

NCR Planning Board
Asian Development Bank

Capacity Development of the National Capital Region Planning Board (NCRPB) – Component B (TA No. 7055-IND)

Drainage Master Plan of Hapur

January 2009



Abbreviations

AD/MM	:	Average Day/Max month
ADB	:	Asian Development Bank
Avg	:	Average
CI	:	Cast Iron
cms	:	Cubic Metres per Second
DI	:	Ductile iron
DMP	:	Drainage Master Plan
DPRs	:	Detailed Project Reports
GoI	:	Government of India
HNNP	:	Hapur Nagar Palika Parishad
HPDA	:	Hapur Pilkhuwa Development Authority
HQ	:	Head Quarters
HUDA	:	Haryana Urban Development Authority
IDF	:	Intensity Duration Frequency
Km	:	Kilometer
lpcd	:	Litres per capita per day
ML	:	Million Litres
MSL	:	Mean Sea Level
NCR	:	National Capital Region
NCRPB	:	National Capital Regional Planning Board
NH	:	National Highway
O&M	:	Operation & Maintenance
RCC	:	Reinforced Cement Concrete
SWD	:	Storm Water Drainage
TA	:	Technical Assistance
UIDSSMT	:	Urban Infrastructure Development Scheme for Small and Medium Towns
ULB	:	Urban Local Body
UP	:	Uttar Pradesh

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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.
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 C: Storm Water Drainage Master Plan of Hapur**, of the Interim Report. This report is the first step in the direction of producing DPR for sewerage in Hapur Town. This report is organized into following six (6) sections including this introductory section: Section 2 describes the methodology used for preparation of this Master Plan; Section 3 describes the profile of Hapur Town; Section 4 presents the assessment of existing drainage system in Hapur; Section 5 establishes the design criteria for development of the Plan, and the last section provides the recommended Master Plan.

II. METHODOLOGY FOR PREPARATION OF SWD MASTER PLAN

A. Overview

15. Current report is study of existing drainage system and its adequacy to meet current and future requirements. The report also identifies short term and long term measures required to improve drainage system. Subsequently detailed feasibility with due diligence for social, environmental, financial and economical safe guards shall be prepared. Finally detailed project report shall be prepared for identified components of drainage system.

B. Objective

16. This drainage Master Plan takes into account the land use element of the current Town Development Plan as well as the existing and proposed zoning in developing the storm water runoff calculations. The objectives of this Drainage Master Plan include:
 - (i) Providing a comprehensive description and mapping of the Town storm drain system (trunk and main drains only) including unlined channels and ditches;
 - (ii) Updating the Town Base Map to show locations of public storm drains and facilities, including their size, material of construction, and flow directions;
 - (iii) Analyzing rainfall data collected over a period of 22 years, including development of IDF curves for different storm frequency periods;
 - (iv) Doing a critical evaluation of the storm drainage and channel systems in order to identify existing and future deficiencies;
 - (v) Evaluating deficiencies in the existing storm drainage maintenance program including recommendations for improvement of existing drainage infrastructure to meet future requirements;
 - (vi) Recommending appropriate O & M practices so that storm water discharges are managed in accordance with Town Development Plans, and in conformity with the regulations of various agencies, such as the State Pollution Control Board, Water Supply & Sanitation Department etc.

C. Scope of Work

17. The Scope of Work for the Drainage Master Plan includes the following tasks:
 - (i) Collection and review of existing information as available with the nodal agencies;
 - (ii) Identification of areas/zones where storm drainage system is cross-connected with the sewerage system;
 - (iii) Identification of other local conditions that may impact the ability of the storm

- drainage system to avoid flooding;
- (iv) Field investigations to verify existing storm drainage system, typical cross-sections of storm water channels, roadside drains and culverts;
 - (v) Collection and analysis of rainfall data and plotting the rainfall intensity duration curve for the city;
 - (vi) Calculation of design flows based on the hydraulic analysis carried out as part of the Drainage Master Plan;
 - (vii) Identification of System Deficiencies;
 - (viii) Based on above preparation of drainage master plan with Identification of all required improvement projects, prioritization of projects and probable construction costs.

D. Approach and Methodology

1. Collection of Secondary Data

18. The project team collected the secondary data available from different nodal agencies. The available reports, as-built records, and O & M practices were reviewed. Town Land Use Plan prepared from the Town Development Plan 2005 was collected. Historical rainfall information, existing drainage information, flood prone areas were collected. For information about the city and drainage conditions, interaction was made with Chief Engineer HPDA, Executive Officer HMC, City Engineer, HMC, Engineer HMC, Health Officer, HMC, public representatives and local residents.

2. Field Verifications

19. The Project Team conducted field investigations to verify existing storm drainage system, typical cross-sections of storm water channels, roadside drains and culverts. Flow directions of channels and surface runoff were verified.

3. Rainfall Analysis

20. For drainage, intensity of the rain is required for analysis. As such hourly rainfall data is required for discharge measurement and hydraulic analysis. Since hourly rainfall data of Hapur is not available, the Project Team plan to utilise the rainfall data of Delhi which is about 65 Km. The monthly rainfall data of two nearby station of Hapur i.e Dehra and Dasna were compared with the data of Delhi and as such hourly data of Delhi was used for calculating the intensity of rainfall for the study. The rainfall data is available from 'Report on rainfall data of New Delhi (Year 198-2006) of UP Jal Nigam for Yamuna Action Plan' of UP Jal Nigam. Subsequently, design intensities were estimated and intensity duration frequency (IDF) curves were plotted.

4. *Hydraulic Analysis*

21. The Project Team calculated the design flows based on the hydraulic analysis carried out as part of the Drainage Master Plan. The Town's storm drainage system was analyzed using In-House-Built Excel Software for open channels.

5. *Identification of System Deficiencies*

22. Hydraulic structures are sized to convey the maximum anticipated runoff of an area, which occurs when the building density of upstream areas reaches its saturation i.e. the maximum development allowable within the zoning under consideration. In this study, the design flow calculations are based upon the assumption that the upstream drainage area has reached maximum allowable development.
23. Hydraulic capacity of the drains was analyzed using Excel Software. Deficiencies within the storm drainage system were identified. For drainage facilities identified as undersized, the drainage area upstream of the structure was evaluated to determine whether "build-out" capacity for the town has been attained. Undersized structures located in areas that have reached "build-out" capacity for the town are given a higher priority for improvement than those located in areas where more development is anticipated.

6. *Preparation of Drainage Master Plan*

24. The Project Team prepared a Drainage Master Plan (DMP) based on recommended system improvements identified during field investigations and hydraulic analysis. The DMP identified improvement of existing drainage facilities, and need of additional drainage facilities to minimize cross connection problems in the town to meet the growth related needs, and included a prioritized listing of each of the projects. Improvement projects are considered those located in areas with little or no anticipated future development. Growth related projects considered are those resulting from the increased runoff associated with future development. The DMP should become a tool that is used by the town to plan subsequent work. The following key elements are included:
 - (i) Identification of all required improvement projects;
 - (ii) Prioritization of projects;
 - (iii) Our opinion of probable construction costs;
25. All above evaluations, analyses, and recommendations performed by the Project Team are used in designing, and subsequently drawing the costs in a phased manner, and documented in the Drainage Master Plan. Based upon the findings, and after review of the available data, the Project Team performed a preliminary delineation of sub-watersheds and finalized the critical basins for hydraulic analysis purposes.

III. PROFILE OF HAPUR TOWN

A. Project Area Profile

1. *Location and Connectivity*

26. It is situated in Ghaziabad district at 28° 44' N latitude and 77° 47' Longitude. The city is well connected with important cities of country. National Highway-24, Delhi-Lukhna-Muradabad passes through Hapur. National Highway -18, Merath-Bulandsahar also passes through Hapur city. The main Rail Line Delhi- Lukhna-Hawra also passes through Hapur city. Hapur is also connected with rail to Merath and Bulandsahar. Hapur city is 54 Km from Delhi, 32 Km from Merath, 39 Km from Bulandsahar and 432 Km from Lukhna.

2. *Climate*

27. Generally the climate is like plain areas of UP. Like north India hot summer season prevails in the month of May and June. Winters are from November to February. The average temperature is 1.80C to 44.90C. The wind in 40% days is from north, north-west and west direction: on 20% days the wind blows in east and south-east direction

3. *Topography*

28. The town has almost flat topography except a small portion in the South, which is a little higher than the general ground level. The general slope of the town is from North to South. The difference between the maximum and minimum ground levels is about 3.0m. Reduced level varies from 213 to 210 m above mean sea level. The depth of sub – soil water in the town varies from 9.0m to 12 m during different seasons. There is no perennial surface source in and near the town except River Ganga which is 30 KMS from Hapur towards east. The city drains through two natural drains generally flowing north to south and named Chaua drain which is situated towards west of Hapur city. These drains converge and finally drain in Kali River. The general nature of the soil is sand mixed with clay.

4. *Socio-economic Conditions*

29. Hapur is an important commercial centre. It is an important town in NCR area, which is being developed to decongest National Capital Delhi by improving infrastructure in NCR towns with the aim of shifting some of the offices and establishments of Government of India. It is a big mandi of Grains, Gur, and Potato etc. Six big silos of grains owned by the Ministry of Food and Agriculture of the Government of India, exist in the town. Small to medium industries manufacturing sewing machines, motor spare parts, all type of agricultural machinery & equipments, oil expellers etc. have already developed in the town. Due to enormous growth of potatoes in the area around, there are many cold

storages in the town. The town has all modern amenities like transportation, electricity, telephone – landline as well as mobile, water supply, sewerage etc. the town has many technical institutions, degree colleges, intermediate colleges, tehsil office, post office, fire station etc. For all the above-mentioned reasons and its strategically important location, Hapur is a fast developing town.

30. The main occupation of inhabitants is agriculture and agro based trade and business. Therefore, the people, specially farmers and traders are generally well to do. The importance of this town is steadily increasing. Economic conditions of the people are similar to those of any average Indian small town. There are double storied houses also in the town apart from single storied pucca & kuchcha houses. The affairs of the town are managed by the local body, Hapur Nagar Palika Parishad.

