ANALYSIS AND DESIGN OF WATER DISTRIBUTION NETWORK AND WASTEWATER COLLECTION SYSTEM FOR AL-SHOYOUKH TOWN

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HEBRON- WEST BANK
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PALESTINE
MAY, 2012

CERTIFICATION

Palestine Polytechnic University (PPU)

Hebron- Palestine

The Senior Project Entitled:

ANALYSIS AND DESIGN OF WATER DISTRIBUTION NETWORK AND WASTEWATER COLLECTION SYSTEM FOR AL-SHOYOUKH TOWN

Prepeared By:

YOUSEF AWAISAH **MAHMOUD ZEIDAT**

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In accordance with the recommendation of the project supervisors, and the acceptance of all examining committee members , this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of Department for the degree of Bachelor of Science in Engineering.

Project Supervisor **Department Chairman**

الإهداء

إلى أقرب من في الوجود إلى نفسي ... والدي الحبيبين .

إلى الشهداء الأبرار الذين قدموا **ارواحهم** رخيصة في سبيل الله ثم الوطن.

إلى الرجل الرجل إلى الأسود الرابضة خلف القضبان
إلى كل الأسرى.

إلى المنارات التي أضاءت لي الدرب ... أساتذتي الأجلاء .

إلى كل اللحظات السعيدة التي قضيناها داخل اسوار هذه الجامعة الغراء .

إلى كل شيء طاهر جميل في هذا الوطن المعطاء .

إليكم جميعا نهدي هذا العمل المتواضع.

فريق العمل
يوسف عوايصة ، **محمود الزيدات**

يوسف شاهين، محمد عواوده

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We like to express our thanks and gratitude to Allah, the Most Beneficent, the most Merciful who granted us the ability and willing to start and complete this project. We pray to his greatness to inspire us the right path to his content and enable us to continue the work started in this project to benefits of our country.

We wish to express our deep and sincere thanks and gratitude to Palestine Polytechnic University, the Department of Civil & Architectural Engineering, College of Engineering and Technology. We wish to express our thanks to Dr.Majed Abu-Sharkh and Dr.wafa alhassan, for a valuable help, encouragement, supervision and guidance in solving the problems that we faced from time to time during this project.

We can find no words to express our sincere, appreciation and gratitude to our parents, sisters and brothers, for their endless support and encouragement, we are deeply indebted to you and we hope that we may someday reciprocate it in someway.

Work Team

ABSTRACT

Analysis and Design of Water Distribution Network and Wastewater Collection System for Al-Shoyoukh Town

By:

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There is no wastewater collection system at present in Al-Shoyoukh town. The sewage from residential and public buildings in the area is drained to cesspits. These have become clogged with time and require frequent emptying. The continued use of cesspits with the increase in population will cause environmental and health problem, and may create contamination of the underground water aquifer. Furthermore, emptying cesspools constitutes an offensive odor nuisance to the population. On the other hand, emptying the vacuum trunks in the nearly wadi causes negative impacts on the visual landscape. In reference to above description of the existing situation, there is a clear need of project in order to improve the sanitary level in Al-Shoyoukh town. The first step is serving the town with wastewater collection system, which is one of the main objectives of this project.

Al-Shoyoukh town also faces big problems in water supply and water services due to population growth. Hence, the water distribution network is not servicing all the areas in the town, and many pipes are old. The people in the town depend mainly on water coming through the network and on water tanking and constructed cisterns for water supply. In view of this bad condition, the need for water supply scheme that will supply the entire area of Al-Shoyoukh town with water requirements become pressing, and subsequently this work was conducted to study and evaluate the present situation and redesign of the existing water distribution network using water-cad software.

The present study considered the annual population growth, their water demand and wastewater quantity for the coming 25 years that will be the design period, along with the commercial and industrial development in the area. The hydraulic calculation needed for the design of water pipelines will be carried out using Water Cad software, and design of the main and sub-main wastewater links will be determined using Sewer Cad software.

By the end of this project, a complete design for water distribution network and waste water collection system for Al-Shoyoukh town will be ready along with bill of quantities, cost estimate, and the suggested phases of construction.

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INTRODUCTION

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CHAPTER ONE

INTRODUCTION

1.1 General Background

Currently, there are no public wastewater collection and treatment facilities serving most of rural areas in the West Bank. And due to the lack of sewage collection and treatment system, large areas in the West Bank and ground water aquifer are being contaminated by raw sewage. This contamination will have long-term impact on agricultural land and creates health hazards when utilized for human consumption. For the above mentioned reasons, serious and major steps should be taken to collect, dispose and treat the wastewater before discharging it in open environment.

The Palestinian cities and towns face water shortage problem. Water demand is increasing from year to year due to increase in the population. At the same time, the development of additional water supplies has been however, far short of the increase in water demand. The amount of water supplies to different communities is very little, and the existing water supply networks are old and do not satisfy the need of water. The amount of water that is lost in the distribution systems ranges between 10%-50% of the quantity of water supplied. Also, Palestinian Water Authority (which supplies areas with water) faces some difficulties in offering good water services that delay any improvement in the existing water supply networks.

1.2 Problem Statement

The wide expansion and accelerated development of AL-Shoyoukh town had led to an increase in amount of water consumption for domestic, public and irrigation uses. The average consumption of water in the town for all purposes does not exceed 60 liter per capita per day due to limited quantities of water and the existing water distribution system. This water demand was mostly met by underground water. Actually, AL-Shoyoukh faces great difficulties and different problems in water supply and water services due to population growth. Hence, the amount of water supplies to the town is very little and the existing water supply network is old and does not satisfy the needs of water.

Another problem AL-Shoyoukh town faces is that more than 60% of the water used for domestic purposes and industry turn into sewage requiring treatment for reuse in irrigation or alternative disposal. Contrarily, if wastewater not treated and not disposed of, sewage may contaminate sources of drinking water. In Palestine, water-borne diseases are very commonplace. Currently, there are no public wastewater collection system or treatment facilities serving the town. Wastewater from individual residences is discharged directly into cesspits, allowing the wastewater to seep into the surrounding soil and percolate into the underlying aquifer. Signs of ground water pollution could be witnessed in springs' water in the surrounding areas.

1.3 Objectives of the Project

The overall objective of the project is to provide the people of AL-Shoyoukh town with good quantity of potable water through produce feasible planning scheme for the water supply, and investigate and evaluate the wastewater collection and treatment processes along with conceptual designs that are suitable for AL-Shoyoukh town. More specifically the main purposes of this project may be classified as follow:

Study and evaluation of the existing water network in AL-Shoyoukh town, and display the difficulties, which the municipality faces in order to develop and improve the existing water mains.
Display the current situation of wastewater disposal in AL-Shoyoukh town.
Investigation and discussion of the appropriate changes in the existing mains and presentation of the proposed water supply network, which meet the present and future water demand for all purposes and around 24 hour water supply.
Development of several plans for the construction of the proposed water supply scheme and prepare bill of quantities.
Propose wastewater collection system for the town and design the main trunks of the proposed sewerage collection network.
Estimate the cost for construction of the wastewater collection network.

The project will help in providing the people with sufficient quantity of fresh water, and protect the public health and the ground water resources. It is also to provide better and safe living conditions for people living in this area and the future generation.

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1.4 Project Area

AL-Shoyoukh is a town in Hebron Governorate located 6 km northeast of Hebron City in the southern part of the West Bank. It is bordered by Sa'ir town from three sides, the north, the west, and the south, and by open spaces to the east (See Figure 1.1). The general view and the aerial photographs for AL-Shoyoukh town are presented in Figures (1.2) and (1.3).

AL-Shoyoukh extends over a mountainous area northeast of Hebron Mountains at an elevation of 965 m above sea level. The climate of AL-Shoyoukh tends to be cold in winter and warm in summer and relatively humid. The mean annual rainfall is about 400 mm, the average annual temperature is 16 °C, the average maximum temperature is about 35°C in summer and the average minimum temperature is 10°C in winter, and the average annual humidity is 61% (ARIJ GIS).

According to the Palestinian Central Bureau of Statistics (PCBS), the total population of AL-Shoyoukh, in 2007, was 8,811; of whom 4,503 were males and 4,308 were females. There were 1,438 households resident in 1,754 housing units. Based on the growth rate of (3.6%), the estimated population for AL-Shoyoukh town for year 2011 is 10,000 person, and for the design year 2036 (25 years ahead) will increase to approximately 24,000 inhabitants.

AL-Shoyoukh town is considered an agricultural town. Lying on a total area of 32,000 dunums, of which 5,000 dunums are considered arable land, the cultivated area in AL-Shoyoukh is 3,758 dunums, while there are about 4,000 dunums uncultivated due to Israeli procedures (either through confiscation or settlement expansion), shortage of capital, and shortage of water.

Almost 80% of the housing units in AL-Shoyoukh town have been connected to a water network since 1978. Currently, the Palestinian Water Authority is the main provider of water in the town. The per capita water consumption for domestic use does not exceed 60 liter per day. There is no sewage disposal network, and the bulk of domestic and wastewater is discharged and disposed of in cesspits. This causes ground water pollution.

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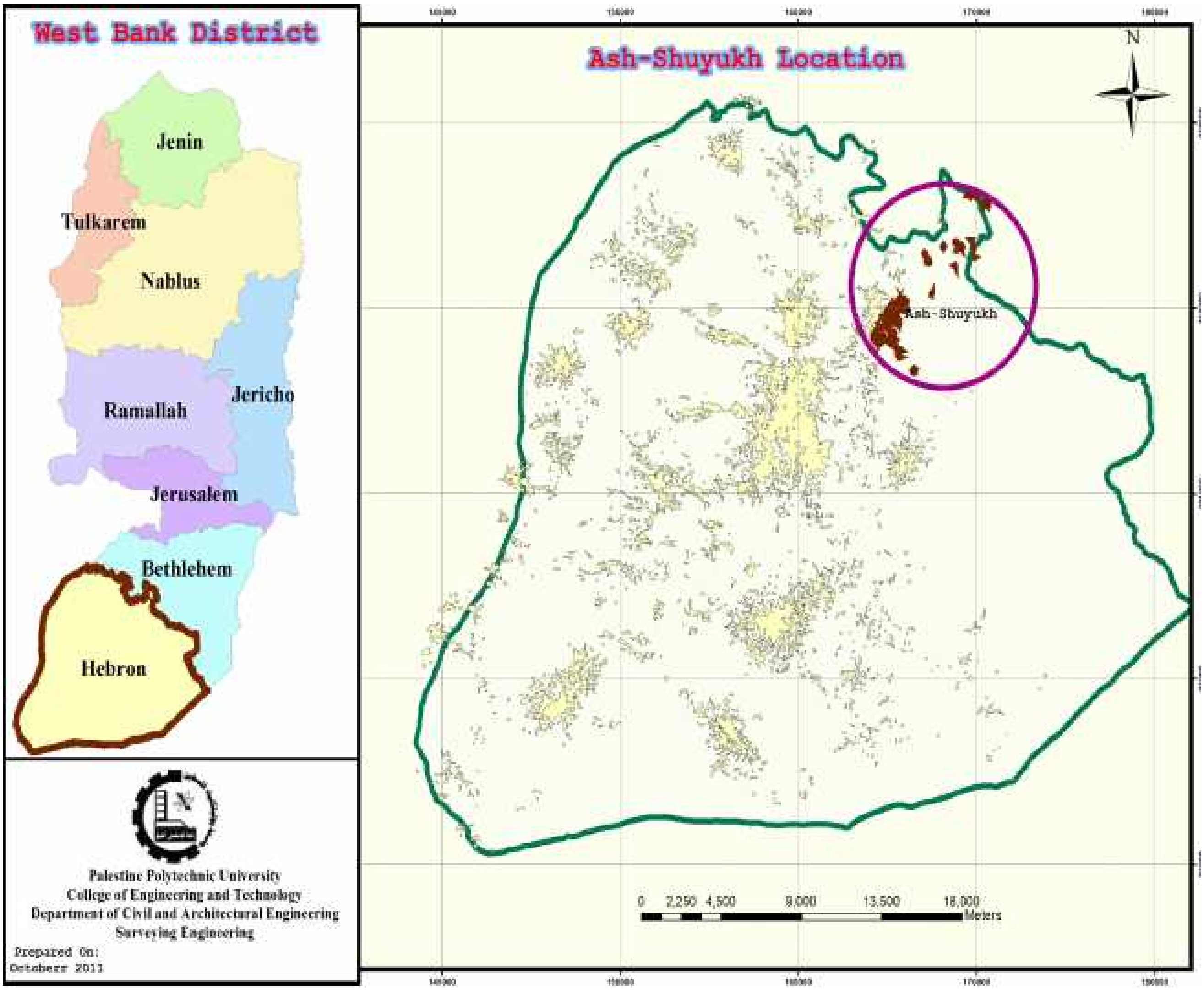

Figure (1.1): Location Map for the Project Area (AL-Shoyoukh Town)

Figure (1.2): General View of the AL-Shoyoukh Town

Figure (1.3): Aerial Picture for the Project Area

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1.5 Work Plan

The project consists of seven phases, which are proposed to be completed in accordance with time schedule shown in (Table 1.1). The description of each of the seven phases of the project and tasks involved is listed below:

Table (1.1): Phases of the Project with their Expected Duration

Phase No.	Title	Duration								
		09/11	10/11	11/11	12/11	01/12	02/12	03/12	04/12	05/12
1	Site Visits and Data Collection	🟦	🟦							
2	Propose Water and Sewage Networks		🟦	🟦						
3	Design of Water Distribution Network			🟦	🟦	🟦				
4	Design of Wastewater Collection System				🟦	🟦	🟦			
5	Draw the layouts and Profiles						🟦	🟦	🟦	
6	Prepare Bill of Quantities								🟦	🟦
7	Write the Report						🟦	🟦	🟦	🟦

Phase 1: Site Visits and Data Collection

During this phase, the available data, and maps were collected from AL-Shoyoukh Municipality. Moreover, many site visits to the project area were undertaken.

Phase 2: Propose Water and Sewage Networks

During the third phase, the areas to be served by water and sewage pipes were defined, and the layout was established

Phase 3: Design of Water Distribution Network

The necessary hydraulic calculation and consequently, the design of water distribution network will be carried out during this phase.

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Phase 4: Design of Wastewater Collection System

The necessary hydraulic calculation and the design of wastewater collection system will be carried out during this phase.

Phase 5: Draw the Layouts and Profiles

The drawings of the layouts and profiles for the two systems will be undertaken during this phase.

Phase 6: Prepare Bill of Quantities

After finishing the design calculation of the main water pipes and sewer trunks, the research team will prepare bill of quantities for the proposed water network and proposed sewerage system.

Phase 7: Writing the Report

Upon the completion of the work, one final report will be written and submitted to the Department of Civil and Architectural Engineering at Palestine Polytechnic University.

1.6 Structure of the Report

The project report has been prepared in accordance with the objectives and scope of work. The report consists of five chapters.

The title of *Chapter One "Introduction"* outlines the general background, problem statement, objectives of the project, project area, work plan and structure of the report.

Chapter Two entitled: ***"Wastewater Collection Systems"*** deals with municipal sewage system, types of wastewater collection systems, sewer appurtenances, flow in sewers, design of sewer system, and sewer construction and maintenance.

Chapter Three entitled *"Water Distribution Systems"* deals with methods of water distribution, types of pipes, pipe appurtenances, service reservoirs pumps and pumping, and excavation and backing fill.

Chapter Four entitled *"Design and Planning Criteria"* presents population and population forecast, projected water demand, design parameters, and design and planning assumption.

Chapter Five entitled *"Analysis and Design"* is devoted to the analysis and design of water distribution network and wastewater collection system, and profile of sewer.

The overall “*Conclusions"* are given in *Chapter six*.

CHAPTER

2

WASTEWATER COLLECTION SYSTEMS

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CHAPTER TWO

WASTEWATER COLLECTIOM SYSTEMS

2.1 GENERAL BACKGROUND

Once used for its intended purposes, the water supply of a community is considered to be wastewater. The individual conduits used to collect and transport wastewater to the treatment facilities or to the point of disposal are called sewers.

There are three types of sewers: sanitary, storm, and combined. Sanitary sewers are designed to carry wastewater from residential, commercial, and industrial areas, and a certain amount of infiltration /inflow that may enter the system due to deteriorated conditions of sewers and manholes. Storm sewers are exclusively designed to carry the storm water. Combined sewers are designed to carry both the sanitary and the storm flows.

The network of sewers used to collect wastewater from a community is known as wastewater collection system. The purpose of this chapter is to define the types of sewers used in the collection systems, types of wastewater collection systems that are used, the appurtenances used in conjunction with sewers, the flow in sewers, the design of sewers, and the construction and maintenance of sewers.

2.2 MUNICIPAL SEWERAGE SYSTEM

2.2.1 Types of Sewers

The types and sizes of sewers used in municipal collection system will vary with size of the collection system and the location of the wastewater treatment facilities. The municipal or the community sewerage system consists of (1) building sewers (also called house connections), (2) laterals or branch sewers, (3) main and submain sewers, (4) trunk sewers, and (5) intercepting sewers.

House sewers connect the building plumbing to the laterals or to any other sewer lines mentioned above. Laterals or branch sewers convey the wastewater to the main sewers. Several main sewers connect to the trunk sewers that convey the wastewater to large intercepting sewers or the treatment plant. The types of sewers usually used in wastewater collection system are shown in Figure 2.1, and a typical layout of a municipal sewerage system is shown in Figure 2.2 (Qasim, 1985).

The diameter of a sewer line is generally determined from the peak flow that the line must carry and the local sewer regulations, concerning the minimum sizes of the laterals and house connections. The minimum size recommended for gravity sewer is 200 mm (8 in).

2.2.2 Sewer Materials

Sewers are made from concrete, reinforced concrete, vitrified clay, asbestos cement, brick masonry, cast iron, ductile iron, corrugated steel, sheet steel, and plastic or polyvinyl chloride (PVC) or ultra polyuinyl chloride (UPVC). Concrete and ultra polyvinyl chlorides are the most common materials for sewer construction.

2.3 TYPES OF WASTEWATER COLLECTION SYSTEMS

2.3.1 Gravity Sewer System

Collecting both wastewater and storm water in one conduit (combined system) or in separate conduits (separate system). In this system, the sewers are partially filled. A typical characteristic is that the gradients of the sewers must be sufficient to create self-cleansing velocities for the transportation of sediment. These velocities are 0.6 to 0.7 m/s when sewers are flowing full or half-full. Manholes are provided at regular intervals for the cleaning of sewers.

2.3.2 Pressure Type System

Collecting wastewater only. The system, which is entirely kept under pressure, can be compared with a water distribution system. Sewage from an individual house connection, which is collected in manhole on the site of the premises, is pumped into the pressure system. There are no requirements with regard to the gradients of the sewers.

2.3.3 Vacuum Type System

Collecting wastewater only in an airtight system. A vacuum of 5-7 m is maintained in the system for the collection and transportation of the wastewater. There is no special requirement for the gradients of the sewers.

