CAPITAL UNIVERSITY OF SCIENCE AND TECHNOLOGY, ISLAMABAD

Hydraulic and Financial Comparison of Combined and Separate Sewer Systems for a Residential Colony in Islamabad

by

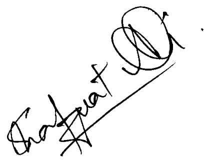
Shafquat Ali Aslam

A thesis submitted in partial fulfillment for the degree of Master of Science

in the

Faculty of Engineering
Department of Civil Engineering

2020



This endeavor is dedicated to my esteemed and loving whole family, who helped me through all hard times of my life and forfeited all the coziness of their lives for my optimistic future. This is also a tribute to my honorable teachers who guided me to face the challenges of life with patience and courage, and who made me what I am today.

CERTIFICATE OF APPROVAL

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Acknowledgements

All praise to Almighty Allah, The Most Merciful and Most Beneficent. The Humblest and deepest gratitude is extended to all time Leader of the world, Muhammad (SAWW), for whom this entire cosmos has been staged.

This thesis, as it appears in its existing shape, is a result of the direction of my supervisor. I express my gratitude to my supervisor **Dr. Engr. Ishtiaq Hassan**. His advice and encouragement during the preparation of this research. Thesis is sincerely appreciated. He always helped me and provided guidance. He remained constant source of encouragement and impetus to me, and provided me with all the resources I needed. I am also thankful to all the teachers for their guidance, support and cooperation during my study period.

My genuine and warmest gratefulness to **Engr. Mukhtar Arshad**, Chief Engineer NESPAK who whole heartedly helped and motivated me to complete my research work.

Lastly and foremost, I express my deepest gratitude to my family members, for their cooperation and encouragement throughout my studies.

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Abstract

Infrastructures are valuable, important and hygienic part of a society. Its several parts like wastewater and storm drainage systems are out of sight. Urban drainage networks are often provided to convey urban wastewater and storm water towards a wastewater treatment plant. Commonly two types of urban drainage networks are in use i.e. separate and combined systems. In separate system, dry weather flow or sanitary sewage and surface water storm flow is transported through separate pipes. In combined system wet weather and dry weather flows are disposed via single conduit. It is an old debate whether to choose separate or combined system. There always confusion remains for infrastructure designers and planners which system is hydraulically suitable, durable and less costly.

Purpose of this study is to check suitability of system selection by doing hydraulic and financial comparison subjected networks. A residential colony in Zone-V Islamabad was selected and both systems were designed. Study area is located about 4.5 km away from Islamabad Expressway, where its one end is touching Japan Road while other end is connected to Naval Anchorage. Residential colony in question is situated in Potohar region having hilly terrain and comprised of 1476 Kanals. Drawings were prepared by using AutoCAD software, whereas design calculations and cost sheets were prepared by using Excel software. According to calculated flow loads, hydraulic behaviour in both systems was varying. Due to mixed flows during wet weather higher discharge and higher velocities observed in combined system as compared to separate system. Hydraulic analysis shows that actual cumulative discharge at outlet no 1 and 2 (located at STP-1 and STP-2) in combined system was 81.91 cusecs, 69.08 cusecs, respectively and at same points it is 0.86 cusecs, 1.36 cusecs in separate system. Maximum velocity at outlet no 1 and 2 in combined system is 18.01 ft/sec, 7.31 ft/sec while at same points it is 3.15 ft/sec, 3.42 ft/sec in separate system sewers. Wastewater flow Velocities and sewer lines grades were kept within specified limits, but in cases of flow velocities more than 8.5 ft/sec steps were provided in drain beds to supress high velocity impacts and to avoid erosional effects. For validation of selected circular shape cross sections, flow depths velocity and discharge were worked out from the table readings based on hydraulic characteristics graph. For rectangular sections velocity and discharge was validated using tables, while at critical discharge locations flow depth was verified through Manning's equation solution by Newton's Method. Flow depths found within limits for the selected cross sections which satisfactorily accommodates velocity and discharge conditions. Finally, the cost comparison of both system shows that cost of combined system is 14.06% higher than separate system. Keeping in view the volume of discharge at two outlet points a larger WWTP and additional diversion structures are required as compare to separate system which could further increase cost of combined system. To the best of author's knowledge it is the first practical comparison of both systems which could help in decision making for the selection of appropriate wastewater collection system.

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Abbreviations

ASCE	American Society of Civil Engineering
AD	Anno Domini
BC	Before Christ
BOD	Biological Oxygen Demand
BSCP	British Standard Code of Practice
CDA	Capital Development Authority
COD	Chemical Oxygen Demand
CS	Combined Sewers
CSO	Combined Sewer Overflow
cusec	Cubic Meter per Second
DWF	Dry Weather Flow
DW	Dry Weather
EL	Energy Level
FGL	Finished Ground Level
FRL	Finished Road Level
ft^2	Square Feet
ft	Feet
ft/sec	Feet per second
ft^3/sec	Cubic Feet per Second
ft/ft	Feet per Feet
gal/min	Gallons per Minute
GPD or gpd	Gallons per Day
gpcd	Gallons per Capita per Day
HGL	Hydraulic Grade Line

ICT	Islamabad Capital Territory
in/hr	Inch per Hour
KG or kg	Kilogram
m	Meter
m/m	Meter per Meter
m^3/sec	Meter Cube per Second
m^2	Square Meter
MGD	Million Gallons per Day
MR	Main Road
Nos	Numbers
PCC	Plain Cement Concrete
PF	Peak Factor
PD	Population Density
PWD	Public Works Department
Q_{act}	Actual Discharge
Q_f or Q_{full}	Full Discharge
Q_{th}	Theoretical Discharge
RCC	Reinforced Cement Concrete
RFT	Running Feet
RoW	Right of Way
Rs	Rupees
Sft	Square Feet
SS	Separate Sewer
SSO	Separate Sewer Overflow
STP	Sewerage Treatment Plant
V_{act}	Actual Velocity
V_f	Velocity at Full Flow Condition
V_{MAX}	Maximum Velocity
V_{Min}	Minimum Velocity
WWTP	Waste Water Treatment Plant
WW	Wet Weather
USA	United Stated of America

Chapter 1

Introduction

1.1 Prologue

Comparison is usually compulsory between different engineering considerations and economies for the selection of wastewater sewer system [1]. Collection and transport of wastewater by sewer system is matter of vital importance. Sewer and Drains are mostly hidden from sight i.e. underground but form invaluable part of urban infrastructure. Sewers minimize the risk of contact between human and its excreta containing harmful bacteria that could spread diseases. The physical layout of an urban district directly effects the choice of sewer system and its installation cost. All the process of collection, carrying and treatment of blackwater (wastewater containing human waste) plus rainwater is known as sanitation [2, 3]. A cost-effective and preferable sewer system could be achieved by making the best use of design alternatives that could reduce infrastructural cost without breaching operational requirements. Most effective usage of network layout, pipe slopes and pipe diameters could minimize construction costs remarkably [4].

Wastewater collection networks considerably contribute to the overall cost of municipal sewer system. The cost of wastewater services systems could be notably reduced by adopting economical design [5]. The most costly component of traditional sewerage is the collecting system which consumes 80 to 90 percent of total cost. So as to achieve cost savings, design criteria and standards could be carefully modified by the use of smaller pipe diameters, shallower excavation depths and fewer accessories. Such alterations introduced should be reliable, harm free and without endangering safety of the system [6, 7]. This study focuses to improve the approach for choice of suitable wastewater disposal system.

A sewer is known as conduit which carries stormwater, wastewater or other waste flows. Sewerage is a systems of sewers. The system may be composed of storm sewers, sanitary sewers or combination of both [8].Three basic systems are used for wastewater disposal from urban community. The combined system, the separate system and the partially separate system. In partially sewer system the considerable part of surface water is handled by surface water sewers, while the surface water from back parts of roofs and courtyards or gardens is diverted towards foul sewers. Partially sewer systems is adopted in those areas where local water consumption is not plentiful high to keep clean foul sewers [1]. Combined sewers are constructed for collection and transfer of sanitary sewage, storm surface runoff and industrial wastewaters in one conduit [9]. The separate system is comprised of two separate pipes or drain networks where one carries storm waters and the other one carries wastewater. Improved separate system is like original separate system but improvement is the interconnection of sewer and storm networks at manholes to divert initial part of rainwater towards wastewater treatment plant [2].

The combined and separate sewer systems have similar behavior and discharge almost the same mass of untreated flow into receiving water body however, the combined scheme discharges somewhat higher mass [10]. Commonly, it is thought that separate system is cheaper than combined network if no treatment works are applied for rainwater but in case of WWTP (Waste Water Treatment Plant) application separate system is expensive [11]. Separate sewer system not often remain separate, yet there is always some quantity of stormwater in foul sewers and in the same way some wastewater in storm systems. In most cases, these both systems behave like two combined systems with varied degree of wastewater dilution [12]. Numerous researches are being done on urban drainage systems but it is much needed to assess the performance of combined and separate sewers in hydraulic and financial perspective.

1.2 Research Motivation

In recent years rapidly growing urban population have increased the importance of urban drainage systems which is foremost part of urban infrastructure. It is confidently forecasted that by the mid of this century, 70% of the global population will reside in urban areas. Urban drainage as an amenity in the city not only plays role for flood protection, pollution management and control but also caters for improvement of qualitative life. For safe and healthy urban environment, properly designed and operated urban wastewater drainage systems are a crucial element [12].

There exist concepts of adopting either Separate System (SS) or Combined System (CS) to carry sewerage and drainage from their point of start to disposal point. The decision rests with the design engineer. So far there is no study that practically gives financial and functional comparison of SS and CS for one project area. Both systems are illustrated in Fig. 1.1. This research study aims to perform this comparison in physically identical conditions to decide which system would carry hydraulic and financial acceptability. The main focus shall be to develop such cross-sections of CS that is capable to carry sewerage during dry season without silting/deposition and is also capable to withstand expected storm flows for 10 years return period efficiently without erosion.

1.3 Overall and Specific Research Objectives

Overall objective of this research is to improve the approach for choice of suitable wastewater disposal system.

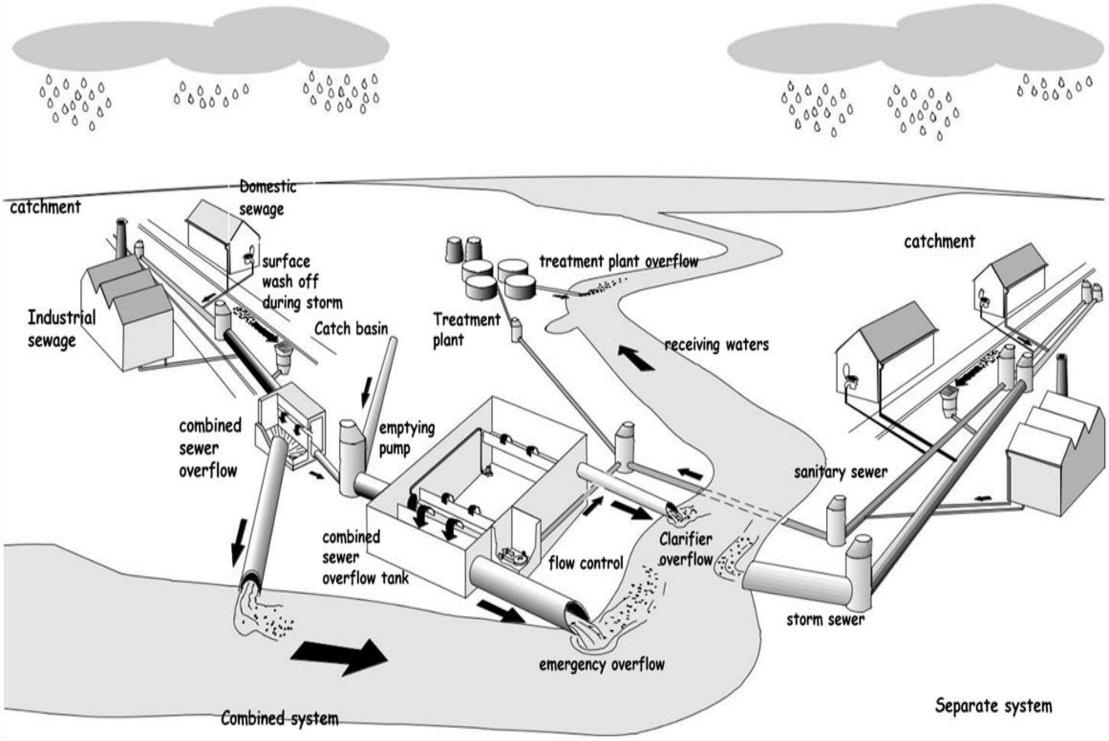

FIGURE 1.1: Customary combined sewer system (left) and separate sewer systems (right) [13].

In this research work, the comparative assessment of combined and separate wastewater collection in hydraulic and financial perspective was performed. Thus, the specific aim of this research is as follows:

"To analyse the hydraulic and financial features of the separate and combined sewer systems in physically identical conditions and their comparison for the selection of suitable sewer system".

1.4 Research Methodology

Drainage of wastewater for selected study area is considered to be compared in hydraulic, financial perspective by using combined and separate sewer systems. Master plan of residential colony located in Zone-V Islamabad prepared by using AutoCAD software is superimposed on survey map to fix location of sewer and drain lines for both systems. Hydraulic design, cost evaluation for both systems is prepared using Excel spreadsheets and results compared to choose suitable wastewater disposal network. Figure 1.2 showing flow chart of whole research process.

1.5 Thesis Layout

The thesis layout comprises of main five chapters. These are:

Chapter 1: Introduction. It explains about the background of sewer drainage systems, research motivation, research objective and methodology, and thesis layout.

Chapter 2: Literature Review. It consists of background, about sewer and sewerage, history of sewers and their types, combined, separate and improved sewer systems, research up to now regarding both systems, Storm drain and sewer components, hydraulic elements like flow types, flow behavior, dry and wet weather flows, factors effecting waste water flow, open channel flow and open channel flow in artificial channels, wastewater flow velocity, channel or conduit geometric elements, Normal depth and its relationship with gradient and friction, hydraulic design equations like Equation of Continuity and Manning's Equation, hydraulic elements graph and use of tables based on it, Peak Factor evaluation for dry weather flows, Rational method for surface water estimation and Weighted Runoff Coefficient "C" calculation, Manning's Equation solution through Newton's Method to work out normal flow depth in rectangular channels, pre design consideration for both systems, return period and design points identification, design steps for drainage networks, importance of cost evaluation, use of Excel spreadsheets for design of drainage systems, historical debate over combined and separate sewer systems.

Chapter 3: Study Area, Data and Methodology. Explains about related data and design methodology for separate and combined sewer systems, study characteristics, data collection contains topography of the area and climate data, design of separate system which contains sewer and storm drain design procedures including hydraulic design equations, sewage quantity assessment based on water consumption, population and water demand for the selected project, peak factor

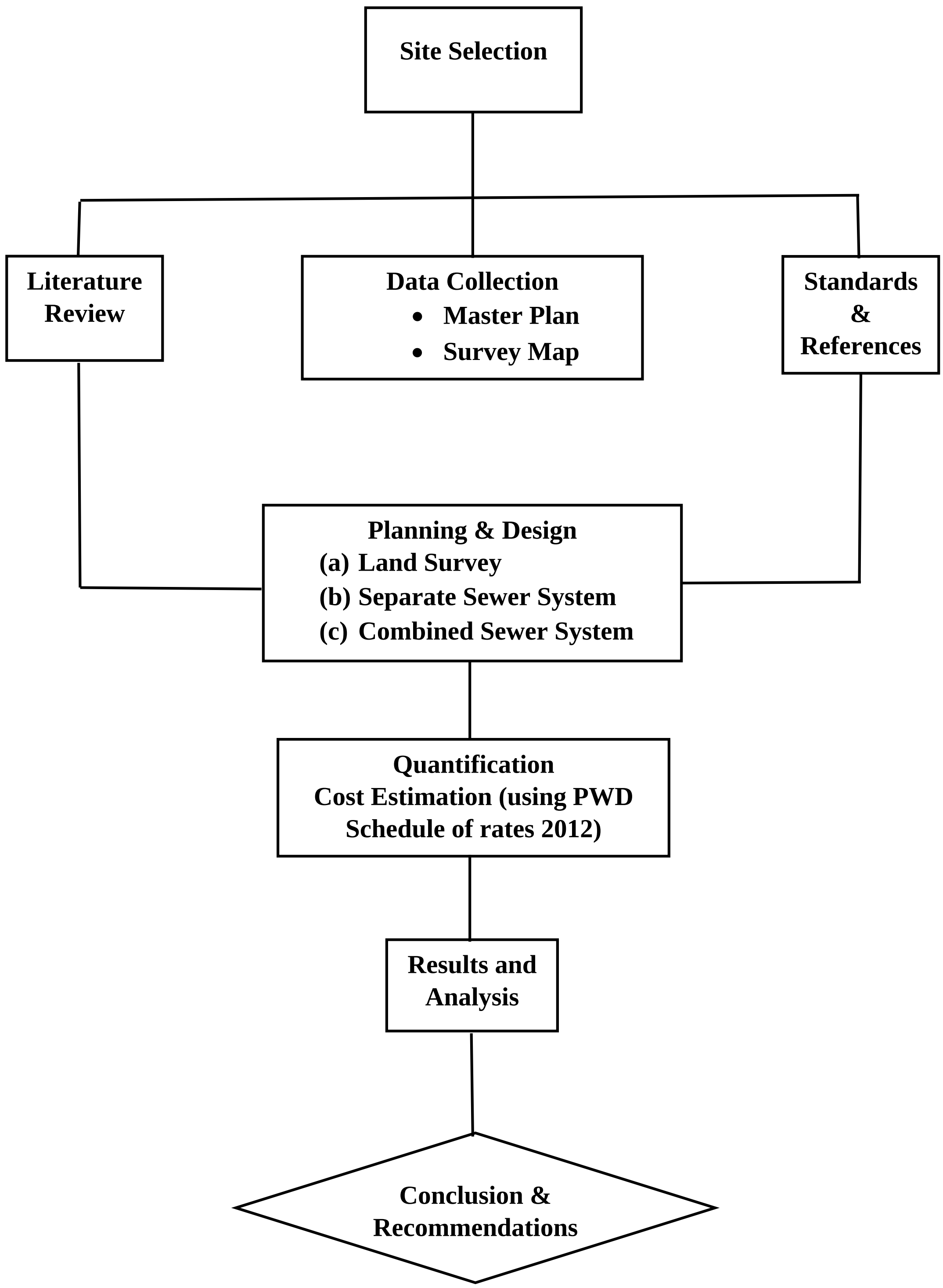

FIGURE 1.2: Research methodology flow diagram.

and peak sewage flows, sewer sizing linked to flow velocity and conduit gradient, part full flow and full flow conditions in conduits, sewer system accessories, Storm drain design for the study area by using Rational Method and calculation of elements in connection with this method, drain sizing, capacity for full flow and part flow conditions, velocity and gradient limitations for flow, estimation of normal flow depth for rectangular drains, appurtenances of storm drains, methods of combined drainage system for study area similar to procedures adopted for separate sewer system, Structural materials used for both drainage systems, cost evaluation procedure for drainage systems in question.

Chapter 4: Results and Analysis. regarding separate and combined sewer systems designed for the selected area. Design outputs prepared in Excel environment for both drainage systems including normal depth calculations and weighted runoff coefficient calculation sheets, costs estimation for both systems, analysis and compassion of both drainage networks systems in hydraulic and financial perspective.

Chapter 5: Conclusions and Recommendations. On the basis of results and analysis report obtained in chapter 4 it is concluded which system behaves better hydraulically and financially. Future recommendations for adoption of suitable drainage system.

All references are listed after the chapter 5.

There are appendices A, B, C, D, E, F, G, H I. J, K, L, M, N, O, P, Q and R. Appendix A contains hydraulic characteristics table for circular conduits. Appendix B consist of hydraulic design sheets for Separate sewer system. Appendix C presents weighted runoff calculation sheet, Appendix D shows hydraulic design sheets for combined sewer system. Appendix E shows quantity and cost estimation spreadsheets for both systems. Appendix F contains dry weather flow layout drawings for separate system. Appendix G shows storm drains layout drawings for separate system. Appendix H presents mixed flow layout drawings for combined sewer system. Appendix I shows x-section drawing of multi diameter circular pipes used for both systems. Appendix J presents shallow, deep circular and square manhole drawings for both networks. Appendix K consist of drawings for multi size rectangular storm drains. Appendix L shows drawings of stormwater feeding catch pits. Appendix M presents drain plus cunette drawings for combined system, Appendix N shows drawings of outfall drainage structures provided at outlets of storm drains. Appendix O presents consist of drawing for steps provided in storm drain beds to suppress flow velocity. Appendix P shows drawings and photograph of trapezoidal shape drain and perforated catch pit cover. Appendix Q presents calculation of peak factor and sewage flow calculations sheets. Appendix R contains X-Sectional drawings of multi ROW roads and walkways showing storm drains and sewer lines placement.

Chapter 2

Literature Review

2.1 Background

The discussion over combined, separate sewers was an old dispute dating back to 1840s in Great Britain. Combined system was cheaper than separate sewer system and was more practicable for heavily populated cities that needed street sewerage. Waring found separate system more efficient to maintain or build as compared to combined system. Rudolph Hering found both separate and combined systems fairly acceptable, if appropriately maintained and well-designed as described in [14, 15]. However, it is need of time to develop a clear approach which could be helpful to select a durable wastewater collection system. Hence, history of sewers, types of sewer systems, design procedures, cost consideration and debate over combined, separate systems are discussed in detail in this chapter.

2.2 Sewer and Sewerage

A sewer is known as conduit which carries stormwater, wastewater or other waste flows. Sewerage is a systems of sewers. The system may composed of storm sewers, sanitary sewers or combination of both as indicated in Ref. [8]. Sewerage is explicated in British Standards Code of Practice (BSCP) 2005 as a meshwork of sewers and some necessary arrangements to dispatch sewage from its inception point towards a treatment place or point of disposal. Modern community is quite dependent upon a sewerage system which is one of fundamental public utilities. Unhappily, most of this work is invisible to general public, and the absence of charm often results in a lack of gratitude to its importance, as reported in Ref. [16].

The sewerage is a system or network of sewers and related works designed to collect foul sewage or wastewater, which is conveyed via conduits, channels, ancillary works and further discharged at a treatment location or convenient disposal point prior to its return into the environment. Clay made pipes to carry water used in 1st century BC at Greece Island KOS shown in Fig. 2.1. Wastewater or foul sewage discharge containing putrefied matters cannot be permitted into natural water courses. Foul water could be allowed to discharge in a natural water course, if it is well treated and quantity is so little that its dilution prevents menace. As well as domestic wastewater, sewer networks accommodate the used water of business arcades, industrial estates, some part or all of the surface water which is named as storm flow coming from roofs and all kinds of paved surfaces. Three basic systems are used to sewer towns. The combined system, separate system and partially separate system. There is specific utilization of these systems. For most purposes separate sewer system is pondered the best but in contrast combined system is advantageous where storm runoff from hard surfaces or roads is so dirty that some sort of its treatment is necessary before sending it to a watercourse or stream. The partly separate drainage system is occasionally enforced where the consumption of local water is low, so the surface water from back parts of roofs and backyards is passed from foul sewers to keep them clean, discussed in Ref. [1].

The sanitary sewers are often called separate sewers. Wastewater could be carried through sanitary sewers may be ordinary gravity sewers, or could be pressure or vacuum systems. Storm sewers only intended to collect solely stormwater and are designed alike sanitary sewers with a few anomalies. Basically, sanitary sewers and storm sewers of separate system were adopted to avoid pollution related problems

FIGURE 2.1: Clay made water carrying pipes at KOS Greece 1^{st} century BC [1].

of unrefined wastewater discharge through combined sewers into channels. Combined sewers are used for the collection of both stormwater and wastewater. The lengths, sizes and types of sewers could vary in a wastewater collection system which depends upon the layout of the community and the locality of treatment facilities. The sizes of sewers are determined by the flow quantities and the local building regulations that allow minimum sizes, Bakalian presented in Ref. [7].

2.3 History of Sewers

The seafaring kings built elegant unfortified palaces with stone walls on Crete Island over 3000 years ago. They created some of the first sanitary sewer systems by installing ceramic drain pipes to carry wastewaters of toilets and baths. The magnificent buildings of Minoan civilization having advanced sewer systems were collapsed in 400 B.C. and fell into disrepair. Machu Picchu a famous archeological site as shown in Fig. 2.2 situated near head waters of Amazon River in the Peruvian Andes Mountains inhabited firstly from 1450 to 1540 AD (Anno Domini) was

FIGURE 2.2: Famous Inca Engineering wonder, Machu Picchu [18].

home to a permanent population of 300 residents that grew up to 1000 when Inca emperor was in residence. Machu Picchu's secret of longevity is its drainage system and foundations. The builders and engineers of Machu Picchu gave important consideration to both subsurface and surface water drainage [18]. The history of water, stormwater and sewer systems which goes back to early Rome. As at that time there were no regulatory agencies or treatment plants but the water systems were notable. Presence of water and wastewater systems in Swedish towns were found in 13th century, disclosed in reference [19].

Rome had sewers, but those basically carried away rainstorm water. Sanitary sewer remains were found in the primeval ruins of Assyria and Crete cities. At that time it was a practice to deposit all sorts of rubbish in streets which was carried away by storm sewers. Sewerage was unknown in practical manner during the Middle Ages and till modern times the sewers construction was not resumed. As late as 1850 the household wastewater discharge was forbidden into sewers of London, narrated n Ref. [20]. Sewer and water systems were not new inventions of 19th century. They had existed for millennium, from the primary forms of drainage network of Mesopotamian and Indian civilization or Roman Empire, and even of medieval age up to advanced systems of modern Europe. Though, after the industrial revolution of 1850 mainly in Great Britain modern water and wastewater technologies began developing. Modern wastewater technology was mainly typified by egg shaped or circular sewers for self-cleansing purposes beside glazed iron or lead circular pipes or larger sized egg shaped brick sewers, as Hallström examined in Ref. [21].

Since dawn of civilization underground conduits served to improve living standards of people. Remnants of water and sewer system structures were found in the ancient civilizations of Asia, Europe, western hemisphere, early natives of Southern and Central America. These primeval engineering structures are often mentioned as the examples of art of engineering. However, science or art, scientists and engineers still stand surprised at these primal water and sewer systems. They appear to bridge the gap between the initial and modern engineering. Here gap is referred to the period recognized as dark ages when little or no underground construction was practiced. Today beneath ground ducts serve in multiple application such as water mains, drain lines, sewer lines, gas lines, electrical and telephone conduits, coal slurry lines, oil lines, culverts, heat distribution lines and subway tunnels. Today by using engineering science it is possible to design underground conduits with such degree of precision as the over ground buildings and bridges. Engineers and planners perceived that underground infrastructure is an utter necessity of modern community. It is true we should build down before we can build up. The underground drinking water supply systems serve like arteries of cities or towns while sewer systems assist like veins to dispose of waste. Sewage is collected at its source and conveyed via buried pipes towards a treatment facility. Though cesspools and septic tanks are widely used today but no longer acknowledge in urban or suburban localities. These are accordingly sanctioned by health agencies in rural farm areas, as examined in Ref. [22].

2.4 Types of Sewer Systems

Main alternatives practiced for wastewater sewerage collection, treatment and disposal are

(i) On-site sewerage system

(ii) Off-site sewerage system

Drainage schemes may composed of combined or separate sewer systems. In separate sewer system stormwater and wastewater are separately transported through independent pipes or drains. Where, in combined sewer system storm and wastewaters run in the same system. In case of combined system pipe diameters are kept larger not only to dispose domestic wastewater flow but mainly the rainwater flow, as illustrated in Ref. [3]. System of sewers may composed of storm sewers, sanitary sewers or a system which can carry both sanitary and storm water wastes. Other types are house connections or building sewers are those pipes that carry buildings wastewater, these are laterals to join a common sewer which serves adjoining properties. A branch or submain sewer takes flow from two or more lateral sewers. Out fall sewer extends from disposal point of a wastewater treatment plant or from the end of wastewater collection system. A trunk or main sewer collects flow from two or more submain laterals. An intercepting sewer obtains dry weather flow and some limited amount of rainwaters from combined sewers. Relief sewer is built to ease an existing sewer of limited capacity. Commonly stormwater or domestic water does not completely fill conduits but sometimes it may flow full and must be capable to withstand some hydraulic pressure. Force main sewers flow full under pressure induced by a pump, as interpreted in Ref. [8]. Types of sewer systems are further detailed below

2.4.1 Combined Sewer System

Combined sewers are constructed for collection and transfer of sanitary sewage, storm surface runoff and industrial wastewaters in one conduit [9]. Combined sewers can import domestic and storm wastewaters at the same time. These type of systems were constructed for larger communities in early half of the 20th century to save higher construction costs. Overflow and diversion structures are provided in combined system to divert sanitary and rainwater mixed overfull towards a watercourse [8]. This means that in combined system wastewater coming from bathrooms, lavatories and kitchens as well as rainfall runoff from roads, streets and roofs are collected in a single pipe or drain. All the system contains a blend of rainwater, wastewater and displaced sewer sediments, so the excess flow discharged into open water remains far from clean. Ill effects of releasing wastewater onto open water cannot be ignored. Oxygen levels of open water may drop to such point that fish begin to die. Water may be polluted with bacteria that restrain it from recreational use. Discharge of heavy metal particles and pesticides could accumulate in organisms and silt. These may affect biodiversity in the long run [2]. In case of combined systems larger diameter pipes are installed to facilitate domestic sewerage flow but mainly to rainwater flow. Sewage flows slowly during dry season in warm climate countries that leads to long dentition times which causes decay and generation of evil-smelling. In this type of system WWTP (wastewater treatment plant) design should be taken into consideration for the comparable fraction of rainwater allowed to enter at treatment site [3].

2.4.2 Separate Sewer System

In a separated sewer system rainfall runoff from roofs, roads and streets is passed through larger diameter pipes or drains which are known as storm drains, while domestic wastewater from bathrooms, kitchens and toilets are transported through sanitary or foul sewers comparatively having less diameter than storm drains. So the separate system is comprised of two separate pipe or drain networks where one carries storm waters and the other one carries wastewater [2]. Sanitary sewers convey a mixture of commercial sewage, industrial wastewater, and household, where groundwater infiltration is contributed through foundation drainage connections, cross connections between sanitary sewers and storm drainage network. Storm sewers mainly transfer storm runoff from roofs, roads, streets, parking lots and form others surfaces towards nearby receiving water body or channel. Storm and Sanitary sewers are often designed to work under gravity flow conditions. In urban drainage systems separate sewer systems are more expansive as compared to combined systems because it uses two parallel ducts [9]. As the CSO (combined sewer overflow) bypass may result in remarkable pollution. The average BOD^5 (Biological Oxygen Demand for 5 days) in stormwater is roughly 30 mg/L, while in case of combined overflows average BOD^5 (Biological Oxygen Demand for 5 days) is between 60 mg/L to 120 mg/L. So the patent solution is to replace combined sewers by separate sewers although the costs and legalities of shifting are vital concerns, as explained in [9, 23].

2.4.3 Improved Separate Sewer System

Historically, combined sewer system was elected by many communities to convey wastewater and stormwater. The resulting mixture of storm and sewage flow have severe adverse effects on water receiving bodies. Current regulations disallow installation of combined system in new facilities, as mentioned in Ref. [24].

As the original separate system is made up of a set of two specific sewer networks. There are clear advantages of separate sewer system over combined because it prevents the diluted discharge of wastewater which allows to reduce flow of water to wastewater treatment plants and also curtails hydraulic loads on treatment plants. Storm flow released from detached network is directed towards a suitable open water stretch and assumed to be more or less clean. But in urban drainage situation storm flow contains fuel, oil, tyre rubbings, atmospheric deposits, organic materials and heavy metals being washed from streets and roads which ends up at open water site. The weakness of separated system is risk of incorrect connections that can cause rainwater to flow in wastewater systems or vice versa. A hydraulic overload of wastewater entering in buildings can create highly unpleasant situation, while releasing wastewater into rainwater is the direct discharge of wastewater into open waters. For combined sewer systems provision of storage and settling basin to limit overflowing water is better option which could allow to infiltrate water into soil but the wastewater could pollute soil. So as to encounter these problems improved separate system has been introduced which allows initial rainwater to mix with wastewater and then delivered to wastewater treatment plant rather than liberating all rainwater directly into open water. Improved separate system is like original separate system having distinct sewer networks but improvement is the interconnection of sewer and storm networks at manholes to divert initial part of rainwater towards wastewater treatment plant. It also helps to flush streets debris into wastewater treatment plant and prevents it to enter open waters. In case of long rainfall event excess rainwater passes directly to open waters. Drawback of this improved system is that roughly half the amount of all rainfall obtained ends up at the wastewater treatment plant, where original separate sewer system do not do so is the major benefit of it, as published in Ref. [2].

2.5 Research to Date Regarding the Nature of Comparison

Brombach [13] analysed pollutant loads in combined and separate sewer systems by using statistical database. Results indicated that in combined sewer system nearly 80% of all runoff passes treatment plant while in case of separate system it is less than 50%. Chemical oxygen demand load of combined sewer system was smaller. The separate sewers release less BOD (Biological Oxygen Demand) loads. Combined sewers are superior to deliver solids/heavy metal loads. Both systems need storm water treatment where separate systems stand unfavourable in terms of cost benefit.

In Ref. [10], the author investigated pollutant loads discharge from separate and combined sewers networks via wastewater treatment plant into receiving waters. Outcome revealed the higher dissolved and individual pollutant mass discharge via separate sewers independent of population density but increases with population growth. Combined sewers discharge slightly higher mass of pollutants as compared to separate. Basin area shows weak effect on discharged mass, therefore, for choice of better sewer plan, PD (population density) is the key parameter. Wastewater treatment plant is necessary for both systems to reduce pollutant loads discharge up to 50% into receiving water body.

The researcher in Ref. [25], evaluated the over flow events during one year in combined and separate sewers for urban catchments of France and Australia. The system operation for both systems was same. Separate networks found worst because annual over flow incidents were many folds higher than combined systems.

Varying rainfall periods resulted in longer over flow events in Sydney but considerable line storage capacities prevented over flows in Lyon networks.

A study in Ref. [26], assessed combined and separate sewer systems of Shanghai and Hefi in terms of pollutant loads, hydraulic performance. The event mean concentrations of dominant pollutants in separate sewer systems found higher in combined sewer systems of same cities. Under same rainfall conditions within catchment, the total annual over flow volumes from combined networks were less than separate networks. The percentage of unlawful connection rates for three separate sewer systems of Shanghai were 51.7%, 35.4% and 27.1% while two networks of Hefi found 74% and 90%. Due to deficient interception capacities and profound illicit connections the discharge of pollutants from separate sewer systems was higher than combined systems during dry weather.

In Ref. [11], combined and separate sewer systems were compared in the viewpoint of pollution emission, cost effectiveness. It was disclosed that the pollutants loads from separate sewers are higher than combined and these loads could be lowered by applying storm flow treatment facilities in separate networks. In case of separate systems Oxygen deficiency and Ammonia absorption are lower in contrast to combined. Discharge loads of nitrogen, copper are dependent on drainage area in addition to dependence on PD (Population density) and type of sewer system. Separate system do better for river but due to oxygen reduction severe poisonous impacts observed on receiving waters.

Authors in Ref. [7], analyzed simplified sewer and conventional sewer system costs according to 1988 prices for project of Bogota, Columbia. Total cost of conventional sewers having pipe lengths of 1530 meter including excavation and appurtenances was US $49505. Simplified sewer system with pipe lengths of 1510 meter including other accessories was costing US $23857. The cost saving from simplified sewer was found more than 50% in comparison to conventional sewer systems.

2.6 Sewer and Storm Drain Appurtenances

According to a study in Ref. [17], all the stormwater and wastewater collection systems are made up of two major components that are sewer pipes and various structures (castings and hardware items) and collectively known as sewer appurtenances.

2.6.1 Principal Appliances of Gravity Flow Sanitary Sewers

(i) Manholes

(ii) Flushing devices

(iii) Building connections

(iv) Catch basins

(v) Street inlets as well as transitions

(vi) Junctions

(vii) Depressed sewers (commonly known as inverted siphons)

(viii) Energy dissipaters

(ix) Vertical drops

(x) Diversion structures for overflow

(xi) Regulating devices

2.6.2 Storm Drainage Constituents

It was stated in Refs. [9, 27] that the storm drainage systems or urban drainage systems are composed of flood runoff paths, which are called the major drainage system that could store, collect, deliver and treat runoff that exceeds minor system. These facilities ordinarily contain

(i) Retention and detention facilities,

(ii) Open channels,

(iii) Street storm sewers

(iv) Special structures such as manholes,

(v) Inlets

(vi) Energy dissipators

(vii) Out fall structures

2.7 Hydraulic Elements

Butler and Davies [28] illustrated that the knowledge of hydraulics is needed to design a new drainage system so as to identify the suitable size of system components, mostly pipes, tanks and channels.

2.7.1 Flow Types

The civil engineering hydraulics concentrates on two basic types of flow.

(i) First one is pipe flow in which liquid runs under pressure and it always fill-up the entire cross-section of the pipe either the pipe may be horizontal or inclined in the flow direction.

(ii) Second type of flow is open channel flow in which liquid flows by gravity under free surface atmospheric conditions. Open channel is only filled by the liquid when the flow rates are equaled or exceeded from the designed capacities and the channel bed slopes are kept inclined in the flow direction.

(iii) In sewer systems most common types of flow are a mixture of previously mentioned two flows, so in such state liquid flows through pipe under gravity with a free surface and is known as part-full pipe flow. In this type of mixed flow the whole pipe area is filled when flow rates are equivalent or above the designed capacity and pipe bed slopes are maintained in the downward direction of flow.

2.7.2 Flow Behavior

In Hydraulics two terms are used for constant flow either uniform or steady, where Uniform flow means constant by distance and steady is termed as constant with reference to time. Inconstant flows are named as nonuniform and unsteady flows. Nonuniform flow is not constant with distance and unsteady flow stands inconstant by time. In urban drainage networks the hydraulic flow conditions could be uniform steady, nonuniform steady, uniform unsteady and nonuniform unsteady. Generally flow in sewers to certain extent is unsteady because foul water flow fluctuates with time of day and storm flow varies during a storm event. Though for the sake of simplicity in numerous hydraulic calculations flow conditions are treated as steady flow.

2.7.3 Wastewater Discharge Characteristics

Henze et al [29] described that categories of wastewater to be disposed are

- domestic
- industrial
- wastewater from institutions
- infiltration into sewers
- storm water

Ismael [30] reported that main resources of wastewater are residential, commercial and industrial.

2.7.3.1 Dry Weather Flow

According to author's study [28] pattern of flow is dependent on its use by community. When the nature of wastewater is mostly domestic then it is called dry weather flow. It is average daily flow in week without rain or on any day with rainfall up to 0.25mm. Commonly during DWF conditions morning and evening are peak flow hours while in night time low flow occurs. Peak flow is important for sewer or drain design calculations and it could be determined by using an acceptable peak factor or multiple.

2.7.3.2 Wet Weather Flow

As described by Lin et al [9] wet weather flow (WWF) occurs when due to intense rainfall events surface water runoff from catch basin is also added into the network. Over land flow across the ground resulted by rainwater and snow melt is called surface runoff.

Torno [31] narrated that the surface water runoff takes place, when rainfall exceeds beyond the interception and soil infiltration limits. Storm water runoff is conveyed to storm drains in case of separate system, while in combined system flow is mixture of storm and domestic water. Peak flow for stormwater is computed by using Rational approach in which discharge is directly proportional to intensity of rainfall, area of catchment and runoff coefficient 'C'. Rational method is very useful for catchments having area between 100 to 200 acres, as detailed by authors in Refs. [9, 17, 28, 31-33].

2.7.4 Primary Factors Effecting Wastewater Flow

Tchobanoglous [17], explained that the wastewater flow is effected by flowing elements,

(i) shape and cross-sectional area of conduit, roughness at interior surface of pipe,

(ii) slope or gradient along channel,

(iii) flow conditions in conduit, which are varied or steady flow, either pipe is partly flowing or flowing full,

(iv) existence or nonexistence of bends,

(v) obstructions and other flow disruptions, viscosity, character, and specific gravity of flowing liquid.

2.7.5 Open Channel Flow

It was illustrated in Ref. [32] that when three sides of natural streams are in contact with ground and top surface is free to air then this kind of flow is known as open channel flow.

Franzini et al [34] elaborated that if a stream is not completely enclosed by solid boundaries and top surface is exposed to atmospheric pressure then it is called open channel. There is no external head to cause flow in open channel but if some slope is applied along the channel then flow would happen under gravity component. Flow in open channels is mostly specified as gravity flow or free surface flow. Primary types of open channels are rivers, natural streams, artificial canals, tunnels, sewers and partially filled pipelines. A researcher in Ref. [31] explained, that the partly full closed conduits are examined as open channel flow conditions.

2.7.6 Uniform Flow Development in Artificial Channels

According to a study in Ref. [34], it is a rule that the uniform flow could only be established in artificial channels of any consistent size and shape. As there are no irregularities in regular shape channels as compare to natural streams. Famous formulas of Chezy and Manning's are frequently used to analyze open channel flow in natural streams. These formulas are quite useful to achieve efficient cross section and uniform flow in artificial channels.

Chow [32] instigated that for the development of uniform flow following main features are taken into account

(i) Water area, velocity, depth and discharge at each section of channel are considered constant.

(ii) Slope of water surface, channel bed and energy line are parallel and equal.

For practicality it is a requirement that flow should possess constant mean velocity. So within uniform flow reach there should be constant flow velocity at each section of channel. This means distribution of velocity across entire channel remains unchanged. It has been carefully evaluated that uniform flow is steady only. Virtually unsteady uniform flow is not existing while in rivers and natural streams uniform steady flow is rare. Despite this variation, uniform flow condition is frequently assumed for velocity and flow computations. It is notable that at very high velocity uniform flow could not occur because at certain high velocity uniform flow becomes unstable. In open channel flow when water flows downstream it is encountered by resistance in direction of motion. This resistance is prevented by the gravity force acting on water body in the direction of flow. If this resistance is balanced by gravity forces then uniform flow would be developed. Extent of resistance depends upon flow velocity when the physical factors of channel are unchanged.

In reference [28], it was explained that the general flow conditions in urban drainage conduits are part-full, so the free surface presence must be considered in hydraulic computations. In uniform steady flow conditions under gravity there exists an equilibrium along a part-full conduit or channel. The energy utilized by the friction between pipe wall and the liquid flowing is in balance with the fall along the pipe length. If for the same flow rate pipe gradient is increased then extra energy would be available to the flow that could result in lower flow depth and higher velocity. It is notable that the equilibrium depth indicates the normal flow depth. When there are uniform flow conditions and pressure at the free surface of liquid is atmospheric then velocity and flow depth will be constant. In this situation

Hydraulic Grade Line (HGL), Energy Grade Line are parallel to the channel or conduit bed and Hydraulic Grade line (HGL) coincides with liquid surface.

2.7.7 Velocity of Wastewater Flow

The velocity of flow in a conduit varies over its cross-section. At the boundary of pipe velocity remains minimum and escalates towards its center. In case of flow depth up to half full maximum velocity will be at the center of surface while more than half depth it will be below the surface. Sewers should convey wastewater without long-term deposition of solid materials and a minimum self-cleansing velocity should be developed for larger diameter sewers. There is no such limit for maximum velocity but care should be taken regarding velocities more than 10ft/sec as proclaimed by Butler and Davies [28].

Tchobanoglous [17] proclaimed, if wastewater flows with low velocities for an extended period of time then solids may be deposited in sewers, so sufficient self-cleansing velocity should be regularly developed to flush out deposited solids during low flow periods. It is normal practice to design sanitary sewer slopes in such way that minimum velocity of 2ft/sec could be established at full flow depth or one half full depth. However velocity of wastewater significantly affects near the bottom of sewer, so a mean velocity of 1ft/sec is commonly sufficient to washout deposited organic solids. An average velocity of 2.5ft/sec is acceptable for sanitary sewers so as to prevent deposition of mineral matters, such as gravel and sand. Erosion in channel or conduit is dependent upon the nature of suspended material in wastewater and the velocity to flush it out. Eroding action is important factor to determine safe maximum wastewater velocities. In general practice at the design flow depth safe maximum velocities of 8ft/sec to 10ft/sec will not cause erosion.

It was expressed in Ref. [34], that in an artificial channel when there is no friction and grade is falling then flow will occur due to gravity force and velocity will go on increasing continuously along the path. Gravity force in open channel is opposed by the resistance of frictional force at boundaries. With increase in velocity frictional force increases but gravity remains constant which results in balance of these to produce uniform flow. When velocity and frictional force not in balance nonuniform flow will happen.

According to Bong [35], British standard documents 1987 advocated about the adoption minimum self-cleansing velocity as 2.5 ft/sec for newly storm drains and 3.28 ft/sec for combined sewer system. Malaysian storm management manual 2012 recommended minimum velocity of 3ft/sec and maximum velocity of 10ft/sec for storm drains.

2.7.8 Geometric Elements of Channel or Conduit

It was elaborated in Ref. [32], that a channel with constant size, cross-sectional shape and bed slope is named as prismatic channel. All natural streams are non-prismatic channels due to irregular and varying shape, size and bottom slope. Mostly man made channels are of regular geometric shape over long stretches. Different shapes of artificial channels are circle, triangular, rectangular and trapezoidal. Geometric properties of an artificial channels section could be defined by the flow depth and entire geometry of section. These geometric components are broadly used for flow computations. Some of these elements are detailed below,

(i) Flow depth denoted by "d" or "y" is the vertical height from channel bed up to free surface, here depth of flow is the normal depth in flow direction.

(ii) Channel section width "T" or "B" is the width of wastewater at free surface.

(iii) Cross sectional area "A" of the channel or conduit

(iv) Wetted perimeter "P" is the sides and bottom of channel in contact with water. An increase in wetted perimeter increases frictional losses which results decrease in head.

(v) Field et al. [36] asserted that when the cross-sectional area of a water stream is divided by the length of that part of boundary in contact with wastewater then it is called hydraulic radius. Hydraulic Radius "R" is the ratio of cross sectional area to its wetted perimeter.

$$R = \frac{A}{P} \tag{2.1}$$

Where,

R = Hydraulics radius in ft or m

A = Area of pipe or channel in ft^2 or m^2

P = Perimeter in ft or m

(vi) Hydraulic depth "D" is the ratio of water area to surface width of water.

$$D = \frac{A}{T} \tag{2.2}$$

Where,

D = Hydraulic depth in ft or m

A = Area of pipe or channel in ft^2 or m^2

T = Width of water at top surface in ft or m

For a given area circle out of all geometric figures has minimum perimeter. Semicircle has the same hydraulics radius as circle. Therefore more water could be discharged from semicircular than of any other shape, presuming surface roughness, area and slope are constant as described in Ref. [34].

