DESIGN OF STORM WATER DRAINAGE SYSTEM FOR THE CENTER OF Al DHARYIA CITY

BY

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PALESTINE POLYTECHNIC UNIVERSITY

HEBRON- WEST BANK

PALESTINE

JANUARY -2009

الملخص

تصميم نظام لتصريف مياه الامطار
في الظاهرية

عمل

أماني زلوم　　　　روبا الجولاني

جامعة بوليتكنك فلسطين

باشراف : د. ماجد أبو شرخ

يعد الصرف الصحي حتى يومنا هذا جانبا مهملا خاصة في الضفة الغربية ، على حين أن تصريف المياه في غاية الاهمية والتي تتراكم في الشوارع نتيجة الهطول الغزير للأمطار ، النمو السكاني و إمتداد مدن الضفة الغربية وتطورها .

ان الامتداد الوسع والتطور السريع في الظاهرية أدى الى تغيير الملامح الهيدرولوجية والجيومورفولوجية ، ويشار هنا الى أن معظم اراضي الظاهرية لا يوجد لها منفذ لتصريف المياه في حين أن نسبة الأمطار الغزيرة تؤدي إلى فيضان الشوارع والمناطق المنخفضة والممارات بالاضافة الى أن النمو السكاني المتسارع أدى إلى إنخفاض نسبة الأراضي المفتوحة المنفذة وأدى ذلك إلى تجمع المياه في المناطق الأقل إرتفاعا .

في ضوء ما سبق ذكره ، فان منطقة الظاهرية بحاجة إلى تصميم نظام صرف مياه الأمطار جديد وهذا ما احتوته هذه الدراسة . وقد تم تطوير المعلومات بالإستناد على الخصائص الجيولوجيه والهيدرولوجيه وطبيعة التضاريس في منطقة الدراسة بالاضافة إلى المناخ والعناصر البيئيه والظروف الاجتماعية والاقتصادية . مع الإشارة إلى أن وجود خارطة طبوغرافية وخرائط توضح الشوارع القائمة و المقترحة تعد من المعلومات الاساسيه لتحديد خط تدفق المياه التمهيدي .

في نهاية هذا المشروع سيتم تطوير نظام تصريف مياه أمطار جديد في منطقة الظاهرية إن شاء الله

ABSTRACT

DESIGN OF STORM WATER DRAINAGE SYSTEM FOR THE CENTER OF Al DHARYIA CITY

BY

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Drainage as mean of disposal, till recently has been largely a neglected aspect in the West Bank now. There is no storm water drainage system at present in the center of Al-Dhahyria city. The storm water accumulate on the main streets as a result of heavy precipitation (running water), population growth, and the development and extension of Al-Dhahyria city. At the same time,

The accelerated development and grow of Al Dharyia city has led to change in the hydrological and geomorphological features. Most of the areas in Al Dharyia city don't have a natural drainage outlet. Heavy rainfall causes storm water to collect in low areas and flood streets and walk way. Rapid growth has decreased the open area available for percolation and rainwater and has greatly increased the runoff to low lying areas.

In view of this prevailing condition, the drainage system in Al Dharyia city would have a new characteristic and development of new water drainage system is very necessary to drain excess water from streets. This study is conducted to design a storm drainage system for the center of Al--Dharyia city.

The results of the study show that the accumulation of storm water in the main streets in Al-Dhahyria city causes problems to the peoples; subsequently there is a big need for immediate steps for construction of the proposed storm water drainage system for the center of Al Dharyia city. Gravity flow drainage sewer was proposed for the main street to minimize the cost of construction and excavations.

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1 *INTRODUCTION*

CHAPTER ONE
INTRODUCTION

1.1 Background

The wide expansion and accelerated development and grow of Al Dharyia city has led to change in the hydrological and geomorphological features. Most of the areas in Al Dharyia city don't have a natural drainage outlet. Heavy rainfall causes storm water to collect in low areas and flood streets and walk way. Rapid growth has decreased the open area available for percolation and rainwater and has greatly increased the runoff to low lying areas.

In view of this prevailing condition, the drainage system in Al Dharyia city would have a new characteristic and development of new water drainage system is very necessary to drain excess water from streets. This study is conducted to design a storm drainage system for the center of Al--Dharyia city.

Data must be developed on topography, geology, hydrology, climate, ecological elements, and social and economic conditions. Topographic maps with existing and proposed streets provide the most important information for preliminary flow routing.

1.2 Problem Definition

Drainage as a mean of disposal, till recently- has been largely a neglected aspect in the West Bank now, water drainage is very important due to water accumulation on the streets as a result of heavy precipitation (running water), population growth, and the development and extension of West Bank cities.

Al Dharyia city is located in a semi – arid region with rainfall generally limited to autumn and winter months. In the past, the open areas of much of Al Dharyia city easily observed most of this rainfall and provided the primary source for recharging the ground water aquifer. Most of the areas in Al Dharyia city do not have a natural drainage outlet. Heavy rainfall causes storm water to collect in low areas and flood streets and walk ways. Rapid growth has decreased the open areas available for percolation of rainwater and has greatly increased the runoff to low lying areas.

In view of this condition, design of a new storm water drainage system in Al Dharyia city becomes very essential. A new drainage system which admits all the flood discharge from the catchments and with low initial and maintenance cost.

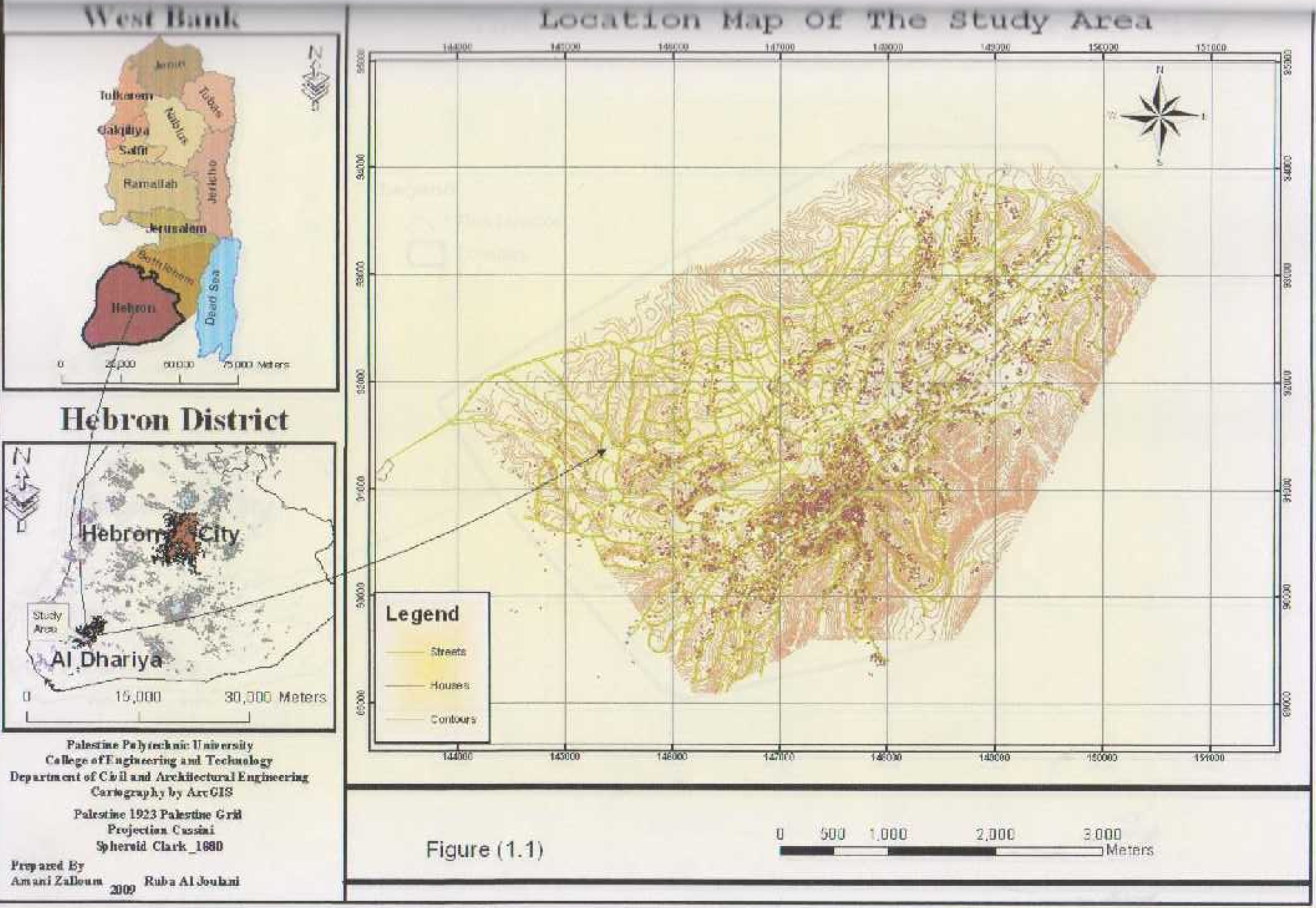
1.3 Objectives of the Project

The overall objective of this study is to investigate water drainage system in Al- Dharyia city and propose storm water drainage system for the city. Achievement of this objective requires estimation of the accumulated areas, the quantities of water, topography of the city, the existing drainage system, etc. More specifically the main objectives of this project are:

1- Study in general, drainage system patterns in Al Dharyia city.
2- Determine the sub catchments and catchments of the study area with the help of aerial photogram metric map and Geographical Information System (GIS).
3- Design of a new storm water drainage network for the center of the city.
4- Development of several plans for the construction of the proposed storm water network and prepare bill of quantities.
5- Finally, providing suggestion and recommendations regarding the reuse of collected water at the end of disposal.