5. *History and Culture*

31. Many stories are prevalent for birth of city such as, i) it was established by King Harischandra, ii) Shree Haridutt of Merath/Bulandsahar established it and gave name of Haripar, iii) The word Hapur means garden and so the name of city is Hapur
32. In 19th century a French General name Pairan appointed by Marathas started distribution of financial assistance to retired and incapacitated persons. Britishers used this city traditionally for many years to provide land to retired and incapacitated persons after cleaning forest bushes. In the year 1805 tehsildar of Hapur Ibrahim Ali saved and protected the city from an attack by Aamir Khan Pindary and his 500 soldiers. During 1985 at the time of India's struggle for independence Walidad Khan of Malagarh planned invasion of this city but because of resistance of jats of Bhadhona it was not successful.
33. The city was surrounded all around by wall and had 5 gates- Dehli, Merath, Garh Mukteshwar, Kothy and Sikandra. However, now none of these exists except some remnants. Jama Masjid was constructed in the year 1670 during rule of Orangjeb. In year 1982 Municipal Corporation was established. Power supply started in year 1932, water supply in year 1957 and sewerage system in year 1974.

B. Municipal Services

1. *Water Supply*

34. Ground water is available in sufficient quantity at shallow depth and as such is source of water supply. The existing water supply in Hapur Town was first introduced in the year 1955 on the basis of the scheme prepared in the year 1952-53 at an estimated cost of Rs. 11.53 Lakhs. The scheme had been designed for design population of 5,500 at the rate of water supply of 135 lpcd. In this scheme, one no. overhead tank 675 Kl capacity on 19 m staging and 4 no. tube wells along with distribution system had been proposed.

35. With the increase in population and consequently greater demand of water, the water supply arrangements fell short of the requirements. Therefore, a water supply reorganization scheme was prepared by the Executive Engineer, II Project Division,
36. EE Project Division, UP Jal Nigam is incharge of all Water Supply and Sewerage works of Hapur and Buland Sahar towns. A project estimated to cost Rs. 32.35 Crores has been sanctioned by the government under UIDSSMT for reorganisation of Water System of Hapur town. The present rate of water supply in the town is around 100 lpcd. There are 18 tube wells for water supply which are directly connected to distribution system except in three areas, where water is supplied through over head reservoirs. There are 5 overhead tanks (storage capacity 3675 KL) spread in 5 water supply zones. All water connections are un-metered including commercial and industrial connections. The tariff is based on rentable value and area of plot and is different for domestic, commercial and industrial consumers.
37. The project proposes to provide water supply to the designed population of 425,331 for the year 2034 by constructing new tube wells, over head tanks and pumping stations. Construction of new tube wells will be staggered in three stages; In first phase requirement of year 2009 will be met; In phase II, requirement of year 2024 will be met and in the 3rd phase ultimate requirement of the year 2034 will be met. It is proposed to supply water @135 lpcd and additional provision of 15% for losses in the system has been accounted. The project has been approved by GOI under UIDSSMT and is waiting for release of funds for start of works.

2. *Sewerage*

38. Sewerage system in city was laid by UP Jal Nigam in year 1974. There is one sewage pumping Station near Bulandsahar road and no sewage treatment plant. The sewage was used for agriculture purpose. However now the cultivable land has come under urbanization/ houses are built. The sewage had large number of takers earlier but due to urbanization farming has greatly reduced in the nearby areas and as such now no takers for sewage. Sewerage system is maintained by Municipal Corporation. The present sewerage system exists in about 30% area of the old town but is almost defunct. Municipal authorities maintaining the sewerage system informed that the existing sewers are choked and over-flowing in number of areas. The sewage flow is so less that at present pumping is done for 2 hours a day and that too with one pump operating against installation of four pumps. This also indicates that most of the sewers are choked or connected to drains.
39. Earlier it was proposed to prepare sewerage scheme for Hapur under UIDSSMT, but subsequently the state government took a decision to have sewerage schemes for District Head Quarter towns only in the first instance and accordingly the work of preparation of sewerage project was dropped by UP Jal Nigam. HPDA informed that they will take up the matter with the state government for giving relaxation in this regard looking to the fact that Hapur is under NCR and probably the only Non District HQ Town which has a Development Authority.

3. *Solid Waste Management*

40. Solid waste management is looked by Municipal Corporation. Proper land fill site does not exist and the waste is disposed improperly. UP Jal Nigam is preparing DPR for Solid Waste Management.

C. Master Plan for Hapur

41. Master plan for Hapur for year 1979-2001 was prepared for population of 2 lac in year 2001. In the year 1985 NCRPB came in existence which formulated regional plan 2001 in which it was envisaged to develop Hapur as regional magnate city with assigned population of 4.5 lac in year 2001. Keeping this fast required growth in mind the Master Plan of hapur was revised and prepared for target year 2005 with population as 4.5 lac. The aims of Master Plan 2005 were i) To stop unplanned and uncontrolled growth of areas in the city and adjoining areas and make guidance for planned development, ii) Adjust planned population in city area on rational and scientific basis of assigned densities for different areas, iii) Provide utilities, services and social services for balanced development of city, iv) To control population of Delhi, develop Hapur city as regional magnate city to increase economic activity and attract jobs. Now new Master Plan is under preparation with UP NCR Cell for next 20 years.

IV. ASSESSMENT OF EXISTING SYSTEM

A. Overview

42. The existing municipal boundary of Hapur Town encompasses about 3.34 Sq. Km. area, whereas the Master Plan area is about 53.01 Sq. Km. The average elevation of the Town is 213 m above the Mean Sea Level (MSL). The general topography of the town is flat having slopes towards North-West to South-East.

B. Major Drains

43. There are four major drains flowing through the master plan area of the Hapur viz Drain No1, Drian No 2 (Choya nallah, Circular road drain and Delhi Garh road drain. Out of these three drains flow through the municipal boundary of the town. The part of the Delhi garh drain flows in Choya nallah.
44. All the drains ultimately flow into the Kali river, which is at the south of the town. Drain No 1 and Choya Nallah converge at Rampur road near Haddi meel and flow in to the Kali river. **Map 1** shows the existing drains on the Hapur map. The details of these drains are as follows:

1. *Drain No. 1*

45. This drain flows outside the municipal boundary of the town. The drain enters into the master plan area from Badnauli and flows to Sabli village converging with choya nallah and draining into the kali river beyond the Hapur Bypass. The length of the drain is about 8.7 Km (within the master plan area)

- (i) Upto the Delhi Moradabad Railway Crossing: The drain flows through the agriculture fields and is kuthca taking the natural course. The photo attached shows the drain just at the u/s of railway crossing.



- (ii) From Railway Crossing to Crossing at NH24: This section is pucca trapezoidal section. The section reduces from about 35m at railway crossing to 14m at culvert near to the railway crossing. Though the section is pucca but is full of weeds, which interrupts the free flow the drain. The photo attached shows the bushes at the base of the drain.



- (iii) From Crossing at NH24 to Rampur Road via Sabli Village: The section (attached photo) is kutchha with width ranging from 17m to to 15m with an average depth as 1.5m passing through the agriculture field.








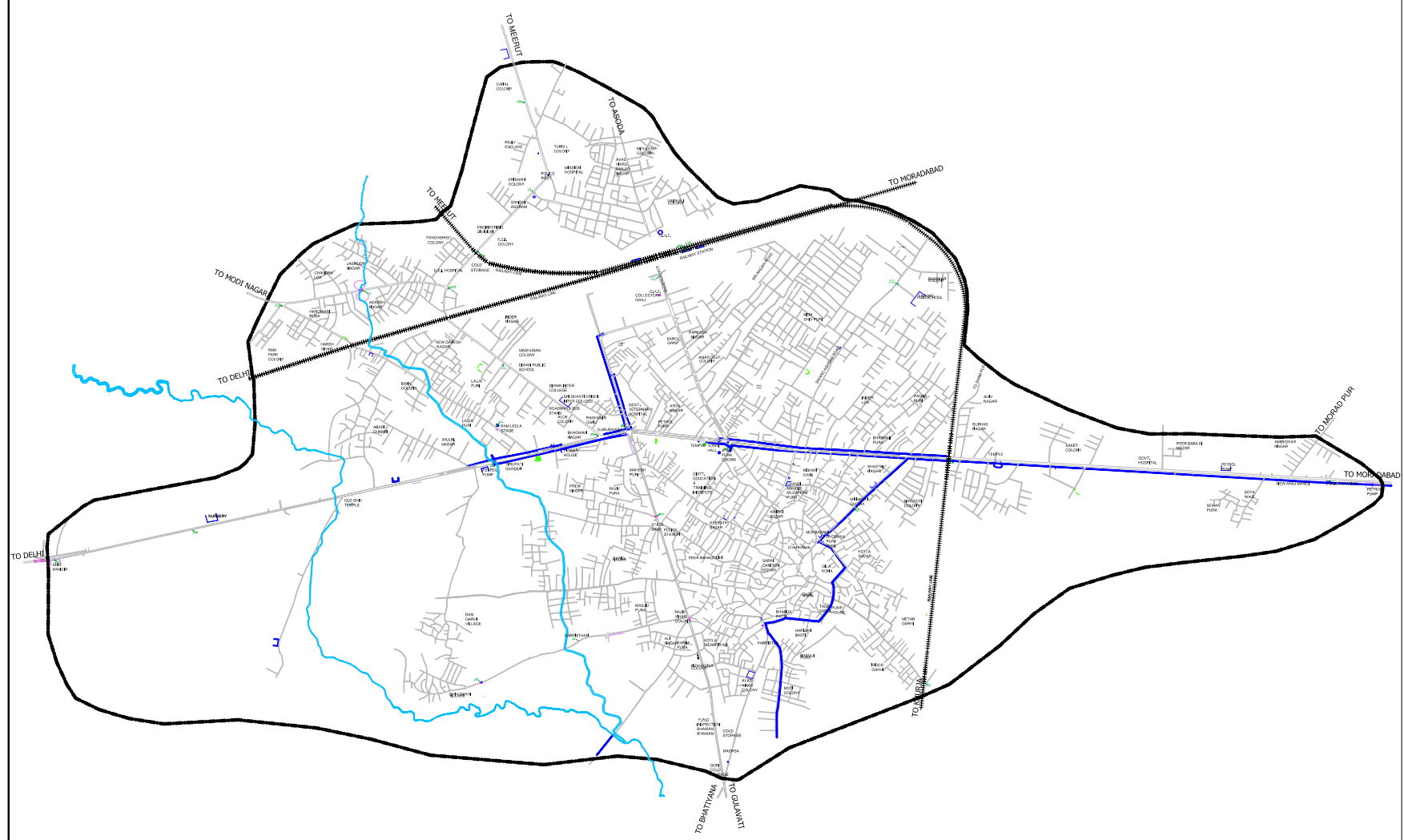
46. As the drain is not flowing mainly through the city area, there are no problematic areas nearby this drain.

