi Parallel canal are passing through the town. They take off from the Munakh head regulator. Water comes at Munakh head through two canals namely WJC canal and Munakh canal. From this regulator, in addition to 'Delhi Carrier Link Channel' and 'Delhi parallel canal', two more canals take off. They are Hansi Branch(7000 cusecs) and Gohana distributary(321 cusecs). The capacity of Delhi Carrier Link Channel is reported to be 2823 cusecs with a slope of 0.20% and Delhi parallel Branch with a capacity of 5545 cusecs and a slope of 0.20%. These two canals again meet at Khubdu head regulator. From this regulator tow canals takes off namely 'Delhi parallel branch' and JLN Canal.

139. The 'Delhi parallel Branch' is a dedicated canal to supply raw water to NCT of Delhi. However, the Link channel provides for the requirement of JLN Canal and also requirement of raw water of NCT of Delhi during maintenance of 'Delhi parallel branch'.

140. The water requirement of Panipat town for the projected population for 2041 works out to be around 100 cusecs. This requirement of raw water can be met out of the present flows through the Link canal. As the canal is passing through the town, it would be desirable to make use of the available resource. The quality of raw water of the canals is fairly good. It was informed that water quality is generally good except during the rainy season.

141. Raw water received through the 'Delhi Parallel Branch' is treated at 'Haiderpur Water Treatment Plant' in NCT of Delhi. The plant was visited and it was informed by the local Chemist that turbidity of raw water is normally very good limited to 50NTU. The maximum turbidity is observed during rainy season which goes up to 6000NTU for one or two days in a year. The turbidity level is between 300 and 500 NTU for about 3 to 4 months period during a year. As regards availability of water in the canal, it was informed that water in the canal is available round the year on 24x7 basis. They have made no provision for raw water storage on this account.

142. JLN Canal, which takes off from Khubdu head is also source of drinking water supply scheme for Rohtak town. This scheme was also visited and it was reported that turbidity level here is also similar to those reported at Haiderpur plant of NCT Delhi. However, regarding availability of water in the canal, it was informed that the canal runs in rotation and accordingly they have provided for raw water storage tanks for a requirement of 8 days. They have taken additional outlet from a near by canal to meet with any exigency of non availability of water in JLN Canal.

143. Looking to above background it is evident that good quality raw water in adequate quantity is available in the Link and Delhi parallel branch canals, which pass through the town. Looking to the proximity of the canals to the town, quality and quantity of raw water and dependability of canal flows, this looks to be a good feasible source for supply of water to Panipat town. It may be pointed out that HUDA is already executing a project to supply canal raw water to industries in HUDA area by laying a pipe line from the above canal.

3. Final Selection

144. In view of above discussion, it is evident that taking Delhi Link Channel canal as a source of raw water for Panipat Water Supply system will be desirable on following grounds amongst others:

(i) The dependability of local ground water has greatly reduced and it has come under over exploited zone.

(ii) The quality of ground water is deteriorating continuously making it unfit for human consumption in many areas.

(iii) The availability of raw water in the Link channel and in Delhi parallel canal all the year round on 24x7 basis is ensured.

(iv) The quality of raw water in the canal is good and treatable. This canal water is already a source for many towns and villages including NCT of Delhi.

(v) The canals are passing through Panipat town only, thus pumping from long distance is not involved. The canals are located above the ground level, thereby facilitating lower pumping head and also reducing chances of any external pollution.

(vi) This is an economical solution than bringing water from Yamuna river as it involves pumping through a much lower head and O&M requirement including logistics requirements will be much less.

(vii) There is a strong public demand for providing drinking water from the canal. Honorable Chief Minister of Haryana has therefore announced in a public meeting his commitment to provide treated canal water to Panipat town on 20th January 2008(a copy of announcement placed at **Annexure 6**).

145. It would however, require formal approval from the Irrigation Department for allocation of required quantity of water including sanction of outlet of required size. It would be desirable that canal out let is provided from each of the canal so that water is available round the year even during closure of one of the canals for repairs or otherwise. The above issues were discussed with the Executive Engineer, Irrigation Department, Panipat wherein he informed that required quantity of water can be provided subject to approval by the government. He also informed that work of construction of outlets will be executed by his department on deposition of required amount by the PWD(WSSD). He also informed that crossing of canal by pipe line will also require permission of Irrigation department and the work in the canal portion will be executed by Irrigation Department at the cost of requesting department. Executive Engineer PWD(WSSD) has requested the EE Irrigation department, Panipat vide his letter no.29143 dated December 31, 2008 (copy placed at **Annexure 7**) for allocation of water and sanction of outlet from the canals.

D. Water Supply Zones

146. There are no defined water supply Zones in Panipat town. Water is supplied from each tube well to some area which it can feed. In the old town area, water from a group of tube wells is first collected in one under ground clear water reservoir and then pumped into the distribution system directly. As it is not possible to supply water to entire area in one go, the area is divided into a number of zones and water is supplied to each zone for 2 hours daily spread over from early morning to late in the evening. The distribution system thus lacks proper design. The tail end pressures are generally low and there are complaints of in-adequate supply during summers from tail end consumers. There are 3 Over Head Service Reservoirs (OHSR) in the town but they are not in service.

147. It would be appropriate to divide the town in number of zones so that water can be supplied with adequate pressure and properly monitored for the purpose of UFW, adequate supply and water quality monitoring. As a matter of standard practice, each zone will have an OHSR with storage capacity adequate to take care of variation in demand during the day and staging to ensure defined minimum terminal pressures. It would be endeavored to keep the size of each zone to accommodate a projected population of around 25000 souls. As per CPHEEO manual on water supply the capacity of OHSR is to be designed for 15 years requirement. Accordingly, zone size is being determined taking into consideration the projected population for 2026. However, the distribution system will be designed for 30 years so that additional storage can be provided at the end of 15 years period.

148. The existing population distribution and the projected population distribution for 2026 have been studied along with visit to different areas of the town. The major considerations have been the railway lines, National high way and the higher areas in the old town portion. The Master Plan area has been divided in 32 Zones. **Map 9** shows the ward map of the town, and **Map 10** shows the proposed water supply zones in Panipat. The composition of zones is summarized in the following table. **Table 20** shows distribution of population of each zone with break up in ward/sector. **Table 21** shows zone-wise water demand.

Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Ward Map

Legend

- Municipal Boundary
- Ward Boundary
- (20) Ward Number
- Major Roads
- Other Roads
- Railway Line
- Cart Track
- House settlement
- Tube Well
- Temple
- Water Course

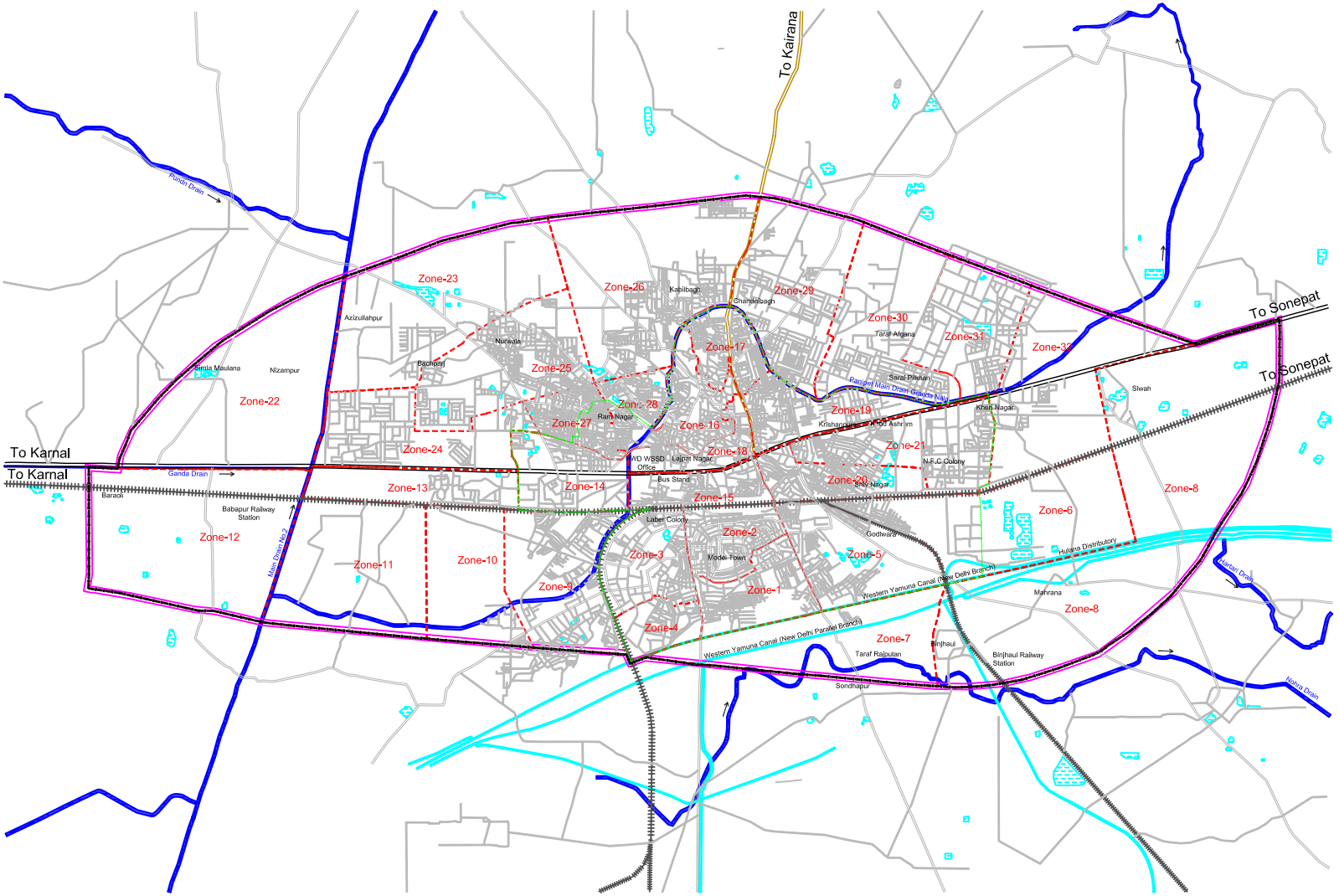
Source:
PHED Panipat, Haryana

Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates Pvt Ltd

Drawn: SK	Checked: OPG
Date: Jan. 2008	Approved: NSS
Scale: NTS	

Map. 9



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Prposed Zonel Plan

Legend

- Study Area Boundary
- Municpal Boundary
- Proposed Road
- National Highway
- State Highway
- Major Roads
- Other Roads
- Railway Line
- Canal
- Drain
- Ponds and Lakes

Overlay Legend

- Zone Boundary
- Zone-16 — Zone Number

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Aslan Development Bank
National Capital Region Planning Board