1.4 Project Area

Al Dharyia city is located 25 Km south west of the Hebron city as shown on the project location map Figure 1.1. The total population within the administrative borders in year 2007 is about 27000. The elevation within the area ranges from 500-700 m with respect to sea level. The average annual rainfall is around 350 mm and the minimum average annual temperature is 10^0C temperature and the maximum average annual temperature rises to 27^0C. The present total administrative area of the city is about 1455 hectare, where building for population occupies 45 hectare.


Location Map Of The Study Area
West Bank
Jenin
Tulkarem
Tubas
Nablus
Qalqiliya
Salfit
Ramallah
Jericho
Jerusalem
Bethlehem
Hebron
Dead Sea
0
25,000
50,000
75,000 Meters
Hebron District
Hebron City
Study Area
Al Dhariya
0
15,000
30,000 Meters
Legend
Streets
Houses
Contours
144000
145000
146000
147000
148000
149000
150000
151000
89000
90000
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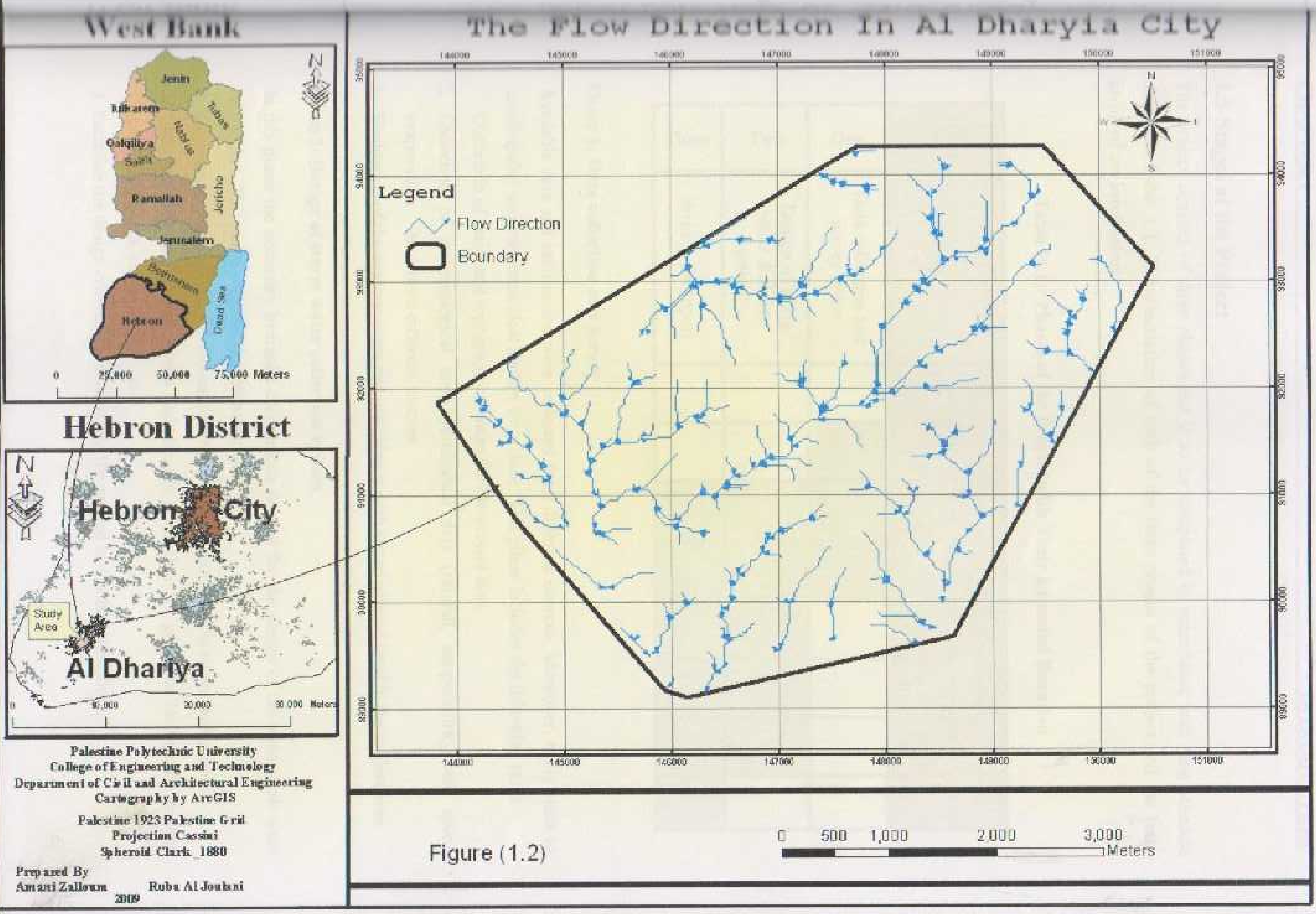
94000
95000
0 500 1,000 2,000 3,000 Meters
Palestine Polytechnic University
College of Engineering and Technology
Department of Civil and Architectural Engineering
Cartography by ArcGIS
Palestine 1923 Palestine Grid
Projection Cassini
Spheroid Clark_1880
Prepared By
Amani Zalloum
Ruba Al Joulani
2009
Figure (1.1)



The Flow Direction In Al Dharyia City
West Bank
Jenin
Tulkarem
Tubas
Nablus
Qalqiliya
Salfit
Jericho
Ramallah
Jerusalem
Bethlehem
Hebron
Dead Sea
0
25,000
50,000
75,000 Meters
Hebron District
Hebron City
Al Dhariya
Study Area
10,000
20,000
30,000 Meters
Legend
Flow Direction
Boundary
0
500
1,000
2,000
3,000
Meters
Palestine Polytechnic University
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Projection Cassini
Spheroid Clark_1880
Prepared By
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Figure (1.2)

1.5 Stages of the Project

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

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

Phase No.	Title	Duration							
		2008							
		2	3	4	5	9	10	11	12
One	Data collection and survey notes								
Two	Design of storm water drainage system								
Three	Writing the report								

Phase 1: Data collection and survey

Available data and information were collected from different sources. Moreover, many visits to municipality and meteorological station were done. This phase includes the following tasks:

1. Collection of aerial and topographical maps for the project area.
2. Collection of meteorological and hydrological data (rainfall, temperature, wind speed, evaporation ...etc.) from different sources.
3. Evaluation of the contour maps and matching it with actual ground level in the project area.

Phase 2: Design of storm water collection system

In this phase the necessary hydraulic calculations needed for the design of the main trunk were carried out. This phase includes the following tasks.

1. Establish the catchments and sub-catchments areas and routes of the storm water pipes.
2. Establish a system layout, which includes the areas that are going to be served, existing streets and roads, topography ....etc.
3. Establish the design criteria and conducting the needed hydraulic calculations.

Phase 3: Writing the report

The present report was written after finishing the design calculations of the main trunks and preparing the different drawings.

1.6 Organization of the Report

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

The **first chapter** entitled **"Introduction"** describes the background of the project, problem definition, project objectives, project area, phases of the project and the summary of the chapter.

Chapter two entitled **"Design of Storm Water Drainage System"** describes the storm water runoff, hydraulic consideration; design of storm water sewers, and the summary of the chapter.

Chapter three entitled **"Design and Planning Criteria"** describes introduction, catchment areas, rainfall characteristics, runoff flow, design parameters, and the summary of the chapter.

Chapter Four entitled **"Analysis and Design"** describes introduction, layout of the system, design computations, the proposed storm water drainage system, profiles of drainage channels, and the summary of the chapter.

Chapter Five entitled **"Bill of Quantities"** deals with the quantities needed to complete the design system.

Chapter Six entitled **"Conclusions"** discusses the conclusions of the study.

CHAPTER

2 *DESIGN OF STORM WATER DRINAGE SYATEM*

2.1 Introduction

2.2 Storm Water Runoff

2.3 Hydraulic Consideration

2.3 Storm Water Sewer Design

2.4 Summary

CHAPTER TWO

DESIGN OF STORM WATER DRAINAGE SYSTEM

2.1 Introduction

Rapid effective removal of storm runoff was a luxury not found in many cities in the early nineteenth century. Today, the modern city dweller has come to think of this as an essential service. Urban drainage facilities have progressed from crude ditches and stepping stones to the present intricate coordinates systems of curbs, gutters, inlets, and under ground conveyance.

The design must consider meteorological factors, geomorphological factors, and the economic value of the land, as well as human value considerations such as aesthetic and public safety aspects of the design. The design of storm water detention basins should also consider the possible effects of inadequate maintenance of the facility.