2.7.8.1 Normal Depth, Friction and Gradient Relationship

When discharge is constant under the force of gravity then flow depth is known as normal depth. Especially normal depth of flow is related to free surface flow where only atmospheric pressure is present. In uniform flow condition HGL slope and EL slope are equal to channel or conduit gradient, while EL and HGL are parallel to the gradient along the channel as indicated by Pazwash [37].

In a gravity uniform steady flow an equilibrium always exists along a channel or part full conduit. The energy depleted due to friction between channel boundary and liquid is balanced due to slope along the channel. If flow rate remains same and conduit slope s increased to some extent then the flow would gain extra energy, so resulting in lower depth and higher velocity. This kind of balanced depth could be mentioned as normal depth pointed out in Ref. [28].

As defined in reference [31], that a flow depth under uniform flow under constant discharge is named as normal depth. In a uniform flow friction at conduit boundary is balanced by the gravity force. This means gravity component and friction are equivalent in flow direction but acting in opposite directions. In case of normal depth slope of energy and hydraulic grade lines are parallel to each other and numerically equal to the invert slope along channel or conduit. Normal depth is a function of channel slope, frictional resistance to flow, discharge, conduit shape and size of channel. Value of normal depth could be calculated by using very common Manning's Equation.

2.8 Hydraulic Design Equations

As there are many equations to solve drainage design problems but some of it are used frequently to carry out hydraulic computations as detailed below,

2.8.1 Equation of Continuity

If drain or pipe section having no side connections and with constant diameter in such situation a mass of a liquid entering in any spell of time from one end of a pipe section should have same mass at exit end as shown in Fig. 2.3. Presuming that mass per unit volume of liquid is same at both ends is equal then its discharge or volume per unit time will be same.

It is one of the basic concepts that in all kinds of flow problems continuity of flow must be satisfied. The fact of continuity states that if a fluid passing through a

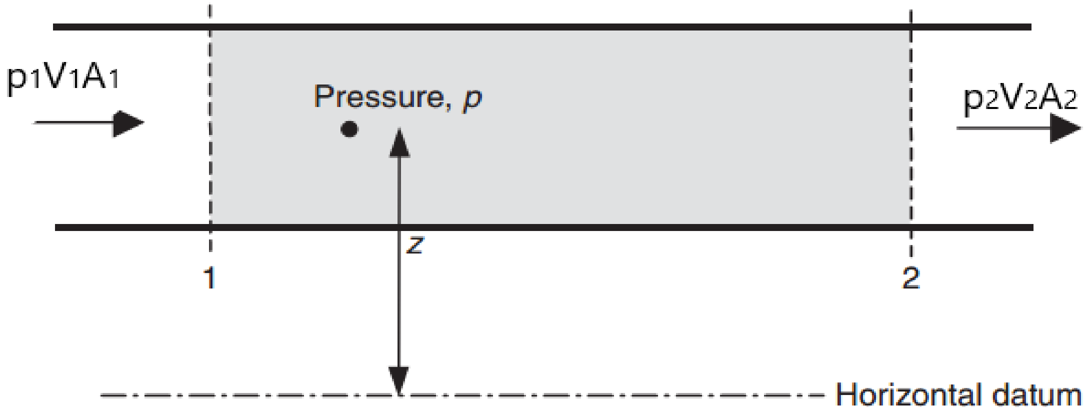

FIGURE 2.3: Continuity of Flow in pipe section [28].

conduit neither it is gained or lost nor it is destroyed or formed as interpreted in Refs. [17, 28, 32, 39]. According to conservation principle mass could not be created or destroyed, so continuity of flow could be expressed as follows,

$$\rho_1 V_1 A_1 = \rho_2 V_2 A_2 = \rho_1 Q_1 = \rho_2 Q_2 \tag{2.3}$$

Where,

ρ = Density of fluid in slug/ft^3 or kg/m^3

V = Velocity of flow in ft/sec or m/sec

A = Cross-sectional area of conduit in ft^2 or m^2

Q = Discharge in ft^3/sec or m^3/sec

As the fluid flowing is incompressible, so $\rho_1 = \rho_2$ then,

$$A_1 V_1 = A_2 V_2 = Q_1 = Q_2 \tag{2.4}$$

In uniform steady flow conditions discharge throughout the channel or conduit is constant, then it becomes,

$$Q = AV \tag{2.5}$$

2.8.2 Manning's Equation

The formula was presented by Irish engineer Robert Manning in 1889. Manning's formula is also familiar as Gauckler-Manning-Strickler equation. Initially this equation was meant for the design of open channels in uniform flow conditions, but now it is now used for both for closed conduits and open channel. Manning's equation was developed from seven various formulas which were based on Bazin's experimental data and further this formula was confirmed through 170 observations. This formula is widely used due to its simplistic formation and satisfactory results for flow computations. This formula was later improved to its well-known present form,

$$V = \frac{1.486}{n} \times R^{2/3} \times S^{1/2} \tag{2.6}$$

Where,

V = Mean velocity of flow in ft/sec or m/sec

n = Manning's roughness coefficient, units often excluded but not dimensionless

R = Hydraulic radius in ft or m

S = Channel bed slope longitudinally in ft/ft or m/m

Although Manning's roughness factor "n" have the same value as Kutter's "n" indicated by Camp [39]. This roughness coefficient is often assumed dimensionless but actually its dimensions are $L^{1/3}T^{-1}$ and same value of "n" for metric and fps system is used. If we look into the numerator 1.49 in formula which could off course absorb the dimensions of "n". It is notable if "n" is assumed dimensionless, then the numerator numerical constant will be solved as $3.2808^{1/3} = 1.486$ m, while 1m = 3.2808ft. For sewer design Manning's equation is routinely used. It is suggested that so as to design new sewers or to analyze well-constructed existing sewers the Manning's "n" should be taken 0.013 and to examine older existing sewers value of 0.015 or higher should be used as claimed in Refs. [17, 28, 41]. Manning's "n" values are well documented and published in literature as highlighted in Table 2.1.

Table 2.1: Values of Manning's "n" for various surfaces [41].

Channel Material	**Manning's Roughness Coefficient "n"**
Concrete	0.013-0.015
Grouted Riprap	0.028-0.040
Soil Cement	0.020-0.025
Asphalt	0.016-0.018
Bare Soil	0.020-0.023
Rock Cut	0.025-0.045
Fiberglass Roving	0.019-0.028
Woven Paper Net	0.015-0.016
Jute Net	0.019-0.028
Synthetic Mat	0.021-0.030

2.8.3 Hydraulic Elements Graph for Circular Conduits

Commonly sewers are designed under maximum conditions to flow full. It is necessary to evaluate flow rate and velocity for sewer design in partly filled situations. Maximum velocity and flow rate will occur in part full conduits when it is running slightly less than full. The relationship between ratios of hydraulic components for other depths and full depth are determined according to Manning's equation are shown in Fig. 2.4. The hydraulic radius and cross-sectional are absolutely geometric functions, therefore independent of roughness factor "n". Discharge and velocity for any specific ratio of depth to diameter is dependent upon constant "n" or variable with depth. Usually value of "n" is assumed constant to obtain curves of velocity and discharge displayed in flow properties graph explained by authors in references [34], [28] and [42].

According to Chow [32], if value of "n" is considered constant and independent of variation in flow depth, then the variation in ratios of velocity and discharge corresponding to their full flow values Q/Q_0 and velocity V/V_0 could be obtained from rating curves pointed out in Fig. 2.4. It is notable that the full flow condition is represented by subscript zero. Both the velocity and discharge curves indicate maximum values which occur at $0.93d_0$ and $0.81d_0$.

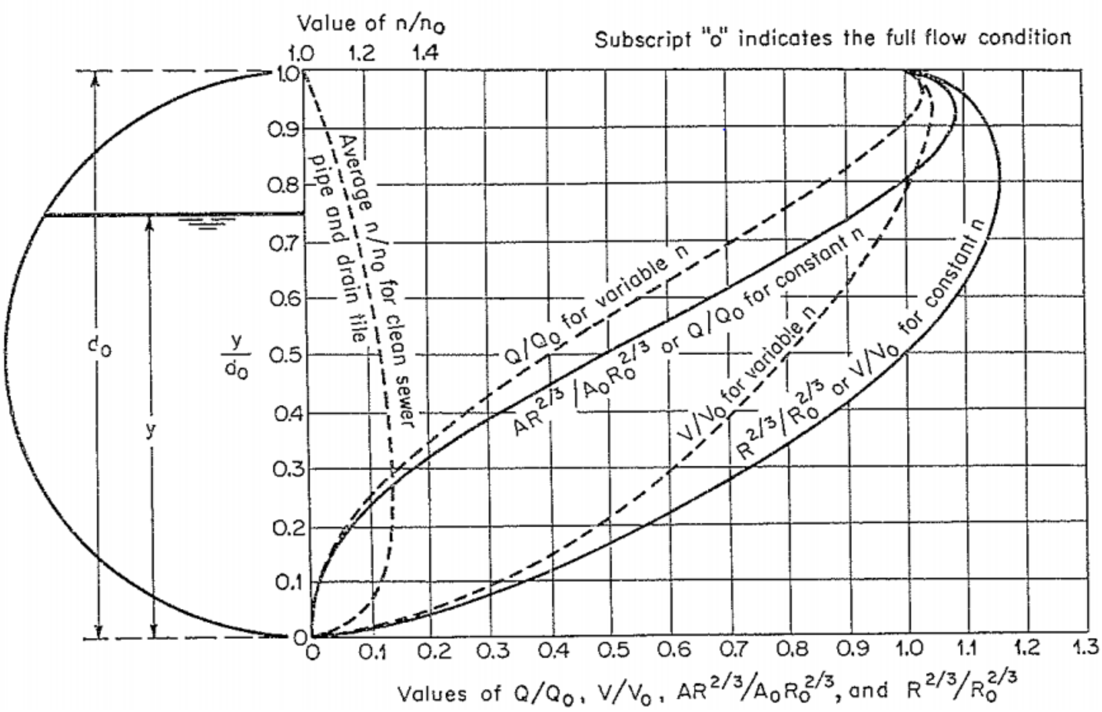

Figure 2.4: Flow properties graph for circular pipes and drains [17, 28, 32, 40, 41].

The discharge ratio Q/Q_f, velocity ratio V/V_f and depth ratio d/D in form of Fig. 2.2 graph are useful to modify velocity and discharge for any case of conduit flowing partly full. In this graph effect of velocity has the same self-cleansing effect either the flow in pipe full or partially full as demonstrated in Refs. [28, 40]

2.8.3.1 Hydraulic Characteristics Tables for Partly Full Circular Pipes

For design of drainage networks it is required to estimate discharge, velocity and flow depth for the pipe lines placed at certain grades flowing partially full. Indeed Manning's formula is the base that permits to evaluate full flow features. Afterwards discharge, velocity and flow depth for partly full conditions could be calculated from the geometrical characteristics of circular sections. In actual design the flow velocity and ratio of discharge Q/Q_0 is first calculated for full flow conditions, then the values of V/V_f and y/d_0 are worked out from Table shown in Annexure-2 for the known value of Q/Q_0. This table is prepared on the basis of flow properties graph (Fig. 2.2) as documented in references [28, 32, 42], also indicated for the use of such tables which developed on the basis of hydraulic elements graph.

Here,

Q = Actual discharge

Q_0 = Discharge at full flow or theoretical discharge

V = Actual Velocity

V_0 = Velocity at full flow or theoretical velocity

y = Actual depth of flow

d_0 = Flow depth at full flow or theoretical depth

2.8.4 Peak Factor Estimation for DWF

Imam [43] recommended that for the proper design of sewer systems, treatment plants and pumping stations it is essential to estimate dependable sewage flow rates. Planning of different sewerage system components must be based on two extreme conditions of peak and low flow rates.

According to Scheepers [44], in a water distribution system flow rate varies constantly and is dependent on water demand. Total volume of water in a certain period of time needed or necessary to be supplied is known as water demand. Two main Categories of water demand are residential and non-residential. Residential water demand could be expressed as the water required by residential consumers for outdoor or indoor use in per unit time. Non-residential water demand could be further subdivided into commercial, institutional and industrial sectors, where according to design guidelines firefighting water demand must be included.

Zhang [45] reported that often meter records for water consumption are not available, so the use of dimensionless peak factor is common to calculate peak flow rates. Peak factor is ratio of maximum flow in a short period of time and flow rate in an extended period of time. Commonly empirical methods are used to work out peak factor for sewerage systems. A peak factor diagram presented by Metcalf and Eddy (1935) in which PF remains at 4 in case of population less than 5000 and later Tchobanoglous et al. (2003) found that when population exceeds 5000 the PF decreases logarithmically.

Zhang further described that in 1942 Johnson expressed following peak factor formula,

$$\text{Peak Factor (PF)} = \frac{5.2}{P^{0.15}} \tag{2.7}$$

State sanitary engineers board of Great Lakes upper Mississippi River recommended Harmon Formula,

$$\text{Peak Factor (PF)} = 1 + \frac{14}{4 + \sqrt{P}} = \frac{4.2}{P^{0.16}} \tag{2.8}$$

In wastewater industry frequently used Babbitt, 1932 formula is expressed as,

$$\text{Peak Factor (PF)} = \frac{5}{P^{0.20}} \tag{2.9}$$

Gifft in 1945 used the data from Johnson, Metcalf and Eddy to revise Babbitt equation

$$\text{Peak Factor (PF)} = \frac{5}{P^{0.167}} \tag{2.10}$$

Above stated wastewater peak factor equations are applicable for Populations (P) in thousands ranging from 1000 to 1000,000. A history of PF formulas hinted in Table 2.2.

The set of peak factor empirical formulas indicated in Table 2.2 were analyzed in a study [46] for the cities of Tehran and Isfahan. Peak factors calculated for the same population of both cites was compared with actual flow metering records, where significant difference found from Harmon and Babbitt formulas.

2.8.5 Rational Method to Manage Surface Water Runoff

It was illustrated in Ref. [28], that there is a long history behind Rational Method established before 19$^{\text{th}}$ century. Basic principles of this method were framed by

TABLE 2.2: PF Historical list being used in design of wastewater systems [45].

Author Name & Published Date	**Formula**	**Limitations**	**Time Step**
Harmon, (1918)	$1 + \frac{14}{4+\sqrt{P}} = \frac{4.2}{P^{0.16}}$	No restriction	1-hour
Babbitt, (1932)	$\frac{5}{P^{0.20}}$	1 ≤ P ≤ 1000	Immediate
Metcalf & Eddy, (1935)	$\frac{4.8}{P^{0.113}}$	1 ≤ P ≤ 1000	1-hour
Johnson, (1942)	$\frac{5.2}{P^{0.15}}$	1 ≤ P ≤ 200	Immediate
Gifft, (1945)	$\frac{5}{P^{0.167}}$	1 ≤ P ≤ 100	Immediate

an Irish Engineer Mulvaney, (1850). According to Americans Kuichling, (1889) developed this method but the British tend to credit Lloyd-Davies, (1906) for this method.

The methods indicated in reference [17] to estimate stormwater runoff for designing stormwater sewers are Rational Method, empirical formulas, hydrograph methods, rainfall runoff interrelationship studies, digital computer models and inlet methods. The procedure selected is dependent on the local hydrological and geographic conditions, drainage area size, availability of old runoff and rainfall data, and the degree of protection required.

The design of surface water sewers excluding very small areas is based on expected rainfall rates, so as a result of experiments Lloyd-Davies was first investigator to set out sound design theory. The foremost principals for surface water design proved by Lloyd-Davies were

(i) Volume of water retained in the sewer system and rainfall rate variations during a storm may be neglected,

(ii) For any drainage area stormwater runoff is directly proportional to the percentage of land surface which is impermeable to water,

(iii) Greatest runoff from a catchment area occurs when the concerned storm duration is roughly equal to the sewage travel time from the furthest portion of the system up to the point at which flow is needed to be known as interpreted by Read, (2004).

According to a study in Ref. [40, 41], Rational Method is the fundamental procedure, which is commonly used to quantify stormwater runoff rates for the design of storm drains or sewers. Rate of runoff "Q" is worked out by following expression,

$$Q = C \times i \times A \tag{2.11}$$

Where,

Q = Peak rate of runoff in ft^3/sec or m^3/sec

C = Dimensionless runoff coefficient depends upon character of basin

A = Drainage area in acres or hectares

i = Intensity of rainfall in mm/hr or inch/hr

ASCE [47] clarified that the assumptions behind the Rational formula are listed below,

(i) Runoff coefficient "C" remains during the design storm

(ii) During the design storm watershed area remains unchanged

(iii) Rainfall remains constant for a time interval and equal to time of concentration

(iv) Peak runoff rate is maximum for a rainfall in given period

2.8.5.1 Weighted Runoff Coefficient

In [33, 48], it was clarified that runoff coefficient "C" of Rational method reflects the catchment losses, so it is dependent on rainfall intensity, terrain slope and nature of catchment. Runoff coefficient "C" in Equation (2.11) is for a catchment with homogenous surface. Values of runoff coefficient for different surfaces are indicated in Table 2.3. If the ground surface of watershed is dissimilar, then the catchment area could be divided into sub areas, so each sub catchment would have different runoff coefficients. In such kind of complex catchment having non-homogeneous land surface weighted runoff coefficient C_j for each sub-area A_j could be calculated by the expression given below,

$$\text{Weighted}C = \sum C_j \times \alpha_j \tag{2.12}$$

In which

$$\alpha_j = \frac{A_j}{A} \tag{2.13}$$

Where,

C = Dimensionless weighted runoff coefficient

C_j = Runoff coefficient of sub-area

A_j = Area of sub catchment in acres

A = Total area of watershed in acres

α_j = Area coefficient for each sub catchment

2.8.6 Newton's Method for the Solution of Manning's Equation

It was elaborated in Refs. [33, 49, 50], that for a given flow rate determination of flow depth by using Manning's equation give no analytical solution because hydraulic radius and cross-sectional area of channel are complex functions of flow depth. An iterative application of Newton's Method could give a numerical solution of Manning's Equation. Where Manning's Equation is,

$$Q = \frac{1.49}{n} \times S^{1/2} \times A \times R^{2/3} \tag{2.14}$$

TABLE 2.3: Values of runoff coefficient "C" for different surfaces [9, 32].

Type of Surface	Flat Slope $< 2\%$	Rolling Slope 2% to 10%	Hilly Slope $< 10\%$
Roofs, pavements	0.86	0.86	0.86
Business areas, city	0.88	0.88	0.88
Dense residential areas	0.60	0.65	0.70
Suburban residential areas	0.49	0.49	0.49
Earth areas	0.60	0.65	0.70
Grassed areas	0.25	0.30	0.30
Cultivated land with clay, loam surface	0.50	0.55	0.60
Sand	0.25	0.30	0.35
Meadows and pasture lands	0.25	0.30	0.30
Forests and wood areas	0.10	0.15	0.20

Suppose the depth y_j is chosen at iteration j to calculate flow rate Q_{jby} using given hydraulic radius and area. So as to select normal depth y the actual flow rate Q is compared with Q_j, while the error is acceptably so,

$$f_{(j)} = Q_j – Q \tag{2.15}$$

$$\frac{df}{dy_j} = \frac{dQ_j}{dy_j} \tag{2.16}$$

After derivation of Manning's Equation with respect to "y" for gradient "f", where Manning's "n" is constant, so the expression solved as

$$\begin{aligned}\left(\frac{df}{dy}\right)_j &= \left(\frac{1.49}{n} \times S^{1/2} \times A_j \times R_j^{2/3}\right) \\ &= \frac{1.49}{n} \times S^{1/2} \times \left(\frac{2AR^{-1/3}}{3}\frac{dR}{dy} + R^{2/3}\frac{dA}{dy}\right)_j \\ &= Q_j\left(\frac{2}{3R}\frac{dR}{dy} + \frac{1}{A}\frac{dA}{dy}\right)_j\end{aligned} \tag{2.17}$$

From above expression the character "j" written slightly below and outside the parenthesis show that the contents are accessed for $y = y_j$.

For a plot of "f" verses "y" following equation for gradient is effective for Newton's method, where y_{j+1} is selected to satisfy for a given choice of y_j.

$$\left(\frac{df}{dy}\right)_j = \frac{0 - f(y)_j}{y_{j+1} - y_j} \tag{2.18}$$

$$y_{j+1} = y_j - \frac{f(y)_j}{\left(\frac{df}{dy}\right)_j} \tag{2.19}$$

Equation (2.19) is the fundamental equation of the Newton's Method. Equations (2.15) and (2.17) are substituted into Equation (2.19) which gives the solution of Manning's Equation by Newton's Method as,

$$y_{j+1} = y_j - \frac{1 - \frac{Q}{Q_j}}{\left(\frac{2}{3R}\frac{dR}{dy} + \frac{1}{A}\frac{dA}{dy}\right)_j} \tag{2.20}$$

Here $\frac{2}{3R}\frac{dR}{dy} + \frac{1}{A}\frac{dA}{dy}$ is channel function which have different values for various channel sections, so for rectangular shape channel section its value given as,

$$\frac{2}{3R}\frac{dR}{dy} + \frac{1}{A}\frac{dA}{dy} = \frac{5B_w + 6y_j}{3y_j\left(B_w + 2y_j\right)}$$

For rectangular channel Manning's Equation becomes for estimation of Q_j, for assumed y_j

$$Q_j = \frac{1.49}{n} \times S^{1/2} \frac{\left(B_w y_j\right)^{5/3}}{\left(B_w + 2y_j\right)^{2/3}} \tag{2.21}$$

In Equation (2.21)

B_w = Channel width

y_j = Assumed flow depth to start iteration

$B_w y_j$ = Area of rectangular section

$B_w + 2y_j$ = Wetted perimeter of rectangular section

So,

$\frac{B_w y_j}{B_w + 2y_j}$ = Hydraulic radius of rectangular section

Finally, Equations (2.20) and (2.21) are the principal equations dependent on channel function to estimate normal depth of flow in a channel or conduit.

2.9 Important Pre-Design Considerations

Tchobanoglous [17] explained that

(i) All-exclusive preliminary investigations are required for the area to be sewered.

(ii) Acquire necessary data for design and construction so as to register relevant details about local conditions before starting project physically.

(iii) If acceptable maps are not available then survey must be conducted according to the degree of precision required for the project.

(iv) Obtain such maps including contour information to locate all existing features along with elevations and underground installed facilities.

According to considerations given in Refs. [9, 52] that, managing urban storm runoff is costly and complicated task. For design purpose

(i) Hydrology and physical features of the drainage area must be considered.

(ii) The hydrologist/engineer should conduct a heedful study of historical rainfall statics before choosing a design storm to be utilized in sizing a new project or analyzing an existing one.

(iii) One should determine hydrologic conditions such as precipitation-runoff relationship, which is the frequency, magnitude and duration of maximum runoff events.

(iv) Local investigations regarding soil types, moisture, evapotranspiration and land use should be carried out.

(v) Size, shape and slope of drainage watershed should be determined.

(vi) It is supposed that a project will work properly, if it can accommodate design flow at full capacity and project functioning will fail whenever design event is surpassed.

2.10 Identification of Design Points and Return Period

It is necessary for the analysis of wastewater flow to establish design points for the related catchments. Position of design points is a function of street layout and topography of the area. A precise layout of area to be drained should be able to define street layouts, direction of flows within the system and location of existing underground facilities. For an economical based design several various layouts should be tried.

Design interval or return period is dependent on the location of design points. For a given design storm the average return period is known as the design interval. For example there is a 4% chance of a 25 year storm event to occur or not for a selected year. Most common design return periods outlined in literature for storm sewers in residential areas are 10 to 15 years. For high value and high value districts it could be 10 to 100 years as recommended in Refs. [31, 47, 48].

Typically urban drainage systems as given in reference [28] are designed for a future life span of 25 to 50 years and could be used for much longer time. Before choosing a suitable design period following factors must be kept in mind,

(i) There should be viability for the future extension of drainage system in question.

(ii) Mechanical, civil and electrical components selected for the system should have useful life.

(iii) Industrial or commercial development and changes in residential area must be considered.

(iv) Thoughtful and precise awareness about financial aspects.

2.11 Drainage Network Design Stages

For the design of a cost-effective and logical drainage system numeral basic phases are required to be followed. These valid stages are elaborated below, based on Refs. [17, 28], which are feasible for any kind of drainage system

(i) **Preparation of Topographical Maps**

Define the contributing area by marking it on a topographical map. The developed or obtained map should contain levels and details of proposed and existing features such as,

- contours at suitable interval
- layout of roads and streets
- natural features like streams or rivers
- proposed and existing buildings
- underground facilities like telephone, electricity cables and sewer or gas pipelines
- mark wastewater outfall point near water receiving body

(ii) **Establish Horizontal Layout**

Horizontal alignment of the network should be aimed on these points

- Pipes and drains to be locate in such way that potential users within the could be easily connected to the system
- Pipes should be placed perpendicular to contour
- According to the topography of contributing area natural drainage to be followed
- Proposed manholes should be located at suitable and accessible positions

(iii) **Foul Sewer Design**

After locating pipes horizontally their size, gradients and flow rates could be estimated by adopting following techniques.

- Choose acceptable design period which is based on industrial, population growth and increasing water utilization rate
- Quantify domestic population of contributing area to work out unit water consumption on the basis of water demand. Also include industrial and commercial wastewater output within the system
- Select design equation or method to calculate peak flow rates during dry weather
- For hydraulic design use suitable equation to establish gradient, flow depths, conduit size to satisfy maximum and minimum flow velocities conditions, in accordance with pipe roughness.

(iv) **Storm Drain or Sewer Design**

Basic design criteria for storm sewers is such as

- Choose design storm on the basis of its duration, intensity and return period
- Access and calculate areas of pervious and impervious surfaces lying within catchment
- Select appropriate method or equation to work out peak flow rates during wet weather conditions keeping in view runoff coefficient

- Use proper equation to compute longitudinal slope, maximum and minimum velocity, flow depths based on channel roughness

(v) **Vertical Alignment of Network Drains and Pipes**
It should be ensured that all sewer pipe lines are placed deep enough that all users could connect easily with the system designed. To avoid pumping pipes or drains should be fixed parallel to ground surface to fulfill gravity flow conditions

(vi) **Revise Horizontal and Vertical Alignment**
Revisit horizontal and vertical profiles of sewer lines along with hydraulic design within the system. This recheck will be helpful to minimize sewer lengths and excavation depths and will also result in cost reduction.

2.12 Cost Aspects of Drainage Networks

In the cost scenario Gupta et al. [52] explained that in developing and developed countries sewerage networks are one of the most capital-intensive below the ground infrastructures. Sewer lines maintenance is essential task to ensure proper conveyance of wastewater to a treatment facility. Whenever a sewer system degrades it allows infiltration inflow which decreases sewer system capacity. As sewer systems buried underground are often neglected due to their low visibility until a major failure takes place which in the end resulting for costly and difficult rehabilitation works. This also increases maintenance and operation costs remarkably. According to Narayanan & Pitt [53] in all project management activities cost estimation plays a vital role. In any decision making activity predicting the total life-cycle project cost for different options is a major step. Where the life-cycle project costs incorporate the initial construction costs, long-term maintenance costs and possible replacement costs. Before stating a project developers, engineers, city planners, funding agencies, private and government agencies are interested to determine these costs (i) total costs, (ii) capital costs, (iii) design, contingency and permitting costs, (iv) operation and maintenance costs, (v) life cycle costs.

2.13 Use of Excel Spreadsheets

Niazkar and Afzali [54] explained that different computational engineering issues could be solved by using excel spreadsheets. For many repetitive and tedious computational tasks which are difficult to perform manually excel provides a proficient platform to resolve these engineering problems. It has progressively become popular due to simple applied ability and natural cell based structure. Excel provides robust coding environment to interlink and cooperate many cells deliberately. Cells can also be explained as matrix index and matrix based codes could be used as a result. Affixed programmable solver have the potential to communicate with cells and could solve engineering related equations. Excel graphical features permit for plotting of multiple plots. Former students' survey of Alabama University Mechanical Engineering Department about software tools revealed that Microsoft Excel was regularly used by 100% respondents on their job places. It is widely being used for various branches of Civil Engineering due to its ability to solve complex systems and much previous knowledge about software Excel s also employed for flow analysis in piping networks. Journal of Hydraulic Engineering December 2001 issue was devoted to the topic of hydraulic design teaching and Excel application in hydraulics engineering.

2.14 Separate vs. Combine Sewer Debate

Since the beginning of urban drainage this question has been discussed, which is the best sewer system so as to minimize pollution of the receiving water body at minimum cost. Two conventional solutions for wastewater drainage were developed either separate or combined sewer system. These systems still form most of the modern sewer systems all over the world and from the last third of 20th century with improved wastewater treatment at the pipe end water quality of receiving water body has been considerably enhanced. Combined sewer systems are regarded to cause hygienic risk and high pollution, so at least in industrial nations there is high trend to adopt separate sewer systems. In combined sewer system nearly 80% of all runoff passes treatment plant while in case of separate system it is less than 50%. Findings revealed that the total chemical oxygen demand (COD) load of combined sewer system was smaller than of a separate system. While the biological oxygen demand (BOD) load from combined system was quite larger than separate system.

Efficiency of wastewater treatment plant (WTTP) to remove BOD for both systems is very good. Separate sewer systems are particularly costly due to double sewers and the overall cost will multiply if stormwater treatment additionally required for storm sewer or treatment for sanitary interceptors are needed to avoid sanitary sewer overflows (SSO) as stated in Ref. [13]. Separate system not often remain separate, there is always some quantity of stormwater in foul sewers and in the same way some wastewater in storm systems. In most cases these both systems behave like two combined systems with varied degree of wastewater dilution as clarified in a study given in reference [12].

It was concluded in Refs. [10, 13, 55] that when two systems compared by means of pollutant mass balance the separate sewer scheme found worse in terms of impact on receiving water body. They claimed generally neither drainage system is better one. A conventional separate system will release lower biological oxygen demand (BOD) loads.

Further explained in Ref. [11] that both in the conditions of intermittent and continuous discharges the separate system is worst in terms of total mass pollutants discharge into receiving water body. If no stormwater treatment is implemented then separate sewer systems could discharge considerable amount of pollutants through their overflow structures into receiving water body.

Carleton [25] said in concluding remarks of his experimental studies that due to significant stormwater inflows into separate system its operational behavior is similar to combined stormwater sewer system. Annual overflow frequencies in both systems are same. Annual flow durations of separate sewer systems were found many times high than combined systems which indicate worseness of separate systems. The preference of separate sewer systems over combined systems so as to solve pollution related problems is questionable. Similar previous studies regarding the topic are also indicated in Section 2.5 of this chapter.

Chapter 3

Study Area, Data and Methodology

3.1 Study Area

The study area is a residential colony which falls in Moza Kongota Saidan, and Jandala in Zone-V, Islamabad. Area of the scheme is about 1476 Kanals and its layout plan has been approved by CDA. Geographical location of study area taken from Google Earth is 33°-34'-28.40" N (latitude) and 73°-13'-8.93" E (longitude) mentioned in Fig. 3.1. Study area image also showing three drainage zones and two STPs locations. The colony is located at a distance of 4.5 Kilometer from Islamabad Expressway, on Japan Road. Neighboring localities of scheme are

- Eastern side — Agricultural land of Moza Mera, Jandala and OPF Housing Scheme,
- Western side — Naval Anchorage Employees Housing scheme
- Southern side — Parliamentarian Enclave Housing scheme and Kongota village
- Northern side — Intelligence Bureau Employees Cooperative Housing Society in Moza Sher Dhamial.

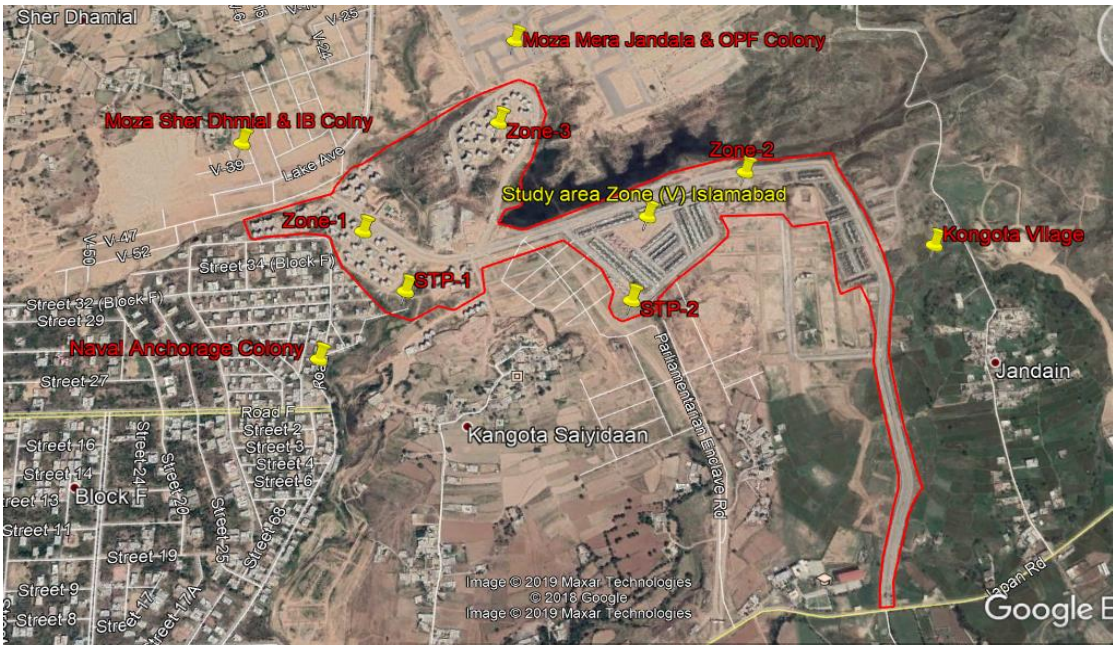

FIGURE 3.1: Image of study area (a residential colony in Zone (V) Islamabad).

3.2 Description of Study Area

Master Planning of study area was carried out by consultant as per the "Modalities and Procedures Framed under ICT (Zoning) Regulations, 1992" issued by CDA. Land use percentages limits for residential colony are listed in Table 3.1.

TABLE 3.1: Land use limits of Residential Colony.

S. No.	Land use Type	Standard usage %	Use in Kanals
(i)	Residential	55%	811.80
(ii)	Open/Green Spaces/Parks	8%	118.08
(iii)	Roads/Streets	26%	383.76
(iv)	Grave Yards	2%	29.52
(v)	Commercial and parking	5%	73.8
(vi)	Public buildings like school, mosque, dispensary, hospital, community center, post office etc.	4%	59.04
		100%	1476 Kanals

Note: (a) Land use are percentages adopted for 1476 Kanals.
(b) Width of vehicular streets provided in layout plan is kept not less than 40ft.

3.3 Data Collection

Master plan, topographic map, longitudinal profiles of roads and road cross-sections along with necessary documents were acquired from consultants. The study area locality accommodates around 500 residential plots of 5 Marla in addition to G+3 apartment blocks (1024 No's Apartments), with civic amenities like Markaz, Sub-sector Shopping areas, Zone for Government offices, Commercial/Public buildings, Parks, Play fields, Schools, Mosques etc. Master plan drawing parts superimposed on survey drawings of study area attached as Appendix F.

3.3.1 Topography of Area

The project area is comprised of rolling as well as mountainous terrain. Survey plans indicate that the natural ground levels vary between 1358 ft to 1550 ft above mean sea level and difference of level is 192 ft. The land parcels accommodate flat as well as steep contours.

3.3.2 Main Roads, Internal Roads and Walkways

According to master plan MR-01 and MR-02 are two dual carriageway main roads having 100 ft wide each. These roads are main linkage between four storied apartment blocks and plots. For access to individual area thirty six internal roads are 40ft wide and two roads have 60ft width. Four walkways between apartment buildings are 12ft wide. Cross-sectional details of multi ROW roads and walkways are attached as Appendix R. Lengths of all roads are mentioned in hydraulic statement for surface water runoff calculations.

3.3.3 Climate Data

It is very important to be familiar with the weather conditions of the region for the design of drainage network. As study area is located in Islamabad, so according to a publication [58] its four main seasons are,

- Pre-monsoon (March — May)
- Monsoon (June — August)
- Post-monsoon (September — November)
- Winter season (December — February)

During monsoon in June maximum mean temperature of Islamabad is 40°C and during January (winter) minimum mean temperature is 3°C. Average annual temperature of Islamabad is 29°C and mean annual rainfall is 44.88 inch (3.74 inch per month). As well heavy rainfall during monsoon which originates from Bay of Bengal Islamabad receives moderate to heavy precipitation during winter season due to western disturbances.

As reported by writers in references [56, 57] Islamabad is located in the upper catch basin of Lai Nullah where our study area falls. The researchers studied extreme rainfall events over Lai Nullah catchment and reported that 10.75 inch rain was recorded from 4 to 9 July 2008 at PMD (Pakistan Metrological Department) Headquarters rain gauge. This five day rainfall was 60% higher than the monthly normal rainfall occurred in July i.e. 13.51 inch at this station. The researcher [56] concluded that 5.04 inch of rainfall in 24 hours over entire catchment of Lai Nullah is the second heaviest precipitation noted during past hundred years. Rehman et al. [57] reported that 4.09 inch of rainfall was recorded over Lai catchment in 100 minutes on 5th July 2008 and overall downpour of 6.38 inch in 5 hours was recorded. A rainfall of 11.02 inch occurred in a day in 2014.

3.3.3.1 Design Rainfall Intensity

It is notable that PMD Headquarters rain gauge is in close vicinity to study area which is quite helpful to fix rain intensity for the storm drains design of study area. On the basis of above reported precipitation records rainfall intensity of 4 inch/hour is fixed for study area. This intensity is used for design to economize the system but even if it is more than 4 inch/hour at some occasion the retention time will be increased and there are no such structures which are going to be damaged by the increase in rainfall intensity. Intensities of rainfall re categorized in Table 3.2.

TABLE 3.2: Classification of precipitation intensities [57].

S. No.	Rain Category	Threshold (inch/hour)
1.	Light	< 0.04
2.	Moderate	0.04-0.16
3.	Heavy	0.04-0.63
4.	Very Heavy	0.63-2
5.	Extreme	> 2

3.4 Methodology

Drainage networks play important role for the collection and suitable disposal of wastewater. For the design of separate and combined sewer systems a residential colony located in Zone (V) Islamabad was selected. To determine terrain features topographic survey maps of the site area were studied. Master plan of the residential colony was superimposed on survey map in AutoCAD environment to locate position of commercial, residential and public facilities according to the given contour elevations. This superimposed map was quite helpful to enable gravity flow from higher elevations to the lowest outfall or disposal point. Road cross-sections and longitudinal profiles were thoroughly reviewed to fix horizontal and vertical layout of drainage systems. Sewer lines, storm drains are placed along multi ROW roads and walkways according to the cross-sections mentioned in Appendix

R. Sewerage and storm drain systems were designed according to the guidelines and standards suggested by the CDA. A flow chart in Fig. 3.2 is showing basic design steps for drainage networks. Quantity and costs for both systems was estimated in accordance to the procedures set forth by PWD.

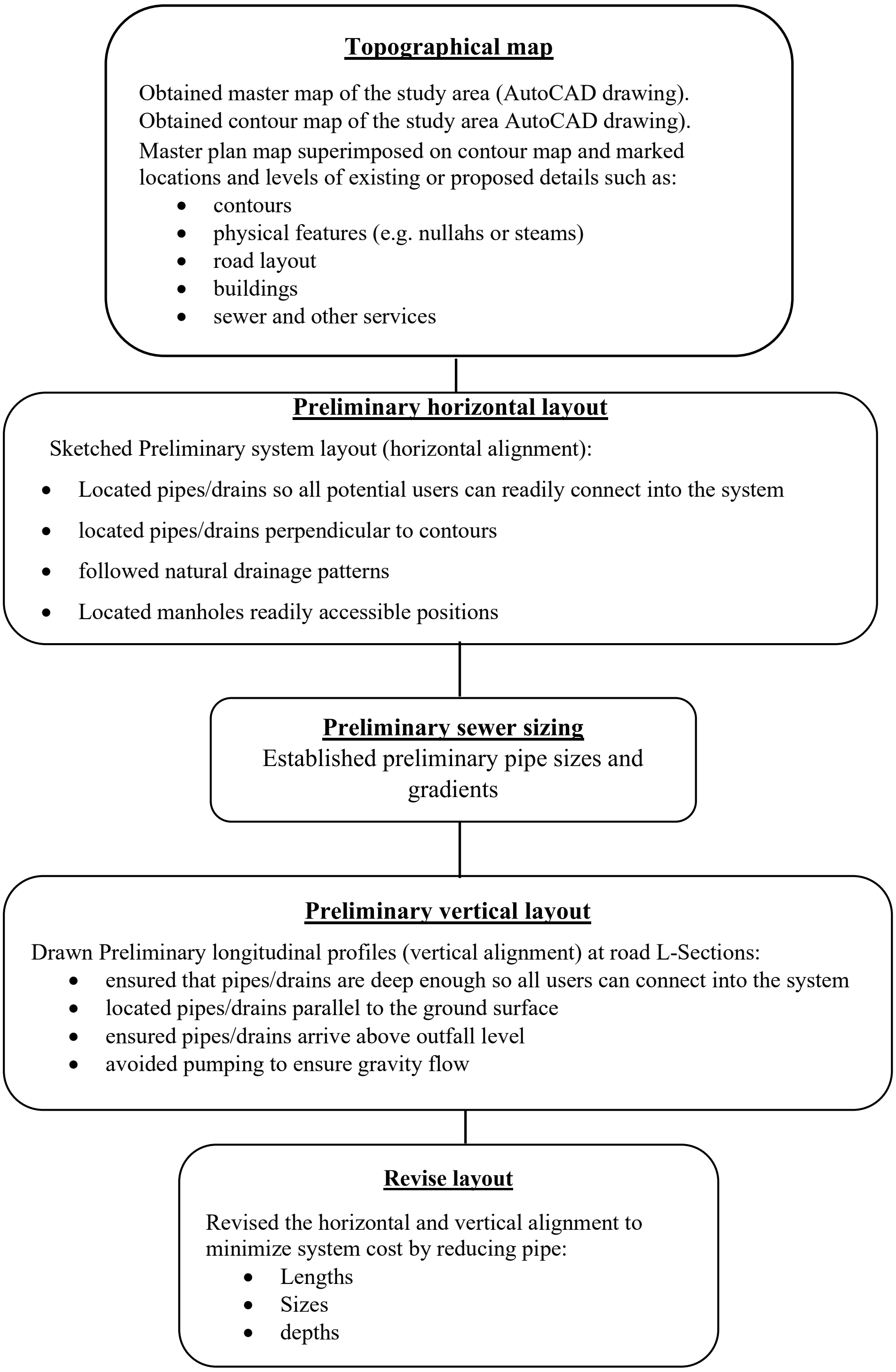

FIGURE 3.2: Basic design procedure for drainage networks mentioned in Ref. [28].

3.4.1 Separate Sewer System

For separate sewer system sanitary sewers are designed to transfer domestic sewage into WWTP, while storm drains are designed to convey wet weather runoff towards nearby nullahs. Design scheme of Separate Network is explained via Fig. 3.3.

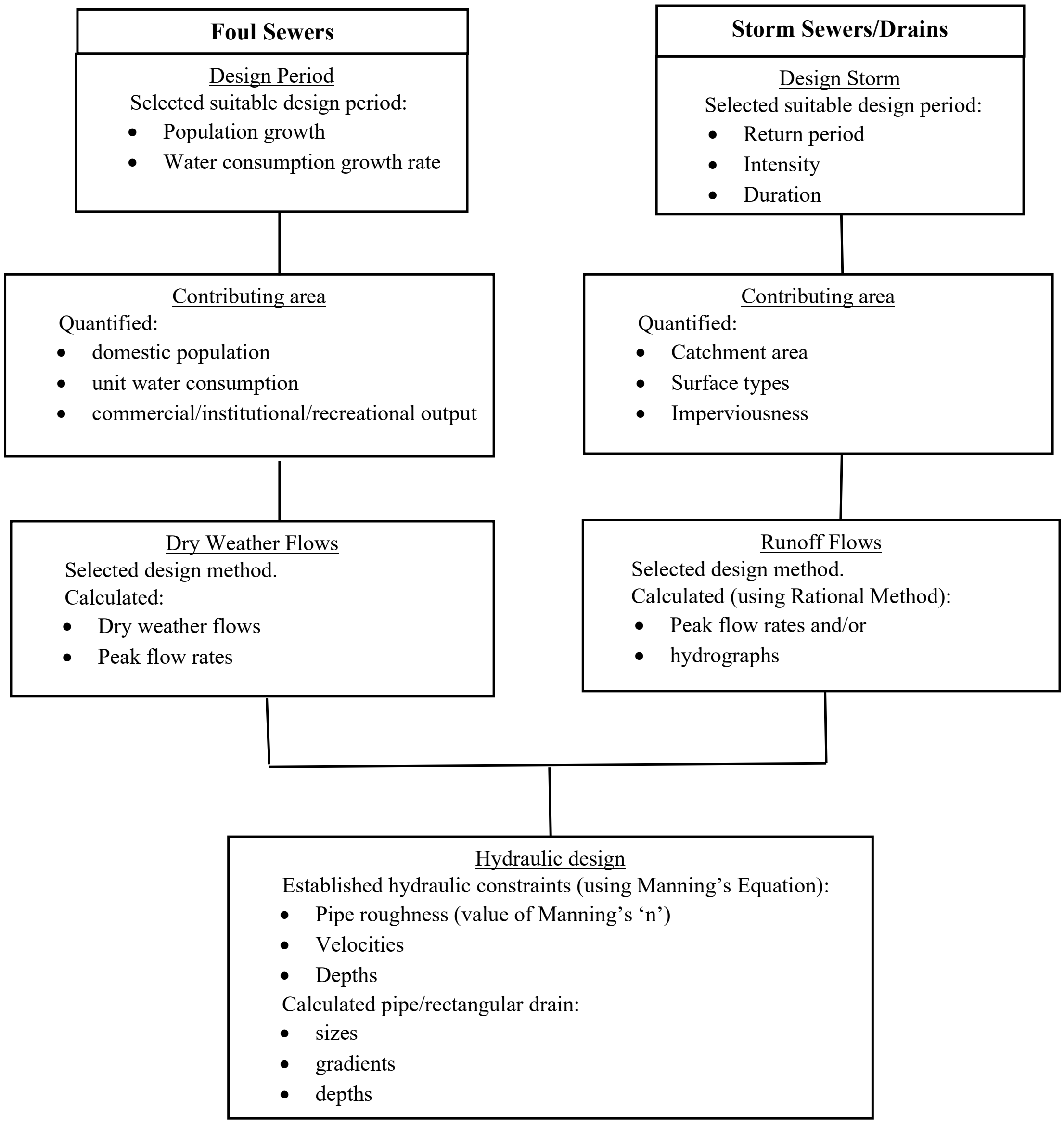

FIGURE 3.3: Separate sewer system design methodology in conjunction with Fig. 3.2, given in Ref. [28]

3.4.1.1 Sewerage Network Design

Proper disposal of wastewater is vital to maintain hygienic conditions in an urban community. It is the first part of separate sewer system. Detailed design of sewerage network could make possible to convey domestic sewage from all units of community into WWTP. Some pre design preparations are,

- Horizontal layout for sewer network is marked on AutoCAD drawing of study area master plan superimposed on survey map to establish design points. Sewerage lines are fixed according to the limits mentioned in road cross-sections.
- Located residential and nonresidential units are coupled each other according to the finalized road, street levels and contour trend for convenient removal of domestic sewage under gravity conditions. This step is helpful to adjust vertical profiles in accordance with velocity and gradient limitations.
- Design flows are established on the basis of details given in Tables 3.3 to 3.8 and Table Q1 of Appendix Q. Design parameters for sewer network are detailed in Tables 3.9 to 3.11.