Consultant

Wilbur Smith Associates Pvt Ltd

Drawn: SK	Checked: OPG
Date: Jan. 2009	Approved: NSS

Scale: -400 0 400 800 1200 1600 Metres

Map. 10

Table 20: Zonal Population: Water Supply Zones

Zones	Wards	Population 2011		Population 2026		Population 2041	
		Wardwise	Zone	Wardwise	Zone	Wardwise	Zone
1	W-31	14,895	17,000	22,532	25,532	34,085	38,360
	W-29p	2,105		3,000		4,275	
2	W-3p	4,211	17,640	6,000	25,135	8,549	35,814
	W-29p	5,917		8,431		12,013	
	W-30	7,512		10,704		15,252	
3	W-2	8,899	16,679	11,588	22,673	15,089	30,884
	W-3p	7,780		11,085		15,795	
4	W-1	17,247	17,247	20,414	20,414	24,163	24,163
5	W-26	9,150	17,428	10,598	19,598	12,275	22,106
	W-25p	4,317		5,000		5,791	
	W-27p	3,961		4,000		4,040	
6	W-24	13,178	19,629	15,375	24,044	17,938	28,005
	W-25p	4,651		5,387		6,240	
	S-32	900		1,555		1,790	
	S-33	900		1,727		2,037	
7	S-1A	11,000	15,500	18,439	28,439	29,916	50,130
	S-34Ap	4,500		10,000		20,214	
8	S-32A	7,500	12,000	11,859	21,030	13,860	25,135
	S-33A	2,000		3,370		3,854	
	S-34Ap	2,500		5,801		7,421	
9	S-35	2,000	12,000	3,208	22,089	3,494	32,316
	S-35A	10,000		18,881		28,822	
10	S-36	5,000	10,800	10,376	23,590	17,856	42,857
	S-37	5,000		11,579		21,845	
	S-37A	800		1,635		3,156	
11	S-38	4,500	9,500	13,616	28,218	31,649	65,438
	S-39	5,000		14,602		33,789	
12	Sp.Zone	10,000	10,000	20,422	20,422	29,266	29,266
13	S-6	1,173	11,777	1,471	20,620	1,845	36,422
	S-7	5,912		10,703		19,375	
	S-8	4,692		8,446		15,202	
14	W-5	10,749	10,749	22,627	22,627	47,632	47,632
15	W-28	8,261	13,876	11,777	19,777	16,790	28,189
	W-4p	5,615		8,000		11,399	
16	W-10	8,176	36,361	8,516	37,332	8,870	38,338
	W-11	11,084		11,544		12,023	
	W-14	7,512		7,587		7,663	
	W-17	9,589		9,685		9,782	
17	W-12	9,091	23,724	9,468	25,141	9,861	26,696
	W-13	6,812		6,880		6,949	
	W-15	7,821		8,793		9,886	
18	W-18	8,558	19,507	9,622	23,081	10,818	27,764
	W-16p	5,589		5,821		6,063	

Zones	Wards	Population 2011		Population 2026		Population 2041	
		Wardwise	Zone	Wardwise	Zone	Wardwise	Zone
	W-4p	5,360		7,638		10,883	
19	W-16p	4,800	20,058	5,000	25,937	5,208	34,847
	W-19p	6,625		10,937		18,056	
	W-20p	8,633		10,000		11,583	
20	W-27p	6,880	22,039	6,949	26,417	7,018	32,550
	W-22p	4,820		6,000		7,469	
	W-23	7,310		8,468		9,809	
	W-19p	3,029		5,000		8,254	
21	W-21	6,378	17,190	15,835	28,624	39,316	54,461
	W-22p	3,082		3,836		4,775	
	W-20p	7,730		8,953		10,370	
22	S-40	6,794	9,255	15,594	22,080	35,790	52,882
	S-19A	2,461		6,486		17,092	
23	S-19	10,000	13,945	20,035	24,935	33,657	39,743
	S-20	3,945		4,900		6,086	
24	S-17	3,401	9,401	6,169	22,460	11,190	42,152
	S-18	6,000		16,291		30,962	
25	S-13	7,000	15,000	13,290	29,696	21,932	51,463
	S-14	8,000		16,406		29,531	
26	S-15	7,000	16,081	17,365	32,785	29,472	50,838
	S-16	4,500		9,352		13,576	
	S-21	2,173		2,819		3,406	
	S-22	2,408		3,249		4,384	
27	S-9p	2,500	18,529	6,000	22,029	10,800	26,829
	W-6	7,708		7,708		7,708	
	W-7	8,321		8,321		8,321	
28	W-8	5,992	15,628	5,992	19,834	5,992	25,682
	W-9	7,636		9,578		12,014	
	S-9p	2,000		4,264		7,676	
29	S-12	7,500	13,000	15,333	27,724	21,296	41,513
	S-23	2,000		3,528		4,263	
	S-24	3,500		8,863		15,954	
30	S-25	8,000	16,000	16,408	33,805	24,612	50,708
	S-28	8,000		17,397		26,096	
31	S-29(1)	5,000	13,000	11,988	30,383	17,982	45,575
	S-29(2)	8,000		18,395		27,593	
32	Sector 30	7,000	10,000	19,929	28,568	29,894	46,168
	Sector 31	3,000		8,639		16,274	
	Total		**500,543**		**805,039**		**1,224,926**

Source: Analysis; KLD – kilo liters per day

149. The above tables also show the projected populations for each zone for 2011 and 2041. Zone wise water demand for each reference year is given in **Table 21**:

Table 21: Zone-wise Water Demand in Panipat

Zones	Demand in KLD		
	2011	**2026**	**2041**
1	2,720	4,085	6,138
2	2,822	4,022	5,730
3	2,669	3,628	4,941
4	2,760	3,266	3,866
5	2,788	3,136	3,537
6	3,141	3,847	4,481
7	2,480	4,550	8,021
8	1,920	3,365	4,022
9	1,920	3,534	5,171
10	1,728	3,774	6,857
11	1,520	4,515	10,470
12	1,600	3,268	4,683
13	1,884	3,299	5,828
14	1,720	3,620	7,621
15	2,220	3,164	4,510
16	5,818	5,973	6,134
17	3,796	4,023	4,271
18	3,121	3,693	4,442
19	3,209	4,150	5,576
20	3,526	4,227	5,208
21	2,750	4,580	8,714
22	1,481	3,533	8,461
23	2,231	3,990	6,359
24	1,504	3,594	6,744
25	2,400	4,751	8,234
26	2,573	5,246	8,134
27	2,965	3,525	4,293
28	2,500	3,173	4,109
29	2,080	4,436	6,642
30	2,560	5,409	8,113
31	2,080	4,861	7,292
32	1,600	4,571	7,387
Total	**80,087**	**128,806**	**195,988**

KLD: kilo liters per day
Source: Analysis

E. Water Demand forecast

150. As per Regional Plan 2021 of NCRPB, the rate of water supply (liters per capital per day) in the NCR area is to be taken as follows:

(i) Urban

- NCT Delhi: 225 lpcd
- Towns (Population 1 lac and above): 200 lpcd

- Town (Population below 1 lac): 135 lpcd

(ii) Rural

- Spot source 70 lpcd
- Pipe supply 100 lpcd

Unaccounted for Water (UFW) should be reduced to 15%.

151. Panipat town comes under the category of towns with population more than 1 lac and according to above norms, the rate of water supply comes to 200 lpcd.

152. As per Manual of Water supply issued by CPHEEO, rate of water supply for all towns having sewerage system shall be 135 lpcd exclusive of UFW. It has been envisaged in the manual that losses in the distribution system should be limited to 15%. The manual also provides that the above requirement shall include demand of water of routine industries, commercial establishments and other institutions. However, the manual specifies that in case water demand of major industries, hospitals, institutions, fire fighting etc. is substantial, the same shall be taken separately.

153. In case of Panipat town, the canal is flowing through the town and water requirement of industries is being taken care of by a separate raw water pipe line being executed by HUDA. There are no major Hospitals or other institutions having substantial water requirement. Executive Engineer PWD(WSSD), Panipat has informed that he has not received any such request for future planning also. Thus we may not take any separate provision for major industries, hospitals and institutions. Even if any such demand is created in future, the same can be met from ground water or canal water. The requirement of water firefighting is highly intermittent and can be met from ground water and canal water.

154. It would therefore be appropriate to adopt the rate of water supply prescribed by CPHEEO i.e. 135 lpcd exclusive of 15% UFW. The water supply is therefore being designed for a gross demand based on 160 lpcd. The water demand has been calculated zone wise in the table above for the years 2011, 2026 and 2041 and the total demand is given bellow:

Water requirement for 2011	91	MLD
Water requirement for 2026	130	MLD
Water requirement for 2041	196	MLD

155. This is the gross water demand to be produced from the clear water pumping station. There will be losses in the Water Treatment Plant, which are 5% as per CPHEEO manual of water supply. This puts the total requirement of raw water from the canal at 206 MLD (85 Cusecs) for the design year 2041. As stated earlier, PWD(WSSD) has requested the Irrigation Department, Panipat for allocation of 100 cusecs of water for Panipat water supply (**Annexure 7**).

F. Water Treatment and Pumping

156. *Raw Water*. The quality of raw water is fairly good. As per the information gathered from the Hayderpur WTP of NCT Delhi, turbidity of raw water of this canal is maximum up to 6000 NTU for about one or two days in a year and around 500NTU for about 3-4 months in a year. The turbidity in raw water is around 50 NTU only during rest of the year i.e. almost 8 months. There is no pre-sedimentation arrangement for raw water before other treatment at this plant. A water quality analysis report of a typical sample of raw water conducted in November 2008 is obtained from the Hayderpur WTP and is presented in **Table 22**.

Table 22: Raw Water Quality

S.No.	Parameter	Units	Value
1	Colour	Hazen	-
2	Odour	-	Earthy
3	Turbidity	NTU	500
4	Ph		7.8
5	Electrical Conductivity	µmhos/cm	255
6	Total Dissolved solids	mg/l	
7	Phenophthlein Alkalinity	mg/l	Nil
8	Total Alkalinity	mg/l	84
9	Total Hardness	mg/l	
10	Carbonate Hardness	mg/l	88
11	Non Carbonate Hardness	mg/l	
12	Ammonia(free&saline)	mg/l	0.03
13	Nitrite-Nitrogen	mg/l	0.006
14	Nitrate NO3	mg/l	0.7
15	Sulphates (SO4)	mg/l	28
16	Chlorides (Cl)	mg/l	11
17	Iron (Dissolved)(Fe)	mg/l	0.24
18	Fluorides (F)	mg/l	0.2
19	Cyanides (CN)	mg/l	Absent
20	Residual Chlorine	mg/l	Nil
21	Chromium	mg/l	Nil
22	Dissolved Oxygen	mg/l	6.8
23	Oxygen Absorption	%	1.04
24	Chlorine demand	mg/l	2.0
25	Alum requirement	mg/l	44

Source: Hayderpur Water Treatment Plant
µmhos/cm – micro mhos per centimeter; mg/l – milligrams per liter

157. The issue of pre-sedimentation required was discussed at Rohtak WTP was also discussed and it was informed that the same is not undertaken there also. It would therefore be appropriate to take water direct from canal to the filtration plant.