2.2 Storm Water Runoff

Storm water runoff is that portion of precipitation which flows over the ground surface during and a short time after a storm. The dependence parameters that controlled the quantity of the storm water which carried by a storm or combined sewer are the surface of the drainage area (ha), the intensity of the rainfall (l/s.ha), and runoff coefficient C dimensionless (the condition of the surface). There are many methods and formulas to determine the storm flow.

2.2.1 Rational method

The rational method has probably been the most popular method for designing storm systems. It has been applied all over the world and runoff is related to rainfall intensity by the formula,

$$Q = C.i.A \qquad (2.1)$$

Where Q – peak runoff rate (l/sec).

C = runoff coefficient, which is actually the ratio of the peak runoff rate to the average rainfall for a period known as the time of concentration.

i = average rainfall intensity, mm/min, for period equal to the time of concentration.

A= drainage area (ha).

For small catchments areas, it continues to be a reasonable method, provided that it is used properly and that results and design concepts are assessed for reasonableness. This procedure is suitable for small systems where the establishment of a computer model is not warranted.

The steps in the rational method calculation procedure are summarised below:

1- The drainage area is first subdivided into sub-areas with homogeneous land use according to the existing or planned development.

2- For each sub-area, estimate the runoff coefficient *C* and the corresponding area *A*.

3- The layout of the drainage system is then drawn according to the topography, the existing or planned streets and roads and local design practices.

4- Inlet points are then defined according to the detail of design considerations. For main drains, for example, the outlets of the earlier mentioned homogeneous sub-areas should serve as the inlet nodes. On the other hand in very detailed calculations, all the inlet points should be defined according to local design practices.

5- After the inlet points have been chosen, the designer must specify the drainage sub-area for each inlet point A and the corresponding mean runoff coefficient *C*. If the sub-area for a given inlet has non-homogeneous land use, a weighted coefficient may be estimated.

6- The runoff calculations are then done by means of the general rational method equations for each inlet point, proceeding from the upper parts of the watershed to the final outlet. The peak runoff, which is calculated at each point, is then used to determine the size of the downstream trunk drain using a hydraulic formula for pipes flowing full.

7- After the preliminary minor system is designed and checked for its interaction with the major system, reviews are made of alternatives, hydrological assumptions are verified, new computations are made, and final data obtained on street grades and elevations. The engineer then should proceed with final hydraulic design of the system.

2.2.2 Runoff coefficient, C

Runoff coefficient is a function of infiltration capacity, interception by vegetation, depression storage, and evapotranspiration. It is requires greatest exercise of judgment by engineer and assumed constant, actually variable with time. It is desirable to develop composite runoff coefficient (weighted average) for each drainage area as:

$$C = \frac{\sum Ci.Ai}{\sum Ai} \tag{2.2}$$

Where $Ai = i^{th}$ area.

$Ci = i^{th}$ runoff coefficient.

The range of coefficients with respect to general character of the area is given in the following tables (Table 2.1 and Table 2.2).

Table (2.1): The Range of Coefficient with Respect to General Character of the Area (Sarikaya 1984)

Description of Area	Runoff Coefficients
Business	
Down town	0.70 to 0.95
Neighborhood	0.50 to 0.70
Residential	
Single-Family	0.30 to 0.50
Multi-unit, detached	0.40 to 0.60
Multi-unit, attached	0.60 to 0.75
Residential (suburban)	0.25 to 0.40
Apartment	0.50 to 0.70
Industrial	
Light	0.50 to 0.80
Heavy	0.60 to 0.90
Parks, Cemeteries	0.10 to 0.25
Playground	0.20 to 0.35
Railroad yard	0.20 to 0.35
Unimproved	0.10 to 0.30

Table (2.2): The Range of Coefficient With Respect To Surface Type of the Area (Sarikaya 1984)

Character of Surface	Runoff Coefficients
Pavement	
Asphalt and concrete	0.70 to 0.95
Brick	0.70 to 0.85
Lawns, Sandy soil	
Flat, 2 percent	0.05 to 0.10
Average,2to7percent	0.10 to 0.15
Steep, 7 percent	0.15 to 0.20
Roofs	0.75 to 0.95
Lawns, heavy soil	
Flat, 2 percent	0.13 to 0.17
Average,2 to 7percent	0.18 to 0.22
Steep, 7 percent	0.25 to 0.35

2.2.3 Rainfall intensity, i

In determining rainfall intensity for use in rational formula it must be recognized that the shorter the duration, the greater the expected average intensity will be. The critical duration of rainfall will be that which produces maximum runoff and this will be that which is sufficient to produce flow from the entire drainage area. Shorter periods will provide lower flows since the total area is not involved and longer periods will produce lower average intensities. The storm sewer designer thus requires some relationship between duration and expected intensity. Intensities vary from place to another and curves or equations are specified for the areas for which they were developed.

The rainfall intensity depends on many factors through which we can do our calculations; we can list these factors as follow:

1- Average frequency of occurrence of storm (n) or (f).

   Average frequency of occurrence is the frequency with which a given event is equaled or exceeded on the average, once in a period of years. Probability of occurrence, which is the reciprocal of frequency, (n) is preferred by sum engineers. Thus, if the frequency of a rain once a 5-year (f=5), then probability of occurrence n=0.20. Selection of storm design rain frequency based on cost-benefit analysis or experience. There is range of frequency of often used:

a. Residential area: f = 2 to 10 years (5 year most common).

b. Commercial and high value districts: f = 10 to 50 (15 year common).

c. Flood protection: f = 50 year.

2- Intensity, duration and frequency characteristics of rainfall.

Basic data derived from gage measurement of rainfall (Point rainfall) over along period can be used to obtain a rainfall height diagram that show the relation between the height of rain (mm) and time (min). The slope of the curve or rain height per unit time is defined as rain intensity:

$$i = (\Delta \text{ height of rain} / \Delta \text{ time}) \left[\frac{mm}{\min}\right]$$

The rain intensity in litter per second. hectare is equal:

$$i\left(\frac{l}{s.ha}\right) = 166.7i\left[\frac{mm}{\min}\right]$$

In order to drive intensity-duration-frequency curves long-term observation of rainfall is needed. Analysis of such observation is given in any text in sanitary engineering.

3- Time of Concentration

The time of concentration is the time required for the runoff to become established and flow from the most remote part (in time) of the drainage area to the point under design.

$$t_c = t_i + t_f \tag{2.3}$$

Where t_c: time of concentration.

t_i: inlet time.

t_f: flow time.

$$\text{Time of flow in storm, } t_f = \frac{\text{Length of pipe line (L)}}{\text{Velocity of flow (v)}} \tag{2.4}$$

Inlet time (t_i): is the time required for water to flow over ground surface and along gutters to drainage inlet. Inlet time is function of rainfall intensity, surface slope, surface roughness, flow distance, and infiltration capacity and depression storage.

2.2.4 Catchments area. A

Most of the catchments are partly developed with residential facilities. The catchments are moderately flat with rural, residential and commercial land uses. The rural areas are located at the downstream end of the catchments.

2.3 Hydraulic Consideration

2.3.1 Introduction

Wastewater systems and (storm water) are usually designed as close 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).

2.3.2 Hydraulic design equations

In principle all closed channel flow formulas can be used in hydraulic design of sewer pipes. The following are the most important formulas:

1. Chezy's formula:

$$V = C\sqrt{RS} \tag{2.5}$$

Where V: the velocity of flow (m/s).

C: the Chezy coefficient; $C = \dfrac{100\sqrt{R}}{m+\sqrt{R}}$, where m = 0.35 for concrete pipe or 0.25 for vitrified clay pipe

R: the hydraulic radius (m)

S: the slope of the sewer pipe (m/m).

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*

$$H = \lambda \frac{L \times V^2}{D \times 2g} \tag{2.6}$$

Where H: the pressure head loss

L: the length of pipe (m).

D: the diameter of pipe (m)

λ : the dimensionless friction factor generally varying between 0.02 to 0.075.

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

$$V = \frac{1}{n} R^{2/3} S^{1/2} \tag{2.7}$$

Where n: the Manning's roughness coefficient [$1/n\ (k_{str}) = 75\ m/s^{1/3}$].

R: the hydraulic radius = area /wetted perimeter (R= A/P).

- For circular pipe flowing full, R=D/4.
- For open channel flowing full, R=A/P.

The Manning's roughness coefficient depends on the material and age of the conduit. Commonly used values of n for different materials are given in Table (2.3).

Table (2.3): Common Values of Roughness Coefficient Used In the Manning Equation (Sarikaya, 1984)

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

2.3.3 Hydraulics of partially field section

The filling rate of a sewer is an important consideration, as sewers are seldom running full, so storm water 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 closed 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%.

2.4 Storm Water Sewers Design

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

2.4.1 Service area

Service area is defined as the total area that will eventually be served by the drainage system.. It is important that the design engineers and project team become familiar with the surface area of the proposed project.

2.4.2 Preliminary investigation

The design engineer must conduct the preliminary investigations to develop a layout plan of the drainage 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.