3.4.1.2 Sewage Quantity Assessment

It is compulsory to estimate accurate quantity of domestic and residential, commercial, institutional, recreational sewage for design and planning of sewers and wastewater treatment facilities. Quantity of sewage out flow is based on the average water consumptions made by the population of the area under consideration.

3.4.1.3 Average Domestic/Residential Water Consumption

As per CDA modalities 100 gpcd is recommended for above one Kanal (equal to 20 Marla or 5445 sqft) plot. This is very high water utilization especially for Residential Colony Zone-V, where all the plot and flat sizes are less than one

Kanal. The 100 gpcd water consumption for above one Kanal means that lot of water is used in lawn watering & car washings. This demand also includes the servant population in bigger houses. Domestic water consumptions gpcd indicated in Table 3.3 are adopted for the population of study area by considering standards mentioned in references [9, 16, 58-60].

TABLE 3.3: Per Capita Water Consumption for Residential Colony.

Plot size	**Per Capita Water Consumption (Gallons)**
One Plot (25' × 45')	50
One Flat (3062 Sft)	40

3.4.1.4 Population Assessment

The population estimation for Residential Colony Zone-V is based on the average house hold size given in detailed layout drawings of Appendix F, G & H. Total population of the study area is computed and shown in Table 3.4.

TABLE 3.4: Estimation of Total Population.

Description	**Total Number of Plots/Flats**	**Habitants per Plot or Flat**	**Total Population**
Average House hold size Plot (25' × 45')	500	6	6 × 500 = 3,000
Average House hold size Flat (3062 Sft)	1,024	5	5 × 1024 = 5120
Grand Total Population	-	-	8,120

For house and flat two persons each unit is assumed and then allowance of 3 to 4 persons per dwelling added according to publication [16, 60] to make 6 inhabitants per house and 5 per flat as mentioned in Table 3.4.

3.4.1.5 Non-residential Water Consumption

This includes water consumption by institutional/commercial/recreational areas. This has been adopted as per CDA Modalities & Procedures mentioned in Table 3.5 based on standards given in publications [9, 16, 58-60].

3.4.1.6 Total Average Day Water Demand

Average Day water demand is essential to calculate peak out flows of wastewater. Total average day water demand is the sum of total domestic, non-domestic (Institutional/Commercial/Recreational) water demands and the unaccounted for water. Here unaccounted for water is the leakage and wastage added in residential/domestic and non-residential water demands. According to CDA procedures unaccounted for water is taken 20% of total water demand. Total average demand worked out for the colony shown in Table 3.5. It is the addition of domestic water consumption given in Table 3.3 for the population given in Table 3.4 and nonresidential consumptions mentioned in Table 3.5 based on standards mentioned in publications [9, 16, 58-60].

Day water demand per house hold is calculated using following formula mentioned in publication [58].

$$y = 37.2x + 69.2(\text{gpd}) \tag{3.1}$$

where y represents water usage per household gallons per day, and x denotes number of persons per dwelling.

TABLE 3.5: Total average day water demands for entire study area.

S. No.	Building Type	Quantity	Population		Area (Sq. ft.)	Water Requirement	Water Demand (gdp)
			Per Unit	Total			
Domestic Water consumption							
1.	House/Plot	500	6	3000	-	50 gallons/capita/day	1,50,000
2.	Flats	1024	5	5120	-	40 gallons/capita/day	2,04,800
Total	**-**	**-**	**-**	**8120**	**-**	**-**	**3,54,800**
Commercial/Institutional/Recreational Water consumptions							
3.	School (15% of Total Population)	-	-	1220	-	8 gallons/capita/day	9,760
4.	Mosque (20% of Total Population)	-	-	1625	-	3 gallons/capita/day	4,875
5.	Community Centre	-	-	-	58095	200 gallons/1000sq.ft./day	11,619
6.	M.I. Room	-	-	-	22500	1000 gallons/acre/day	517
7.	Commercial	-	-	-	142110	1000 gallons/acre/day	3,262
8.	Shops	-	-	-	13230	1000 gallons/acre/day	304
9.	Public Buildings	-	-	-	29250	200 gallons/1000sq.ft./day	5,850
10.	Park	-	-	-	485756	1000 gallons/acre/day	11,160
11.	Fire (4 Nos *FHs working for 60 minutes)	-	4	-	-	60 gallons/minute/*FH	14,400
Average Day Demand							**4,16,547**
Unaccounted for water @ 20% of the average Day Demand							83.309
Total Water Demand of the colony							4,99,856
Say							5,00,000

3.4.1.6.1 Maximum Day Water Requirement As per standards mentioned in publications [9, 16, 58-60] maximum day water requirement is taken 1.5 times of the total average day water demand. In addition to maximum day water requirement along with water requirements discussed in Table 3.5 are summarized in Table 3.6. Maximum day water requirement is useful to workout peak sewage out flows of the study area when multiplied with peak factor for entire population.

Table 3.6: Summary of water demands for entire residential colony.

Description	Gallons per day	Million Gallons per day (MGD)	Cusecs (ft^3/sec)
Avg. Day Domestic Water Demand	3,54,800 (sum of S. No. 1 & 2 of Table 3.5)	0.355	0.66
Avg. Day Non-Domestic Water Demand	61,747 (sum of S. No. 3 to 11 of Table 3.5)	0.062	0.12
Total Avg. Day Water Demand	4,16,547 (sum of S. No. 1 & 2 of this Table)	0.416	0.78
Un-accounted for water @ 20% of Total Avg. Day Water Demand	83,309 (20% of S. No. 3 of this Table)	0.083	0.16
Total Average Water Requirement (Unaccounted for water + Total Day Demand)	5,00,000 (sum of Table 3.5)	0.50	0.94
Maximum Day Water Requirement (1.5 times of Total Average Water Demand)	7,50,000 (1.5 times of S. No. 5 of this Table)	0.75	1.41

3.4.1.7 Peak Factor

Peak Factor for the peak sewage is the function of total population contributing the flow. Peak factor is actually the time ratio of peak hour water usage in 24 hours for house, flat, commercial and hospital etc. All the sewer lines are designed on peak flow to cater for the substantial variation in flow because of climatic conditions, local pattern of water usage and hourly changes in waste water flow. Equation (2.10) mentioned in Chapter 2 is applied for calculation of peak factor.

Peak factor based on population break up given in Table 3.4 is evaluated in Table 3.7.

Gifft's equation is selected on the basis of a practical comparison elaborated in reference [46] also mentioned in Section 2.8.4. Due to its revised format it has less chances of over or underestimation regarding calculation of peak flows.

Table 3.7: Peak factors for individual and total population of residential colony.

Description	**Habitants per Plot or Flat (P)**	$\mathbf{PF = \frac{5}{P^{0.167}}}$
Plot	6	3.71
Flat	5	3.81
Total Population (Plots + Flats)	8,120	1.1

It is notable that peak factor value 1.1 for entire population of residential colony is used to estimate peak flows for residential and nonresidential buildings given in Appendix Q. Peak Factor values 3.71 and 3.81 are used to calculate individual peak sewage flows for sewer lines of separate and combined system hydraulic statements as given n Appendices B, D.

3.4.1.8 Peak Sewage Flows Estimation

The average dry weather sewage flows are taken as 80% of the sum of the average day water demand for domestic and nondomestic or public/commercial uses on the basis of standards mentioned in references [9, 16, 45, 46, 58-60]. The sewage flows from houses, flats, other public and commercial units are calculated on the basis of maximum day water demands compiled in Table 3.6. Peak sewage flows in dry weather conditions worked out for the study area are mentioned in Table 3.8. These peak sewage flows are advantageous for sewer sizing.

Individual peak sewage flows for all residential and nonresidential units are calculated and attached as Appendix Q.

TABLE 3.8: Peak Sewage flow for study area.

Description	GPD	Flow (cusecs)
Avg. Total Water Requirement	5,00,000	0.94
Maximum day water requirement	7,50,000	1.41
Avg. Day sewage flows @ 80% of Maximum day water requirement	6,00,000	1.13
Peak Factor for Total Population	1.1	-
Peak Sewage flow for whole colony (Peak Factor × 80% Max flow)	6,60,000	1.24

Note: 1ft^3/sec = 373.7293 gal/minute and 1gal/minute = 0.0027 ft^3/sec

3.4.1.9 Sewer Sizing, Flow Velocity and Gradients

Sewer lines in a sewer system should have the ability to transfer individual and commulative dry weather peak sewage flows from initial point of network up to its final destination i.e. WTTP. For Separate network such pipe cross sections are selected which could accommodate peak sewage gravity flows. Gradients in longitudinal direction of sewer lines are maintained to provide minimum self-cleansing velocity of 2.5 ft/sec and maximum non-scouring velocity of 8.5 ft/sec. According to criteria mentioned in Ref. [17, 41, 42, 55, 58] minimum 9 inch diameter R.C.C pipes are used, while cross-sectional drawings of multi-diameter pipes are shown in Figure I1 of Appendix I. Sewer sizing, flow velocity and gradients are calculated on the basis of Manning's equation. Maximum and minimum gradients for different sewer sizes to maintain non-silting and non-scouring velocities are indicated in Table 3.9. Where Manning's equation is

$$V = \frac{1.486}{n} \times R^{2/3} \times S^{1/2} \tag{3.2}$$

and

$$\text{Slope}, S = \left(\frac{V \times n}{1.486 \times R^{2/3}}\right)^2 \tag{3.3}$$

were V is the velocity, R represents hydraulic radius, and n is the Manning's roughness coefficient.

TABLE 3.9: Pipe Sizes in accordance with gradient and flow velocity restrictions [17, 41, 42, 55, 58].

Pipe Dia (inch)	**Area of Pipe $= \frac{\prod D^2}{4}$ (sft)**	**$R = \frac{D}{4}$ (ft)**	**Manning's "n"**	**Slope (ft/ft) at V = 2ft/sec**	**Slope (ft/ft) at V = 8.5ft/sec**
9	0.442	0.1875	0.013	0.0029	0.0521
12	0.785	0.2500	0.013	0.0019	0.0355
18	1.766	0.3750	0.013	0.0011	0.0207
24	3.140	0.5000	0.013	0.0008	0.0141
30	4.906	0.6250	0.013	0.0006	0.0103

This tabulated data is handy for its further use as design criteria in hydraulic design sheets, where value of Manning's roughness constant "*n*" is taken 0.013. Sanitary sewer gradients are developed on the basis of finished road levels and contour elevations.

3.4.1.10 Full Flow Conditions in Circular Conduits

In this phase of hydraulic design preparations the network sewer lines must satisfy continuity of flow condition. For pipes to flow full continuity equation is used, where Manning's equation is to maintain non-silting and non-scouring full flow velocities for the developed gradient limitations. To check full flow conditions the full flow worked out through continuity equation should be greater than peak commulative flows at each sewer line of network and maximum velocity should not exceed 8.5 ft/sec. Maximum and minimum flows estimated for multi diameter pipes at specified gradients to provide non-silting, non-scouring velocities are shown in Table 3.10.

3.4.1.11 Part Full Flow Case in Sewer Pipes

Sewer networks are commonly designed to flow full but it is rare to flow full, so part full flow conditions should also be examined. It is the final aspect of hydraulic

TABLE 3.10: Full flow for multi pipe sizes with gradient and flow velocity limitations [17, 41, 42, 55, 58].

Pipe Sizes (inch)	Max & Min Slope (ft/ft)	Pipe Parameters		Min & Max Velocity (ft/sec)	Full Flow (cusec)
		Area (Sft)	$R = \frac{D}{4}$ (ft)	$Vf = \frac{1.486}{n} \times R^{2/3} \times S^{1/2}$	$Q_f = A.V_f$
9	0.0029	0.442	0.1875	2.0	0.89
9	0.0521	0.442	0.1875	8.5	3.78
12	0.0019	0.785	0.2500	2.0	1.55
12	0.0355	0.785	0.2500	8.5	6.71
18	0.0011	1.766	0.3750	2.0	3.48
18	0.0207	1.766	0.3750	8.5	15.11
24	0.0008	3.140	0.5000	2.0	6.40
24	0.0141	3.140	0.5000	8.5	26.85
30	0.0006	4.906	0.6250	2.0	10.04
30	0.0103	4.906	0.6250	8.5	41.61

design process for sewer networks. For partial flow conditions the discharge ratio Q/Q_f, velocity ratio V/V_f and depth ratio d/D are worked out using flow characteristics graph for circular conduits shown in Fig. 2.4 (Chapter 2). Flow characteristics graph is based on geometric elements of circular pipes. It is helpful to manage minimum self-cleansing velocity and estimate normal flow depth. Procedure to use flow characteristics graph is described as,

- Divide individual peak flow of a sewer line by full flow calculated through continuity equation to obtain discharge ratio Q/Q_f.
- For second step mark this discharge ratio Q/Q_f calculated value at horizontal (bottom) axis of graph and draw a vertical right angled upward line from this point up to discharge curve solid line.
- Discharge curve point which located in previous step draw a line parallel to horizontal axis towards left side to take reading for depth ratio d/D.
- From discharge curve point again draw a line parallel to horizontal (bottom) axis towards right side up to velocity ratio curve solid line (ratio of scouring velocity to full flow velocity) and mark a point here.

- From velocity curve point located in fourth step draw a right angled downward line up to horizontal (bottom) axis to take velocity ratio V/V_f reading
- To calculate minimum self-cleansing velocity multiply V/V_f reading with full flow velocity calculated through Manning's Equation
- To obtain normal depth of sewage flow multiply selected diameter of pipe with depth ratio d/D reading

This graph reading process is time taking so velocity and depth readings are obtained from a table detailed in reference [16, 42] shown in Table A1 of Appendix A, on the basis of flow characteristics graph shown in Fig. 2.4 of Chapter 2. For check the velocity calculated should be slightly higher than the minimum self-cleansing velocity of 2 ft/sec.

3.4.1.12 Sewer System Appurtenances

Sewer systems components are detailed below,

(1) Manholes

Deep and shallow manholes are designed at sewer lines change points to collect and transfer sewage flows. For less than 7.5 ft depth square shape P.C.C manholes are suggested, while for depth more than 8 ft depth circular shape man holes are designed. Detailed drawings for both types of manholes are shown in Figures J1-J8 of Appendix J.

(1a) Location of Manholes

Manholes are provided at the following locations in the sewer system by taking into consideration the house connections and the other operational requirements.

- Change in direction of sewer
- Change in level/grades
- Change in Alignment

- Sewer Junctions
- For house connection

(1b) Spacing between Manholes

The manhole spacing varies within the system depending upon the type of housing served by the sewer line. Generally one manhole is provided for two houses along the sewer line. On the straight runs, manhole spacing as per CDA procedures is kept as under:

Internal Dia of sewer	Manhole Spacing
Up to 24" dia	200 ft. c/c
More than 24" dia	300 ft. c/c

(1c) Size of Manhole

According to CDA procedures the internal diameter of the manhole varies depending on the size of the incoming/outgoing sewers. Criteria adopted for study area is detailed in Table 3.11.

TABLE 3.11: Criteria for internal diameter of manhole [17, 41, 42, 47, 55, 58].

Minimum Size of the incoming/outgoing pipe (inch)	**Internal Diameter of Manhole (ft)**
Up to 18 inch	4
24 inch to 30 inch	5

(2) Pipe Joints

The pipe joints for RCC pipes of the following types are adopted according to BS 8301:1985(Former CP 301) and ASTM C76-08a

- Pipe Size below 24 inch – Bell and Spigot Type
- Pipe size 24 inch and above – Socket and Spigot Type

(3) Bedding for Sewers

Sand bedding is recommended under all sizes of sewers. The minimum thickness of this bedding below the pipe is 6 inch. Minimum sand encasement around pipe except bed is 3ft.

(4) Minimum Depth of Cover

Minimum depth of soil cover over the sewer is taken as 4ft from the finished road level up to invert level of pipe. Calculation of invert levels, slopes and earth covers designed are mentioned in hydraulic design sheets shown in results section of Chapter 4.

3.4.2 Storm Drains

Storm drains are important component of separate sewer system which are used to convey surface water runoff separately during wet weather conditions. This is the second and final part of separate drainage network. This section represents a brief description and design of various components of the drainage system designed for study area. The design of this system is based on the design criteria as given in the CDA modalities and procedure for such housing projects. The forthcoming sub-section presents the said criteria and the design for the entire drainagesystem. The main objective of the system is to dispose of the surface run off in such a way which could avoid any kind of damage to the infrastructure and inconvenience to the inhabitants. Main components of system are;

- Drains
- Nallahs

3.4.2.1 Topography

The project area mainly consists of rolling and mountainous terrain with two water channels, which have been naturally developed carrying the rain water flow from East to West and North to South which ultimately joins the Swan River after crossing Japan road. The topography of the area and the paths of natural drains/nallahs have, added advantage of small length of drains finding disposal to nearby nallah. Horizontal layout of storm drains is established according to the limits mentioned in road cross sections drawings attached as Appendix R. Vertical profile of storm drains is fixed on the basis of contour elevations and FRL's of road, streets. Gravity flow is ensured for surface water runoff within the given velocity and gradient restrictions.

3.4.2.2 Design Criteria for Storm Drains

Design flows for storm drains in separate system are based on details given in Tables 3.1 to 3.8 and Table Q1 of Appendix Q. Design criteria for storm networks is detailed in Tables 3.9 to 3.11. In case of flow velocities exceeding upper specified limit of 8.5 ft/sec steps are provided in drain beds to suppress high velocity effects.

3.4.2.3 Rational Method

The rational method which introduced in 1850 is one of the best known empirical techniques used in flood analysis. The rational method has been used successfully for drainage design in many parts of the world. This method is used to evaluate storm water runoff generated during wet weather conditions. The rational formula is very simple to use and is expressed as follows:

$$Q = C \times i \times A \tag{3.4}$$

Where,

Q = Discharge in ft^3/sec

C = Run-off Coefficient

I = Design rainfall intensity (in/hr)

A = Catchment area

The main parameters of method are design rainfall intensity, runoff coefficient and contributing area. The estimation of these parameters is discussed briefly below,

- **Design Rainfall Intensity**

  The design rainfall intensity is average of a storm whose duration is equal to the time of concentration of the catchments under study. The time of concentration is defined as the time required for the rain falling on the most distant part of the catchment to reach the design point. It is usually calculated using an empirical equation based on physical characteristics of the catchment. The rainfall intensity used to calculate of run-off for study area is 4 in/hr. Rainfall intensity of 4 in/hr applied for design to economize the system. Although it is more than 4 in/hr at some occasion as shown in Table 3.2 which could increase the retention time, but there are no such structures, which are going to be damaged by the increase in rainfall intensity.

- **Estimation of Contributing Area**

  Details of land use mentioned on master plan drawings prepared in Auto-CAD enjoyment are based on Table 3.1 of section 3.2. Area of each type of residential, nonresidential, paved and unpaved units are calculated. Terrain slopes are archived from predefined road levels and contour elevations for proper drainage of wet weather surface water runoff into nearby Nullahs. Area estimation for each section of study area is helpful to determine runoff coefficients according to the surfaces involved and further to develop weighted runoff coefficient for entire area.

- **Run-off Coefficient "C"**

  The coefficient largely accounts for the effect of soil type, land use and hydrologic cover condition of contributing area on the volume and rate of run-off caused during wet weather conditions. Effective run-off coefficient is used considering paved area, residences and open area. Selection of the correct run-off coefficient is one of the most common difficulties associated with the rational method. The run-off coefficient, which is based on land use, is estimated from standard design Table 2.4 (mentioned in Chapter 2). To attain effective run-off coefficient Equations (2.12) and (2.13) are used to estimate weighted runoff coefficient for composite drainage area surfaces like roofs, lawns and pavements etc. Weighted run-off coefficient calculated for the study area is 0.68 shown in table attached as Appendix C, which is dependent upon the land use details given on master plan.

3.4.2.4 Run-off Volume Computation

fter determining rainfall intensity and weighted runoff coefficient the discharge for set of individual drains based on type of contributing area is calculated using Excel spread sheets. Runoff volume estimated through Rational Method is key to assess drain capacity within velocity, gradient limitations and it is supportive for suitable drain sizing.

3.4.2.5 Selection of Drain X-Section

P.C.C drains with R.C.C portable covers are adopted to carry the runoff to nearby disposal point for 40ft, 60ft and 100ft wide roads. Rectangular cross sections are considered and analyzed for the storm water drains. Although trapezoidal section is hydraulically more efficient but due to space constraints rectangular section is preferred for the study area. Minimum size of drain is taken 12" $\times$ 12", while maximum size is 30" $\times$ 30" and shown in drawings attached as Appendix K. The depth of drain is equal at the start and the end of the drain.

3.4.2.6 Minimum, Maximum Velocity, Gradient and Drain Capacity at Full Flow

On the basis of predicted surface water runoff volumes the capacity, minimum, maximum velocities associated to gradient limitations for full flow conditions are developed on Excel spreadsheets. The topography mainly consist of mountainous terrain, so minimum velocity of 3ft/sec is adopted for commulative peak flow at individual drains. The maximum velocity of 8.5 ft/sec is maintained to avoid scouring effects. Where velocity is exceeding 8.5ft/sec steps are provided in drain bed to suppress this high velocity and to avoid scouring effects. Provision of steps in drain bed is mentioned in drawings attached as Appendix O. Gradients are managed on the basis of finished road levels and contour elevations. Actual velocity and drain capacity is worked out using Continuity equation while Manning's equation is used to estimate maximum velocity for selected drain size to carry given peak flow. For the capacity and cross section check of drains the actual commulative peak flow should be less than the calculated discharge through Continuity Equation.

3.4.2.7 Storm Drains Flowing Partly Full

It is not necessary that drains or conduits always run full so partially full conditions must be analyzed. Hydraulics characteristics graph shown in Fig. 2.4 (Chapter 2) is used for part full flow analysis. Following features are estimated from the graph to satisfy part full flow conditions in each drain. Detailed calculations are shown in hydraulic design sheets of storm drains attached in Results section of Chapter 4.

- Discharge ratio Q/Q_f is obtained by Dividing individual peak flow by full flow calculated through continuity equation.
- For second step mark this discharge ratio Q/Q_f calculated value is marked at horizontal axis of graph and a vertical right angled upward line drawn from this point up to discharge curve.
- To attain velocity ratio V/V_f reading, a line parallel to horizontal axis originating from discharge curve point is drawn towards right side of graph up to velocity curve. Again a vertical right angled downward line beginning from velocity curve point is drawn up to horizontal axis and velocity ratio value recorded.
- Minimum non-silting velocity is calculated by multiplying V/V_f graph reading with maximum discharge calculated through Continuity Equation. For

check minimum self-cleansing velocity should be higher than 3 ft/sec, but at some locations when it exceeds 8.5ft/sec then steps in drain bed are provided to split velocity as discussed in Section 3.4.2.6.

- As flow characteristics graph is useful for circular conduits while storm drain section is of rectangular shape, so this graph is unable to give depth ratio d/D.
- Normal flow depth for each drain of drainage network during wet weather conditions is calculated by solving Manning's Equation through Newton's Method elaborated in Section 2.8.6.of Chapter 2.

3.4.2.8 Normal Flow Depth

Normal depth of storm flows carried by rectangular drains is estimated by utilizing Equations 2.20 and 2.21 as explained in Section 2.8.6. For Equation 2.20 value of flow depth y_j is assumed to estimate Q_j which is inserted in Equation 2.21 to start iteration. The first value of Q_j obtained approximately equals full flow condition and at the end of iteration when the value of y_j equals in the same way value of Q_j equals the actual or given flow Q. As this is iterative method and time taking, so applied on selective drain sections where commulative peak flow rates are high. Normal flow depth for chosen drain lines are solved though Excel sheets are shown in Results section of Chapter 4.

3.4.2.9 Storm Drainage Components

Elements of storm drainage network are detailed below,

- **Catch Pits**
  P.C.C (1:3:6) Catch Pits of size 2' $\times$ 2' and variable depth are designed to collect surface water runoff and covey it to nearby drain. These catch pits are provided at each 50 ft length and are connected with drain via 6" dia R.C.C pipes. Catch pits are covered with 1 inch thick Mild Steel perforated sheet

of length 2.33 ft and width 2.33 ft. Perforated type steel covers allow storm water to enter easily into catch pits and further transfer into rectangular drain. Catch pits shown in drawings attached as Annexure I. It is notable that MR-01 and MR-02 which are 100 ft wide storm drain is placed at right side of center median while the catch pits are provided at left side of center median and are connected via 6 inch dia R.C.C pipes to transport storm water into rectangular drain. Storm drain at right side would receive storm water from right side through 1 inch wide openings between R.C.C portable drain covers. Minimum spacing between catch pits is kept 50 ft. Drawings of catch pits are shown in Figs. L1-L3 of Appendix L.

- **Trapezoidal Shape Cunette**
  Six inch deep Trapezoidal shape open drains are provided to collect and transport surface water into catch pits. Trapezoidal shape drain is to convey surface water via catch pits to storm drain. Detailed cross-sectional drawings and photographs of trapezoidal shape drain are shown in Appendix P.

- **Outfall Structures**
  Such type of structures are provided at the exit ends of storm drains. Out fall structures are designed to avoid erosional effects at outfall end of storm drains. R.C.C Out fall structures contain head wall with opening, wing walls and sloping bed. Dry stone pitching apron is provided beyond R.C.C structure to secure properly out fall end of storm drains. Drawings of out fall structures along with stone apron are shown in Figures N1 to N3 of Appendix N.

3.4.3 Combined Sewer System

When for a community dry and wet weather flows are transported through single conduit or drain, then it is known as combined drainage network. Combined system is contrary to separate sewer system where dry and wet weather flows are conveyed through separate conduits. Combined network design techniques are elaborated in Fig. 3.4.

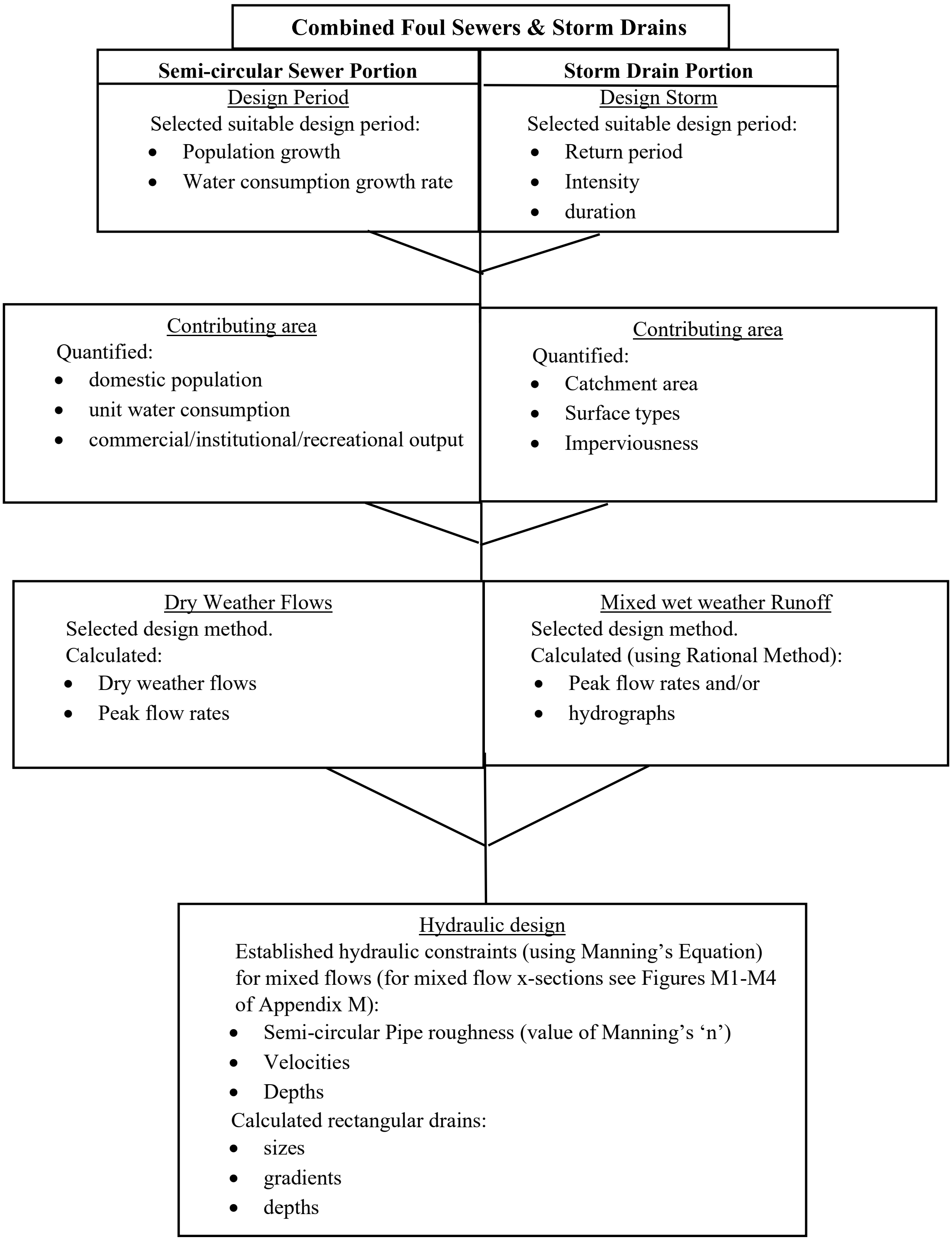

FIGURE 3.4: Design procedure for Combined of network in affiliation with Fig. 3.2.

3.4.3.1 Design of Combined Sewer System

After designing separate system for study area combined sewer system is designed for the same location. Design methods for combined sewer system are similar to separate sewer system and it is combination of procedures adopted for sewerage system and storm drains. Following steps are adopted for the design of combined sewer system.

- Horizontal layout of combined system is placed on the same track on which sewerage network was established for separate sewer system.
- For the transportation of dry weather flows half circled cunette of 6 inch diameter was provided in the base portion of rectangular shape drain. For disposal of sewage same methods and limitations are adopted as mentioned in Sections 3.4.1 to 3.4.1.12 for sewerage network.
- Methodology adopted for wet weather flows which also contains dry weather flow is similar to the approach followed for storm drains from Sections 3.4.2 to 3.4.2.8.
- In first phase design for dry weather flows carried cunette is prepared while for the second and final phase design for dry weather flow plus wet weather flow is prepared using Excel sheets also mentioned in Results Section of Chapter 4.
- Combined sewer system designed for the study area is of improved type. System is able to dispose of dry and wet weather flows jointly as well, but at some locations where wet weather flows could not be attached with combined system a network of separate drains is designed.
- Design criterion for combined network are same as mentioned in sections 3.4.1.1 and 3.4.2.2 due to mixed flow conditions.

3.4.3.2 Channel Cross-section Selection

Following type of channel cross-sections are adopted for the combined sewer system,

- Half circled six inch diameter cunette is furnished in the bed of rectangular shape drain to carry dry weather flows.
- For combined flow minimum size of 18" × 18" is chosen for rectangular shape drain, while 30" × 30" is taken the maximum size.
- Within the system at some portions where drains are necessarily placed against the vertical profile of roads exaction volumes increased. so as to reduce excavation volumes circular conduits of 9 inch diameter to of 30 inch diameter are used.
- For separated portion of combined system to carry wet weather flows rectangular drain sizes from 12" × 12" to 30" × 30" are selected.
- (v) Detailed drawings of above mentioned drain plus semi-circular sections are shown in Figures M1-M7 of Appendix M.

3.4.3.3 Combined Sewer System Components

Combined sewer system accessories are explained below

- **Manholes**
  Manhole design criteria for combined systems is same as mentioned in Section 3.4.1.12.
- **Trapezoidal cunette Drains, Outfall structures and Catch pits**
  Design and shape of these components adopted for combined system have the same basis as discussed in Section 3.4.2.9 for storm drains.

3.4.4 Structural Composition of System Components

Types of materials suggested for the construction of separate and combined sewer system appurtenances are shown in Table 3.12, while dimension and other details are shown in drawings of Appendices J to P. Usage of materials and dimensions are based on CDA modalities and PWD schedule of rates 2012.

Table 3.12: Details of construction materials used for drainage components extracted from drawings given in Appendices J to P.

Type of Material	Usage in Component
Stone Ballast	Foundation of deep circular manholes
P.C.C (1:4:8)	Foundation of deep circular manholes, Square manholes, catch pits, storm drains and outfall drainage structures
Brick Masonry with cement mortar (1:3)	Walls of deep circular manholes
Cement plaster with ratio (1:3)	Inside and outside walls of deep circular manholes
Concrete (1:2:4) benching	Inside bottom of deep manholes and storm drains
R.C.C (1:2:4)	Manhole cover, manhole cover resting area, covers of square manholes, covers of storm drains, culverts and outfall structures
Mild Steel Angle Iron plates 1/2" & 1/4" thick	Manhole cover ring and resting area ring along with anchors
Mild Steel plate 1 inch thick	Perforated catch pit covers
Bitumen Coating	Outside walls of deep manholes, Square manholes, and storm drain walls
P.C.C (1:2:4)	Complete Trapezoidal drain
P.C.C (1:3:6)	For walls and base portion of Storm Drains, Catch Pits & Square Manholes
Dry Stone Masonry	Apron of Drainage Outlet Structures
Cement Pointing (1:2)	Apron of Drainage Outlet Structures
Steel Reinforcement Dia #3 & #4	Manhole covers, storm drain covers, Drainage outlet structures
Sand	Pipes Encasement
R.C.C Pipes	Diameters 6", 9", 12", 18", 24" and 30"

3.4.5 Cost Evaluation for Both Systems

Quantity of each item utilized in both drainage system is calculated by using Excel spreadsheets. For cost estimation of combined and separate sewer items PWD schedule of rates 2012 is used. As this is old version of rates so as per CDA procedures 35% premium is added to each item to calculate current price. Individual and commulative quantities, costs for both systems are elaborated in Results Section of Chapter 4 and details are given in Table E1 of Appendix E.

3.4.6 Hydraulic Comparison of SS and CS

Hydraulic design of both sewer systems was prepared using Excel sheets is given in Appendix B, D. Table 4.1 and 4.2 are developed for separate sewer system extracted from Tables B1 to B6 of Appendix B. Table 4.3 and 4.4 are developed for combined network is withdrawn from Tables D1 to D9 of Appendix D. Comparison of both systems is presented in Table 4.11.

3.4.7 Cost Comparison of SS and CS

Quantity and cost of for both systems prepared using Excel sheets is given in Appendix E. Quantity and cost of separate system presented in Tables 4.5, 4.6 extracted from Table of E1 Appendix E. Quantity and cost of combined system elaborated in Tables 4.7 to 4.9 extracted from Table E1 of Appendix E. Quantity and cost comparisons are presented in Table 4.12.

Chapter 4

Results and Analysis

4.1 Results

In previous chapter selected study area and methodology for the design of separate, combined drainage networks is discussed. Motive of this study is to compare both drainage networks hydraulically and financially for the area in question. This chapter contains the design and cost out puts of the drainage networks obtained by using the methodology disclosed in Chapter 3. The design and cost outputs for both the systems prepared in MS Excel are,

(1) Separate Sewer System Design

- Hydraulic statements of sanitary sewers
- Hydraulic statement of storm drains
- Weighted runoff coefficient "C" evaluation sheet related to Rational Method for storm drains
- Spread sheet for calculation of normal flow depth for rectangular drains through Manning's Equation solution by Newton's Method

(2) Combined Sewer System Design

- Design sheet for dry weather flow calculations
- Hydraulic statement of merged flows in cunette plus rectangular drain portion and circular pipe sections for combined network.
- Hydraulic statement of storm drains separated in combined system
- Normal flow depth estimation sheets for rectangular drain plus cunette
- Weighted runoff coefficient estimation sheet

(3) Cost Estimation

- Quantities of items relevant to drainage network components and their cost estimation are also included in this chapter.

4.2 Hydraulic Statement of Sewerage System for Separate Network

Sewer network layout and design is prepared on the basis of considerations established in Section 3.4.1 of Chapter 3. Residential area is divided in three drainage regions, where WWTP-1 would receive greywater from Zone-1 containing blocks (3, 4, 5, 6, 7, 8, 9, 10, 11 & 12 having 576 No of flats) and Zone-3 possess blocks (1, 2, 13, 14, 15, 16 & 17 having 448 No of flats) including non-residential area. Zone-2 which consist of 500 No's of residential plots including no-residential area is planned to convey sanitary waste towards WWTP-2. Final detailed design sheets are shown as Tables B1, B2 and B3 of Appendix B which holds following information, where each sewer pipe run is starting from the upstream node and ending at downstream node.

(i) "Section" column (a) the road, street or block no on which pipe run is located.

(ii) "Manhole no" starting from a node of sewer line and to end node columns (b) and (c).

(iii) "Sewer length" column (d).

(iv) "Sewer Dia" column (e).

(v) "Peak factor" column (f) based on Table 3.7 for habitants per plot.

(vi) "Individual peak flow" column (g) peak flows taken from Annexure H multiplied by no of buildings on that section (individual peak flows calculated for residential and nonresidential units).

(vii) "Individual peak flow rate" column (h) is obtained by multiplying columns (f) and (g).

(viii) "commulative flow" column (i)

(ix) "FRL (Finished Road Level)" from "End-1" of sewer line up to "End-2" columns (j) and (k). FRL are obtained from finalized road levels or contour elevations in case of sewer line away from road.

(x) "Invert Level" from "End-1" of sewer line inner bottom up to "End-2" columns (l) and (m). Invert levels are kept minimum 48 inch below FRL.

(xi) "Slope" column (n) the difference of invert levels at both ends divided by the length of sewer line. Gradient for multi dia pipes is adjusted on the basis limitations given in Table 3.10.

(xii) "Cover" is FRL minus Invert level at "End-1" and "End-1" of sewer line columns (o) and (p) to workout excavation depth at both ends.

(xiii) "Pipe Parameters" contains "Area" of circular section and "Hydraulic Radius of pipe section" columns (q) and (r).

(xiv) "Velocity V_f" column (s) the maximum flow velocity attained by using Manning's Equation 2.6, where value of Manning's "n" is taken 0.013.

(xv) "Full flow" column (t) the discharge estimated at full flow condition by using Continuity Equation (2.4).

(xvi) "Flow check $Q < Q_f$" column (u) is OK if commulative flow in column (i) is less than full flow in column (t).

(xvii) "Remarks from Hydraulic Characteristics Table" to satisfy partly full flow condition are "Q/Q_f", "V/V_f" and "V" columns (v), (w) and (x), where "Q/Q_f" is calculated by dividing commulative flow in column (i) with full flow of column (t). Here "V/V_f" column (w) is accessed from Table A1 (given in Appendix A) reading against calculated "Q/Q_f". Minimum velocity "V" of column (x) is estimated by multiplying maximum velocity in column (s) with "V/V_f" reading given in column (w).

(xviii) "Minimum Specified Velocity" column (y) i.e. 2ft/sec.

(xix) "Final check for Velocity" column (z) is "OK" if minimum velocity calculated in column (x) is greater than minimum specified velocity of column (y).

(xx) "Depth Ratio d/D" column (aa) accessed from hydraulics characteristics Table A1 readings based on Fig. 2.4 given in Appendix A.

(xxi) "Flow Depth" column (ab) achieved by multiplying depth ratio reading of column (aa) with selected sewer diameter given in column (e).

- **Important Outputs from Sewer Design Sheets**
  Above stated 21 design steps are repeated for each length of sewer line given in hydraulic statement to convey wastewater towards required STPs. For the disposal of sanitary waste into two WWTPs the whole residential colony is split in three zones whose final riddance details based on three design sheets are shown in Table 4.1. Sanitary waste of Zone-3 and Zone-1 is discarded at STP-2. Greywater of Zone-2 is transferred to STP-1. It could be observed from Table 4.1 that all three zones of entire residential colony are transferring 2.22 cusecs of wastewater.

- **Layout plan Drawings of Separate Sewer System**
  Key plan of separate network layout is given in Fig. F1, while detailed layout is shown in Figs. F2 to F18 of Appendix F. All these AutoCAD drawings are based on hydraulic design Tables B1 to B3 of Appendix B.

TABLE 4.1: Sewerage disposal Zones for residential colony extracted from Tables B1, B2 and B3 of Appendix B.

Zone (No)	Disposal Nodes (From - To)	Ejection point	Contributing House/Flats (Nos)	Q_{act} (ft^3/sec)	Q_{full} (ft^3/sec)	V_{full} (ft/sec)	V_{Min} (ft/sec)	Flow Depth (inch)	Remarks
3	C34 – A12	STP-1	1024	1.36	1.39	3.15	3.59	7.2	S. No. 33 of Table B1
1	A28 – STP1								
2	B51 – STP2	STP-2	500	0.86	1.51	3.42	3.52	4.86	S. No. 68 of Table B3
Total	–	–	–	**2.22**	–	–	–	–	

- **Layout plan Drawings of Separate Sewer System**
  Key plan of separate network layout is given in Fig. F1, while detailed layout is shown in Figs F2 to F18 of Appendix F. All these AutoCAD drawings are based on hydraulic design Tables B1 to B3 of Appendix B.

4.2.1 Hydraulic Statement of Storm Drains for Separate Network

Surface water runoff disposal design and layout is prepared on the ground of aims flourished in Section 3.4.2 of Chapter 3. The whole area of residential colony is split into sub catchments keeping in view terrain slope for drainage of surface water into nearby nullahs. Storm drain design is comprised of two spreadsheets. In the first sheet shown as Table B4 of Appendix B discharge for each drain is estimated by using Rational Method. The flows computed in first sheet are analyzed in second sheet shown as Table B5 of Appendix B to workout drain capacity and size along with velocity.

Following are the features of area and discharge computation spread sheet or Rational Method spreadsheet shown as Table B4 of Appendix B.

(i) "Section" column (a) the road, street or block no on which drain line is located.

(ii) "Total Length of Road" column (b) length of road, street or walkway.

(iii) "Feeding Road Length" column (c) length of road, street or walkway feeding surface water to drain.

(iv) "Drain Length" column (d)

(v) "Side of Drain" column (e) the position of drain either right or left side of road.

(vi) "Extended Drain Length" column (f) the part of drain length crossing a road or street. It is the culvert portion of a drain line.

(vii) "Nodes" are starting point of a drain length "From" up "To" its end point columns (g) and (h).

(viii) "Total Drain Length" column (i) the addition of columns (d) and (f).

(ix) "Total Width of Road" column (j) the width of asphaltic portion of a road on which a drain line is located. It is helpful to calculate asphaltic area feeding surface water to a drain.

(x) "Shoulder Width on both sides of Road" column (k) the width of that portion of road which is without asphalt. It is applicable to work out area of unpaved surface feeding a drain.

(xi) "Green Area of Feeding Roads" column (l) estimated by multiplying columns (c) and (k) to obtain of Green (Shoulders of roads) area of road feeding surface water to a drain.

(xii) "Width of Green belt for MR-01 & MR-02" column (m) the width of green belt at the center median of 100ft wide main roads no 1 and 2. It is helpful to calculate area of unpaved surface feeding drains placed along the center median of main roads.

(xiii) "Green Area feeding from Center median of MR-01 & MR-02" column (n) the area calculated for unpaved green belt by multiplying columns (c) and (m).

(xiv) "Pavement Width of Roads" column (o) the width of asphaltic portion of roads. It is helpful to workout area of asphalt feeding a drain.

(xv) "Paved area of Feeding Roads" column (p) the asphaltic area of a road is calculated by multiplying columns (c) and (o).

(xvi) "Green area for one house or Apartment" column (q) the area of unpaved area within a house which is taken 10% of the total roof area of one house but apartments are fully covered so nil for it.

(xvii) "Roof area foe one House or Apartment" column (r) the area of one house or apartment. Here apartment/flats are considered fully covered. Size of one house is 25ft × 45ft, so its area is 1125sft, while the area of one apartment 3062sft is estimated from master plan AutoCAD drawing.

(xviii) "No of Houses or Apartments" column (s) the no of houses or apartments located on both sides of a drain line.

(xix) "Total Green area of Houses/Apartments" column (t) the total green area of houses located on a drain line which is obtained by multiplying columns (q) and (s).

(xx) "Total Roof area of Houses/Apartments" column (u) the total area of roofs of houses or apartments located on a drain line to share surface water runoff.

(xxi) "Columns (v) to (ah)" are the other non-residential areas and buildings contributing storm runoff to drain lines. Surface flow is directed to nearby drain according to ground slope trend. Areas are calculated from master plan AutoCAD drawings, Runoff generated through different surfaces from columns (l) to (ah) are useful to determine Weighted Runoff Coefficient "C" for entire residential colony.

(xxii) "Total Paved Area" column (ai) the sum of all paved areas contributing surface water runoff to a drain line.

(xxiii) "Total Green Area" column (aj) the sum of all green areas sharing surface storm runoff to a drain line.

(xxiv) "Rational Formula" column (ak) the flow computation by multiplying Weighted Runoff Coefficient "C", Intensity of rainfall and the total area (green + paved) involved for each drain line.

(xxv) "Sub-catchment No" column (al).

(xxvi) "Sub-catchment area" column (am) the area of each sub-basin.

Above mentioned 24 design steps are repeated for each drain line to work out discharge. Spreadsheet Column (ak) showing different intensities of flow loads for individual drain lines. Various flow concentrations are based on fixed rain intensity, Weighted Value of "*C*", residential and nonresidential areas contributing. Multiple forms of surface areas are summed at the end of sheet. Storm runoffs calculated for network of drains scattered in the residential colony are utilized for the following drain size confirmation spreadsheet.