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

**Hapur
Existing Drains**

Legend

- Municipal Boundary 
- Road 
- Railway Line 
- Existing Drain 
- Water Body 



Client:
**Asian Development Bank
National Capital Region Planning Board**

Consultant:
Wilbur Smith Associates Pvt Ltd

Drawn: SK
Date: Jan. 2009
Scale: NTS

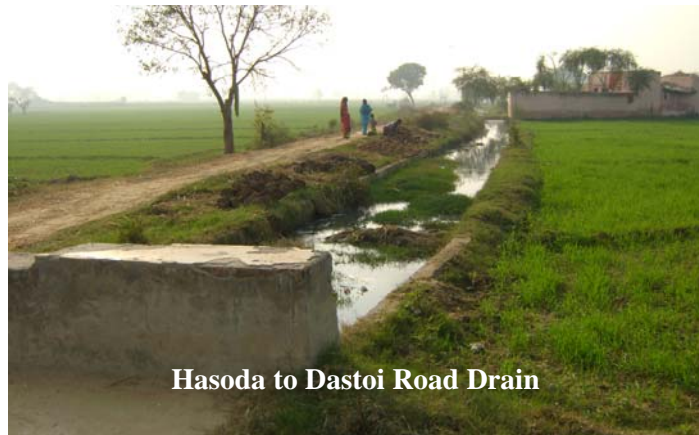
Checked: HVS
Approved: NSS



2. *Drain No. 2 (Choya Nallah)*

47. This is the main drain of the Hapur city and most important drain of the city. The drain enters the master plan area at Hasoda village and flows to Kali river passing through Jasroop Nagar, Adarsh Nagar, New Ganesh nagar, Lajja puri, Ramgarhi village and Shivgarhi village of the town. The length of the drain within the master plan area is about 4Km. For study purpose, the drain has been divided in following seven sections and the details of each section are mentioned below:

- (i) Hasoda to Dastoi Road. This is a pucca rectangular channel with dimensions of 3mx1.4m. The drain carries the sewerage of dheerukheda industrial area and other areas upstream of the drain. The photograph 4.4 shows this section of the drain.



- (ii) Dastoi Road to Modinagar Crossing. In this portion the drain is almost nonexistent and all the water flows in the field and take a course from the habitation. The area is not densely populated and many fields filled up with water can be seen.



- (iii) Modinagar Crossing to Delhi Moradabad Railway Crossing. At Modinagar road crossing, the drain is presently dry as the black water is not finding path from the field. There is no defined path of water in this section also

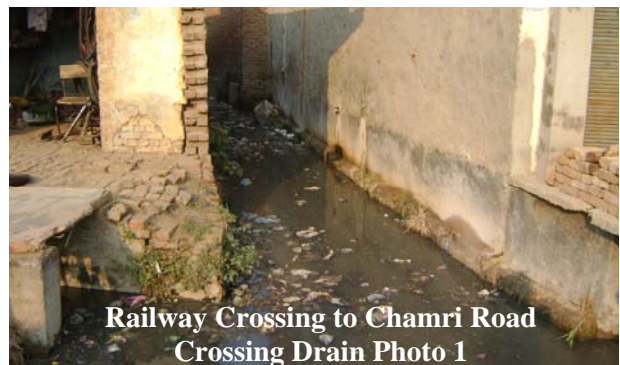


and colony Adarsh Nagar has come up in this section. The drain is only defined at railway crossing where width is 12m.



Modinagar Crossing to Delhi Moradabad Railway Crossing Drain Photo 2 and 3

- (iv) Railway Crossing to Chamri Road Crossing. This is the densely populated area through which the drain passes. In this section the drain takes path between the houses of colony New Ganesh Nagar. At Chamri road crossing the section is about 2mx1.5m. The pipe culvert is blocked and garbage dumping place is also at the drain, thereby making path for entry of solid waste into the drain.



Railway Crossing to Chamri Road Crossing Drain Photo 1



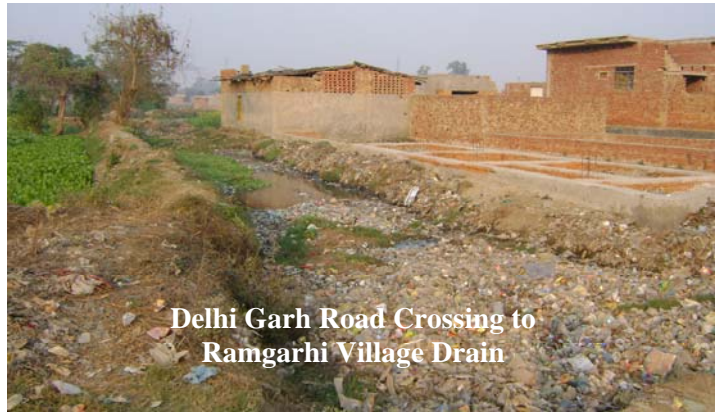
Railway Crossing to Chamri Road Crossing Drain Photo 2 and 3

- (v) Chamri Road Crossing to Delhi Garh Road Crossing. The drain passes through Lajjapuri colony and at Tirupati gardens at Delhi Garh road the section is 12m with water depth of 1.5m. The major flow from the drain on Delhi Garh road meets at this junction. The section of the delhi Garh road at this junction is 2.2m X3m depth.



Chamri Road Crossing to Delhi Garh Road Crossing Drain

- (vi) Delhi Garh Road Crossing to Ramgarhi Village. The drain is also kutchra in this area and the section at Ramgarhi village is 7.4m x 1m. The area is relatively less dense.



- (vii) Ramgarhi Village to Rampur Road and to Kali River. The section is kutchra and flows through Idgah road and further through agricultural area to Rampur road where it converges with the flow coming from Drain No 1 and ultimately flows into the Kali river.

48. This is the major drain which has most problematic areas and particularly in absence of the sewerage system the drain acts as sewer line.

3. *Circular Road Drain*

49. This is a channelled drain along with the circular road of the town and flows from near Shastri nagar at Delhi Garh road to sikander gate to Kali river. The drain passes through Shastri nagar, Minakhshi Chowk, Ayodhya puri, Qila Kona, harijan basti, Kabristan and Moti colony. The section at the start is almost a small drain with 0.3m width which increases from 0.8mx0.45m at Garh ghati chowki to 3mX2.8m at Sikander gate. Here also the drain takes the waste water of all the habitations in course of this drain. The length of the drain is about 2.1 Km.



Circular Road Drain

4. *Delhi Garh Road Drain*

50. The part of the drain from Khurja Delhi railway crossing flows westwards and flows ultimately to the Kali river. The major part of the other portion flows towards the choya nallah. The drains are at both sides of the road with a width ranging from 1.5m to 2.5m. The length of the drain is about 2 Km However this drain is not on full stretch and breaks

near the town hall up to the Merrut road junction.

C. Flood Prone Areas

51. The information about the flood prone area was gathered from public representatives, municipal corporation officials and local public and following areas were identified. The area was physically inspected and problems were discussed with local residents. The details of the problematic areas are as follows;
- (i) Adarsh Nagar. This is the area in the basin of Choya nallah and in this area the choya nallah disappears and the water spreads in to the field and the colony. In absence of any course for the drain the problem acute during the rain. The habitation has been settled on the bed of choya nallah and due to house construction and other residential activities the area has become flood prone.
 - (ii) Ganesh Nagar. This area is also on the basin of Choya nallah and the drain passes through the area. As the area is densely populated the course of the nallah has been restricted to about 2m width and flows in between the houses. In absence of sewerage and proper solid waste management system, the drain acts as sewer and is blocked by solid waste.
 - (iii) Lajja Puri. The area's problem is similar to that of Ganesh nagar and the small drains also are full of waste water and do not take path into the drain due to inadequate size of the main drain, inadequate slope of the drain and blockage of drains due to solid waste.
 - (iv) Gol Market. The area is just at the Delhi Garh road. The section at this area is small and the drain flows below the shops. Due to break in the Delhi Garh drain, the water from this road takes path into this area and causes flooding.

D. Major Cross Connections to Sewers

52. In absence of the sewerage system in most part of the city, the drains act as carrier of waste water. The Choya nallah and Circular drain takes sewer of Jasroop Nagar, Adarsh Nagar, New Ganesh nagar, Lajja puri, Ramgarhi village, Shiv garhi village.

E. Existing and Proposed Drainage Zones






53. For drainage planning, the town has been divided into various zones. The nomenclatures of the zones have been made as per the Drain. The first number indicates the drain and second to the number assigned to the zone. The basin has been marked based on the proposed and existing drains. The drainage basin in Hapur is shown in **Map 2**.

- (i) Drain Basin 2-1. The basin contributes to the section Hasoda to Delhi Moradabad railway crossing. The area consists of Dheerkhera Industrial area, Hasoda, Panchsheel colony, Jasroop nagar and Adarsh nagar and nearby areas. At present the Hasoda area is mostly agricultural. The most part of this basin has been indicated as Industrial area in the master plan. The total area of this catchment is 4.79 SqKm.
- (ii) Drain Basin 2-2. The basin contributes to the section Delhi Moradabad railway crossing to Garh Delhi road. The contributory areas are colonies of municipal ward no 2. The area is residential. The total area of this catchment is 3.5 Sq Km.
- (iii) Drain Basin 2-4. The basin flows into the section Garh Delhi road to Ramgarhi Village. The contributory areas are colonies of municipal ward no 11. The area is residential. The total area of this catchment is 3.07 Sq Km.
- (iv) Drainage Basin 2-5. The basin contributes to the section Ramgarhi Village to Kali river. The contributory areas are outskirts of the Hapur city. The area is agricultural and most area has been assigned as green belt area in the master plan. The total area of this catchment is 4.31 Sq Km.
- (v) Drainage Basin 4-1. The basin contributes to the Delhi garh Road drain. The contributory areas are colonies of municipal ward no 10, 12, 13, 18, 23 and 25. The area is residential. The total area of this catchment is 7.76 Sq Km.
- (vi) Drainage Basin 5-1. The basin contributes to the Delhi garh Road drain beyond the Khura railway line. The contributory areas are colonies of municipal ward no 1. The area is residential. The total area of this catchment is 7.8 Sq Km.
- (vii) Drainage Basin 3-1. The basin contributes to the circular drain. The contributory areas are colonies of municipal ward no 3, 5, 8, 14, 15, 20, 21 and 27. The area is residential. The total area of this catchment is 6.59 Sq Km.
- (viii) Drainage Basin 6-1 and 6-2. The basin will be contributing to the new proposed drain at Merrut road. The contributory areas are colonies of municipal ward no 16, 17, 19 and 26. The area is residential. The total area of this catchment is 1.26 (6-1) Sq. Km. and 2.21 (6-2) Sq Km.