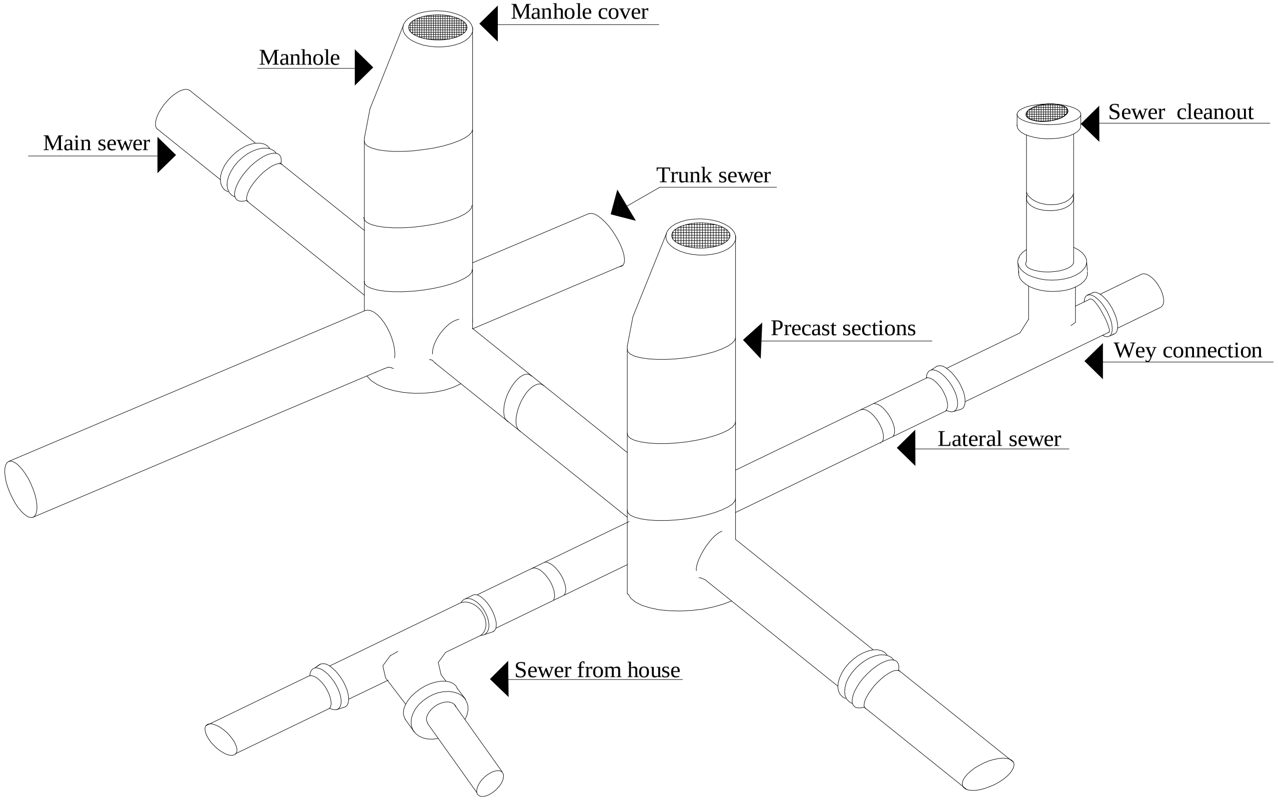

Figure 2.1: Types of Sewers Used in Wastewater Collection System

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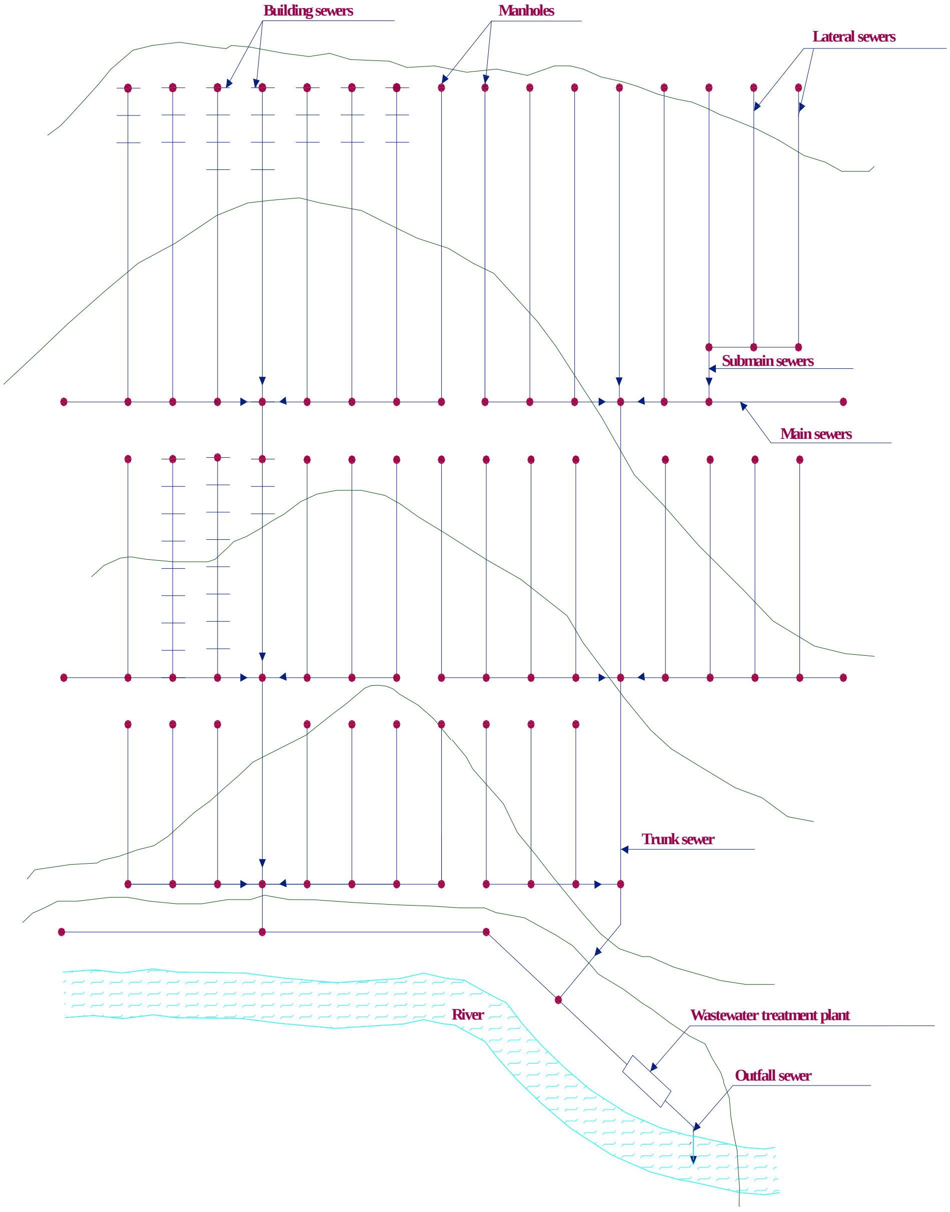

Figure 2.2: Typical Layout of Municipal Sewarage System

Pressure and vacuum–types systems require a comparatively high degree of mechanization, automation and skilled manpower. They are often more economical than gravity system, when applied in low population density and unstable soil conditions. Piping with flexible joints has to be used in areas with expansive soils.

2.4 SEWER APPURTENANCES

2.4.1 Manholes

Manholes should be of durable structure, provide easy access to the sewers for maintenance, and cause minimum interference to the sewage flow. Manholes should be located at the start and at the end of the line, at the intersections of sewers, at changes in grade, size and alignment except in curved sewers, and at intervals of 90-180 m in straight lines.

The general shapes of the manholes are square, rectangular or circular in plan, the latter is common. Manholes for small sewers are generally 1.0-1.2 m in diameter. For larger sewers larger manhole bases are provided. The maximum spacing of manholes is 90-180 m depending on the size of sewer and available size of sewer cleaning equipment (Qasim,1985).

Standard manholes consist of base, risers, top, frame and cover, manhole benching, and step-iron. The construction materials of the manholes are usually precast concrete sections, cast in place concrete or brick. Frame and cover usually made of cast iron and they should have adequate strength and weight.

Drop Manholes

A drop manhole is used where an incoming sewer, generally a lateral, enters the manhole at a point more than about 0.6 m above the out going sewer. The drop pipe permits workmen to enter the manhole without fear of being wetted, avoid the splashing of sewage and corrosion of manhole bottom. Typical sewer and drop manholes are shown in Figure 2.3 (Hammer, 1977).

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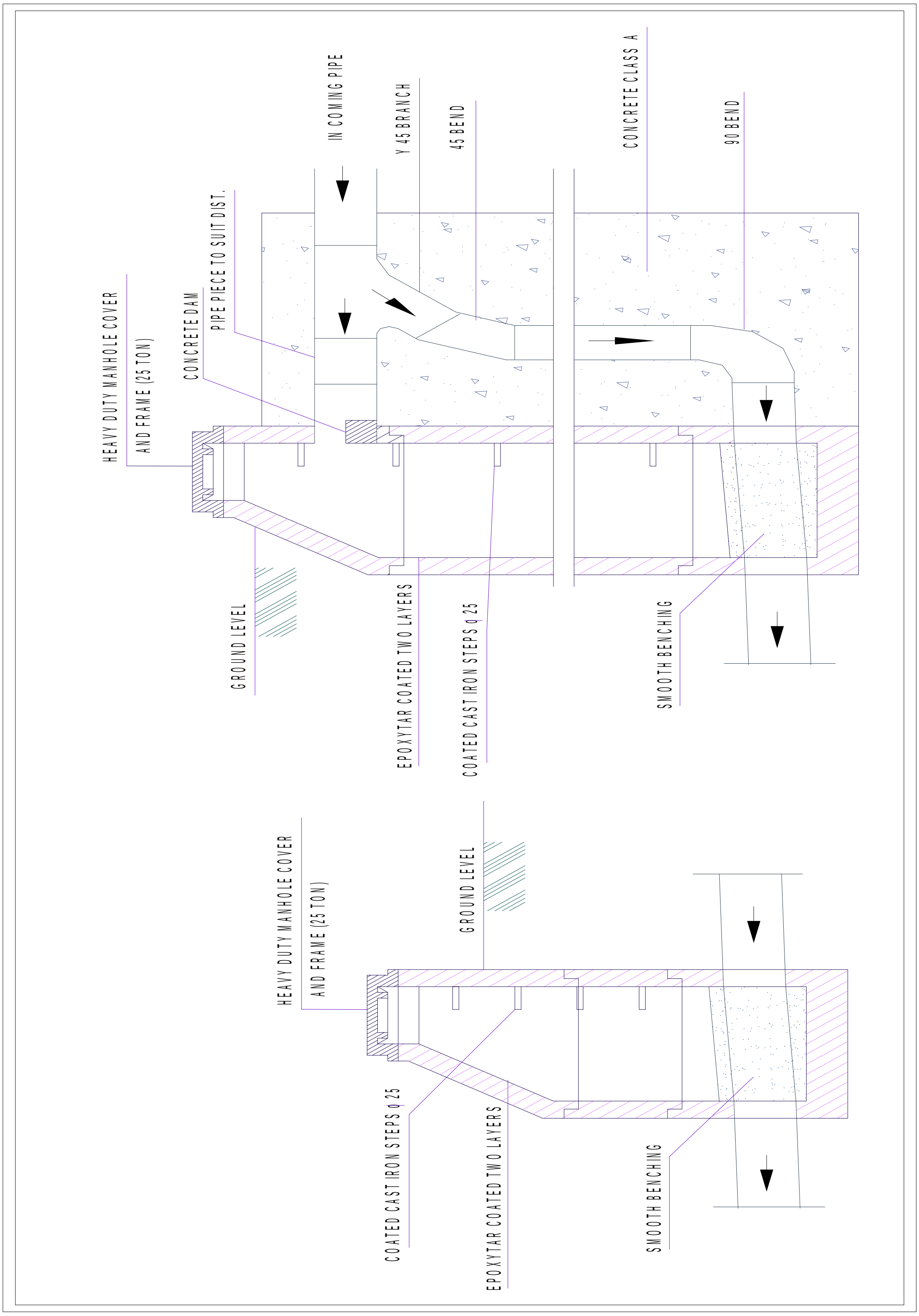

Figure 2.3: Typical Layout of Municipal Sewarage System

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2.4.2 House Connections

The house sewers are generally 10-15 cm in diameter and constructed on a slop of 0.02 m/m. house connections are also called, service laterals, or service connections. Service connections are generally provided in the municipal sewers during construction. While the sewer line is under construction, the connections are conveniently located in the form of (Y)s or (T)s, and plugged tightly until service connections are made. In deep sewers, a vertical pipe encased in concrete is provided for house connections (Qasim, 1985).

2.4.3 Inlets

Inlets are structures through which storm water enters the sewers. Their design and location require consideration of how far water will be permitted to extend into the street under various conditions. The permissible depth of water in the gutter is limited to 150 mm on residential streets and to that depth, which will leave two lanes, clear of standing water on arterials and one lane on major streets (Mc Ghee, 1991).

2.4.4 Inverted Siphons

An inverted siphon is a section of sewer, which is dropped below the hydraulic grade line in order to avoid an obstacle such as a railway or highway cut, a subway, or a stream. Such sewers will flow full and will be under some pressure; hence they must be designed to resist low internal pressures as well as external loads. It is also important that the velocity be kept relatively high (at least 0.9 m/s) to prevent deposition of solids in locations, which would be very difficult or impossible to clean (Mc Ghee, 1991).

Since sewage flow is subject to large variation, a single pipe will not serve adequately in this application. If it is small enough to maintain a velocity of 0.9 m/s at minimum flow, the velocity at peak flow will produce very high head losses and may actually damage the pipe. Inverted siphons normally include multiple pipes and an entrance structure designed to divide the flow among them so that the velocity in those pipes in use will be adequate to prevent deposition of solids (Mc Ghee, 1991).

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2.4.5 Sewer Outlets and Outfalls

Storm water and treated wastewater may be discharged to surface drainage or to bodies of water such as lakes, estuaries, or the ocean. Outlets to small streams are similar to the outlets of high way culverts, consisting of simple concrete headwall and apron to prevent erosion. Some wastewater treatment plants are located at elevations, which might be flooded. Present regulations require that sewage treatment works be protected against a 100-year flood, which may require levees around low-lying installations and pumping of the treated flow when stream levels are high. Gravity discharge line in such circumstances must be protected by flap gates or other automatically closed valves, which will prevent the stream flow from backing up into the plant (Mc Ghee, 1991).

Sewers discharging into large bodies of water are usually extended beyond the banks into fairly deep water where dispersion and diffusion will aid in mixing the discharge with the surrounding water. The outfall lines are constructed of either iron or reinforced concrete and may be placed from barges or joined by divers. Iron is generally preferred for outfall 610 mm in diameter or less. In bodies of water which are sufficiently large to permit heavy wave action. The outfall may be protected by being placed in a dredged trench or by being supported on pile bents. Subsurface discharges normally employ multiple outlets to aid in distribution and dilution of the wastewater (Mc Ghee, 1991).

2.4.6 Pumping of Sewer

There are many communities in which it is possible to convey all the sewage to a central treatment location or point of discharge in only a gravity system. In other areas with flat terrain, more than one drainage area, low-lying sections, or similar complications, pumping may be required. Pumping may also be required at or within sewage treatment plants, in the basements of buildings which are below the grade of the sewer, and to discharge treated wastewater to streams which are above the elevation of the treatment plant (Mc Ghee, 1991).

Pumping of untreated sanitary sewage requires special designs, since sewage often contains large solids. Nonclog pumps have impellers, which are usually closed and have, at most, two or three vanes. The clearance between the vanes is sufficiently large that anything, which will clear the pump suction, will pass through the pump. A bladeless impeller, sometimes used as a fish pump, has also been applied to this service. For a specified capacity, bladeless impellers are larger and less efficient than vaned designs (Mc Ghee, 1991).

Sewage pumping stations within the collection system include a wet well, which serves to equalize the incoming flow, which is always variable. Although pumps that can operate at variable speed are available, their cost and the complexity of their control systems generally make them an expensive alternative. Ordinary constant-speed pumps with standard motors should not be turned on and off too frequently since this can cause them to overheat. In small pumping stations there may be only two pumps, each of which must be able to deliver the maximum anticipated flow. Lower flows are allowed to accumulate in the wet well until a sufficient volume has been accumulated to run the pump for about 2 min. The wet well may also be sized to ensure that the pump will not start more often than once in about 5 minutes. The specific values of running time and cycle time depends upon the characteristics of the motor used and must be obtained from the manufacturers (Mc Ghee, 1991).

2.5 HYDRAULICS OF SEWER DESIGN

2.5.1 Introduction

Wastewater systems are usually designed as open channels except where lift stations are required to overcome topographic barriers. The hydraulic problems associated with these flows are complicated in some cases by the quality of the fluid, the highly variable nature of the flows, and the fact that an unconfined or free surface exists. The driving force for open-channel flow and sewer flow is gravity. For the hydraulic calculations of sewers, it is usually assumed uniform flow in which the velocity of flow is constant, and steady flow condition in which the rate discharge at any point of a sewer remains constant (Metcalf,1982).

2.5.2 Flow Formulas

In principle all open channel flow formulas can be used in hydraulic design of sewer pipes through Manning's formula. The following are the most important formulas:

1. Chezy formula: Using the Chezy equation, the velocity of flow in sewers can be determined according to

$$V = C\sqrt{RS} \qquad (2.1)$$

Where V is the velocity of flow, C is the Chezy coefficient ($C = 100\ R/(m+\sqrt{R})$, where m = 0.35 for concrete pipe or 0.25 for vitrified clay pipe), R is the hydraulic radius, and S is the slope of the sewer pipe.

2. Darcy-Weisbach formula: It is not widely used in wastewater collection design and evaluation because a trial and error solution is required to determine pipe size for a given flow and head loss, since the friction factor is based on the relative roughness which involves the pipe diameter, making it complicated. Darcy-Weishbach formula states that

$$H = \lambda\ L*V^2/(D*2g) \qquad (2.2)$$

Where H is the pressure head loss in mwc, L is the length of pipe, D is the diameter of pipe, λ is the dimensionless friction factor generally varying between 0.02-0.075.

3. The Manning formula: Manning's formula, though generally used for gravity conduits like open channel, it is also applicable to turbulent flow in pressure conduits and yields good results, provided the roughness coefficient n is accurately estimated. Head loss, according to Manning's equation is given by

$$V = 1/n\ R^{2/3}\ S^{1/2} \qquad (2.3)$$

Where n is the Manning coefficient ($1/n = 75\ m/s^{1/3}$), R is the hydraulic radius = area /wetted perimeter (circular pipe flowing full, R= D/4). Coefficient of roughness depends on the material and age of the conduit. Comm-only used values of n for different materials are given in Table 2.1.

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Table 2.1: Common Values of Roughness Coefficient Used in Manning Equation.

Commonly Used Values of n	Material
0.013 and 0.015	Concrete
0.013 and 0.015	Vitrified clay
0.013 and 0.015	Cast iron
0.015 and 0.017	Brick
0.022 and 0.025	Corrugated metal pipe
0.013 and 0.015	Asbestos cement
0.025 and 0.003	Earthen channels

2.5.3 Hydraulics of Partially Filled Sections

The filling rate of a sewer is an important consideration, as sewers are seldom running full, so sanitary sewers designed for 40% or 50% running full, that is means only 40 % to 50 % of the pipe capacity should be utilized to carry the peak flow.

Partially filled sewers are calculated by using partial flow diagram and tables indicating the relation between water depth, velocity of flow and rate flow .The hydraulic characteristics are similar as for open channels, but the velocity of flow is reduced by increased air friction in the pipe with increasing water level, particularly near the top of the pipe. The velocity of flow and the flow rate are reduced at filling rates between 60% and 100%; the water level in the pipe is unstable at filling rates above 90% or 95%.

2.6 DESIGN SYSTEM AND CONSTRUCTION COMMUNITY SEWERAGE SYSTEM

Designing a community sewerage system is not a simple task. It requires considerable experience and a great deal of information to make proper decisions concerning the layout, sizing, and construction of a sewer network that is efficient and cost-effective. The design engineer needs to generally undertake the following tasks (Qasim,1985, Peavy,1985):

1. Define the service area.
2. Conduct preliminary investigations.

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3. Develop preliminary layout plan and profile.
4. Selection of design parameters.
5. Review construction considerations.
6. Conduct field investigation and complete design and final profiles.
7. Prepare contract drawing and specifications.

2.6.1 Service Area

Service area is defined as the total area that will eventually be served by the sewage system. The service area may be based on natural drainage or political boundaries, or both. It is generally a part of the area wide waste management plan.

2.6.2 Preliminary Investigations

The design engineer must conduct the preliminary investigations to develop a layout plan of the sewerage system. Site visits and contacts with the city and local planning agencies and state officials should be made to determine the land use plans, zoning regulations, and probable future changes that may affect both the developed and undeveloped land. Data must be developed on topography, geology, hydrology, climate, ecological elements, and social and economic conditions. Topographic maps with existing and proposed streets and other utility lines provide the most important information for preliminary flow routing (Qasim, 1985).

If reliable topographic maps are not available, field investigations must be conducted to prepare the contours, place bench marks, locate building, utility lines, drainage ditches, low and high areas, stream, and the like. All these factors influence the sewer layout.

2.6.3 Layout Plan

Proper sewer layout plan and profiles must be completed before design flows can be established. The following is a list of basic rules that must be followed in developing a sewer plan and profile (Qasim, 1985):

1. Select the site for the wastewater treatment plant. For gravity system, the best site is generally the lowest elevation of the entire drainage area.

2. The preliminary layout of sewers is made from the topographic maps. In general, sewers are located on streets, or on available right-of-way; and sloped in the same direction as the slope of the natural ground surface.
3. The trunk sewers are commonly located in valleys. Each line is started from the intercepting sewer and extended uphill until the edge of the drainage area is reached, and further extension is not possible without working downhill.
4. Main sewers are started from the trunk line and extended uphill intercepting the laterals.
5. All laterals or branch lines are located in the same manner as the main sewers. Building sewers are directly connected to the laterals.
6. Preliminary layout and routing of sewage flow is done by considering several feasible alternatives. In each alternative, factors such as total length of sewers; and cost of construction of laying deeper lines versus cost of construction, operation, and maintenance of lift station, should be evaluated to arrive at a cost- effective sewerage system.
7. Sewers should not be located near water mains. State and local regulations must be consulted for appropriate separation distance between the sewers and water lines.
8. After the preliminary sewer layout plan is prepared, the street profiles are drawn. These profiles should show the street elevations, existing sewer lines, and manholes. These profiles are used to design the proposed lines.

Finally, these layout plans and profiles are revised after the field investigations and sewer designs are complete. A typical sewer layout and profile are shown in Figure 2.4 and Figure 2.5 (Viessman, 1985).