2.4.3 Layout plan

Proper storm 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 disposal of the storm water at the end of the network, generally the lowest elevation of the entire drainage area.
2. The preliminary layout of storm 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 storm 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 storm sewers are started from the trunk line and extended uphill intercepting the laterals.
5. Preliminary layout and routing of storm sewage flow is done by considering several feasible alternatives. In each alternative, factors such as total length of storm 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 drainage system.
6. After the preliminary storm sewer layout plan is prepared, the street profiles are drawn. These profiles should show the street elevations, existing storm sewer lines, and manholes and inlets. These profiles are used to design the proposed lines.

Finally, these layout plans and profiles are revised after the field investigations and storm sewer designs are complete (Viessman, 1985).

2.4.4 Selection of design parameters

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

1. **Design Flow Rate:** Storm water sewers should be designed to carry the largest storm that occurred in the period of design; commonly it is 5 years because of consideration of the cost and the frequently factors.

2. **Minimum Size:** As mentioned earlier, the minimum storm sewer size recommended is 250 to 300 mm for closed system, and for open channel depend on the type of profile that selected.

3. **Minimum and Maximum Velocities:** In storm water 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. The minimum allowable velocity is 0.75 m/s, and 0.9 m/s is desirable. This way the lines will be flushed out at least once or twice a day. The maximum velocities for storm water system are between 4 to 5 m/s. The maximum velocity is limited to prevent the erosion of sewer inverts.

4. **Slope:** For closed system minimum slopes determined from minimum velocities, for minimum velocity 0.9 m/s, the slopes are shown in Table 2.4.

Table (2.4): Minimum Recommended Slopes of Storm Sewer (n = 0.015) (Sarikaya, 1984)

Pipe Diameter (D)		Slope (min)	Slope (max) =1/D
mm	Inch	mm	mm
250	10	0.00735	0.04
300	12	0.00576	0.033
450	18	0.00336	0.0222
600	24	0.00229	0.0167

Note: for a velocity of 0.75m/s the slopes shown above should be multiplied by1.56.

Maximum slopes determined from maximum velocities, 0.9/D (cm) can be used as a guide.

5. Depth: The depth of storm sewers when using closed system is generally just enough to receive flow but not less than 1 m below the ground surface. Depth depends on the water table, lowest point to be served, topography, and the freeze depth. But for the open channel it is at the ground surface.

6. Appurtenances: Storm Sewer appurtenances include manholes, inlets, outlets and outfall, and others. Appropriate storm sewer appurtenances must be selected in design of storm water sewers.

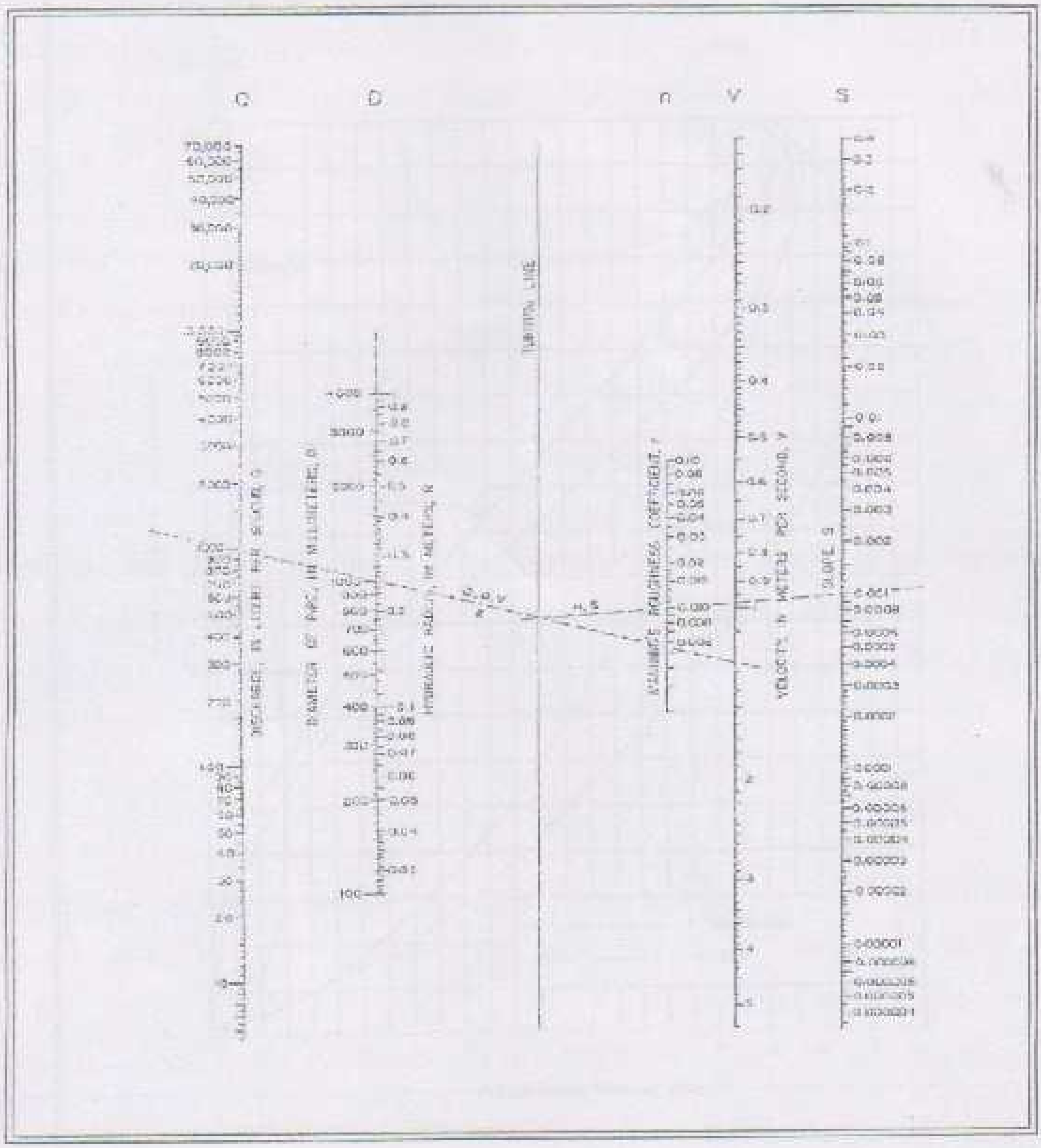
7. Design Equations and Procedures: Storm water sewers are mostly designed to flow partially full. Once the peak, average, and minimum flow estimates and made general layout and topographic features for each line are established, the design engineer begins to size the sewers. Design equations proposed 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 is expressed below:

$$V=\frac{1}{n}R^{2/3}S^{1/2} \tag{2.7}$$

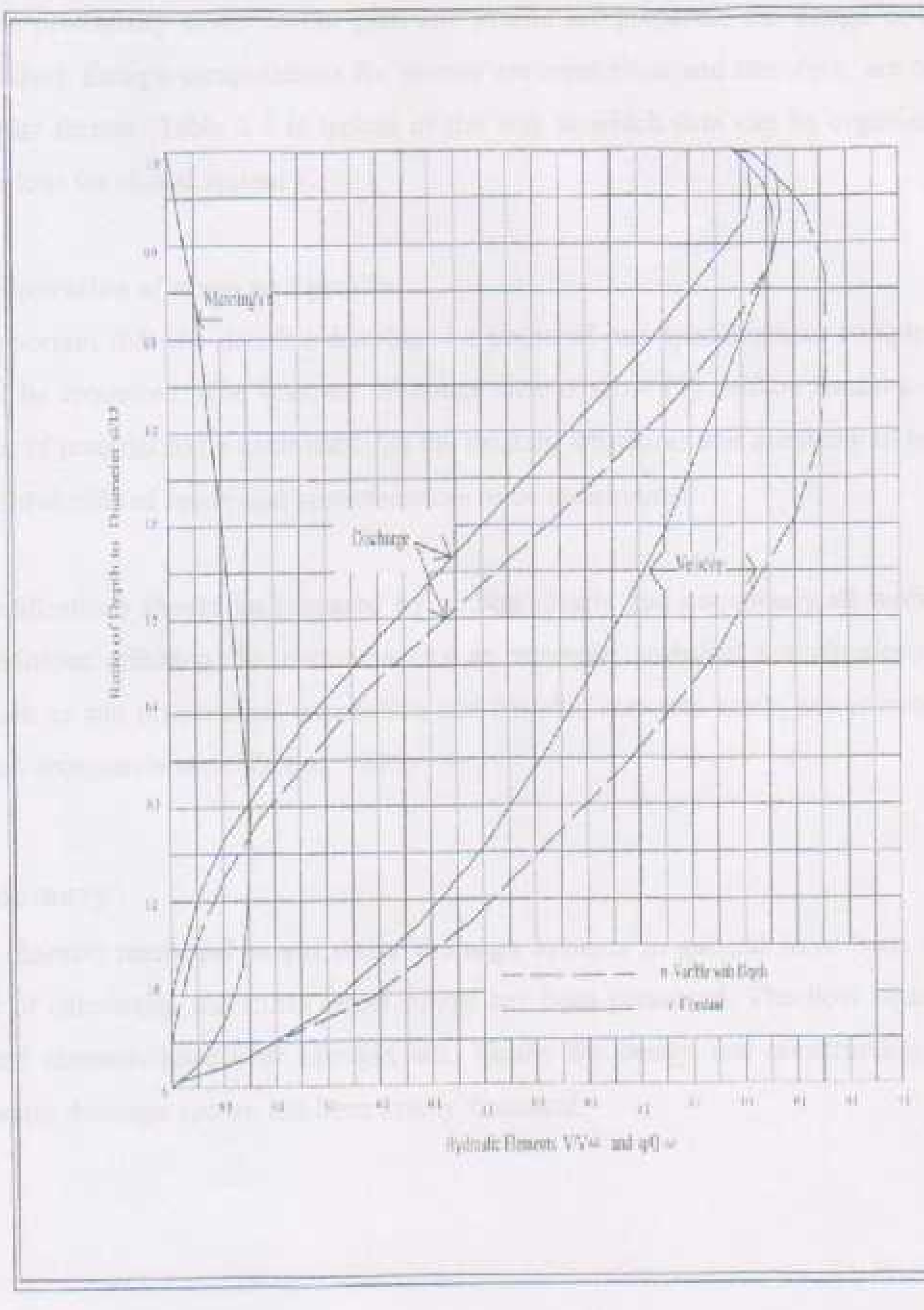
And as mentioned earlier, the runoff flow is calculated using the following formula:

$$Q = C.i.A \tag{2.1}$$

Various types of monographs have been developed for solution of problems involving sewers flowing full. Monographs based on Manning's equation for circular pipe flowing full and variable n values are provided in Figure 2.1. Hydraulic elements of circular pipes under partially-full flow conditions are provided in Figure 2.2. It may be noted that the value of n decreases with the depth of flows Figure 2.1. 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 2.1 and 2.7 and Figures 2.1 and 2.2, one can design the drainage system.



Fig, 2.1: Diagram for Solution of the Manning Formula



Fig, 2.2: Hydraulic Properties of Circular Sewer

2.4.5 Design computations

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 2.5 is typical of the way in which data can be organized to facilitate computations for closed system.

2.4.6 Preparation of maps and profile

It is important that the detailed drawings be prepared and specifications completed before the bide 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 lying, and acceptance tests (Qasim, 1985).

2.5 Summary

In this chapter, municipal storm water drainage systems in general have been described. The method of calculating the storm water runoff has been presented. The flow equations of sewer pipes and channels have been brought out. Finally the design and construction of community storm water drainage system has been briefly discussed.

Table (2.5) Typical Computation Sheet for Storm Water Desing of Closed System

Number	LOCATION			Length	Length Comulative	Area	RAIN FALL INTENSITY								
	Line Name	Upper MH.No.	Lower MH. no.				C FACTOR Area	C.A	(C.A) Comulative	Tc	(i)	Q	Upper MH. Elev.	Lower MH. Elev.	Street Slope
				(m)	(m)	(ha)		(ha)	(ha)	(min)	(l/s.ha)	(l/s)	(m)	(m)	(%)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

CHAPTER

3 DESIGN AND PLANNING CRITEREA

CHAPTER THREE
DESIGN AND PLANNING CRITERIA

3.1 Introduction

In the previous chapters, the problem of the study has been defined and the objectives of the project have been listed. The characteristics of the project area of Dharyia city have been described. Storm water drainage system and design of storm water sewers were explained. In this chapter, basis for planning and design will be discussed including catchment areas, rainfall characteristics, runoff flow, and the design parameters.

3.2 Catchment Areas

Dharyia city is divided into three main drainage catchment areas; the city is divided into regional catchment areas based on the topography of the area and street. The three main catchments are divided into many sub-catchments areas as illustrated in Figure 3.1.