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

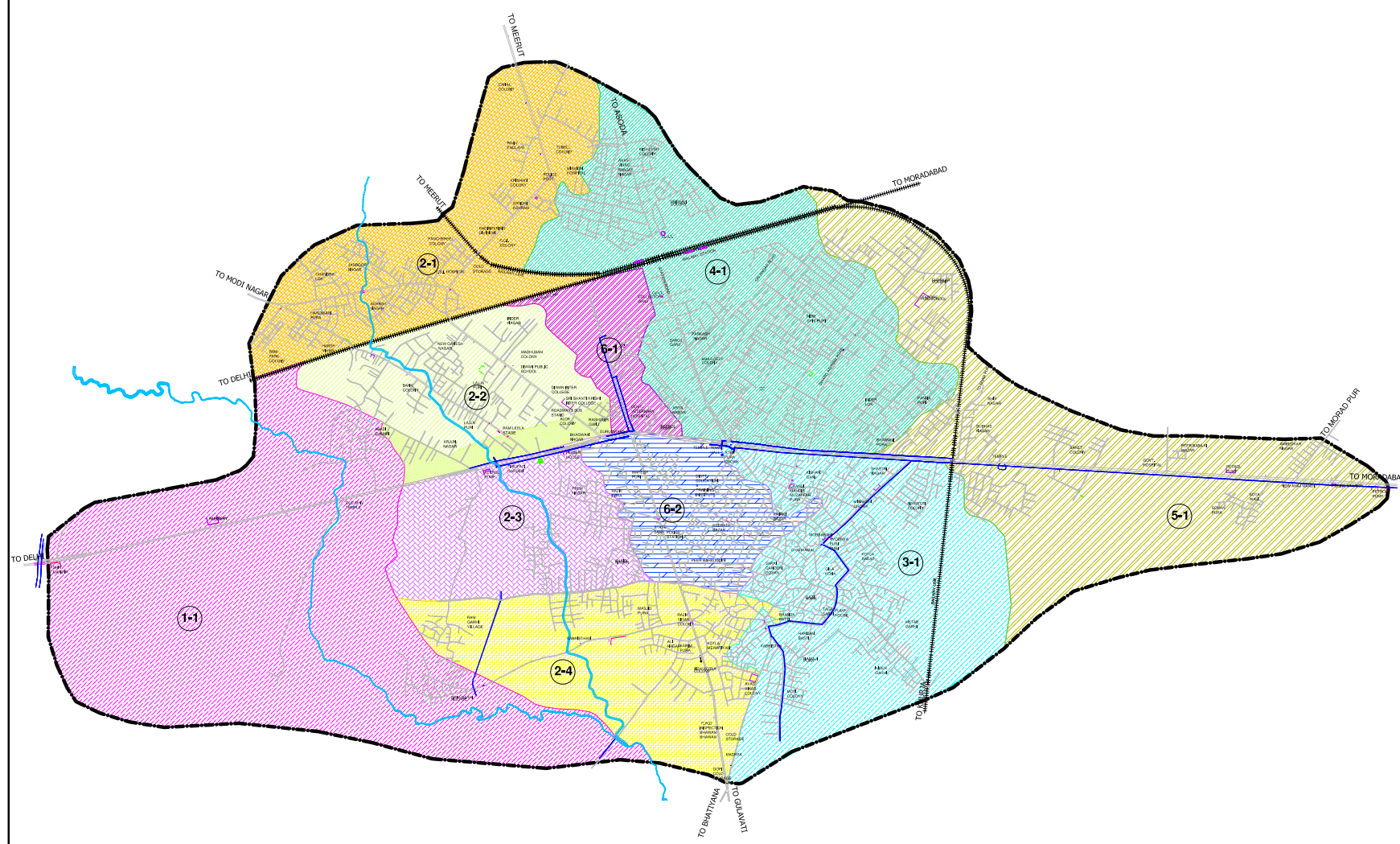
**Hapur
Proposed Drains Basin**

Legend

Municipal Boundary	
Road	
Railway Line	
Drain	
Water Body	

Overlay Legend


Drainage Basin 1 for Drain 1	
Drainage Basin 1 for Drain 2	
Drainage Basin 2 for Drain 2	
Drainage Basin 3 for Drain 2	
Drainage Basin 4 for Drain 2	
Drainage Basin 1 for Drain 3	
Drainage Basin 1 for Drain 4	
Drainage Basin 5 for Drain 1	
Drainage Basin 1 for Drain 6	
Drainage Basin 2 for Drain 6	



Client:
**Asian Development Bank
National Capital Region Planning Board**

Consultant:
Wilbur Smith Associates Pvt Ltd

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

Map. 2 

F. Administrative and Institutional Arrangement

54. The major institutions that provide and maintain Storm Water Drainage services in Hapur are Hapur Municipal Council (HMC) and Hapur Pilkhuwa Development Authority (HPDA), Hapur.

1. Hapur Municipal Council

55. The HMC is the main administrative body responsible for solid waste management, water and wastewater management, and maintenance of roads, storm water disposal, street lighting and slum improvements.

2. Hapur Pilkhuwa Development Authority (HPDA),

56. Modern and planned development of Hapur is necessary in view of the geographical, historical, commercial industrial importance and planned development of NCR. As such Hapur Pilakhua Development Authority (HPDA) was established as a second and an independent authority from GDA by U.P. Administration during 1996-97. Since its inception, the HPDA has acted as the nodal agency for all major urban development activities. These include developing housing colonies, providing social infrastructure facilities like parks, playgrounds as well as improvement of the environment, roads, drains and sanitation facilities.

3. Institutional Arrangement

57. Though there is no marked administrative responsibility for construction of new drains in Hapur city, but by an large the construction of drains within the municipal area is taken care by Hapur municipal council and outside this taken care by HPDA. The construction of the new drains by HMC is under the works department of HMC, whereas cleaning of drains is taken care by Health department of HMC.

V. DRAINAGE PLANNING - DESIGN CRITERIA

A. Planning Capacity

58. The need for future drainage infrastructure improvement and the expansion of the Town depends on actual Town development, rainfall intensity, and storm recurrence period (storm frequency). Planning Capacity refers to maintaining proper infrastructure of the Town for projected loadings. Development planning for the town serves three purposes:
- (i) It allows the system to remain effective over the required period to implement capital improvement projects (typically 2 to 5 years). Planning gives the town a mechanism to initiate master planning updates and staged improvements over the planning horizon. This should allow the Town to stay ahead of system needs.
 - (ii) It allows the system to accommodate unplanned or unforeseen developments and consequent storm water loads over short time periods without unduly overtaxing the system, thereby allowing the town to adjust infrastructure upgrade schedules to encounter the deviations.
 - (iii) It is necessary to address flow variations. Storm water flow can vary considerably from projected flows depending on actual land uses, growth trends and seasonal rainfall.

B. Design Parameters

59. The guidelines of CPHEEO manual on Sewerage have been followed for drainage system design. Based on the guidelines, the discharge that the system will require to drain off has been calculated. The discharge is dependent upon intensity and duration of precipitation characteristic of the area and the time required for such flow to reach the drain. The storm water flow for this purpose has been determined by using the rational method.
60. As part of planning, design and project formulation process, the basic design parameters have to be predetermined so as to analyse the carrying capacity of existing drains and also for the design of new drains. These parameters are as follows:
- (i) Frequency of storm / return period
 - (ii) Depth –duration of storm
 - (iii) Time of concentration
 - (iv) Run off coefficient for the project area
 - (v) Method of computing flow in the channels

61. Based on the above parameters, the pattern of rainfall, runoff and time of concentration for the flood to occur, time acceptable to allow for draining have been decided. This is particularly essential as the rate of urbanisation is very high. Analysis of the existing drains carrying capacity has been arrived at based on the finalized design parameters.

1. *Computation Of Design Flow*

62. The entire storm water would not reach the Storm Water Drainage (SWD). Fraction of it would flow to SWD, which depends on the imperviousness, topography, shape of the drainage basin and duration of the storm. This imperviousness is quantified by a coefficient of runoff, which needs to be determined for each sub-catchment of the drain. The peak runoff at any given point is calculated using the following rational formula.

$$Q_p = C_s CIA/360$$

Where,

Q_p - peak flow in m^3 /sec

C – Runoff coefficient

I – design rainfall intensity mm/hr

A – Contributory area in hectares

C_s – storage coefficient

2. *Coefficient of Runoff*

63. Because runoff is directly proportional to the value assigned to “C”, the proper selection of this value is critical for storm water runoff calculations. Care has to be exercised in selecting this value as it incorporates all of the hydrological extractions, surface imperviousness and antecedent conditions.
64. As development increases, the amount of runoff also increases. Runoff coefficient “C” values selected for this report are based on the land use pattern described in the Hapur Master Plan 2005, and are listed in **Table 1** given below. The values of the runoff coefficient “C” for each land use type have been selected to reflect the most recently approved land use zoning.
65. The land use zoning used in this study is assumed to be the most dense that could occur in the future under the Development Plan. It is important that during the actual design stage, the then current land use zoning for the specific site in question be evaluated.

Table 1: Runoff Coefficients “C”

Duration, t, minutes	10	20	30	45	60	75	90	100	120	135	150	180
Weighted Average Coefficients												
1) Sector concentrating in stated time												
(a) Impervious	0.525	0.588	0.642	0.7	0.74	0.771	0.795	0.813	0.828	0.84	0.85	0.865
(b) 60% Impervious	0.365	0.427	0.477	0.531	0.569	0.598	0.622	0.641	0.656	0.67	0.682	0.701
(c) 40% Impervious	0.285	0.346	0.395	0.446	0.482	0.512	0.535	0.554	0.571	0.585	0.597	0.618
(d) Pervious	0.125	0.185	0.23	0.277	0.312	0.33	0.362	0.382	0.399	0.414	0.429	0.454
2) Rectangle (length = 4 x width) concentrating in stated time												
(a) Impervious	0.55	0.648	0.711	0.768	0.808	0.837	0.856	0.869	0.879	0.887	0.892	0.903
(b) 50% Impervious	0.35	0.442	0.499	0.551	0.59	0.618	0.639	0.657	0.671	0.683	0.694	0.713
(c) 30% Impervious	0.269	0.36	0.414	0.464	0.502	0.53	0.552	0.572	0.588	0.601	0.614	0.636
(d) Pervious	0.149	0.236	0.287	0.334	0.371	0.398	0.422	0.445	0.463	0.479	0.495	0.522
Note: Values obtained from interpolation												

Source: Analysis from Rainfall Data

66. The values for “C” have been followed as listed in the **Table 3** of Manual for Sewerage and Sewage Treatment, CPHEEO (ref. **Table 1**). Finally adopted values have been presented in **Table 8**, at the end of this chapter. The values are somewhat conservative because they assume maximum build-out in the associated zone. Some portions of rural and low-density areas may or may not develop to full potential. Because the costs of storm water drainage systems are expensive, it is generally preferable to size the system for the maximum development rather than upsizing later at additional cost as upsizing always requires some unnecessary expenditures. It may be better to plan for 80% development rather than for maximum development, as this would have a relatively minor effect in overall storm flow.