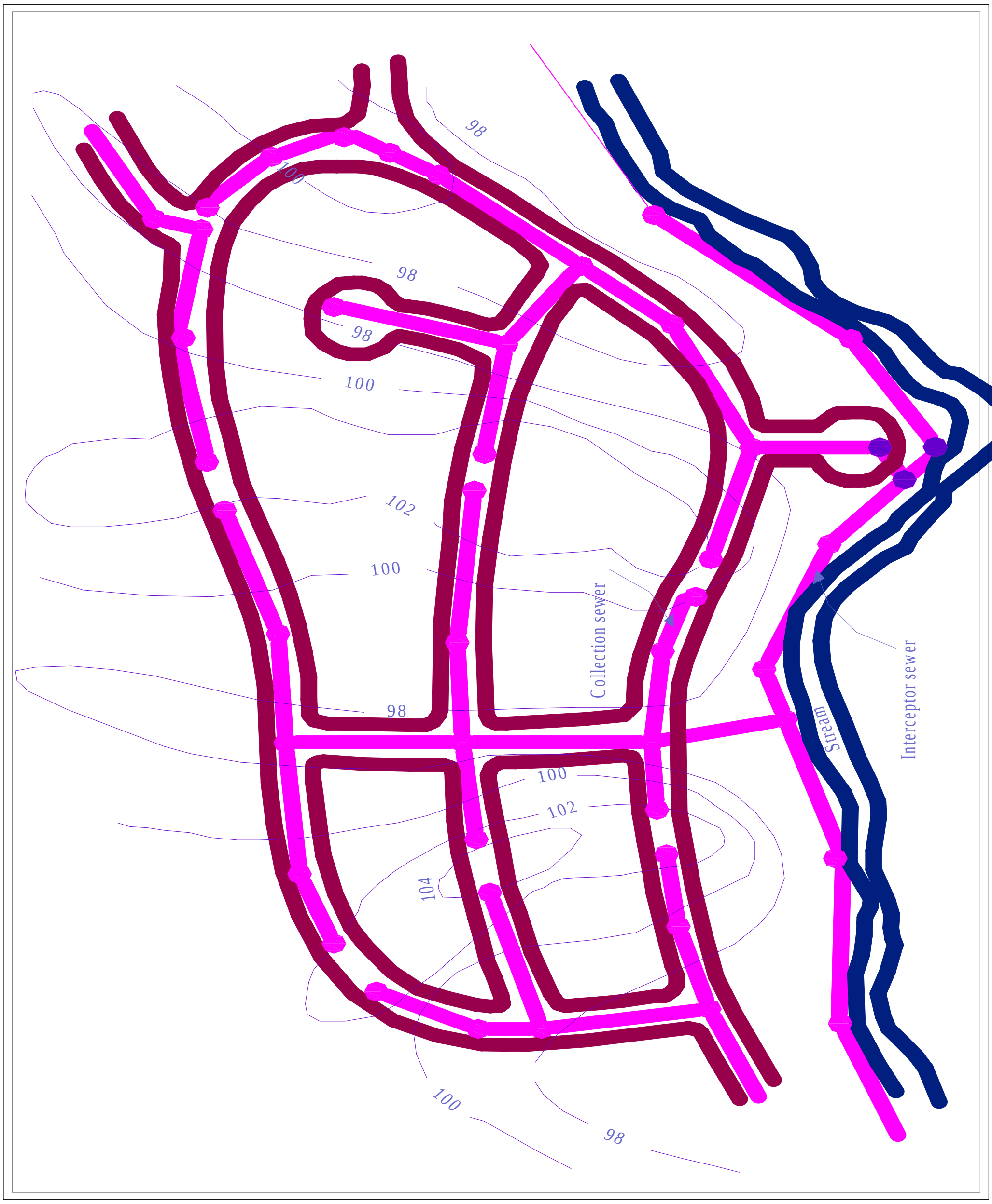
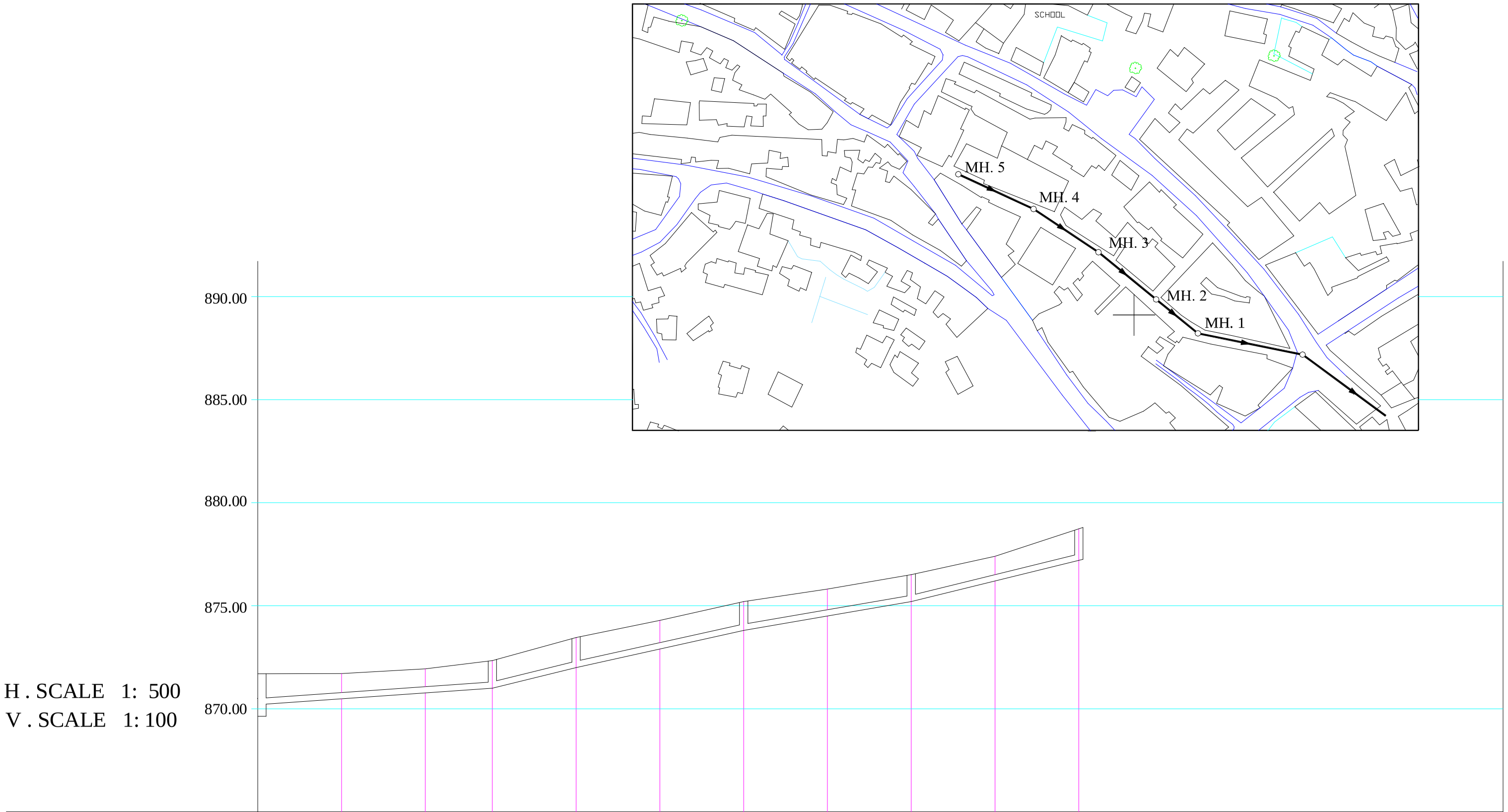


Figure 2.4: Typical Layout of Municipal Sewarage System



POINT NUMBER	0	1	2	3	4	5	6	7	8	9	10
MANHOLE NUMBER	EX. MH.			MH 1	MH 2		MH 3		MH 4		MH 5
STATION	0+00	0+ 20	0+ 40	0+ 56	0+ 76	0+ 96	0+ 116	0+ 136	0+ 156	0+ 176	0+ 196
GROUND ELEVATION	871.70	871.71	871.94	872.37	873.46	874.29	875.20	875.81	876.51	877.40	878.73
INVERT ELEVATION	870.20	870.49	870.77	971.00	872.00	872.90	873.80	874.50	875.20	876.20	877.20
DEPTH OF MANHOLES	1.50	1.22	1.17	1.37	1.46	1.39	1.40	1.31	1.31	1.20	1.53
DISTANCES	0.00	20.00	40.00	56.00	76.00	96.00	116.00	136.00	156.00	176.00	196.00
DISTANCE OF MANHOLES m	56.00			20.00	40.00		40.00		40.00		
PIPE DIAMETER mm	UPVC ϕ 300mm			UPVC ϕ 300mm	UPVC ϕ 300mm		UPVC ϕ 300mm		UPVC ϕ 300mm		
PIPE SLOPE %	1.43 %			5.00 %	4.50 %		3.50 %		5.00 %		
TYPE OF SURFACE	ASPHALTED ROAD						ASPHALTED ROAD				

Figure 2.5: Typical Plan and Profile Drawing for Sanitary Sewer

-

2.6.4 Selection of Design Parameters

Many design factors must be investigated before sewer design can be completed. Factors such as design period; peak, average, and minimum flows; sewer slopes and minimum velocities; design equations; etc. are all important in developing sewer design. Many of the factors are briefly discussed below.

1. **Design Period:** Design period should be based on ultimate tributary population. It is not uncommon to design sewers for a design period of 25-50 years or more.

2. **Design Population:** Population projections must be made for the population at the end of the design year. Discussion on population projection can be found in chapter four.

3. **Design Flow Rate:** Sanitary sewers should be designed to carry peak residential, commercial, and industrial flows, and the normal infiltration and inflow where unfavorable conditions exist.
4. **Minimum Size:** As mentioned earlier, minimum sewer size recommended is 20 cm (8 in). Many countries allow 15 cm (6 in) lateral sewers.

5. **Minimum and Maximum Velocities:** In sanitary sewers, solids tend to settle under low-velocity conditions. Self-cleaning velocities must be developed regularly to flush out the solids. Most countries specify minimum velocity in the sewers under low flow conditions. A good practice is to maintain velocity above 0.3 m/s under low flow conditions. Under peak dry weather condition, the lines must attain velocity greater than 0.6 m/s. This way the lines will be flushed out at least once or twice a day. In depressed sewers self-cleaning velocities of 1.0 m/s must be developed to prevent accumulation of solids. Velocities higher than 3 m/s should be avoided as erosion and damage may occur to the sewers or manholes.

6. **Slope:** Flat sewer slopes encourage solids deposition and production of hydrogen sulfide and methane. Hydrogen sulfide gas is odorous and causes serious pipe corrosion. Methane gas has caused explosions. The minimum slopes are such that a

velocity of 0.6 m/s is reached when flowing full and n =0.015. Minimum sewer slopes for different diameter lines are summarized in Table 2.2.

Table 2.2: Minimum Recommended Slopes of Sanitary Sewer.

Slope	Diameter	
Mm	mm	inch
0.006	150	6
0.004	200	8
0.0028	250	10
0.0022	310	12
0.0017	360	14
0.0015	380	15
0.0014	410	16
0.0012	460	18
0.0008	610	24
0.00067	690	27
0.00058	760	30
0.00046	910	36
0.00038	1050	42
0.00032	1200	48
0.00026	1370	54

7. Depth: The depth of sewers is generally 1-2 m below the ground surface. Depth depends on the water table, lowest point to be served, topography, and the freeze depth.

8. Appurtenances: Sewer appurtenances include manholes, building connections, inlets, inverted siphons, outlets and outfall, and others. These are discussed briefly in section 3.4. Appropriate sewer appurtenances must be selected in design of sanitary sewers. Manholes for small sewers are generally 1.2 m in diameter. For larger sewers larger manhole bases are provided. The maximum spacing of manholes is 90-180 m.

9. Design Equations and Procedures: Sanitary sewers are mostly designed to flow partially full. Once the peak, average, and minimum flow estimates and made general layout and topographic features for each line are established, the design engineer begins to size the sewers. Design equations proposed by Manning, Chezy, Gangullet, Kutter, and Scobey have been used for designing sewers and drains. The Manning equation, however, has received most widespread application. This equation in various forms is expressed below:

$$V = 1/n\ R^{2/3}\ S^{1/2} \qquad (2.3)$$

$$Q = (0.312\ /n)\ D^{8/3}\ S^{1/2} \qquad \text{(circular pipe flowing full)} \qquad (2.4)$$

Where Q is the flow rate.

Various types of nomographs have been developed for solution of problems involving sewers flowing full. Nomographs based on Manning's equation for circular pipe flowing full and variable n values are provided in Figure 2.6. Hydraulic elements of circular pipes under part-full flow conditions are provided in Figure 2.7. It may be noted that the value of n decreases with the depth of flows Figure 2.7. However, in most designs n is assumed constant for all flow depths. Also, it is a common practice to use d, v, and q notations for depth of flow, velocity, and discharge under partial flow condition while D, V, Q notations for diameter, velocity, and discharge for sewer flowing full. Use of equations 2.3 and 2.4 and Figures 2.6 and 2.7 are shown in the design calculation in chapter five (Qasim, 1985).

After the preliminary sewer layout plan and profile are prepared, the design computations are accomplished. Design computations for sewers are repetitious and therefore, are best performed in a tabular format. Table 2.3 is typical of the way in which data can be organized to facilitate computations (Viesman, 1985).

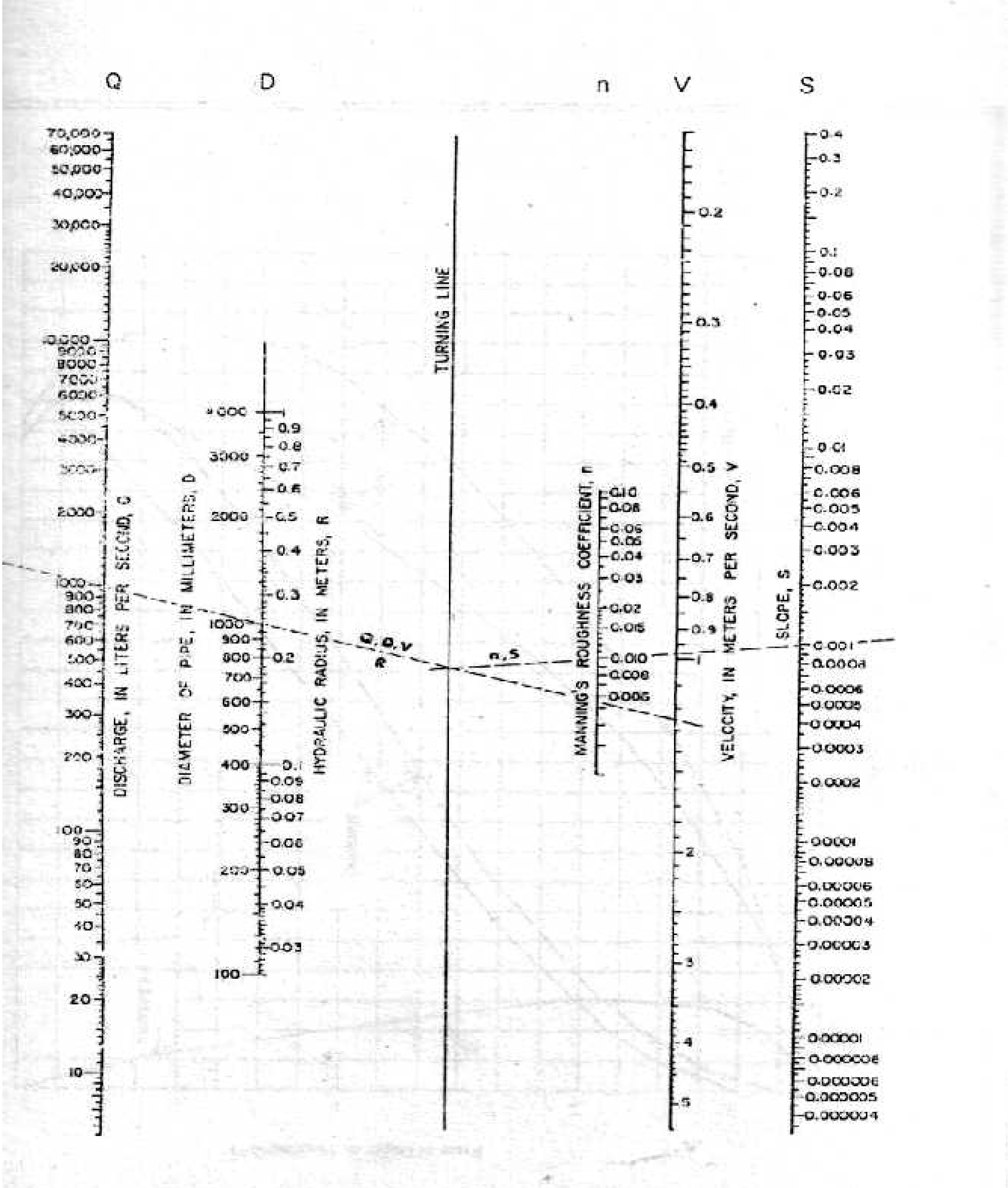


Figure 2.6 Manning's equation for circular pipe flowing full and variable n values

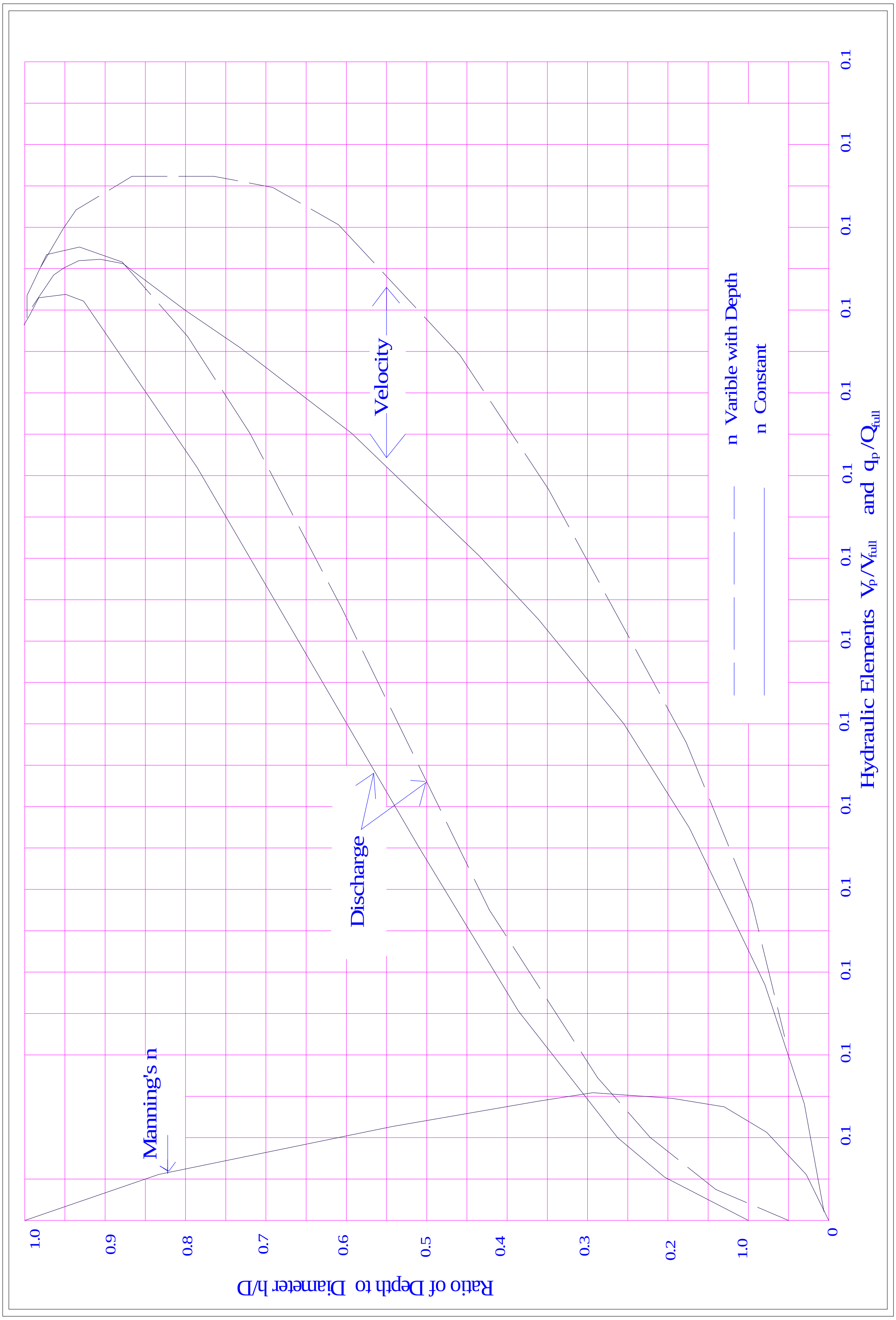


Figure 2.7: Hydraulic Properties of Circular Sewer

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2.6.5 Construction Consideration

1. **Construction Materials:** As mention earlier, sewers are made from concrete, reinforced concrete, vitrified clay, asbestos cement, brick masonry, cast iron, corrugated steel, sheet steel, and plastic. Important factors in selection of sewer material include the following:

- Chemical characteristics of wastewater and degree of resistance to corrosion against acid, base, gases, solvent, etc.
- Resistance to scour and flow.
- External forces and internal pressure.
- Soil conditions.
- Type of backfill and bedding material to be used.
- Useful life.
- Strength and water tightness of joints required, and effective control of infiltration and inflow.
- Availability in diameter, length, and ease of installation.
- Cost of construction and maintenance.

2. **Joints and Infiltration:** The method of making joints should be fully covered in the specifications. Joints should be designed to make sewers water-tight, root-resistant, flexible, and durable. A leakage test should be specified. The leakage shall not exceed 0.5 m^3 per day per cm of pipe diameter per Km. It has been experimentally demonstrated that joints made from rubber gasket and hot-poured bituminous material produced almost no infiltration, whereas cement mortar joints cause excessive infiltration.

3. **Sewer Construction:** Sewer construction involves excavation, sheeting and bracing of trenches, pipe installation, and backfilling. Each of these construction steps is discussed briefly below (Qasim,1985).

- **Excavation**: After the sewer alignment is marked on the ground, the trench excavation being. Machinery such as backhoe, clamshell, dragline, front-end loader or other specialized equipment is used. Hand excavation may be possible only for short distances. Hard rock's may be broken by drilling; explosives may also be used where situations permit.

-

- **Sheeting and Bracing**: Trenches in unstable soil condition require sheeting and bracing to prevent caving. Sheeting is placing planks in actual contact with the trench sides. Bracing is placing crosspieces extending from one side of the trench to the other. Sheeting and bracing may be of various types depending on the depth and width of the trenches and the type of soils supported. Common types are stay bracing, poling boards, box sheeting, vertical sheeting, and skeleton sheeting. In many situations pumping may be necessary to dewater the trenches.

- **Sewer Installation**: after the trench is completed, the bottom of the trench is checked for elevation and slope. In firm, cohesive soils the trench bottom is shaped to fit the pipe barrel and projecting collars. Often granular material such as crushed stones; slag, gravel, and sand are used to provide uniform bedding of the pipe. The pipes are inspected and lowered with particular attention being given to the joints. The pipe lengths are placed on line and grade with joints pressing together with a level or winch. The joints are then filled per specifications.

- **Backfilling:** The trenches are filled immediately after the pipes are laid. The fill should be carefully compacted in layers of 15 cm deep around, under the over the pipe. After completion of the filling, the surface is then finished.

2.6.6 Field Investigations and Completion of Design

Fieldwork should be conducted to establish benchmarks on all streets that will have sewer lines. Soil borings should be conducted to develop subsurface data needed for trenching and excavation. The depth of boring should be at least equal to the estimated depth of the sewer lines. Detailed plans should be drawn showing the following: (1) contours at 0.5 m intervals in map with scale 1 cm equal to 6 m, (2) existing and proposed streets, (3) streets elevations, (4) railroads, building, culverts, drainage ditches, etc, (5) existing conduits and other utility lines, and (6) existing and proposed sewer lines and manholes. The sewer profiles should also be developed showing ground surface and sewer elevations, slop, pipe size and type, and location of special structures and the appurtenances. Profile drawing should be prepared immediately under the sewer plan for ready reference Figure 2.5.