158. As has been mentioned earlier, the Delhi Link Channel flows round the year. Whenever water is not available in this channel, full water is available in Delhi parallel Canal. It is reported that water is available in either of these two canals all the year round without exception. This is also true from the fact that this canal also supplies 900 MLD water to Hayderpur WTP of NCT Delhi and also number of towns and villages on down stream side. In view of these facts, it is felt that no raw water storage be provided for Panipat Water supply for the present. At a later date if any new development takes place requiring raw water storage for a defined period, the same may be considered at that time.

159. It is therefore proposed to construct two outlets of 100 cusecs each, one in Delhi Link Channel and the other in Delhi Parallel Canal and bring the water up to Raw Water Sump through an open channel. These works are taken up by the Irrigation Department of Haryana, who owns the canals, as deposit work. EE PWD(WSSD), Panipat has already made a formal request for allocation of 100 cusecs water and sanction of outlet. He has also initiated action for acquisition of 33 acres of land for the purpose. Some of the area required fall in the proposed ring road in the development plan 2021. Senior Town Planner Rohtak has recommended for appropriate permission to the Director of Country and Town Planning Department, GOH vide his letter dated June 13, 08, copy of which is placed at **Annexure 8**.

160. Water Treatment: Looking to the quality of raw water mentioned above, it is appropriate to go for Rapid Gravity Filtration. This has been practiced at Hayderpur in Delhi, Rohtak and other urban water supply based on water from this canal system. The water treatment shall comprise of following:

(i) Pre-Chlorination
(ii) Allum/PAC dosing for coagulation
(iii) Mixing of chemicals with raw water
(iv) Clarifloculation
(v) Filtration
(vi) Post-Chlorination

161. The ultimate capacity of WTP will be 200 MLD for the design year 2041. However, as mentioned under Design Criteria adopted, the present capacity will be for 15 years period i.e. for design year 2026. The water requirement for 2026 has been worked out as 130 MLD. It would be appropriate to construct WTP in modular form i.e. we may go for one unit of 100 MLD capacity in first phase and another unit of 100 MLD in the second phase. It may be pointed out that water supply to Panipat town is presently made through a battery of tube wells and the same will be phased out gradually. It is therefore proposed that the remaining requirement of water for 2026 amounting to 30 MLD may be drawn from ground water if needed. The WTPs shall comprise of all components mentioned above. The capacities of the RGF WTPs proposed are as follows:

(i)	Phase I	100 MLD
(ii)	Phase II	100 MLD (To be constructed by 2026)

G. Pumping System

1. Raw Water Pump House

162. Raw water will be received from the canal through an open channel in a raw water sump. Raw water will have to be pumped into the inlet channel of WTP. The raw water sump may be provided for the ultimate capacity of 2041. For pumping raw water, it will be desirable to go for turbine pumps as the head involved will be less, say 8m only and pump house may be constructed on the sump directly. This will give a very economical and compact alternative. The capacity of pumping may be 110 MLD in the first phase and additional 110 MLD in the second phase. The raw water pipe line from raw water pumps to the WTP may be provided for ultimate requirement of 2041 in the first go. The length of pipe line will be limited to maximum 200m as both the units of WTP & Raw Water Pump House will be located in the same campus.

163. *Design of Pumps*.

Pump BKW = 9.81x Qx H/ nx1000 where

Q (Discharge) = 1275 lps

H (Head(= 8 m

N= Overall efficiency of pump and motor

The combine efficiency of pump and motor is assumed as 72%

BKW = 9.81x1275x8/0.72x1000 = 139 KW

It would be appropriate to provide two pumps of half the capacity with the third pump as stand by. In the second phase another 3 pumps may be added of same capacity. The capacity of each Vertical Turbine pump shall be as follows:

Discharge = 640 lps

Head = 8 m

BKW = 70 KW

Quantity = 6 (3 in phase I and 3 in phase II)

2. Clear Water Pumping Station with CWR

164. *Clear Water Reservoir*. There will be a Clear Water Reservoir attached to the WTP, which will receive treated water after post chlorination under gravity from the WTP. The capacity of the CWR is proposed to be equal to 2 hours out put of WTP ultimate capacity. The CWR is proposed to be for the ultimate requirement looking to the fact that in first phase the system may take some time to stabilize and has to work in combination with TW water. However, after 2026 the water system will stabilize and storage of 2 hours will be adequate. The capacity of CWR will be as follows:

Total capacity of WTP for 2041 = 200 MLD

2 Hours capacity of WTP for 2041 = 200x4/24 ML = 33.3 ML

Capacity of proposed CWR = 35 ML

165. The CWR shall be in two compartments with a sump to facilitate putting suction pipes of pumps. Alternatively, if VT pumps are found to be suitable and economical during detailed engineering, pump house may be constructed directly over the sump. In case Horizontal centrifugal pumping sets are found suitable and economical, a pump house may be separately constructed such that conditions for positive suction are obtained to facilitate pump operation without problem of priming.

166. *Clear Water Pumping Station.* It is proposed to pump water from the Clear Water Pumping Station (CWPS) direct into the Zonal Reservoirs. Water shall be pumped through four trunk mains in the form of two ring mains with connections to each Zonal OHSR (Discussed in detail below). However in case of Zone 15, the elevation of the area, which is the old town portion, is higher by 10 to 12m compared to the remaining part of the town. It would not be prudent to pump entire quantity of clear water with a higher head on account of higher elevation of this zone. It is therefore proposed to provide an on-line booster pumping station to provide this additional head to fill the Zone 15 OHSR. As per design of pumping mains, requirement of pumping head for clear water pumps work out to 46m. The requirement of pumping capacity is worked out below:

Total water to be pumped = 200 MLD

Total Head (Average) = 46m

Pump BKW = 9.81x Qx H/ nx1000, where

Q (Discharge) = 200 MLD = 2315 lps

H (Head) = 46 m

N (Overall efficiency of pump and motor) - the combine efficiency of pump and motor is assumed as 72%

BKW =1450 KW

167. It is proposed to provide 8 pump sets of following capacity having 4 pumps working and 4 pumps as stand by. In the first phase 4 pump sets will be provided with 2 working and 2 as stand by and remaining 4 pump sets will be provided in the second phase. The manual on water supply provides for stand by pumps as 50% to 100% with minimum one pump as stand by. 100% stand by is being proposed in the present case as it is proposed to provide 24x7 water supply and to ensure the same a higher level of stand by pumps. The capacity of pumps proposed are as follows:

(i) Discharge 580 lps

(ii) Head 46 m

(iii) BKW 365 KW

H. Storage Reservoirs

168. It is proposed to provide a Over Head Storage reservoir (OHSR) in each Zone to provide adequate storage to meet with the fluctuation in water consumption during different periods of the day. The capacity of the reservoir will depend upon the pattern of drawl of water by the consumers and their habits. CPHEEO manual on water supply provides a typical pattern of such a water drawl. As an empirical formula capacity of OHSR of a zone

may be taken equal to 33% of the daily water demand. As water supply is proposed to made continuous 24X7, these tanks will act as balancing reservoirs. In the first phase it is proposed to use these reservoirs as storage reservoirs i.e. fill and draw type. However, once the 24X7 system stabilizes and people get assured of continuous water supply, it would be possible to go for these reservoirs on balancing pattern in the second phase. The requirement of storage is worked out below. In the Phase I storage for requirement up to 2026 will be provided and balance storage will be provided in 2026 in Phase II.

Total Supply in Phase I:	130 Mld
Additional Supply in Phase II:	70 MLD
Storage required in Phase I (130x0.30):	42 ML
Storage required in Phase II: (70x0.30):	22 ML
Total Storage:	64 ML

169. The OHSRs shall be with a staging of 20m so that a terminal head of 12 meters could be obtained. The tanks shall be of RCC. Executive engineer PWD(WSSD) has been requested to identify appropriate land for the OHSRs. The zone wise capacity and staging of OHSR is given the Table below:

Table 23: Capacity of Zonal Over Head Service Reservoirs

Zones.	**2026**			**2041**			**Balance OHSR capacity to be provided in 2026**
	Water Demand	**OHSR Capacity @30%of demand**	**OHSR Capacity adopted KL**	**Water Demand**	**OHSR Capacity@30 %of demand**	**OHSR Capacity adopted KL**	
1	4,085	1,362	1,500	6,138	2,046	2,000	500
2	4,022	1,341	1,500	5,730	1,910	2,000	500
3	3,628	1,209	1,000	4,941	1,647	1,500	500
4	3,266	1,089	1,000	3,866	1,289	1,500	500
5	3,136	1,045	1,000	3,537	1,179	1,000	0
6	3,847	1,282	1,500	4,481	1,494	1,500	0
7	4,550	1,517	1,500	8,021	2,674	2,500	1,000
8	3,365	1,122	1,000	4,022	1,341	1,500	500
9	3,534	1,178	1,000	5,171	1,724	1,500	500
10	3,774	1,258	1,500	6,857	2,286	2,500	1,000
11	4,515	1,505	1,500	10,470	3,490	3,500	2,000
12	3,268	1,089	1,000	4,683	1,561	1,500	500
13	3,299	1,100	1,000	5,828	1,943	2,000	1,000
14	3,620	1,207	1,000	7,621	2,540	2,500	1,500
15	3,164	1,055	1,000	4,510	1,503	1,500	500
16	5,973	1,991	2,000	6,134	2,045	2,000	-
17	4,023	1,341	1,500	4,271	1,424	1,500	-
18	3,693	1,231	1,000	4,442	1,481	1,500	500
19	4,150	1,383	1,500	5,576	1,859	2,000	500
20	4,227	1,409	1,500	5,208	1,736	1,500	-

Zones.	2026			2041			Balance OHSR capacity to be provided in 2026
	Water Demand	OHSR Capacity @30%of demand	OHSR Capacity adopted KL	Water Demand	OHSR Capacity@30 %of demand	OHSR Capacity adopted KL	
21	4,580	1,527	1,500	8,714	2,905	3,000	1,500
22	3,533	1,178	1,000	8,461	2,820	2,500	1,500
23	3,990	1,330	1,500	6,359	2,120	2,000	500
24	3,594	1,198	1,000	6,744	2,248	2,000	1,000
25	4,751	1,584	1,500	8,234	2,745	2,500	1,000
26	5,246	1,749	1,500	8,134	2,711	2,500	1,000
27	3,525	1,175	1,000	4,293	1,431	1,500	500
28	3,173	1,058	1,000	4,109	1,370	1,500	500
29	4,436	1,479	1,500	6,642	2,214	2,000	500
30	5,409	1,803	2,000	8,113	2,704	2,500	500
31	4,861	1,620	1,500	7,292	2,431	2,500	1,000
32	4,571	1,524	1,500	7,387	2,462	2,500	1,000
Total		42,935	42,000		65,329	64,000	22,000

KL – kilo liters; OHSR – Overhead Service Reservoir
Source: Analysis

I. Pumping Net Work

170. It is proposed to take off four branch pumping main pipe lines to feed different group of Zonal Reservoirs from the CWPS. The following three alternatives have been considered:

(i) Each branch pipe line will feed group of Zonal Reservoirs as follows
- Branch A feeding Zones 9, 10, 11, 12, 13, 22, 23 & 24
- Branch B feeding Zones 3, 4, 14, 15, 16, 18, 25, 27 & 28
- Branch C feeding Zones 1, 2, 5, 7, 8, 17, 19 & 20
- Branch D feeding Zones 6, 21, 26, 29, 30, 31 & 32

(ii) In the second alternative it is proposed to connect pumping mains A & D and B & C at their tails to make them in two loops. This will facilitate balancing of the two branch flows and also provide security during breakdowns.