3. *Imperviousness*

67. The impervious cover percentage of the drainage area can generally be obtained from the records of a particular district. In the absence of such data, **Table 2** may serve as the guide (CPHEEO Manual on Sewerage and Sewage Treatment):

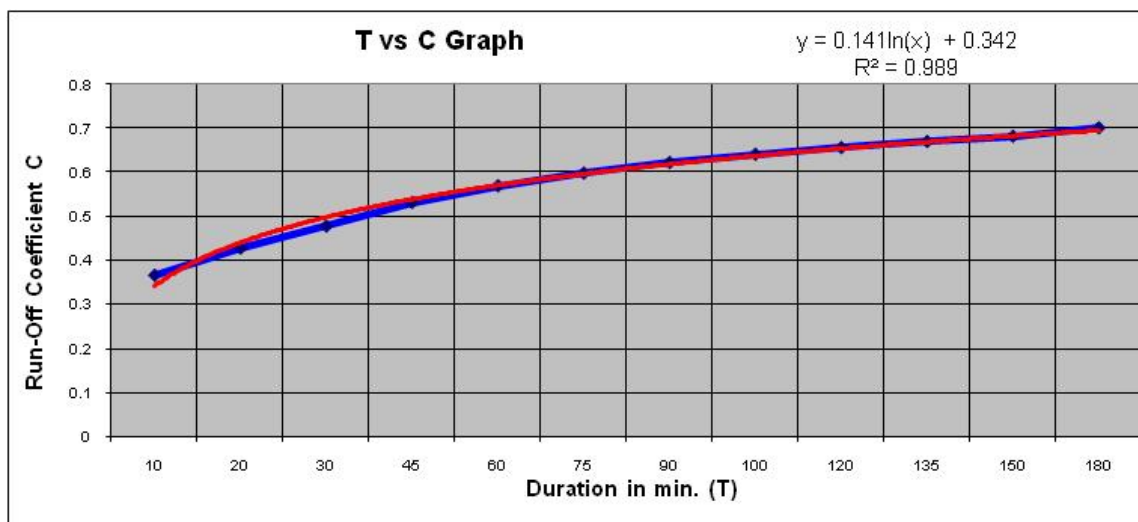
Table 2: Guidelines

Sl. No.	Type of area	% of impervious cover
1	Commercial & Industrial area	70 to 90
2	Residential area	
	i) High Density	60 to 75
	ii) Low Density	35 to 60
3	Parks & Underdeveloped areas	10 to 20

Source: CPHEEO Manual on Sewerage

68. The town area is mainly residential with high density to low density, imperviousness cover of 60% has been considered at master plan stage. For 60% imperviousness, the corresponding runoff coefficient for respective time of concentration has been plotted below:

Figure 1: T Vs C Graph



4. *Rainfall Intensity and Duration*

69. It has been observed that shorter the duration of critical rainfall, the greater would be the expected average intensity during the period. The critical duration of rainfall will be which produces maximum runoff. The duration will be equal to the time of concentration.
70. Return period or frequency of storm for which the storm drains are designed depends on the importance of the area to be drained. Storm Frequency criterion has been adopted as per CPHEEO Manual for Sewerage and sewage Treatment, **Table 3** below:

Table 3: Storm Frequency for Different Areas

Sl No.	Type of area	Storm frequency
1	Residential areas i) Peripheral area ii) Central and comparatively high priced area	Twice a year Once a year
2	Commercial and high priced area	Once in two years

Source: CPHEEO Manual on Sewerage

71. As the Hapur Town has predominantly residential wards and sectors with a few pockets of mixed-land pattern, the storm frequency has been adopted as once in a year.
72. For determining the appropriate rainfall intensity, historical rainfall data have to be collected and accordingly the rainfall intensity duration curve have to be developed. The best possible estimation of peak run off rate is possible where the gauge records of rainfall are available from automatic rain gauge recorder. If only maximum day rainfall is available, the intensity of rainfall can be calculated as follows (IRC:SP-13-2004)

$$I_c = F/T (T+1/t+1)$$

Where; F= Total precipitation and T= duration of rainfall

5. *Rainfall Data Analysis*

73. As indicated, the best possible estimation of peak run off rate is possible where the gauge records of rainfall are available from automatic rain gauge recorder. As such the nearest rain gauge station with short duration rainfall data is Delhi. As such rainfall data of New Delhi (65 Km from Hapur) for year 1984 to 2006, as available, were used for rainfall data analysis. The isohytel map of the NCR indicates that the rainfall analysis of Delhi may be used for Hapur.
- (i) Frequency of Storm. The amount of precipitation obtained from the rainfall data for 15, 30, 45, 60, 75 and 90 minutes are sorted in number of occurrences with 10mm, 15mm, 20mm, 25mm, 30mm, 35 mm, 40mm, 45mm, 50mm, 55mm, 60mm, 75mm, 100mm, 125mm.. **Table 4** presents the total counts of such occurrences over a period of 24 years obtained by summation of the corresponding values.

Table 4: Sorted Rainfall Occurrences

Precipitation Duration	5 mm	10 mm	15 mm	20 mm	25 mm	30 mm	35 mm	40 mm	50 mm	60 mm	75 mm	100 mm	125 mm
15	346	346	344	319	265	229	177	162	79	72	66	63	46
30	256	252	206	151	73	44	44	37	18	17	10	10	7
45	128	95	37	24	24	18	12	8	4	2	2	2	0
60	58	31	16	15	13	13	12	8	7	7	3	3	2
75	38	13	13	12	11	9	6	5	0	0	0	0	0
90	12	4	3	3	2	1	1	1	1	0	0	0	0

Source: Report on rainfall data of New Delhi (Year 198-2006), UPJN

- (ii) Rainfall Intensity from Occurrences. From the sorted rainfall occurrences, the cascades for 1 year (24 occurrences), 2 year (12 occurrences) and storm frequency for different return period may be developed by interpolating the higher and lower numbers of occurrences with corresponding maximum and minimum amount of precipitation, the precipitation along the cascade line is obtained. Once the intensity of rainfall is obtained, RMSD calculation for the respective storm return period is carried out to obtain the values of the constants of the empirical expression given by Metcalf and Eddy. **Table 5** presents the cascade for 1 year storm frequency

$$i = a/t^m$$

Where :

i = Intensity of rainfall (mm/hr)

a,m = Constant

t = Duration (min.)

Table 5: Cascade for 1 year

Duration (t) (min.)	Higher No. of Occurrences	Lower No. of Occurrences	Intensity (mm/hr) Corresponding to Higher No. of Occurrence	Intensity (mm/hr) Corresponding to Lower No. of Occurrence	Intensity (i) (mm/hr)
15	46	17	75	100	79.31
30	37	18	40	45	41.05
45	37	24	15	20	14.23
60	31	16	10	15	12.00
75	38	13	5	10	6.80

Source: Analysis

Sample calculation of intensity corresponding to rainfall duration of 30 minutes:

$$40 + (45-40)*(22-18) / (37-18) = 41.05 \text{ mm/hr}$$

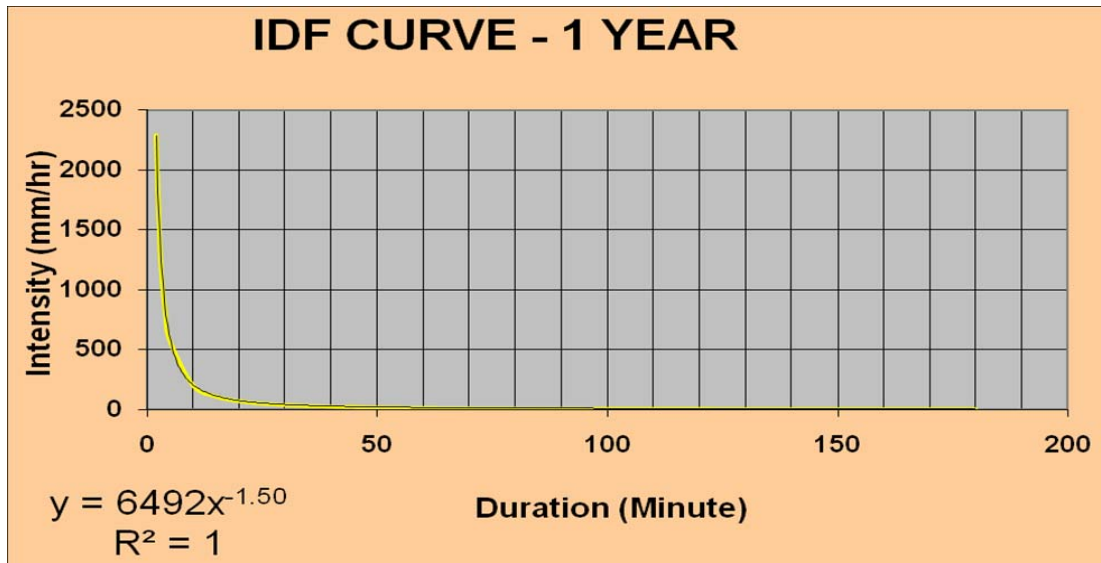
Table 6: RMSD for 1 Year

Duration (t) (min)	X =log t	Y =log i	X ²	XY		I = a/t ^m
15	1.176	1.981	1.383	2.330	m =1.50564 Log a = 3.812 a =6492	110.054
30	1.477	1.643	2.182	2.427		38.758
45	1.653	1.426	2.733	2.357		21.049
60	1.778	1.114	3.162	1.981		13.650
75	1.875	0.914	3.516	1.713		9.755
	∑ X = 7.95964	∑ Y =7.07752	∑ X ² =12.9759	∑ XY =10.8081		

Source: Analysis

74. Based on above, Intensity Duration Frequency curve has been plotted as below:

Figure 2: IDF Curve for One Year



Based on the curve, the equation for IDF curves is:

$$I = 6492/(t)^{1.5}$$

Where I = intensity of rainfall in mm/hr; and t = Duration of rainfall

Table 7: Intensity of Rainfall for Duration

Duration (t) in min	Intensity (i) in mm/hour (For 1 year freq)
2	2286
3	1242
4	805
5	575
10	203
15	110
20	71
25	51
30	39
35	31
40	25
45	21
50	18
55	16
60	14
70	11
80	9
90	7
100	6
110	5
120	5
150	3
180	3

Source: Rainfall Data and Analysis

6. *Time of Concentration*

75. Time of concentration is the longest time required for a particle to travel from the watershed divide to the watershed outlet. The remotest point in each zone is found out and then the level difference between the remote point and the point of discharge is calculated. As per IRC: SP:13-2004.

$$t_c = \left(\frac{0.87 \times L^3}{H} \right)^{0.385}$$

Where,

L= the distance from the critical point to the point at which discharge is to be estimated in Kms.