2.6.7 Preparation of Contract Drawings and Specifications

It is important that the detailed drawings be prepared and specifications completed before thebide can be requested. The contract drawings should show (1) surface features, (2) depth and character of material to be excavated, (3) the existing structures that are likely to be encountered, and (4) the details of sewer and appurtenances to be constructed.

The specifications should be prepared by writing clearly and completely all work requirements and conditions affecting the contracts. As an example, technical specifications should cover items such as site preparation, excavation and backfill, concrete work, sewer materials and pipe laying, jointing, appurtenances, and acceptance tests (Qasim, 1985).

2.7 INFORMATION CHECKLIST FOR THE DESIGN OF SANITARY SEWER

Design of sanitary sewers involves preliminary investigations, a detailed field survey, design calculations, and field drawings. The design engineer should be familiar with the service area, the local and state design criteria, and the design procedures. Adherence to a carefully planned sequence of activities to develop sewer design minimizes project delays and expenditures. A checklist of design activities is presented below. These activities are listed somewhat in their order of performance. However, in many cases separate tasks can be performed concurrently or even out of the order given below.

1. Develop a sewer plan showing existing and proposed streets and sewers, topographic features with contour of 0.5 m, elevations of street intersections, and location of permanent structures and existing utility lines. Mark the proposed sewer lines and tentative slopes.
2. Locate manholes and number them in accordance with a convenient numbering system.

3. Prepare vertical profile showing ground surface, manhole location, and elevation at the surface of each manhole.
4. Determine total land surface area that will be eventually served by different sewer lines.
5. Determine expected saturation population densities and average per capita wastewater flow rate.
6. Estimate peak design flow, peak, average, and minimum initial flows.
7. Reviews design equations and develop hydraulic properties of the conduits.
8. Obtain state standards, sewer codes, or any design and maintenance criteria established by the concerned regulatory agencies.

2.8 SUMMARY

In this chapter, municipal sewage collection systems in general have been described. The various types of wastewater collection systems have been narrated. Some literature on the sewer appurtenances has been reviewed. The flow equations of sewer pipes have been brought out. The design and construction of community sewage system has been briefly discussed. Finally the information checklist for the design of sanitary sewers has been pointed out.

CHAPTER

3 WATER DISTRIBUTION SYSTEMS

3.1 General Background

3.2 Methods of Distribution

3.3 Types of Pipes

3.4 Pipes Appurtenances

3.5 Service Reservoirs

3.6 Pumps and Pumping

3.7 Excavation and Backing Fill

CHAPTER THREE

WATER DISTRIBUTION SYSTEMS

3.1 General Background

The term distribution system is used to describe collectively the facilities used to supply water from its source to the point of usage. To deliver water to individual consumers with appropriate quantity, quality, and pressure in a community setting requires an extensive system of pipes, storage reservoirs, pumps, and related appurtenances. It is the purpose of this chapter to explain these elements.

3.2 Methods of Distribution

Depending upon the topography, location of the source, and other considerations, water can be transported to a community in a number of ways. For transportation of water, canals, flumes, tunnels, and pressure pipes can be employed. Water can be supplied to the consumers with adequate pressure either by means of gravity, pumping, or a combination of both (see Figure 3.1)(Peary, Rowe and Techobanolous, 1985).

3.2.1 Gravity Distribution System

In this system, the water from the high leveled source is distributed to the consumers at lower levels, by the mere action of gravity without any pumping. For proper functioning of this system, the difference of head available between the source and localities, must be sufficient enough, as maintain adequate pressure at the consumer’s door –steps, after allowing the frictional and other loss in the pipes. This method is the most economical and reliable, since no pumping is involved at any stage. However, it needs a lake or reservoir as a source of supply (Garge,1998).

3.2.2 Pumping With Storage System

In this system, the water is pumped at a constant rate and stored into an elevated distribution reservoir, from where it distributed to the consumers by the mere action of gravity. Sometimes, the entire water is first of all pumped into the distribution reservoir, many times, it is pumped into the distribution mains and reservoirs simultaneously. This method thus, combined as well as gravity flow (Garge,1998).

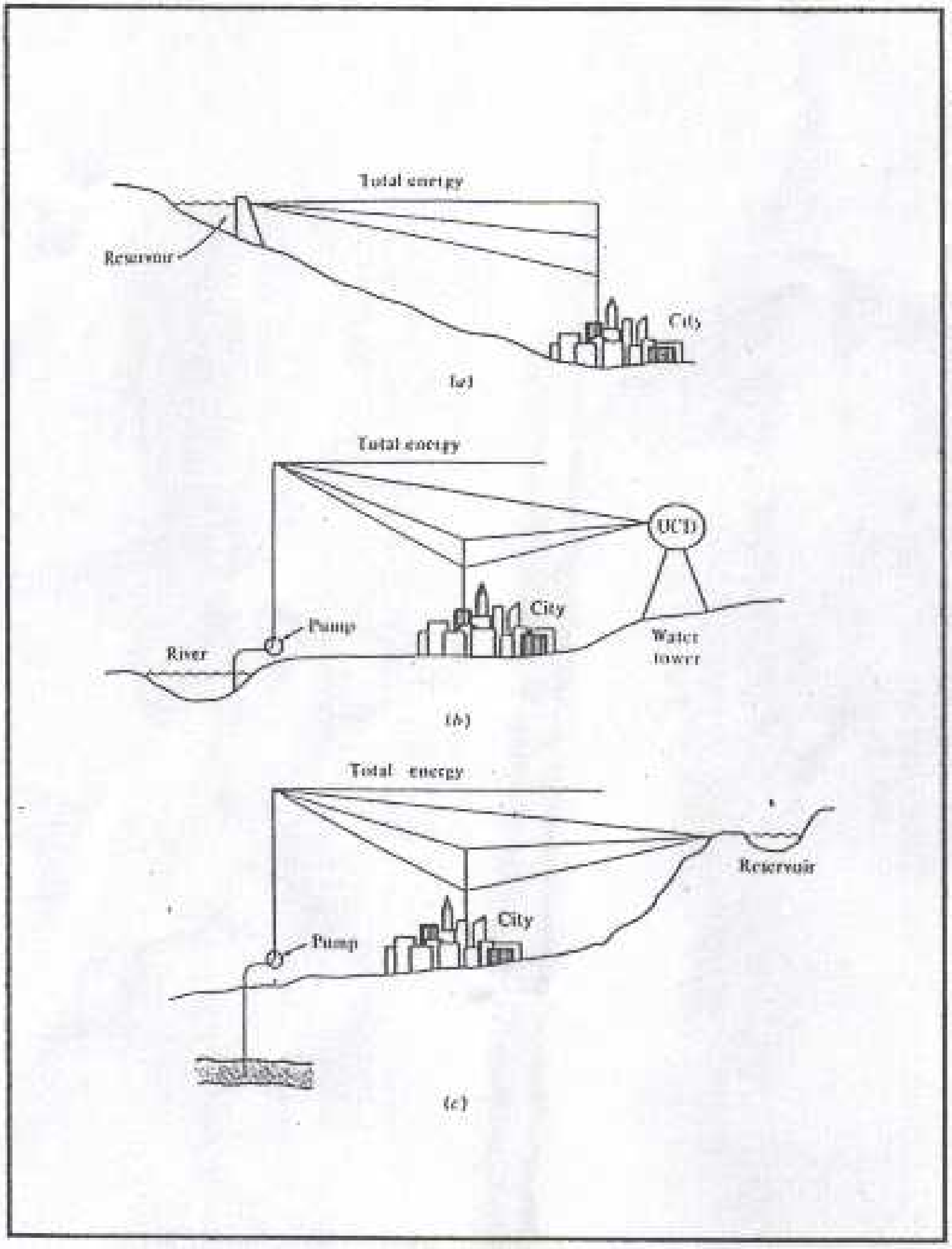

Figure (3.1): Typical Distribution System: (a) Gravity, (b) Pumped, and (c) Combined

2.2.3 Pumping Without Storage System

In the pumping system, the water is directly pumped into the distribution mains without storing it anywhere. High lift pumps are required in this system, which have to operate at variable speeds, so as to meet the variable demand of water. Thus a continuous attendance is needed at the pumping station, so to ensure the desired flow in the distribution system (Garge,1998). Moreover, if the power supply fails there will be complete stoppage of water supply, and if by chance, a fire breaks out at such a time, it will bring disaster. This method is therefore, generally not used. However, the only advantage of this method is that during fires, it can force large volumes of water under high pressure in the required direction, so that the motor pumps may be eliminated.

3.3 Types of Pipes

The pipe is a circular closed conduit, used for conveying water from a point to another one, under gravity or under pressure. The pipes are generally classified into three categories of usage:

(i) Mains: A large pipes which go through the main streets in cities or towns and used to convey water to other pipes (sub-mains) in the network, or from one reservoir to another.

(ii) Sub-mains: Smaller pipes connected to mains and supplies water to service pipes.

(iii) Service pipes: The pipes which supply water to consumers, houses, flats, and farms and connect to mains and sub-main pipes.

(iv) Plumping pipes: Pipes work within a building for the distribution of water of various appliances.

Pipes are also classified according to their material of construction. The following types of pipes are in use for construction of mains:

1. Cast iron pipes
2. Asbestos cement pipes
3. Steel pipes
4. Reinforced concrete pipes
5. Plastic pipes

The selection of particular types of material for a pipe depends mainly upon the first cost, maintenance cost, durability, carrying capacity, the maximum pressure, the maximum permissible size, availability of materials and labor for their construction, etc. The type of water to be conveyed and its possible corrosive effect upon the pipe material must be taken into account.

In Palestine, the use of steel pipes is more favorable considering the rocky terrain and steep slopes along most of the lines. Steel pipelines under such conditions are less exposed to damages by subsequent construction activities than other material pipes.

3.4 Pipes Appurtenances

In order to isolate and drain the pipeline sections for tests, inspection, cleaning and repairs, a number of appurtenances such as pipe fittings, valves, manholes, etc. are provided at various suitable places along the pipelines, as described below.

3.4.1 Pipe Fittings

The various pipe fittings such as bends, crosses, tees, elbows, wye, union, capes, reducers, plugs, etc. are frequently used in making service connections and bigger sized mains or sub-mains. Fittings are supplied in case of interruption of pipelines, such as change in diameters, materials, pipeline direction or if valve and water meters have to be installed. Various types of bends and other important pipe fittings are shown in Fig. 3.2 Proper selection and installation of joints and fittings is very important because they are often source of leakage (Steel and McGhee 1991).

3.4.2 Valves

A large number of different types of valves are required for the proper functioning of the pipelines. Generally, valves have three main tasks: flow and/or regulation (e.g. flow control valves, pressure reducing valves, etc.), exclusion of the parts of the network due to emergency or maintenance reasons, and protection of reservoirs and pumps in the system (e.g. float valves, non-return valves). With respect to the purpose, the following types of valves can be distinguished.

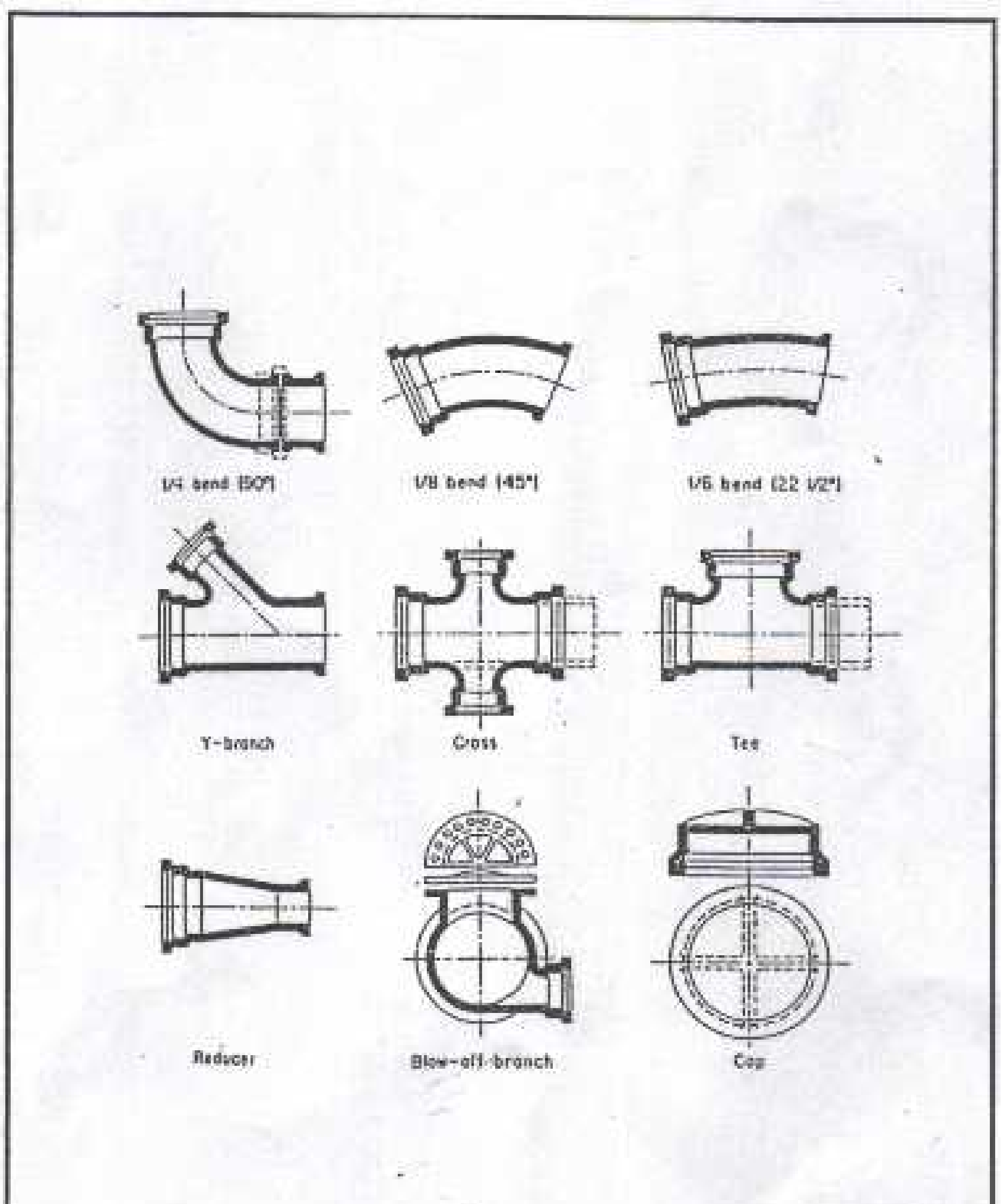

Figure (3.2):Various Pipe Fitting

1. **Gate Valves or Sluice Valves:** They are isolating valves, used most often in the distribution system to shut off the flow whenever desired, especially, when repairs are needed in the system, they are also helpful in dividing the water mains into suitable sections. Gate valves have the advantage of low cost, availability and low head losses when fully opened. In general, these valves are installed at street crossing where lines intersect.

2. **Pressure Reduce Valves:** They are installed at locations along the pipelines where pressure is high, especially at low point in the network and those that are near the pump station. When pressure in the pipe exceeds the maximum allowed limit, the valve relive pressure through cross pipe. An adjustable control permits setting downstream pressure at the desired level and the valve will throttle itself until that pressure is attained.

3. **Air Relief Valves:** Water flowing through pipelines always contains some air which tries to accumulate at high points, and may interface with the flow. Air relief valves are therefore provided at the summit along the pipe, these valves are needed to discharge air when a main is being filled and to admit air when it is being emptied.

4. **Scour or Blow off Valves:** These are ordinary sluice valves that are located either at dead end or at the lowest point of the main. They are provided to blow off or remove the sand and silt deposited in pipelines. They are operated manually.

5. **Non-Return Valves:** These valves are used to primate the flow of water in one direction only. They consist of flat disc within the pipeline, when they are forced by water they are opened. They are used through the main pipes to the pumping station to prevent reverse flowing, and at the end of suction line to prevent draining the suction when the pump stops.

6. **Float Valves:** These valves are installed at the entrance of the storage reservoirs. There task is to close or open depending on the movement of a floating sphere on water to control the water surface inside the reservoir.

3.4.3 Water Meters

Purpose of metering in water distribution systems is twofold: it provides information about hydraulic behavior of the network, useful for the future design, as well as, it basis for water billing. In both cases the accuracy is vital, so the quality and good maintenance of these devices are very important (UNDP,1990).

3.4.4 Fire Hydrants

Fire hydrants are constructed in many different versions. They are generally distinguished as underground or ground installations. Underground installations are better protected from frost and traffic damage, but on the other hand they can be covered by parked vehicle when being requested for use. Required capacity, pressure and distance for hydrants vary from case to case and they are related to the potential risks and consequences from fire. Generally, the capacities are within the range (30-500 m^3/h), and the distance between (100-300 m) (UNDP,1990).

3.4.5 Service Connections

Service connection link users within the distribution system. The standard set-up usually consists of: connection, pipe, outdoor and indoor stop valve and water meter. In newer installation, a non return valve may be added as well.

3.5 Service Reservoirs

3.5.1 Functions

Distribution reservoirs are the storage reservoirs, which store the water for supplying water during emergencies, such as break-down of pumps, heavy fire demand, repairs, etc. and to help in absorbing the hourly fluctuation in the normal water demand. Storage reservoirs are also used to maintain pressure and reduce pressure variation within the distribution system. In large cites, distribution reservoirs may be used at several location within the system. Regardless of the locations, the water level in the reservoir must be at sufficient elevation to permit gravity flow at an adequate pressure. Types and storage capacity of the service reservoirs is explained in the following sections.

3.5.2 Types of Service Reservoirs

The service reservoirs may be made of steel, reinforcement cement concrete, or masonry. Depending upon their elevation with respect to the ground and local environmental conditions, storage reservoirs may be classified into the following two types:

1. **Surface Reservoirs:** Surface reservoirs are circular or rectangular tanks, constructed at ground level or below the ground level. They are generally constructed at high point in the city. In gravitational type of distribution system, water is stored in the ground service reservoir, and then directly sent from there into the distribution system.

2. **Elevated Reservoirs**: Elevated reservoirs are the rectangular, circular, or elliptical over head tank erected at a certain suitable elevation above the ground level and supported on the towers. They are constructed where the pressure requirements necessitate considerable elevation above the ground surface, and where the use of stand pipes becomes impracticable (Garge,1998).

3.5.3 Operating Storage of the Reservoirs

The total storage of a service reservoir is the summation of balancing storage (or equalizing or operating storage), breakdown storage, and fire storage. The main and primary function of a service reservoir is to meet the fluctuation in demand with a constant rate of water supply. The quantity of water required to be stored in the reservoir for balancing this variable demand against the constant supply is known as balancing storage or storage capacity of a reservoir. This balancing storage can be determined analytically or graphically. In the analytically solution method, the hourly excess of demand as well as the hourly excess of supply are worked out. The summation of maximum of the excess of demand and the maximum of excess of supply will give us the required storage capacity.

The breakdown storage or the emergency storage is the storage preserved in order to tide over the emergencies posed by the failure of pump, the electricity or any other mechanism driving the pump. The amount of breakdown storage is very difficult to assess. For this reason, a lump sum provision generally made for this storage. A value of about 25 percent of total storage capacity of the reservoir, or 2 times of the average hourly supply, may be considered as enough provision for accounting this storage, under all normal circumstances.

The third component of the total reservoir storage is the fire storage. In case of fires sufficient amount of water must remain available in the reservoir for throwing it over the fire. The total volume of water required for fire fighting is generally small, say of the order of 1 to 1.5 liters per day per person.

The total reservoir storage can finally obtained by adding all the three storage's, viz., balancing storage, emergency storage, and fire storage.

3.6 Pumps and Pumping

The transport of water from low lying sources, e.g. underground water, rivers and lakes, to the elevated water towers, reservoirs, directly to the consumers under pressure is accomplished with the help pumps. In a water supply scheme, pumps are required at one or more stages.

In the design of pumping works, stand-by units must be provided that in case of break dawn or during repairs the water supply is not effected. The number of units in reserve will depend upon the particular station and operational conditions.

3.6.1 Types of Pumps

There are various types of pumps, but the two types which the hydraulic engineers generally encounter, are :

1. **Roto-dynamic pumps:** A rotodynamic pump has a wheel or a rotating elements which rotates the water in a casing, and thus imparting energy to the water. Such a pump may be of the following two types:
   a) Centrifugal pumps
   b) Axial-flow pumps

2. Displacement pumps

A displacement pumps works on the principle of mechanically inducing vacum in a chamber, thereby drawing in a volume of water which is then mechanically displaced and forced out of the chamber. Such a pump may be of the following two types:

a) The reciprocating pump
b) The rotary type pump

In addition to these two major types of pumps, other types, such as air lift pumps, jet pumps, hydraulic rams, etc. are also used under special conditions.

3.6.2 Guide for Selection of Pumps

The various factors which must be thoroughly considered while selecting a particular type of pump for a particular project are :

a) Capacity of pumps
b) Importance of water supply scheme
c) Initial cost of pumping arrangement
d) Maintenance cost
e) Space requirements for locating the pump
f) Number of units required
g) Total lift of water required
h) Quantity of water to be pumped

3.6.3 Pumping Station

The location of a pumping station is primarily governed by the location of the place from where it is to receive water, and also by the location of the place where it is to supply that water. The various points which are to be kept in mind while selecting a suitable site are enumerated below:

a) The site should be a ways from all the sources of contamination or pollution.
b) The site should be above the highest flood level of the rivers.
c) It should be so selected that its future growth and expansion is easily possible.
d) Possibilities of fire hazard should also be considered while selecting the site for the pumping stations.

e) The proximity of the site to the railways, from where the coal can be quickly made available for producing power, may also have be considered.

3.7 Excavation and Backing Fill

Great care is not necessary in lying water pipes accurately to grade, but sufficient cover is necessary to give protection against traffic loads and to prevent freezing. The filling height is usually between 1 to 1.5 m measured from the upper tip of the pipe, this depends mainly on the volume and density of the traffics in the area of the project, in addition to the material of pipes and type of filling materials.