Following are the features of spreadsheet shown as Table B5 of Appendix B for verification of drain size, capacity and velocity components.

(i) "Drain Nodes" is initial point of drain "From" up "To" end point of drain columns (a) and (b).

(ii) "Drain Length" columns (c).

(iii) "FGL" at the finished ground level of drain line at "End-1" up to "End-2" columns (d) and (e).

(iv) "Invert Level at" from "End-1" of drain line inner bottom up to "End-2" columns (f) and (g). Invert levels at both ends are calculated by deducting drain depth given in column (l) from FGLs stated in columns (d) and (e).

(v) "Slope %" column (h) the difference of invert levels at both ends multiplied by hundred and divided with drain line length.

(vi) "Discharge" contains "Individual discharge" column (i) linked to column (ak) of Rational Method spreadsheet and column (j) "Commulative discharge" for each drain line.

(vii) "Drain Size" the internal width "*b*" and depth "*d*" of selected drain section columns (k) & (l).

(viii) "Drain Area" column (m) the area of rectangular drain section obtained by multiplying columns (k) and (l).

(ix) "Drain Wetted Perimeter" column (n) calculated by multiplying 2 with drain depth in column (l) and adding it with drain width of column (k).

(x) "Hydraulic Radius of Drain" column (o) estimated by dividing cross sectional area of drain section in column (m) with the drain perimeter calculated in column (n).

(xi) "Velocity actual" column (p) calculated by multiplying commulative discharge given in column (j) with area of drain section from column (m).

(xii) "Velocity Max" column (q) estimated by using Manning's Equation 2.6. Value of Manning's constant "n" is adopted 0.013.

(xiii) "Capacity Max" column (r) the discharge obtained by multiplying area of drain section in column (m) with maximum velocity of column (q).

(xiv) "OK or NG" column (s) the check of drain capacity which is "OK" if commulative discharge given in column (j) is less than the capacity calculated in column (r), if the column (j) value is greater than column (j) then "NG" means Not Generic or not comparable.

(xv) "Readings from Hydraulic Characteristic Table" to satisfy partially full flow condition are discharge ratio, velocity ratio, minimum velocity columns (t), (u) and (v), where discharge ratio is calculated by dividing commulative flow in column (j) with full flow discharge of column (r). Here velocity ratio column (u) is accessed from Table A1 (given in Appendix A) reading against calculated discharge ratio. Minimum velocity "V" of column (v) is obtained by multiplying drain capacity of column (r) with velocity ratio column (u).

(xvi) "Min Specified velocity" column (w).

(xvii) "Final check for velocity" column (x) is "OK" if minimum flow velocity calculated in column (v) is greater than minimum specified velocity of column (w) and "FALSE" if value of column (v) is less than column (w).

(xviii) "Max Specified velocity" column (y).

(xix) "Stepped Drain or Not" column (z) the provision of 6inch steps in drain bed if minimum velocity of column (v) is greater than maximum specified velocity in column (y). If minimum velocity of column (v) is less than the value of column (y) then "FALSE" means steps not required in drain bed. Steps in drain bed are to suppress high value of flow velocity.

(xx) "Sub-Catchments No" column (aa) the catchment no and column length is the extent of catchment.

(xxi) "Sub-basin area" column (ab) the area of each catchment.

(xxii) "Q from Sub-Catchment" column (ac) the total outflow from each sub-basin.

- **Principal Outputs from both Storm Drain Design Sheets**
  Above explained 18 design steps are repeated for each length of rectangular shape drain line to convey storm runoff towards adjacent nullahs or streams. For proper drainage entire residential is divided in 17 sub-catchments whose disposal details are given in Table 4.2, where area of each sub-catchment(Green plus paved), actual commulative discharge, drain size, actual velocity, maximum velocity, minimum velocity and normal depth of flow at terminal nodes are shown. Weighted value of runoff coefficient 'C' is applied from spreadsheet shown as Table C1 of Appendix C. It could be observed from the design sheet that minimum velocity is exceeding the specified maximum velocity so the drain is stepped to avoid scouring effects.

Table 4.2 is also indicating total storm water discharge of 235.24 cusecs generated by total feeding area of 3948235 sft.

- **Layout Plan Drawings of Storm Drains for Separate Sewer System**
  Key plan of storm drains network layout is given in Figure G1, while detailed layout AutoCAD drawings of 17 sub catchments are shown in Figures mentioned below of Appendix G.

  (i) Figure G2 to G6 (SC-9)

TABLE 4.2: Sub-catchments drainage pattern extracted from storm drains design sheets given in Table B5 of Annexure B.

S. No.	Area G* + P* (Sft)	Exit Nodes	Drain Size B" × D"	Q_{act} (cusec)	Q_{th} (cusec)	V_{act} (ft/sec)	V_{Max} (ft/sec)	V_{Min} (ft/sec)	Flow Depth (ft)	Remarks
1	842899 (column 'ab')	B2.6	30" × 30"	45.58	66.3	7.29	10.61	71.61	1.85	S. No. 23 of Table B5
2	221797(column 'ab')	B28.1	18" × 18"	13.02	23.59	5.79	10.48	24.06	0.93	S. No. 34 of Table B5
3	285279 (column 'ab')	B24.5	12" × 18"	17.96	26.85	11.97	16.42	26.85	1.15	S. No. 44 of Table B5
4	580271 (column 'ab')	B40.5	24" × 24"	34.99	49.74	8.75	12.43	48.74	1.50	S. No. 56 of Table B5
5	251368 (column 'ab')	B32.9	18" × 18"	15.83	40.83	7.03	18.15	38.38	0.71	S. No. 90 of Table B5
6	136192 (column 'ab')	C44	12" × 12"	7.76	10.05	7.76	10.05	11.05	0.81	S. No. 94 of Table B5
7	54968 (column 'ab')	C39	12" × 12"	3.46	27.48	3.46	27.48	19.23	0.21	S. No. 99 of Table B5
8	240479 (column 'ab')	C42	18" × 18"	15.14	36.11	6.73	16.05	34.66	0.76	S. No. 108 of Table B5
9	623624 (column 'ab')	A26.1	24" × 24"	39.27	100.53	9.82	25.13	94.50	0.96	S. No. 142 of Table B5
10	33143 (column 'ab')	A30	12" × 12"	2.09	13.31	2.09	13.31	9.85	0.25	S. No. 143 of Table B5
11	105374 (column 'ab')	A34	12" × 12"	6.63	17.19	6.63	17.19	16.16	0.47	S. No. 150 of Table B5
12	13816 (column 'ab')	C10.1	12" × 12"	0.87	23.83	0.87	23.83	12.16	0.95	S. No. 151 of Table B5
13	213202 (column 'ab')	C8.2	12" × 18"	10.86	38.83	7.24	25.88	28.34	0.37	S. No. 166 of Table B5
14	109885 (column 'ab')	C12	12" × 12"	6.92	13.62	6.92	13.62	13.75	0.58	S. No. 169 of Table B5
15	25120 (column 'ab')	C14	12" × 12"	1.58	4.15	1.58	4.15	3.86	0.47	S. No. 170 of Table B5
16	107764 (column 'ab')	C19.1	12" × 12"	6.79	7.86	6.79	7.86	8.81	0.88	S. No. 175 of Table B5
17	103054 (column 'ab')	C21	24" × 24"	6.49	22.50	1.62	5.63	19.58	1.65	S. No. 176 of Table B5
			Note: G* means Green and P* stands for paved							
Total	**3948235**	–		**235.24**	–	–	–	–	–	

(ii) Figure G7 (SC-10,11)

(iii) Figure G8 (SC-12)

(iv) Figure G9 to G12 (SC-13)

(v) Figure G13 (SC-14)

(vi) Figure G14 (SC-15)

(vii) Figure G15 & G16 (SC-16)

(viii) Figure G17 (SC-17)

(ix) Figure G18 (SC-6)

(x) Figure G19 (SC-8)

(xi) Figure G20 (SC-7)

(xii) Figure G21 to G28 (SC-1)

(xiii) Figure G28 to G31 (SC-2)

(xiv) Figure G32 to G34 (SC-3)

(xv) Figure G35 to G38 (SC-5)

(xvi) Figure G39 to G43 (SC-4)

All these AutoCAD drawings are based on hydraulic design Tables B4 and B5 of Appendix B for storm drains in separate network.

4.2.1.1 Flow Depth Estimation Spreadsheet for Rectangular Drain Sections

Normal flow depth at terminal nodes of sub-catchments shown in Table 4.2 are calculated by using Eqs. (2.20) & (2.21) are elaborated in design sheet shown as Table B6 of Appendix B.

Properties of flow depth sheet is detailed below,

(i) "Drain Nodes" is start point of drain "From" up "To" end columns (a) and (b).

(ii) "Drain Length" column (c).

(iii) "Q_{act}" column (d) the actual discharge at terminal node of a sub-catchment taken form storm drain sizing and capacity spreadsheet.

(iv) "Slope" column (e) gradient of drain line.

(v) "Selected Drain Size" column (f) width and depth of drain section.

(vi) "Manning's n" column (g) value of Manning's constant.

(vii) "Channel Width" column (h) taken from column (f).

(viii) "Assumed y_j" column (i) first value of flow depth is assumed as starting guess.

(ix) "Equation (2.20)" column (j) for calculation Q_j discharge for assumed y_j.

(x) "Equation (2.21)" column (k) to attain depth y_{j+1} for current assumed depth y_j.

Above mentioned ten steps are adopted in spreadsheet for estimation of flow depth at outlet locations of sub-catchments having higher discharge. After iteration flow depths calculated are well within limits to accommodate given discharge for selected drain section.

4.2.1.2 Weighted Run-off Coefficient Calculation Sheet

As the study area have different kinds of surfaces to contribute surface water runoff which have different values of Runoff coefficient 'C' so weighted runoff coefficient is calculated using Eqs. (2.12) and (2.13). Features of weighted runoff coefficient computation spreadsheet shown as Table C1 of Appendix C are detailed below.

(i) "Description (Sub-Areas Draining)" column (a) type of surface areas contributing flow.

(ii) "Sub-Areas, A_j" column (b) area in sft of surface kinds mentioned in column (a).

(iii) "Value of C_j for each sub-area A_j" column (c) value of runoff coefficient taken for each type of surface area form Table 2.4.

(iv) "Total Area of Drainage Basin" column (d) sum of all A_j in column (b).

(v) "Equation (2.12)" column (e) where α_j for each sub area is obtained by dividing each A_j with total area of drainage basin.

(vi) "Equation (2.12)" column (f) runoff coefficient C_j is multiplied with A_j and then sum of all gives weighted C for entire catchment.

4.3 Hydraulic Design Spreadsheets for Combined Sewer System

Combined drainage network nodes are fixed on same the locations as for the sewer system of separate scheme. Spreadsheets prepared for combined system given in Annexure D are detailed below.

(i) Data elaboration and design operations for dry weather flow sheet is same as mentioned in Section 4.2 except column (f) added for multi diameter entirely circular sections, column (k) for actual flow distribution where dual circular pipe lines are used and column (v) for hydraulic radius of fully rounded pipe runs.

(ii) Rational method sheet for combined flows prepared for cunette plus rectangular section have same features as mentioned in Section 4.2.1.

(iii) Separated portion of storm drain spreadsheet for combined system also possesses equivalent functions as intimated Section 4.2.1(drain sizing sheet).

(iv) Wet weather flow design sheet which contains mixed flow bears identical computation procedures as adopted in Section 4.2.1.

(v) Normal depth of flow computation for rectangular section plus cunette functions are similar as mentioned in Section 4.2.1.1.

(vi) Weighted runoff coefficient sheet operations are similar as mentioned in Section 4.2.1.1 and value of Weighted "C" for both systems is same.

4.3.1 Foremost Outputs from Dry Weather Flow Spreadsheets

Design steps by columns mentioned in Section 4.2 are repeated for each length of circular and half circled cunette sections to convey dry weather flows towards required STPs. Residential colony is separated in three zones to transfer grey water into two WWTPs. Table 4.3 is showing final wastewater removal details based on design spreadsheets.

Table 4.3: Dry Weather flows for combined system extracted from Tables, D1, D2 and D3 of Appendix D.

Zone No	Disposal Nodes (From - To)	Ouster Point	House/ Flat (Nos)	Section Type	Q_{act} (ft^3/sec)	Q_{full} (ft^3/sec)	V_{full} (ft/sec)	V_{Min} (ft/sec)	Flow Depth (inch)	Remarks
2	B51 – STP2	STP-2	500	9" dia cunette	0.861	0.863	3.91	4.46	3.69	S. No. 76 of Table D1
3	A39.4 –A12	STP-1	1024	30" dia dual pipes	0.677	35.85	7.31	2.92	1.50	S. No. 52 of Table D3
1	A28 – STP1				0.677	35.85	7.31	2.92	1.50	

4.3.2 Outputs from Combined Flow Spreadsheets

Combined flow spreadsheets have alike design operations as acknowledged in Section 4.2 (hydraulic statement of sewerage system for S.S). Mingled sanitary and wet weather runoff removal from sub-catchments, zones extracted from spreadsheets are described in Table 4.4. The total actual dry weather discharge of 2.22 cusecs mentioned in Table 4.3 is included in Table 4.4 and showing combined discharge of 237.63 cusecs against total drainage area of residential colony 3948235 sft.

4.3.3 Outputs from Separated Drain Design Sheet

Separated portion of drain spreadsheet shown as Table D8 of Appendix D for combined system has the same functions as stated in Section 4.2.1. Principal outputs from fourteen sub-catchments are categorized in Table 4.4.

4.3.4 Layout Plan Drawings of Combined Sewer System

Key plan of combined network layout is given in Figure H1, while detailed layout is shown in Figures H2 to H35 of Appendix H. All these AutoCAD drawings are based on hydraulic design Tables D1 to D8 of Appendix D.

Table 4.4: Mixed Flow disposal details obtained from combined design spreadsheets shown as Tables D4, D5, D6, D7, D8 and D9 of Appendix D.

S. No.	Area Feeding (Sft)	Oulet Nodes	Section Type	Q_{act} (Qusec)	Q_{th} (Qusec)	V_{act} (ft/sec)	V_{Max} (ft/sec)	V_{Min} (ft/sec)	Flow Depth (inch)	Remarks
Z-1	542906 (Table D4, S. No. 75 to 119, Column 'al')	STP-1	30" dia	34.54	35.85	7.31	8.33	8.33	1.97	S. No. 54 of Table D7
Z-3	766521 (Table D4, S. No. 120 to 172, Column 'al')		Dual pipes	34.54	35.85	7.31	8.33	8.33	1.97	
Z-2	1262786 (Table D4, S. No. 1 to 74, Column 'al')	STP-2	30" × 30"	81.91	116.56	12.66	18.01	19.45	2.04	S. No. 73 of Table D5
1	525040 (Table D4, S. No. 173 to 181, Column 'al')	B2.6	24" × 24"	33.06	36.57	8.26	9.14	10.42	1.84	S. No. 9 of Table D4
2	87860 (Table D4, S. No. 182 to 186, Column 'al')	B28.1	12" × 12"	5.53	8.00	5.53	8.00	8.64	0.74	S. No. 14 of Table D4
3	96552 (Table D4, S. No. 187 to 194, Column 'al')	B24.5	12" × 12"	6.08	15.18	6.08	15.18	14.27	0.49	S. No. 22 of Table D4
4	119400 (Table D4, S. No. 195 to 203, Column 'al')	B32.9	12" × 12"	7.52	13.85	7.52	13.85	14.13	0.61	S. No. 31 of Table D4
5	30123 (Table D4, S. No. 204, Column 'al')	C21.1	12" × 12"	1.90	3.54	1.90	3.54	3.61	0.61	S. No. 32 of Table D8
6	87786 (Table D4, S. No. 205 to 207, Column 'al')	C44	12" × 12"	5.53	10.05	5.53	10.05	10.25	0.62	S. No. 35 of Table D8
7	77731 77731 (Table D4, S. No. 208 to 211, Column 'al')	C42	12" × 12"	4.89	12.25	4.89	12.25	11.51	0.49	S. No. 39 of Table D8
8	116400 (Table D4, S. No. 212 to 216, Column 'al')	A35.1	12" × 12"	7.33	27.80	7.33	27.80	23.35	0.36	S. No. 44 of Table D8
9	24059.5 (Table D4, S. No. 217, Column 'al')	A30	12" × 12"	1.51	13.31	1.51	13.31	9.19	0.20	S. No. 45 of Table D8
10	13815.6 (Table D4, S. No. 218, Column 'al')	C10.2	12" × 12"	0.87	23.83	0.87	23.83	12.16	0.095	S. No. 46 of Table D8
11	20300 (Table D4, S. No. 219 to 221, Column 'al')	C8.2	12" × 12"	1.28	23.93	1.28	23.93	12.68	0.12	S. No. 49 of Table D8
12	112031 (Table D4, S. No. 222 to 224, Column 'al')	C12	12" × 12"	7.05	13.62	7.05	13.62	13.89	0.59	S. No. 52 of Table D8
13	24120 (Table D4, S. No. 225, Column 'al')	C14	12" × 12"	1.52	4.15	1.52	4.15	3.86	0.46	S. No. 53 of Table D8
14	40804 (Table D4, S. No. 226, Column 'al')	C23.1.1	12" × 12"	2.57	29.80	2.57	29.80	18.78	0.17	S. No. 54 of Table D8
Total	**3948235**	–	**237.63**	–	–	–	–	–		

4.3.5 Outputs from Normal Flow Depth Spreadsheet

Combined Flow depth computation spreadsheet is shown as Table D9 of Appendix D possess same operational elements as mentioned in Section 4.2.1.1, while normal flow depth at outlet points of sub catchments are shown in Table 4.4.

4.3.6 Outputs from Weighted Run-off Co-efficient Spreadsheet

Value of weighted constant 'C' is same as calculated for storm drains in separate system. Properties of weighted runoff coefficient Excel sheet is shown as Table C1 of Appendix C are resembling to procedures mentioned in Section 4.2.1.2.

4.4 Cost Estimation Spreadsheets for Combined and Separate Sewer Systems

Cost evaluation spreadsheet for combined and separate systems is given as Table E1 of Appendix E. Following are the aspects of Abstract of cost sheet.

(i) "Serial No" column (a).

(ii) "PWD Ref No" column (b) reference no of items taken from PWD schedule of rates 2012.

(iii) "Description" column (c) detail of items involved for the construction of system components.

(iv) "Sched or not" column (d) the items are available in PWD schedule of rates or not.

(v) "Unit" column (e) the measuring unit of item.

(vi) "Quantity" column (f) the quantity of each construction item obtained from quantity back up spreadsheets.

(vii) "Unit Rates 2012" column (g) the unit rates of items as per PWD schedule of rates 2012.

(viii) "Add 35% premium" column (h) is calculated by multiplying column (g) with 35% and adding it in unit rates 2012 to obtain current price of each item.

(ix) "Total Amount" column (i) the amount of individual construction item is obtained by multiplying column (g) with column (h). Total cost for both drainage systems is summed up in the same column.

4.4.1 Principal outputs from Quantity and Cost Estimation Spreadsheets

Itemized actual quantity and cost of components, construction materials used for both drainage systems are worked out in spreadsheets. Main features of Excel sheets mentioned in Table E1 of Appendix E for both systems are expressed in following sections.

4.4.1.1 Quantity and Cost Aspects of Separate System

Quantity and cost of items for separate network extracted from spreadsheets are shown in Tables 4.5 and Table 4.6. It could be viewed from Tables 4.5, 4.6 that the total cost of sewer portion is 53255694 Rupees (53.25 millions) and total cost of storm drains portion is 69435268 Rupees (69.43 millions).

TABLE 4.5: Quantity and cost details of sewer system for separate network extracted from Table E1 (S.No-1 to 62) of Appendix E .

S. No.	Item Name	Quantity	Cost of Item (Rs)
1	Excavation for pipes in common soil	7,68,151 ft^3 (Sum of S.No-3 to 9, column 'h' of Table E1)	7,975,509 (Sum of S.No-3 to 9, column 'i' of Table E1)
2	Excavation for pipes in soft rock	3,78343 ft^3 (Sum of S.No-12 to 18, column 'h' of Table E1)	7,912,085 (Sum of S.No-12 to 18, column 'i' of Table E1)

3	Laying of 9" dia pipes	25,368 ft (S.No-19, column 'h' of Table E1)	8,570,435 (S.No-19, column 'h' of Table E1)
4	Sand encasement of pipes	2,93,696 ft^3 (S.No-20, column 'h' of Table E1)	9,071,134 (S.No-20, column 'i' of Table E1)
5	Excavation of circular manholes in common	1,30,743 ft^3 (Sum of S.No-23 to 30, column 'h' of Table E1)	1,832,843 (Sum of S.No-23 to 30, column 'i' of Table E1)
6	Excavation of circular manholes in rock	64,396 ft^3 (Sum of S.No-33 to 39, column 'h' of Table E1)	1,146,207 (Sum of S.No-33 to 39, column 'i' of Table E1)
7	Stone Ballast in foundation of circular MH	4,071 ft^3 (S.No-40, column 'h' of Table E1)	2,12,358 (S.No-40, column 'i' of Table E1)
8	P.C.C (1:4:8) in foundation of circular MH	2,829 ft^3 (S.No-41, column 'h' of Table E1)	4,35,535 (S.No-41, column 'i' of Table E1)
9	Brick Masonry for circular manholes	25,879 ft^3 (Sum of S.No-44 to 47, column 'h' of Table E1)	8,397,351 (Sum of S.No-44 to 47, column 'i' of Table E1)
10	Cement plaster (1:3) at walls of circular MH	50,856 ft^2 (S.No-48, column 'h' of Table E1)	1,430,509 (S.No-48, column 'i' of Table E1)
11	Bitumen coating at outside walls of circular MH	30,497 ft^2 (S.No-49, column 'h' of Table E1)	2,66,816 (S.No-49, column 'i' of Table E1)
12	Benching concrete (1:2:4) for circular MH	1,736 ft^3 (S.No-50, column 'h' of Table E1)	4,14,694 (S.No-50, column 'i' of Table E1)
13	R.C.C (1:2:4) for circular MH covers rest area	594 ft^3 (S.No-51, column 'h' of Table E1)	1,87,128 (S.No-51, column 'i' of Table E1)
14	R.C.C (1:2:4) for circular MH covers	127 ft^3 (S.No-52, column 'h' of Table E1)	37,967 (S.No-52, column 'i' of Table E1)
15	Steel for circular MH covers, steps	2,726 kg (S.No-53, column 'h' of Table E1)	3,80,048 (S.No-53, column 'i' of Table E1)
16	MS Angle iron for circular MH covers, rest area	3,585 kg (S.No-54, column 'h' of Table E1)	9,67,834 (S.No-54, column 'i' of Table E1)
17	Excavation of square shape MH in common soil	52,258 ft^3 (S.No-55, column 'h' of Table E1)	6,42,978 (S.No-55, column 'i' of Table E1)
18	Excavation of square shape MH in soft rock	25,739 ft^3 (S.No-56, column 'h' of Table E1)	4,21,222 (S.No-56, column 'i' of Table E1)
19	P.C.C (1:4:8) in foundation of square shape MH	1,270 ft^3 (S.No-57, column 'h' of Table E1)	2,47,976 (S.No-57, column 'i' of Table E1)

20	P.C.C (1:3:6) in walls & base of square MH	6,469 ft^3 (S.No-58, column 'h' of Table E1)	1,922,302 (S.No-58, column 'i' of Table E1)
21	R.C.C (1:2:4) for square manhole covers	494 ft^3 (S.No-59, column 'h' of Table E1)	1,47,794 (S.No-59, column 'i' of Table E1)
22	Steel reinforcement for square MH covers, steps	3,006 kg (S.No-60, column 'h' of Table E1)	4,19,184 (S.No-60, column 'i' of Table E1)
23	Half circled MS Angle iron for square MH cover	288 kg (S.No-61, column 'h' of Table E1)	77,690 (S.No-61, column 'i' of Table E1)
24	Bitumen coating at outside walls of square MH	15,784 ft^2 (S.No-62, column 'h' of Table E1)	1,38,095 (S.No-62, column 'i' of Table E1)
Total Cost	–	–	**53,255,694/-**

Table 4.6: Quantity and cost details of storm drain portion for separate network extracted from Table E1 (S.No-63 to 90) of Appendix E.

S. No.	Item Name	Quantity	Cost of Item (Rs)
1	Excavation for storm drains in common soil	2,44,253 ft^3 (S.No-63, column 'h' of Table E1)	3,005,262 (S.No-63, column 'i' of Table E1)
2	Excavation for storm drains in soft rock	1,20,304 ft^3 (S.No-64, column 'h' of Table E1)	1,968,781 (S.No-64, column 'i' of Table E1)
3	P.C.C (1:4:8) in foundation of storm drains	18,816 ft^3 (S.No-65, column 'h' of Table E1)	3,674,226 (S.No-65, column 'i' of Table E1)
4	P.C.C (1:3:6) in walls & base of storm drains	4,96,266 ft^3 (S.No-66, column 'h' of Table E1)	14,639,839 (S.No-66, column 'i' of Table E1)
5	Benching concrete (1:2:4) at bottom of drains	8,412 ft^3 (S.No-67, column 'h' of Table E1)	2,009,299 (S.No-67, column 'i' of Table E1)
6	Precast R.C.C (1:2:4) storm drains slab covers	15,231 ft^3 (S.No-68, column 'h' of Table E1)	13,670,559 (S.No-68, column 'i' of Table E1)
7	Bitumen coating at outside walls of storm drains	73,541 ft^2 (S.No-69, column 'h' of Table E1)	6,43,415 (S.No-69, column 'i' of Table E1)
8	Excavation for P.C.C catch pits in common soil	34,500 ft^3 (S.No-70, column 'h' of Table E1)	4,24,482 (S.No-70, column 'i' of Table E1)
9	Excavation for P.C.C catch pits in soft rock	16,992 ft^3 (S.No-71, column 'h' of Table E1)	2,78,083 (S.No-71, column 'i' of Table E1)

10	P.C.C (1:4:8) in foundation of catch pits	2,323 ft^3 (S.No-72, column 'h' of Table E1)	4,53,693 (S.No-72, column 'i' of Table E1)
11	P.C.C (1:3:6) in walls & base of catch pits	5,117 ft^3 (S.No-73, column 'h' of Table E1)	1,520,549 (S.No-73, column 'i' of Table E1)
12	Excavation of 6" dia pipes for catch pits in common	15,238 ft^3 (S.No-74, column 'h' of Table E1)	1,87,484 (S.No-74, column 'i' of Table E1)
13	Excavation of 6" dia pipes for catch pits in soft rock	7,505 ft^3 (S.No-74, column 'h' of Table E1)	1,22,823 (S.No-74, column 'i' of Table E1)
14	Laying of 6" dia pipes to carry stormwater from CP	4,332 ft (S.No-75, column 'h' of Table E1)	1,088,292 (S.No-75, column 'i' of Table E1)
15	Bitumen coating at outside walls of catch pits	12,444 ft^2 (S.No-76, column 'h' of Table E1)	1,08,873 (S.No-76, column 'i' of Table E1)
16	MS Angle iron for catch pit covers resting area	19,819 kg (S.No-77, column 'h' of Table E1)	5,351,174 (S.No-77, column 'i' of Table E1)
17	MS perforated manhole cover for catch pits	28,721 kg (S.No-78, column 'h' of Table E1)	7,754,751 (S.No-78, column 'i' of Table E1)
18	Excavation of cunette drains in common soil	24,940 ft^3 (S.No-79, column 'h' of Table E1)	3,06,859 (S.No-79, column 'i' of Table E1)
19	Excavation of cunette drains in soft rock	12,284 ft^3 (S.No-80, column 'h' of Table E1)	2,01,027 (S.No-80, column 'i' of Table E1)
20	Concrete (1:2:4) for trapezoidal drains	27,546 ft^3 (S.No-81, column 'h' of Table E1)	6,579,608 (S.No-81, column 'i' of Table E1)
21	R.C.C (1:2:4) for drains crossing roads (culverts)	9,018 ft^3 (S.No-82, column 'h' of Table E1)	2,841,783 (S.No-82, column 'i' of Table E1)
22	Steel reinforcement for culverts	13,667 kg (S.No-83, column 'h' of Table E1)	1,905,677 (S.No-83, column 'i' of Table E1)
23	Excavation for outfall structures in common	2,300 ft^3 (S.No-84, column 'h' of Table E1)	28,304 (S.No-84, column 'i' of Table E1)
24	Excavation for outfall structures in soft rock	1,133 ft^3 (S.No-85, column 'h' of Table E1)	18,542 (S.No-85, column 'i' of Table E1)
25	P.C.C (1:4:8) in foundation of outfall structures	629 ft^3 (S.No-86, column 'h' of Table E1)	1,22,737 (S.No-86, column 'i' of Table E1)
26	Dry Stone pitching for outfall drainage structures	1,875 ft^3 (S.No-87, column 'h' of Table E1)	1,00,226 (S.No-87, column 'i' of Table E1)

27	Cement pointing of stone pitching for outfall	1,855 ft^2 (S.No-88, column 'h' of Table E1)	24,843 (S.No-88, column 'i' of Table E1)
28	R.C.C (1:2:4) for outfall drainage structures	1,079 ft^3 (S.No-89, column 'h' of Table E1)	2,30,967 (S.No-89, column 'i' of Table E1)
29	Steel reinforcement for outfall drainage structures	1,242 kg (S.No-90, column 'h' of Table E1)	1,73,110 (S.No-90, column 'i' of Table E1)
Total Cost	–	–	**69,435,268/-**

4.4.1.2 Quantity and Cost Aspects of Combined Drainage Network

Quantity and cost of items for combined system extracted from spreadsheets are given in Tables 4.7, 4.8 and Table 4.9. It could be observed from Tables 4.7, 4.8, 4.9 that the total cost of circular pipes portion is 63891051 Rupees (63.89 millions), total cost of separated storm drains portion is 39925910 Rupees (39.92 millions) and total cost of drain plus cunette portion is 36125643 Rupees (36.12 millions).

TABLE 4.7: Quantity and cost details of circular pipes portion for combined network extracted from Table E1 (S.No-103a to 172) of Appendix E.

S. No.	Item Name	Quantity	Cost of Item (Rs)
1	Excavation for pipes in common soil	8,46,755 ft^3 (Sum of S.No-103a to 112, column 'h' of Table E1)	9,162,588 (Sum of S.No-103a to 112, column 'i' of Table E1)
2	Excavation for pipes in soft rock	4,17,059 ft^3 (Sum of S.No-113 to 122, column 'h' of Table E1)	8,904,432 (Sum of S.No-113 to 122, column 'i' of Table E1)
3	Laying of 9" dia pipes	4,293 ft (S.No-123, column 'h' of Table E1)	1,450,394 (S.No-123, column 'i' of Table E1)
4	Laying of 12" dia pipes	2,059 ft (S.No-124, column 'h' of Table E1)	1,402,611 (S.No-124, column 'i' of Table E1)
5	Laying of 18" dia pipes	2,321 ft (S.No-125, column 'h' of Table E1)	2,612,901 (S.No-125, column 'i' of Table E1)
6	Laying of 24" dia pipes	3,364 ft (S.No-126, column 'h' of Table E1)	6,331,665 (S.No-126, column 'i' of Table E1)

7	Laying of 30” dia pipes	1,920 ft (S.No-127, column ‘h’ of Table E1)	4,629,260 (S.No-127, column ‘i’ of Table E1)
8	Sand encasement of pipes	2,20,393 ft^3 (S.No-128, column ‘h’ of Table E1)	6,807,080 (S.No-128, column ‘i’ of Table E1)
9	Excavation of circular manholes in common soil	1,55,982 ft^3 (Sum of S.No-129 to 138, column ‘h’ of Table E1)	2,205,782 (Sum of S.No-129 to 138, column ‘i’ of Table E1)
10	Excavation of circular manholes in rock	76,827 ft^3 (Sum of S.No-139 to 148, column ‘h’ of Table E1)	1,379,612 (Sum of S.No-139 to 148, column ‘i’ of Table E1)
11	Stone Ballast in foundation of circular manholes	5,634 ft^3 (S.No-149, column ‘h’ of Table E1)	2,93,943 (S.No-149, column ‘i’ of Table E1)
12	P.C.C (1:4:8) in foundation of circular manholes	3,427 ft^3 (S.No-150, column ‘h’ of Table E1)	5,27,478 (S.No-150, column ‘i’ of Table E1)
13	Brick Masonry for circular manholes	34,166 ft^3 (Sum of S.No-151 to 156, column ‘h’ of Table E1)	11,094,840 (Sum of S.No-151 to 156, column ‘i’ of Table E1)
14	Cement plaster (1:3) at walls of circular manholes	61,942 ft^2 (S.No-157, column ‘h’ of Table E1)	1,742,333 (S.No-157, column ‘i’ of Table E1)
15	Bitumen coating at outside walls of circular manholes	36,123 ft^2 (S.No-158, column ‘h’ of Table E1)	3,16,045 (S.No-158, column ‘i’ of Table E1)
16	Benching concrete (1:2:4) at bottom of circular manholes	1,033 ft^3 (S.No-159, column ‘h’ of Table E1)	2,46,835 (S.No-159, column ‘i’ of Table E1)
17	R.C.C (1:2:4) for circular manhole covers resting area	576 ft^3 (S.No-160, column ‘h’ of Table E1)	1,81,455 (S.No-160, column ‘i’ of Table E1)
18	R.C.C (1:2:4) for circular manhole covers	123 ft^3 (S.No-161, column ‘h’ of Table E1)	36,815 (S.No-161, column ‘i’ of Table E1)
19	Steel reinforcement for circular manhole covers, steps	2,042 kg (S.No-162, column ‘h’ of Table E1)	2,84,753 (S.No-162, column ‘i’ of Table E1)

20	MS Angle iron for circular manhole covers, rest area	3,512 kg (S.No-163, column 'h' of Table E1)	9,48,240 (S.No-163, column 'i' of Table E1)
21	Excavation of square shape manholes in common soil	42,843 ft^3 (S.No-164, column 'h' of Table E1)	5,27,135 (S.No-164, column 'i' of Table E1)
22	Excavation of square shape manholes in soft rock	21,102 ft^3 (S.No-165, column 'h' of Table E1)	3,45,332 (S.No-165, column 'i' of Table E1)
23	P.C.C (1:4:8) in foundation of square shape manholes	1,053 ft^3 (S.No-166, column 'h' of Table E1)	2,05,717 (S.No-166, column 'i' of Table E1)
24	P.C.C (1:3:6) in walls & base of square manholes	5,223 ft^3 (S.No-167, column 'h' of Table E1)	1,552,205 (S.No-167, column 'i' of Table E1)
25	R.C.C (1:2:4) for square manhole covers	485 ft^3 (S.No-168, column 'h' of Table E1)	14,5301 (S.No-168, column 'i' of Table E1)
26	Steel reinforcement for square manhole covers, steps	2,640 kg (S.No-169, column 'h' of Table E1)	3,68,107 (S.No-169, column 'i' of Table E1)
27	Half circled MS Angle iron for square manhole cover	283 kg (S.No-170, column 'h' of Table E1)	76,378 (S.No-170, column 'i' of Table E1)
28	Bitumen coating at outside walls of square manholes	12,780 ft^2 (S.No-171, column 'h' of Table E1)	1,11,814 (S.No-171, column 'i' of Table E1)
Total Cost	–	–	**63,891,051/-**

TABLE 4.8: Quantity and cost details of separated storm drain portion for combined network extracted from Table E1 (S.No-173 to 198) of Appendix E.

S. No.	Item Name	Quantity	Cost of Item (Rs)
1	Excavation for P.C.C storm drains in common	83,753 ft^3 (S.No-172, column 'h' of Table E1)	1,030,485 (S.No-172, column 'i' of Table E1)
2	Excavation for P.C.C storm drains in soft rock	41,251 ft^3 (S.No-173, column 'h' of Table E1)	6,75,083 (S.No-173, column 'i' of Table E1)
3	P.C.C (1:4:8) in foundation of storm drains	6,756 ft^3 (S.No-174, column 'h' of Table E1)	1,319,284 (S.No-174, column 'i' of Table E1)
4	P.C.C (1:3:6) in walls & base of storm drains	20,390 ft^3 (S.No-175, column 'h' of Table E1)	6,059,224 (S.No-175, column 'i' of Table E1)

5	Benching concrete (1:2:4) at bottom of drains	2,960 ft^3 (S.No-176, column ‘h’ of Table E1)	7,06,951 (S.No-176, column ‘i’ of Table E1)
6	Precast R.C.C (1:2:4) storm drains slab covers	5,248 ft^3 (S.No-177, column ‘h’ of Table E1)	4,710,273 (S.No-177, column ‘i’ of Table E1)
7	Bitumen coating at outside walls of storm drains	25,358 ft^2 (S.No-178, column ‘h’ of Table E1)	2,21,857 (S.No-178, column ‘i’ of Table E1)
8	Excavation for P.C.C catch pits in common soil	45,658 ft^3 (S.No-179, column ‘h’ of Table E1)	5,61,767 (S.No-179, column ‘i’ of Table E1)
9	Excavation for P.C.C catch pits in soft rock	22,488 ft^3 (S.No-180, column ‘h’ of Table E1)	3,68,020 (S.No-180, column ‘i’ of Table E1)
10	P.C.C (1:4:8) in foundation of catch pits	1,192 ft^3 (S.No-181, column ‘h’ of Table E1)	2,32,826 (S.No-181, column ‘i’ of Table E1)
11	P.C.C (1:3:6) in walls & base of catch pits	6,370 ft^3 (S.No-182, column ‘h’ of Table E1)	1,892,773 (S.No-182, column ‘i’ of Table E1)
12	Excavation of 6” dia pipes for catch pits in common soil	14,520 ft^3 (S.No-183, column ‘h’ of Table E1)	1,78,656 (S.No-183, column ‘i’ of Table E1)
13	Excavation of 6” dia pipes for catch pits in soft rock	7,152 ft^3 (S.No-184, column ‘h’ of Table E1)	1,17,039 (S.No-184, column ‘i’ of Table E1)
14	Laying of 6” dia pipes to carry stormwater from catch pits	4,128 ft (S.No-185, column ‘h’ of Table E1)	1,037,042 (S.No-185, column ‘i’ of Table E1)
15	Bitumen coating at outside walls of catch pits	16,537 ft^2 (S.No-186, column ‘h’ of Table E1)	1,44,683 (S.No-186, column ‘i’ of Table E1)
16	MS Angle iron for manhole covers resting area of catch pits	17,137 kg (S.No-187, column ‘h’ of Table E1)	4,627,026 (S.No-187, column ‘i’ of Table E1)
17	MS perforated catch pit cover	24,835 kg (S.No-188, column ‘h’ of Table E1)	6,705,339 (S.No-188, column ‘i’ of Table E1)
18	Excavation of open cunette drains in common	31,788 ft^3 (S.No-189, column ‘h’ of Table E1)	3,91,116 (S.No-189, column ‘i’ of Table E1)
19	Excavation of cunette drains in soft rock	15,657 ft^3 (S.No-190, column ‘h’ of Table E1)	2,56,225 (S.No-190, column ‘i’ of Table E1)

20	Concrete (1:2:4) for trapezoidal drains	34,020 ft^3 (S.No-191, column 'h' of Table E1)	8,126,030 (S.No-191, column 'i' of Table E1)
21	Excavation for outfall drainage structures in common soil	1,852 ft^3 (S.No-192, column 'h' of Table E1)	22,793 (S.No-192, column 'i' of Table E1)
22	Excavation for outfall structures in soft rock	912 ft^3 (S.No-193, column 'h' of Table E1)	14,932 (S.No-193, column 'i' of Table E1)
23	P.C.C (1:4:8) in foundation of outfall structures	514 ft^3 (S.No-194, column 'h' of Table E1)	1,00,420 (S.No-194, column 'i' of Table E1)
24	Dry Stone pitching for outfall drainage structures	1,541 ft^3 (S.No-195, column 'h' of Table E1)	82,382 (S.No-195, column 'i' of Table E1)
25	Cement pointing of stone pitching for outfall structures	1,525 ft^2 (S.No-196, column 'h' of Table E1)	20,421 (S.No-196, column 'i' of Table E1)
26	R.C.C (1:2:4) for outfall drainage structures	859 ft^3 (S.No-197, column 'h' of Table E1)	1,83,880 (S.No-197, column 'i' of Table E1)
27	Steel reinforcement for outfall drainage structures	1000 kg (S.No-198, column 'h' of Table E1)	1,39,383 (S.No-198, column 'i' of Table E1)
Total Cost	–	–	**39,925,910/-**

Table 4.9: Quantity and cost details of Cunette plus rectangular drain portion for combined system extracted from Table E1 (S.No-91 to 103) of Appendix E.

S. No.	Item Name	Quantity	Cost of Item (Rs)
1	Excavation of drains plus cunette in common soil	336,898 ft^3 (Sum of S.No-91 to 94, column 'h' of Table E1)	4,164,533 (Sum of S.No-91 to 94, column 'i' of Table E1)
2	Excavation of drains plus cunette in soft rock	1,65,935 ft^3 (Sum of S.No-95 to 98, column 'h' of Table E1)	2,727,469 (Sum of S.No-95 to 98, column 'i' of Table E1)
3	P.C.C (1:4:8) in foundation of drains plus cunette	1,101 ft^3 (S.No-99, column 'h' of Table E1)	2,167,663 (S.No-99, column 'i' of Table E1)
4	P.C.C (1:3:6) in walls & base of cunette plus drain	43,269 ft^3 (S.No-100, column 'h' of Table E1)	12,857,738 (S.No-100, column 'i' of Table E1)

5	R.C.C (1:2:4) for drain plus cunette top slab	12,371 ft^3 (S.No-101, column 'h' of Table E1)	3,702,864 (S.No-101, column 'i' of Table E1)
6	Steel reinforcement for drain plus cunette top slab	72,512 kg (S.No-102, column 'h' of Table E1)	10,111,186 (S.No-102, column 'i' of Table E1)
7	Bitumen coating at outside walls of drain plus cunette	45,055 ft^2 (S.No-103, column 'h' of Table E1)	3,94,190 (S.No-103, column 'i' of Table E1)
Total Cost	–	–	**36,125,643/-**

4.4.1.3 Summary of Costs for Separate and Combined Drainage Systems

Total cost of both systems is outlined in Table 4.10. It could be viewed that total cost of separate system is 122690962 Rupees (122.69 millions) and total cost of combined network is 139942604 Rupees (139.91 millions).

TABLE 4.10: Summary of cost for combined and separate drainage systems extracted from Table E1 of Appendix E.

Network Type	Portion of Network	Total Cost (Rs)
Separate	Sewer (circular pipes)	53,255,694 (Sum of S.No-1 to 62, column 'i' of Table E1)
Separate	Storm Drains	69,435,268 (Sum of S.No-63 to 90, column 'i' of Table E1)
Separate Total	–	**1,22,690,962**
Combined	Cunette plus Storm Drain	36,125,643 (Sum of S.No-91 to 103, column 'i' of Table E1)
Combined	Sewer (circular pipes)	63,891,051 (Sum of S.No-103a to 171, column 'i' of Table E1)
Combined	Separated part of Storm Drain	39,925,910 (Sum of S.No-172 to 198, column 'i' of Table E1)
Combined Total	–	**1,39,942,604**

4.5 Analysis

On the basis of Hydraulic design results for separate system presented in Tables 4.1, 4.2 based on Tables B1 to B6 of Appendix B and for combined network results furnished in Tables 4.3, 4.4 based on Tables D1 to D9 of Appendix D compared in Table 4.11. Financial aspects for both systems which presented in Tables 4.5

to 4.10 based on Table E1 of Appendix E are compared in Table 4.12. Layout drawings of both drainage systems for residential colony established on the basis of design sheets given in Appendices B, D are given in Appendices F and G. Detailed hydraulic and financial analysis is elaborated below.

4.5.1 Hydraulic Comparison of Combined and Separate Sewer Systems

Dry, wet weather flows of residential colony are conveniently disposed of through designed drains and pipe lines. Important features of the hydraulic comparison for both sewer systems elaborated in Table 4.11 are explained below.

(i) For separate sewer system dry weather flow of 1024 flats is conveyed via 9 inch diameter node A28 towards WWTP1 (Shown in Layout Figure F5 of Appendix F). Actual commulative discharge at this location is 1.39 cusecs, actual velocity 3.15 ft/sec and normal depth of flow is 0.58 ft.

(ii) Dry weather flow of 500 houses in separate network is transferred via node B51 to WWTP2 (Shown in Figure F18 of Appendix F). Actual velocity at this point is 3.42 ft/sec, total actual discharge 0.86 cusec and normal depth of flow 0.41 ft.

(iii) In separate network the storm water of residential colony is disposed of through 17 sub-catchments (Shown in Figures G2 to G43 of Appendix G) having total drainage area of 3948235 sft and total outflow is 235.24 cusecs. Drainage pattern of sub basins are given in Table 4.2.

(iv) For combined sewer system sewerage flow of 1024 flats and storm runoff generated by 1309427 sft adjoined area is transported via 30 inch diameter dual pipes from nodes A28 to WWTP1 (Shown in Figures H11 of Appendix H). Commulative discharge at each node is 34.54 cusecs, actual velocity 7.31 ft/sec and normal flow depth 1.97 ft. Total discharge at dual nodes is 69.08 cusecs.

(v) Dry weather flows of 500 houses and wet weather flows occurred from 1262786 sft is transferred via 30" × 30" size drain plus 9" dia cunette via node B51 towards WWTP2 (Shown in Figures H35 of Appendix H). Combined discharge at this point is 81.91 cusecs, actual velocity is 12.66 ft/sec and normal depth of flow 2.04 ft.

(vi) Remaining area of 1276022 sft draining 86.64 cusecs of surface storm runoff in combined system is drained via 14 sub-basins.

(vii) It could be noted from above explanation that the flow loads, velocities and normal depth of flow at terminal nodes A28, B51 located in combined system are quite higher as compare to same nodes in separate sewer system.

(viii) It is notable that the drain line B51 to STP2 in combined system has actual velocity of 12.66m/sec which is quite higher than maximum velocity limit of 8.5 ft/sec, so this part of drain is furnished with steps to reduce high velocity impact.

TABLE 4.11: Hydraulic behavior of wastewater flow for separate and combined sewer systems extracted from Tables 4.1, 4.2, 4.3 and 4.4.