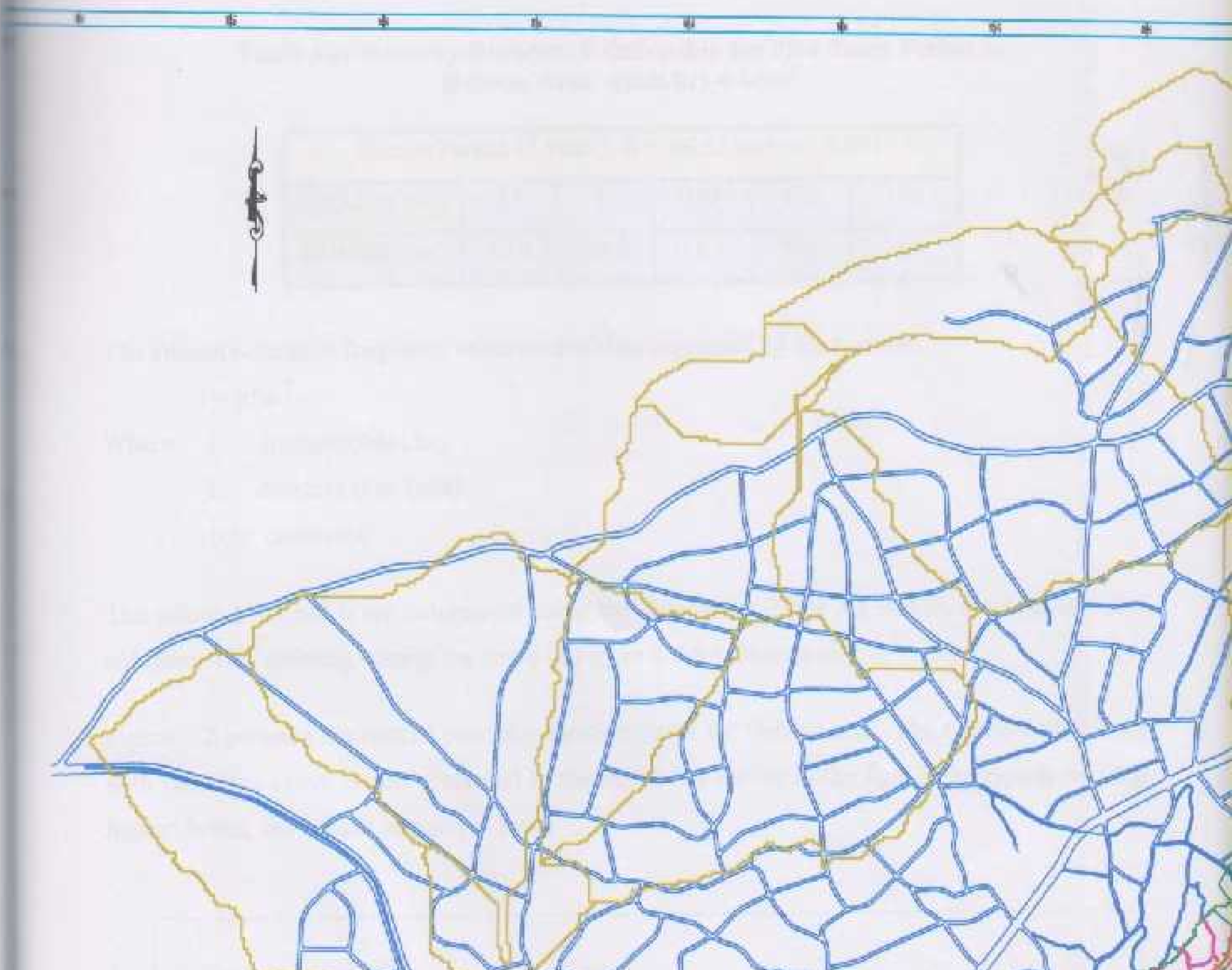
3.3 Rainfall Characteristics

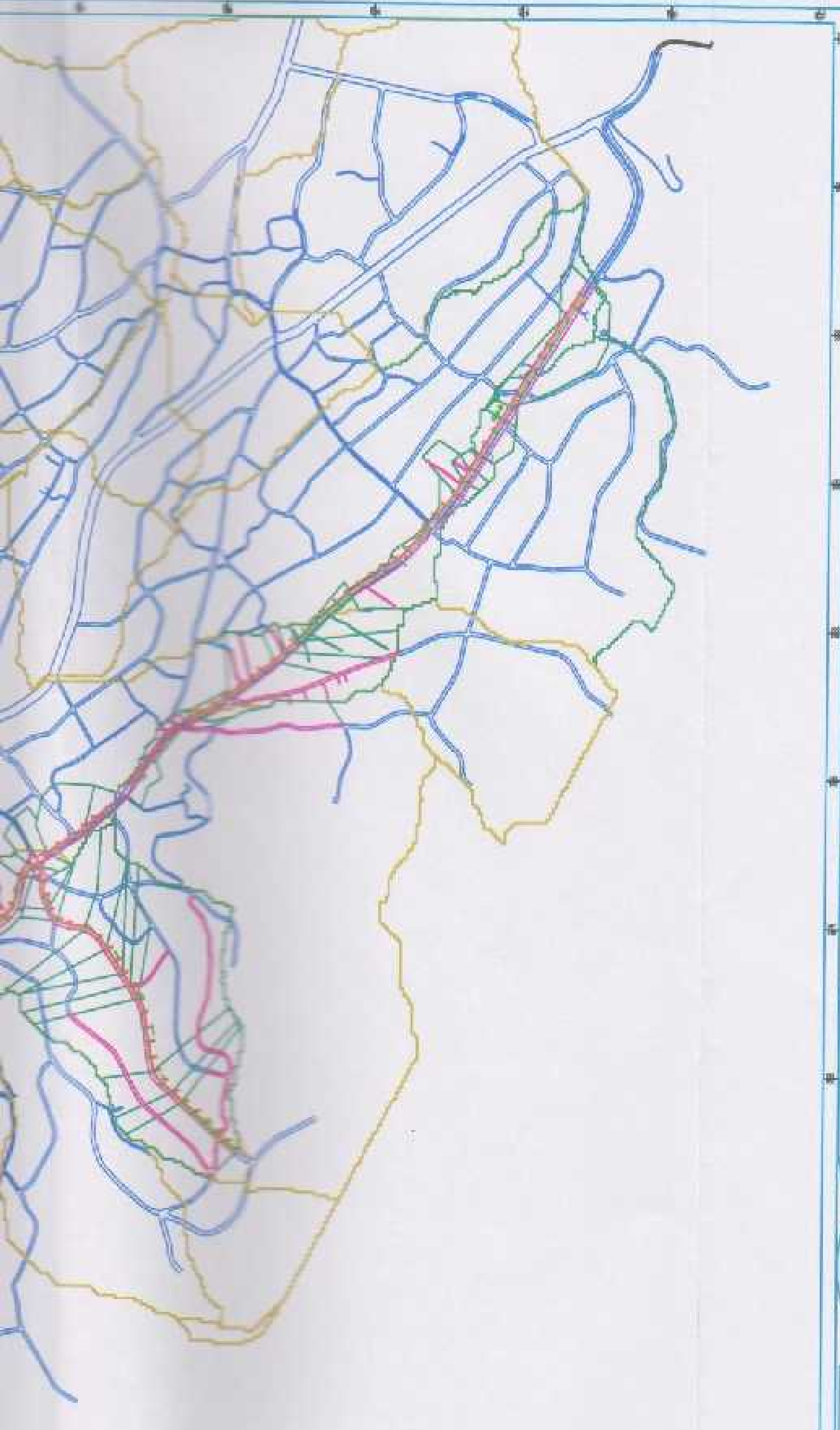
3.3.1 General condition

There is no significant variation in annual rainfall along Dharyia city from the north to the south, the average annual rainfall in Dharyia city for the last five years is 350 mm, of which about 98 percent falls between October and April. There are two well defined seasons, the wet season start in October and extending into April, and the dry season extending from May to September. The monthly average rainfall varies widely, the highest in the last five years (2003 to 2008) being 166 mm occurring in February, 2004, and the second highest of 150 mm on January, 2005.

3.3.2 Intensity-Duration Curve

Standard runoff calculations are based on rainfall intensity for a given time period (rainfall intensity-duration curve). Hebron station measurements have been used as the basis for rainfall throughout Dharyia city, the mean annual rainfall rate at Dharyia station area is approximately equal for the Hebron city. The data obtained from Dharyia station on rainfall intensity are used to draw the intensity- duration curve for Dharyia city. The calculation is presented in Table 3.1.





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Design of Storm Water Drainage System for the Center of AL-Dharyia city

By:
Amani Zalloum
Ruba AL-Joulani

Supervisor:
Dr.Majed Abu Sharkh

Legend:
- area
- Roads
- watershed
- Flow Direction
- Manhole
- Main Line
- Submaim line

catchment area

Scale: 1/20000	Figure Number: 3.1
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Table 3.1: Intensity-Duration Relationship for Five Years Period in Hebron Area $i(mm/hr) = b*m^T$

Return Period (5 years), B = 66.53 and m= 0.993					
Duration(min)	15	75	105	165	180
Rainfall(mm)	15.5	10.2	12.3	9.8	21.3

The intensity-duration frequency relations could be expressed by the formula:

$$i = b*m^T \quad (3.1)$$

Where i: intensity (mm/hr).

T: duration time (min).

b,m: constants.

The values of m and b are determined using the data in the Table 3.1 and by the help of Excel software. This allowing tracing the curve of Figure 3.2 for Dharyia city.

Figure 3.2 presents the rainfall intensity-duration curve for Hebron area. The typical curve along with Gaza city curve is also presented in the figure. As shown in the figure, the typical curve is higher; hence, the rainfall intensity is more.

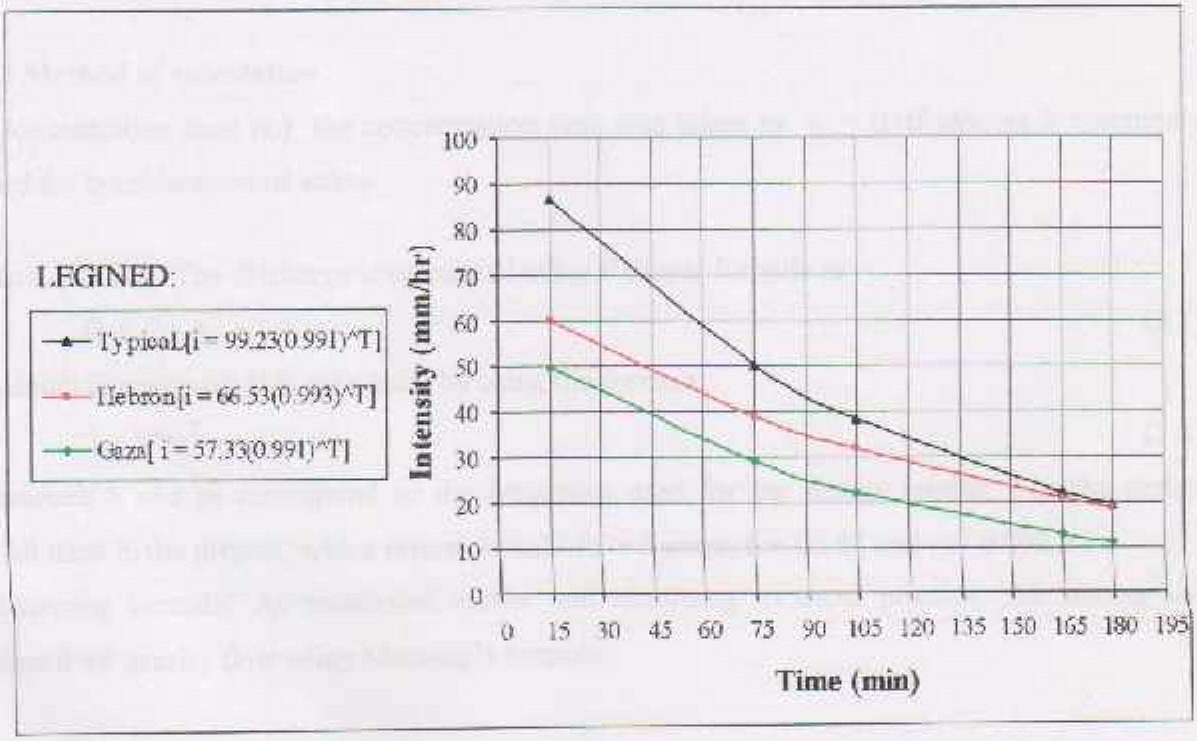


Figure 3.2 - The Rainfall Intensity- Duration Curve

3.4 Runoff flow

3.4.1 Runoff coefficient

The runoff coefficient is a function of the permeability of the surfaces and interception/ retention/ infiltration of storm water in the drainage area. In an developed area, C is a function of the surface and natural soil type. In a developed area, C is a function of the amount of paving and/or development. Because of this, runoff coefficient values for developed areas are closely linked to various type of land use. Typical C values are as shown below in Table 3.2.

Table 3.2: Typical Runoff Coefficients for Developed Area

Development	Coefficient
Pavement, Road/ Parking	0.9
Commercial/ Public	0.7
Residential Communities	0.6
Parks/ Unimproved areas	0.3
Irrigation areas	0.2
Natural zones	0.05

In this project used runoff coeficients(C) =0.7.

3.4.2 Method of calculation

a. Concentration time (t_c): the concentration time was taken as t_c = ti+tf min, as it commonly used for consideration of safety.

b. Flow rate (Q): The discharge is calculated using Rational formula as

$$Q = C.i.A \tag{2.1}$$

c. Rainfall intensity (i): It is calculated by using the formula:

$$i = b*m^T \tag{3.1}$$

Parameters b and m correspond to the frequency used for the design rainfall. For the design rainfall used in the project, with a return period of f = 5 years, b = 66.53 and m= 0.992.

d. Manning formula: As mentioned earlier and according to usual practice, the sewers are designed for gravity flow using Manning's formula:

$$V = \frac{1}{n} R^{2/3} S^{1/2} \quad (2.7)$$

Depending on pipe materials, the typical values of n are:

- Reinforced Concrete (RC) $n = 0.013$
- Polyvinyl Chloride (PVC) $n = 0.011$
- Ductile Iron: $n = 0.013$
- Asbestos Cement: $n = 0.012$

3.5 Design Parameters

3.5.1 Minimum and maximum velocities

Sewers should be "self cleansing" to limit the settling of grit, which in case of "closed channel" determined by the gradient of the sewer invert. The minimum velocity is 0.75 m/s and 0.9 m/s is desirable. The maximum velocity is limited to prevent the erosion of sewer inverts, it is between 4 to 7.5 m/s. In open channel design the minimum and maximum velocity depend on the size and type of profile were we use.