(iii) In the third alternative it is proposed to connect the two loops also at the points of tails of each branch. This is likely to balance the whole system and pumping at a common pumping head may be possible.

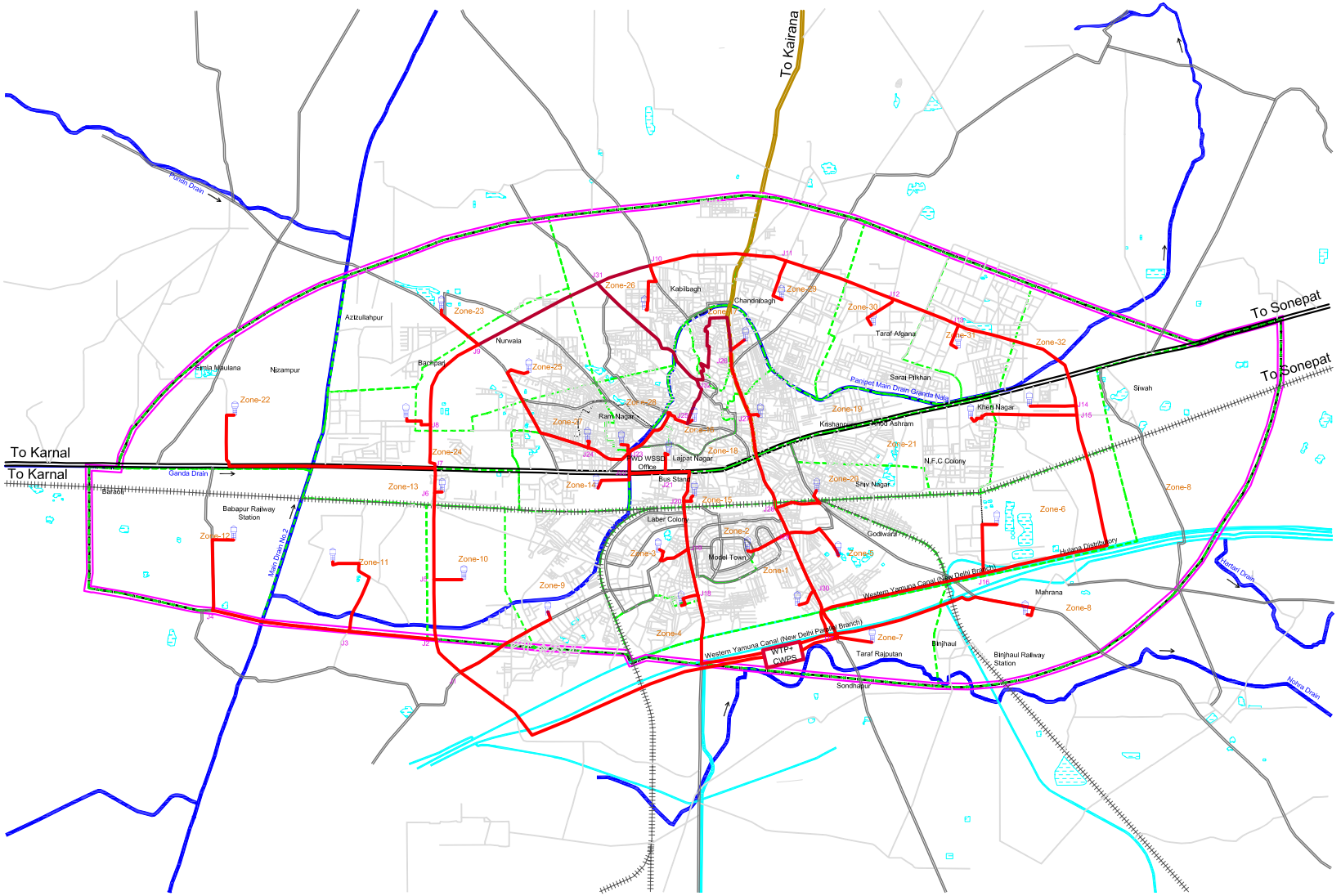
171. Details of population served and water demand served by each section of pumping main pipe line is given in **Table 24**:

Table 24: Zones covered in each Pumping Main Pipe Line with Water Demand

Pumping Main	Zones Covered	Population			Demand (in MLD)		
		2011	2026	2041	2011	2026	2041
Pipe A	9	12,000	16,992	32,316	1.92	2.72	5.17
	10	10,800	18,146	42,857	1.73	2.90	6.86
	11	9,500	21,706	65,438	1.52	3.47	10.47
	12	10,000	15,709	29,266	1.60	2.51	4.68
	13	11,777	15,862	36,422	1.88	2.54	5.83
	22	9,255	16,985	52,882	1.48	2.72	8.46
	23	13,945	19,181	39,743	2.23	3.07	6.36
	24	9,401	17,277	42,152	1.50	2.76	6.74
	Total	**86,678**	**141,857**	**341,076**	**13.87**	**22.70**	**54.57**
Pipe B	3	16,679	17,441	30,884	2.67	2.79	4.94
	4	17,247	15,703	24,163	2.76	2.51	3.87
	14	10,749	17,405	47,632	1.72	2.78	7.62
	15	13,876	15,213	28,189	2.22	2.43	4.51
	16	36,361	28,717	38,338	5.82	4.59	6.13
	18	19,507	17,755	27,764	3.12	2.84	4.44
	25	15,000	22,843	51,463	2.40	3.65	8.23
	27	18,529	16,945	26,829	2.96	2.71	4.29
	28	15,628	15,257	25,682	2.50	2.44	4.11
	Total	**163,576**	**167,279**	**300,944**	**26.17**	**26.76**	**48.15**
Pipe C	1	17,000	19,640	38,360	2.72	3.14	6.14
	2	17,640	19,335	35,814	2.82	3.09	5.73
	5	17,428	15,075	22,106	2.79	2.41	3.54
	7	15,500	21,876	50,130	2.48	3.50	8.02
	8	12,000	16,177	25,135	1.92	2.59	4.02
	17	23,724	19,339	26,696	3.80	3.09	4.27
	19	20,058	19,952	34,847	3.21	3.19	5.58
	20	22,039	20,321	32,550	3.53	3.25	5.21
	Total	**145,389**	**151,75**	**265,638**	**23.26**	**24.27**	**42.50**
Pipe D	6	19,629	18,495	28,005	3.14	2.96	4.48
	21	17,190	22,018	54,461	2.75	3.52	8.71
	26	16,081	25,219	50,838	2.57	4.04	8.13
	29	13,000	21,326	41,513	2.08	3.41	6.64
	30	16,000	26,004	50,708	2.56	4.16	8.11
	31	13,000	23,372	45,575	2.08	3.74	7.29
	32	10,000	21,975	46,168	1.60	3.52	7.39
	Total	**104,900**	**158,410**	**317,268**	**16.78**	**25.35**	**50.76**
Total		**500,543**	**619,261**	**1,224,926**	**80.09**	**99.08**	**195.99**

Source: Analysis; MLD – million liters per day

172. Computer Analysis of the pumping network will be carried out on EPANET software for all the three alternatives and the same will be incorporated in the DPR. The branch line sizes have been determined for the first alternative but keeping the concept of looping the branches and interconnecting them. The proposed pumping main network is shown in **Map 11**. The following table shows the pipe selection for each branch line with velocities achieved and head loss in each section.



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Proposed Pumping Main Network

Legend

- Study Area Boundary
- Municipal Boundary
- Proposed Road
- National Highway
- State Highway
- Major Roads
- Other Roads
- Railway Line
- Canal
- Drain
- Pond and Lakes

Overlay Legend

- Proposed Pumping Main
- Looping
- Zone Boundary
- Overhead Service Reservoir (OHSR)

Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates Pvt Ltd

Drawn: SK | Checked: OPG
Date: Jan. 2009 | Approved: NSS

Scale: -400 0 400 800 1200 1600 Metres

Map. 11

Table 25: Branch Lines Feeding OHSR

Zones	Length of Pipe leading to OHSR (m)	Demand (in KLD)	Proposed Dia.(mm)	Velocity (m/s)	Friction loss (m/km)	Total friction loss (m)
1	344	6,138	350	0.75	1.40	0.48
2	698	5,730	350	0.75	1.35	0.94
3	701	4,941	300	0.8	2.16	1.51
4	394	3,866	300	0.6	1.27	0.51
5	933	3,537	300	0.59	1.08	1.01
6	907	4,481	300	0.75	1.62	1.47
7	705	8,021	350	0.9	2.27	1.60
8	2,931	4,022	300	0.7	1.40	4.12
9	1,605	5,171	300	0.85	2.16	3.47
10	396	6,857	350	0.8	1.84	0.73
11	1,537	10,470	400	0.95	1.94	2.99
12	1,314	4,683	300	0.75	1.84	2.41
13	106	5,828	350	0.8	1.84	0.19
14	660	7,621	350	0.9	2.16	1.43
15	236	4,510	300	0.75	1.78	0.42
16	459	6,134	350	0.75	1.46	0.67
17	246	4,271	300	0.7	1.51	0.37
18	430	4,442	300	0.75	1.62	0.70
19	174	5,576	300	0.9	2.43	0.42
20	864	5,208	300	0.9	2.27	1.96
21	1,590	8,714	400	0.75	1.30	2.06
22	3,436	8,461	400	0.75	1.30	4.45
23	745	6,359	350	0.75	1.51	1.13
24	463	6,744	350	0.8	1.73	0.80
25	2,005	8,234	350	1	2.38	4.76
26	776	8,134	350	1	2.38	1.84
27	158	4,293	300	0.7	1.62	0.26
28	250	4,109	300	0.7	1.51	0.38
29	702	6,642	350	0.8	1.62	1.14
30	583	8,113	350	1	2.38	1.39
31	426	7,292	350	0.85	2.00	0.85
32	591	7,387	350	0.85	2.00	1.18

Source: Analysis

KLD – kilo liters per day; m – metre; m/s – metre per sec; OHSR – Overhead Service Reservoir

Table 26: Diameter-wise Length of Branch Pipes

Pipe Diameter	Zone no	Length	Total Length
mm		*m*	*m*
300	3	701	11,143
	4	394	
	5	933	
	6	907	
	8	2,931	
	9	1,605	
	12	1,314	
	15	236	
	17	246	
	18	430	
	19	174	
	20	864	
	27	158	
	28	250	
350	1	344	9,659
	2	698	
	7	705	
	10	396	
	13	106	
	14	660	
	16	459	
	23	745	
	24	463	
	25	2,005	
	26	776	
	29	702	
	30	583	
	31	426	
	32	591	
400	11	1,537	6,563
	21	1,590	
	22	3,436	
Total		**27,365**	**27,365**

m – metre; mm - millimetre
Source: Analysis

J. Boosting Pumping Station

173. One online boosting pumping station is proposed to be provided for Zone 16. This is required because the ground levels are generally higher in this zone by about 10m compared to remaining areas of the town. Online booster will be economical because it will require less space, which is scarcely available and there will be no loss of energy as terminal head of the main pipe line will be utilized. The capacity of pumps is worked out below:

Total water to be pumped = 6134 KLD

Total Head (Average) = 12 m

Pump BKW = 9.81x Qx H/ nx1000, where

Q (Discharge) = 6134 KLD = 71 lps

H (Head) = 12 m

n (Overall efficiency of pump and motor): The combine efficiency of pump and motor is assumed as 72%

BKW = 9.81x71x12/0.72x1000 = 11.61 KW say 15KW

174. The demand of water for this zone is 5973 KLD which is marginally less than the projected demand for 2041. It would therefore be appropriate to provide pumps for ultimate capacity in Phase I itself. It is therefore proposed to provide 2 pumps sets of 15 KW with discharge of 71 lps and 12 m working head suitable for working against positive suction pressures.