Trenches or ditches should be wide enough to allow good workmanship. Required widths range from 0.5 to 1.2 m depends on pipe size. In rock excavation the rock should be removed so that it is at least 150 mm away from the finished pipeline. A cushion of sand or earth should be placed between rock and the pipe (Steel and McGhee,1991).

Backfill material should be free from cinders, refuse, or large stones. Backfill from the trench bottom to the centerline of the pipe should be with sand, gravel, shell or other satisfactory material laid in layers and tamped. This material should extend to the trench sides. Excavation material can be used as filling material depending on the type of soil excavation and this will save money.

CHAPTER

4 DESIGN AND PLANNING CRITERIA

CHAPTER FOUR

DESIGN AND PLANNING CRITERIA

4.1 General

In the previous chapter, the problem of the study has been defined and the objectives of the study have been listed. The wastewater collection and water distribution systems have been described. In this chapter, design and planning criteria will be discussed including population and population forecasting, future water demand, design parameters, and and planning assumption.

4.2 Population

4.2.1 Introduction

The ideal approach for population forecasting is by the study and use of previous census records, which cover along period. The longer the period, the more comprehensive the census data, the more accurate will be the results, which will be obtained. In the analysis of these data, demographical, economical and political factors should be considered in order to develop a method of forecasting which will predict the expected growth rate, future population and its distribution in the different zones of the area under consideration.

In Al-Shoyoukh town, there is great uncertainty in the political and economical future. Additionally there were no accurate population data since the occupation of the West Bank in 1967, until 1997 and later in different years when the Palestinian Central Bureau of Statistic (PCBS) conducted comprehensive census covering the West Bank and Gaza Strip.The final results of this census show that the total population of Al-Shoyoukh town is 10000 for year 2011 inhabitants.

Due to the unstable condition of the area during the last 50 years, it would be very difficult to develop a statistical interpretation to extrapolate future population. Some reasonable assumptions have, therefore, been made to project the future population of Al-Shoyoukh town over the next 25 years.

4.2.2 Population Forecast

Prediction of the future population of Al-Shoyoukh town is very difficult due to the lack of reliable historic data, and the political uncertainties, which will greatly influence future social and economic development At the same time, the available data on past population growth do not constitute a reliable basis for projecting the future population growth in Al-Shoyoukh town.

The base for the forecast is the 2011 population for Al-Shoyoukh town obtained from PCBS of 10000 inhabitants. The rate of population growth for the purpose of our study was based on estimation used for other towns of similar population composition and characteristics. The rate of population growth in other towns in the West Bank is between 3.0-4.0%. Therefore, the rate of 3.6% per year was used for the future growth of the population of Al-Shoyoukh town.

To calculate the population at the end of the design period (year 2035), a geometric increase is assumed, represented by the following equation:

$$P = Po * (l + r)^{n} \qquad (3.1)$$

Where, P is the future population, Po is the present population, r is the annual population growth rate, and n is the period of projection.

Using the above assumption and equation, Table 3.1 presents the population projection up to the design horizon of 2035. The data show that the population of Al-Shoyoukh town is estimated to be 22833 in year 2035.

Table 4.1: Population Forecasts for Al-Shoyoukh Town

Year	2011	2021	2026	2031	2036
Population	10000	14243	16998	20286	24210

4.2.3 Population Density

When determining the density of population, it is either related to the total municipal area (gross density) or to the built—up area only (net density). The gross density related to the municipal area includes large industrial areas, agricultural areas, un-built areas, public parks, large water surfaces, forests ... etc. The net density is related to the built up area, but it includes small-scale industries, schools, public and commercial buildings, and roads.

Water supply system, however, is based on the net densities of population, because the provision of net works is limited to the built-up areas. The net density of population varies considerably from district to district. There are no studies done concerning the population densities in Al-Shoyoukh town. Population densities are based on the city structure plan, which serves for issuing building permit. The population density for Al-Shoyoukh town is calculated using structure plan map as follow:

The peopled area divided to three sectors A (dense area as 50% of capacity), B (partial dense area as 75%) and C (Weak density as 85%).

Developing area of the AL- Shoyoukh town = 360 hectare .

Area of sector A=103 h , B= 185 h , C=72 h.

Number of houses in sector A/10hectare = 52 = 5.2 house/he.

Number of houses in sector B/10hectare = 28= 2.8 house/he

Number of houses in sectorc/10hectare = 10 = 1 house/he

Currently there are little building in the sector C and there is no accommodation, but there is expected within 25 years to become the region population. The current population density in sectors above calculated as follow:

In sector A (mid town) approximately each building has two storey. Assumed that in each storey live six persons and the full capacity of each building four floors, the maximum density will be 24 persons / building in the future as there's no enough space to a new constructions. Dependent on this analyses the current population density calculated as:

The sector A in this day for each building has 2 storey .

6x2x6=72 p/ha.

The total population number in this sector = 72 x103=7416p.

The sector B in this day for each building has 1 storey

In sector B there's 3 houses/hectare, assuming 6 people live in each house.

The current population density =3x1x6=18p/h.

The total population number in this sector = 18x185=3330p.

The sector C in this day for each building has 1 storey.

In sector C there's 1 houses/hectare, assuming 6 person live in each house.

The current population density =1x 1x6=6p/h.

The total population number in this sector = 6x72=432 p.

The current population number in AL- Shoyoukh town is 10000 person

The calculated number above =7416+ 3330+432=11178p.

Correction factor 10000/11178 = 0.89461

The realistic population number in each sector:

Sector A 7416x 0.89461 = 6634p.

Sector B 3330 x 0.89461=2979p.

Sector C 432 x 0.89461 =386p.

Sum. = 6634+2979+387=10000p.

Population density at the end of design period

The population density at the end of design period (25 years) estimated as :-

$P_f = P_c(1+I)^n$

P_f : Population in future.

P_c : Current population.

I: Natural increasing ratio /year

The natural increasing of population according the central statistic department = 3.6%.

n: Design period (years).

$P_f = 6634\ (1+0.036)^{25} = 16061p$. In sector (A)

But the maximum =6634x2=13268p ➔ p.density 13268/103 = 129p/ha.

So:

16061-13268 = 2793p should be divided on sectors B and C 0.75 on B and 0.25 on C

Assume in each building has 4storeys.

In sector(B) P_f =2979x4 +(0.75x2793)=14011p.

➔Density 14011/183 = 76p/ha.

In sector(C) P_f =386x4 +(0.25x2793) = 2242p.

➔Density 2242/72 = 31p/ha.

The total population in 2039 as estimated (129x103)+(76x185)+(31x72)=29579p.

$P_f = 10000(1+0.036)^{25} = 24209p < 29579$ p ……. OK.

4.3 Future Water Demand

4.3.1 Introduction

Water consumption is not constant, yearly, monthly, weekly, daily, and hourly variations in water consumption are observed. Certain dry years cause more consumption. In hot months water is consumed in drinking, bathing, and watering lawns and gardens. On holidays and weekends the water consumption may be high Even during a day water use varies with high use during morning hours and close to noon and low use at night.

Maximum daily demand or maximum daily consumption usually occurs during summer months. The ideal approach to assess the existing and future per capita water consumption is by analyzing and extrapolating the available record on water consumption and demand in conjunction with the expected social and economical development. This approach can be adopted in areas having continuous supply systems where reliable information about population, population distribution and demand are known. There are problems in adopting this approach for Hebron area including Al-Shoyoukh town due to insufficient data and also the intermittent water supply.

Restrictions on the Palestinian use of the annual ground water resources of the West Bank led to the availability limited quantities of water and due to this condition, the average consumption of water in Al-Shoyoukh town for all purposes does not exceed 21.9 cubic meter per capita per year. Given these circumstances, the approach to determine per capita water consumption depends on the analysis of the existing information. The existing per capita consumption has already been assessed at (60 litter/capita, day).

4.3.2 Future Water Demand

The present average consumption of water for domestic use in Al-Shoyoukh town is low (60 liter/capita.day) and does not represent the present and actual demand of water. The future water demand should be calculted with the assumption of better living standard and economic condition, but the Muncipilty doses not expect any appreciable increase in the quantity of water in the near future expect that which meet with the increase in the population. So, the present and near future water demand for domestic purposes of Al-Shoyoukh town will be the same as 60 liter/capita.day. The value could reach 70 l/c.d after 10 years and 100 l/c.d at the end of the design period in 2036

Based on the above assumptions, the population of Al-Shoyoukh town at years 2020, 2030 and 2035, and the annual residential water demand per capita for the same years were calculated along with water demand per capita per day. The data obtained were given in Table 3.2

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Table 4.2: Future Water Demand for *Al-Shoyoukh* Town

Year	Population	Water Demand(m^3/year)		Water Demand(l/c.d)
		Per Capita	Total	
2011	10000	21.90	219000	60
2021	14243	25.55	363909	70
2026	16998	29.20	496342	80
2031	20286	32.85	666395	90
2036	24210	36.50	883665	100

It may be noted from Table 3.2 that the projected water demand for the design period (year 2036) is 883665 cubic meter per year which is equivalent to 2421 cubic meter per day.

4.4 Water Sources

The water supply for Al-Shoyoukh town falls short of the requirements due to insufficient water sources and due to limited quantities of water supplied to the towns and villages by the Palestinian Water Authortiy. The water is provided to the town by cisterns, water tanking, and underground water. The main source of water for the town is from Wadi Al Saeer underground water wells. The present total water supplied to the town from these wells is 600 cubic meter per day

4.5 Design Parameters

The design and planning assumptions used in this project are as follow:

A) General

1. Design period 25 year (from 2011-2036).
2. Present (2011) population of municipality of Al-Shoyoukh town is 10000 capita.
3. The growth rate will be 3.5% .
4. The existing per capita water consumption has been assessed 60 l/c.d.
5. Total administrative area of municipality of Al-Shoyoukh town 32000 dounm.
6. Future 2036 population of Al-Shoyoukh town 24210 capita.
7. Per capita water consumption by 2036 will reaches 100 l/c.d.

B) Water Network

8. Formula to be used in design of pipes :(Hazen- William's formula)

$$V = 0.85\ C_H\ R^{0.63}\ S^{0.54} \qquad (3.2)$$

9. Dimensionless coefficient (C_H) ranges between 110-150 according to the material of the pipes.
10. Minimum velocity 0.18m/sec.
11. Maximum velocity 2 m/sec.
12. Minimum pressure = 0.5 bar (5m)
13. Maximum pressure = 9 bar (90m)
14. Minimum diameter of 2"(50 mm)

C) Sewer Lines

15. The wastewater production is about 80% of their water consumption.
16. Formula to be used in design of sewers :(Manning formula)

$$V=(1/n)^*\ R^{2/3}\ {}^*S^{1/2} \qquad (3.3)$$

17. Minimum velocity 0.55 m/sec.
18. Maximum velocity 3.0 m/sec.
19. h/D = 0.5 for main trunks.
20. Maximum manhole spacing 50 m for main trunk.
21. Minimum pipe diameter = 8 inch (200 mm)

CHAPTER

5 ANALYSIS AND DESIGN

CHAPTER FIVE

ANALYSIS AND DESIGN

5.1 General Background

In this project, an attempt is made to evaluate and design wastewater collection system for AL-Shoyoukh town, and develop a future plans for construction of the collection system, corresponding to population growth and the water consumption and subsequently the wastewater production from different sources in the future, in order to reduce the problem causes by the disposal of raw wastewater in the area. At the same time, an attempt is made to study the exiting water distribution network, and proposed a new network that supplies all the inhabitants of AL-Shoyoukh town with a sufficient amount of good quality drinking water.

In this chapter, the layout of the wastewater system established is presented, and the computation procedures and tables are given along the drawings of layout and profiles for all the lines designed. The method of calculation for water system analysis is described followed by discussion of the existing and proposed main water network.

5.2 Method of Calculation

5.2.1 Introduction

The detailed design of sanitary sewers involves the selection of appropriate pipe sizes and slopes to transport the quantity of wastewater expected from the surroundings and areas, were the design of water network involves the selection of appropriate pipe sizes with required velocities and pressure..

The design calculations necessary for AL-Shoyoukh sanitary sewers are performed using SewerCAD Vs5 software. This computer program is developed by the Haestad Methods, Inc. More detailed about this program is given below. The design of water distribution network was carried out using Water-CAD developed by Bentley.

5.2.2 What is SewerCAD?

SewerCAD is an extremely powerful program for the design and analysis of gravity flow and pressure flow through pipe networks and pumping stations. The program can be run in AutoCAD mode, giving you all the power of AutoCAD’s capabilities, or in Stand-lone mode utilizing our own graphical interface. SewerCAD allows you to construct a graphical representation of a pipe network containing information such as pipe data, pump data, loading, and infiltration. You have a choice of conveyance elements including circular pipes, arches, boxes and more.

The gravity network is calculated using the built-in numerical model, which utilizes both the direct step and standard step gradually varied flow methods. Flow calculations are valid for both surcharged and varied flow situations, including hydraulic jumps, backwater, and drawdown curves. You also have the flexibility to mix gravity and pressure components freely, building your systems in parallel or in series as they exist in the field.

Pressure elements can be controlled based on system hydraulics, turning pumps on and off due to changes in flows and pressures.

SewerCAD’s flexible reporting feature allows you to customize and print the model results in both a report format and as a graphical plot.

5.2.3. When to Use SewerCAD?

SewerCAD is so flexible you can use it for all phases of your project, from the feasibility report to the final design drawings and analysis of existing networks. During the feasibility phase, you can use SewerCAD to create several different system layouts with an AutoCAD or Micro Station drawing as the background, or within AutoCAD itself. For the final design, you can complete detailed drawings with notes that can be used to develop the construction plans. In summary, you can use SewerCAD to:

- Design multiple sanitary sewer systems.
- Analyze various design scenarios for sanitary sewer systems.
- Import and export AutoCAD and Micro Station .DXF files.
- Generate professional-looking reports for clients.
- Generate plan and profile plots of a network.

5.2.4 Water-CAD Software

The computer program Water-CAD V8 XM Edition performs the calculations necessary for the water distribution network design. This computer program is developed by Bentley, USA.

Water-CAD is a computer program that performs extended period simulation of hydraulic and waters quality behavior within drinking water distribution system. A network can consist of pipes, nodes (pipe functions), pumps, valves, and storage tank or reservoirs. Water-CAD tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of the substance throughout the network during a multi-time period simulation. In addition to substance concentration, water age and source tracing can also perform. The water quality is equipped to the model such phenomena as reactions within the bulk flow, reactions at the pipe wall, and mass transport between the bulk flow and pipe wall.

The algorithm makes of the Hardy-Cross method. This method makes use of either the Hazen- Williams’s formula or Darcy-Weisbach equation. The computer program assumes distribution of flow in the network and balances the head losses. Pipe flow formulas are used to determine the actual head losses, correction will then be made in the flow until the heads losses are balanced. The flow corrections are based on the concept that the flow at a node will continue, which means that the sum of the incoming flows equals the sum of the outgoing flows.

The computer program facilitates the selection of the appropriate pipe diameter. A number of data is required before the program can start its calculations. The length of pipes, the reservoir level, the demand per node, the elevation of the nodes, the Hazen–Williams and Darcy-Weisbach coefficients for the friction, the stopping criterion for the Hardy- Cross algorithm, and the expected diameter for each pipe are required for this computer program. The program uses a simplified layout of the network. All significant components in the network were marked by nodes.

The pipelines are divided from node to node. The reservoir is represented as a node. At these nodes the water supply or consumption of the surrounding area is linked.

The result of this approach is that every node has its share in (1/s) of the demand of the total area. The friction of the pipeline is taken into account by using the Hazen-William or Darcy-Weisbach coefficient. This dimensionless coefficient (C) ranges between 110-150 according to the material of the pipes. The chosen coefficient for this network is 130. The stopping criterion for the Hardy –Cross is chosen at 0.01.

Filling up the computer program only the pipe diameters remain. Varying these diameters enables then computer program to calculate the head losses, the velocity, the flow in each pipe and the pressure at each node. The velocity and the pressure are restricted between margins. These margins should be considered, but can be crossed if sensible. Finally the most suitable diameters are found, so that the pressure in the nodes will meet the requirements as close as possible (5-90 m) and the velocities will mostly be between the range of (0.2-2 m/s).

5.2.5 Water Pipe Hydraulics

As mentioned earlier, pipe hydraulic calculation has been carried out by the Water-CAD software, which uses the Hazen-Williams equation to calculate the friction head loss. The design criteria adopted for different parameters are:

(i)Velocity:

- Minimum velocity = 0.2 m/s to prevent deposits of silt in the pipe (achieve self-cleansing).
- Maximum velocity = 2.0 m/s to minimize friction loss and water hammer effect.

(ii) Pressure:

- Minimum pressure = 0.5 bar (5m)
- Maximum pressure = 9 bar (90m)

The minimum and maximum pressures in the distribution lines are defined as the pressure at the nodes in the model. The minimum value of 5 m is adopted to let the water rise at least one story and overcome the frictional resistance of the house connection pipes and small diameter distribution. The upper value is limited to 90 m in order to have excessive pressure in the network and so minimize the leakage from the system.

(iii) Pipe: The pipes of the distribution system are chosen to be Galvanized iron due to their advantages. Minimum diameter of 2"(50 mm) is taken. The Hazen –Williams constant of a new steel pipes is 130.

5.3 Layout of the Sewer System

The first step in designing a sewerage system is to establish an overall system layout that includes a plan of the area to be sewered, showing roads, streets, buildings, other utilities, topography, soil type, and the cellar or lowest floor elevation or all buildings to be drained. Where part of the drainage area to be served is undeveloped and proposed development plans are not yet available , care must be taken to provide adequate terminal manholes that can later be connected to the system constructed serving the area .

In establishing the layout of wastewater collection system for AL-Shoyoukh area, the following basic steps were followed:

1. Obtain a topographic map of the area to be served.
2. Locate the drainage outlet. This is usually near the lowest point in the area and is often along a stream or drainage way.
3. Sketch in preliminary pipe system to serve all the contributors.
4. Pipes are located so that all the users or future users can readily tap on. They are also located so as to provide access for maintenance and thus are ordinarily placed in streets or other rights-of-way.
5. Sewers layout is followed natural drainage ways so as to minimize excavation and pumping requirements. Large trunk sewers are located in low-lying areas closely paralleling streams or channels.
6. Establish preliminary pipe sizes. Eight inches pipe size (usually the minimum allowable) can serve several hundred residences even at minimal grades.
7. Revise the layout so as to optimize flow-carrying capacity at minimum cost. Pipe lengths and sizes are kept as small as possible, pipe slopes are minimized, and followed the ground surface slope to minimize the depth of excavation, and the numbers of appurtenances are kept as small as possible.
8. The pumping is avoided across drainage boundaries. Pumping stations are costly and add maintenance problems.

The final layout of the wastewater collection system for AL-Shoyoukh town is given in attached drawings (Figures (5A)).

5.4 The Existing Water Distribution Network

The existing water distribution network has been studied and evaluated. The existing water network consists of main pipelines and sub-mains. The main pipelines receives the water directly from the source and supplies the smaller diameters pipelines, no storage reservoir is available. The drawings for the existing water distribution network are shown in Figures (5B1).

5.5 The proposed Wastewater Collection System

In the proposed study for the wastewater collection system for AL-Shoyoukh town, the trial is made to design the main trunks of the collection system for year 2036. There are two main trunks. This section deals with the results of the suggested wastewater collection network for year 2036.

The appropriate pipe diameters, lengths, land slopes, and location of the manholes are found by doing the calculations given in the previous section. During and once the sewer design computations have been completed, alternative alignments have be examined, and the most cost–and energy–effective alignment has been selected. The final results for the appropriate diameters for the proposed wastewater collection system, slopes and lengths of the pipes are given in attached tables along with all relevant data. The calculated velocities, flow rates, and depth of flow in pipes are given in the same tables..

It is observed form the tables and figures that the collection network covers most of the area of AL-Shoyoukh, the slope of the pipes follow in most cases the slope of the ground.

5.6 Profiles of Sewer

The profiles of sewer area assist in the design and are used as the basis of construction drawings. The profiles are usually prepared for each sewer line at a horizontal and vertical scale. The profile shows the ground or street surface, tentative manhole locations, elevation of important subsurface strata such as rock, locations of borings, all underground structures, basement elevations, and cross streets. A plan of the line and relevant other structures are usually shown on the same street (McGhee, 1991).

After all the calculation is completed and all the maps of the proposed collection system are prepared, detailed profiles for each sewer is drawn. The profiles of sewer lines are shown in attached figures, These profiles had shown the ground elevation, the proposed sewer lines, manholes (manholes number and the spacing between the manholes), depth of excavations, the diameters and slopes of the pipes, and the type of soil.

The final profiles of the wastewater collection system for AL-Shoyoukh town is given in attached drawings (Figures (SB-SB1-SB2-SB3-SB4-SB5-SB6-SA-PLA-PLB-PLC)

5.7 The proposed Water Distribution Network

In the proposed study for the water distribution network, the trial is made to design the network for AL-Shoyoukh town. The appropriate pipe diameters are found by use of the computer program filled with basic data (nodes water demand, elevation of the nodes, the length of each pipe). So that, the pressure in the nodes and velocity in the links will meet the requirements as close as possible. The appropriate diameters for proposed network are found are given in table in appendix A. The calculated velocities, head loss, grads, and pressure are given in table in appendix A. The drawings for the proposed water distribution network are shown in Figures (5B2&5B3&5B4).