3.5.2 Storm water channels slope

The natural ground slope(G) is used because it is the technical and economic solution. But if $S_{min} < G < S_{max}$ channel slope(S)=G, $G > S_{max}$ $S = S_{max}$, $G < S_{min}$ $S = S_{min}$.

3.5.3 Design period

In designing of storm water system the appropriate period that used is 25 years, which is selected in the this project.

3.6 Summary

in this chapter "Basis for Planning and Design criteria", catchment areas have been found, intensity-duration curve has been estimated, runoff flow chosen, and the design parameters have been described.

4 ANALYSIS AND DESIGN

4.1 Introduction

4.2 Layout of the System

4.3 Design Computation

4.4 The Proposed Storm Water Drainage System

4.5 Profiles of Sewer

CHAPTER FOUR
ANALYSIS AND DESIGN

4.1 Introduction

In this project, an attempt is made to evaluate and design storm water drainage system for the Dharyia city, in order to solve the problem causes by the cumulative flooded storm water in the streets. In this chapter, the layout of the system established will be presented followed by discussion of detailed design computations and the final design and profiles of the suggested storm water drainage system.

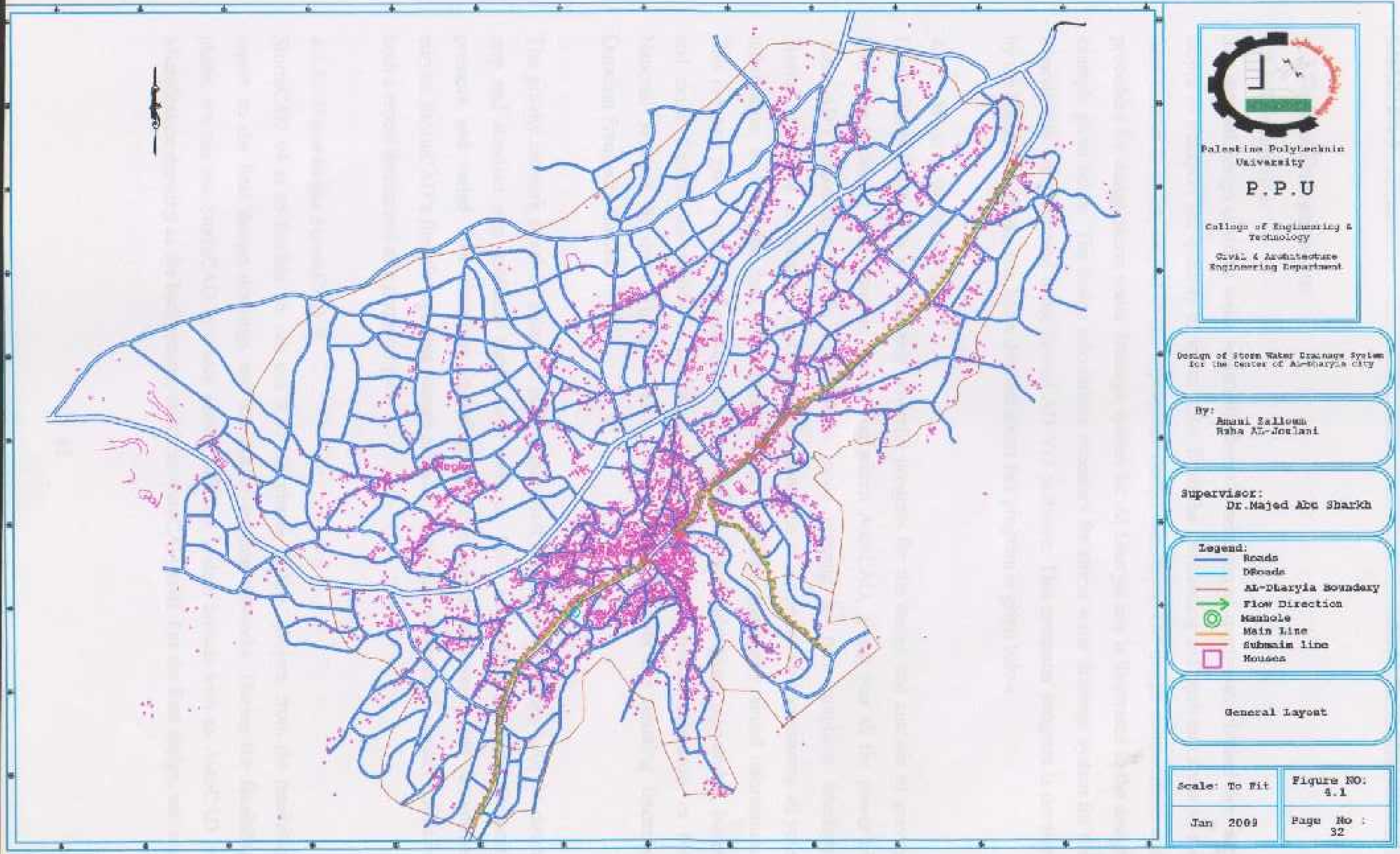
4.2 Layout of the System

The first step in designing a storm water drainage system is to establish an overall system layout that includes a plan of the area, showing roads, streets, buildings, other utilities, topography, and soil type.

In suggesting the layout of storm water drainage system for Al Dharyia city, the following basic steps were followed:

1. Obtain a topographic map of the area to be served.
2. Locate the catchments area of the city and determine the area of these catchments, the catchments are determined by using GIS and Arc View program.
3. Sketch in preliminary closed channel system to serve all the areas.
4. Sewers layout is followed natural drainage ways so as to minimize excavation and pumping requirements.
5. Establish preliminary channel sizes that can drain the required water runoff.
6. Revise the layout so as to optimize flow-carrying capacity at minimum cost. Channel lengths and sizes are kept as small as possible, channel 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.

The final layout of storm water drainage system for Al Dharyia city is illustrated in the Fig. 4.1.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Legend:
Roads
DRoads
AL-Dharyia Boundery
Flow Direction
Manhole
Main Line
Submain line
Houses
General Layout
Scale: To Fit
Figure NO: 4.1
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4.3 Design Computations

4.3.1 Introduction

The detailed design of storm water sewers involves the selection of appropriate channel sizes and slopes to transport the quantity of storm water from the surrounding and upstream areas to the next channel in series, subject to the appropriate design constrains. The design computations and procedure for design storm water drainage system for Al Dharyia city is illustrated in the design example given below. The design calculations necessary for storm water drainage system for the Dharyia city are performed using SewerCAD Vs5 software. This computer program is develop by the Haestad Methods, Inc. More detailed about this program is given below.

4.3.2 What is StomCAD ?

Design StormCAD v4 is an extremely powerful program for the design and analysis of gravity flow pipe networks. The program can be run within AutoCAD, giving you all the power of AutoCAD's capabilities, or in Stand-Alone mode utilizing its own graphical interface. StormCAD allows to construct a graphical representation of a pipe network containing all your information, such as pipe data, inlet characteristics, watershed areas, and rainfall information. This program give a choice of conveyance elements including circular pipes, pipe arches, boxes and more. Rainfall information is calculated using rainfall tables, rainfall equations, or the National Weather Service's Hydro-35 data. StormCAD also plots the resulting Intensity Duration Frequency Curves.

The gravity network is solved 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 pressure and varied flow situations, including hydraulic jumps, backwater, and drawdown curves. StormCAD's flexible reporting feature allows to customize and print the model results in both a report format and as a graphical plot.

4.3.3 When to use StormCAD ?

StormCAD v4 is so flexible we can use it for all phases of this project, from the feasibility report to the final design drawings and analysis of existing networks. During the feasibility phase, we can use StormCAD to create several different system layouts with an AutoCAD or MicroStation drawing as the background, or within AutoCAD itself. For the final design, we can complete detailed drawings with notes that can be used to develop the construction plans. In summary, we can use StormCAD to:

• Design multiple storm sewer systems.
• Analyze various design scenarios for storm sewer systems.
• Import and export AutoCAD and MicroStation .DXF files.
• Predict rainfall runoff rates.
• Generate professional-looking reports for clients.
• Generate plan and profile plots of a network.

4.3.4 Design Example: Design a gravity flow storm water drainage channel

In the design of the gravity flow storm water drainage system, the design flow for each line is calculated first, then the values of design flows are used to determine the diameters of the pipes and other design parameters such as velocity, flow, depth of flow, etc. The following design criteria have been developed and adopted based on an analysis of local conditions and codes.

1. Runoff coefficient (C) 0.7.
2. Inlet time (T_i) use 10 minuets.
3. Concentration time (T_c) use equation (2.3).
4. Rainfall intensity = 66.53 $(0.993)^{\wedge T_c}$.
5. Runoff rate depending on the formula: Q = C i A.

In the solution of this example, we will explain how we calculated the design flow of part of line A. The complete design of line A and other lines will be presented in the final report of this project.