K. Improvement of Existing system

175. It has been mentioned earlier that there is no proper distribution system in Panipat town. There are no defined zones of distribution. Water is supplied from each tube well directly into the distribution system and then to consumers. In the proposed system, there will be zonal distribution, each zone being fed by an independent OHSR. It would therefore require designing of zonal distribution for each zone. This detailed distribution network analysis is proposed to be undertaken during preparation of DPR. However, attempt shall be made to utilize all the existing distribution lines.

176. It is proposed that existing tube wells will not be closed immediately on commissioning of the new canal based system. The tube wells are proposed to be discontinued gradually. At the beginning of the project period, the total capacity of the system will be as follows:

Capacity of proposed WTP	100 MLD
Capacity of PHED system within Municipal area	56.31 MLD
Capacity of PHED system outside Municipal area	9.07 MLD
Capacity of HUDA system	15.66 MLD
Total	181.05 MLD

177. The level of UFW is estimated to be around 40%. This is proposed to be reduced to 15% over a period of time. Therefore at the beginning of the project period total available water will be 108.6 MLD (net of 40% losses). The operational hours of tube wells or canal water may be adjusted to provide for the actual requirement of water. However, required actions will be taken to identify leakages and plug them to reduce them to 15% level maximum. The tube wells which get defunct for any reason will not be replaced. This will be done in a manner to ensure the demand is fully met by the system.

1. Tube Wells

178. As the tube sells are presently connected to distribution system, it will require connecting them to the Zonal OHSR at the time of commissioning canal system. This will require following actions:

(i) Replacement of Tube well pump set and electrical switch gear

(ii) Connecting Tube Well delivery to the OHSR inlet pipe

(iii) Provide automation on tube well to improve efficiency and better control on pump operation.

(iv) Providing water meter at the delivery of tube well for recording water produced and rate of flow.

2. Distribution System

179. The distribution system will be rehabilitated as per detailed distribution network analysis. It is proposed to carry out this computer analysis during preparation of DPR. However, improvement works in distribution system will have to be undertaken simultaneously so that benefits of zonal reservoirs and zonal distribution are available. The network analysis will be possible for the area already developed only as no layout plans of the remaining area are available. It would be worthwhile to undertake leakage detection and control through DMA methodology and change all customer service pipelines with MDPE pipes in order to achieve the target of UFW to be below 15%. Block estimation for distribution improvement has been done on the basis of past experience in similar projects on per capita basis.

3. Pipe Material Selection

180. The selection process of pipe material for the trunk mains and distribution system will comprise the following four stages.

(i) Technical Selection

(ii) Operational Consideration

(iii) Structural design

(iv) Economic consideration

181. The range of materials available for selection are:

(i) Ductile iron

(ii) Mild Steel

(iii) Cast Iron

(iv) Bar Wrapped Steel Cylinder Concrete

(v) Pre Stressed Concrete

(vi) Glass fibre reinforced

(vii) Asbestos Cement

(viii) HDPE

(ix) PVC

(x) MDPE

182. *Pumping Main Pipelines*. Experience of use of GRP pipe as trunk main is very limited in India. Backfilling the GRP pipe requires high standards of compaction to limit deflection. There are significant risks of overstrain due to subsidence and ground movement. Again, experience of Pre Stressed Concrete pipe in India is not encouraging. Jointing of PSC pipes needs high skill. Joints are also relatively inflexible and use of such pipe in trunk main may lead to excessive leakage at a later stage. It has also other limitation such as heavy weight, slow progress of work, difficulty in leakage detection etc. Hence, only remaining materials e.g. BWSC, cast iron, ductile iron, mild steel, HDPE, PVC and MDPE are technically desirable in the materials selected for the evaluation. The major advantages and limitations of BWRC, ductile iron, cast iron and steel pipes are shown in the table below:

Table 27: Advantages and Limitations of Selected Pipe Materials

Pipe Material	**Advantage**	**Limitation**
Ductile Iron	• Strength and toughness • Resistance to pressure fatigue • Ease of jointing. Flexible joints tolerate some deflection Well established method of repair • Easy location and leak detection • Imported bedding not required	• Not good for aggressive soils • Requires protection against internal and external corrosion • Potential rise in pH while conveying soft water Corrosion protection system at risk in certain soils Corrosion protection system susceptible to impact and accidental damage • Susceptible to attack by stray currents
Cast Iron	• Long life Can be used in slightly aggressive soil.Easy jointing • Well established method of repair	• Heavy and difficult to transport • Due to brittleness they break or crack easily
Steel	• Strength and Toughness • Resistance to pressure fatigue • Ease of jointing • Can be welded to form leak free and load resistant system • Flexible joints tolerate some deflection • Impermeable to organic contaminants Well established method of repair • Easy location and leak detection • Can be produced to any diameter and pressure rating	• Not good in aggressive soils • Requires protection against internal and external corrosion • Potential rise in pH conveying soft water. • Corrosion protection system susceptible to impact and accidental damage. • Welded joints require special equipment and framing • Cathodic protection system requires regular maintenance. • Susceptible to attack by stray currents • The walled pipes with large diameter to thickness ratio rely on support from soil. Thin walled pipes jointed with mechanical fittings may suffer breakage.

Pipe Material	Advantage	Limitation
Bar Wrapped Steel Cylinder	• Longevity • Strength • Corrosion Resistance • Durability • Economical • Easy location and leak detection • Can be produced to large diameters and pressure rating	• Pipes have to be tailor made. Accordingly close monitoring of quality control of raw material and finished product required. • Laying and jointing has to be under skilled supervision. • Handling of pipes during transportation requires care to avoid damage to mortar cover. • The weld joints are to be covered with special cement mortar require special attention.

183. For operation and maintenance of pipelines in the selected materials, PHED is familiar and experienced. They already have trained manpower and a strategy of maintenance for steel and cast iron pipes. However, they have less experience in operation and maintenance of ductile iron pipes. Structurally, all the materials mentioned above will be able to withstand the expected internal water pressure and external loading.

184. For final selection of the appropriate pipe material an economic comparison has been made amongst the selected ones for equivalent working pressure of water. It has been found that the cost differential between cast iron and ductile iron pipe is low. Cast iron pipe is marginally costlier than ductile iron by about (5%). It is also observed that for large diameter, steel pipes are cheaper than ductile iron and cost iron pipe by more than 30%. Cost differential between ductile iron and steel pipe for small diameter pipe (300 mm) is less of about 5%. BWSC pipes are cheaper compared to steel pipes of same diameter and pressure rating by ad mush as 20 to 30%. A final selection of pipe material will depend on actual cost comparison for a particular situation of pipe size, length and pressure requirement.

185. *Distribution Pipelines*. PVC, HDPE and MDPE pipes are good for use for sizes up to 600mm. These pipes are most suitable for use in distribution network. HDPE pipes are very good in strength, flexibility, jointing and handling. Compared to PVC pipes, they are more flexible, leak proof etc. HDPE pipes are joined by welding through a hot plat and are absolutely leak proof. Accordingly, HDPE is now replacing all other materials for use in distribution system. HDPE pipes are cheaper to DI pipes in sizes up to 600 mm by 30 to 45%. Further, fittings bends etc. can be locally manufactured and all other fittings including saddles for consumer connections are easily available. It is therefore proposed to use HDPE pipes in the distribution system.

186. Presently GI pipes are used for providing consumer service lines. These suffer from the disadvantage of corrosion and leakages over a period of time. The leakages result in not only loss of water but are a serious cause of pollution in distribution system. It is therefore proposed to use MDPE pipes, which are highly flexible, strong and durable for use in consumer service pipe lines. Compression fittings are available for joining pipe lengths and for connecting to water meter couplings.

4. Water Meters

187. At present there is metering of water produced by tube wells and also water received by the consumers except recent introduction of meters for commercial consumers. Supply of water to consumers result in waste of water as there is no disincentive to consumers consuming large quantity of water and no incentive to consumers economizing in use of water.

188. Similarly, in absence of metering of water produced and water received by consumers, it is not possible to estimate Non Revenue Water (NRW) or the Unaccounted For Water (UFW). These elements are of such serious nature that they adversely affect finances of a water utility. On one hand it increases gap between O&M expenditure and Revenue assessed and on the other hand it increases requirement of avoidable additional investment for providing higher production capacity. Further, leakages in distribution system are one of the main sources of pollution of drinking water reaching consumers putting health of people at risk.

189. It is therefore proposed to provide water meters at the following locations:

(i) Outside the CWPS on each of the four pumping main branch pipe lines.

(ii) One water meter in the pumping main just before each of the 32 Zonal OHSRs.

(iii) One water meter at the delivery of each Tube Well (195nos.)

(iv) Domestic Water Meters on each of the consumer premises (All domestic, commercial and industrial consumers)

190. The requirement of meters for first three applications is classified under Bulk Meters and for the forth application under 'Domestic Meters'. Bulk meters are available in following classifications:

(i) Electromagnetic Full bore flow meters

(ii) Ultrasonic flow meters

(iii) Mechanical flow meters

191. Ultrasonic flow meters are available for use with all sizes of pipe lines. These are external probes installed across any pipe line section. They are suitable for both portable as well as fixed applications. Electromagnetic Full bore flow metes are also available in all sizes and have a flow tube, flanged on both sides with probes fixed in the tube body at works and these meters are calibrated in factory. These meters provide more reliable and accurate flow measurements. However, the EMFB flow meters are more expensive compared to ultrasonic flow meters. The cost of EMFB flow meters is very high for small size meters. These meters provides instantaneous flow rate, flow rate at any point of time during previous day and integrated water flow. These flow meters also equipped to provide many other output data through programming. Woltman type bulk flow meters are mechanical type and are very useful in small sizes due to economy and easy to maintain. These meters are also now available with electronics suitable for remote reading (for SCADA application etc.).

192. Based on past experience, as a thumb rule it is proposed to use Woltman type bulk flow meters with remote reading facility for all sizes up to and including 400mm. For all sizes above 400mm and up to 1000mm, Electromagnetic Full Bore flow meters may be used and for pipe sizes above 1000mm and for open channel flow measurement ultrasonic flow meters may be used.