CHAPTER

6

BILL OF THE QUANTATIY

6.1 Bill of the quantity for the proposed wastewater collection system .

6.2 Bill of the quantity for the proposed water network collection system.

CHAPTER SIX

BILL OF THE QUANTATIY

6.1 Bill of the quantity for the proposed waste water collection system .

No.	**EXCAVATION**	**UNIT**	**QTY**	**UNIT PRICE**		**TOTAL PRICE**	
				$	**C**	**$**	**C**
A1	Excavation of pipes trench in all kind of soil for one pipe diameter 8 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	9700				
A2	Excavation of pipes trench in all kind of soil for one pipe diameter 10 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	1850				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 12 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	350				

A4	Excavation of pipes trench in all kind of soil for one pipe diameter 14 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	100				
A5	Excavation of pipes trench in all kind of soil for one pipe diameter 16 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	100				
A6	Excavation of pipes trench in all kind of soil for one pipe diameter 18 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	650				
B	***PIPE BEDDING AND BACKFILLING*** **Dimension and material**						
B1	Supplying and embedment of sand for one pipe diameter 8 inch, depth up to 1.00 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	9700				
B2	Supplying and embedment of sand for one pipe diameter 10 inch,.	LM	1850				

B3	Supplying and embedment of sand for one pipe diameter 12 inch,	LM	350				
B4	Supplying and embedment of sand for one pipe diameter 14 inch.	LM	100				
B5	Supplying and embedment of sand for one pipe diameter 16 inch.	LM	100				
B6	Supplying and embedment of sand for one pipe diameter 18inch,.	LM	650				
D	**MANHOLES, Details according to the drawing**						
D1	Supplying and installing of precasted manhole including excavation pipe connection, epoxytar coating, 25-ton cast iron cover and backfill, size 1200mm.	NR	278				
E	**Concrete Surround**						
E1	Suppying and installing of reinforced concrete (B 200) protection concrete encasement for sewer pipe.	LM	12750				
F	**Air And Water Leakage Test**						

F1	Air leakage test for sewer pipe lines 8,10,12,14,16and 18inch according to specifications,	LM	12750				
G	**Survey work**						
G1	Topographical survey required for shop drawings and as built DWGS using absoluet Elev. And coordinate system	LM	12750				

6.2 Bill of the quantity for the proposed water network collection system.

No.	EXCAVATION	UNIT	QTY	UNIT PRICE		TOTAL PRICE	
				$	**C**	**$**	**C**
A1	Excavation of pipes trench in all kind of soil for one pipe diameter 1 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	10517				
A2	Excavation of pipes trench in all kind of soil for one pipe diameter 1.5 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	875				
A3	Excavation of pipes trench in all kind of soil for one pipe diameter 2 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	4751				
A4	Excavation of pipes trench in all kind of soil for one pipe diameter 3 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	8046				
A5	Excavation of pipes trench in all kind of soil for one pipe diameter 4 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	1313				

A6	Excavation of pipes trench in all kind of soil for one pipe diameter 5 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	211				
A7	Excavation of pipes trench in all kind of soil for one pipe diameter 6 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	711				
A8	Excavation of pipes trench in all kind of soil for one pipe diameter 8 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	638				
A9	Excavation of pipes trench in all kind of soil for one pipe diameter 10 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	846				
A10	Excavation of pipes trench in all kind of soil for one pipe diameter 12 inch depth and disposing of the debris and the top soil unsuitable for backfill outside the site	LM	23				
B	**PIPE WORK**						
B1	Supplying, storing and installing of steel	LM	27931				
B2	Fire hydrants with 2” quick connection coupling	NR	0				
B3	Welding and installation of gate valve with dresser coupling	NR	11				

C	***PIPE BEDDING AND BACKFILLING*** **Dimension and material**						
C1	Supplying and embedment of sand for one pipe diameter 1 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	10517				
C2	Supplying and embedment of sand for one pipe diameter 1.5 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	875				
C3	Supplying and embedment of sand for one pipe diameter 2 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	4751				
C4	Supplying and embedment of sand for one pipe diameter 3 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	8046				
C5	Supplying and embedment of sand for one pipe diameter 4 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	1313				

C6	Supplying and embedment of sand for one pipe diameter 4 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	211				
C7	Supplying and embedment of sand for one pipe diameter 4 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	711				
C8	Supplying and embedment of sand for one pipe diameter 8 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	638				
C9	Supplying and embedment of sand for one pipe diameter 10 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	846				
C10	Supplying and embedment of sand for one pipe diameter 12 inch, depth up to 1.10 meter and disposing of the debris and the top soil unsuitable for backfill outside the site.	LM	23				

CHAPTER

7

CONCLUSIONS

CHAPTER SEVEN

CONCLUSIONS

In this project, the existing water distribution network in Al-shoyoukh town has been studied and The trial is also made for design the water distribution network for year 2036 and The trial is made to evaluate and design wastewater collection system for Al-shoyoukh town considering the annual growth of the people and their water consumption for the coming 25 years. The result brought out many important conclusions. The main conclusions drawn from the present study are summarized below:

1. Al-shoyoukh town has no sewage facility. The people are using laterains cesspits and septic tanks. The waste water has been seeping into the ground through the over flow of the deteriorated cesspits and laterains, causing series environmental and health problem .

2. Restrictions on the Palestinian use of the annual ground water resources of the West Bank led to limited quantities of water supplied to Al-shoyoukh town and due to this condition the average consumption of water in general is low (60 l/c.d.) and does not represent the present actual demand of water. As a result of the long period of occupation, the town lacks well studies and prepared master plan for land uses, town planning, and the design of utilities. The future water consumption is estimated to be 100 l/c.d.

3. The present population of Al-shoyoukh town is around 10000 person. Prediction of the future population of Al-shoyoukh town is very difficult due the political uncertainties. The rate of population growth is taken as 3.6%.

4. The proposed waste water collection system and water distribution network system for Al-shoyoukh Town covers most of the areas of the Town.

REFERENCES

REFERENCES

1. Qasim, Sayed R.(1985),"Wastewater treatment plants planning, Design, and operation".The University of Texas at Arlington,USA.
2. Mc Ghee, Terence J. (1991), “Water Supply and Sewage “, Sixth Edition, MC Ghee- Hill International Editions, U.S.A.

3.Abu Sharkh, M. (1994) “ Domestic Water Demand in the Hebron District ”, Dept.of Research and Development, U.G.U., Hebron, West Bank, Palestine.

4.Halawani, B., Mohammad, B.,Hmidat, M. and Slemeh, N.(2002), “Analysis And Design of the Water Supply System in Sourif Town ”, College of Engineering and Technology, Hebron, West Bank, Palestine.

5.Hourani, I., Al-Issa, N. and Hmdan, M. (1997), “ A Study of the Existing Water Distribution Network in Hebron City ”, College of Engineering and Technology, Hebron, West Bank, Palestine.

6.Metcalf and Eddy, Inc. (1982), Wastewater Engineering: Treatment, Disposal, and Reuse”, Mc Grew-Hill, U.S.A.

7.Rossman,L.(1994)“ Epanet User Manual ”, Drinking Water Research Division, Risk Reduction Engineering Laboratory, Cininnati, Ohio, U.S.A.

APPENDIX-A

A.1 WASTEWATER

A.2 WATER NETWORK (Excel Sheet)

A.2.1 Junction Report

A.2.2 Pipe Report

A.1 WASTEWATER

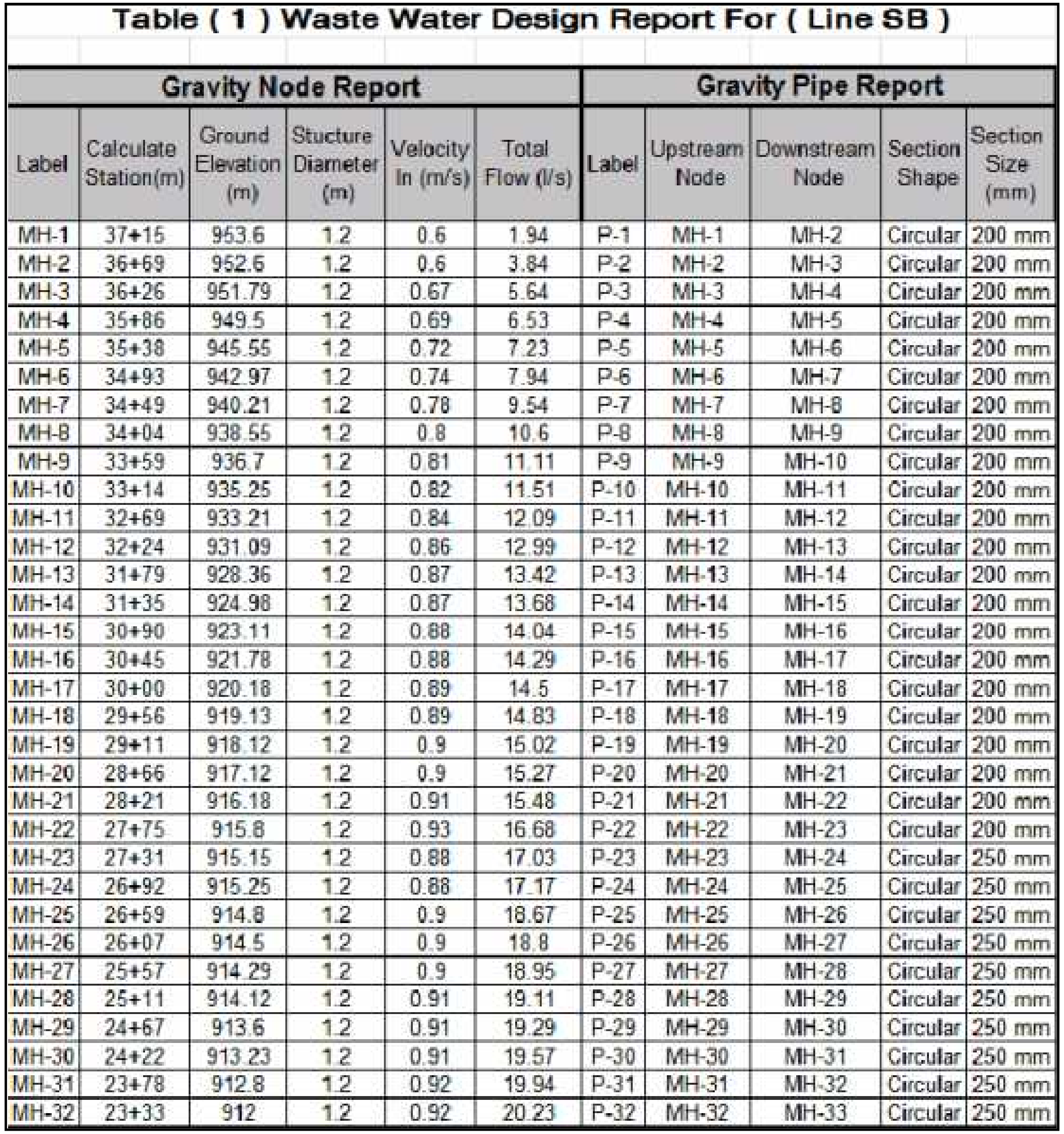

Table (1) Waste Water Design Report For (Line SB)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	37+15	953.6	1.2	0.6	1.94	P-1	MH-1	MH-2	Circular	200 mm
MH-2	36+69	952.6	1.2	0.6	3.84	P-2	MH-2	MH-3	Circular	200 mm
MH-3	36+26	951.79	1.2	0.67	5.64	P-3	MH-3	MH-4	Circular	200 mm
MH-4	35+86	949.5	1.2	0.69	6.53	P-4	MH-4	MH-5	Circular	200 mm
MH-5	35+38	945.55	1.2	0.72	7.23	P-5	MH-5	MH-6	Circular	200 mm
MH-6	34+93	942.97	1.2	0.74	7.94	P-6	MH-6	MH-7	Circular	200 mm
MH-7	34+49	940.21	1.2	0.78	9.54	P-7	MH-7	MH-8	Circular	200 mm
MH-8	34+04	938.55	1.2	0.8	10.6	P-8	MH-8	MH-9	Circular	200 mm
MH-9	33+59	936.7	1.2	0.81	11.11	P-9	MH-9	MH-10	Circular	200 mm
MH-10	33+14	935.25	1.2	0.82	11.51	P-10	MH-10	MH-11	Circular	200 mm
MH-11	32+69	933.21	1.2	0.84	12.09	P-11	MH-11	MH-12	Circular	200 mm
MH-12	32+24	931.09	1.2	0.86	12.99	P-12	MH-12	MH-13	Circular	200 mm
MH-13	31+79	928.36	1.2	0.87	13.42	P-13	MH-13	MH-14	Circular	200 mm
MH-14	31+35	924.98	1.2	0.87	13.68	P-14	MH-14	MH-15	Circular	200 mm
MH-15	30+90	923.11	1.2	0.88	14.04	P-15	MH-15	MH-16	Circular	200 mm
MH-16	30+45	921.78	1.2	0.88	14.29	P-16	MH-16	MH-17	Circular	200 mm
MH-17	30+00	920.18	1.2	0.89	14.5	P-17	MH-17	MH-18	Circular	200 mm
MH-18	29+56	919.13	1.2	0.89	14.83	P-18	MH-18	MH-19	Circular	200 mm
MH-19	29+11	918.12	1.2	0.9	15.02	P-19	MH-19	MH-20	Circular	200 mm
MH-20	28+66	917.12	1.2	0.9	15.27	P-20	MH-20	MH-21	Circular	200 mm
MH-21	28+21	916.18	1.2	0.91	15.48	P-21	MH-21	MH-22	Circular	200 mm
MH-22	27+75	915.8	1.2	0.93	16.68	P-22	MH-22	MH-23	Circular	200 mm
MH-23	27+31	915.15	1.2	0.88	17.03	P-23	MH-23	MH-24	Circular	250 mm
MH-24	26+92	915.25	1.2	0.88	17.17	P-24	MH-24	MH-25	Circular	250 mm
MH-25	26+59	914.8	1.2	0.9	18.67	P-25	MH-25	MH-26	Circular	250 mm
MH-26	26+07	914.5	1.2	0.9	18.8	P-26	MH-26	MH-27	Circular	250 mm
MH-27	25+57	914.29	1.2	0.9	18.95	P-27	MH-27	MH-28	Circular	250 mm
MH-28	25+11	914.12	1.2	0.91	19.11	P-28	MH-28	MH-29	Circular	250 mm
MH-29	24+67	913.6	1.2	0.91	19.29	P-29	MH-29	MH-30	Circular	250 mm
MH-30	24+22	913.23	1.2	0.91	19.57	P-30	MH-30	MH-31	Circular	250 mm
MH-31	23+78	912.8	1.2	0.92	19.94	P-31	MH-31	MH-32	Circular	250 mm
MH-32	23+33	912	1.2	0.92	20.23	P-32	MH-32	MH-33	Circular	250 mm

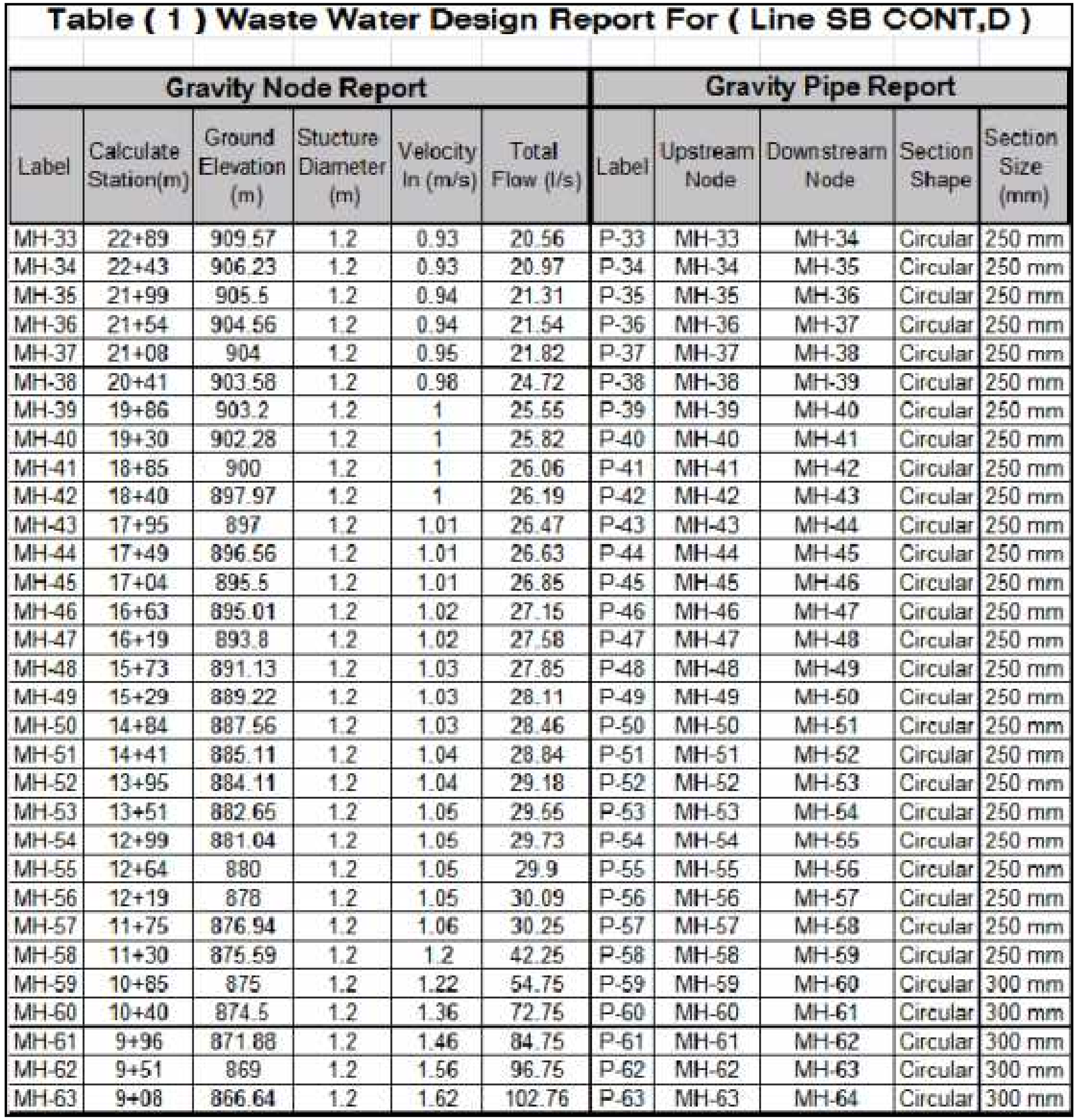

Table (1) Waste Water Design Report For (Line SB CONT,D)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-33	22+89	909.57	1.2	0.93	20.56	P-33	MH-33	MH-34	Circular	250 mm
MH-34	22+43	906.23	1.2	0.93	20.97	P-34	MH-34	MH-35	Circular	250 mm
MH-35	21+99	905.5	1.2	0.94	21.31	P-35	MH-35	MH-36	Circular	250 mm
MH-36	21+54	904.56	1.2	0.94	21.54	P-36	MH-36	MH-37	Circular	250 mm
MH-37	21+08	904	1.2	0.95	21.82	P-37	MH-37	MH-38	Circular	250 mm
MH-38	20+41	903.58	1.2	0.98	24.72	P-38	MH-38	MH-39	Circular	250 mm
MH-39	19+86	903.2	1.2	1	25.55	P-39	MH-39	MH-40	Circular	250 mm
MH-40	19+30	902.28	1.2	1	25.82	P-40	MH-40	MH-41	Circular	250 mm
MH-41	18+85	900	1.2	1	26.06	P-41	MH-41	MH-42	Circular	250 mm
MH-42	18+40	897.97	1.2	1	26.19	P-42	MH-42	MH-43	Circular	250 mm
MH-43	17+95	897	1.2	1.01	26.47	P-43	MH-43	MH-44	Circular	250 mm
MH-44	17+49	896.56	1.2	1.01	26.63	P-44	MH-44	MH-45	Circular	250 mm
MH-45	17+04	895.5	1.2	1.01	26.85	P-45	MH-45	MH-46	Circular	250 mm
MH-46	16+63	895.01	1.2	1.02	27.15	P-46	MH-46	MH-47	Circular	250 mm
MH-47	16+19	893.8	1.2	1.02	27.58	P-47	MH-47	MH-48	Circular	250 mm
MH-48	15+73	891.13	1.2	1.03	27.85	P-48	MH-48	MH-49	Circular	250 mm
MH-49	15+29	889.22	1.2	1.03	28.11	P-49	MH-49	MH-50	Circular	250 mm
MH-50	14+84	887.56	1.2	1.03	28.46	P-50	MH-50	MH-51	Circular	250 mm
MH-51	14+41	885.11	1.2	1.04	28.84	P-51	MH-51	MH-52	Circular	250 mm
MH-52	13+95	884.11	1.2	1.04	29.18	P-52	MH-52	MH-53	Circular	250 mm
MH-53	13+51	882.65	1.2	1.05	29.56	P-53	MH-53	MH-54	Circular	250 mm
MH-54	12+99	881.04	1.2	1.05	29.73	P-54	MH-54	MH-55	Circular	250 mm
MH-55	12+64	880	1.2	1.05	29.9	P-55	MH-55	MH-56	Circular	250 mm
MH-56	12+19	878	1.2	1.05	30.09	P-56	MH-56	MH-57	Circular	250 mm
MH-57	11+75	876.94	1.2	1.06	30.25	P-57	MH-57	MH-58	Circular	250 mm
MH-58	11+30	875.59	1.2	1.2	42.25	P-58	MH-58	MH-59	Circular	250 mm
MH-59	10+85	875	1.2	1.22	54.75	P-59	MH-59	MH-60	Circular	300 mm
MH-60	10+40	874.5	1.2	1.36	72.75	P-60	MH-60	MH-61	Circular	300 mm
MH-61	9+96	871.88	1.2	1.46	84.75	P-61	MH-61	MH-62	Circular	300 mm
MH-62	9+51	869	1.2	1.56	96.75	P-62	MH-62	MH-63	Circular	300 mm
MH-63	9+08	866.64	1.2	1.62	102.76	P-63	MH-63	MH-64	Circular	300 mm