Ssytem	Outlet Nodes	Flow Type	No of Dwellings & Feeding Area (Sft)		Type & Size of Section	Q_{act} (ft^3/sec)	V_{act} (ft/sec)	Flow Depth (ft)	Total Outflow (cusecs)
SS	A28 – STP1	DW	1024 Flats		9" dia pipes	1.39	3.15	0.58	1.36
SS	B51 – STP2	DW	500 Houses		9" dia pipes	0.86	3.42	0.41	0.86
SS	17 sub-basins	WW	3948235		vary	vary	vary	vary	235.24
SS	–	–	**3948235**		–	–	–	–	**237.50**
CS	A28 – STP1	*D+W*	1024 Flats	1309427	30" dia dual pipes	34.54 34.54	7.31 7.31	1.97 1.97	69.08
CS	B51 – STP2	*D+W*	500 Houses	1262786	30" × 30"	81.91	12.66	2.04	81.91
CS	14 sub-basins	WW	–	1276022	vary	vary	vary	vary	86.64
CS	–	–	–	3948235	–	–	–	–	237.64

4.5.2 Financial Comparison of Combined and Separate Sewer Systems

Cost and quantity of components extracted from Tables 4.7 to 4.10 for both sewer systems are compared in Table 4.12 and its essential elements are detailed below.

(i) Generally excavations for drainage networks dominantly effect the entire system costs. Excavation volume for combined is higher than separate system and in the same way its cost. It is notable that in Zone-3 excavation depths increased because sewer lines of Blocks-13, 14, 15, 16, 17 and girls high school are located at an average elevation of 1480 ft (see Figures H12 to H17 of Appendix H). These drains cross lower elevation of 1400 ft (see Figures H18 to H19 of Appendix H) around MI Room and then join sewer lines at higher elevation of 1430 ft (see Figures H22 of Appendix H) across MR-01 for its final disposal WWTP-1 at elevation of 1390 ft (see Figures H11 of Appendix H). So in Zone-3 drain lines going against natural gradient responsible to increase excavation depths. In Zone-2 natural trend of terrain slope along MR-02 is towards Japan Road, here the drain lines of houses located along MR-01 are at lower elevation of 1450 ft (see Figures H24 of Appendix H) have to run against the slope and cross a hump at elevation of 1490 ft (see Figures H25 of Appendix H) to join sewer line at elevation 1460 ft (see Figures H26 of Appendix H) along MR-01 for its final disposal WWTP-2 at elevation 1400 ft (see Figures H35 of Appendix H).

(ii) Cost of pipes laying item for separate system is lower as compare to combined network. For separate system laying of 6 inch to 9 inch dia pipes is involved while for combined systems 6 inch to 30 inch dia pipes are used to accommodate mixed flows.

(iii) There is also increase in cost and quantity of other items for combined network as compare to separate system due separated portion of storm drain used for combined network.

(iv) Difference of total cost for both system shows that the cost of combined system is 17.25 million Rupees higher and it is 14% costlier than separate system.

Table 4.12: Cost and quantity comparison of separate and combined sewer systems extracted from Tables 4.5 to 4.10.

Separate Sewer System			**Combined Sewer System**		
Item	**Quantity**	**Cost (Rs)**	**Item**	**Quantity**	**Cost (Rs)**
Excavation for Pipes dia 6" - 9"	1,524,519 ft^3	26,472,491	Excavation for Pipes dia 6"-30"	2,328,432 ft^3	33,032,999
Laying of Pipes dia 6"-9"	29,700 RFT	9,658,727	Laying of Pipes dia 6"-30"	18,085 RFT	17,463,873
Sand encasement	2,93,696 ft^3	9,071,134	Sand encasement	2,20,393 ft^3	6,807,080
Stone Ballast	4,071 ft^3	2,12,358	Stone Ballast	5,634 ft^3	2,93,943
PCC 1:4:8	25,867 ft^3	4,934,167	PCC 1:4:8	14,043 ft^3	4,553,388
Brick Masonry	25,879 ft^3	8,397,351	Brick Masonry	34,166 ft^3	11,094,840
CP 1:3	50,856 ft^2	1,430,509	CP 1:3	61,942 ft^2	1,742,333
Bitumen Coating	1,32,266 ft^2	1,157,199	Bitumen Coating	1,35,853 ft^2	1,188,589
Benching 1:2:4	10,148 ft^3	2,423,993	Benching 1:2:4	3,993 ft^3	9,53,786
RCC 1:2:4	38,858 ft^3	10,025,247	RCC 1:2:4	48,434 ft^3	12,376,345
Steel	73,054 kg	17,029,468	Steel	1,23,960 kg	23,260,412
PCC 1:3:6	5,07,852 ft^3	18,082,690	PCC 1:3:6	75,252 ft^3	22,361,940
Precast RCC 1:2:4	15,231 ft^3	13,670,559	Precast RCC 1:2:4	5,248 ft^3	4,710,273
Dry Stone Masonry	1,875 ft^3	1,00,226	Dry Stone Masonry	1,541 ft^3	82,382
Cement Pointing 1:2	1,855 ft^2	24,843	Cement Pointing 1:2	1,525 ft^2	20,421
Total Cost	–	**12,26,90962**	**Total Cost**	–	**13,99,42604**

Difference in Cost = 13,99,42604 – 12,26,90962 = 17,251,642 Rupees (17.25 Million)

Increase in Cost % = (17,251,642)/(122,690,962) × 100 = 14.06%

Chapter 5

Conclusion and Recommendations

5.1 Conclusion

The study has been carried out in Potohar religion which is almost hilly area, with steep gradients. While combining sewer and drain, more depths than the required cross-sections have resulted in more construction costs.

In combined sewers hydraulic efficiency has been ensured by creating a cross-section shown in drawings given in Appendix M. In this cross-section sewerage will flow in lower part following the concept of self-cleansing velocity when there is dry weather.

In wet weather i.e. during times of rainfall, stormwater will help in cleaning of conduits that would otherwise be needed for separate sewers.

Separate sewers experience day time issue for low sewerage flow rates in initial upper level sewers. So, there may require flushing effects at some time.

In separate storm sewers, sewerage could be recycled for irrigation by installing WWTP of lower costs however in case of combined storm sewers, this is neither possible nor economical, In hilly areas, separate sewer costs @ Rs = 12,269,0962 Rs / 237.50 cusecs = 5,16,594 / cusec and combined storm sewer costs @ Rs = 139,942,604 Rs / 237.50 cusecs = 5,89,232 / cusec. In other words, combined storm sewer costs @ Rs = 17,251,642 Rs / 237.50 cusecs = 72,638 / cusec more more than separate network. In hydraulic perspective during wet weather high flow loads observed in combined systems as compare to separate system. Due to high flow loads drain and pipe diameters in combined system also increased. In financial outlook Separate system have lower cost due to lower excavations depths as compare to combined systems. WWTP's location limitations and topography of area involved is also cause to increase cost of combined system. So keeping in view the topography of such areas where residential colony is located separate system is suitable system as compare to combine network. Keeping in view the topography of such areas where residential colony is located separate system is suitable system as compare to combine network.

5.2 Future Recommendations

In hilly terrain combined system looks costly as compare to separate network. A similar study may be carried out for plain areas to establish more appropriate conclusions for the planners and designers. In plane regions running of sewer lines against the gradient would not be a problematic feature, so the excavation cost of combined sewers could be quite under control as compare to the situation occurred regarding terrain topography restrictions for the study area in question.

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Appendix A

Hydraulic Values for Circular Conduits

Hydraulic Characteristics Table

TABLE A1: Hydraulic and geometric values for circular sections based on Fig. 2.4 [42].

Discharge Ratio Q/Q_f	**Depth Ratio** d/D	**Velocity Ratio** V/V_f	**Discharge Ratio** Q/Q_f	**Depth Ratio** d/D	**Velocity Ratio** V/V_f
(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
					S.1/2
0.01	0.07	0.30	0.31	0.39	0.88
0.02	0.10	0.40	0.32	0.40	0.89
0.03	0.13	0.46	0.33	0.40	0.90
0.04	0.15	0.51	0.34	0.41	0.91
0.05	0.16	0.53	0.35	0.41	0.92
0.06	0.17	0.55	0.36	0.42	0.92
0.07	0.19	0.59	0.37	0.43	0.93
0.08	0.20	0.61	0.38	0.43	0.93
0.09	0.21	0.63	0.39	0.44	0.94
0.10	0.20	0.65	0.40	0.44	0.94
0.11	0.23	0.67	0.41	0.45	0.95
0.12	0.24	0.69	0.42	0.45	0.96
0.13	0.25	0.70	0.43	0.46	0.97
0.14	0.26	0.71	0.44	0.47	0.98
0.15	0.27	0.73	0.45	0.47	0.98
0.16	0.28	0.74	0.46	0.48	0.98
0.17	0.29	0.75	0.47	0.48	0.99
0.18	0.30	0.76	0.48	0.49	0.99
0.19	0.30	0.77	0.49	0.49	0.99
0.20	0.31	0.78	0.50	0.50	1.00
0.21	0.32	0.79	0.51	0.51	1.01
0.22	0.33	0.80	0.52	0.52	1.01
0.23	0.33	0.81	0.53	0.52	1.02

0.24	0.34	0.83	0.54	0.53	1.02
0.25	0.35	0.84	0.55	0.53	1.02
0.26	0.35	0.84	0.56	0.54	1.03
0.27	0.36	0.85	0.57	0.54	1.03
0.28	0.37	0.86	0.58	0.55	1.03
0.29	0.38	0.87	0.59	0.56	1.04
0.30	0.38	0.88	0.60	0.56	1.04

Discharge Ratio Q/Q_f	**Depth Ratio** d/D	**Velocity Ratio** V/V_f	**Discharge Ratio** Q/Q_f	**Depth Ratio** d/D	**Velocity Ratio** V/V_f
(1)	**(2)**	**(3)**	**(1)**	**(2)**	**(3)**
0.61	0.57	1.05	0.91	0.75	1.13
0.62	0.57	1.05	0.92	0.76	1.14
0.63	0.58	1.05	0.93	0.77	1.14
0.64	0.59	1.06	0.94	0.77	1.14
0.65	0.59	1.06	0.95	0.78	1.14
0.66	0.60	1.07	0.96	0.79	1.14
0.67	0.60	1.07	0.97	0.80	1.14
0.68	0.61	1.07	0.98	0.80	1.14
0.69	0.61	1.08	0.99	0.81	1.14
0.70	0.62	1.08	1.00	0.82	1.14
0.71	0.63	1.08	1.01	0.83	1.14
0.72	0.63	1.09	1.02	0.84	1.14
0.73	0.64	1.09	1.03	0.85	1.14
0.74	0.64	1.09	1.04	0.86	1.13
0.75	0.65	1.10	1.05	0.88	1.12
0.76	0.65	1.10	1.06	0.90	1.12
0.77	0.66	1.10	1.07	0.91	1.11
0.78	0.67	1.10	1.08	0.93	1.10
0.79	0.67	1.10	1.07	0.95	1.08
0.80	0.68	1.11	1.06	0.97	1.07

0.81	0.68	1.11	1.05	0.98	1.06
0.82	0.69	1.11	1.04	0.98	1.05
0.83	0.70	1.12	1.03	0.99	1.04
0.84	0.70	1.12	1.02	0.99	1.03
0.85	0.71	1.12	1.01	1.00	1.02
0.86	0.72	1.12	1.00	1.00	1.00
0.87	0.72	1.12	–	–	–
0.88	0.73	1.13	–	–	–
0.89	0.74	1.13	–	–	–
0.90	0.74	1.13	–	–	–
					S.2/2

Appendix B

Hydraulic Design Sheets for Separate System

Table B1: Hydraulic Design Sheet of Sewer System (Zone-1).

HYDRAULIC STATEMENT FOR (ZONE-1) OF SEPARATE SEWERAGE SYSTEM DESIGN RESIDENTIAL COLONY AT ZONE-V, ISLAMABAD **S.1/2**

S/No	Section	MH		Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow			FRL AT		I.L (ft)		Slope ft/ft	Cover		Pipe		Vf	Qf	Q < Qf	Remarks from Hydraulic Table			Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
		From	To				Indivi.	Peak Indivi.	Comm.	E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/4 (ft)				$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
1-	R-34	A1	A4	180	9	3.8	0.01	0.0274	0.0274	1481	1475	1473.20	1466	0.0400	7.5	8.5	0.442	0.1875	7.49	3.31	OK	0.01	0.3	2.25	2	OK	0.07	0.63
2-	R-35	A4	A5	210	9	3.8	0.01	0.0274	0.0549	1475	1468	1466.00	1461	0.0238	8.5	7	0.442	0.1875	5.78	2.55	OK	0.02	0.4	2.31	2	OK	0.1	0.9
3-	R-36	A6	A7	160	9	3.8	0	0.0183	0.0183	1484	1480	1480.00	1474	0.0406	4	6.5	0.442	0.1875	7.55	3.33	OK	0.01	0.3	2.26	2	OK	0.07	0.63
		Drop MH											1472															
4-	R-32	A7	A5	210	9	3.8	0.01	0.0274	0.0457	1480	1468	1472.00	1464	0.0381	8	4	0.442	0.1875	7.31	3.23	OK	0.01	0.3	2.19	2	OK	0.07	0.63
		Drop MH											1461															
5-	R-32	A5	A3	235	9	3.8	0	0.0183	0.1189	1468	1466	1461.00	1459	0.0079	7.5	6.7	0.442	0.1875	3.32	1.47	OK	0.08	0.61	2.03	2	OK	0.2	1.8
6-	R-33	A2	A3	192	9	3.8	0.01	0.0274	0.0274	1472	1466	1468.10	1461	0.0370	4	4.9	0.442	0.1875	7.20	3.18	OK	0.01	0.3	2.16	2	OK	0.07	0.63
		Drop MH											1459															
7-	R-32	A3	A9	163	9	3.8	0	0.0000	0.1463	1466	1466	1459.15	1458	0.0064	6.7	8.4	0.442	0.1875	3.01	1.33	OK	0.11	0.67	2.01	2	OK	0.23	2.07
8-	MR-01	A8	A9	130	9	3.8	0	0.0072	0.0072	1474	1466	1468.00	1462	0.0427	6.2	4	0.442	0.1875	7.74	3.42	OK	0.01	0.3	2.32	2	OK	0.07	0.63
		Drop MH											1458															
9-		A9	A10	160	9	3.8	0	0.0000	0.1535	1466	1456	1458.10	1452	0.0381	8.4	4	0.442	0.1875	7.31	3.23	OK	0.05	0.53	3.88	2	OK	0.16	1.44
		Drop MH											1447															
10-	R-31	A14	A10	192	9	3.8	0.01	0.0358	0.0358	1457	1456	1452.70	1447	0.0318	4.1	9.4	0.442	0.1875	6.67	2.95	OK	0.01	0.3	2.00	2	OK	0.07	0.63
11-	MR-01	A10	A11	220	9	3.8	0	0.0183	0.2076	1456	1442	1446.60	1438	0.0382	9.4	4	0.442	0.1875	7.32	3.23	OK	0.06	0.55	4.02	2	OK	0.17	1.53
		Drop MH											1434															
12-	R-30	A20	A11	328	9	3.8	0.01	0.0549	0.0549	1443	1442	1438.70	1434	0.0136	4	8	0.442	0.1875	4.36	1.93	OK	0.03	0.46	2.01	2	OK	0.13	1.17
13-	MR-01	A11	A11.1	230	9	3.8	0	0.0183	0.2807	1442	1427	1434.25	1423	0.0507	8	4	0.442	0.1875	8.43	3.72	OK	0.08	0.61	5.14	2	OK	0.2	1.8
		Drop MH											1419															
14-	MR-01	A11.1	A12	235	9	3.8	0	0.0183	0.2990	1427	1412	1419.00	1407	0.0511	7.6	4.7	0.442	0.1875	8.46	3.74	OK	0.08	0.61	5.16	2	OK	0.2	1.8
		A25											1430															
		Drop MH											1424															
15-	WW-06	A25	A23	150	9	3.8	0.01	0.0366	0.0366	1433	1421	1424.20	1417	0.0513	8.3	4.1	0.442	0.1875	8.48	3.75	OK	0.01	0.3	2.55	2	OK	0.07	0.63
		Drop MH											1413															
16-	R-29	A23	A22	250	9	3.8	0.01	0.0549	0.0914	1421	1404	1412.85	1400	0.0514	7.8	4.2	0.442	0.1875	8.49	3.75	OK	0.02	0.4	3.40	2	OK	0.1	0.9

S/No	Section	MH From	MH To	Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow Indiv.	Flow Peak Indiv.	Flow Comm.	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Pipe A (sft)	Pipe R=D/4 (ft)	Vf	Qf	Q < Qf	Remarks from $\frac{Q}{Qf}$	Remarks from $\frac{V}{Vf}$	Remarks from V	Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
17-	GREEN	A22	A26	250	9	3.8	0	0.0183	0.1097	1404	1395	1400.00	1391	0.0352	4.2	4	0.442	0.1875	7.03	3.10	OK	0.04	0.51	3.58	2	OK	0.15	1.35
18-	R-28	A26	A28	135	9	3.8	0	0.0091	0.1189	1395	1399	1391.20	1390	0.0078	4	8.8	0.442	0.1875	3.30	1.46	OK	0.08	0.61	2.01	2	OK	0.2	1.8
		A27 Drop MH											1411 1403															
19-	WW-03	A27	A28	161	9	3.8	0	0.0183	0.0183	1415	1399	1403.25	1395	0.0512	12	4	0.442	0.1875	8.48	3.74	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		Drop MH											1390															
20-	Block.10 & MR-01	A30	A31	200	9	3.8	0.01	0.0274	0.0274	1470	1464	1466.00	1460	0.0320	4	4.3	0.442	0.1875	6.70	2.96	OK	0.01	0.3	2.01	2	OK	0.07	0.63
21-	R-37	A31	A33	235	9	3.8	0	0.0183	0.0457	1464	1454	1459.60	1448	0.0515	4.3	6.1	0.442	0.1875	8.50	3.75	OK	0.01	0.4	3.40	2	OK	0.1	0.9
22-	R-38	A32	A34.1	92	9	3.8	0.01	0.0366	0.0366	1462	1457	1457.30	1453	0.0510	4.3	4	0.442	0.1875	8.45	3.73	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		Drop MH											1451															
23-	Block-11	A34	A34.1	143	9	3.8	0.01	0.0274	0.0274	1460	1457	1456.00	1451	0.0318	4	5.2	0.442	0.1875	6.68	2.95	OK	0.01	0.3	2.00	2	OK	0.07	0.63
24-	R-38	A34.1	A33	81	9	3.8	0.01	0.0274	0.0914	1457	1454	1451.45	1450	0.0233	5.2	4	0.442	0.1875	5.72	2.53	OK	0.04	0.51	2.92	2	OK	0.15	1.35
		D/MH											1448															
25-	R37	A33	A39	37	9	3.8	0	0.0000	0.0914	1454	1452	1447.50	1447	0.0095	6.1	4.8	0.442	0.1875	3.64	1.61	OK	0.06	0.55	2.00	2	OK	0.17	1.53
		Drop MH											1442															
26-	GREEN	A40	A39	140	9	3.8	0	0.0183	0.0183	1450	1452	1446.00	1442	0.0318	4	10	0.442	0.1875	6.68	2.95	OK	0.01	0.3	2.00	2	OK	0.07	0.63
27-	Block-12	A39	A39.1	120	9	3.8	0	0.0091	0.1646	1452	1445	1441.55	1441	0.0058	10	4.2	0.442	0.1875	2.86	1.26	OK	0.13	0.7	2.00	2	OK	0.25	2.25
28-		A39.1	A41	232	9	3.8	0	0.0183	0.1829	1445	1450	1440.85	1440	0.0054	4.2	11	0.442	0.1875	2.75	1.21	OK	0.15	0.73	2.01	2	OK	0.27	2.43
29-	MR-01	A41	A43	211	9	3.8	0.01	0.0274	0.2103	1450	1436	1439.60	1432	0.0372	11	4	0.442	0.1875	7.22	3.19	OK	0.07	0.59	4.26	2	OK	0.19	1.71
		Drop MH											1426															
30-	MR-01	A43	A44	353	9	3.8	0	0.0000	0.2103	1436	1412	1426.00	1408	0.0510	9.8	4.3	0.442	0.1875	8.46	3.73	OK	0.06	0.55	4.65	2	OK	0.17	1.53
31-		A44	A12	82	9	3.8	0	0.0000	0.2103	1412	1412	1408.00	1407	0.0122	4.3	4.7	0.442	0.1875	4.14	1.83	OK	0.12	0.69	2.85	2	OK	0.24	2.16
		Drop MH											1387															
32-	R-28	A12	A28	230	9	3.8	0	0.0183	0.5276	1412	1399	1386.80	1386	0.0048	25	13	0.442	0.1875	2.59	1.14	OK	0.46	0.98	2.54	2	OK	0.48	4.32
33-		A28	'WTP	85	9	3.8	0	0.0000	1.3553	1399	1390	1385.70	1385	0.0071	13	4.9	0.442	0.1875	3.15	1.39	OK	0.98	1.14	3.59	2	OK	0.8	7.2

Table B2: Hydraulic Design Sheet of Sewer System (Zone-3).

S/No	Section	MH From	MH To	Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow Indivi.	Flow Peak Indivi.	Flow Comm.	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Pipe A (sft)	Pipe R=D/4 (ft)	Vf	Qf	Q < Qf	Remarks from Hydraulic Table $\frac{Q}{Qf}$	Remarks from Hydraulic Table $\frac{V}{Vf}$	Remarks from Hydraulic Table V	Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
1-	BLOCK-17	C1	C2	73	9	3.8	0.0048	0.0183	0.0183	1490	1488	1486.00	1483.65	0.0322	4	4.35	0.442	0.1875	6.72	2.97	OK	0.01	0.3	2.02	2	OK	0.07	0.63
		DROP MH											1482.55															
2-	BLOCK-17	C2	C3	128	9	3.8	0.0072	0.0274	0.0457	1488	1480	1482.55	1476	0.0512	5.5	4	0.442	0.1875	8.47	3.74	OK	0.01	0.3	2.54	2	OK	0.07	0.63
3-	Community Centre	C3.1	C3	135	9	3.8	0.0174	0.0664	0.0664	1480	1480	1476	1474.5	0.0111	4	5.5	0.442	0.1875	3.95	1.74	OK	0.04	0.51	2.01	2	OK	0.15	1.35
		C3											1476															
		DROP MH											1474.5															
4-	GREEN BLOCK.17 & R-22	C3	C4	118	9	3.8	0.0048	0.0183	0.1304	1480	1488	1474.5	1472.9	0.0136	5.5	14.6	0.442	0.1875	4.36	1.93	OK	0.07	0.46	2.01	2	OK	0.13	1.17
5-	R-23	C2.1	C4	222	9	3.8	0.0120	0.0457	0.0457	1496	1488	1492.06	1483.5	0.0386	4	4	0.442	0.1875	7.35	3.25	OK	0.01	0.3	2.21	2	OK	0.07	0.63
		DROP MH											1472.9															
6-	R-22, R-23	C4	C7	228	9	3.8	0.0024	0.0091	0.1853	1488	1480	1472.9	1470	0.0127	15	10.2	0.442	0.1875	4.22	1.86	OK	0.10	0.59	2.49	2	OK	0.19	1.71
7-		C5.1	C8.1	163	9	3.8	0.0096	0.0366	0.0366	1494	1486	1487.83	1482.25	0.0342	6	4	0.442	0.1875	6.93	3.06	OK	0.01	0.3	2.08	2	OK	0.07	0.63
		DROP MH											1481.8															
8-	R-22	C10.1	C8.1	226	9	3.8	0.0072	0.0274	0.0274	1498	1486	1493.4	1481.8	0.0513	4.7	4.45	0.442	0.1875	8.48	3.75	OK	0.01	0.3	2.55	2	OK	0.07	0.63
9-		C8.1	C7	203	9	3.8	0.0048	0.0183	0.0823	1486	1480	1481.8	1476	0.0286	4.5	4.2	0.442	0.1875	6.33	2.79	OK	0.03	0.46	2.91	2	OK	0.13	1.17
		DROP MH											1470															
10-	R-22 & BLOCK-14	C7	C9	216	9	3.8	0.0000	0.0000	0.2676	1480	1468	1470	1464	0.0278	10	4	0.442	0.1875	6.24	2.76	OK	0.10	0.53	3.31	2	OK	0.16	1.44
11-	BLOCK-14 & BLOCK 13	C9	C9.1	324	9	3.8	0.0288	0.1097	0.3773	1468	1460	1464	1456	0.0247	4	4	0.442	0.1875	5.88	2.60	OK	0.15	0.65	3.82	2	OK	0.22	1.98
		DROP MH											1452.4															
12-	BLOCK-13	C9.1	C15.2	127	9	3.8	0.0072	0.0274	0.4047	1460	1450	1452.4	1446	0.0504	7.6	4	0.442	0.1875	8.41	3.71	OK	0.11	0.61	5.13	2	OK	0.2	1.8
13-	GREEN	C15.2	C15.3	104	9	3.8	0.0024	0.0091	0.4139	1450	1450	1446	1445.45	0.0053	4	4.55	0.442	0.1875	2.72	1.20	OK	0.34	0.84	2.29	2	OK	0.35	3.15
		DROP MH											1439															

S/No	Section	MH		Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow			FRL AT		I.L (ft)		Slope ft/ft	Cover		Pipe		Vf	Qf	Q < Qf	Remarks from			Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
		From	To				Indiv.	Peak Indiv.	Comm.	E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/4 (ft)				$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
14-	GREEN	C15.3	C15.4	98	9	3.8	0.0000	0.0000	0.4139	1450	1438	1439	1434	0.0510	11	4	0.442	0.1875	8.46	3.73	OK	0.11	0.61	5.16	2	OK	0.2	1.8
15-		C15.4	C15.5	83	9	3.8	0.0000	0.0000	0.4139	1438	1435	1434	1431	0.0361	4	4	0.442	0.1875	7.12	3.14	OK	0.13	0.63	4.49	2	OK	0.21	1.89
		DROP MH											1422.3															
16-		C15.5	C14.2.1	317	9	3.8	0.0000	0.0000	0.4139	1435	1420	1422.3	1406	0.0514	13	14	0.442	0.1875	8.49	3.75	OK	0.11	0.61	5.18	2	OK	0.2	1.8
17-	GREEN & MR-01	C14.2.1	C14.3	140	9	3.8	0.0000	0.0000	0.4139	1420	1408	1406	1404.13	0.0134	14	4	0.442	0.1875	4.33	1.91	OK	0.22	0.73	3.16	2	OK	0.27	2.43
18-	MR-01	C14.3	C34	83	9	3.8	0.0000	0.0000	0.4139	1408	1408	1404.13	1403.7	0.0052	4	4.43	0.442	0.1875	2.70	1.19	OK	0.35	0.84	2.26	2	OK	0.35	3.15
		DROP MH											1387.85															
19-	BLOCK-14 & GREEN	C5	C15	225	9	3.8	0.0072	0.0274	0.0274	1470	1450	1457.5	1446	0.0511	13	4	0.442	0.1875	8.47	3.74	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		DROP MH											1443.1															
20-	GREEN	C15	C16	139	9	3.8	0.0000	0.0000	0.0274	1450	1440	1443.1	1436	0.0511	6.9	4	0.442	0.1875	8.46	3.74	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		DROP MH											1428.35															
21-	GREEN	C18	C16	204	9	3.8	0.0019	0.0072	0.0072	1441	1440	1437	1428.35	0.0424	4	11.7	0.442	0.1875	7.71	3.40	OK	0.01	0.3	2.31	2	OK	0.07	0.63
22-		C16	C17	215	9	3.8	0.0000	0.0000	0.0346	1440	1430	1428.35	1421.5	0.0319	12	8.5	0.442	0.1875	6.68	2.95	OK	0.01	0.3	2.01	2	OK	0.07	0.63
		DROP MH											1411.9															
23-	GREEN	C17	C19	115	9	3.8	0.0000	0.0000	0.0346	1430	1410	1411.9	1406	0.0513	18	4	0.442	0.1875	8.48	3.75	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		DROP MH											1396.3															
		C23											1430															
		DROP MH											1428.3															
24-	R-22	C23	C23.1	250	9	3.8	0.0057	0.0217	0.0217	1435	1420	1428.3	1415.5	0.0512	6.2	4.35	0.442	0.1875	8.47	3.74	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		DROP MH											1412.7															
25-		C23.1	C23.2	150	9	3.8	0.0000	0.0000	0.0217	1420	1410	1412.7	1405	0.0513	7.1	5.47	0.442	0.1875	8.48	3.75	OK	0.01	0.3	2.55	2	OK	0.07	0.63
26-		C23.2	C24	150	9	3.8	0.0000	0.0000	0.0217	1410	1406	1405	1400.2	0.0320	5.5	6.01	0.442	0.1875	6.70	2.96	OK	0.01	0.3	2.01	2	OK	0.07	0.63
27-		C24	C19	123	9	3.8	0.0000	0.0000	0.0217	1406	1410	1400.2	1396.3	0.0317	6	13.7	0.442	0.1875	6.67	2.94	OK	0.01	0.3	2.00	2	OK	0.07	0.63
28-	GREEN	C19	C20	172	9	3.8	0.0000	0.0000	0.0563	1410	1410	1396.3	1393.95	0.0137	14	16.1	0.442	0.1875	4.38	1.93	OK	0.03	0.46	2.01	2	OK	0.13	1.17

S/No	Section	MH		Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow			FRL AT		I.L (ft)		Slope ft/ft	Cover		Pipe		Vf	Qf	Q < Qf	Remarks from			Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
		From	To				Indivi.	Peak Indivi.	Comm.	E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/4 (ft)				$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
29-	GREEN	C20	C22	220	9	3.8	0.0050	0.0189	0.0752	1410	1411	1393.95	1391.5	0.0111	16	19.6	0.442	0.1875	3.95	1.74	OK	0.04	0.51	2.02	2	OK	0.15	1.35
30-	MR-01	C22	C25	88	9	3.8	0.0000	0.0000	0.0752	1411	1412	1391.5	1390.5	0.0114	20	21.5	0.442	0.1875	3.99	1.76	OK	0.04	0.51	2.04	2	OK	0.15	1.35
31-	R-25	C26	C25	187	9	3.8	0.0160	0.0609	0.0609	1421	1412	1416.98	1407.96	0.0482	4	4	0.442	0.1875	8.22	3.63	OK	0.02	0.4	3.29	2	OK	0.1	0.9
		DROP MH											1390.5															
32-	MR-01	C25	C27	235	9	3.8	0.0048	0.0183	0.1544	1412	1415	1390.5	1388.95	0.0066	21	26.3	0.442	0.1875	3.04	1.34	OK	0.11	0.69	2.10	2	OK	0.24	2.16
		C28											1436.85															
		DROP MH											1433.85															
33-	R-26	C28	C28.1	207	9	3.8	0.0057	0.0217	0.0217	1442	1427	1433.85	1423.3	0.0510	8	4	0.442	0.1875	8.45	3.73	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		DROP MH											1421.5															
34-	R-26	C28.1	C27	203	9	3.8	0.0120	0.0457	0.0674	1427	1415	1421.5	1411.23	0.0506	5.8	4	0.442	0.1875	8.42	3.72	OK	0.02	0.4	3.37	2	OK	0.1	0.9
		DROP MH											1388.95															
35-	MR-01	C27	C30	121	9	3.8	0.0024	0.0091	0.2309	1415	1411	1388.95	1388.35	0.0050	26	22.8	0.442	0.1875	2.64	1.16	OK	0.20	0.78	2.06	2	OK	0.31	2.79
36-	BLOCK-2	C29	C30	164	9	3.8	0.0096	0.0366	0.0366	1420	1411	1415.5	1407.16	0.0509	4.5	4	0.442	0.1875	8.44	3.73	OK	0.01	0.3	2.53	2	OK	0.07	0.63
		DROP MH											1388.35															
37-	MR-01	C30	C34	99	9	3.8	0.0024	0.0091	0.2767	1416	1408	1388.35	1387.85	0.0051	28	20.3	0.442	0.1875	2.66	1.18	OK	0.24	0.83	2.21	2	OK	0.34	3.06
38-		C34	A12	240	9	3.8	0.0000	0.0000	0.6905	1408	1412	1387.85	1386.75	0.0046	20	25	0.442	0.1875	2.54	1.12	OK	0.62	1.05	2.66	2	OK	0.57	5.13

Table B3: Hydraulic Design Sheet of Sewer System (Zone-2).

S/No	Section	MH		Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow			FRL AT		I.L (ft)		Slope ft/ft	Cover		Pipe		Vf	Qf	Q < Qf	Remarks from Hydraulic Table			Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
		From	To				Indivi.	Peak Indivi.	Comm.	E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/4 (ft)				$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
1-	R-01	B1	B2	185	9	3.71	0.0036	0.0134	0.0134	1453.93	1443.73	1449.2	1439.7	0.0514	4.73	4.03	0.442	0.1875	8.49	3.75	OK	0.01	0.3	2.55	2	OK	0.07	0.63
2-	R-02	B3	B4	398	9	3.71	0.0095	0.0351	0.0351	1468.88	1449.01	1464.88	1445	0.0499	4	4.01	0.442	0.1875	8.37	3.70	OK	0.01	0.3	2.51	2	OK	0.07	0.63
		DROP MH											1437.75															
3-	MR-02	B2	B4	107	9	3.71	0.0000	0.0000	0.0484	1443.73	1449.01	1439.7	1437.75	0.0182	4.03	11.3	0.442	0.1875	5.06	2.23	OK	0.02	0.4	2.02	2	OK	0.1	0.9
		B4	B11	230	9	3.71	0.0032	0.0117	0.0601	1449.01	1455.85	1437.75	1434.6	0.0137	11.26	21.3	0.442	0.1875	4.38	1.94	OK	0.03	0.46	2.02	2	OK	0.13	1.17
4-	R-05	B6	B7	115	9	3.71	0.0023	0.0083	0.0083	1463.28	1462.79	1459.28	1454.4	0.0424	4	8.39	0.442	0.1875	7.71	3.41	OK	0.01	0.3	2.31	2	OK	0.07	0.63
5-	R-04	B5	B7	70	9	3.71	0.0018	0.0067	0.0067	1462.88	1462.79	1458.88	1455.9	0.0426	4	6.89	0.442	0.1875	7.73	3.41	OK	0.01	0.3	2.32	2	OK	0.07	0.63
		DROP MH											1454.4															
6-	R-04	B7	B8	99	9	3.71	0.0014	0.0050	0.0200	1462.79	1462.69	1454.4	1451.25	0.0318	8.39	11.4	0.442	0.1875	6.68	2.95	OK	0.01	0.3	2.00	2	OK	0.07	0.63
7-	R-03	B9	B10	165	9	3.71	0.0063	0.0234	0.0234	1456.77	1459.33	1452.77	1447.5	0.0319	4	11.8	0.442	0.1875	6.69	2.96	OK	0.01	0.3	2.01	2	OK	0.07	0.63
		DROP MH											1447.1															
8-	R-06	B8	B10	130	9	3.71	0.0000	0.0000	0.0200	1462.69	1459.33	1451.25	1447.1	0.0319	11.44	12.2	0.442	0.1875	6.69	2.95	OK	0.01	0.3	2.01	2	OK	0.07	0.63
9-	R-06	B10	B11	111	9	3.71	0.0000	0.0000	0.0434	1459.33	1455.85	1447.1	1445.1	0.0180	12.23	10.8	0.442	0.1875	5.03	2.22	OK	0.02	0.4	2.01	2	OK	0.1	0.9
		DROP MH											1434.6															
10-	R-07	B13	B14	115	9	3.71	0.0018	0.0067	0.0067	1462.86	1462.59	1458.86	1455.2	0.0318	4	7.39	0.442	0.1875	6.68	2.95	OK	0.01	0.3	2.00	2	OK	0.07	0.63
11-	R-04	B12	B14	76	9	3.71	0.0018	0.0067	0.0067	1462.66	1462.59	1458.66	1455.2	0.0455	4	7.39	0.442	0.1875	7.99	3.53	OK	0.01	0.3	2.40	2	OK	0.07	0.63
12-	R-04	B14	B15	130	9	3.71	0.0014	0.0050	0.0184	1462.59	1462.14	1455.2	1451.05	0.0319	7.39	11.1	0.442	0.1875	6.69	2.95	OK	0.01	0.3	2.01	2	OK	0.07	0.63
13-	R-03	B17	B18	190	9	3.71	0.0063	0.0234	0.0234	1460.12	1461.34	1456.12	1449.6	0.0343	4	11.7	0.442	0.1875	6.94	3.06	OK	0.01	0.3	2.08	2	OK	0.07	0.63
14-	R-08	B16	B15	110	9	3.71	0.0045	0.0167	0.0167	1462.71	1462.14	1458.71	1455.2	0.0319	4	6.94	0.442	0.1875	6.69	2.95	OK	0.01	0.3	2.01	2	OK	0.07	0.63
		DROP MH											1451.05															
15-		B15	B18	130	9	3.71	0.0023	0.0083	0.0668	1462.14	1461.34	1451.05	1449.6	0.0112	11.09	11.7	0.442	0.1875	3.95	1.75	OK	0.04	0.51	2.02	2	OK	0.15	1.35
16-		B18	B19	110	9	3.71	0.0014	0.0050	0.0718	1461.34	1460.14	1449.6	1448.35	0.0114	11.74	11.8	0.442	0.1875	3.99	1.76	OK	0.04	0.51	2.04	2	OK	0.15	1.35
		DROP MH											1433.25															
17-	MR-02	B11	B19	252	9	3.71	0.0032	0.0117	0.1870	1455.85	1460.14	1434.6	1433.25	0.0054	21.25	26.9	0.442	0.1875	2.74	1.21	OK	0.15	0.73	2.00	2	OK	0.27	2.43
18-	MR-02	B19	B21	107	9	3.71	0.0000	0.0000	0.1870	1460.14	1458.19	1433.25	1432.65	0.0056	26.89	25.5	0.442	0.1875	2.80	1.24	OK	0.15	0.73	2.05	2	OK	0.27	2.43
19-	R-09	B20	B21	350	9	3.71	0.0063	0.0234	0.0234	1472.47	1458.19	1465.47	1451.2	0.0408	7	6.99	0.442	0.1875	7.56	3.34	OK	0.01	0.3	2.27	2	OK	0.07	0.63
		DROP MH											1432.65															
20-	R-11	B22	B23	270	9	3.71	0.0050	0.0184	0.0184	1469.03	1454.35	1464.2	1450.35	0.0513	4.83	4	0.442	0.1875	8.48	3.74	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		DROP MH											1430															
21-	MR-02	B21	B27	252	9	3.71	0.0032	0.0117	0.2220	1458.19	1445.13	1432.65	1431.4	0.0050	25.54	13.7	0.442	0.1875	2.64	1.16	OK	0.19	0.77	2.03	2	OK	0.3	2.7
22-	R-10	B25	B26	230	9	3.71	0.0036	0.0134	0.0134	1458.26	1449.66	1454.26	1444.55	0.0422	4	5.11	0.442	0.1875	7.69	3.40	OK	0.01	0.3	2.31	2	OK	0.07	0.63
		DROP MH											1430.8															
23-	R-12	B27	B26	120	9	3.71	0.0014	0.0050	0.2271	1445.13	1449.66	1431.4	1430.8	0.0050	13.73	18.9	0.442	0.1875	2.65	1.17	OK	0.19	0.77	2.04	2	OK	0.3	2.7

S/No	Section	MH		Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow			FRL AT		I.L (ft)		Slope ft/ft	Cover		Pipe		Vf	Qf	Q < Qf	Remarks from			Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
		From	To				Indivi.	Peak Indivi.	Comm.	E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/4 (ft)				$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
24-	R-12	B26	B23	175	9	3.71	0.0027	0.0100	0.2504	1449.66	1454.35	1430.8	1430	0.0046	18.86	24.3	0.442	0.1875	2.53	1.12	OK	0.22	0.8	2.03	2	OK	0.33	2.97
25-	R-11	B23	B24	115	9	3.71	0.0018	0.0067	0.2755	1454.35	1448.28	1430	1429.4	0.0052	24.35	18.9	0.442	0.1875	2.70	1.19	OK	0.23	0.81	2.19	2	OK	0.33	2.97
26-	MR-01	B28	B24	225	9	3.71	0.0036	0.0134	0.0134	1443.64	1448.28	1439.64	1432.5	0.0317	4	15.8	0.442	0.1875	6.67	2.95	OK	0.01	0.3	2.00	2	OK	0.07	0.63
		DROP MH											1429.4															
		B29											1451.5															
		DROP MH											1450.5															
27-	R-13	B29	B30	205	9	3.71	0.0036	0.0134	0.0134	1455.9	1445.2	1450.5	1440	0.0512	5.4	5.2	0.442	0.1875	8.47	3.74	OK	0.01	0.3	2.54	2	OK	0.07	0.63
		DROP MH											1428.5															
28-		B24	B30	109	9	3.71	0.0000	0.0000	0.2888	1448.28	1445.2	1429.4	1428.5	0.0083	18.88	16.7	0.442	0.1875	3.40	1.50	OK	0.19	0.77	2.62	2	OK	0.3	2.7
29-	MR-01	B30	B31	656	9	3.71	0.0071	0.0262	0.3284	1445.2	1439.54	1428.5	1425.35	0.0048	16.7	14.2	0.442	0.1875	2.59	1.15	OK	0.29	0.87	2.26	2	OK	0.38	3.42
30-		B32	B31	101	9	3.71	0.0005	0.0017	0.0017	1439.54	1439.54	1435.54	1431.25	0.0425	4	8.29	0.442	0.1875	7.72	3.41	OK	0.01	0.3	2.32	2	OK	0.07	0.63
		DROP MH											1425.35															
31-	R-14	B31	B33	474	9	3.71	0.0131	0.0484	0.3785	1439.54	1430.21	1425.35	1423.05	0.0049	14.19	7.16	0.442	0.1875	2.61	1.15	OK	0.33	0.9	2.35	2	OK	0.4	3.6
32-		B33	B39	159	9	3.71	0.0027	0.0100	0.3885	1430.21	1428.65	1423.05	1422.3	0.0047	7.16	6.35	0.442	0.1875	2.57	1.14	OK	0.34	0.91	2.34	2	OK	0.41	3.69
		B38											1431.05															
		DROP MH											1429.83															
33-	R-15	B38	B39	370	9	3.71	0.0122	0.0451	0.0451	1435.05	1428.65	1429.83	1422.6	0.0195	5.22	6.05	0.442	0.1875	5.23	2.31	OK	0.02	0.4	2.09	2	OK	0.1	0.9
		DROP MH											1422.3															
34-	R-17	B40.1	B40.2	112	9	3.71	0.0023	0.0083	0.0083	1427.2	1420.99	1422.6	1416.85	0.0513	4.6	4.14	0.442	0.1875	8.48	3.75	OK	0.00	0.3	2.55	2	OK	0.07	0.63
		DROP MH											1413.7															
35-	R-17	B40.3	B40.4	175	9	3.71	0.0032	0.0117	0.0117	1426.15	1421.06	1422.15	1416.6	0.0317	4	4.46	0.442	0.1875	6.67	2.94	OK	0.00	0.3	2.00	2	OK	0.07	0.63
36-		B40.4	B40.2	88	9	3.71	0.0014	0.0050	0.0167	1421.06	1420.99	1416.6	1413.7	0.0330	4.46	7.29	0.442	0.1875	6.80	3.00	OK	0.01	0.3	2.04	2	OK	0.07	0.63
37-	R-18	B40.2	B42.1	220	9	3.71	0.0054	0.0200	0.0451	1420.99	1411.74	1413.7	1406	0.0350	7.29	5.74	0.442	0.1875	7.01	3.09	OK	0.01	0.3	2.10	2	OK	0.07	0.63
38-		B42.1	B43.5	185	9	3.71	0.0054	0.0200	0.0651	1411.74	1407.17	1406	1403.1	0.0157	5.74	4.07	0.442	0.1875	4.69	2.07	OK	0.03	0.46	2.16	2	OK	0.13	1.17
39-	R-14	B39	B41	160	9	3.71	0.0027	0.0100	0.4436	1428.65	1425.78	1422.3	1421.35	0.0059	6.35	4.43	0.442	0.1875	2.89	1.27	OK	0.35	0.92	2.65	2	OK	0.41	3.69
40-		B41	B47	240	9	3.71	0.0072	0.0267	0.4703	1425.78	1413.34	1421.35	1409.1	0.0510	4.43	4.24	0.442	0.1875	8.46	3.74	OK	0.13	0.7	5.92	2	OK	0.25	2.25
		DROP MH											1408.75															
41-	R-19	B45	B46	280	9	3.71	0.0086	0.0317	0.0317	1422.57	1412.01	1418	1407.2	0.0386	4.57	4.81	0.442	0.1875	7.35	3.25	OK	0.01	0.3	2.21	2	OK	0.07	0.63
42-		B44	B44.4	121	9	3.71	0.0027	0.0100	0.0100	1415.07	1407.18	1409.5	1403.5	0.0496	5.57	3.68	0.442	0.1875	8.34	3.68	OK	0.00	0.3	2.50	2	OK	0.07	0.63
43-	R-20	B44.4	B43.1	75	9	3.71	0.0014	0.0050	0.0150	1407.18	1405.44	1403.5	1401.1	0.0320	3.68	4.34	0.442	0.1875	6.70	2.96	OK	0.01	0.3	2.01	2	OK	0.07	0.63
44-		B46.1	B46	111	9	3.71	0.0023	0.0083	0.0083	1415.4	1412.01	1412.3	1408.75	0.0320	3.1	3.26	0.442	0.1875	6.70	2.96	OK	0.00	0.3	2.01	2	OK	0.07	0.63
		DROP MH											1407.2															
45-		B46	B43.5	129	9	3.71	0.0023	0.0083	0.0484	1412.01	1407.17	1407.2	1403.1	0.0318	4.81	4.07	0.442	0.1875	6.68	2.95	OK	0.02	0.4	2.67	2	OK	0.1	0.9
46-		B43.5	B43.1	90	9	3.71	0.0014	0.0050	0.1185	1407.17	1405.44	1403.1	1401.1	0.0222	4.07	4.34	0.442	0.1875	5.58	2.46	OK	0.05	0.53	2.96	2	OK	0.16	1.44

S/No	Section	MH From	MH To	Sewer 'L' (ft)	Sewer 'D' (in)	P.F	Flow Indiv.	Flow Peak Indiv.	Flow Comm.	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Pipe A (sft)	Pipe R=D/4 (ft)	Vf	Qf	Q < Qf	Remarks from $\frac{Q}{Qf}$	Remarks from $\frac{V}{Vf}$	Remarks from V	Min speci. Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)
47-	L,R-20 & R-21	B43.1	B43.2	105	9	3.71	0.0000	0.0000	0.1336	1405.44	1401.02	1401.1	1397	0.0390	4.34	4.02	0.442	0.1875	7.40	3.27	OK	0.04	0.51	3.77	2	OK	0.15	1.35
48-	R-14	B47	B49	130	9	3.71	0.0000	0.0000	0.4703	1413.34	1405.37	1408.75	1402.09	0.0512	4.59	3.28	0.442	0.1875	8.48	3.74	OK	0.13	0.7	5.93	2	OK	0.25	2.25
49-	R-21	B43.2	B43.3	26	9	3.71	0.0000	0.0000	0.1336	1401.02	1400.86	1397	1396.5	0.0192	4.02	4.36	0.442	0.1875	5.19	2.29	OK	0.06	0.55	2.86	2	OK	0.17	1.53
		DROP MH											1395.6															
		B48											1410.23															
		DROP MH											1408.45															
50-	R-21	B48	B48.1	153	9	3.71	0.0059	0.0217	0.0217	1414.23	1404.51	1408.45	1400.6	0.0513	5.78	3.91	0.442	0.1875	8.48	3.75	OK	0.01	0.3	2.54	2	OK	0.07	0.63
51-		B48.1	B43.3	125	9	3.71	0.0041	0.0150	0.0367	1404.51	1400.86	1400.6	1396.5	0.0328	3.91	4.36	0.442	0.1875	6.78	2.99	OK	0.01	0.3	2.03	2	OK	0.07	0.63
		B49.1											1404.17															
		DROP MH											1402.17															
52-	R-21	B49.1	B43.3	309	9	3.71	0.0108	0.0401	0.0401	1407.32	1400.86	1402.17	1395.6	0.0213	5.15	5.26	0.442	0.1875	5.46	2.41	OK	0.02	0.4	2.18	2	OK	0.1	0.9
53-	L, R-21 & R-14	B43.3	B41.1	107	9	3.71	0.0000	0.0000	0.2104	1400.86	1400.14	1395.6	1394.8	0.0075	5.26	5.34	0.442	0.1875	3.24	1.43	OK	0.15	0.73	2.36	2	OK	0.27	2.43
54-	R-14	B49	B50	111	9	3.71	0.0000	0.0000	0.4703	1405.37	1401.55	1402.09	1397	0.0459	3.28	4.55	0.442	0.1875	8.02	3.54	OK	0.13	0.7	5.61	2	OK	0.25	2.25
55-		B50	B51	185	9	3.71	0.0018	0.0067	0.4770	1401.55	1398.56	1397	1392.5	0.0243	4.55	6.06	0.442	0.1875	5.84	2.58	OK	0.18	0.77	4.50	2	OK	0.3	2.7
56-	MR-01	B34	B34.1	246	9	3.71	0.0045	0.0167	0.0167	1441.74	1438.79	1437.74	1429.85	0.0321	4	8.94	0.442	0.1875	6.71	2.96	OK	0.01	0.3	2.01	2	OK	0.07	0.63
57-		B34.2	B34.1	130	9	3.71	0.0005	0.0017	0.0017	1438.79	1438.79	1434.75	1429.85	0.0377	4.04	8.94	0.442	0.1875	7.27	3.21	OK	0.01	0.3	2.18	2	OK	0.07	0.63
58-		B34.1	B34.3	204	9	3.71	0.0041	0.0150	0.0334	1438.79	1430.26	1429.85	1423	0.0336	8.94	7.26	0.442	0.1875	6.86	3.03	OK	0.01	0.3	2.06	2	OK	0.07	0.63
59-		B34.3	B34.4	250	9	3.71	0.0036	0.0134	0.0467	1430.26	1422.76	1423	1415.2	0.0312	7.26	7.56	0.442	0.1875	6.61	2.92	OK	0.02	0.4	2.65	2	OK	0.1	0.9
60-		B34.4	B34.5	200	9	3.71	0.0036	0.0134	0.0601	1422.76	1418.64	1415.2	1412.4	0.0140	7.56	6.24	0.442	0.1875	4.43	1.96	OK	0.03	0.46	2.04	2	OK	0.13	1.17
61-		B34.5	B35	134	9	3.71	0.0014	0.0050	0.0651	1418.64	1414.58	1412.4	1409.6	0.0209	6.24	4.98	0.442	0.1875	5.41	2.39	OK	0.03	0.46	2.49	2	OK	0.13	1.17
		B36											1438.3															
		DROP MH											1435.6															
62-	R-16	B36	B36.1	252	9	3.71	0.0050	0.0184	0.0184	1442.56	1427.17	1435.6	1423	0.0500	6.96	4.17	0.442	0.1875	8.37	3.70	OK	0.00	0.3	2.51	2	OK	0.07	0.63
63-	R-16	B36.1	B36.2	220	9	3.71	0.0032	0.0117	0.0301	1427.17	1418.98	1423	1414.5	0.0386	4.17	4.48	0.442	0.1875	7.36	3.25	OK	0.01	0.3	2.21	2	OK	0.07	0.63
64-	R-16	B36.2	B37	506	9	3.71	0.0086	0.0317	0.0618	1418.98	1414.74	1414.5	1407.5	0.0138	4.48	7.24	0.442	0.1875	4.41	1.95	OK	0.03	0.46	2.03	2	OK	0.13	1.17
65-	R-14	B35	B37	125	9	3.71	0.0000	0.0000	0.0651	1414.58	1414.74	1409.6	1407.9	0.0136	4.98	6.84	0.442	0.1875	4.37	1.93	OK	0.03	0.46	2.01	2	OK	0.13	1.17
		DROP MH											1407.5															
66-	R-14	B37	B41.1	393	9	3.71	0.0095	0.0351	0.1619	1414.74	1400.14	1407.5	1396	0.0293	7.24	4.14	0.442	0.1875	6.41	2.83	OK	0.06	0.55	3.52	2	OK	0.17	1.53
		DROP MH											1394.8															
67-	R-14	B41.1	B51	157	9	3.71	0.0032	0.0117	0.3840	1400.14	1398.56	1394.8	1392.5	0.0146	5.34	6.06	0.442	0.1875	4.53	2.00	OK	0.19	0.77	3.49	2	OK	0.3	2.7
68-	TO STP	B51	STP-2	120	9	3.71	0.0000	0.0000	0.8609	1398.56	1396	1392.5	1391.5	0.0083	6.06	4.5	0.442	0.1875	3.42	1.51	OK	0.57	1.03	3.52	2	OK	0.54	4.86

Table B4: Rational Method Sheet for Storm Flow Design in Separate Sewer System.