193. Domestic flow meters are also available in two patterns namely, Inferential type and Positive displacement type. The performance of Positive displacement meters is superior to Inferential meters but in circumstances prevailing in the country on water supply schemes, only inferential meters are being used. It would be appropriate to go for inferential meters which are certified under EC standards to ensure their quality. The performance of domestic meters has been a cause of serious concern through out the country. Use of EC certified meters may reduce chances of getting sub standard meters. It is further proposed to go for water meters with an interface for remote reading either through a logger or transfer of data through GPRS/telephone line etc. This has a definite advantage in doing away with the requirement of meter readers, who are generally a source of problem for the departments. Secondly, readings will be available timely and accurately which can be transferred directly to a billing program to produce water bills quickly. This is likely to make the billing work efficient, accurate and transparent. The program fed into the meter can even help determine if a consumer handles the meter at his end for manipulation. This however is at a higher cost, as these meters will be expensive compared to normal meters. In case of Panipat town, as no meters exist in municipal area, it would be appropriate to adopt these improved meters in the first go to avoid normal meters becoming obsolete in near future.

5. Supervisory Control and Data Acquisition (SCADA)

194. It is proposed to provide a SCADA system in the WTP with access to Raw Water Pump House, CWPS, Tube Wells and OHSRs including distribution system. This will make the total system controllable from one point. Haryana PHED is already exposed to SCADA for WTP at Rohatak. Thus it will be appropriate to extend the scope of SCADA to tube wells and to OHSRs. Control of distribution system through SCADA may be taken up at a later date when operational staff becomes friendly with the new system. This will reduce the requirement of additional man power for operating new assets. This will improve performance of the equipment and other assets being provided and make water supply more reliable with water quality being ensured. With the introduction of remote reading water meters and installation of bulk meters, it would be possible to control losses in the system, issue water bills accurately and in time. It would be possible to take time action for disconnecting water supply to defaulting consumers or take other measures prescribed.

6. Stake Holder Consultation

195. Involvement and participation of all stake holders and public in particular is of utmost important at all stages of project starting from planning to implementation and during O&M. It is therefore proposed to organize a Consultation Workshop with all stake holders about the proposals made in this Master Plan. This workshop is proposed to be held at Panipat in the middle of February 2009. The following are proposed to be included in consultation work shop amongst others:

- Members of Municipal council, Panipat
- Members of UIT, Panipat
- Representatives from District Administration
- Engineers and other members from PHED, Panipat
- Representatives from CE, PHED, Chandigarh
- Representatives from Town Planning Department, Haryana
- Representatives from HUDA
- Representatives from Ground Water Cell, Karnal
- Representatives from State Electricity Board
- Representatives from State Irrigation Department
- Representatives from NCRPB
- Any other stake holder like NGOs etc.

VIII. UFW REDUCTION & WATER SAFETY PLAN

A. Overview

196. Water distribution systems get exposed to pollution loads due to various reasons that pollute the system and the supplies. The health of consumer is at stake and the system needs to be corrected. The water security system thus needs an in depth study and implementation scrupulously.

B. UFW Reduction Program

197. Considerable quantity of water is normally not accounted due to a variety of reasons, some of them are given below:

- Leakages in the transmission, distribution network and storage;
- Unauthorised and illegal tapings.
- Wrong and inefficient water meter functions.
- Un-metered supply.
- Insufficient consumer awareness
- Inefficient system
- Upset of pressures due to illegal sucking
- Aging of pipes, corrosion, incrustation etc.

198. Thus the primary function of a water distribution system to reliably deliver adequate good quality and good quantity of water to its customer is not achieved. As such water audit becomes an important and unavoidable issue.

199. Water distribution systems are changing continuously as a result of growth or decline of demand, changes in water quality, aging of infrastructure, corrosion etc. The performance indicators that are generally adopted for evaluating the system are:

- Adequacy: Quantity, Quality, Pressure.
- Dependability: Duration without interruptions, absorption of consumer's shocks
- Efficiency: Better control over Un-accounted For Water (UFW)
- Quality of service: Customer satisfaction regarding aesthetics and above three aspects, better O&M services.

200. In order to achieve the required performance indicators, the present day answer is to divide the reticulation system into District Metered Areas (DMAs).

201. The term District metering is used to describe the method whereby flow meters are installed such that several thousand consumers are supplied via each meter or combination of meters. DMA is a discrete area of a distribution system usually created by the closure of

valves or complete disconnection of the pipe network in which the quantities of water entering and leaving the area are metered. The whole system is put under designed pressure. The flow is analysed to quantify the level of leakage. This enables to determine more precisely where and when it is most beneficial to undertake leak detection activities. Normally a DMA comprises of 3000 to 5000 consumers.

202. At present there is no water meter installed in Panipat city water supply system. The meters are neither provided on tube wells delivery nor on consumer connections. It is therefore essential that water meters are installed on the delivery of each tube well and also on each of the delivery main at CWPS near WTP proposed. This will enable us determine the total quantity of water produced. In addition to these, one bulk water meter needs to be installed at the feeding pipe line of each OHSR to determine the Zonal distribution of water. The total requirement of water meters for production part comes to as below:

Bulk Meters for four pumping mains	4 nos.
Bulk meters for tube wells	194 nos.
Bulk meters near OHSR	32 nos.

203. There are reported to be around 27303 connections in the city as on 1.11.2008. All these connections are proposed to be metered. Therefore consumer meters of 15mm size 30000 nos. needs to be provided under this plan. The department may make obligatory on the part of consumers to bring their own water meters at the time of getting new connections or department may charge cost of water meter from the applicant consumer.

204. Provision of these bulk and consumer water meters will help in regular monitoring of water supply and overall gap between water produced and water billed every month on one hand and help in carrying out leak detection and control and there by UFW reduction work on the other hand. This one time investment in metering will ease and expedite the process of DMA evaluation and reduction in UFW. A dedicated team needs to be formed to undertake UFW reduction program involving DMA formation, leak assessment, detection and control etc. The zonal distribution also needs to be designed in a fashion which will help easy formation of DMAs.

205. One of the key component of distribution system contributing to high leakage level is consumer service pipe lines. These are generally of GI pipes which gets corroded and starts leaking. These service pipes are not only responsible for high leakage loss but also main source of pollution in distributed water. It would be desirable that all service pipe lines are replaced under the project with MDPE pipe. These pipes have given excellent performance without leakage on long term basis. In future, the service agency also need enforce use of MDPE pipes only for consumer service pipe lines.

206. A continuous exercise of leak assessment, detection and removal is likely to bring down the UFW to below 15% level. This will improve the financial condition of the water supply system and thereby reducing burden on the consumers. This also likely to improve consumer satisfaction and reduce chances of water pollution in distribution network.

C. Water Safety Plan

207. The main objective of the water security plan (WSP) is to supply water of a quality that will allow health based targets to be met. WHO guidelines for Drinking Water Quality (GDWQ) proposed a more effective risk assessment and risk management approach for drinking water quality and its control. The conventional approach of water quality and safety management is to be focused on testing of drinking water before contamination take place and to control. In the WSP approach the study is focused on vulnerable points and remedial measures with in the water distribution system which prevents the contamination before it reaches the consumer.

208. In the water distribution systems contamination is mainly caused due to leakages, lack of consumer awareness, cross connections of Sewerage/Storm Water drainage and Water supply network, recalcitrant attitude of the staff and bad O&M practices etc.

209. A Water Safety Plan (WSP) highlights the effective control in water supply systems to produce safe water and reticulate to the consumer maintaining quality at the designed rate of supply. Under WSP, water quality analysis is mainly used for periodic verification of water safety. The design and construction phases of water supply provision should take into account the risks of contamination and provide means of controlling the risks identified and this should take into account the risks of contamination and provide means of controlling the risks identified and this should be based on the concept of a WSP. Control of risks needs good operation and maintenance practices that are simple and rapidly applicable. These practices should help to detect and apply remedial measures at a rapid stage. WSP addresses the following aspects:

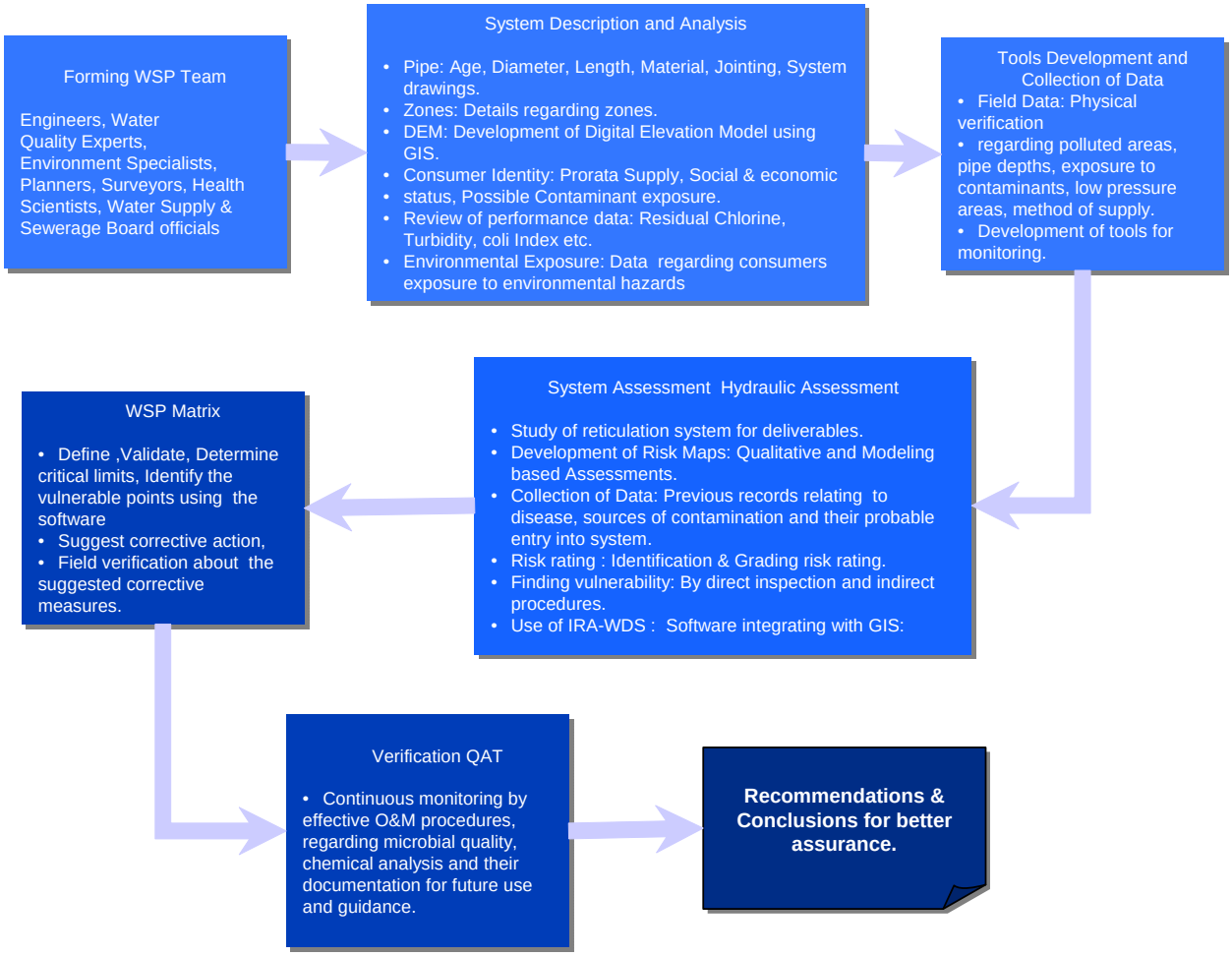
- The hazards that the water supply is exposed to and the level of risk associated with each.
- How each Hazard will be controlled;
- How the means of control will be monitored;
- How the operator can tell if control has been lost;
- What actions are required to restore control and
- How the effectiveness of the whole system can be verified.