Solution:

1. Lay out the storm water sewer. Draw a line to represent the proposed sewer
2. Locate and number the upper and lower manhole of the line.
3. The necessary computations for the storm water sewer (see Appendix A). The data in the table are calculated as follow:

a. The entries in columns 1 through 4 are used to identify the point locations, their numbers and the length between them and 5 to 6 the length.
b. The entries in columns and 7 are used to identify the sewered area of streets, shows the partial sewered area in hectare,

c. The entries in columns 8 through 16 are used to identify rainfall intensity and to calculate the design flow. Runoff coefficient (C) is entered in column 8. The area in hectare is multiplied by runoff coefficient (C) and the result is given in column 9.The cumulative multiplication of the sewered area in hectare is multiplied by runoff coefficient (C) are given in column 10. The concentration time is shown in column 11 and rainfall intensity is shown in column 12. Column (13) shows the cumulative runoff rate (Q) which obtained by multiply column (12) by column (10).

d. The slope is obtain by subtracting the elevation of the lower manhole(column15) from the elevation of the upper manhole (column15) and divide the result by the value of length (column 5).

4.4 The Proposed Storm Water Drainage System

In the proposed study for the Storm Water Drainage System for the center of Dharyia, the trial is made to design the main trunks of the collection system. This section deals with the results of the suggested wastewater collection network.

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 Storm Water Drainage System for the center, slopes and lengths of the pipes are given in Tables of Appendix-A. The calculated velocities, flow rates, and depth of flow in pipes are given in the same tables.

4.5 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 .

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 Figures of Appendix-B . 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.

CHAPTER 5

BILL OF QUANTITY

CHAPTER FIVE

BILL OF QUANTITY

1 – Excavations and backfilling

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
1.1	Excavations and backfilling nominal pipe diameter 600 mm				
1.1.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2m and disposing surplus material outside the site according to drawings. And specifications.	L.m			
1.1.2	Ditto, but for excavations between 2.00-2.5m	L.m	2050		
1.1.3	Ditto, but for excavations between 2.5-3 m	L.m	50		
1.1.4	Ditto, but more than 3m				
1.2	Excavations and backfilling nominal pipe diameter 450 mm				
1.2.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2 m and disposing surplus material outside the site according to drawings. And specifications.	L.m	750		
1.2.2	Ditto, but for excavations between 2.00-2.5m	L.m	600		
1. 2.3	Ditto, but for excavations between 2.5-3 m	L.m	200		
1.2.4	Ditto, but more than 3m		100		
1.3	Excavations and backfilling nominal pipe diameter 375 mm				
1.3.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2 m and disposing surplus material outside the site according to drawings. And specifications.	L.m	400		
1.3.2	Ditto, but for excavations between 2.00-2.5m	L.m			
1.3.3	Ditto, but for excavations between 2.5-3 m	L.m			
1.3.4	Ditto, but more than 3m		200		
1.4	Excavations and backfilling nominal pipe diameter 300 mm				
1.4.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2 m and disposing surplus material outside the site according to drawings. And specifications.	L.m	900		
1.4.2	Ditto, but for excavations between 2.00-2.5m	L.m	50		
1.4.3	Ditto, but for excavations between 2.5-3 m	L.m	100		
1.4.4	Ditto, but more than 3m				

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
1.5	Excavations and backfilling nominal pipe diameter 250 mm				
1.5.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2 m and disposing surplus material outside the site according to drawings. And specifications.	L.m	300		
1.5.2	Ditto, but for excavations between 2.00-2.5m	L.m	100		
1.5.3	Ditto, but for excavations between 2.5-3 m	L.m			
1.5.4	Ditto, but more than 3m				
1.6	Excavations and backfilling nominal pipe diameter 200 mm				
1.6.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2 m and disposing surplus material outside the site according to drawings. And specifications.	L.m	250		
1.6.2	Ditto, but for excavations between 2.00-2.5m	L.m			
1.6.3	Ditto, but for excavations between 2.5-3 m	L.m			
1.6.4	Ditto, but more than 3m				
1.7	Excavations and backfilling nominal pipe diameter 150 mm				
1.7.1	Excavation of pipe trench in all kinds of soil, rock, etc, the price shall include cost of backfilling with selected suitable material approved by the engineer, and shall include leveling and compaction to a depth not exceeding 2 m and disposing surplus material outside the site according to drawings. And specifications.	L.m	150		
1.7.2	Ditto, but for excavations between 2.00-2.5m	Lm			
1.7.3	Ditto, but for excavations between 2.5-3 m	Lm			
1.7.4	Ditto, but more than 3m				

2– Pipes

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
	Pipes				
2.1	Supply, store and installation of pipes diameter **600(uPVC)** with the Techen stamp or equivelant, along with the fittings, according to drawings, and specifications.	L.m	2100		
2.2	Ditto, but for pipes diameter **450mm(u PVC)**	L.m	1650		
2.3	Ditto, but for pipes diameter **375mm(u PVC)**	L.m	600		
2.4	Ditto, but for pipes diameter **300mm(u PVC)**	L.m	1050		
2.5	Ditto, but for pipes diameter **250mm(u PVC)**	L.m	400		
2.6	Ditto, but for pipes diameter **200mm(u PVC)**	L.m	250		
2.7	Ditto, but for pipes diameter **150mm(u PVC)**	L.m	150		

3- Concrete manholes

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
3	**Concrete manholes** **Precast manholes**				
3.1	Supplying and installation of manhole, coated with coal tar epoxy, including excavations in all kinds of soil, rock, etc, shall include cost of backfilling with selected suitable material approved by the engineer, and steps and benching, heavy duty cover 25 tons for streets, and 8 tons for cross country fields and backfilling not exceeding 2m .**Diameter1200mm** according to drawings and specifications.	No.	112		
3.2	Ditto, but depth between 2.00-2.50m	No.	8		
3.3	Ditto, but depth between 2.50-3.00m	No.	4		
3.4	Ditto, but more than 3m	No.	4		

4 – Pipe bedding

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
4	**Pipe bedding**				
4.1	Supplying, installation and compaction of (**Absolet**) fine granular material, under, above and around pipe Diameter (according to depth at items 1.1) **600mm** according to the drawings and specifications.	L.m	2100		
4.2	Ditto, but for pipes diameter 450mm	L.m	1650		
4.3	Ditto, but for pipes diameter 375mm	L.m	600		
4.5	Ditto, but for pipes diameter 300mm	L.m	1050		
4.6	Ditto, but for pipes diameter 250mm	L.m	400		
4.7	Ditto, but for pipes diameter 200mm	L.m	250		
4.8	Ditto, but for pipes diameter 150mm	L.m	150		

5– concrete works

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
5	**Concrete works**				
5.1	Supply and cast encasement plain concrete (B-200) surround for sewer, according to drawings and specifications.	m^3	50		

6 – Air leakage test

Item	Item Description	Unit	Quantity	Unit Price €	Total amount €
6	**Air leakage test**				
6.1	Air leakage test for **sewer** pipelines according to specifications, including for all temporary works				
6.1.1	Nominal bore 600mm	L.m	2100		
6.1.2	Nominal bore 450mm	L.m	1650		
6.1.3	Nominal bore 375mm	L.m	600		
6.1.4	Nominal bore 300mm	L.m	1050		
6.1.5	Nominal bore 250mm	L.m	400		
6.1.6	Nominal bore 200mm	L.m	250		
6.1.7	Nominal bore 150mm	L.m	150		
6.2	Water leakage test for all **manholes**, according to specifications, including for all temporary works.	NO.	128		

7 – Road reinstatement

Item	Item Description	Unit	Quantity	Unit Price €	Amount €
7.1	Provide and place 250 mm, base coarse For Sewer Pipes Ø 600,450,375,300,250,200, , & 150along with 50 mm asphalt over it, after compaction, all the work includes compaction, bitumen layer (1.0 lt./m 2) between the base coarse layer.	Lm	5535		

Summary Table (for the project)

1	**Excavations and backfilling**	**6200**
2	**Pipes**	**6200**
3	**Concrete manholes**	**128**
4	**Pipe bedding**	**6200**
5	**Concrete works**	**50**
6	**Air leakage test**	**6200+128**
7	**Road reinstatement**	**5535**

Discount as percentage of the total amount = ------------------------

TOTAL CONTRACT AMOUNT AFTER DISCOUNT = ----------------

CHAPTER 6 CONCLUSIONS

CHAPTER SIX
CONCLUSIONS

In this project, the trial is made to evaluate and design storm water drainage system for the center of AL Dharyia city, considering the water runoff, the wide expansion, accelerated development and growth of the city. The result brought out many important conclusions. The main conclusions drawn from the present study are summarized below:

1. Most of the areas in AL Dharyia city do not have a natural drainage outlet. Heavy rainfall causes storm water to collect in low areas and flood streets and walk ways.

2. The accumulation of storm water in the main streets in Al-Dhahyria city causes problems to the peoples; subsequently there is a big need for immediate steps for construction of the proposed storm water drainage system for the center of Al Dharyia city.

3. The flow in the proposed storm water drainage system is going by gravity, hence, the topographical features of the area is allowed.

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REFERENCES

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APPENDIX- A COMPUTATION AND REPORT TABLES

APPENDIX- B LAYOUT AND PROFILES

THE END