RAINFALL INTENSITY FOR ISLAMABAD= 4 in/hr (0.000093 ft/sec)
VALUE OF WEIGHTED RUNOFF COEFFICIENT 'C' = 0.68 (Based on Table C-1 of Appendix C)

Annexure B
S.1/4

S.No	Section	Total R 'L' (ft)	Feeding 'L' (ft)	Drain 'L'(ft)	Drain Side	E 'L'(ft)	Nodes From	Nodes To	Total D 'L'= D 'L '+ E. D 'L' (ft)	R 'W'(ft)	S 'W' (ft)	G 'A' Sh(sft)	CM 'W' (ft)	G 'A' CM (sft)	P 'W' of R (ft)	P 'A' R (sft)	G 'A' of 1 H/A (sft)	R 'A' of 1 H/A (sft)	No of H/A	Total G 'A' of H/A (sft)	Total R 'A' of H/A (sft)	Commer 'A' (sft)	Masjid (sft)	School 'R' (sft)	School 'G' (sft)	P.P.Pa (sft)	Parking (sft)	Park/PG 'G' (Sft)	MI.R 'G' (Sft)	MI.R 'R' (Sft)	WW/ P (sft)	P.B 'G' (sft)	P.B 'R' (sft)	Misc G 'A'(sft)	Total Paved 'A' (sft)	Total Green 'A' (sft)	Q = CIA (cusecs)	Sub-Catch No	Sub-Catch 'A' (sft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)
1-	R-01	187.79	187.5	187	L/S	49	B1	B2	236	40	20	3750	0	0	20	3750	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	11850	4650	1.04		
2-	R-02	409.91	308.9	308	L/S	0	B3	B9	308	40	20	6178.2	0	0	20	6178	112.5	1125	18	2025	18225	0	0	0	0	0	0	0	0	0	0	0	0	0	24403.2	8203.2	2.05		
3-	R-03	438.09	200	200	R/S	10	B10	B9	210	40	20	4000	0	0	20	4000	112.5	1125	14	1575	14175	0	0	0	0	0	0	0	0	0	0	0	0	0	18175	5575	1.50		
4-	R-02	409.91	101	101	L/S	49	B9	B4	150	40	20	2020	0	0	20	2020	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5057.5	2357.5	0.47		
5-	MR02	3663.4	123	123	R/S of C. M	0	B4	B2	123	100	38	4674	10	1230	52	6396	0	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1555	6396	7459	0.87		
6-	R-04	438.09	110	109	R/S	0	B5	B7	109	40	20	2200	0	0	20	2200	112.5	1125	4	450	4050	0	0	0	0	0	0	0	0	0	0	0	0	0	6250	2650	0.56		
7-	R-05	148.81	148.8	148	R/S	28	B6	B7	175.81	40	20	2976.2	0	0	20	2976	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	6800	0	0	0	0	0	0	8038.7	10338.7	1.16		
8-	R-04	438.09	220	220	R/S	0	B7	B14	220	40	20	4400	0	0	20	4400	112.5	1125	7	787.5	7087.5		0	0	0	0	0	6800	0	0	0	0	0	0	11487.5	11987.5	1.48		
9-	R-07	134.29	134.3	133	L/S	28	B13	B14	161.29	40	20	2685.8	0	0	20	2686	112.5	1125	4	450	4050	0	0	0	0	0	0	6800	0	0	0	0	0	0	6735.8	9935.8	1.05		
10-	R-08	374.99	143	142	L/S	0	B16	B15	142	40	20	2860	0	0	20	2860	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0		11972.5	3872.5	1.00		
11-	R-04	438.09	108.1	108	R/S	28	B14	B15	136.09	40	20	2161.8	0	0	20	2162	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0		5199.3	2499.3	0.48		
12-	R-08	374.99	232	232	L/S	49	B15	B19	280.99	40	20	4639.8	0	0	20	4640	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	1298	13752.3	6950.3	1.30		
13-	R-06	230.9	129	129	L/S	0	B17.1	B17	129	40	20	2580	0	0	20	2580	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2580	2580	0.32		
14-	R-03	438.09	195	177	R/S	0	B18	B17	177	40	20	3900	0	0	20	3900	112.5	1125	14	1575	14175	0	0	0	0	0	0	0	0	0	0	0	0	0	18075	5475	1.48		
15-	R-06	230.9	101.9	102	L/S	49	B17	B11	150.9	40	20	2038	0	0	20	2038	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		2038	2038	0.26		
16-	MR02	3663.4	230	230	R/S of C. M	0	B19	B11	227	100	38	8740	10	2300	52	11960	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	10124	19047.5	21951.5	2.58	S.C-1	842899
17-	MR02	3663.4	238	238	R/S of C. M	0	B11	B4	238	100	38	9044	10	2380	52	12376	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	8079	19463.5	20290.5	2.50		
18-	MR02	3663.4	712	712	R/S of C. M	0	B2	B2.1	712	100	38	27056	10	7120	52	37024	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	53250	37024	87426	7.84		
19-	MR02	3663.4	550	550	R/S of C. M	0	B2.1	B2.2	550	100	38	20900	10	5500	52	28600	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57266	28600	83666	7.07		
20-	MR02	3663.4	550	550	R/S of C. M	0	B2.2	B2.3	550	100	38	20900	10	5500	52	28600	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37361	28600	63761	5.82		
21-	MR02	3663.4	485	485	R/S of C. M	0	B2.3	B2.4	485	100	38	18430	10	4850	52	25220	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	34765	25220	58045	5.24		
22-	MR02	3663.4	83.75	83.8	R/S of C. M	0	B2.4	B2.5	83.75	100	38	3182.5	10	838	52	4355	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8710	4355	12730	1.08		
23-	MR02	3663.4	231.3	231	R/S of C. M	0	B2.5	B2.6	231.25	100	38	8787.5	10	2313	52	12025	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15754	12025	26854	2.45		
24-	MR02	3663.4	131	131	R/S of C. M	0	B19.1	B21	126	100	38	4978	10	1310	52	6812	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4695	6812	10983	1.12		
25-	R-09	363.92	200	198	L/S	0	B20	B20.1	198.08	40	20	4000	0	0	20	4000	112.5	1125	8	900	8100	0	0	0	0	0	0	11385	0	0	0	0	0	0	12100	16285	1.79		
26-	R-09	363.92	163.9	164	L/S	49	B20.1	B21	212.92	40	20	3278.4	0	0	20	3278	112.5	1125	6	675	6075	0	0	0	0	0	0	0	0	0	0	0	0	0	9353.4	3953.4	0.84		
27-	R10	243.85	243.9	242	R/S	28	B25	B26	269.85	40	20	4877	0	0	20	4877	112.5	1125	8	900	8100	0	0	0	0	0	0	11608	0	0	0	0	0	0	12977	17385	1.91		
28-	R-12	244.5	140	138	L/S	0	B23	B26	138	40	20	2800	0	0	20	2800	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	9023	0	0	0	0	0	0	7862.5	12385.5	1.27		
29-	R-12	244.5	104.5	105	L/S	49	B26	B27	153.5	40	20	2090	0	0	20	2090	112.5	1125	4	450	4050	0	0	0	0	0	0	0	0	0	0	0	0	0	6140	2540	0.55		
30-	MR02	3663.4	222	222	R/S of C. M	0	B21	B27	222	100	38	8436	10	2220	52	11544	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	4034	19644	15590	2.22		
31-	R-11	396.86	396.9	395	R/S	49	B22	B24	443.86	40	20	7937.2	0	0	20	7937	112.5	1125	15	1687.5	15188	0	0	0	0	0	0	0	0	0	0	0	0	0	23124.7	9624.7	2.06	S.C-2	221797.2
32-	MR01	4534.7	260	260	R/S of C. M	0	B24	B28	260	100	38	9880	10	2600	52	13520	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	21620	13380	2.20		
33-	MR02	3663.4	160.5	106	R/S of C. M	54	B27	B28	160.54	100	38	6100.5	10	1605	52	8348	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1778	8348.08	9483.92	1.12		
34-	MR01	4534.7	75	75	R/S of C. M	0	B28	B28.1	75	0	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
35-	MR01	4534.7	150	150	R/S of C. M	0	B24.1	B24.2	150	100	38	5700	10	1500	52	7800	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7800	7200	0.94		
36-	R-13	218.29	218.3	213	L/S	49	B29	B24.2	262.29	40	20	4365.8	0	0	20	4366	112.5	1125	8	900	8100		0	0	0	0	0	0	0	0	0	0	0	0	12465.8	5265.8	1.12		
37-	MR01	4534.7	250	250	R/S of C. M	0	B24.2	B24.3	250	100	38	9500	10	2500	52	13000	112.5	1125	0	0	0	11233	2355	0	0	0	0	44662	0	0	0	0	0	0	26588	56662	5.24		
38-	MR01	4534.7	100	100	R/S of C. M	0	B24.3	B24.4	100	100	38	3800	10	1000	52	5200	112.5	1125	0	0	0	0	7398	10360	6906.8		0	0	0	0	0	0	0	0	22958.2	11706.8	2.18	S.C-3	285279.1
39-	MR01	4534.7	118	118	R/S of C. M	0	B31	B32	118	100	38	4484	10	1180	52	6136	112.5	1125	3	337.5	3037.5	0	0	0		6552	0	0	0	0	0	0	0	0	15725.5	6001.5	1.37		
40-	MR01	4534.7	32	32	R/S of C. M	0	B32	B31.1	32	100	38	1216	10	320	52	1664	112.5	1125	0	0	0	0	0	0		6552	0	0	0	0	0	0	0	0	8216	1536	0.61		

S.No	Section	Total R 'L' (ft)	Feeding 'L' (ft)	Drain 'L'(ft)	Drain Side	E 'L'(ft)	Nodes		Total D 'L'= D 'L '+ E. D 'L' (ft)	R 'W'(ft)	S 'W' (ft)	G 'A' Sh(sft)	CM 'W' (ft)	G 'A' CM (sft)	P 'W' of R (ft)	P 'A' R (sft)	G 'A' of 1 H/A (sft)	R 'A' of 1 H/A (sft)	No of H/A	Total G 'A' of H/A (sft)	Total R 'A' of H/A (sft)	Commer 'A' (sft)	Masjid (sft)	School 'R' (sft)	School 'G' (sft)	P.P.Pa (sft)	Parking (sft)	Park/PG 'G' (Sft)	MLR 'G' (Sft)	MLR 'R' (Sft)	WW/ P (sft)	P.B 'G' (sft)	P.B 'R' (sft)	Misc G 'A'(sft)	Total Paved 'A' (sft)	Total Green 'A' (sft)	Q = CIA (cusecs)	Sub-Catch No	Sub-Catch 'A' (sft)
							From	To																															
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)
41-	R-14	2052.9	152.9	153	R/S	49	B33	B32	201.94	40	24	3670.6	0	0	34	5200	112.5	1125	6	675	6075	0	0	0		0	0	0	0	0	0	0	0	0	11275	4345.56	0.98		
42-	MR01	4534.7	150	150	R/S of C. M	0	B31.1	B31.2	150	100	38	5700	10	1500	52	7800	112.5	1125	0	0	0	0	0	30761	20507.2	6552	0	0	0	0	0	0	0	0	45112.8	27707.2	4.58		
43-	MR01	4534.7	100	100	R/S of C. M	0	B31.2	B24.4	100	100	38	3800	10	1000	52	5200	112.5	1125	0	0	0	0	4713	0	0	0	0	0	0	0	0	0	0	0	9913	4800	0.93		
44-	MR01	4534.7	128	128	R/S of C. M	0	B24.4	B24.5	128	0	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
45-	R-14	2052.9	248	248	R/S	0	B33.1	B34	248	60	24	5952	0	0	34	8432	112.5	1125	22	2475	22275	0	0	0	0	0	0	0	0	0	0	0	0	0	30707	8427	2.46		
46-	R-14	2052.9	61	61	R/S	0	B34	B35	61	60	24	1464	0	0	34	2074	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5111.5	1801.5	0.44		
47-	R-14	2052.9	156	156	R/S	0	B35	B36	156	60	24	3744	0	0	34	5304	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	13404	4644	1.14		
48-	R-15	364.01	189	175	R/S	0	B38	B38.1	175	40	20	3780.2	0	0	20	3780	112.5	1125	16	1800	16200	0	0	0	0	0	0	0	0	0	0	0	0	0	19980.2	5580.2	1.61		
49-	R-15	364.01	189	189	R/S	46	B38.1	B36	235.01	40	20	3780.2	0	0	20	3780	112.5	1125	11	1237.5	11138	0	0	0	0	0	0	0	0	0	0	0	0	0	14917.7	5017.7	1.26		
50-	R-14	2052.9	169	169	R/S	0	B36	B37	169	60	24	4056	0	0	34	5746	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	13846	4956	1.18		
51-	R-14	2052.9	150	150	R/S	0	B37	B38.2	150	60	24	3600	0	0	34	5100	112.5	1125	14	1575	14175	0	0	0	0	0	0	0	0	0	0	0	0	0	19275	5175	1.54		
52-	R-14	2052.9	200	200	R/S	0	B38.2	B38.3	200	60	24	4800	0	0	34	6800	112.5	1125	1	112.5	1012.5	0	0	0	0	0	0	0	0	0	0	0	0	13611	7812.5	18523.5	1.66		
53-	R-14	2052.9	115	115	R/S	0	B38.3	B39	115	60	24	2760	0	0	34	3910	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5183	3910	7943	0.75		
54-	R-14	2052.9	185	185	R/S	0	B39	B40	185	60	24	4440	0	0	34	6290	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11352.5	5002.5	1.03		
55-	R-14	2052.9	157	157	R/S	0	B41	B40	157	60	24	3768	0	0	34	5338	112.5	1125	6	675	6075	0	0	0	0	0	0	0	0	0	0	0	0	0	11413	4443	1.00		
56-	R-14	2052.9	126	126	R/S	0	B40	B40.5	126	0	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
57-	R-14	2052.9	100	100	R/S	0	B44.1	B43	100	60	24	2400	0	0	34	3400	112.5	1125	2	225	2025	0	0	0	0	0	0	0	0	0	0	0	0	0	5425	2625	0.51		
58-	R-14	2052.9	150	150	R/S	0	B43	B42	150	60	24	3600	0	0	34	5100	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	14212.5	4612.5	1.19		
59-	R-14	2052.9	143	143	R/S	0	B42	B41	143	60	24	3432	0	0	34	4862	112.5	1125	11	1237.5	11138	0	0	0	0	0	0	0	0	0	0	0	0	0	15999.5	4669.5	1.30		
60-	R-17	420.52	200	175	R/S	0	B40.3	B40.4	175	40	20	4000	0	0	20	4000	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11087.5	4787.5	1.00		
61-	R-17	420.52	88	88	R/S	0	B40.4	B40.2	88	40	20	1760	0	0	20	1760	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4797.5	2097.5	0.43		
62-	R-17	420.52	130	112	R/S	0	B40.1	B40.2	112	40	20	2600	0	0	20	2600	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7662.5	3162.5	0.68	S.C-4	580271
63-	R-18	335.25	170	170	L/S	28	B40.2	B42.1	198	40	20	3400	0	0	20	3400	112.5	1125	12	1350	12150	0	0	0	0	0	0	0	0	0	0	0	0	0	15550	4750	1.28		
64-	R-19	272.37	147	137	L/S	0	B45	B45.1	137.37	40	20	2940	0	0	20	2940	112.5	1125	10	1125	10125	0	0	0	0	0	0	0	0	0	0	0	0	0	13065	4065	1.08		
65-	R-20	569.83	120	111	R/S	0	B46	B46.1	111	40	20	2400	0	0	20	2400	112.5	1125	4	450	4050	0	0	0	0	0	0	0	0	0	0	0	0	0	6450	2850	0.59		
66-	R-19	272.37	125	125	L/S	10	B45.1	B46.1	135	40	20	2500	0	0	20	2500	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11612.5	3512.5	0.95		
67-	R-20	569.83	144	120	R/S	0	B44	B44.4	120	40	20	2880	0	0	20	2880	112.5	1125	6	675	6075	0	0	0	0	0	0	28514	0	0	0	0	0	0	8955	32069	2.58		
68-	R-20	569.83	75	75	R/S	0	B44.4	B43.1	75	40	20	1500	0	0	20	1500	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	28514	0	0	0	0	0	0	4537.5	30351.5	2.20		
69-	R-18	335.25	150	150	L/S	10	B42.1	B43.5	160	40	20	3000	0	0	20	3000	112.5	1125	12	1350	12150	0	0	0	0	0	0	0	0	0	0	0	0	0	15150	4350	1.23		
70-	R-20	569.83	129	129	R/S	0	B46.1	B43.5	129	40	20	2580	0	0	20	2580	112.5	1125	6	675	6075	0	0	0	0	0	0	0	0	0	0	0	0	0	8655	3255	0.75		
71-	R-20	569.83	90	90	R/S	0	B43.5	B43.1	90	40	20	1800	0	0	20	1800	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4837.5	2137.5	0.44		
72-	PASSAGE	89	89	89	C/L	38	B43.1	B43.2	127	10	0	0	0	0	10	890	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	890	0	0.06		
73-	R-21	625.66	323.8	309	R/S	0	B49	B43.3	308.82	40	20	6476.4	0	0	20	6476	112.5	1125	22	2475	22275	0	0	0	0	0	0	0	0	0	0	0	0	0	28751.4	8951.4	2.37		
74-	R-21	625.66	175.7	152	R/S	0	B48	B48.1	151.66	40	20	3513.2	0	0	20	3513	112.5	1125	12	1350	12150	0	0	0	0	0	0	0	0	0	0	0	0	0	15663.2	4863.2	1.29		
75-	R-21	625.66	112.2	112	R/S	0	B48.1	B43.2	112.2	40	20	2244	0	0	20	2244	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11356.5	3256.5	0.92		
76-	R-21	625.66	13.98	14	R/S	0	B43.2	B43.3	13.98	40	20	279.6	0	0	20	279.6	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	279.6	279.6	0.04		
77-	PASSAGE	93	93	93	C/L	74	B43.3	B41	167	10	0	0	0	0	10	930	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	930	0	0.06		
78-	R-16	1004.4	284.4	269	L/S	0	B36.1	B36.2	269.44	40	20	5688.8	0	0	20	5689	112.5	1125	11	1237.5	11138	0	0	0	0	0	0	0	0	0	0	0	0	0	16826.3	6926.3	1.50		
79-	R-16	1004.4	220	220	L/S	0	B36.2	B36.3	220	40	20	4400	0	0	20	4400	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11487.5	5187.5	1.05		
80-	R-16	1004.4	503	503	L/S	46	B36.3	B44.2	549	40	20	10060	0	0	20	10060	112.5	1125	17	1912.5	17213	0	0	0	0	0	0	0	0	0	2848	0	0	0	30120.5	11972.5	2.65		
81-	R-14	2052.9	88	88	R/S	49	B44.2	B44.3	137	60	20	1760	0	0	20	1760	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1760	1760	0.22		
82-	MR01	4534.7	148	148	R/S of C. M	0	B32.1	B32.2	148	100	38	5624	10	1480	52	7696	112.5	1125	6	675	6075	0	0	0	0	6552	0	0	0	0	0	0	0	0	20323	7779	1.77		
83-	MR01	4534.7	200	200	R/S of C. M	0	B32.2	B32.3	200	100	38	7600	10	2000	52	10400	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	17487.5	10387.5	1.76		
84-	MR01	4534.7	150	150	R/S of C. M	0	B32.3	B32.4	150	100	38	5700	10	1500	52	7800	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	10837.5	7537.5	1.16	S.C-5	251367.6
85-	MR01	4534.7	150	150	R/S of C. M	0	B32.4	B32.5	150	100	38	5700	10	1500	52	7800	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	14887.5	7987.5	1.44		
86-	MR01	4534.7	150	150	R/S of C. M	0	B32.5	B32.6	150	100	38	5700	10	1500	52	7800	112.5	1125	6	675	6075	0	0	0	0	0	0	0	0	0	0	0	0	0	13875	7875	1.37		
87-	MR01	4534.7	150	150	R/S of C. M	0	B32.6	B32.7	150	100	38	5700	10	1500	52	7800	112.5	1125	6	675	6075	0	0	0	0	0	0	0	0	0	0	0	0	0	13875	7875	1.37		
88-	MR01	4534.7	100	100	R/S of C. M	0	B32.7	B44.3	100	100	38	3800	10	1000	52	5200	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5200	4800	0.63		

S.No	Section	Total R 'L' (ft)	Feeding 'L' (ft)	Drain 'L'(ft)	Drain Side	E 'L'(ft)	Nodes From	Nodes To	Total D 'L'= D 'L'+ E. D 'L' (ft)	R 'W'(ft)	S 'W' (ft)	G 'A' Sh(sft)	CM 'W' (ft)	G 'A' CM (sft)	P 'W' of R (ft)	P 'A' R (sft)	G 'A' of 1 H/A (sft)	R 'A' of 1 H/A (sft)	No of H/A	Total G 'A' of H/A (sft)	Total R 'A' of H/A (sft)	Commer 'A' (sft)	Masjid (sft)	School 'R' (sft)	School 'G' (sft)	P.P.Pa (sft)	Parking (sft)	Park/PG 'G' (Sft)	MLR 'G' (Sft)	MLR 'R' (Sft)	WW/ P (sft)	P.B 'G' (sft)	P.B 'R' (sft)	Misc G 'A'(sft)	Total Paved 'A' (sft)	Total Green 'A' (sft)	Q = CIA (cusecs)	Sub-Catch No	Sub-Catch 'A' (sft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)
89-	MR01	4534.7	146	146	R/S of C. M	0	B44.3	B32.8	146	100	38	5548	10	1460	52	7592	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7592	7008	0.92		
90-	MR01	4534.7	81.4	81.4	R/S of C. M	0	B32.8	B32.9	81.4	100	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
91-	R-25	191.9	186.9	187	L/S	49	C24	C25	235.9	40	20	3738	0	0	20	3738	0	3062	2	0	6124	0	0	0	0	0	0	6332	0	0	0	0	0	13971	9862	24041	2.13		
92-	MR01	4534.7	124	124	R/S of C. M	0	C29	C25	124	100	38	4712	10	1240	52	6448	0	3062	0.5	0	1531	0	0	0	0	0	0	0	9253	4960	0	0	0	0	12939	15205	1.77		
93-	MR01	4534.7	200	200	R/S of C. M	0	C25	C43	200	100	38	7600	10	2000	52	10400	0	3062	0	0	0	0	0	0	0	0	0	0	9253	4960	0	8088	18872	0	34232	26941	3.85	S.C-6	136192
94-	MR01	4534.7	133.8	134	R/S of C. M	0	C43	C44	133.75	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
95-	R-27	442.67	50	50	L/S	0	C34	C35	50	40	20	1000	0	0	20	1000	0	3062	0	0	0	0	0	6745	4497	0	0	0	0	0	0	0	0	0	7745	5497	0.83		
96-	R-27	442.67	50	50	L/S	0	C35	C36	50	40	20	1000	0	0	20	1000	0	3062	0	0	0	0	0	6745	4497	0	0	0	0	0	0	0	0	0	7745	5497	0.83		
97-	R-27	442.67	50	50	L/S	0	C36	C37	50	40	20	1000	0	0	20	1000	0	3062	0	0	0	0	0	6745	4497	0	0	0	0	0	0	0	0	0	7745	5497	0.83	S.C-7	54968
98-	R-27	442.67	100	100	L/S	0	C37	C38	100	40	20	2000	0	0	20	2000	0	3062	0	0	0	0	0	6745	4497	0	0	0	0	0	0	0	0	0	8745	6497	0.96		
99-	R-27	442.67	60	60	L/S	0	C38	C39	60	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
100-	R-27	442.67	45	45	L/S	0	C33	C32	45	40	20	900	0	0	20	900	0	3062	0	0	0	0	0	6143	4096	0	0	0	0	0	0	0	0	0	7043	4996	0.76		
101-	R-27	442.67	50	50	L/S	0	C32	C31	50	40	20	1000	0	0	20	1000	0	3062	0	0	0	0	0	6143	4096	0	0	0	0	0	0	0	0	0	7143	5096	0.77		
102-	R-27	442.67	92.67	92.7	L/S	10	C31	C30	102.67	40	20	1853.4	0	0	20	1853	0	3062	0	0	0	0	0	6143	4096	0	0	0	0	0	0	0	0	0	7996.4	5949.4	0.88		
103-	R-26	418.87	100	95	R/S	0	C26	C30	95	40	20	2000	0	0	20	2000	0	3062	0	0	0	0	0	6143	4096	0	0	0	0	0	0	0	0	0	8143	6096	0.90		
104-	R-26	418.87	318.9	319	R/S	49	C30	C27	367.87	40	20	6377.4	0	0	20	6377	0	3062	2.5	0	7655	0	0	0	0	0	0	28780	0	0	0	0	0	23388	14032.4	58545.4	4.57		
105-	MR01	4534.7	102.2	102	R/S of C. M	0	C28	C27	102.23	100	38	3884.7	10	1022	52	5316	0	3062	0.5	0	1531	31469	0	0	0	0	0	0	0	0	0	0	0	0	38316	4907.04	2.72	S.C-8	240478.6
106-	MR01	4534.7	165	165	R/S of C. M	0	C27	C40	165	100	38	6270	10	1650	52	8580	0	3062	1	0	3062	14539	0	0	0	0	0	0	0	0	0	0	0	22009	26181	29929	3.53		
107-	MR01	4534.7	50	50	R/S of C. M	0	C40	C41	50	100	38	1900	10	500	52	2600	0	3062	0.5	0	1531	0	0	0	0	0	9574	0	0	0	0	0	0	0	13705	2400	1.01		
108-	MR01	4534.7	150	150	R/S of C. M	0	C41	C42	150	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
109-	R-34	570.91	150	100	R/S	0	A1	A1.1	100	40	20	3000	0	0	20	3000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	4531	3000	0.47		
110-	R-34	570.91	274.2	274	R/S	0	A1.1	A1.2	274.16	40	20	5483.2	0	0	20	5483	0	3062	1.5	0	4593	0	0	0	0	0	0	0	0	0	0	0	0	0	10076.2	5483.2	0.98		
111-	R-34	570.91	120.9	116	R/S	0	A1.4	A1.3	115.91	40	20	2418.2	0	0	20	2418	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2418.2	2418.2	0.30		
112-	R-34	570.91	25.84	25.8	R/S	0	A1.3	A1.2	25.84	40	20	516.8	0	0	20	516.8	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	516.8	516.8	0.07		
113-	R34 to R33		81.9	81.9	R/S	0	A1.2	A2	81.9	0	0	0	0	0	0	0	0	3062	0	0	0	3997	0	0	0	0	0	0	0	0	0	0	0	0	3997	0	0.25		
114-	R-33	192.13	56	56	R/S	0	A2	A2.1	56	40	20	1120	0	0	20	1120	0	3062	0.5	0	1531	7493	0	0	0	0	0	0	0	0	0	0	0	7000	10144	8120	1.15		
115-	R-33	192.13	92.13	92.1	R/S	10	A2.1	A3	102.13	40	20	1842.6	0	0	20	1843	0	3062	0.5	0	1531	0	4429	0	0	0	0	0	0	0	0	0	0	0	7802.6	1842.6	0.61		
116-	R-35	192.2	192.2	187	L/S	10	A4	A5	197.2	40	20	3844	0	0	20	3844	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	27710	9968	31554	2.61		
117-	R-36	243.81	208.3	198	L/S	0	A6	A7	198.28	40	20	4165.6	0	0	20	4166	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	7227.6	4165.6	0.72		
118-	R-32	603.72	110	100	L/S	10	A7	A7.1	110	40	20	2200	0	0	20	2200	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	3731	2200	0.37		
119-	R-32	603.72	100	100	L/S	0	A7.1	A7.2	100	40	20	2000	0	0	20	2000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	3531	2000	0.35		
120-	R-32	603.72	64	64	L/S	0	A7.2	A5	64	40	20	1280	0	0	20	1280	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1280	1280	0.16		
121-	R-32	603.72	224	224	L/S	0	A5	A3	224	40	20	4480	0	0	20	4480	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	20806	7542	25286	2.07	S.C-9	623624.5
122-	R-32	603.72	118	118	L/S	49	A3	A9	167	40	20	2360	0	0	20	2360	0	3062	0	0	0	0	5346	0	0	0	0	0	0	0	0	0	0	0	7706	2360	0.63		
123-	MR01	4534.7	257	252	R/S of C. M	0	A8	A9	252	100	38	9766	10	2570	52	13364	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	16426	12336	1.81		
124-	MR01	4534.7	143	143	R/S of C. M	0	A9	A10	143	100	38	5434	10	1430	52	7436	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7436	6864	0.90		
125-	R-31	217.09	217.1	212	R/S of C. M	49	A14	A10	261.09	40	20	4341.8	0	0	20	4342	0	3062	1	0	3062	0	0	29910	19940	0	0	0	0	0	0	0	0	0	37313.8	24281.8	3.88		
126-	MR01	4534.7	209	209	R/S of C. M	0	A10	A11	209	100	38	7942	10	2090	52	10868	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	0	16992	10032	1.70		
127-	R-30	362.73	362.7	358	R/S	49	A20	A11	406.73	40	20	7254.6	0	0	20	7255	0	3062	3.5	0	10717	0	0	0	0	0	0	0	0	0	0	0	0	42613	17971.6	49867.6	4.27		
128-	MR01	4534.7	491	491	R/S of C. M	0	A11	A35	491	100	38	18658	10	4910	52	25532	0	3062	1	0	3062	0	0	0	0	0	0	21563	0	0	0	0	0	0	28594	45131	4.64		
129-	G B-6	-	229	179	L/S	50	A22	A23.3	229	30	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	6405	3062	6405	0.60		
130-	WW06	238.17	238.2	216	L/S	28	A25	A23.1	244.17	12	0	0	0	0	12	2858	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	8979	8982.04	8979	1.13		

S.No	Section	Total R 'L' (ft)	Feeding 'L' (ft)	Drain 'L'(ft)	Drain Side	E 'L'(ft)	Nodes From	Nodes To	Total D 'L'= D 'L '+ E. D 'L' (ft)	R 'W'(ft)	S 'W' (ft)	G 'A' Sh(sft)	CM 'W' (ft)	G 'A' CM (sft)	P 'W' of R (ft)	P 'A' R (sft)	G 'A' of 1 H/A (sft)	R 'A' of 1 H/A (sft)	No of H/A	Total G 'A' of H/A (sft)	Total R 'A' of H/A (sft)	Commer 'A' (sft)	Masjid (sft)	School 'R' (sft)	School 'G' (sft)	P.P.Pa (sft)	Parking (sft)	Park/PG 'G' (Sft)	MI.R 'G' (Sft)	MI.R 'R' (Sft)	WW/ P (sft)	P.B 'G' (sft)	P.B 'R' (sft)	Misc G 'A'(sft)	Total Paved 'A' (sft)	Total Green 'A' (sft)	Q = CIA (cusecs)	Sub-Catch No	Sub-Catch 'A' (sft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)
131-	R-29	427.89	97.89	91	R/S	0	A23	A23.1	91	40	20	1957.8	0	0	20	1958	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	5019.8	1957.8	0.44		
132-	R-29	427.89	81	81	R/S	0	A23.1	A23.2	81	40	20	1620	0	0	20	1620	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	6988	3151	8608	0.74		
133-	R-29	427.89	167	167	R/S	0	A23.2	A23.3	167	40	20	3340	0	0	20	3340	0	3062	1.5	0	4593	0	0	0	0	0	0	0	0	0	0	0	0	20961	7933	24301	2.03		
134-	R-29	427.89	80	80	R/S	0	A23.3	A23.4	80	40	20	1600	0	0	20	1600	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6405	1600	8005	0.60		
135-	WW03	227.77	227.8	203	L/S	10	A27	A28.2	212.77	12	0	0	0	0	12	2733	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	7001	5795.24	7001	0.81		
136-	MR01 to R26	-	109.1	109	L/S	0	A35	A28	109.13	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6915	0	6915	0.44		
137-	R-28	534.33	50	50	L/S	0	A28	A28.1	50	40	20	1000	0	0	20	1000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	6915	2531	7915	0.66		
138-	R-28	534.33	124	124	L/S	0	A28.1	A28.2	124	40	20	2480	0	0	20	2480	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	6982	4011	9462	0.85		
139-	R-28	534.33	76	76	L/S	0	A28.2	A28.3	76	40	20	1520	0	0	20	1520	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	2242	3051	3762	0.43		
140-	R-28	534.33	175	175	L/S	0	A28.3	A26	175	40	20	3500	0	0	20	3500	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	19352	6562	22852	1.85		
141-	G B-6	-	229.1	229	R/S	0	A23.4	A26	229.11	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11820	0	11820	0.74		
142-	G	-	123	123	R/S	0	A26	A26.1	123	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
143-	WW14	512.29	512.3	505	R/S	0	A29	A30	504.6	12	0	0	0	0	12	6147	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	20871	12271.5	20871	2.09	S.C-10	33142.5
144-	R-38	192.93	192.9	188	L/S	30	A32	A31.3	217.66	40	20	3858.6	0	0	20	3859	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	6947	9982.6	10805.6	1.31		
145-	R-37	417.6	85	60	R/S	0	A31	A31.1	60	40	20	1700	0	0	20	1700	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	24563	4762	26263	1.95		
146-	R-37	417.6	65	65	R/S	0	A31.1	A31.2	65	40	20	1300	0	0	20	1300	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	10354	2831	11654	0.91		
147-	R-37	417.6	50	50	R/S	0	A31.2	A31.3	50	40	20	1000	0	0	20	1000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	3400	2531	4400	0.44	S.C-11	105374.2
148-	R-37	417.6	132.6	128	R/S	0	A31.5	A31.4	127.6	40	20	2652	0	0	20	2652	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	6889	5714	9541	0.96		
149-	R-37	417.6	85	85	R/S	0	A31.4	A31.3	85	40	20	1700	0	0	20	1700	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5075	1700	6775	0.53		
150-	G	-	132.6	133	R/S	0	A31.3	A34	132.55	0	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	6884	1531	6884	0.53		
151-	R-24	192.29	192.3	182	R/S	20	C10	C10.1	201.84	40	20	3845.8	0	0	20	3846	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	0	9969.8	3845.8	0.87	S.C-12	13815.6
152-	R-23	472.14	54	54	L/S	0	C5	C5.1	54	40	20	1080	0	0	20	1080	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1080	1080	0.14		
153-	R-23	472.14	46	46	L/S	0	C5.1	C5.2	46	40	20	920	0	0	20	920	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	920	920	0.12		
154-	R-23	472.14	50	50	L/S	0	C5.2	C5.3	50	40	20	1000	0	0	20	1000	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	10549	4062	11549	0.98		
155-	R-23	472.14	100	100	L/S	10	C5.3	C6	110	40	20	2000	0	0	20	2000	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	10509	5062	12509	1.11		
156-	G	-	135.7	136		0	C22	C23	135.72	10	0	0	0	0	0	0	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	34567	6124	34567	2.56		
157-	R-23	472.14	45	45	L/S	0	C1	C2	45	40	20	900	0	0	20	900	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	2431	900	0.21		
158-	R-23	472.14	50	50	L/S	0	C2	C3	50	40	20	1000	0	0	20	1000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	3272	2531	4272	0.43		
159-	R-23	472.14	122.1	122	L/S	60	C3	C4	182.14	40	20	2442.8	0	0	20	2443	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	5504.8	2442.8	0.50	S.C-13	213202.4
160-	R-22	3103.7	333.7	320	R/S	0	C7	C6	320	60	24	8009.3	0	0	34	11346	0	3062	2.5	0	7655	0	0	0	0	0	0	0	0	0	0	0	0	19615	19001.5	27624.3	2.94		
161-	R-22	3103.7	190	190	R/S	0	C6	C8	190	60	24	4560	0	0	34	6460	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	3498	9522	8058	1.11		
162-	R-22	3103.7	70	70	R/S	0	C8	C8.1	70	60	24	1680	0	0	34	2380	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	13751	3911	15431	1.22		
163-	R-22	3103.7	46	46	R/S	0	C8.1	C4.1	46	60	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
164-	R-22	3103.7	120	120	L/S	0	C9	C4	120	60	24	2880	0	0	34	4080	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	5611	2880	0.53		
165-	R-22	3103.7	230	230	L/S	0	C4	C4.1	230	60	24	5520	0	0	34	7820	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	8807	10882	14327	1.59		
166-	R-22	3103.7	106	106	L/S	0	C4.1	C8.2	106	60	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00		
167-	R-22	3103.7	145	145	L/S	0	C11	C11.1	145	60	24	3480	0	0	34	4930	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	6461	3480	0.63		
168-	R-22	3103.7	150	150	L/S	0	C11.1	C11.2	150	60	24	3600	0	0	34	5100	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5100	3600	0.55	S.C-14	109885
169-	R-22	3103.7	397	397	L/S	0	C11.2	C12	397	60	24	9528	0	0	34	13498	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	68218	13498	77746	5.74		
170-	R-22	3103.7	172	172	L/S	0	C13	C14	172	60	24	4128	0	0	34	5848	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15144	5848	19272	1.58	S.C-15	25120
171-	R-22	3103.7	155.5	156	L/S	0	C15	C16	155.5	60	24	3732	0	0	34	5287	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12198	5287	15930	1.34		
172-	R-22	3103.7	260.4	260	L/S	0	C16	C17	260.36	60	24	6248.6	0	0	34	8852	0	3062	0	0	0	0	0	12786	8524	0	0	0	0	0	0	0	0	0	21638.2	14772.6	2.29		
173-	R-22	3103.7	250	250	L/S	0	C17	C18	250	60	24	6000	0	0	34	8500	0	3062	0	0	0	0	0	12786	8524	0	0	0	0	0	0	0	0	0	21286	14524	2.25	S.C-16	107763.9
174-	R-22	3103.7	100	100	L/S	0	C18	C19	100	60	24	2400	0	0	34	3400	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3400	2400	0.37		
175-	R-22	3103.7	147	147	L/S	0	C19	C19.1	147	60	24	3528	0	0	34	4998	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4998	3528	0.54		
176-	R-22	3103.7	392	392	L/S	0	C20	C21	392	60	24	9408	0	0	34	13328	0	3062	0	0	0	41080	0	0			0	0		7387	0		0	31851	61795	41259	6.49	S.C-17	103054
																																					Grand Total Area of 17 Sub- Catchments	=	**3948235**

Table B5: Design Sheet of Storm Drainage containing 17 sub-basins for Separate Sewer System.