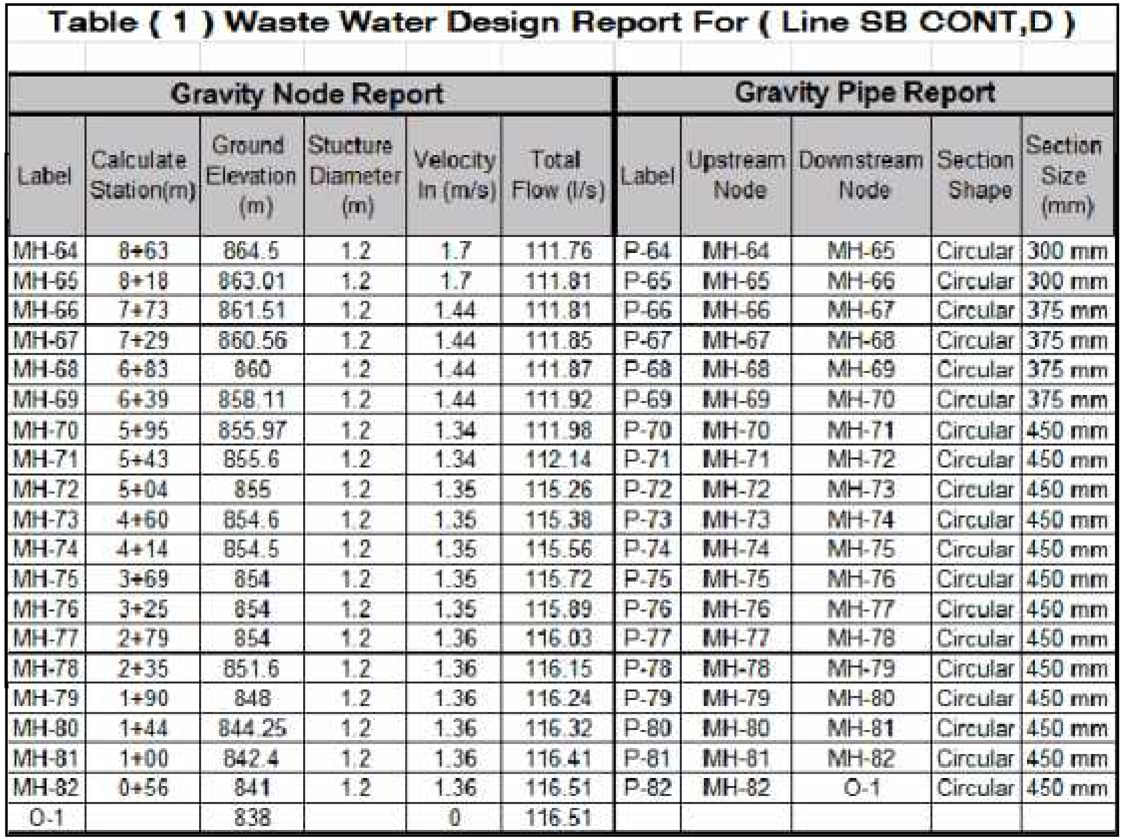

Table (1) Waste Water Design Report For (Line SB CONT,D)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-64	8+63	864.5	1.2	1.7	111.76	P-64	MH-64	MH-65	Circular	300 mm
MH-65	8+18	863.01	1.2	1.7	111.81	P-65	MH-65	MH-66	Circular	300 mm
MH-66	7+73	861.51	1.2	1.44	111.81	P-66	MH-66	MH-67	Circular	375 mm
MH-67	7+29	860.56	1.2	1.44	111.85	P-67	MH-67	MH-68	Circular	375 mm
MH-68	6+83	860	1.2	1.44	111.87	P-68	MH-68	MH-69	Circular	375 mm
MH-69	6+39	858.11	1.2	1.44	111.92	P-69	MH-69	MH-70	Circular	375 mm
MH-70	5+95	855.97	1.2	1.34	111.98	P-70	MH-70	MH-71	Circular	450 mm
MH-71	5+43	855.6	1.2	1.34	112.14	P-71	MH-71	MH-72	Circular	450 mm
MH-72	5+04	855	1.2	1.35	115.26	P-72	MH-72	MH-73	Circular	450 mm
MH-73	4+60	854.6	1.2	1.35	115.38	P-73	MH-73	MH-74	Circular	450 mm
MH-74	4+14	854.5	1.2	1.35	115.56	P-74	MH-74	MH-75	Circular	450 mm
MH-75	3+69	854	1.2	1.35	115.72	P-75	MH-75	MH-76	Circular	450 mm
MH-76	3+25	854	1.2	1.35	115.89	P-76	MH-76	MH-77	Circular	450 mm
MH-77	2+79	854	1.2	1.36	116.03	P-77	MH-77	MH-78	Circular	450 mm
MH-78	2+35	851.6	1.2	1.36	116.15	P-78	MH-78	MH-79	Circular	450 mm
MH-79	1+90	848	1.2	1.36	116.24	P-79	MH-79	MH-80	Circular	450 mm
MH-80	1+44	844.25	1.2	1.36	116.32	P-80	MH-80	MH-81	Circular	450 mm
MH-81	1+00	842.4	1.2	1.36	116.41	P-81	MH-81	MH-82	Circular	450 mm
MH-82	0+56	841	1.2	1.36	116.51	P-82	MH-82	O-1	Circular	450 mm
O-1		838		0	116.51					

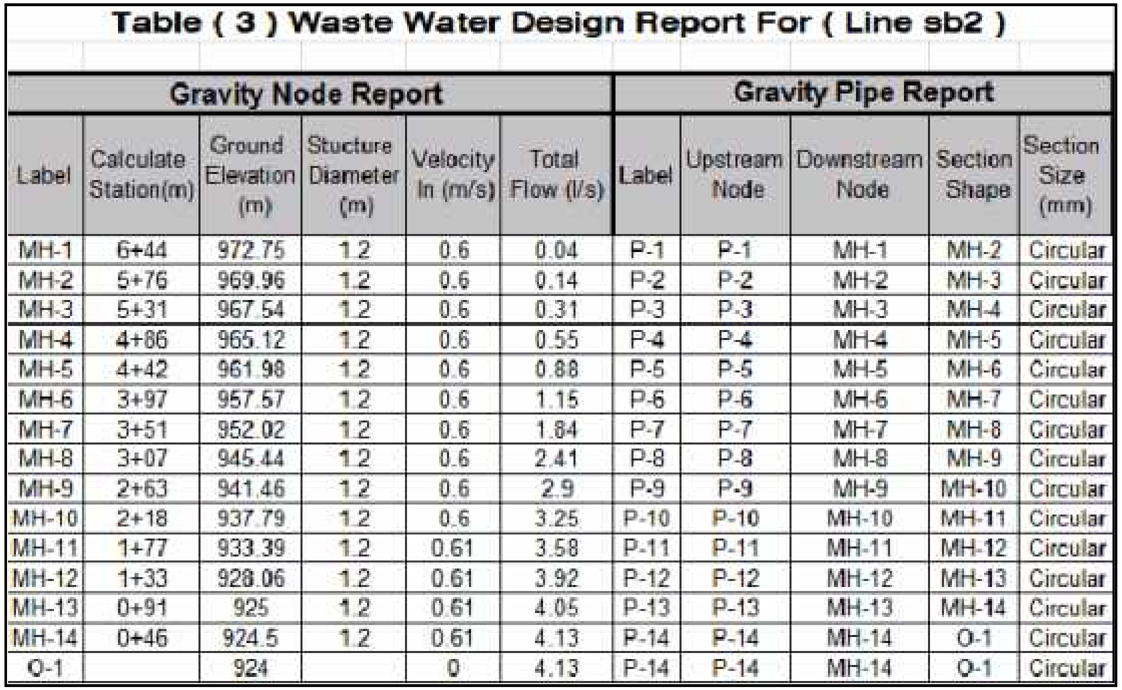

Table (3) Waste Water Design Report For (Line sb2)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	6+44	972.75	1.2	0.6	0.04	P-1	P-1	MH-1	MH-2	Circular
MH-2	5+76	969.96	1.2	0.6	0.14	P-2	P-2	MH-2	MH-3	Circular
MH-3	5+31	967.54	1.2	0.6	0.31	P-3	P-3	MH-3	MH-4	Circular
MH-4	4+86	965.12	1.2	0.6	0.55	P-4	P-4	MH-4	MH-5	Circular
MH-5	4+42	961.98	1.2	0.6	0.88	P-5	P-5	MH-5	MH-6	Circular
MH-6	3+97	957.57	1.2	0.6	1.15	P-6	P-6	MH-6	MH-7	Circular
MH-7	3+51	952.02	1.2	0.6	1.84	P-7	P-7	MH-7	MH-8	Circular
MH-8	3+07	945.44	1.2	0.6	2.41	P-8	P-8	MH-8	MH-9	Circular
MH-9	2+63	941.46	1.2	0.6	2.9	P-9	P-9	MH-9	MH-10	Circular
MH-10	2+18	937.79	1.2	0.6	3.25	P-10	P-10	MH-10	MH-11	Circular
MH-11	1+77	933.39	1.2	0.61	3.58	P-11	P-11	MH-11	MH-12	Circular
MH-12	1+33	928.06	1.2	0.61	3.92	P-12	P-12	MH-12	MH-13	Circular
MH-13	0+91	925	1.2	0.61	4.05	P-13	P-13	MH-13	MH-14	Circular
MH-14	0+46	924.5	1.2	0.61	4.13	P-14	P-14	MH-14	O-1	Circular
O-1		924		0	4.13	P-14	P-14	MH-14	O-1	Circular

Table (4) Waste Water Design Report For (Line SB3)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	20+59	976.54	1.2	0.6	0.12	P-1	MH-1	MH-2	Circular	200 mm
MH-2	20+14	974.1	1.2	0.6	0.23	P-2	MH-2	MH-3	Circular	200 mm
MH-3	19+68	971.7	1.2	0.58	0.42	P-3	MH-3	MH-4	Circular	200 mm
MH-4	19+23	968	1.2	0.63	0.61	P-4	MH-4	MH-5	Circular	200 mm
MH-5	18+78	965	1.2	0.67	0.69	P-5	MH-5	MH-6	Circular	200 mm
MH-6	18+33	962	1.2	0.62	0.77	P-6	MH-6	MH-7	Circular	200 mm
MH-7	17+88	959	1.2	0.61	0.88	P-7	MH-7	MH-8	Circular	200 mm
MH-8	17+43	956	1.2	0.63	1.01	P-8	MH-8	MH-9	Circular	200 mm
MH-9	16+98	954	1.2	0.61	1.11	P-9	MH-9	MH-10	Circular	200 mm
MH-10	16+53	951	1.2	0.63	1.2	P-10	MH-10	MH-11	Circular	200 mm
MH-11	16+08	949	1.2	0.67	1.33	P-11	MH-11	MH-12	Circular	200 mm
MH-12	15+63	947	1.2	0.63	1.5	P-12	MH-12	MH-13	Circular	200 mm
MH-13	15+18	945	1.2	0.68	1.73	P-13	MH-13	MH-14	Circular	200 mm
MH-14	14+73	944	1.2	0.62	2.01	P-14	MH-14	MH-15	Circular	200 mm
MH-15	14+29	941	1.2	0.63	2.31	P-15	MH-15	MH-16	Circular	200 mm
MH-16	13+83	939	1.2	0.63	2.63	P-16	MH-16	MH-17	Circular	200 mm
MH-17	13+38	937	1.2	0.63	2.93	P-17	MH-17	MH-18	Circular	200 mm
MH-18	12+93	935	1.2	0.57	3.28	P-18	MH-18	MH-19	Circular	200 mm
MH-19	12+48	933	1.2	0.57	3.28	P-19	MH-19	MH-20	Circular	200 mm
MH-20	12+03	930	1.2	0.57	3.28	P-20	MH-20	MH-21	Circular	200 mm
MH-21	11+59	928	1.2	0.57	3.28	P-21	MH-21	MH-22	Circular	200 mm
MH-22	11+13	925	1.2	0.57	3.28	P-22	MH-22	MH-23	Circular	200 mm
MH-23	10+68	923	1.2	0.57	3.28	P-23	MH-23	MH-24	Circular	200 mm
MH-24	10+25	920	1.2	0.58	3.4	P-24	MH-24	MH-25	Circular	200 mm
MH-25	9+80	917	1.2	0.59	3.57	P-25	MH-25	MH-26	Circular	200 mm
MH-26	9+34	914	1.2	0.63	3.75	P-26	MH-26	MH-27	Circular	200 mm
MH-27	8+89	911	1.2	0.6	3.98	P-27	MH-27	MH-28	Circular	200 mm
MH-28	8+44	909	1.2	0.61	4.12	P-28	MH-28	MH-29	Circular	200 mm
MH-29	7+98	905	1.2	0.61	4.22	P-29	MH-29	MH-30	Circular	200 mm
MH-30	7+54	902	1.2	0.62	4.36	P-30	MH-30	MH-31	Circular	200 mm
MH-31	7+09	899	1.2	0.62	4.5	P-31	MH-31	MH-32	Circular	200 mm
MH-32	6+64	896	1.2	0.63	4.63	P-32	MH-32	MH-33	Circular	200 mm

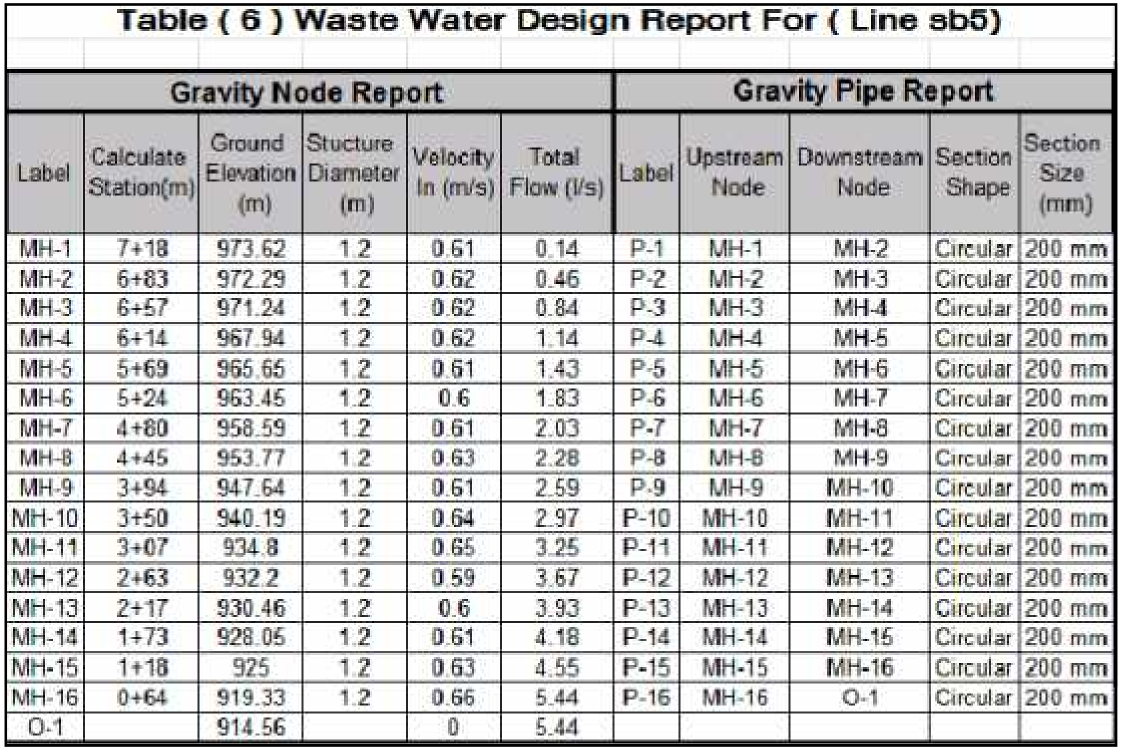

Table (6) Waste Water Design Report For (Line sb5)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	7+18	973.62	1.2	0.61	0.14	P-1	MH-1	MH-2	Circular	200 mm
MH-2	6+83	972.29	1.2	0.62	0.46	P-2	MH-2	MH-3	Circular	200 mm
MH-3	6+57	971.24	1.2	0.62	0.84	P-3	MH-3	MH-4	Circular	200 mm
MH-4	6+14	967.94	1.2	0.62	1.14	P-4	MH-4	MH-5	Circular	200 mm
MH-5	5+69	965.65	1.2	0.61	1.43	P-5	MH-5	MH-6	Circular	200 mm
MH-6	5+24	963.45	1.2	0.6	1.83	P-6	MH-6	MH-7	Circular	200 mm
MH-7	4+80	958.59	1.2	0.61	2.03	P-7	MH-7	MH-8	Circular	200 mm
MH-8	4+45	953.77	1.2	0.63	2.28	P-8	MH-8	MH-9	Circular	200 mm
MH-9	3+94	947.64	1.2	0.61	2.59	P-9	MH-9	MH-10	Circular	200 mm
MH-10	3+50	940.19	1.2	0.64	2.97	P-10	MH-10	MH-11	Circular	200 mm
MH-11	3+07	934.8	1.2	0.65	3.25	P-11	MH-11	MH-12	Circular	200 mm
MH-12	2+63	932.2	1.2	0.59	3.67	P-12	MH-12	MH-13	Circular	200 mm
MH-13	2+17	930.46	1.2	0.6	3.93	P-13	MH-13	MH-14	Circular	200 mm
MH-14	1+73	928.05	1.2	0.61	4.18	P-14	MH-14	MH-15	Circular	200 mm
MH-15	1+18	925	1.2	0.63	4.55	P-15	MH-15	MH-16	Circular	200 mm
MH-16	0+64	919.33	1.2	0.66	5.44	P-16	MH-16	O-1	Circular	200 mm
O-1		914.56		0	5.44					

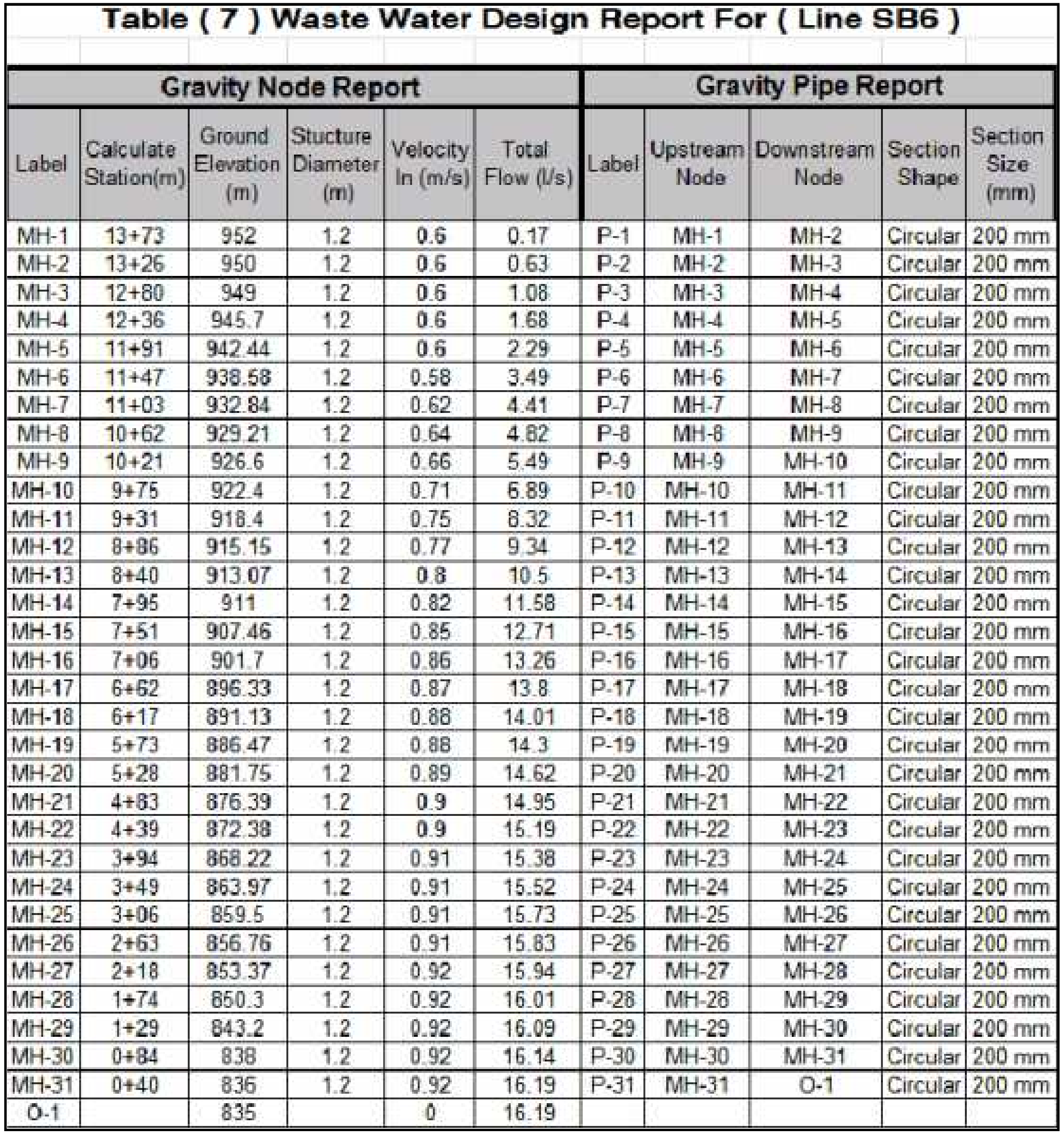

Table (7) Waste Water Design Report For (Line SB6)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	13+73	952	1.2	0.6	0.17	P-1	MH-1	MH-2	Circular	200 mm
MH-2	13+26	950	1.2	0.6	0.63	P-2	MH-2	MH-3	Circular	200 mm
MH-3	12+80	949	1.2	0.6	1.08	P-3	MH-3	MH-4	Circular	200 mm
MH-4	12+36	945.7	1.2	0.6	1.68	P-4	MH-4	MH-5	Circular	200 mm
MH-5	11+91	942.44	1.2	0.6	2.29	P-5	MH-5	MH-6	Circular	200 mm
MH-6	11+47	938.58	1.2	0.58	3.49	P-6	MH-6	MH-7	Circular	200 mm
MH-7	11+03	932.84	1.2	0.62	4.41	P-7	MH-7	MH-8	Circular	200 mm
MH-8	10+62	929.21	1.2	0.64	4.82	P-8	MH-8	MH-9	Circular	200 mm
MH-9	10+21	926.6	1.2	0.66	5.49	P-9	MH-9	MH-10	Circular	200 mm
MH-10	9+75	922.4	1.2	0.71	6.89	P-10	MH-10	MH-11	Circular	200 mm
MH-11	9+31	918.4	1.2	0.75	8.32	P-11	MH-11	MH-12	Circular	200 mm
MH-12	8+86	915.15	1.2	0.77	9.34	P-12	MH-12	MH-13	Circular	200 mm
MH-13	8+40	913.07	1.2	0.8	10.5	P-13	MH-13	MH-14	Circular	200 mm
MH-14	7+95	911	1.2	0.82	11.58	P-14	MH-14	MH-15	Circular	200 mm
MH-15	7+51	907.46	1.2	0.85	12.71	P-15	MH-15	MH-16	Circular	200 mm
MH-16	7+06	901.7	1.2	0.86	13.26	P-16	MH-16	MH-17	Circular	200 mm
MH-17	6+62	896.33	1.2	0.87	13.8	P-17	MH-17	MH-18	Circular	200 mm
MH-18	6+17	891.13	1.2	0.88	14.01	P-18	MH-18	MH-19	Circular	200 mm
MH-19	5+73	886.47	1.2	0.88	14.3	P-19	MH-19	MH-20	Circular	200 mm
MH-20	5+28	881.75	1.2	0.89	14.62	P-20	MH-20	MH-21	Circular	200 mm
MH-21	4+83	876.39	1.2	0.9	14.95	P-21	MH-21	MH-22	Circular	200 mm
MH-22	4+39	872.38	1.2	0.9	15.19	P-22	MH-22	MH-23	Circular	200 mm
MH-23	3+94	868.22	1.2	0.91	15.38	P-23	MH-23	MH-24	Circular	200 mm
MH-24	3+49	863.97	1.2	0.91	15.52	P-24	MH-24	MH-25	Circular	200 mm
MH-25	3+06	859.5	1.2	0.91	15.73	P-25	MH-25	MH-26	Circular	200 mm
MH-26	2+63	856.76	1.2	0.91	15.83	P-26	MH-26	MH-27	Circular	200 mm
MH-27	2+18	853.37	1.2	0.92	15.94	P-27	MH-27	MH-28	Circular	200 mm
MH-28	1+74	850.3	1.2	0.92	16.01	P-28	MH-28	MH-29	Circular	200 mm
MH-29	1+29	843.2	1.2	0.92	16.09	P-29	MH-29	MH-30	Circular	200 mm
MH-30	0+84	838	1.2	0.92	16.14	P-30	MH-30	MH-31	Circular	200 mm
MH-31	0+40	836	1.2	0.92	16.19	P-31	MH-31	O-1	Circular	200 mm
O-1		835		0	16.19					