210. By developing a WSP, the system managers and operators will gain a thorough understanding of their system and the risks that must be managed. This knowledge can then be used to develop operational plans and identify key priorities for action. The development of a WSP will also identify requirement to support and improve the performance of the water supplies in meeting the water safety targets.

211. WSP will increase the amount of time that the staff spends in the field for inspecting the system and undertaking physico-chemical analysis and reduce the dependence on analyzing samples of water for micro-organisms in a laboratory. Crucially the WSP enables the operators to get to know their system more effectively as they spend more time to identify and control risks rather than just analyzing them.

212. Water Environment Development Center (WEDC), Loughborough University, UK has developed WSP model and further integrated with GIS application. A typical methodology for development of WSP as per this model is given below:

Figure 2: Methodology for WSP Model



IX. OPERATION & MAINTENANCE PLAN

A. General

213. A well designed Operation and Maintenance (O&M) Plan for a water supply system is critical to ensure that the design intent is conveyed in daily operation resulting in maximum benefit to the residents at the minimum possible level of investment. Proper implementation of the O&M plan results in low maintenance costs and ensures longer service life of all system components. A detailed analysis has been performed on the water supply system of Panipat City and modifications recommended as part of this improvement project include the following:

(i) Construction of out lets across Delhi Link Channel and the Delhi Parallel Canal along with the inlet channel

(ii) Construction of Raw water sump and pump house

(iii) Construction of Rapid Gravity Filter Plant 100 MLD in the first phase.

(iv) Construction of a Clear Water Reservoir and a Clear Water Pumping Station near the WTP.

(v) Construction of OHSR, one for each zone. There are 32 zones but in the Phase I only _____OHSR shall be constructed in the area already developed.

(vi) Laying of trunk main pumping pipe line from the CWPS connecting all OHSRs.

(vii) Providing bulk water meters, one on each pumping main and one near each OHSR.

(viii) Replacement of submersible pumps of all tube wells including sluice valves and check valves near them and connecting their delivery to near by OHSR.

(ix) To provide automation system for each tube well so that they may be operated and controlled remotely.

(x) To put a SCADA system in place for automatic operation of Raw Waater Pump House, WTP, CWPS, All Tube Wells etc.

(xi) Construction of an online boosting pumping station to feed OHSR of Zone no.16 as the elevation of local ground is about 10m compared to rest of the town.

(xii) Providing of distribution system in the areas not covered so far.

(xiii) Providing of distribution system as per new zonal system designed.

(xiv) Non Revenue Water assessment and reduction works.

214. The critical issues that will be dealt in development of an O&M Plan will be the maintenance of equipment, pipelines, valves and other appurtenances and the system of providing house service connections.

B. Existing System of O&M

215. The existing O&M plan of Panipat City requires to be upgraded to reflect present day operational conditions and labour/material requirements to handle the existing system and proposed improvements. Presently, as is the situation in most of the Govt.Deptts, repairs are performed on need basis without proper analysis directed towards identification and long term rectification of system deficiencies.

216. The Operation and Maintenance issues of the present water supply system in Panipat City are:

(i) Lack of training to enhance skills of O & M staff: No periodic training of O & M staff is arranged by the department to upgrade their skills. The staff mostly learns the O & M practices during job. This leads to improper handling of equipments, which results in untimely damage of equipments.

(ii) Field engineers are responsible for large areas: The jurisdiction areas of field engineers are large. This has resulted in insufficient attendance to the work fronts by the field engineers.

(iii) Shortage of field staff such as fitters, operators, mechanics: There is shortage of skilled fitters, operators and mechanics in PHED. Because, of this, operational problems are not attended to, in time.

(iv) Lack of motivation of operational and field staff: Operational and field staff is not motivated to perform efficiently in the organization. There is no incentive or reward in performing efficiently to operate and maintain water supply system.

(v) Submersible pump and electrical equipment quality and their repairs: The quality of Submersible pump sets results in frequent breakdowns. There is no system for checking quality of repairs with regard to the post repair performance. This results in recurring breakdowns and lower efficiency resulting in higher electrical consumption.

C. Proposed Maintenance System

1. Preventative Maintenance

217. Preventive Maintenance of a water supply and distribution system is a set of activities that shall be performed on a regular basis. Preventive maintenance may increase the initial project cost marginally, but will result in economical maintenance of the system over the project life. Specifically in the internal distribution system, Preventive Maintenance will increase the life of water mains and appurtenances, which in turn will assure regular and uninterrupted water supply to consumers. The distribution system is usually the most expensive component of a water supply system and its proper maintenance will reflect on the functioning of a system and its associated service life.

218. Maintenance issues in pipelines will differ from place to place depending on conditions encountered. Selection of suitable pipe material and periodical maintenance is essential to ensure that the public receives protected water supply at the most economical rate with minimum breakdowns, which will ultimately manifest itself as consumer satisfaction. Salient points to be considered while planning are enumerated below:

- Inspection of mechanical / electrical equipment such as pumps, valves, capacitors for trouble-free operation and optimum performance
- Equipment shall be chosen of established quality to provide sustained desired performance.
- Newly laid mains shall be tested to ensure leakage level below specified in IS.
- Precautionary measures against corrosion shall be performed
- A leak detection survey and control shall be performed throhg DMAs.
- Ducts shall be provided across streets in large towns to permit easy laying of additional mains, if and where required.
- Provisions of stubs (short length mains) to accommodate a group of ferrule connections where required.
- Use of equipment like submersible dewatering pumps, pipe cutting machines, under pressure cutting machines, pipe detectors, leak detectors, lighting sets, butterfly valves etc.
- Use of proper chlorinators
- Preparation of 'ward manuals' with details of mains, valves, hydrants, etc. within a ward or zone
- Maintaining emergency labour teams to work on Sundays and holidays to attend to emergency works
- Liaison with other utilities for proper work co-ordination and reduced interference
- Adequate staff training
- Application of SCADA and automation to the extent feasible to improve system reliability and performance.
- System of information dissemination to consumers on possible disruption in supply

2. Breakdown/Emergency Maintenance

219. In case of damage (burst) resulting on a branch main, the following operational sequence shall be adopted:

- Labour workforce (skilled & unskilled) shall be mobilised and required materials shall be assimilated and the team shall be directed to the breakdown site.
- Main control stations, senior officers concerned with maintenance and distribution shall be informed of the situation and kept updated on progress.
- The concerned control office shall be intimated to isolate the damaged main and alternative supply arrangements (if possible tankers) for water supply to the localities affected shall be pressed into action.
- Utilities such as Gas, Electricity and Telephones shall be informed on the breakdown and request them to be present at site to ensure contractor co-ordination.
- The local traffic police shall be informed to ensure proper traffic regulation.
- Isolation of the water main by closing sluice valves on both the sides. This will have to be done if the pipe is damaged severely (pipeline burst).

3. Maintenance & Appurtenances

220. The objective of installing appurtenances on water pipelines is to permit control of water supply, protect the pipelines and assist with periodical cleaning. Normally installed appurtenances are described below.

4. Sluice valves

221. Sluice valves are required to control and regulate water supply and shall be provided at key locations. Defects normally reported on the sluice valves are:

- Gland leaks: Gland leaks can be rectified by replacing the hemp packing at specified intervals or through visual observation
- Spindle damage: Unequal application of effort results in damage to the spindle, which can be avoided by training valve operators to operate the valve in accordance with manufacturer recommendations on tightening pressure. It is necessary to have spare spindles for the full range to ensure replacement in the shortest possible timeframe
- Partial valve closure: Debris accumulated in the valve seat and around spindle heads causes this problem and can be removed by opening the top cover of the sluice valves. Rounding of spindle heads are a direct consequence of wear and tear and this can be reduced by using specially prepared caps. It is a recommended practice to provide a name plate near the curb or edge of a footpath detailing sluice valves with location, size and direction of opening. This will incidentally reduce

the complaint regarding sluice valves getting buried during road construction and/or trench backfill. When possible, sluice valves shall be installed along pavements. Sluice valves in roads where there is intense traffic shall be provided with heavy-duty pre-cast concrete cover slabs to avoid intentional or accidental damage. The longer side of the cover shall be kept parallel to the pipeline to indicate alignment.

- Scour Valves: Scour valves are normally provided at the bottom of pipelines (normally horizontal) and operated to flush and dewater the mains.

5. Maintenance of Service Reservoirs

222. Important aspects to be considered in the maintenance of service reservoir are:

- Measurement of inflows / outflows: Supply /Discharge flows shall be measured to ensure that they tally. Water level indicators and flow indicators / recorders shall be in working condition.
- Structural leakage: There shall be no structural damages and leak and shall be promptly repaired as soon as noticed.
- External Pollution: Manhole openings, ventilation shafts and overflow pipes shall be adequately protected and checked periodically to prevent any contaminant infiltration.
- General cleanliness in and around the service reservoirs should be maintained and observed.
- A garden around the service reservoir may be provided for aesthetic considerations.
- A program to clean the service reservoir at least once in a year shall be undertaken. Such cleaning process shall be performed during non-supply times or a facility to by-pass the water supply shall be in place.
- Appropriate measures to prevent entry of unauthorised persons shall be provided.
- All guide and hand railings shall be maintained in a safe and firm condition.

6. Maintenance of Water Distribution System

223. Conveyance and water distribution are items that involve substantial expenditure in a large water supply scheme. For effective maintenance, the entire water distribution system shall be divided into Zones served preferably from one elevated service reservoir. Operation and Maintenance of the water distribution system should be entrusted to a Junior Engineer who shall be the authorised official and controlling authority to receive and deal with complaints. Redressel of consumer complaints promptly is key to success of operational agency. Appropriate registers shall be maintained to record complaints and track follow up action to ensure that the complaint is addressed timely. If the complaint is such that it cannot be dealt with at his level, the Junior Engineer shall promptly refer the matter to a higher authority and also intimate the action taken to the complainant. Frequent vigilance checks in areas receiving maximum complaints shall be made an essential part of the supervisory staff's daily schedule of duties.