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	FRL at End 1 (ft)	FRL at End 2 (ft)	Invert Level at End 1 (ft)	Invert Level at End 2 (ft)	Slope % age	Discharge Indivi. (cusec)	Discharge Commu.(cusec)	Drain Size b (inch)	x	Drain Size d (inch)	Drain 'A' (sft)	Wetted P= B+2Y (ft)	Hydraulic R=A/P (ft)	Vel actual (ft/sec)	Vel Max (ft/sec)	Capacity Max (cusec)	OK or NG	Remarks from Hydraulic Table Q/Qf	V/Vf	V	Min Speci. Vel ft/sec	Final check for Vel	Max Speci. Vel ft/sec	Stepped or Not	Sub-Basin No
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)		(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)
1-	B1	B2	236	1454.75	1443.48	1453.75	1442.48	4.78	1.04	1.04	12	x	12	1	3	0.333	1.04	12.01	12.01	OK	0.09	0.46	5.52	3	OK	8.5	FALSE	
2-	B3	B9	308	1469.75	1455.5	1468.75	1454.5	4.63	2.05	2.05	12	x	12	1	3	0.333	2.05	11.82	11.82	OK	0.17	0.61	7.21	3	OK	8.5	FALSE	
3-	B10	B9	210	1458.97	1455.5	1457.97	1454.5	1.65	1.50	1.50	12	x	12	1	3	0.333	1.50	7.06	7.06	OK	0.21	0.79	5.58	3	OK	8.5	FALSE	
4-	B9	B4	150	1455.5	1448.65	1454.5	1447.65	4.57	0.47	4.02	12	x	12	1	3	0.333	4.02	11.74	11.74	OK	0.34	0.91	10.69	3	OK	8.5	STEPPED	
5-	B5	B7	109	1462.66	1462.05	1461.66	1461.05	0.56	0.56	0.56	12	x	12	1	3	0.333	0.56	4.11	4.11	OK	0.14	0.88	3.62	3	OK	8.5	FALSE	
6-	B6	B7	176	1463.25	1462.05	1462.25	1461.05	0.68	1.16	1.16	12	x	12	1	3	0.333	1.16	4.54	4.54	OK	0.25	0.9	4.09	3	OK	8.5	FALSE	
7-	B7	B14	220	1462.05	1461.55	1460.55	1460.05	0.23	1.48	3.20	18	x	18	2.25	4.5	0.500	1.42	3.43	7.72	OK	0.41	1.04	8.03	3	OK	8.5	FALSE	
8-	B13	B14	161	1462.65	1461.55	1461.65	1460.55	0.68	1.05	1.05	12	x	12	1	3	0.333	1.05	4.54	4.54	OK	0.23	0.95	4.31	3	OK	8.5	FALSE	
9-	B16	B15	142	1462.59	1460.85	1461.59	1459.85	1.23	1.00	1.00	12	x	12	1	3	0.333	1.00	6.08	6.08	OK	0.16	0.8	4.87	3	OK	8.5	FALSE	
10-	B14	B15	136	1461.55	1460.85	1460.05	1459.35	0.51	0.48	4.73	12	x	18	1.5	4	0.375	3.15	4.26	6.39	OK	0.74	1.09	6.97	3	OK	8.5	FALSE	
11-	B15	B19	281	1460.85	1459.99	1459.35	1458.49	0.31	1.30	7.03	18	x	18	2.25	4.5	0.500	3.12	3.98	8.96	OK	0.78	1.03	9.23	3	OK	8.5	STEPPED	
12-	B17.1	B17	129	1462.41	1459	1461.41	1458	2.64	0.32	0.32	12	x	12	1	3	0.333	0.32	8.93	8.93	OK	0.04	0.51	4.56	3	OK	8.5	FALSE	S.C-1
13-	B18	B17	177	1461.22	1459	1460.22	1458	1.25	1.48	1.48	12	x	12	1	3	0.333	1.48	6.15	6.15	OK	0.24	0.83	5.11	3	OK	8.5	FALSE	
14-	B17	B11	151	1459	1456.1	1458	1455.1	1.92	0.26	2.06	12	x	12	1	3	0.333	2.06	7.62	7.62	OK	0.27	0.85	6.48	3	OK	8.5	FALSE	
15-	B19	B11	227	1459.99	1456.1	1458.49	1454.6	1.71	2.58	9.61	12	x	18	1.5	4	0.375	6.41	7.78	11.67	OK	0.82	1.11	12.96	3	OK	8.5	STEPPED	
16-	B11	B4	238	1456.1	1448.65	1454.6	1447.15	3.13	2.50	14.18	18	x	18	2.25	4.5	0.500	6.30	12.74	28.67	OK	0.49	0.99	28.38	3	OK	8.5	STEPPED	
17-	B4	B2	123	1448.65	1443.48	1447.15	1441.98	4.20	0.87	15.05	18	x	18	2.25	4.5	0.500	6.69	14.76	33.22	OK	0.45	0.98	32.55	3	OK	8.5	STEPPED	
18-	B2	B2.1	712	1443.48	1413.95	1441.98	1412.45	4.15	7.84	23.93	18	x	18	2.25	4.5	0.500	10.63	14.66	33.00	OK	0.73	0.87	28.71	3	OK	8.5	STEPPED	
19-	B2.1	B2.2	550	1413.87	1399.47	1411.87	1397.47	2.62	7.07	31.00	24	x	24	4	6	0.667	7.75	14.12	56.46	OK	0.55	1.02	57.59	3	OK	8.5	STEPPED	
20-	B2.2	B2.3	550	1399.47	1383.89	1397.47	1381.89	2.83	5.82	36.81	24	x	24	4	6	0.667	9.20	14.68	58.73	OK	0.63	1.05	61.66	3	OK	8.5	STEPPED	
21-	B2.3	B2.4	485	1383.89	1361.18	1381.89	1359.18	4.68	5.24	42.05	24	x	24	4	6	0.667	10.51	18.88	75.51	OK	0.56	1.03	77.77	3	OK	8.5	STEPPED	
22-	B2.4	B2.5	83.8	1361.18	1359.21	1359.18	1357.21	2.35	1.08	43.13	24	x	24	4	6	0.667	10.78	13.38	53.52	OK	0.81	1.11	59.40	3	OK	8.5	STEPPED	
23-	B2.5	B2.6	231	1359.21	1356.67	1356.71	1354.17	1.10	2.45	45.58	30	x	30	6.25	7.5	0.833	7.29	10.61	66.30	OK	0.69	1.08	71.61	3	OK	8.5	STEPPED	
24-	B19.1	B21	126	1459.86	1457.21	1458.86	1456.21	2.10	1.12	1.12	12	x	12	1	3	0.333	1.12	7.97	7.97	OK	0.14	0.71	5.66	3	OK	8.5	FALSE	
25-	B20	B20.1	198	1474.63	1462.13	1473.63	1461.13	6.31	1.79	1.79	12	x	12	1	3	0.333	1.79	13.80	13.80	OK	0.13	0.7	9.66	3	OK	8.5	STEPPED	
26-	B20.1	B21	213	1462.13	1457.21	1461.13	1456.21	2.31	0.84	2.63	12	x	12	1	3	0.333	2.63	8.35	8.35	OK	0.31	0.88	7.35	3	OK	8.5	FALSE	
27-	B25	B26	270	1459.85	1449.41	1458.85	1448.41	3.87	1.91	1.91	12	x	12	1	3	0.333	1.91	10.81	10.81	OK	0.18	0.76	8.21	3	OK	8.5	FALSE	
28-	B23	B26	138	1454.65	1449.41	1453.65	1448.41	3.80	1.27	1.27	12	x	12	1	3	0.333	1.27	10.71	10.71	OK	0.12	0.69	7.39	3	OK	8.5	FALSE	
29-	B26	B27	154	1449.41	1444.88	1448.41	1443.88	2.95	0.55	3.73	12	x	12	1	3	0.333	3.73	9.44	9.44	OK	0.40	0.94	8.87	3	OK	8.5	STEPPED	S.C-2
30-	B21	B27	222	1457.21	1444.88	1456.21	1443.88	5.55	2.22	5.96	12	x	12	1	3	0.333	5.96	12.95	12.95	OK	0.46	0.98	12.69	3	OK	8.5	STEPPED	
31-	B22	B24	444	1469.86	1448.21	1468.86	1447.21	4.88	2.06	2.06	12	x	12	1	3	0.333	2.06	12.14	12.14	OK	0.17	0.75	9.10	3	OK	8.5	STEPPED	
32-	B24	B28	260	1448.21	1441.34	1447.21	1440.34	2.64	2.20	2.20	12	x	12	1	3	0.333	2.20	8.93	8.93	OK	0.25	0.84	7.50	3	OK	8.5	FALSE	
33-	B27	B28	161	1444.88	1441.34	1443.38	1439.84	2.21	1.12	10.82	12	x	18	1.5	4	0.375	7.21	8.83	13.24	OK	0.82	1.11	14.70	3	OK	8.5	STEPPED	
34-	B28	B28.1	75	1441.34	1439.75	1439.84	1438.25	2.12	0.00	13.02	18	x	18	2.25	4.5	0.500	5.79	10.48	23.59	OK	0.55	1.02	24.06	3	OK	8.5	STEPPED	
35-	B24.1	B24.2	150	1448.27	1443.45	1447.27	1442.45	3.21	0.94	0.94	12	x	12	1	3	0.333	0.94	9.85	9.85	OK	0.10	0.65	6.40	3	OK	8.5	FALSE	
36-	B29	B24.2	262	1456.96	1443.45	1455.96	1442.45	5.15	1.12	1.12	12	x	12	1	3	0.333	1.12	12.47	12.47	OK	0.09	0.63	7.86	3	OK	8.5	FALSE	
37-	B24.2	B24.3	250	1443.45	1431.03	1442.45	1430.03	4.97	5.24	7.30	12	x	12	1	3	0.333	7.30	12.25	12.25	OK	0.60	1.04	12.74	3	OK	8.5	STEPPED	
38-	B24.3	B24.4	100	1431.03	1429.52	1429.53	1428.02	1.51	2.18	9.49	12	x	18	1.5	4	0.375	6.32	7.30	10.96	OK	0.87	1.12	12.27	3	OK	8.5	STEPPED	
39-	B31	B32	118	1442.51	1439.62	1441.51	1438.62	2.45	1.37	1.37	12	x	12	1	3	0.333	1.37	8.60	8.60	OK	0.16	0.74	6.36	3	OK	8.5	FALSE	S.C-3
40-	B33	B32	202	1443.94	1439.62	1442.94	1438.62	2.14	0.98	0.98	12	x	12	1	3	0.333	0.98	8.04	8.04	OK	0.12	0.69	5.55	3	OK	8.5	FALSE	
41-	B32	B31.1	32	1439.62	1438.11	1438.62	1437.11	4.72	0.61	2.97	12	x	12	1	3	0.333	2.97	11.94	11.94	OK	0.25	0.84	10.03	3	OK	8.5	STEPPED	
42-	B31.1	B31.2	150	1438.11	1431.13	1437.11	1430.13	4.65	4.58	7.55	12	x	12	1	3	0.333	7.55	11.85	11.85	OK	0.64	1.06	12.57	3	OK	8.5	STEPPED	
43-	B31.2	B24.4	100	1431.13	1429.52	1429.63	1428.02	1.61	0.93	8.48	12	x	18	1.5	4	0.375	5.65	7.54	11.31	OK	0.75	1.1	12.44	3	OK	8.5	STEPPED	
44-	B24.4	B24.5	128	1429.52	1419.75	1428.02	1418.25	7.63	0.00	17.96	12	x	18	1.5	4	0.375	11.97	16.42	24.63	OK	0.73	1.09	26.85	3	OK	8.5	STEPPED	

S.No	Drain Nodes From	To	Drain Length (ft)	FRL at End 1 (ft)	End 2 (ft)	Invert Level at End 1 (ft)	End 2 (ft)	Slope % age	Discharge Indivi. (cusec)	Commu.(cusec)	Drain Size b (inch)	x	d (inch)	Drain 'A' (sft)	Wetted P= B+2Y (ft)	Hydraulic R=A/P (ft)	Vel actual (ft/sec)	Vel Max (ft/sec)	Capacity Max (cusec)	OK or NG	Remarks from Hydraulic Table Q/Qf	V/Vf	V	Min Speci. Vel ft/sec	Final check for Max	Speci. Vel ft/sec	Stepped or Not	Sub-Basin No
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)		(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)
45-	B33.1	B34	248	1443.85	1431.75	1442.85	1430.75	4.88	2.46	2.46	12	x	12	1	3	0.333	2.46	12.14	12.14	OK	0.20	0.78	9.47	3	OK	8.5	STEPPED	
46-	B34	B35	61	1431.75	1429.91	1430.75	1428.91	3.02	0.44	2.90	12	x	12	1	3	0.333	2.90	9.54	9.54	OK	0.30	0.88	8.40	3	OK	8.5	FALSE	
47-	B35	B36	156	1429.91	1428.65	1428.91	1427.65	0.81	1.14	4.04	12	x	12	1	3	0.333	4.04	4.94	4.94	OK	0.82	1.11	5.48	3	OK	8.5	FALSE	
48-	B38	B38.1	175	1436.4	1430.41	1435.4	1429.41	3.42	1.61	1.61	12	x	12	1	3	0.333	1.61	10.17	10.17	OK	0.16	0.74	7.52	3	OK	8.5	FALSE	
49-	B38.1	B36	235	1430.41	1428.65	1429.41	1427.65	0.75	1.26	2.86	12	x	12	1	3	0.333	2.86	4.76	4.76	OK	0.60	1.04	4.95	3	OK	8.5	FALSE	
50-	B36	B37	169	1428.65	1425.82	1427.15	1424.32	1.67	1.18	8.08	12	x	18	1.5	4	0.375	5.39	7.69	11.54	OK	0.70	1.08	12.46	3	OK	8.5	STEPPED	
51-	B37	B38.2	150	1425.82	1418.97	1424.82	1417.97	4.57	1.54	9.62	12	x	12	1	3	0.333	9.62	11.74	11.74	OK	0.82	1.11	13.04	3	OK	8.5	STEPPED	
52-	B38.2	B38.3	200	1418.97	1406.73	1417.97	1405.73	6.12	1.66	11.28	12	x	12	1	3	0.333	11.28	13.59	13.59	OK	0.83	1.11	15.09	3	OK	8.5	STEPPED	
53-	B38.3	B39	115	1406.73	1401.3	1405.73	1400.3	4.72	0.75	12.03	12	x	12	1	3	0.333	12.03	11.94	11.94	NG	1.01	1.14	13.61	3	OK	8.5	STEPPED	
54-	B39	B40	185	1401.3	1398.31	1399.8	1396.81	1.62	1.03	13.06	18	x	18	2.25	4.5	0.500	5.80	9.15	20.60	OK	0.63	1.05	21.63	3	OK	8.5	STEPPED	
55-	B41	B40	157	1399.89	1398.31	1397.89	1396.31	1.01	1.00	21.93	24	x	24	4	6	0.667	5.48	8.75	35.00	OK	0.63	1.14	39.90	3	OK	8.5	STEPPED	
56-	B40	B40.5	126	1398.23	1395.67	1396.23	1393.67	2.03	0.00	34.99	24	x	24	4	6	0.667	8.75	12.43	49.74	OK	0.70	0.98	48.74	3	OK	8.5	STEPPED	
57-	B44.1	B43	100	1414.49	1410.75	1413.49	1409.75	3.74	0.51	0.51	12	x	12	1	3	0.333	0.51	10.63	10.63	OK	0.05	0.53	5.63	3	OK	8.5	FALSE	
58-	B43	B42	150	1410.75	1403.89	1409.75	1402.89	4.57	1.19	1.69	12	x	12	1	3	0.333	1.69	11.75	11.75	OK	0.14	0.71	8.34	3	OK	8.5	FALSE	
59-	B42	B41	143	1403.89	1399.89	1402.89	1398.89	2.80	1.30	2.99	12	x	12	1	3	0.333	2.99	9.19	9.19	OK	0.33	0.89	8.18	3	OK	8.5	FALSE	
60-	B40.3	B40.4	175	1425.9	1420.81	1424.9	1419.81	2.91	1.00	1.00	12	x	12	1	3	0.333	1.00	9.37	9.37	OK	0.11	0.67	6.28	3	OK	8.5	FALSE	
61-	B40.4	B40.2	88	1420.81	1420.05	1419.81	1419.05	0.86	0.43	1.43	12	x	12	1	3	0.333	1.43	5.11	5.11	OK	0.28	0.88	4.49	3	OK	8.5	FALSE	S.C-4
62-	B40.1	B40.2	112	1426.95	1420.05	1425.95	1419.05	6.16	0.68	0.68	12	x	12	1	3	0.333	0.68	13.64	13.64	OK	0.05	0.53	7.23	3	OK	8.5	FALSE	
63-	B40.2	B42.1	198	1420.05	1411.49	1419.05	1410.49	4.32	1.28	3.39	12	x	12	1	3	0.333	3.39	11.43	11.43	OK	0.30	0.87	9.94	3	OK	8.5	STEPPED	
64-	B45	B45.1	137	1422.81	1418.11	1421.81	1417.11	3.42	1.08	1.08	12	x	12	1	3	0.333	1.08	10.16	10.16	OK	0.11	0.67	6.81	3	OK	8.5	FALSE	
65-	B46	B46.1	111	1415.15	1411.32	1414.15	1410.32	3.45	0.59	0.59	12	x	12	1	3	0.333	0.59	10.21	10.21	OK	0.06	0.55	5.61	3	OK	8.5	FALSE	
66-	B45.1	B46.1	135	1418.11	1411.32	1417.11	1410.32	5.03	0.95	2.03	12	x	12	1	3	0.333	2.03	12.32	12.32	OK	0.16	0.74	9.12	3	OK	8.5	STEPPED	
67-	B44	B44.4	120	1414.82	1406.93	1413.82	1405.93	6.57	2.58	2.58	12	x	12	1	3	0.333	2.58	14.09	14.09	OK	0.18	0.76	10.71	3	OK	8.5	STEPPED	
68-	B44.4	B43.1	75	1406.93	1405.19	1405.93	1404.19	2.32	2.20	4.78	12	x	12	1	3	0.333	4.78	8.37	8.37	OK	0.57	1.03	8.62	3	OK	8.5	STEPPED	
69-	B42.1	B43.5	160	1411.49	1406.5	1410.49	1405.5	3.12	1.23	4.62	12	x	12	1	3	0.333	4.62	9.70	9.70	OK	0.48	0.99	9.61	3	OK	8.5	STEPPED	
70-	B46.1	B43.5	129	1411.32	1406.5	1410.32	1405.5	3.74	0.75	3.37	12	x	12	1	3	0.333	3.37	10.62	10.62	OK	0.32	0.89	9.45	3	OK	8.5	STEPPED	
71-	B43.5	B43.1	90	1406.5	1405.19	1405	1403.69	1.46	0.44	8.43	12	x	18	1.5	4	0.375	5.62	7.17	10.76	OK	0.78	1.1	11.83	3	OK	8.5	STEPPED	
72-	B43.1	B43.2	127	1405.19	1400.77	1403.69	1399.27	3.48	0.06	13.26	12	x	18	1.5	4	0.375	8.84	11.09	16.63	OK	0.80	1.11	18.46	3	OK	8.5	STEPPED	
73-	B49	B43.3	309	1407.07	1400.61	1406.07	1399.61	2.09	2.37	2.37	12	x	12	1	3	0.333	2.37	7.95	7.95	OK	0.30	0.89	7.07	3	OK	8.5	FALSE	
74-	B48	B48.1	152	1413.98	1404.26	1412.98	1403.26	6.41	1.29	1.29	12	x	12	1	3	0.333	1.29	13.91	13.91	OK	0.09	0.65	9.04	3	OK	8.5	STEPPED	
75-	B48.1	B43.2	112	1404.26	1400.77	1403.26	1399.77	3.11	0.92	2.21	12	x	12	1	3	0.333	2.21	9.69	9.69	OK	0.23	0.83	8.04	3	OK	8.5	FALSE	
76-	B43.2	B43.3	14	1400.77	1400.61	1399.27	1399.11	1.14	0.04	2.25	12	x	18	1.5	4	0.375	1.50	6.36	9.54	OK	0.24	0.94	8.97	3	OK	8.5	STEPPED	
77-	B43.3	B41	167	1400.61	1399.89	1398.61	1397.89	0.43	0.06	17.94	24	x	24	4	6	0.667	4.49	5.73	22.91	OK	0.78	1.12	25.66	3	OK	8.5	STEPPED	
78-	B36.1	B36.2	269	1443.39	1426.92	1442.39	1425.92	6.11	1.50	1.50	12	x	12	1	3	0.333	1.50	13.59	13.59	OK	0.11	0.67	9.10	3	OK	8.5	STEPPED	
79-	B36.2	B36.3	220	1426.92	1418.73	1425.92	1417.73	3.72	1.05	2.55	12	x	12	1	3	0.333	2.55	10.60	10.60	OK	0.24	0.84	8.91	3	OK	8.5	STEPPED	
80-	B36.3	B44.2	549	1418.73	1414.34	1417.23	1412.84	0.80	2.65	5.20	12	x	18	1.5	4	0.375	3.46	5.32	7.97	OK	0.65	0.93	7.42	3	OK	8.5	FALSE	
81-	B44.2	B44.3	137	1414.34	1411.64	1412.84	1410.14	1.97	0.22	5.42	12	x	18	1.5	4	0.375	3.61	8.34	12.52	OK	0.43	1.09	13.64	3	OK	8.5	STEPPED	
82-	B32.1	B32.2	148	1442.49	1440.07	1441.49	1439.07	1.64	1.77	1.77	12	x	12	1	3	0.333	1.77	7.03	7.03	OK	0.25	0.84	5.90	3	OK	8.5	FALSE	
83-	B32.2	B32.3	200	1440.07	1432.09	1439.07	1431.09	3.99	1.76	3.52	12	x	12	1	3	0.333	3.52	10.98	10.98	OK	0.32	0.9	9.88	3	OK	8.5	STEPPED	
84-	B32.3	B32.4	150	1432.09	1426.4	1431.09	1425.4	3.79	1.16	4.68	12	x	12	1	3	0.333	4.68	10.70	10.70	OK	0.44	0.98	10.49	3	OK	8.5	STEPPED	S.C-5
85-	B32.4	B32.5	150	1426.4	1422.5	1425.4	1421.5	2.60	1.44	6.12	12	x	12	1	3	0.333	6.12	8.86	8.86	OK	0.69	1.08	9.57	3	OK	8.5	STEPPED	
86-	B32.5	B32.6	150	1422.5	1419.57	1421.5	1418.57	1.95	1.37	7.49	12	x	12	1	3	0.333	7.49	7.68	7.68	OK	0.98	1.14	8.76	3	OK	8.5	STEPPED	
87-	B32.6	B32.7	150	1419.57	1415.51	1418.57	1414.51	2.71	1.37	8.86	12	x	12	1	3	0.333	8.86	9.04	9.04	OK	0.98	1.14	10.31	3	OK	8.5	STEPPED	
88-	B32.7	B44.3	100	1415.51	1411.64	1414.01	1410.14	3.87	0.63	9.49	12	x	18	1.5	4	0.375	6.33	11.69	17.54	OK	0.54	1.13	19.82	3	OK	8.5	STEPPED	
89-	B44.3	B32.8	146	1411.64	1404.92	1410.14	1403.42	4.60	0.92	15.83	18	x	18	2.25	4.5	0.500	7.03	15.45	34.76	OK	0.46	0.98	34.06	3	OK	8.5	STEPPED	

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	FRL at End 1 (ft)	FRL at End 2 (ft)	Invert Level at End 1 (ft)	Invert Level at End 2 (ft)	Slope % age	Discharge Indivi. (cusec)	Discharge Commu.(cusec)	Dran Size b (inch)	x	Dran Size d (inch)	Drain 'A' (sft)	Wetted P= B+2Y (ft)	Hydraulic R=A/P (ft)	Vel actual (ft/sec)	Vel Max (ft/sec)	Capacity Max (cusec)	OK or NG	Remarks from Hydraulic Table Q/Qf	V/Vf	V	Min Speci. Vel ft/sec	Final check for Max	Speci. Vel ft/sec	Stepped or Not	Sub-Basin No
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)		(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)
90-	B32.8	B32.9	81.4	1404.92	1399.75	1403.42	1398.25	6.35	0.00	15.83	18	x	18	2.25	4.5	0.500	7.03	18.15	40.83	OK	0.39	0.94	38.38	3	OK	8.5	STEPPED	
91-	C24	C25	236	1421.5	1412.98	1420.5	1411.98	3.61	2.13	2.13	12	x	12	1	3	0.333	2.13	10.44	10.44	OK	0.20	0.78	8.15	3	OK	8.5	FALSE	
92-	C29	C25	124	1416.1	1412.98	1415.1	1411.98	2.52	1.77	1.77	12	x	12	1	3	0.333	1.77	8.72	8.72	OK	0.20	0.78	6.80	3	OK	8.5	FALSE	
93-	C25	C43	200	1412.98	1404.22	1411.98	1403.22	4.38	3.85	7.76	12	x	12	1	3	0.333	7.76	11.50	11.50	OK	0.67	1.07	12.31	3	OK	8.5	STEPPED	S.C-6
94-	C43	C44	134	1404.22	1399.75	1403.22	1398.75	3.34	0.00	7.76	12	x	12	1	3	0.333	7.76	10.05	10.05	OK	0.77	1.1	11.05	3	OK	8.5	STEPPED	
95-	C34	C35	50	1446.32	1445.39	1445.32	1444.39	1.86	0.83	0.83	12	x	12	1	3	0.333	0.83	7.49	7.49	OK	0.11	0.67	5.02	3	OK	8.5	FALSE	
96-	C35	C36	50	1445.39	1442.75	1444.39	1441.75	5.28	0.83	1.67	12	x	12	1	3	0.333	1.67	12.63	12.63	OK	0.13	0.7	8.84	3	OK	8.5	STEPPED	
97-	C36	C37	50	1442.75	1439.41	1441.75	1438.41	6.68	0.83	2.50	12	x	12	1	3	0.333	2.50	14.20	14.20	OK	0.18	0.76	10.79	3	OK	8.5	STEPPED	S.C-7
98-	C37	C38	100	1439.41	1434.75	1438.41	1433.75	4.66	0.96	3.46	12	x	12	1	3	0.333	3.46	11.86	11.86	OK	0.29	0.87	10.32	3	OK	8.5	STEPPED	
99-	C38	C39	60	1434.75	1419.75	1433.75	1418.75	25.00	0.00	3.46	12	x	12	1	3	0.333	3.46	27.48	27.48	OK	0.13	0.7	19.23	3	OK	8.5	STEPPED	
100-	C33	C32	45	1446.28	1445.54	1445.28	1444.54	1.64	0.76	0.76	12	x	12	1	3	0.333	0.76	7.05	7.05	OK	0.11	0.67	4.72	3	OK	8.5	FALSE	
101-	C32	C31	50	1445.54	1443.04	1444.54	1442.04	5.00	0.77	1.53	12	x	12	1	3	0.333	1.53	12.29	12.29	OK	0.12	0.69	8.48	3	OK	8.5	FALSE	
102-	C31	C30	103	1443.04	1436.23	1442.04	1435.23	6.63	0.88	2.41	12	x	12	1	3	0.333	2.41	14.15	14.15	OK	0.17	0.75	10.61	3	OK	8.5	STEPPED	
103-	C26	C30	95	1442.9	1436.23	1441.9	1435.23	7.02	0.90	0.90	12	x	12	1	3	0.333	0.90	14.56	14.56	OK	0.06	0.55	8.01	3	OK	8.5	FALSE	
104-	C30	C27	368	1436.23	1414.33	1435.23	1413.33	5.95	4.57	7.87	12	x	12	1	3	0.333	7.87	13.41	13.41	OK	0.59	1.04	13.94	3	OK	8.5	STEPPED	S.C-8
105-	C28	C27	102	1416.22	1414.33	1415.22	1413.33	1.85	2.72	2.72	12	x	12	1	3	0.333	2.72	7.47	7.47	OK	0.36	0.92	6.87	3	OK	8.5	FALSE	
106-	C27	C40	165	1414.33	1408.57	1412.83	1407.07	3.49	3.53	14.13	12	x	18	1.5	4	0.375	9.42	11.11	16.66	OK	0.85	1.12	18.66	3	OK	8.5	STEPPED	
107-	C40	C41	50	1408.57	1407.2	1407.07	1405.7	2.74	1.01	15.14	18	x	18	2.25	4.5	0.500	6.73	11.92	26.82	OK	0.56	1.03	27.62	3	OK	8.5	STEPPED	
108-	C41	C42	150	1407.2	1399.75	1405.7	1398.25	4.97	0.00	15.14	18	x	18	2.25	4.5	0.500	6.73	16.05	36.11	OK	0.42	0.96	34.66	3	OK	8.5	STEPPED	
109-	A1	A1.1	100	1483.41	1477.34	1482.41	1476.34	6.07	0.47	0.47	12	x	12	1	3	0.333	0.47	13.54	13.54	OK	0.04	0.51	6.90	3	OK	8.5	FALSE	
110-	A1.1	A1.2	274	1477.34	1471.55	1476.34	1470.55	2.11	0.98	1.45	12	x	12	1	3	0.333	1.45	7.99	7.99	OK	0.18	0.76	6.07	3	OK	8.5	FALSE	
111-	A1.4	A1.3	116	1479.95	1471.89	1478.95	1470.89	6.95	0.30	0.30	12	x	12	1	3	0.333	0.30	14.49	14.49	OK	0.02	0.4	5.80	3	OK	8.5	FALSE	
112-	A1.3	A1.2	25.8	1471.89	1471.55	1470.89	1470.55	1.32	0.07	0.37	12	x	12	1	3	0.333	0.37	6.30	6.30	OK	0.06	0.55	3.47	3	OK	8.5	FALSE	
113-	A1.2	A2	81.9	1471.55	1470.36	1470.55	1469.36	1.45	0.25	2.08	12	x	12	1	3	0.333	2.08	6.62	6.62	OK	0.31	0.88	5.83	3	OK	8.5	FALSE	
114-	A2	A2.1	56	1470.36	1467.18	1469.36	1466.18	5.68	1.15	3.23	12	x	12	1	3	0.333	3.23	13.10	13.10	OK	0.25	0.84	11.00	3	OK	8.5	STEPPED	
115-	A2.1	A3	102	1467.18	1465.44	1466.18	1464.44	1.70	0.61	3.83	12	x	12	1	3	0.333	3.83	7.17	7.17	OK	0.53	1.02	7.32	3	OK	8.5	FALSE	
116-	A4	A5	197	1474.04	1466.73	1473.04	1465.73	3.71	2.61	2.61	12	x	12	1	3	0.333	2.61	10.58	10.58	OK	0.25	0.84	8.89	3	OK	8.5	STEPPED	
117-	A6	A7	198	1484.87	1479.79	1483.87	1478.79	2.56	0.72	0.72	12	x	12	1	3	0.333	0.72	8.80	8.80	OK	0.08	0.61	5.37	3	OK	8.5	FALSE	
118-	A7	A7.1	110	1479.79	1473.16	1478.79	1472.16	6.03	0.37	1.09	12	x	12	1	3	0.333	1.09	13.49	13.49	OK	0.08	0.61	8.23	3	OK	8.5	FALSE	
119-	A7.1	A7.2	100	1473.16	1468.24	1472.16	1467.24	4.92	0.35	1.44	12	x	12	1	3	0.333	1.44	12.19	12.19	OK	0.12	0.69	8.41	3	OK	8.5	FALSE	
120-	A7.2	A5	64	1468.24	1466.73	1467.24	1465.73	2.36	0.16	1.60	12	x	12	1	3	0.333	1.60	8.44	8.44	OK	0.19	0.77	6.50	3	OK	8.5	FALSE	
121-	A5	A3	224	1466.73	1465.44	1465.23	1463.94	0.58	2.07	6.28	12	x	18	1.5	4	0.375	4.19	4.51	6.77	OK	0.93	1.14	7.71	3	OK	8.5	FALSE	
122-	A3	A9	167	1465.36	1464.67	1463.36	1462.67	0.41	0.63	10.75	24	x	24	4	6	0.667	2.69	5.61	22.43	OK	0.48	0.99	22.20	3	OK	8.5	STEPPED	S.C-9
123-	A8	A9	252	1482.41	1464.75	1481.41	1463.75	7.01	1.81	1.81	12	x	12	1	3	0.333	1.81	14.55	14.55	OK	0.12	0.69	10.04	3	OK	8.5	STEPPED	
124-	A9	A10	143	1464.75	1455.75	1462.75	1453.75	6.29	0.90	13.46	24	x	24	4	6	0.667	3.36	21.88	87.54	OK	0.15	0.9	78.78	3	OK	8.5	STEPPED	
125-	A14	A10	261	1456.72	1455.75	1455.22	1454.25	0.37	3.88	3.88	12	x	18	1.5	4	0.375	2.59	3.62	5.43	OK	0.71	1.08	5.87	3	OK	8.5	FALSE	
126-	A10	A11	209	1455.75	1441.64	1453.75	1439.64	6.75	1.70	19.04	24	x	24	4	6	0.667	4.76	22.67	90.66	OK	0.21	0.98	88.85	3	OK	8.5	STEPPED	
127-	A20	A11	407	1442.71	1441.64	1441.21	1440.14	0.26	4.27	4.27	18	x	18	2.25	4.5	0.500	1.90	3.69	8.31	OK	0.51	1.01	8.39	3	OK	8.5	FALSE	
128-	A11	A35	491	1441.56	1409.78	1439.56	1407.78	6.47	4.64	27.95	24	x	24	4	6	0.667	6.99	22.19	88.77	OK	0.31	0.88	78.12	3	OK	8.5	STEPPED	
129-	A22	A23.3	229	1439.75	1405.13	1438.75	1404.13	15.12	0.60	0.60	12	x	12	1	3	0.333	0.60	21.37	21.37	OK	0.03	0.46	9.83	3	OK	8.5	STEPPED	
130-	A25	A23.1	244	1436.74	1421.03	1435.74	1420.03	6.43	1.13	1.13	12	x	12	1	3	0.333	1.13	13.94	13.94	OK	0.08	0.61	8.50	3	OK	8.5	STEPPED	
131-	A23	A23.1	91	1423.56	1421.03	1422.56	1420.03	2.78	0.44	0.44	12	x	12	1	3	0.333	0.44	9.16	9.16	OK	0.05	0.53	4.86	3	OK	8.5	FALSE	
132-	A23.1	A23.2	81	1421.03	1416.77	1420.03	1415.77	5.26	0.74	2.31	12	x	12	1	3	0.333	2.31	12.60	12.60	OK	0.18	0.76	9.58	3	OK	8.5	STEPPED	
133-	A23.2	A23.3	167	1416.77	1405.13	1415.77	1404.13	6.97	2.03	4.34	12	x	12	1	3	0.333	4.34	14.51	14.51	OK	0.30	0.88	12.77	3	OK	8.5	STEPPED	
134-	A23.3	A23.4	80	1405.13	1399.55	1404.13	1398.55	6.98	0.60	5.54	12	x	12	1	3	0.333	5.54	14.51	14.51	OK	0.38	0.93	13.50	3	OK	8.5	STEPPED	

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	FRL at End 1 (ft)	FRL at End 2 (ft)	Invert Level at End 1 (ft)	Invert Level at End 2 (ft)	Slope % age	Discharge Indivi. (cusec)	Discharge Commu.(cusec)	Drain Size b (inch)	x	Drain Size d (inch)	Drain 'A' (sft)	Wetted P= B+2Y (ft)	Hydraulic R=A/P (ft)	Vel actual (ft/sec)	Vel Max (ft/sec)	Capacity Max (cusec)	OK or NG	Remarks from Hydraulic Table Q/Qf	V/Vf	V	Min Speci. Vel ft/sec	Final check for Max	Speci. Vel ft/sec	Stepped or Not	Sub-Basin No
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)		(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)
135-	A27	A28.2	213	1418.05	1397.95	1417.05	1396.95	9.45	0.81	0.81	12	x	12	1	3	0.333	0.81	16.89	16.89	OK	0.05	0.53	8.95	3	OK	8.5	STEPPED	
136-	A35	A28	109	1409.78	1408.12	1407.78	1406.12	1.52	0.44	28.39	24	x	24	4	6	0.667	7.10	10.76	43.04	OK	0.66	1.07	46.05	3	OK	8.5	STEPPED	
137-	A28	A28.1	50	1408.12	1405.79	1406.12	1403.79	4.66	0.66	29.05	24	x	24	4	6	0.667	7.26	18.83	75.32	OK	0.39	0.94	70.80	3	OK	8.5	STEPPED	
138-	A28.1	A28.2	124	1405.79	1397.87	1403.79	1395.87	6.39	0.85	29.89	24	x	24	4	6	0.667	7.47	22.05	88.18	OK	0.34	0.91	80.25	3	OK	8.5	STEPPED	
139-	A28.2	A28.3	76	1397.87	1395.29	1395.87	1393.29	3.39	0.43	31.13	24	x	24	4	6	0.667	7.78	16.07	64.29	OK	0.48	0.99	63.65	3	OK	8.5	STEPPED	
140-	A28.3	A26	175	1395.29	1391.88	1393.29	1389.88	1.95	1.85	32.98	24	x	24	4	6	0.667	8.25	12.18	48.71	OK	0.68	1.07	52.12	3	OK	8.5	STEPPED	
141-	A23.4	A26	229	1399.55	1391.96	1398.55	1390.96	3.31	0.74	6.29	12	x	12	1	3	0.333	6.29	10.00	10.00	OK	0.63	1.05	10.50	3	OK	8.5	STEPPED	
142-	A26	A26.1	123	1391.88	1381.67	1389.88	1379.67	8.30	0.00	39.27	24	x	24	4	6	0.667	9.82	25.13	100.53	OK	0.39	0.94	94.50	3	OK	8.5	STEPPED	
143-	A29	A30	505	1482.37	1452.75	1481.37	1451.75	5.87	2.09	2.09	12	x	12	1	3	0.333	2.09	13.31	13.31	OK	0.16	0.74	9.85	3	OK	8.5	STEPPED	S.C-10
144-	A32	A31.3	218	1462.72	1452.72	1461.72	1451.72	4.59	1.31	1.31	12	x	12	1	3	0.333	1.31	11.78	11.78	OK	0.11	0.67	7.89	3	OK	8.5	FALSE	
145-	A31	A31.1	60	1460.94	1456.79	1459.94	1455.79	6.92	1.95	1.95	12	x	12	1	3	0.333	1.95	14.45	14.45	OK	0.14	0.71	10.26	3	OK	8.5	STEPPED	
146-	A31.1	A31.2	65	1456.79	1453.48	1455.79	1452.48	5.09	0.91	2.87	12	x	12	1	3	0.333	2.87	12.40	12.40	OK	0.23	0.81	10.04	3	OK	8.5	STEPPED	
147-	A31.2	A31.3	50	1453.48	1452.72	1452.48	1451.72	1.52	0.44	3.30	12	x	12	1	3	0.333	3.30	6.78	6.78	OK	0.49	0.99	6.71	3	OK	8.5	FALSE	S.C-11
148-	A31.5	A31.4	128	1461.49	1455.02	1460.49	1454.02	5.07	0.96	0.96	12	x	12	1	3	0.333	0.96	12.37	12.37	OK	0.08	0.61	7.55	3	OK	8.5	FALSE	
149-	A31.4	A31.3	85	1455.02	1452.72	1454.02	1451.72	2.71	0.53	1.49	12	x	12	1	3	0.333	1.49	9.04	9.04	OK	0.17	0.75	6.78	3	OK	8.5	FALSE	
150-	A31.3	A34	133	1452.72	1439.75	1451.72	1438.75	9.78	0.53	6.63	12	x	12	1	3	0.333	6.63	17.19	17.19	OK	0.39	0.94	16.16	3	OK	8.5	STEPPED	
151-	C10	C10.1	202	1487.72	1449.75	1486.72	1448.75	18.81	0.87	0.87	12	x	12	1	3	0.333	0.87	23.83	23.83	OK	0.04	0.51	12.16	3	OK	8.5	STEPPED	S.C-12
152-	C5	C5.1	54	1495.81	1494.75	1494.81	1493.75	1.96	0.14	0.14	12	x	12	1	3	0.333	0.14	7.70	7.70	OK	0.02	0.55	4.23	3	OK	8.5	FALSE	
153-	C5.1	C5.2	46	1494.75	1493.65	1493.75	1492.65	2.39	0.12	0.25	12	x	12	1	3	0.333	0.25	8.50	8.50	OK	0.03	0.4	3.40	3	OK	8.5	FALSE	
154-	C5.2	C5.3	50	1493.65	1490.83	1492.65	1489.83	5.64	0.98	1.23	12	x	12	1	3	0.333	1.23	13.05	13.05	OK	0.09	0.63	8.22	3	OK	8.5	FALSE	
155-	C5.3	C6	110	1490.83	1486.38	1489.83	1485.38	4.05	1.11	2.34	12	x	12	1	3	0.333	2.34	11.05	11.05	OK	0.21	0.79	8.73	3	OK	8.5	STEPPED	
156-	C22	C23	136	1479.75	1439.75	1478.75	1438.75	29.47	2.56	2.56	12	x	12	1	3	0.333	2.56	29.83	29.83	OK	0.09	0.63	18.80	3	OK	8.5	STEPPED	
157-	C1	C2	45	1495.73	1495	1494.73	1494	1.62	0.21	0.21	12	x	12	1	3	0.333	0.21	7.00	7.00	OK	0.03	0.46	3.22	3	OK	8.5	FALSE	
158-	C2	C3	50	1495	1492.93	1494	1491.93	4.14	0.43	0.64	12	x	12	1	3	0.333	0.64	11.18	11.18	OK	0.06	0.55	6.15	3	OK	8.5	FALSE	
159-	C3	C4	182	1492.93	1481.75	1491.93	1480.75	6.14	0.50	1.14	12	x	12	1	3	0.333	1.14	13.61	13.61	OK	0.08	0.61	8.31	3	OK	8.5	FALSE	S.C-13
160-	C7	C6	320	1503.98	1486.38	1502.98	1485.38	5.50	2.94	2.94	12	x	12	1	3	0.333	2.94	12.89	12.89	OK	0.23	0.81	10.44	3	OK	8.5	STEPPED	
161-	C6	C8	190	1486.38	1481.66	1485.38	1480.66	2.48	1.11	6.38	12	x	12	1	3	0.333	6.38	8.66	8.66	OK	0.74	1.09	9.44	3	OK	8.5	STEPPED	
162-	C8	C8.1	70	1481.66	1480.13	1480.66	1479.13	2.19	1.22	7.60	12	x	12	1	3	0.333	7.60	8.12	8.12	OK	0.94	1.14	9.26	3	OK	8.5	STEPPED	
163-	C8.1	C4.1	46	1480.13	1479.79	1478.63	1478.29	0.74	0.00	7.60	18	x	18	2.25	4.5	0.500	3.38	6.19	13.93	OK	0.55	1.02	14.21	3	OK	8.5	STEPPED	
164-	C9	C4	120	1481.79	1480.75	1480.79	1479.75	0.87	0.53	0.53	12	x	12	1	3	0.333	0.53	5.12	5.12	OK	0.10	1.02	5.22	3	OK	8.5	FALSE	
165-	C4	C4.1	230	1480.75	1479.85	1479.25	1478.35	0.39	1.59	3.26	12	x	18	1.5	4	0.375	2.17	3.72	5.58	OK	0.58	1.06	5.91	3	OK	8.5	FALSE	
166-	C4.1	C8.2	106	1479.85	1459.75	1478.35	1458.25	18.96	0.00	10.86	12	x	18	1.5	4	0.375	7.24	25.88	38.83	OK	0.28	0.73	28.34	3	OK	8.5	STEPPED	
167-	C11	C11.1	145	1481.67	1477.2	1480.67	1476.2	3.08	0.63	0.63	12	x	12	1	3	0.333	0.63	9.65	9.65	OK	0.06	0.55	5.31	3	OK	8.5	FALSE	
168-	C11.1	C11.2	150	1477.2	1468.47	1476.2	1467.47	5.82	0.55	1.17	12	x	12	1	3	0.333	1.17	13.26	13.26	OK	0.09	0.63	8.35	3	OK	8.5	FALSE	S.C-14
169-	C11.2	C12	397	1468.47	1444.09	1467.47	1443.09	6.14	5.74	6.92	12	x	12	1	3	0.333	6.92	13.62	13.62	OK	0.51	1.01	13.75	3	OK	8.5	STEPPED	
170-	C13	C14	172	1444.97	1443.99	1443.97	1442.99	0.57	1.58	1.58	12	x	12	1	3	0.333	1.58	4.15	4.15	OK	0.38	0.93	3.86	3	OK	8.5	FALSE	S.C-15
171-	C15	C16	156	1445.06	1441.56	1444.06	1440.56	2.25	1.34	1.34	12	x	12	1	3	0.333	1.34	8.24	8.24	OK	0.16	0.74	6.10	3	OK	8.5	FALSE	
172-	C16	C17	260	1441.56	1429	1440.56	1428	4.82	2.29	3.63	12	x	12	1	3	0.333	3.63	12.07	12.07	OK	0.30	0.88	10.62	3	OK	8.5	STEPPED	
173-	C17	C18	250	1429	1413.23	1428	1412.23	6.31	2.25	5.88	12	x	12	1	3	0.333	5.88	13.80	13.80	OK	0.43	0.97	13.39	3	OK	8.5	STEPPED	S.C-16
174-	C18	C19	100	1413.23	1408.4	1412.23	1407.4	4.83	0.37	6.25	12	x	12	1	3	0.333	6.25	12.08	12.08	OK	0.52	1.01	12.20	3	OK	8.5	STEPPED	
175-	C19	C19.1	147	1408.4	1405.39	1407.4	1404.39	2.05	0.54	6.79	12	x	12	1	3	0.333	6.79	7.86	7.86	OK	0.86	1.12	8.81	3	OK	8.5	STEPPED	
176-	C20	C21	392	1406.91	1405.28	1404.91	1403.28	0.42	6.49	6.49	24	x	24	4	6	0.667	1.62	5.63	22.50	OK	0.29	0.87	19.58	3	OK	8.5	STEPPED	S.C-17

Grand Total Area & Discharge of 17 Sub-Basins =

Total Sewer Outflow from Zone-1 &Zone-3 =

Total Sewer Outflow from Zone-2 =

Total Dry & Wet outflow from entire Study Area =

Table B6: Normal Depth of flow at outlet drains of 17 sub-catchments using Newton's Method for separate system.