H = the fall in level from the critical point to the point at which discharge is to be estimated in metres.

76. Inlet time for improved areas can vary widely and accurate values are difficult to obtain. Values between 5 and 30 minutes are used for developed areas with steep slopes or closely spaced inlets. Since the area has closely spaced inlets and economical viability with flood acceptability, time of concentration of 25 minutes have been kept at master plan stage level. The coefficient of runoff for 60% imperviousness and 20% imperviousness as calculated is in **Table 8**.

Table 8: Runoff Coefficient for time of Concentration and Imperviousness

Duration T (Min.)	Run-off Coeff. C for imperviousness	
	20%	60%
10	0.125	0.365
20	0.185	0.427
30	0.23	0.477
45	0.277	0.531
60	0.312	0.569
75	0.33	0.598
90	0.362	0.622
100	0.382	0.641
120	0.399	0.656
135	0.414	0.67
150	0.429	0.682
180	0.454	0.701

Source: Analysis

C. Drainage Development Strategy

1. Flood Zones

77. There are areas like Adarsh Nagar, Lajja puri, Ganesh nagar within the town that are subject to flooding during severe storm events. They are either low lying areas or wetland/ponds. Areas that are being developed at present have large vacant spaces, which are prone to flooding as construction surrounding them does not give way to over land flow.
78. Since the terrain of hapur is generally flat, a heavy storm may exceed the capacity of the town's storm drainage system. Such an event may result in localized flooding and standing water in low areas.

2. Design Criteria

79. The design of the storm water facilities is planned to withstand a 1-year design storm while maintaining full flow in the channels. A 1-year design storm means a minimum average recurrence interval of one year. This design criterion has been used throughout the Drainage Master Plan.

3. Hydrology Model

80. The hydrology model predicts the volume of flow generated at any point of the catchment basin based on the approved rainfall data. Nodes were located at critical drainage facilities. A node represents a location where runoff rates are calculated. All nodes are designated based on the drainage sub-basins contributing to them. Each drainage basin in the study area was divided at nodes into sub-basins. The drainage basin boundaries are presented in **Map 2**.

4. Hydraulic Models

81. The purpose of the hydraulic analysis was to evaluate the adequacy of the existing storm drainage system (major drains only) and to determine design options for inadequately sized channels. Channels and storm drains were simulated using the flow data generated in the hydrology model. Storm drains were simulated using Manning's equation as below:

$$V = 1/n \times R^{2/3} \times S^{1/2}$$

Where,

V = Velocity (m/s); n = Friction Factor; R = Hydraulic Radius (m); and S = Channel Slope (m/m)

5. *Hydraulic Analysis Methods*

82. The hydraulic models utilize Manning's equation to relate depth of flow in the channel to the flow rate (Q), cross sectional area of the channel (A), slope of the channel (S), and roughness of the structure (Manning's roughness coefficient, 'n').

6. *Flow Rates*

83. In the hydrology model, runoff flow rates were computed at each node for the appropriate design storms. Runoff is assumed to enter the drainage channels at node locations. Within the hydraulic model, the flow that enters at each node location is assumed to be flowing through the entire upstream length of the channel.
84. For this study, the following Manning's roughness coefficients were used (Manual on Sewerage and Sewage Treatment, CPHEEO):

Cement Concrete with Good finish = 0.013

Concrete channel, wood troweled = 0.015

Earth channel, ordinary condition = 0.025

Earth channel, poor condition = 0.035

Earth channel, partially obstructed with debris or weeds = 0.050

- (i) Methodology for Hydraulic Modeling. The channels to be modeled were assigned node numbers based on the sub-catchment basins (one node for each sub-basin). Using the hydrologic information of catchment basin, such as surface permeability, designed rainfall intensity and coefficient of run-off; and other relevant design parameters, such as time of concentration, catchment area etc., run-off discharges were estimated. These estimated discharges were compared with the carrying capacity of the existing drains. In case the existing sections were found inadequate, sections were adopted from the Standard Table (ref. **Table 9**) for the particular discharge. In a similar manner, the sections of the proposed new drains are also adopted.

Table 9: Standard Drain Size

Size (m x m)		Manning's Coefficient	Wetted X-Section (Sqm)	Wetted Perimeter (mtr)	Hydraulic Radius 'R' (mtr)	Slope	Velocity	Capacity
Width	Depth					<i>l in Mtr</i>	(m/s)	(cum/sec)
1	0.5	0.013	0.50	2.0	0.25	1000	0.97	0.48
1.5	0.75	0.013	1.13	3.0	0.38	1500	1.03	1.16
2	1	0.013	2.00	4.0	0.50	2000	1.08	2.17
2.5	1.25	0.013	3.13	5.0	0.63	3000	1.03	3.21
3	1.5	0.013	4.50	6.0	0.75	3500	1.07	4.83
3.5	1.75	0.013	6.13	7.0	0.88	4500	1.05	6.43
4	2	0.013	8.00	8.0	1.00	5000	1.09	8.70
4.5	2.25	0.013	10.13	9.0	1.13	6000	1.07	10.88
5	2.5	0.013	12.50	10.0	1.25	7000	1.07	13.34
5.5	2.75	0.013	15.13	11.0	1.38	8000	1.06	16.08
6	3	0.013	18.00	12.0	1.50	9000	1.06	19.13
6.5	3.25	0.013	21.13	13.0	1.63	10000	1.06	22.46
7	3.5	0.013	24.50	14.0	1.75	11000	1.07	26.09
7.5	3.75	0.013	28.13	15.0	1.88	12000	1.07	30.03
8	4	0.013	32.00	16.0	2.00	13000	1.07	34.27
8.5	4.25	0.013	36.13	17.0	2.13	14000	1.07	38.82
9	4.5	0.013	40.50	18.0	2.25	15000	1.08	43.68
9.5	4.75	0.013	45.13	19.0	2.38	16000	1.08	48.85
10	5	0.013	50.00	20.0	2.50	17000	1.09	54.34
10.5	5	0.013	52.50	20.5	2.56	18000	1.07	56.34
11	5	0.013	55.00	21.0	2.62	19000	1.06	58.32
11.5	5	0.013	57.50	21.5	2.67	20000	1.05	60.26
12	5	0.013	60.00	22.0	2.73	21000	1.04	62.17
12.5	5	0.013	62.50	22.5	2.78	22000	1.02	64.05
13	5	0.013	65.00	23.0	2.83	23000	1.01	65.90
13.5	5	0.013	67.50	23.5	2.87	24000	1.00	67.72
14	5	0.013	70.00	24.0	2.92	24000	1.01	70.95
14.5	5	0.013	72.50	24.5	2.96	25000	1.00	72.70
15	5	0.013	75.00	25.0	3.00	25000	1.01	75.90
15.5	5	0.013	77.50	25.5	3.04	25000	1.02	79.11
16	5	0.013	80.00	26.0	3.08	25000	1.03	82.34
16.5	5	0.013	82.50	26.5	3.11	25000	1.04	85.57
17	5	0.013	85.00	27.0	3.15	25000	1.05	88.83
17.5	5	0.013	87.50	27.5	3.18	25000	1.05	92.09
18	5	0.013	90.00	28.0	3.21	25000	1.06	95.36
18.5	5	0.013	92.50	28.5	3.25	25000	1.07	98.65
19	5	0.013	95.00	29.0	3.28	25000	1.07	101.94
19.5	5	0.013	97.50	29.5	3.31	25000	1.08	105.25
20	5	0.013	100.00	30.0	3.33	25000	1.09	108.56
20.5	5	0.013	102.50	30.5	3.36	25000	1.09	111.88
21	5	0.013	105.00	31.0	3.39	25000	1.10	115.21
21.5	5	0.013	107.50	31.5	3.41	25000	1.10	118.55
22	5	0.013	110.00	32.0	3.44	25000	1.11	121.89
22.5	5	0.013	112.50	32.5	3.46	25000	1.11	125.24
23	5	0.013	115.00	33.0	3.48	25000	1.12	128.60
23.5	5	0.013	117.50	33.5	3.51	27500	1.07	125.82
24	5	0.013	120.00	34.0	3.53	27500	1.08	129.03
24.5	5	0.013	122.50	34.5	3.55	27500	1.08	132.25

Size (m x m)		Manning's Coefficient	Wetted X-Section (Sqm)	Wetted Perimeter (mtr)	Hydraulic Radius 'R' (mtr)	Slope	Velocity	Capacity
Width	Depth					<i>l in Mtr</i>	<i>(m/s)</i>	<i>(cum/sec)</i>
25	5	0.013	125.00	35.0	3.57	27500	1.08	135.48
25.5	5	0.013	127.50	35.5	3.59	27500	1.09	138.70
26	5	0.013	130.00	36.0	3.61	27500	1.09	141.94
26.5	5	0.013	132.50	36.5	3.63	27500	1.10	145.17
27	5	0.013	135.00	37.0	3.65	27500	1.10	148.42
27.5	5	0.013	137.50	37.5	3.67	27500	1.10	151.66
28	5	0.013	140.00	38.0	3.68	27500	1.11	154.91
28.5	5	0.013	142.50	38.5	3.70	27500	1.11	158.16
29	5	0.013	145.00	39.0	3.72	30000	1.07	154.55
29.5	5	0.013	147.50	39.5	3.73	30000	1.07	157.67
30	5	0.013	150.00	40.0	3.75	30000	1.07	160.80

Source: Analysis

D. Adequacy of Drains and Drainage System

85. According to the basin characteristics, coefficient of runoff, intensity of rainfall corresponding to the time of concentration, the discharge at each section has been calculated. Accordingly, the adequacies of the size of existing drains have been determined. **Table 10** shows the discharge from each basin and tentative size of the drain required.

Table 10: Tentative Size of Drain for Different Basins

Section	Area of catchment basin	Type of area	Impervio -usness	Runoff coefficient	Discharge	Cum discharge	Tentative size required
1-1	1153.00	Agriculture	20%	0.221	36.10	36.10	8 x 4
2-1	479.00	Agriculture/ Residential	20%	0.221	15.00	15.00	5 x 3
2-2	351.30	Residential	60%	0.467	23.24	38.24	8 x 4
2-3	306.70	Residential	60%	0.467	20.29	58.53	11 x 5
2-4	431.20	Residential	60%	0.467	28.53	87.06	17 x 5
3-1	659.60	Residential	60%	0.467	43.64	43.64	9 x 4.5
4-1	776.70	Residential	60%	0.467	51.39	51.39	10 x 5
5-1	786.40	Residential	60%	0.467	52.03	52.03	10.5 x 5
6-1	126.80	Residential	60%	0.467	8.39	8.39	4 x 2
6-2	221.20	Residential	60%	0.467	14.63	23.02	5 X 2.5

Source: Analysis

86. These are tentative size of the drains. However, exact size will have to be calculated during detail designing. Also in case the drains are proposed on both side of the drain, the size of each drain will be reduced relatively.