7. Distribution System Losses & Leak Detection

224. Wastage of water is the principal problem and concern in a water distribution system. Wastage of water accounts for nearly 40% of the total flow and is often due to the following reasons:

- Leaks from storage reservoirs due to cracks, leaky joints and valves
- Leakage from water mains due to leaky joints, corroded pipes, fractures in ferrule connections, valves and hydrants
- Leak through abandoned or unused service pipes and damaged pipes
- High pressure in the water distribution system intensifying existing leakage
- Leaks in service piping and fittings within the consumer premises due to faulty joints, corrosion, faulty washers or glands in stop valves and faucets
- Unregulated and excessive consumption of water by consumers for garden watering, flushing, cleaning utensils and washing
- Failure to close faucets inside or outside premises wilfully or inadvertently or complete removal of taps
- Misuse of protected water for miscellaneous purposes

225. Major areas in a water distribution system that contribute to a high wastage of water are house service piping and connections to public taps, hydrants and leaky plumbing fixtures. Leak in a water distribution system can be significantly reduced or even eliminated through systematic detection and damage control procedures. A program of Leak Detection shall be established for the entire water distribution system such that each section of the system turns up for leak detection at least once in three years. Leaks and damages detected shall be promptly repaired.

226. One other major cause of system loss is unauthorised connections. Procedures for granting connections require streamlining and regulation. The officer in-charge of this operation shall be equipped with the required authority to inspect households for water supply and ascertain the authenticity of an application for a new connection. The procedure for release of new connections shall be simplified and expeditious to encourage people taking connections legally.

8. Pipe Flushing

227. The pipe flushing process involves allowing water at high flow rates through piping to assist removal of deposits and contaminants in the pipelines. In a systematic flushing program, water from the cleaned main is allowed to enter the affected main for cleaning within in an isolated zone of the water distribution system. For effective flushing, a minimum velocity of 1.00 m/s (preferably 1.20 to 2.40 m/s) in the mains flowing full shall be maintained. Water shall be allowed to exit through a hydrant, scour valve or a temporary opening for a period of 5 to 15 minutes.

228. It is recommended to perform this operation during periods when storage or supply at the source is satisfactory. In some situations, even with high scouring velocity of 1.20 to 2.40 m/sec certain deposits, slime and heavier particles are not eliminated.

D. Public Private Partnership in Water Supply O&M

229. It will be desirable to involve private agencies in O&M to reduce O&M expenditure, improve efficiency and ensure timely preventive maintenance. To achieve this, giving some activities of O&M like new production system from canal, comprising of Inlet channel, Raw Water Pump House, WTP, CWPS, Booster pumping station, Pumping mains and OHSRs including bulk meters on service /management contract may be considered. This will also ensure that designed capacities of water are timely available for distribution. The existing technical employees may continue to look after the maintenance of distribution system. This will also improve the maintenance of distribution system as well as make it possible to work upon water safety plan and better customer service.

230. Another area which may be considered for giving on management contract is water meter reading, billing and revenue collection. This is an area which is mainly responsible for customer dissatisfaction. By giving this work on management contract customer satisfaction level is likely to increase substantially.

X. COST ESTIMATES

A. Basis of Costing

231. The proposed cost of this water supply improvements project in Panipat City has been performed based on the following sources:

- Design of the Proposed Improvements.
- PWD Standard Schedule of Rates (SOR).
- Consultant's data bank and experience on similar projects.
- Nominally applicable labor and material costs for items not present in the aforementioned SOR.

232. Block rates have been determined for improvement of distribution system, construction of WTP, Pumping Stations, Tube Well improvement etc. for projecting the cost each activity. Reference ahs been made to prevailing rates for current projects like Rohatak Water supply Project involving construction of Water Treatment Plant with Raw and Clear Water pumping stations and also improvement of distribution system.

B. Cost Estimate

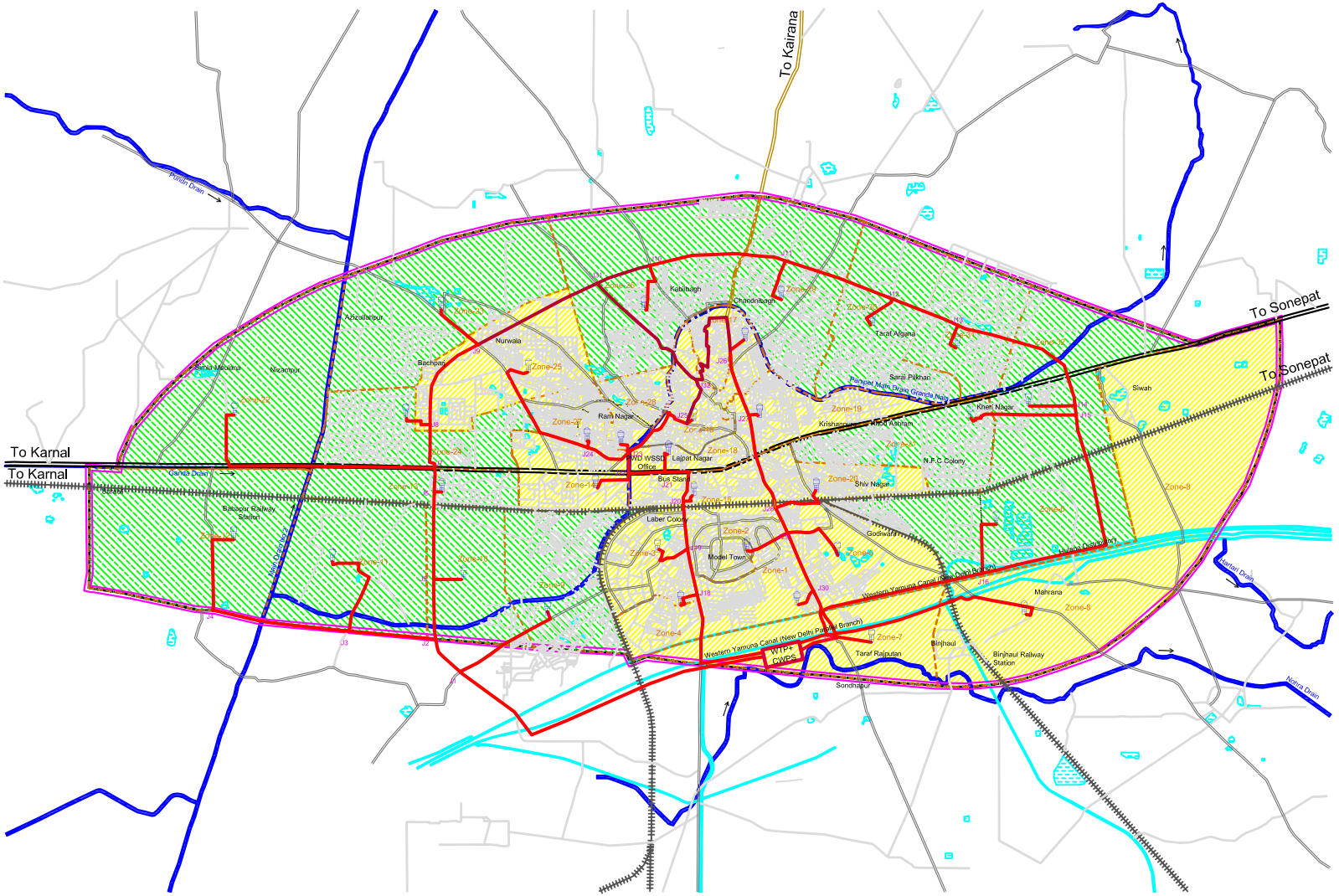
233. The following **Table 28** shows the costs estimates of the proposed works identified in the earlier sections. The total estimated cost of Master Plan proposals is Rs. 3,035 million. These works are proposed in two phases. Total cost of Phase is Rs. 1,950 million, which is about 64.2 percent of the total cost, while Phase II cost 1,085 million (35.8 percent). Phase-wise proposed projects location is shown in **Map 12**. Details of these cost estimates are given in **Annexure 9**.

Table 28: Cost Estimates

S. No	Item	Estimates Cost (Rs. Million)		
		Total	**Phase I**	**Phase II**
1	Providing out lets in Delhi Link Channel and Delhi Parallel Canal of 100 cusecs each and construction of inlet channel up to WTP site including construction of siphon across Delhi Parallel canal (As per estimate from Irrigation Department)	47.88	47.88	-
2	Construction of Raw Water Pumping Station comprising of Sump, Pump House building and 6nos. VT Pumping sets with required electrical switch gear (Total KW 420)@Rs25000 per KW	10.50	7.98	2.52
3	Construction of Water Treatment Plant complete Two units of 100 MLD each including SCADA system @ Rs.25 lac/MLD	500.00	250.00	250.00
4	Construction of Clear Water Pumping Station comprising of Sump, Pump House building and 6 nos. Pumping sets with required electrical switch gear(Total 2920 KW)@Rs25000 per KW	73.00	55.48	17.52

5	Construction of Clear Water Reservoir near WTP of 35 ML capacity @Rs.2000 per KL	70.00	70.00	-
6	Providing 33 KV Electrical feeder line from 132 KV GSS to WTP site along with construction of 33/0.4KV substation 1000KVA (As per estimate of Electricity department)	32.00	21.60	10.40
7	Cost of land 33 acres required for construction of WTP, RWPH, CWPS, supporting infrastructure etc.@ Rs.30 lac/acre	99.00	99.00	-
8	Cost of pumping main pipe line BWSC/MS/DI complete with valves, chambers, rail line and NHW crossings etc. complete	640.79	215.23	425.56
9	Cost of rehabilitation of 195 Tube Wells by replacement of pumping machinery, electrical switch gear, automation equipment, water meter and connecting pipe line to OHSR	91.00	91.00	-
10	Construction of 32 nos. OHSR with a staging of 20m and a total storage capacity of 64 ML complete in all respect @Rs.10000per KL	640.00	420.00	220.00
11	Improvement of distribution system in zones where water supply network already exist or unserved areas by laying of new, additional or higher sized pipelines with required appurtenances, chambers, thrust blocks etc. for a population of 1224926 @Rs.908 per capita	111.23	51.45	59.78
12	Cost of providing a Boosting pumping station online for Zone 16 with 2 pump sets 15KW each @Rs.25000 per KW	0.75	0.75	-
13	Providing Bulk water meters(4nos. EMFB type) and 28000 Domestic water meters complete including installation and commissioning	183.30	183.30	-
14	Replacement of consumer service pipe lines with MDPE pipes for 33000 connections @Rs.1500 per connection	59.40	59.40	-
15	NRW Identification and Reduction Works lump sum	150.00	150.00	-
16	Centralized Training Center of PHED lump sum	50.00	50.00	-
17	Sub Total	2758.85	1773.07	985.78
	Physical contingencies @10% of sub total	275.88	177.30	98.58
	Grand Total	**3034.73**	**1950.37**	**1084.36**

Source: Analysis



Capcity Development of the NCRPB: Component B (ADB TA-7055)

Panipat
Phase-wise Proposed Projects

Legend

- Study Area Boundary
- Municipal Boundary
- Proposed Road
- National Highway
- State Highway
- Major Roads
- Other Roads
- Railway Line
- Canal
- Drain
- Pond and Lakes

Overlay Legend

- Proposed Pumping Main
- Looping
- Zone Boundary
- Overhead Service Reservoir (OHSR)
- Phase -I
- Phase -II

Client
Asian Development Bank
National Capital Region Planning Board

Consultant
Wilbur Smith Associates Pvt Ltd

Drawn: SK	Checked: OPG
Date: Jan. 2009	Approved: NSS

Scale: -400 0 400 800 1200 1600 Metres

Map. 12

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