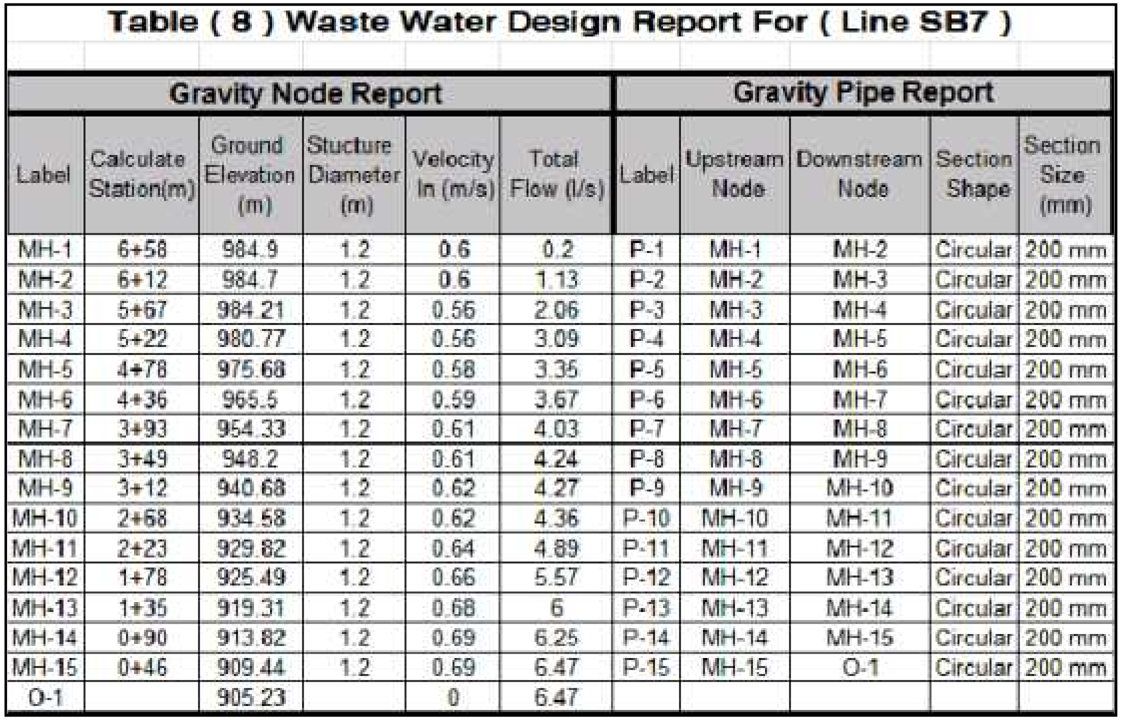

Table (8) Waste Water Design Report For (Line SB7)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	6+58	984.9	1.2	0.6	0.2	P-1	MH-1	MH-2	Circular	200 mm
MH-2	6+12	984.7	1.2	0.6	1.13	P-2	MH-2	MH-3	Circular	200 mm
MH-3	5+67	984.21	1.2	0.56	2.06	P-3	MH-3	MH-4	Circular	200 mm
MH-4	5+22	980.77	1.2	0.56	3.09	P-4	MH-4	MH-5	Circular	200 mm
MH-5	4+78	975.68	1.2	0.58	3.35	P-5	MH-5	MH-6	Circular	200 mm
MH-6	4+36	965.5	1.2	0.59	3.67	P-6	MH-6	MH-7	Circular	200 mm
MH-7	3+93	954.33	1.2	0.61	4.03	P-7	MH-7	MH-8	Circular	200 mm
MH-8	3+49	948.2	1.2	0.61	4.24	P-8	MH-8	MH-9	Circular	200 mm
MH-9	3+12	940.68	1.2	0.62	4.27	P-9	MH-9	MH-10	Circular	200 mm
MH-10	2+68	934.58	1.2	0.62	4.36	P-10	MH-10	MH-11	Circular	200 mm
MH-11	2+23	929.82	1.2	0.64	4.89	P-11	MH-11	MH-12	Circular	200 mm
MH-12	1+78	925.49	1.2	0.66	5.57	P-12	MH-12	MH-13	Circular	200 mm
MH-13	1+35	919.31	1.2	0.68	6	P-13	MH-13	MH-14	Circular	200 mm
MH-14	0+90	913.82	1.2	0.69	6.25	P-14	MH-14	MH-15	Circular	200 mm
MH-15	0+46	909.44	1.2	0.69	6.47	P-15	MH-15	O-1	Circular	200 mm
O-1		905.23		0	6.47					

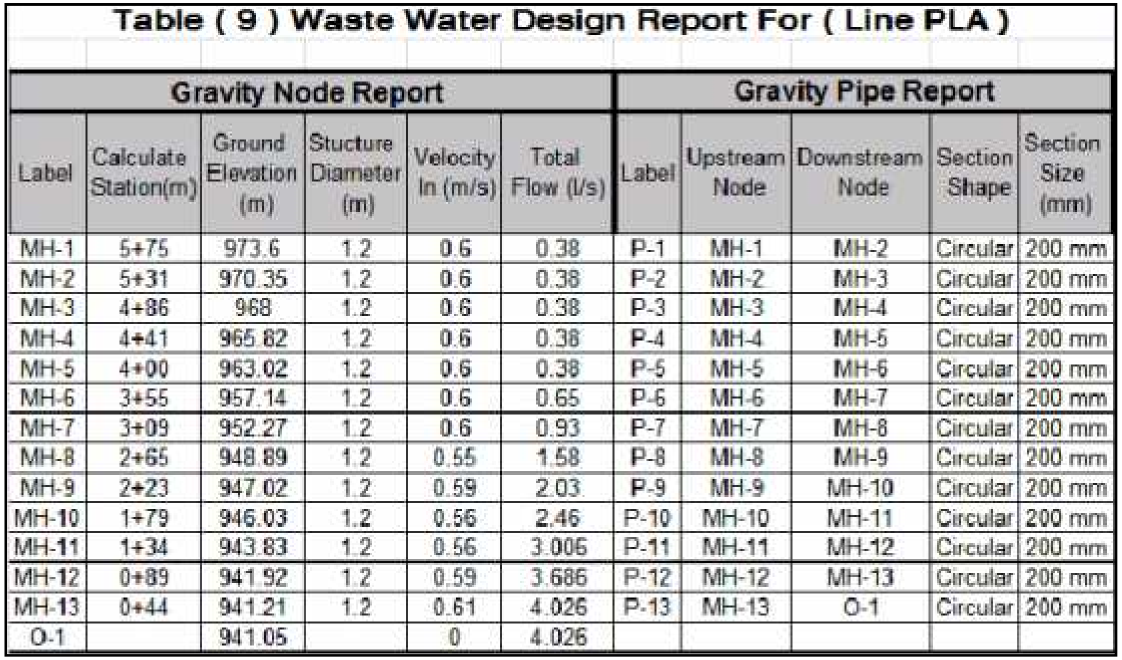

Table (9) Waste Water Design Report For (Line PLA)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	5+75	973.6	1.2	0.6	0.38	P-1	MH-1	MH-2	Circular	200 mm
MH-2	5+31	970.35	1.2	0.6	0.38	P-2	MH-2	MH-3	Circular	200 mm
MH-3	4+86	968	1.2	0.6	0.38	P-3	MH-3	MH-4	Circular	200 mm
MH-4	4+41	965.82	1.2	0.6	0.38	P-4	MH-4	MH-5	Circular	200 mm
MH-5	4+00	963.02	1.2	0.6	0.38	P-5	MH-5	MH-6	Circular	200 mm
MH-6	3+55	957.14	1.2	0.6	0.65	P-6	MH-6	MH-7	Circular	200 mm
MH-7	3+09	952.27	1.2	0.6	0.93	P-7	MH-7	MH-8	Circular	200 mm
MH-8	2+65	948.89	1.2	0.55	1.58	P-8	MH-8	MH-9	Circular	200 mm
MH-9	2+23	947.02	1.2	0.59	2.03	P-9	MH-9	MH-10	Circular	200 mm
MH-10	1+79	946.03	1.2	0.56	2.46	P-10	MH-10	MH-11	Circular	200 mm
MH-11	1+34	943.83	1.2	0.56	3.006	P-11	MH-11	MH-12	Circular	200 mm
MH-12	0+89	941.92	1.2	0.59	3.686	P-12	MH-12	MH-13	Circular	200 mm
MH-13	0+44	941.21	1.2	0.61	4.026	P-13	MH-13	O-1	Circular	200 mm
O-1		941.05		0	4.026					

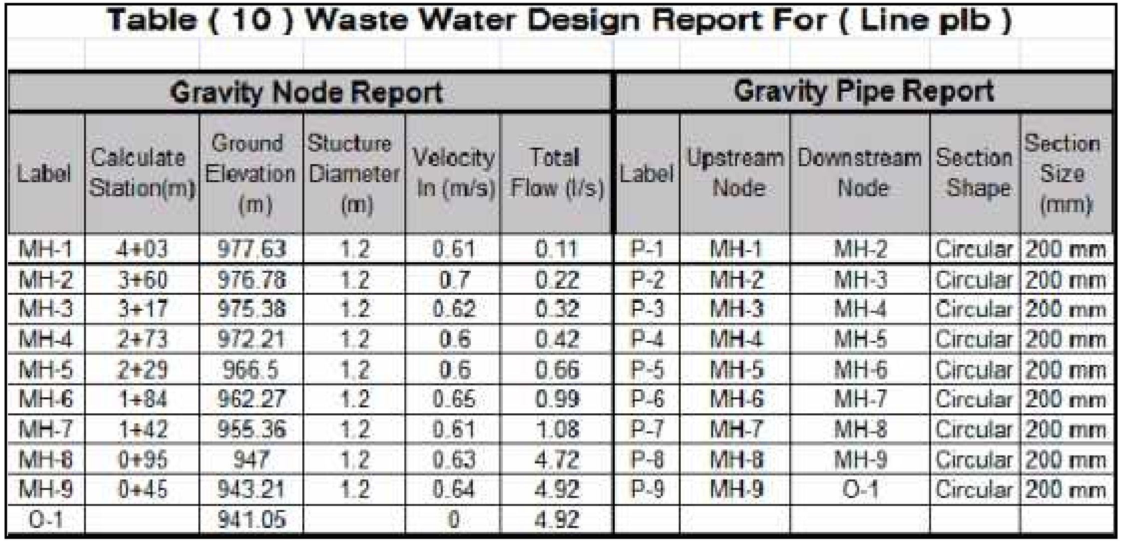

Table (10) Waste Water Design Report For (Line plb)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	4+03	977.63	1.2	0.61	0.11	P-1	MH-1	MH-2	Circular	200 mm
MH-2	3+60	976.78	1.2	0.7	0.22	P-2	MH-2	MH-3	Circular	200 mm
MH-3	3+17	975.38	1.2	0.62	0.32	P-3	MH-3	MH-4	Circular	200 mm
MH-4	2+73	972.21	1.2	0.6	0.42	P-4	MH-4	MH-5	Circular	200 mm
MH-5	2+29	966.5	1.2	0.6	0.66	P-5	MH-5	MH-6	Circular	200 mm
MH-6	1+84	962.27	1.2	0.65	0.99	P-6	MH-6	MH-7	Circular	200 mm
MH-7	1+42	955.36	1.2	0.61	1.08	P-7	MH-7	MH-8	Circular	200 mm
MH-8	0+95	947	1.2	0.63	4.72	P-8	MH-8	MH-9	Circular	200 mm
MH-9	0+45	943.21	1.2	0.64	4.92	P-9	MH-9	O-1	Circular	200 mm
O-1		941.05		0	4.92					

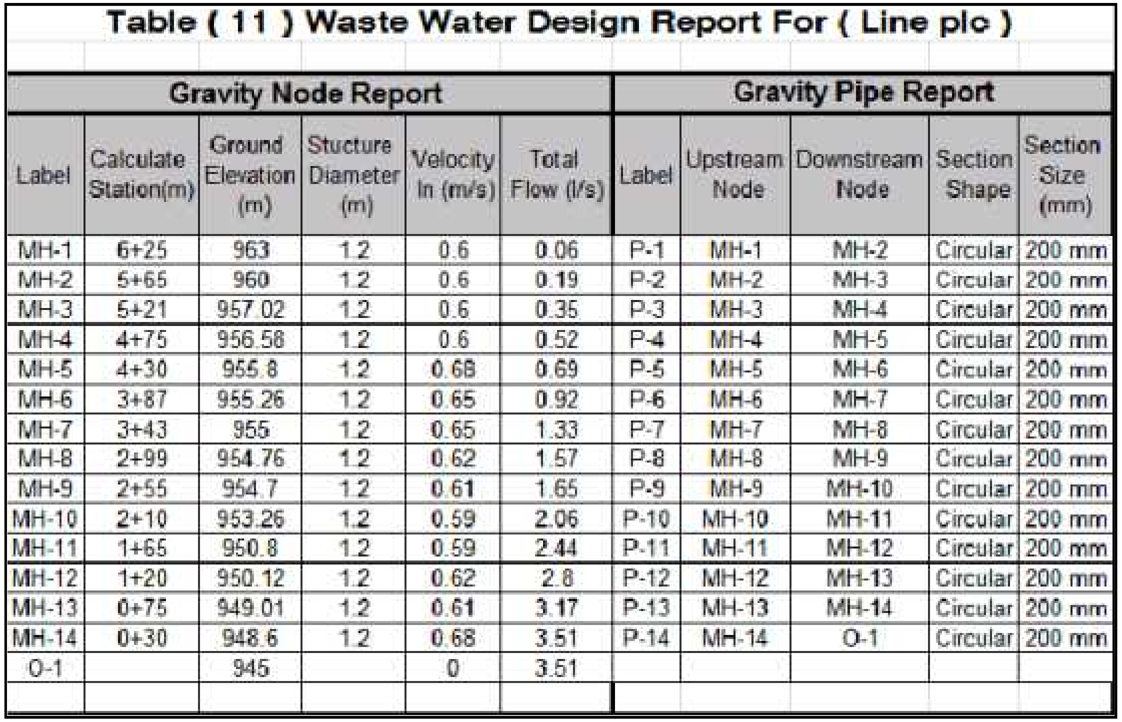

Table (11) Waste Water Design Report For (Line plc)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	6+25	963	1.2	0.6	0.06	P-1	MH-1	MH-2	Circular	200 mm
MH-2	5+65	960	1.2	0.6	0.19	P-2	MH-2	MH-3	Circular	200 mm
MH-3	5+21	957.02	1.2	0.6	0.35	P-3	MH-3	MH-4	Circular	200 mm
MH-4	4+75	956.58	1.2	0.6	0.52	P-4	MH-4	MH-5	Circular	200 mm
MH-5	4+30	955.8	1.2	0.68	0.69	P-5	MH-5	MH-6	Circular	200 mm
MH-6	3+87	955.26	1.2	0.65	0.92	P-6	MH-6	MH-7	Circular	200 mm
MH-7	3+43	955	1.2	0.65	1.33	P-7	MH-7	MH-8	Circular	200 mm
MH-8	2+99	954.76	1.2	0.62	1.57	P-8	MH-8	MH-9	Circular	200 mm
MH-9	2+55	954.7	1.2	0.61	1.65	P-9	MH-9	MH-10	Circular	200 mm
MH-10	2+10	953.26	1.2	0.59	2.06	P-10	MH-10	MH-11	Circular	200 mm
MH-11	1+65	950.8	1.2	0.59	2.44	P-11	MH-11	MH-12	Circular	200 mm
MH-12	1+20	950.12	1.2	0.62	2.8	P-12	MH-12	MH-13	Circular	200 mm
MH-13	0+75	949.01	1.2	0.61	3.17	P-13	MH-13	MH-14	Circular	200 mm
MH-14	0+30	948.6	1.2	0.68	3.51	P-14	MH-14	O-1	Circular	200 mm
O-1		945		0	3.51					

Table (12) Waste Water Design Report For (Line SA)

Gravity Node Report						Gravity Pipe Report				
Label	Calculate Station(m)	Ground Elevation (m)	Stucture Diameter (m)	Velocity In (m/s)	Total Flow (l/s)	Label	Upstream Node	Downstream Node	Section Shape	Section Size (mm)
MH-1	13+73	952	1.2	0.6	0.17	P-1	MH-1	MH-2	Circular	200 mm
MH-2	13+26	950	1.2	0.65	0.63	P-2	MH-2	MH-3	Circular	200 mm
MH-3	12+81	949.24	1.2	0.58	1.08	P-3	MH-3	MH-4	Circular	200 mm
MH-4	12+36	945.72	1.2	0.59	1.68	P-4	MH-4	MH-5	Circular	200 mm
MH-5	11+92	943.44	1.2	0.52	2.29	P-5	MH-5	MH-6	Circular	200 mm
MH-6	11+47	938.58	1.2	0.58	3.49	P-6	MH-6	MH-7	Circular	200 mm
MH-7	11+03	932.84	1.2	0.62	4.41	P-7	MH-7	MH-8	Circular	200 mm
MH-8	10+62	929.13	1.2	0.64	4.82	P-8	MH-8	MH-9	Circular	200 mm
MH-9	10+20	926.88	1.2	0.66	5.49	P-9	MH-9	MH-10	Circular	200 mm
MH-10	9+75	922.41	1.2	0.71	6.89	P-10	MH-10	MH-11	Circular	200 mm
MH-11	9+31	918.4	1.2	0.75	8.32	P-11	MH-11	MH-12	Circular	200 mm
MH-12	8+86	915.15	1.2	0.77	9.34	P-12	MH-12	MH-13	Circular	200 mm
MH-13	8+41	913.07	1.2	0.8	10.5	P-13	MH-13	MH-14	Circular	200 mm
MH-14	7+96	911	1.2	0.82	11.58	P-14	MH-14	MH-15	Circular	200 mm
MH-15	7+51	907.47	1.2	0.85	12.71	P-15	MH-15	MH-16	Circular	200 mm
MH-16	7+07	901.71	1.2	0.86	13.26	P-16	MH-16	MH-17	Circular	200 mm
MH-17	6+62	896.34	1.2	0.87	13.8	P-17	MH-17	MH-18	Circular	200 mm
MH-18	6+18	891.14	1.2	0.88	14.01	P-18	MH-18	MH-19	Circular	200 mm
MH-19	5+73	886.48	1.2	0.88	14.3	P-19	MH-19	MH-20	Circular	200 mm
MH-20	5+28	881.75	1.2	0.89	14.62	P-20	MH-20	MH-21	Circular	200 mm
MH-21	4+83	876.82	1.2	0.9	14.95	P-21	MH-21	MH-22	Circular	200 mm
MH-22	4+38	872.38	1.2	0.9	15.19	P-22	MH-22	MH-23	Circular	200 mm
MH-23	3+94	868.29	1.2	0.91	15.38	P-23	MH-23	MH-24	Circular	200 mm
MH-24	3+49	863.98	1.2	0.91	15.52	P-24	MH-24	MH-25	Circular	200 mm
MH-25	3+06	859.51	1.2	0.91	15.73	P-25	MH-25	MH-26	Circular	200 mm
MH-26	2+64	856.76	1.2	0.91	15.83	P-26	MH-26	MH-27	Circular	200 mm
MH-27	2+19	853.37	1.2	0.92	15.94	P-27	MH-27	MH-28	Circular	200 mm
MH-28	1+73	850.31	1.2	0.92	16.01	P-28	MH-28	MH-29	Circular	200 mm
MH-29	1+29	843.05	1.2	0.92	16.09	P-29	MH-29	MH-30	Circular	200 mm
MH-30	0+85	836.98	1.2	0.92	16.14	P-30	MH-30	MH-31	Circular	200 mm
MH-31	0+40	833.52	1.2	0.86	16.19	P-31	MH-31	O-1	Circular	250 mm
O-1		835		0	16.19					