VI. RECOMMENDED MASTER PLAN

A. Summary

87. Recommendation on Storm Drainage Improvement includes i) remodeling and channelization of drains (9.0 Km) ii) providing drain covers (2.5 km) iii) construction of new drains (9.5 Km).

B. Storm Drainage Improvements Recommended

88. The recommended projects includes
- (i) Elimination of cross sewer connections;
 - (ii) Rehabilitation and desilting of existing drains;
 - (iii) Augmentation and rectifying the missing links of existing drains and
 - (iv) Provision of new drains.
89. . The essential components of the improvement project include repair of the existing major drains, resizing/augmentation of the existing major drains based on the hydrologic and hydraulic calculations, proposal of new major drains in areas having no existing drainage facilities, and elimination of cross-connections with sewers.
90. Elevations presented in this section are preliminary based on existing topography and may be subject to change on account of development that may take place in the future.
91. The hydraulic capacities of the existing and proposed major drains have been calculated with the hydraulic models for 1-year design storm. This chapter presents and discusses the capacities of existing major drains, the hydraulically deficient drain-sections, 1-year design flows, and problem areas for each drainage basin. Hydraulically deficient drains are those that are undersized for the 1-year design flow. Estimated peak flows generated from a 1-year storm event at maximum build-out are used as a basis for sizing the drainage channels.
92. Major emphasis was placed on developing a plan that would minimize costs and solve all known existing drainage problems. Recommendations have also been made to upgrade existing drains that have been found to be under-sized by hydraulic modeling for the design conditions. Because this plan is intended as a guide for the development of future drainage facilities, it does not attempt to present detailed drainage designs for individual areas. Rather, it determines peak flows for individual drainage systems and appropriate sizes to serve these areas. It should be noted that detailed designs and construction plans would be required before individual proposed projects are constructed. Recommended

drainage improvement projects are as follows.

1. *Elimination of Cross-Connections of Sewers with Drains*

93. By cross-connection between sewer and drain, it is meant any physical interconnection existing between the two owing to a deliberate construction, illegal practice, or by chance happening. All the drains of the city are acting as sewer line. Basic reason for this happening is lack of sewerage/drainage facilities in the town. Further there is no recourse but to dispose of the wastewater of unsewered areas into drains and vice versa. Major areas identified as unsewered are Jasrop Nagar, Adarsh nagar, New Ganesh nagar, Lajja puri, Arjun nagar, prem nagar, Rafiq nagar, ram garhi village, Shiv garhi village, Moti colony, Harijan basti, Ayodhya puri etc.
94. Apart from domestic wastewater, certain industrial effluent is also being disposed of in the drains. A major industrial waste of Dheerkhera Industrial area also discharges into u/s of Choya nallah. Effluent, treated or untreated, from all these industries, is disposed of directly or indirectly into the drains. This need to be rectified and the areas required to be sewerred.

2. *Rehabilitation and Augmentation of Existing Drains*

95. The Drain no 1 and Drain No 2 (choya nallah) are earthen drains and needs to be desilted and needs to be channeled with regular shape and size as per the estimated discharge. The sectionwise recommendations for rehabilitation and augmentation are as follows:

(i) Drain No 1.

- a. *From railway crossing to crossing at NH24.* Though the section is channelized, but weeds have grown, thereby blocking the flow. This needs to be rehabilitated.
- b. *From Crossing at NH24 to Rampur road via Sabli village.* As the drain is kutchra in this area, the drain needs to be channelized and made pucca. The tentative size required for this section is 32 Sqm.

(ii) Drain No 2 (Choya Nallah). This need to be linked with Drain No 1 for distributing of excess flow from upstream of this drain to Drain no 1. Presently, Hapur Pilukhwa Development authority is planning for a bypass from drain near Dastoi road to Drain No 1 through a chak road. As link in drain no 2 breaks at this section, this will divert the flow from Dheerukhera industrial area to Drain No 1. The section wise recommendations are as follows:

- (a). *Hasoda to Dastoi road.* As the drain carries the waste water, the arrangement for diverting this waste water to sewerage system is the prime necessity. As this is pucca, the drain required to be provided with cover.
- (b). *Dastoi Road to Modinagar road crossing and further to Delhi Moradabad*

railway crossing. The drain has to be constructed in this portion. As the residential area has come up in this portion, the option for alignment either through existing roads or alignment available between the residential available has to be checked during detailed designing. The pond near Modinagar road crossing needs to be revamped, as it will prevent flooding. The tentative size of the drain required is 5m x 3m.

- (c). *Railway crossing to chamri road crossing and further to Delhi Garh road*. As the drain passes through the populated area and sewerage makes way into the drain. It is recommended to eliminate the sewerage from the existing drain through sewerage system in adjoining colonies. The option of taking drain along the Chamri road may be explored or augmentation of existing drain may be checked, if land available. Presently, as the solid waste is dumped near the drain at chamri road crossing, the solid waste enters into the drain. It is recommended to provide a waste bin at this location. At crossing, the pipe culverts need to be redesigned as they have been blocked due to insufficient size. The tentative size of the drain required is 8m x 4m.
 - (d). *Delhi Garh road crossing to Ramgarhi village and further to kali river*. As the drain is kutchha in this area, the drain needs to be remodeled and channelized and made pucca.
- (iii) Circular Road Drain. As the drain takes the waste water of all the habitations in course of this drain, sewerage system of the adjacent colonies is the prime requirement. The drain requires desilting and cleaning to take care of storm water flow. The drain requires to be covered.
- (iv) Delhi Garh Road Drain. The drain from Khurja railway line to Tirupati garden is the main secondary drain of Choya nallah and need to be augmented. The missing link from town hall to Merrut road is to be provided. The discharge has been checked for drains on both sides. The elimination of sewerage from this drain is also required.






3. *New Proposed Drains*

96. A drain along with the Merrut-Gulavati road has been proposed with a branch along the Idgah road to meet at Choya nallah. The proposed drains are shown in **Map 3**.
97. *Secondary and Tertiary Drains*. In addition to the main drains, all the roads should have secondary drains and colonies road should have tertiary drains. The tertiary drains may be integrated along with the roads and proper slope should be provided as to drain out the storm water. During construction of roads, proper camber should be provided and sufficient longitudinal slope need to be designed and accordingly the road should be drain.

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

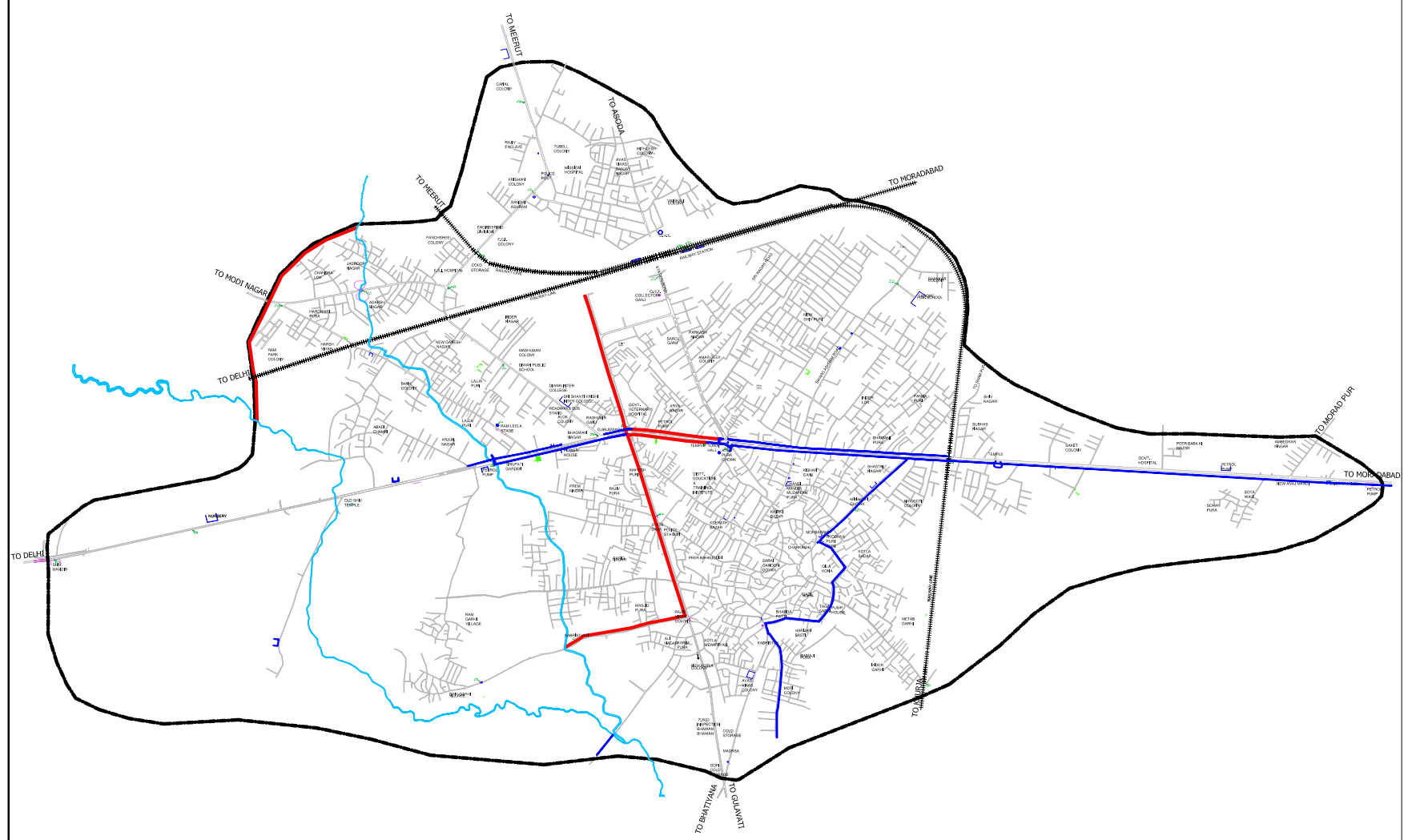
**Hapur
Proposed Drains**

Legend

- Municipal Boundary 
- Road 
- Railway Line 
- Existing Drain 
- Water Body 

Overlay Legend

- Proposed Drain 



Client:
**Asian Development Bank
National Capital Region Planning Board**

Consultant:
Wilbur Smith Associates Pvt Ltd

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

C. Operation and Maintenance Recommendations

98. Following are the recommendations regarding proposed operation and maintenance polices to be adopted by nodal agencies responsible for stormwater management based on the key subject areas:

1. Storm Water Management Policies

- (i) Control flows from developed areas by proper storm water management (storage in storm water ponds, wetlands, dry ponds) to prevent increasing flooding and erosion problems downstream;
- (ii) Preserve and protect any existing wetlands and develop them as necessary to manage storm water runoff;
- (iii) Encourage the use of Best Management Practices to control runoff rates and improve water quality including the use of wetlands in preference to dry ponds.

2. Storm Water Management Plan

- (i) Develop the preliminary designs of storm water ponds and trunk facilities through the development of a basin master plan in each basin; confirm the locations, sizes, and costs of major storm water management facilities to form the basis for a cost-sharing formula;
- (ii) Encourage the dual use of parks to allow for storm water management where occasional flooding can be tolerated;
- (iii) Plan and design major drainage channels as drainage parkways including walkways and other recreational features to minimize the maintenance requirements and to provide an aesthetic and recreation resource;
- (iv) Link the proposed storm water management facilities, especially the drainage parkways, with park spaces;
- (v) Look for opportunities to minimize the number of outfalls in future subdivisions and to reduce the number of outfalls in presently developed areas. Ensure that outfalls are suitably located and adequately protected from erosion.
- (vi) The level of the drain for new colonies to match with the main drain and also ensure the drainage plan of the colony as per the master drainage plan of the city.

3. Operation and Maintenance

- (i) Review the Town operating budget for storm water drainage to provide for adequate programs of preventative maintenance and routine inspection;
- (ii) Inspect the storm drains on a yearly cycle to monitor any deterioration in any concerned channel that may require repair;
- (iii) Conduct a hydrology study to confirm the availability of storage capacity for the

- Town in the reservoir;
- (iv) Conduct additional monitoring at different sites to enable further calibration of the runoff model for local conditions.

D. Additional Recommendations

99. This component is applicable to the Town's departments that operate or maintain a storm drain system. The storm drain system functions primarily to collect and convey surface runoff and to receive water during storms to prevent flooding. It is a common activity to maintain the storm drain system as intended so that it functions hydraulically during storms. The goal of this program is to reduce the impact of storm drain operation and maintenance activities on storm water quality.

100. The Town program must meet the requirements of the Bahadurgarh Municipal Storm water Regulation and implement minimum Best Management Practices to protect water quality. The following design criteria to be adopted by implementing agency.

1. Design Criteria

- (i) The drains should be designed as per the criteria developed in Chapter 4 of this master plan. The coefficient of runoff and intensity of rainfall for design shall be considered for time of concentration.
- (ii) Design on-site storm water management areas to minimize operation, maintenance, and flooding problems and to operate only in the less frequent storms.

2. Maintenance Schedule

101. Implement a maintenance schedule for all controls designed to reduce pollutant discharges in the storm water conveyance system. Thus, it would include:

- (i) Inspection & removal of waste before the onset of Monsoon;
- (ii) Additional cleaning during the Monsoon;
- (iii) Records of cleaning and waste removal quantity;
- (iv) Proper waste disposal;
- (v) Measures to eliminate discharges during maintenance & cleaning;
- (vi) Limit infiltration from sanitary sewer to storm drains through routine maintenance;
- (vii) Implement an Educational Program for all pertinent target audiences; and
- (viii) Document activities for Urban Runoff Management Program.

- (i) Objectives of Maintenance Schedule. Objectives of this program component are to
 - (a) Inspect and clean catch basins, keeping appropriate records; and
 - (b) Remove

trash and debris from open channels with proper disposal of these materials to prevent them from being washed into receiving waters.

- (ii) Maintenance Schedule Activities. The purpose of this section is to identify activities required to operate and maintain the storm drain system that may be a potential source of pollutants to the storm drain conveyance system and receiving waters. Storm drain O&M activities include the following: (a) Storm Drain Inlet Inspection and Cleaning – Cleaning timing and frequency and identifying known problem areas; (b) Storm Drain Cleanout and Structure Inspection – Cleaning timing and frequency; (c) Management of Storm Drain System Solid Waste – Management of material removed by storm drain operation and maintenance activities, including debris capture systems, containment, storage and disposal; (d) Drainage Ditches Cleaning – Concrete lined and natural open channels; and (e) Emergency Operations – Plugged lines/flooding.
- (iii) Routine Inspection and Cleaning. (a) Inspect, and clean as needed, all inlets/catch basins at least once every other year (at least 50% of the entire system inspected and cleaned each year); (b) Inspect, and clean as needed, all inlets/catch basins in known problem areas at least once a year; (c) Inspect, and clean as needed, all storm drain lines in known problem areas at least once a year; (d) Inspect, and clean as needed, sumps and debris racks at detention basins, drainage ditches and debris basins throughout the year; (e) Cleaning activities may occur on a yearly basis, however, known problem areas shall be targeted prior to the rainy season; (f) Inspect, and clean as needed, all storm drain facilities that have been affected by emergency response activities; and (g) Additional cleanings must be conducted as necessary during the rainy season.
- (iv) Slide and Embankment Repair of Channels. (a) Transport debris or removed material to an approved dump site as soon as practical. Do not dump material into or near storm drain inlets, ditches, or watercourses; and (b) Notify proper regulatory agencies about material that has fallen naturally into a watercourse due to a substantial slide;
- (v) Solid Waste Management. (a) Remove debris, silt, trash and sediment from the storm drain system when cleaning; debris capture systems should be used to prevent material from washing into streams or channels; (b) Provide proper containment for the temporary storage of removal debris during cleaning; (c) The removed solid waste should not drain again to storm drains or receiving waters; and (d) Identify, quantify and record waste collected from drain systems.
- (vi) Record Keeping and Evaluation. (a) Maintain records tracking all cleaning activities. The records should show when and which facilities have been inspected and cleaned; (b) Provide a referral and follow-up process between storm drain operation and maintenance of illicit connection and illegal dumping investigation staff for problems found; (c) Document any unusual flows observed during inspection (particularly dry weather flows) and the follow-up actions/referrals, i.e. Storm water Program contacted, etc.; (d) Review the records annually to critically

study the effectiveness of storm drain operation and maintenance activities; (e) Modifications to O&M policies and procedures shall be documented and reported; and (f) Report modifications and corrective actions identified during self- inspection to the Storm water Program annually as part of the Program Assessment.

- (vii) Operational Improvement, Structural Retrofit and Design Changes. (a) Review the storm drain operation and maintenance program annually and identify any needed operational improvements, opportunities for structural retrofit and design changes; and (b) Include operation and maintenance provisions in planning and design phases to ensure that storm water quality issues are considered in the design of storm drain systems.

3. *Training and Coordination*

102. The following trainings are suggested:

- (i) Civil works: Detail design of storm water drains including calculation of time of concentration, rainfall analysis and discharge measurement;
- (ii) Operation and Maintenance: Training on controlling storm water pollution through storm drain operation and maintenance;
- (iii) Best Management Practices: Best practices of storm water drainages at other parts of the country and international practices

E. Identification of Drainage Projects to be taken up

103. The Master Plan has identified three phases of work. These phases are:

- (i) Immediate Phase, 2009- 2011: This work will consist of de-silting, minor repairs, and slab covering wherever it is structurally possible; and
- (ii) Phase I, 2011 – 2020: These includes construction of new drains. Channelization of existing drain.

104. The final projects recommended will take into account important criteria, such as availability of funds, the need to provide projects in all of the towns, and the need to take up projects in all the concerned towns. The implementation schedule focuses on the immediate period (2008-10) and the period of implementation i.e. the year 2010-2013.

F. Recommended Immediate Priority Projects

105. The overall work has to be completed in two phases:
- (i) Short Term measures for year 2009- 2011: The works will primarily consist of the following:
 - (a) De-silting and garbage removal in all drains;
 - (b) Removing of weeds form Drain 1 with minor repair, such as repair of damaged work masonry, coping, plastering etc;
 - (c) Slab covers to be provided in Industrial Drain i.e for section 1 of choya nallah containing industrial waste water;
 - (d) Preparation and implementation of operation and management plan for storm water drains.
 - (ii) Long Term measures for year 2011 – 2020: The works will primarily consists of the following:
 - (a) Augmentation of existing drains;
 - (b) Major rehabilitation, such as construction of retaining walls, flooring, and top cover;
 - (c) Construction of complete new drains as proposed above;
 - (d) Elimination of cross-connections with sewers and industrial discharges

G. Cost Estimates

106. At the Master Plan (MP) stage, the costs for various project elements have been estimated for the purpose of fund allocation. The basis for arriving at these cost estimates for the different elements of the drainage system is presented in subsequent sections.
107. Actual costs include Engineering Cost along with Contractor's overheads and profit, physical contingencies and other administrative expenses. All the costs are calculated as of December 2008.
108. Drains of depth less than 1.5 m are considered made up of brick work, whereas drains of more than 1.5 m depth are predominantly made of RCC. All the necessary items for construction of drains, like excavation, PCC, RCC, brickwork, plastering etc., have been included in the per meter cost of drain.
109. Only main drains have been considered under this project, and their costs have been taken and lateral drains are not considered as a part of the project.

1. *Proposed Subprojects and Costing*

110. The following **Table 11.** shows the proposed subprojects and estimated costs of storm water drainage system improvement in Hapur. The total cost is estimated as Rs. 605 million.

Table 11: Proposed Subprojects and Costs of Hapur Drainage

S. No	Component	Length	Estimated Cost	
		Km	Rs.	Million
1	Remodeling and channelization with construction of missing link	20.0		3,70.00
2	Provision of drain covers	2.0		25.00
3	Construction a new major drain	2.5		35.00
4	Construction/ remodeling of secondary & tertiary drains			1,20.00
5	Sub Total			550.00
6	Physical contingencies @10% of sub total			55.00
	Total			605.00

2. *De-silting & Rehabilitation of Existing Drains*

111. Wherever possible, existing drains would be rehabilitated after de-silting. Where the discharge capacity is not found adequate, they shall be augmented as per the design. Where the drains are damaged, e.g. damage in the retaining walls; they shall be repaired.

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WilburSmith
A S S O C I A T E S

#8, Second Floor, 80 Feet Road,
RT Nagar Bangalore Karnataka - 560 032. India
w +91.80. 3918.7500 f +91.80. 2363.4097