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	Q(act) (cusec)	Slope (ft/ft)	Selected Drain Size (B × D inch)	Manning's 'n'	Channel Width (ft)	Assumed (ft) y_j	$Q_j = \frac{1.49}{n} \times S^{1/2} \times \frac{(Bw \times yj)^{5/3}}{(Bw + 2yj)^{2/3}}$ (cusecs)	$y_{j+1} = yj - \frac{1 - Q/Qj}{\frac{5Bw+6yj}{3yj(Bw+2yj)}}$ (ft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1-	B2.5	B2.6	231.25	**45.58**	0.01098	**30 × 30**	0.013	2.5	1.5	34.88893715	1.852752326
				45.58	0.01098		0.013	2.5	1.852752326	45.7742927	1.846553139
				45.58	0.01098		0.013	2.5	1.846553139	45.58004631	1.846551661
				45.58	0.01098		0.013	2.5	1.846551661	45.58	1.846551661
				45.58	0.01098		0.013	2.5	1.846551661	45.58	1.846551661
2-	B28	B28.1	75	13.02	0.0212	**18 × 18**	0.013	1.5	1	14.22932336	0.933898133
				13.02	0.0212		0.013	1.5	0.933898133	13.02661516	0.933532461
				13.02	0.0212		0.013	1.5	0.933532461	13.02000022	0.933532449
				13.02	0.0212		0.013	1.5	0.933532449	13.02	0.933532449
				13.02	0.0212		0.013	1.5	0.933532449	13.02	0.933532449
3-	B24.4	B24.5	128	**17.96**	0.0763	**12 × 18**	0.013	1	1	15.22033981	1.147272675
				17.96	0.0763		0.013	1	1.147272675	17.97846497	1.146292666
				17.96	0.0763		0.013	1	1.146292666	17.96000067	1.14629263
				17.96	0.0763		0.013	1	1.14629263	17.96	1.14629263
				17.96	0.0763		0.013	1	1.14629263	17.96	1.14629263
4-	B40	B40.5	126	**34.99**	0.0203	**24 × 24**	0.013	2	1.2	26.16422571	1.510650216
				34.99	0.0203		0.013	2	1.510650216	35.16440867	1.504729771
				34.99	0.0203		0.013	2	1.504729771	34.99004772	1.50472815
				34.99	0.0203		0.013	2	1.50472815	34.99	1.50472815
				34.99	0.0203		0.013	2	1.50472815	34.99	1.50472815
5-	B32.8	B32.9	81.4	15.83	0.0635	**18 × 18**	0.013	1.5	1	24.62652768	0.722179926
				15.83	0.0635		0.013	1.5	0.722179926	16.06436782	0.714315009
				15.83	0.0635		0.013	1.5	0.714315009	15.83027637	0.714305713
				15.83	0.0635		0.013	1.5	0.714305713	15.83	0.714305713

S.No	Drain Nodes From (a)	Drain Nodes To (b)	Drain Length (ft) (c)	Q(act) (cusec) (d)	Slope (ft/ft) (e)	Selected Drain Size (B × D inch) (f)	Manning's 'n' (g)	Channel Width (ft) (h)	Assumed (ft) y_j (i)	$Q_j = \frac{1.49}{n} \times S^{1/2} \times \frac{(B_w \times y_j)^{5/3}}{(B_w + 2y_j)^{2/3}}$ (cusecs) (j)	$y_{j+1} = y_j - \frac{1 - Q/Q_j}{\frac{5B_w + 6y_j}{3y_j(B_w + 2y_j)}}$ (ft) (k)
				15.83	0.0635		0.013	1.5	0.714305713	15.83	0.714305713
6-	C43	C44	133.75	7.76	0.0334	**12 × 12**	0.013	1	1	10.07013547	0.812305322
				7.76	0.0334		0.013	1	0.812305322	7.785234939	0.810205655
				7.76	0.0334		0.013	1	0.810205655	7.760004202	0.810205306
				7.76	0.0334		0.013	1	0.810205306	7.76	0.810205306
				7.76	0.0334		0.013	1	0.810205306	7.76	0.810205306
7-	C38	C39	60	3.46	0.25	**12 × 12**	0.013	1	0.75	19.26142232	0.264256779
				3.46	0.25		0.013	1	0.264256779	4.699773756	0.215717789
				3.46	0.25		0.013	1	0.215717789	3.500861919	0.21399998
				3.46	0.25		0.013	1	0.21399998	3.460060374	0.213997434
				3.46	0.25		0.013	1	0.213997434	3.46	0.213997434
				3.46	0.25		0.013	1	0.213997434	3.46	0.213997434
8-	C41	C42	150	15.14	0.0497	**18 × 18**	0.013	1.5	1	21.78685348	0.762711264
				15.14	0.0497		0.013	1.5	0.762711264	15.28678362	0.757207039
				15.14	0.0497		0.013	1.5	0.757207039	15.14010916	0.757202939
				15.14	0.0497		0.013	1.5	0.757202939	15.14	0.757202939
				15.14	0.0497		0.013	1.5	0.757202939	15.14	0.757202939
9-	A26	A26.1	123	**39.27**	0.083	**24 × 24**	0.013	2	1	41.60306182	0.957940683
				39.27	0.083		0.013	2	0.957940683	39.28046624	0.957750274
				39.27	0.083		0.013	2	0.957750274	39.27000022	0.95775027
				39.27	0.083		0.013	2	0.95775027	39.27	0.95775027
				39.27	0.083		0.013	2	0.95775027	39.27	0.95775027
10-	A29	A30	504.6	2.09	0.0587	**12 × 12**	0.013	1	0.75	9.333346729	0.290483832
				2.09	0.0587		0.013	1	0.290483832	2.607053344	0.249960539

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	Q(act) (cusec)	Slope (ft/ft)	Selected Drain Size (B × D inch)	Manning's 'n'	Channel Width (ft)	Assumed (ft) y_j	$Q_j = \frac{1.49}{n} \times S^{1/2} \times \frac{(Bw \times yj)^{5/3}}{(Bw + 2yj)^{2/3}}$ (cusecs)	$y_{j+1} = yj - \frac{1 - Q/Qj}{\frac{5Bw+6yj}{3yj(Bw+2yj)}}$ (ft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
				2.09	0.0587		0.013	1	0.249960539	2.102013251	0.248971557
				2.09	0.0587		0.013	1	0.248971557	2.090008139	0.248970886
				2.09	0.0587		0.013	1	0.248970886	2.09	0.248970886
				2.09	0.0587		0.013	1	0.248970886	2.09	0.248970886
11-	A31.3	A34	132.55	6.63	0.0978	**12 × 12**	0.013	1	0.75	12.04724595	0.48374995
				6.63	0.0978		0.013	1	0.48374995	6.805145563	0.474450567
				6.63	0.0978		0.013	1	0.474450567	6.630364757	0.474431118
				6.63	0.0978		0.013	1	0.474431118	6.630000002	0.474431118
				6.63	0.0978		0.013	1	0.474431118	6.63	0.474431118
				6.63	0.0978		0.013	1	0.474431118	6.63	0.474431118
12-	C10	C10.1	201.84	0.87	0.1881	**12 × 12**	0.013	1	0.5	9.863566812	0.15807627
				0.87	0.1881		0.013	1	0.15807627	1.912835528	0.100872062
				0.87	0.1881		0.013	1	0.100872062	0.961274614	0.094711603
				0.87	0.1881		0.013	1	0.094711603	0.871401602	0.094613981
				0.87	0.1881		0.013	1	0.094613981	0.870000364	0.094613956
				0.87	0.1881		0.013	1	0.094613956	0.87	0.094613956
				0.87	0.1881		0.013	1	0.094613956	0.87	0.094613956
13-	C4.1	C8.2	106	10.86	0.1896	**12 × 18**	0.013	1.5	1	42.55351944	0.420717359
			106	10.86	0.1896		0.013	1.5	0.420717359	13.14145739	0.36953641
			106	10.86	0.1896		0.013	1.5	0.36953641	10.90680197	0.368440256
			106	10.86	0.1896		0.013	1.5	0.368440256	10.86002396	0.368439695
			106	10.86	0.1896		0.013	1.5	0.368439695	10.86	0.368439695
			106	10.86	0.1896		0.013	1.5	0.368439695	10.86	0.368439695
14-	C11.2	C12	397	6.92	0.0614	**12 × 12**	0.013	1	0.75	9.545584685	0.587137005

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	Q(act) (cusec)	Slope (ft/ft)	Selected Drain Size (B × D inch)	Manning's 'n'	Channel Width (ft)	Assumed (ft) y_j	$Q_j = \frac{1.49}{n} \times S^{1/2} \times \frac{(Bw \times yj)^{5/3}}{(Bw + 2yj)^{2/3}}$ (cusecs)	$y_{j+1} = yj - \frac{1 - Q/Qj}{\frac{5Bw+6yj}{3yj(Bw+2yj)}}$ (ft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
			397	6.92	0.0614		0.013	1	0.587137005	6.966532603	0.584135547
			397	6.92	0.0614		0.013	1	0.584135547	6.920021459	0.584134162
			397	6.92	0.0614		0.013	1	0.584134162	6.92	0.584134162
			397	6.92	0.0614		0.013	1	0.584134162	6.92	0.584134162
15-	C13	C14	172	1.58	0.0057	**12 × 12**	0.013	1	0.75	2.908410991	0.479557087
			172	1.58	0.0057		0.013	1	0.479557087	1.623831777	0.469899034
			172	1.58	0.0057		0.013	1	0.469899034	1.580096395	0.469877699
			172	1.58	0.0057		0.013	1	0.469877699	1.58	0.469877699
			172	1.58	0.0057		0.013	1	0.469877699	1.58	0.469877699
16-	C19	C19.1	147	6.79	0.0205	**12 × 12**	0.013	1	0.75	5.515631965	0.88680391
			147	6.79	0.0205		0.013	1	0.88680391	6.804598058	0.885270098
			147	6.79	0.0205		0.013	1	0.885270098	6.790001472	0.885269943
			147	6.79	0.0205		0.013	1	0.885269943	6.79	0.885269943
			147	6.79	0.0205		0.013	1	0.885269943	6.79	0.885269943
17-	C20	C21	392	6.49	0.0042	**24 × 24**	0.013	1	1.5	5.794015671	1.65444159
			392	6.49	0.0042		0.013	1	1.65444159	6.491974617	1.654005796
			392	6.49	0.0042		0.013	1	1.654005796	6.490000013	1.654005793
			392	6.49	0.0042		0.013	1	1.654005793	6.49	1.654005793
			392	6.49	0.0042		0.013	1	1.654005793	6.49	1.654005793

Appendix C

Weighted Run-off Coefficient Estimation Sheet for Both Systems

Table C1: Weighted Runoff Coefficient "C" calculation sheet used in Rational Method for both networks.

Description (Sub-areas Draining)	**Sub-areas (A_j)(sft)**	**Value of C_j for each sub-area (Aj)**	**Total Area of Drainage Basin (A) (sft)**	$\alpha_j = \frac{A_j}{A}$	**Weighted C =** $\sum C_j \times \alpha_j$
Roads Paved	8,42,899.6	0.86		0.2135	0.184
Roads Green (Shoulders)	6,72,090.1	0.49		0.1702	0.083
Centre Median Green (MR-01 & MR-02)	78,757.7	0.49		0.0199	0.010
Roofs (House & Flat)	6,68,536	0.88		0.1693	0.149
Green (House & Flat)	56,250	0.49		0.0142	0.007
Commercial (Paved)	1,36,192	0.88	**3948235.36**	0.0345	0.030
Masjids (Paved)	24,241	0.88		0.0061	0.005
Schools Roof	1,76,505	0.88		0.0447	0.039
Schools Green	80,787	0.49		0.0205	0.010
Petrol Pump (Paved)	19,656	0.88		0.0050	0.004
Parking (Paved)	19,149	0.88		0.0049	0.004
Parks/Playgrounds (Green)	2,05,219	0.49		0.0520	0.025
MI Room Roof (Paved)	17,307	0.88		0.0044	0.004
MI Room (Green)	18,506	0.49		0.0047	0.002
Walkways/Paths (Paved)	2,848	0.86		0.0007	0.001
Public Buildings (Roof)	43,001	0.88		0.0109	0.010
Public Buildings (Green)	8,088	0.49		0.0020	0.001
Misc. (Green)	8,78,203	0.49		0.2224	0.109
Total Area	**39,48,235**				0.678
					Weighted C = 0.68

Appendix D

Hydraulic Design Sheets for Combined System

Table D1: Hydraulic Design Sheet of Dry weather Flow in Combined Sewer System (Zone-2).

HYDRAULIC STATEMENT FOR (ZONE-2) OF COMBINED SEWERAGE SYSTEM DESIGN RESIDENTIAL COLONY AT ZONE-V, ISLAMABAD S.1/3

S/No	Section	Cunette From	Cunette To	Cu Sewer 'L' (ft)	Cu Sewer 'D' (in)	Circular Pipe 'D' (in)	P.F	Flow Indivi.	Flow Peak Indiv.	Flow Commu.	Equal Flow Distri in two Pipes	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Cunette A (sft)	Cunette R=D/8 (ft)	Pipe A (sft)	Pipe R=D/4 (ft)	Vf	Qf	Q < Qf	Remarks from Hydraulic Table $\frac{Q}{Qf}$	Remarks from Hydraulic Table $\frac{V}{Vf}$	Remarks from Hydraulic Table V	Min Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)
1-	R-01	B1	B2	185	6	-	3.71	0.0036	0.0134	0.0134	-	1455	1443.73	1452.00	1440.73	0.0609	3	3	0.098	0.0625	0.000	0.000	4.44	0.44	OK	0.03	0.46	2.04	2	OK	0.13	0.39
		Drop MH													1439.73																	
2-	R-02	B3	B9	303	6	-	3.71	0.0077	0.0284	0.0284	-	1470	1455.75	1467	1452.75	0.0470	3	3	0.098	0.0625	0.000	0.000	3.90	0.38	OK	0.07	0.59	2.30	2	OK	0.19	0.57
		Drop MH													1447.95																	
3-	R-03	B10.1	B9	228	-	9	3.71	0.0063	0.0234	0.0234	-	1459.22	1455.75	1455.22	1447.95	0.0319	4	7.8	0.000	0.0000	0.442	0.1875	6.69	2.95	OK	0.01	0.30	2.01	2	OK	0.07	0.32
4-	R-02	B9	B4	116	-	12	3.71	0.0018	0.0067	0.0584	-	1455.75	1449.01	1447.95	1445	0.0254	7.8	4.01	0.000	0.0000	0.785	0.2500	7.23	5.68	OK	0.01	0.30	2.17	2	OK	0.07	0.42
		Drop MH													1436.3																	
5-	MR-02	B2	B4	107.61	-	9	3.71	0.0000	0.0000	0.0134	-	1443.73	1449.01	1439.73	1436.3	0.0319	4	12.7	0.000	0.0000	0.442	0.1875	6.69	2.95	OK	0.00	0.30	2.01	2	OK	0.07	0.32
6-		B4	B11	230	-	18	3.71	0.0032	0.0117	0.0835	-	1449.01	1455.85	1436.3	1433.4	0.0126	12.7	22.4	0.000	0.0000	1.766	0.3750	6.67	11.79	OK	0.01	0.30	2.00	2	OK	0.07	0.63
7-	R-05	B6	B7	173	-	9	3.71	0.0023	0.0083	0.0083	-	1463.5	1462.79	1459.5	1454	0.0318	4	8.79	0.000	0.0000	0.442	0.1875	6.68	2.95	OK	0.00	0.30	2.00	2	OK	0.07	0.32
8-	R-04	B5	B7	100	-	9	3.71	0.0018	0.0067	0.0067	-	1462.91	1462.79	1458.91	1454	0.0491	4	8.79	0.000	0.0000	0.442	0.1875	8.30	3.66	OK	0.00	0.30	2.49	2	OK	0.07	0.32
9-		B7	B8	100	-	12	3.71	0.0014	0.0050	0.0200	-	1462.79	1462.69	1454	1451.8	0.0220	8.79	10.9	0.000	0.0000	0.785	0.2500	6.73	5.28	OK	0.00	0.30	2.02	2	OK	0.07	0.42
10-	R-06	B8	B10	135	-	12	3.71	0.0000	0.0000	0.0200	-	1462.69	1459.33	1451.8	1448.85	0.0219	10.9	10.5	0.000	0.0000	0.785	0.2500	6.71	5.26	OK	0.00	0.30	2.01	2	OK	0.07	0.42
11-	R-03	B18	B10	214	-	9	3.71	0.0063	0.0234	0.0234	-	1461.47	1459.33	1457.47	1450.65	0.0319	4	8.68	0.000	0.0000	0.442	0.1875	6.68	2.95	OK	0.01	0.30	2.01	2	OK	0.07	0.32
		Drop MH													1448.85																	
12-	R-06	B10	B11	116	-	12	3.71	0.0000	0.0000	0.0434	-	1459.33	1455.85	1448.85	1446.3	0.0220	10.5	9.55	0.000	0.0000	0.785	0.2500	6.73	5.28	OK	0.01	0.30	2.02	2	OK	0.07	0.42
		Drop MH													1433.4																	
13-	R-04	B12	B14	93	-	9	3.71	0.0018	0.0067	0.0067	-	1462.65	1462.55	1458.65	1455.7	0.0317	4	6.85	0.000	0.0000	0.442	0.1875	6.67	2.94	OK	0.00	0.30	2.00	2	OK	0.07	0.32
		Drop MH													1454.15																	
14-	R-07	B13	B14	149	-	9	3.71	0.0018	0.0067	0.0067	-	1462.9	1462.55	1458.9	1454.15	0.0319	4	8.4	0.000	0.0000	0.442	0.1875	6.69	2.95	OK	0.00	0.30	2.01	2	OK	0.07	0.32
15-	R-04	B14	B15	143	-	12	3.71	0.0014	0.0050	0.0184	-	1462.55	1461.83	1454.15	1451.05	0.0217	8.4	10.8	0.000	0.0000	0.785	0.2500	6.68	5.24	OK	0.00	0.30	2.00	2	OK	0.07	0.42
16-	R-08	B16	B15	136	-	9	3.71	0.0041	0.0150	0.0150	-	1462.84	1461.83	1458.84	1454.5	0.0319	4	7.33	0.000	0.0000	0.442	0.1875	6.69	2.95	OK	0.01	0.30	2.01	2	OK	0.07	0.32
		Drop MH													1451.05																	
17-	R-08	B15	B19	238	-	18	3.71	0.0041	0.0150	0.0484	-	1461.83	1460.14	1451.05	1448.05	0.0126	10.8	12.1	0.000	0.0000	1.766	0.3750	6.67	11.79	OK	0.00	0.30	2.00	2	OK	0.07	0.63
		Drop MH													1431.2																	
18-	MR-02	B11	B19	255	-	24	3.71	0.0032	0.0117	0.1386	-	1455.85	1460.14	1433.4	1431.2	0.0086	22.4	28.9	0.000	0.0000	3.140	0.5000	6.69	21.00	OK	0.01	0.30	2.01	2	OK	0.07	0.84
19-	MR-02	B19	B21	104	-	24	3.71	0.0000	0.0000	0.1870	-	1460.14	1458.19	1431.2	1430.3	0.0087	28.9	27.9	0.000	0.0000	3.140	0.5000	6.70	21.03	OK	0.01	0.30	2.01	2	OK	0.07	0.84
20-	R-09	B20	B20.1	191	6		3.71	0.0036	0.0134	0.0134	-	1474.88	1462.38	1470.88	1459.38	0.0602	4	3	0.098	0.0625	0.000	0.000	4.42	0.43	OK	0.03	0.46	2.03	2	OK	0.13	0.39
21-	R-09	B20.1	B21	179	6		3.71	0.0027	0.0100	0.0234	-	1462.38	1458.19	1459.38	1453	0.0356	3	5.19	0.098	0.0625	0.000	0.000	3.40	0.33	OK	0.07	0.59	2.01	2	OK	0.19	0.57
		Drop MH													1430.3																	
22-	MR-02	B21	B27	254	-	24	3.71	0.0032	0.0117	0.2220	-	1458.19	1455.13	1430.3	1428.1	0.0087	27.9	27	0.000	0.0000	3.140	0.5000	6.70	21.04	OK	0.01	0.30	2.01	2	OK	0.07	0.84
23-	R-12	B27	B26	127	-	24	3.71	0.0014	0.0050	0.2271	-	1455.13	1449.66	1428.1	1427	0.0087	27	22.7	0.000	0.0000	3.140	0.5000	6.70	21.04	OK	0.01	0.30	2.01	2	OK	0.07	0.84
24-	R-10	B25	B26	276	-	9	3.71	0.0036	0.0134	0.0134	-	1460.1	1449.66	1456.1	1445.6	0.0380	4	4.06	0.000	0.0000	0.442	0.1875	7.30	3.23	OK	0.00	0.30	2.19	2	OK	0.07	0.32
		Drop MH													1427																	
25-	R-12	B26	B23	175	-	30	3.71	0.0023	0.0083	0.2488	-	1449.66	1454.35	1427	1425.85	0.0066	22.7	28.5	0.000	0.0000	4.906	0.6250	6.77	33.23	OK	0.01	0.30	2.03	2	OK	0.07	1.05
26-	R-11	B22	B23	286	6		3.71	0.0054	0.0200	0.0200	-	1470.11	1454.35	1467.11	1451.35	0.0551	3	3	0.098	0.0625	0.000	0.000	4.23	0.41	OK	0.05	0.53	2.24	2	OK	0.16	0.48
		Drop MH													1425.85																	
27-	R-11	B23	B24	115	-	30	3.71	0.0018	0.0067	0.2755	-	1454.35	1448.28	1425.85	1425.1	0.0065	28.5	23.2	0.000	0.0000	4.906	0.6250	6.75	33.11	OK	0.01	0.30	2.02	2	OK	0.07	1.05
28-	MR-01	B28	B24	225	-	9	3.71	0.0036	0.0134	0.0134	-	1443.64	1448.28	1439.64	1432.5	0.0317	4	15.8	0.000	0.0000	0.442	0.1875	6.67	2.95	OK	0.00	0.30	2.00	2	OK	0.07	0.32
		Drop MH													1425.1																	
29-	MR-01	B24	B30	109	-	30	3.71	0.0000	0.0000	0.2888	-	1448.28	1445.2	1425.1	1424.4	0.0064	23.2	20.8	0.000	0.0000	4.906	0.6250	6.70	32.85	OK	0.01	0.30	2.01	2	OK	0.07	1.05
30-	R-13	B29	B30	229	6		3.71	0.0036	0.0134	0.0134	-	1455.9	1445.2	1452.9	1439.45	0.0587	3	5.75	0.098	0.0625	0.000	0.000	4.36	0.43	OK	0.03	0.46	2.01	2	OK	0.13	0.39
		Drop MH													1424.4																	
31-	MR-01	B30	B31	656	-	30	3.71	0.0071	0.0262	0.3284	-	1445.2	1439.54	1424.4	1419.85	0.0069	20.8	19.7	0.000	0.0000	4.906	0.6250	6.96	34.14	OK	0.01	0.30	2.09	2	OK	0.07	1.05

S/No	Section	Cunette From	Cunette To	Cu Sewer 'L' (ft)	Cu Sewer 'D' (in)	Circular Pipe 'D' (in)	P.F	Flow Indivi.	Flow Peak Indiv.	Flow Commu.	Equal Flow Distri in two Pipes	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Cunette A (sft)	Cunette R=D/8 (ft)	Pipe A (sft)	Pipe R=D/4 (ft)	Vf	Qf	Q < Qf	Remarks from $\frac{Q}{Qf}$	$\frac{V}{Vf}$	V	Min Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)
32-	MR-01	B32	B31	120	-	9	3.71	0.0005	0.0017	0.0017	-	1439.54	1439.54	1435.54	1431.7	0.0320	4	7.84	0.000	0.0000	0.442	0.1875	6.70	2.96	OK	0.00	0.30	2.01	2	OK	0.07	0.32
		Drop MH													1419.85																	
33-	R-14	B31	B33	474	-	24	3.71	0.0140	0.0518	0.3818	0.1909	1439.54	1430.21	1419.85	1415.75	0.0086	19.7	14.5	0.000	0.0000	3.140	0.5000	6.70	21.03	OK	0.01	0.30	2.01	2	OK	0.07	0.84
						24		Dual Pipes			0.1909	1439.54	1430.21	1419.85	1415.75	0.0086	19.7	14.5	0.000	0.0000	3.140	0.5000	6.70	21.03	OK	0.01	0.30	2.01	2	OK	0.07	0.84
34-	R-14	B33	B39	159	-	24	3.71	0.0032	0.0117	0.3935	0.1967	1430.21	1428.65	1415.75	1414.35	0.0088	14.5	14.3	0.000	0.0000	3.140	0.5000	6.76	21.22	OK	0.01	0.30	2.03	2	OK	0.07	0.84
						24		Dual Pipes			0.1967	1430.21	1428.65	1415.75	1414.35	0.0088	14.5	14.3	0.000	0.0000	3.140	0.5000	6.76	21.22	OK	0.01	0.30	2.03	2	OK	0.07	0.84
37-	R-15	B38	B38.1	175	6	-	3.71	0.0063	0.0234	0.0234	-	1436.65	1430.66	1433.65	1427.4	0.0357	3	3.26	0.098	0.0625	0.000	0.000	3.40	0.33	OK	0.07	0.59	2.01	2	OK	0.19	0.57
38-	R-15	B38.1	B39	221	6	-	3.71	0.0059	0.0217	0.0451	-	1430.66	1428.65	1427.4	1422.5	0.0222	3.26	6.15	0.098	0.0625	0.000	0.000	2.68	0.26	OK	0.17	0.75	2.01	2	OK	0.29	0.87
		Drop MH													1414.35																	
39-	R-14	B39	B41	160	-	24	3.71	0.0023	0.0083	0.4469	0.2235	1428.65	1425.78	1414.35	1412.75	0.0100	14.3	13	0.000	0.0000	3.140	0.5000	7.20	22.61	OK	0.01	0.30	2.16	2	OK	0.07	0.84
						24		Dual Pipes			0.2235	1428.65	1425.78	1414.35	1412.75	0.0100	14.3	13	0.000	0.0000	3.140	0.5000	7.20	22.61	OK	0.01	0.30	2.16	2	OK	0.07	0.84
40-	R-17	B40.1	B40.2	112	6	=	3.71	0.0023	0.0083	0.0083	-	1427.2	1420.99	1424.2	1415.5	0.0777	3	5.49	0.098	0.0625	0.000	0.000	5.02	0.49	OK	0.02	0.40	2.01	2	OK	0.1	0.30
		Drop MH													1413.8																	
41-	R-17	B40.3	B40.4	175	-	9	3.71	0.0032	0.0117	0.0117	-	1426.15	1421.06	1422.15	1416.6	0.0317	4	4.46	0.000	0.0000	0.442	0.1875	6.67	2.94	OK	0.00	0.30	2.00	2	OK	0.07	0.32
42-	R-17	B40.4	B40.2	88	-	9	3.71	0.0014	0.0050	0.0167	-	1421.06	1420.99	1416.6	1413.8	0.0318	4.46	7.19	0.000	0.0000	0.442	0.1875	6.68	2.95	OK	0.01	0.30	2.00	2	OK	0.07	0.32
43-	R-18	B40.2	B42.1	220	-	12	3.71	0.0054	0.0200	0.0451	-	1420.99	1411.74	1413.8	1407.7	0.0277	7.19	4.04	0.000	0.0000	0.785	0.2500	7.55	5.93	OK	0.01	0.30	2.27	2	OK	0.07	0.42
44-	R-18	B42.1	B43.5	186	-	12	3.71	0.0054	0.0200	0.0651	-	1411.74	1407.17	1407.7	1403	0.0253	4.04	4.17	0.000	0.0000	0.785	0.2500	7.21	5.66	OK	0.01	0.30	2.16	2	OK	0.07	0.42
45-	R-19	B45	B45.1	137	6	-	3.71	0.0050	0.0184	0.0184	-	1423.06	1418.36	1420.06	1414	0.0442	3	4.36	0.098	0.0625	0.000	0.000	3.79	0.37	OK	0.05	0.53	2.01	2	OK	0.16	0.48
46-	R-19	B45.1	B46.1	161	6	-	3.71	0.0041	0.0150	0.0334	-	1418.36	1412.01	1414	1408	0.0373	4.36	4.01	0.098	0.0625	0.000	0.000	3.48	0.34	OK	0.10	0.65	2.26	2	OK	0.22	0.66
		Drop MH													1407.85																	
47-	R-20	B46	B46.1	111	-	9	3.71	0.0023	0.0083	0.0083	-	1415.4	1412.01	1411.4	1407.85	0.0320	4	4.16	0.000	0.0000	0.442	0.1875	6.70	2.96	OK	0.00	0.30	2.01	2	OK	0.07	0.32
48-	R-20	B46.1	B43.5	129	-	9	3.71	0.0023	0.0083	0.0501	-	1412.01	1407.17	1407.85	1403	0.0376	4.16	4.17	0.000	0.0000	0.442	0.1875	7.26	3.21	OK	0.02	0.40	2.90	2	OK	0.1	0.45
49-	R-20	B43.5	B43.1	90	6	-	3.71	0.0014	0.0050	0.1202	-	1407.17	1405.44	1403	1401.95	0.0117	4.17	3.49	0.098	0.0625	0.000	0.000	1.94	0.19	OK	0.63	1.04	2.02	2	OK	0.56	1.68
		Drop MH													1399																	
50-	R-20	B44	B44.4	121	6	-	3.71	0.0027	0.0100	0.0100	-	1415.07	1407.18	1412.07	1402.65	0.0779	3	4.53	0.098	0.0625	0.000	0.000	5.02	0.49	OK	0.02	0.40	2.01	2	OK	0.1	0.30
51-	R-20	B44.4	B43.1	75	6	-	3.71	0.0014	0.0050	0.0150	-	1407.18	1405.44	1402.65	1399	0.0487	4.53	6.44	0.098	0.0625	0.000	0.000	3.97	0.39	OK	0.04	0.51	2.03	2	OK	0.15	0.45
52-	Link R20 & R21	B43.1	B43.2	105	6	-	3.71	0.0000	0.0000	0.1352	-	1405.44	1401.02	1399	1397.7	0.0124	6.44	3.32	0.098	0.0625	0.000	0.000	2.00	0.20	OK	0.69	1.01	2.02	2	OK	0.52	1.56
53-	R-20	B43.2	B43.3	26	6	-	3.71	0.0000	0.0000	0.1352	-	1401.02	1400.86	1397.7	1397.3	0.0154	3.32	3.56	0.098	0.0625	0.000	0.000	2.23	0.22	OK	0.62	1.05	2.34	2	OK	0.57	1.71
		Drop MH													1396.3																	
54-	R-21	B48	B48.1	153	6	-	3.71	0.0059	0.0217	0.0217	-	1414.23	1404.51	1410.75	1401.03	0.0635	3.48	3.48	0.098	0.0625	0.000	0.000	4.54	0.45	OK	0.05	0.53	2.40	2	OK	0.16	0.48
55-	R-21	B48.1	B43.3	125	6	-	3.71	0.0041	0.0150	0.0367	-	1404.51	1400.86	1401.03	1396.3	0.0378	3.48	4.56	0.098	0.0625	0.000	0.000	3.50	0.34	OK	0.11	0.67	2.35	2	OK	0.23	0.69
56-	R-21	B49.1	B43.3	309	6	-	3.71	0.0113	0.0417	0.0417	-	1407.32	1400.86	1403.8	1396.3	0.0243	3.52	4.56	0.098	0.0625	0.000	0.000	2.80	0.28	OK	0.15	0.73	2.05	2	OK	0.27	0.81
57-	Link R21 & R14	B43.3	B41.1	107	6	-	3.71	0.0000	0.0000	0.2137	-	1400.86	1400.14	1396.3	1394.7	0.0150	4.56	5.44	0.098	0.0625	0.000	0.000	2.20	0.22	OK	0.99	1.14	2.51	2	OK	0.81	2.43
58-	R-14	B41	B47	240	9	-	3.71	0.0072	0.0267	0.4736	-	1425.78	1413.34	1412.75	1410.34	0.0100	13	3	0.221	0.0938	0.000	0.000	2.36	0.52	OK	0.91	1.13	2.67	2	OK	0.75	3.38
59-	R-14	B47	B49	130	9	-	3.71	0.0000	0.0000	0.4736	-	1413.34	1405.37	1410.34	1402.37	0.0613	3	3	0.221	0.0938	0.000	0.000	5.84	1.29	OK	0.37	0.93	5.43	2	OK	0.43	1.94
60-	R-14	B49	B50	111	9	-	3.71	0.0000	0.0000	0.4736	-	1405.37	1400.68	1402.37	1397	0.0484	3	3.68	0.221	0.0938	0.000	0.000	5.19	1.15	OK	0.41	0.95	4.93	2	OK	0.45	2.03
61-	R-14	B50	B51	185	9	-	3.71	0.0018	0.0067	0.4803	-	1400.68	1398.56	1397	1395	0.0108	3.68	3.56	0.221	0.0938	0.000	0.000	2.45	0.54	OK	0.89	1.13	2.77	2	OK	0.74	3.33
		Drop MH													1393.8																	
62-	R-16	B36.1	B36.2	269	6	-	3.71	0.0050	0.0184	0.0184	-	1443.64	1427.17	1440.2	1423.73	0.0612	3.44	3.44	0.098	0.0625	0.000	0.000	4.45	0.44	OK	0.04	0.51	2.27	2	OK	0.15	0.45
63-	R-16	B36.2	B36.3	220	6	-	3.71	0.0036	0.0134	0.0317	-	1427.17	1418.98	1423.73	1414.95	0.0399	3.44	4.03	0.098	0.0625	0.000	0.000	3.60	0.35	OK	0.09	0.63	2.27	2	OK	0.21	0.63
64-	R-16	B36.3	B37	508	-	18	3.71	0.0086	0.0317	0.0634	-	1418.98	1414.74	1414.95	1408.55	0.0126	4.03	6.19	0.000	0.0000	1.766	0.3750	6.67	11.78	OK	0.01	0.30	2.00	2	OK	0.07	0.63
65-	MR-01	B34	B34.1	246	-	9	3.71	0.0050	0.0184	0.0184	-	1441.74	1438.79	1437.74	1429.9	0.0319	4	8.89	0.000	0.0000	0.442	0.1875	6.68	2.95	OK	0.01	0.30	2.01	2	OK	0.07	0.32
66-	MR-01	B34.2	B34.1	130	-	9	3.71	0.0005	0.0017	0.0017	-	1438.79	1438.79	1434.79	1430.65	0.0318	4	8.14	0.000	0.0000	0.442	0.1875	6.68	2.95	OK	0.00	0.30	2.00	2	OK	0.07	0.32
		Drop MH													1429.9																	
67-	MR-01	B34.1	B34.3	204	-	9	3.71	0.0041	0.0150	0.0351	-	1438.79	1430.26	1429.9	1423.4	0.0319	8.89	6.86	0.000	0.0000	0.442	0.1875	6.68	2.95	OK	0.01	0.30	2.01	2	OK	0.07	0.32
68-	MR-01	B34.3	B34.4	250	-	9	3.71	0.0036	0.0134	0.0484	-	1430.26	1422.76	1423.4	1417.9	0.0220	6.86	4.86	0.000	0.0000	0.442	0.1875	5.55	2.45	OK	0.02	0.40	2.22	2	OK	0.1	0.45
69-	MR-01	B34.4	B34.5	200	-	12	3.71	0.0036	0.0134	0.0618	-	1422.76	1418.64	1417.9	1413.55	0.0218	4.86	5.09	0.000	0.0000	0.785	0.2500	6.69	5.25	OK	0.01	0.30	2.01	2	OK	0.07	0.42
70-	MR-01	B34.5	B35	134	-	12	3.71	0.0014	0.0050	0.0668	-	1418.64	1414.58	1413.55	1410.5	0.0228	5.09	4.08	0.000	0.0000	0.785	0.2500	6.84	5.37	OK	0.01	0.30	2.05	2	OK	0.07	0.42
71-	R-14	B35	B37	125	-	18	3.71	0.0000	0.0000	0.0668	-	1414.58	1414.74	1410.5	1408.55	0.0156	4.08	6.19	0.000	0.0000	1.766	0.3750	7.42	13.11	OK	0.01	0.30	2.23	2	OK	0.07	0.63

S.3/3

		Cunette						Flow				FRL AT		I.L (ft)			Cover		Cunette		Pipe					Remarks from						
S/No	Section	From	To	Cu Sewer 'L' (ft)	Cu Sewer 'D' (in)	Circular Pipe 'D' (in)	P.F	Indivi.	Peak Indiv.	Commu.	Equal Flow Distri in two Pipes	E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)	Slope ft/ft	E-1 (ft)	E-2 (ft)	A (sft)	R=D/8 (ft)	A (sft)	R=D/4 (ft)	Vf	Qf	Q < Qf	$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V	Min Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)
72-	R-14	B37	B43	100	-	18	3.71	0.0009	0.0033	0.1336	-	1414.74	1411	1408.55	1406.95	0.0160	6.19	4.05	0.000	0.0000	1.766	0.3750	7.52	13.28	OK	0.01	0.30	2.26	2	OK	0.07	0.63
73-	R-14	B43	B42	150	6	-	3.71	0.0041	0.0150	0.1486	-	1411	1404.14	1406.95	1401.14	0.0387	4.05	3	0.098	0.0625	0.000	0.000	3.54	0.35	OK	0.43	0.97	3.44	2	OK	0.46	1.38
74-	R-14	B42	B41.1	143	6	-	3.71	0.0045	0.0167	0.1653	-	1404.14	1400.14	1401.14	1395.7	0.0380	3	4.44	0.098	0.0625	0.000	0.000	3.51	0.34	OK	0.48	0.99	3.48	2	OK	0.49	1.47
		Drop MH													1394.7																	
75-	R-14	B41.1	B51	157	9	-	3.71	0.0005	0.0017	0.3806	-	1400.14	1398.56	1394.7	1393.8	0.0057	5.44	4.76	0.221	0.0938	0.000	0.000	1.79	0.39	OK	0.97	1.14	2.04	2	OK	0.8	3.60
76-	TO STP	B51	STP-2	162	9	-	3.71	0.0000	0.0000	0.8609	-	1398.56	1396	1393.8	1389.35	0.0275	4.76	6.65	0.221	0.0938	0.000	0.000	3.91	0.86	OK	1.00	1.14	4.46	2	OK	0.82	3.69

Table D2: Hydraulic Design Sheet of Dry weather Flow in Combined Sewer System (Zone-1).

S.1/2

S/No	Section	Cunette From	Cunette To	Cu Sewer 'L' (ft)	Cu Sewer 'D' (in)	Circular Pipe 'D' (in)	P.F	Flow Indivi.	Flow Peak Indiv.	Flow Commu.	Equal Flow Distri in two Pipes	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Cunette A (sft)	Cunette R=D/8 (ft)	Pipe A (sft)	Pipe R=D/4 (ft)	Vf	Qf	Q < Qf	Remarks from $\frac{Q}{Qf}$	$\frac{V}{Vf}$	V	Min Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)
														Zone-1																		
1-	R-34	A1	A1.1	100	6	-	3.81	0.0048	0.0183	0.0183	-	1485.12	1477.59	1482.12	1474.4	0.0772	3	3.19	0.098	0.0625	0.000	0.000	5.00	0.49	OK	0.04	0.51	2.55	2	OK	0.15	0.45
2-	R-34	A1.1	A4	114	6	-	3.81	0.0048	0.0183	0.0366	-	1477.59	1474.54	1474.4	1469.35	0.0443	3.19	5.19	0.098	0.0625	0.000	0.000	3.79	0.37	OK	0.10	0.65	2.46	2	OK	0.22	0.66
3-	R-35	A4	A5	210	6	-	3.81	0.0096	0.0366	0.0732	-	1474.54	1468	1469.35	1463.75	0.0267	5.19	4.25	0.098	0.0625	0.000	0.000	2.94	0.29	OK	0.25	0.84	2.47	2	OK	0.35	1.05
4-	R-36	A6	A7	199	6	-	3.81	0.0048	0.0183	0.0183	-	1485.12	1479.99	1482.12	1473.3	0.0443	3	6.69	0.098	0.0625	0.000	0.000	3.79	0.37	OK	0.05	0.53	2.01	2	OK	0.16	0.48
5-	R-32	A7	A7.1	80	6	-	3.81	0.0024	0.0091	0.0274	-	1479.99	1473.41	1473.3	1470.41	0.0361	6.69	3	0.098	0.0625	0.000	0.000	3.42	0.34	OK	0.08	0.61	2.09	2	OK	0.2	0.60
6-	R-32	A7.1	A7.2	100	6	-	3.81	0.0024	0.0091	0.0366	-	1473.41	1468.49	1470.41	1465.49	0.0492	3	3	0.098	0.0625	0.000	0.000	3.99	0.39	OK	0.09	0.63	2.52	2	OK	0.21	0.63
7-	R-32	A7.2	A5	69	6	-	3.81	0.0000	0.0000	0.0366	-	1468.49	1468	1465.49	1463.75	0.0252	3	4.25	0.098	0.0625	0.000	0.000	2.86	0.28	OK	0.13	0.70	2.00	2	OK	0.25	0.75
8-	R-32	A5	A3	224	6	-	3.81	0.0048	0.0183	0.1280	-	1468	1465.89	1463.75	1461	0.0123	4.25	4.89	0.098	0.0625	0.000	0.000	1.99	0.20	OK	0.65	1.02	2.03	2	OK	0.53	1.59
		Drop MH													1456.2																	
9-	R-34	A4.1	A1.2	155	0	-	3.81	0.0000	0.0000	0.0000	-	1474.54	1471.8	1472.46	1469.72	0.0177	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.53	0.00	2	FALSE	0.16	0.00
10-	R-34	A1.4	A1.3	116	0	-	3.81	0.0000	0.0000	0.0000	-	1480.2	1472.14	1478.12	1470.06	0.0695	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0.16	0.00
11-	R-34	A1.3	A1.2	26	0	-	3.81	0.0000	0.0000	0.0000	-	1472.14	1471.8	1470.06	1469.72	0.0131	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0.16	0.00
12-	R-33	A1.2	A2	66	0	-	3.81	0.0000	0.0000	0.0000	-	1471.8	1472.1	1469.72	1469.3	0.0064	2.08	2.8	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.53	0.00	2	FALSE	0.16	0.00
		Drop MH													1468.6																	
13-	R-33	A2	A2.1	84	6	-	3.81	0.0048	0.0183	0.0183	-	1472.1	1467.43	1468.6	1464.2	0.0524	3.5	3.23	0.098	0.0625	0.000	0.000	4.12	0.40	OK	0.05	0.53	2.18	2	OK	0.16	0.48
14-	R-33	A2.1	A3	102	6	-	3.81	0.0024	0.0091	0.0274	-	1467.43	1465.89	1464.2	1461	0.0314	3.23	4.89	0.098	0.0625	0.000	0.000	3.19	0.31	OK	0.09	0.63	2.01	2	OK	0.21	0.63
15-	R-32	A3	A9	163	9	-	3.81	0.0000	0.0000	0.1554	-	1465.89	1466.46	1461	1459.3	0.0104	4.89	7.16	0.221	0.0938	0.000	0.000	2.41	0.53	OK	0.29	0.84	2.02	2	OK	0.35	1.58
16-	MR-01	A8	A9	130	9	-	3.81	0.0019	0.0072	0.0072	-	1474.22	1466.46	1471.22	1460.75	0.0805	3	5.71	0.221	0.0938	0.000	0.000	6.69	1.48	OK	0.00	0.30	2.01	2	OK	0.07	0.32
		Drop MH													1459.3																	
17-	MR-01	A9	A10	160	6	-	3.81	0.0000	0.0000	0.1626	-	1466.46	1456	1459.3	1453	0.0394	7.16	3	0.098	0.0625	0.000	0.000	3.57	0.35	OK	0.46	0.94	3.36	2	OK	0.44	1.32
		Drop MH													1448.25																	
		Drop MH													1441.15																	
18-	R-31	A14	A10	218	-	12	3.81	0.0094	0.0358	0.0358	-	1456.97	1456	1452.97	1448.25	0.0217	4	7.75	0.000	0.0000	0.785	0.2500	6.67	5.24	OK	0.01	0.30	2.00	2	OK	0.07	0.42
19-	MR-01	A10	A11	209	-	24	3.81	0.0048	0.0183	0.2167	-	1456	1442.23	1441.15	1438.23	0.0140	14.8	4	0.000	0.0000	3.140	0.5000	8.51	26.73	OK	0.01	0.30	2.55	2	OK	0.07	0.84
		Drop MH													1430.9																	
		Drop MH													1425.8																	
20-	R-30	A20	A11	373	-	12	3.81	0.0192	0.0732	0.0732	-	1442.96	1442.23	1438.96	1430.9	0.0216	4	11.3	0.000	0.0000	0.785	0.2500	6.67	5.23	OK	0.01	0.30	2.00	2	OK	0.07	0.42
21-	MR-01	A11	A11.1	230	-	24	3.81	0.0048	0.0183	0.3082	-	1442.23	1426.64	1425.8	1422.64	0.0137	16.4	4	0.000	0.0000	3.140	0.5000	8.44	26.50	OK	0.01	0.30	2.53	2	OK	0.07	0.84
22-	WW-06	A25	A23.1	222	6	-	3.81	0.0096	0.0366	0.0366	-	1436.99	1421.28	1433.99	1418	0.0720	3	3.28	0.098	0.0625	0.000	0.000	4.83	0.47	OK	0.08	0.61	2.95	2	OK	0.2	0.60
		Drop MH													1416.9																	
23-	R-29	A23	A23.1	91	-	9	3.81	0.0048	0.0183	0.0183	-	1423.81	1421.28	1419.81	1416.9	0.0320	4	4.38	0.000	0.0000	0.442	0.1875	6.70	2.96	OK	0.01	0.30	2.01	2	OK	0.07	0.32
24-	R-29	A23.1	A23.2	81	-	9	3.81	0.0024	0.0091	0.0640	-	1421.28	1417.02	1416.9	1413	0.0481	4.38	4.02	0.000	0.0000	0.442	0.1875	8.22	3.63	OK	0.02	0.30	2.47	2	OK	0.07	0.32
25-	R-29	A23.2	A23.3	170	6	-	3.81	0.0072	0.0274	0.0914	-	1417.02	1404.16	1413	1401.16	0.0696	4.02	3	0.098	0.0625	0.000	0.000	4.75	0.47	OK	0.20	0.75	3.56	2	OK	0.29	0.87
26-	G, b/w R-28 & R-29	A23.3	A26	247	6	-	3.81	0.0048	0.0183	0.1097	-	1404.16	1395.19	1401.16	1392.19	0.0363	3	3	0.098	0.0625			3.43	0.34	OK	0.33	0.87	2.98	2	OK	0.38	1.14
		Drop MH													1391.19																	0.00
27-	R-28	A26	A28	126	-	18	3.81	0.0024	0.0091	0.1189	-	1395.19	1398.96	1391.19	1389.6	0.0126	4	9.36	0.000	0.0000	1.766	0.3750	6.68	11.79	OK	0.01	0.30	2.00	2	OK	0.07	0.63
28-	WW-03	A27	A28	211	6	-	3.81	0.0048	0.0183	0.0183	-	1418.3	1398.96	1413.8	1395.2	0.0882	4.5	3.76	0.098	0.0625	0.000	0.000	5.34	0.52	OK	0.03	0.46	2.46	2	OK	0.13	0.39
		Drop MH													1389.6																	
		Drop MH													1388.1																	
29-	MR-01	A11.1	A12	246	6	-	3.81	0.0048	0.0183	0.3264	-	1426.64	1411.73	1422.64	1407.6	0.0611	4	4.13	0.098	0.0625	0.000	0.000	4.45	0.44	OK	0.75	1.06	4.72	2	OK	0.59	1.77
30-	BL-10 & MR-01	A31.6	A31	207	6	-	3.81	0.0072	0.0274	0.0274	-	1470	1463.92	1467	1460.5	0.0314	3	3.42	0.098	0.0625	0.000	0.000	3.19	0.31	OK	0.09	0.63	2.01	2	OK	0.21	0.63
31-	R-37	A31	A31.1	108	6	-	3.81	0.0024	0.0091	0.0366	-	1463.92	1457.04	1460.5	1454.04	0.0598	3.42	3	0.098	0.0625	0.000	0.000	4.40	0.43	OK	0.08	0.61	2.69	2	OK	0.2	0.60

S.2/2

S/No	Section	Cunette		Cu Sewer 'L' (ft)	Cu Sewer 'D' (in)	Circular Pipe 'D' (in)	P.F	Flow			Equal Flow Distri in two Pipes	FRL AT		I.L (ft)		Slope ft/ft	Cover		Cunette		Pipe		Vf	Qf	Q < Qf	Remarks from				Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
		From	To					Indivi.	Peak Indiv.	Commu.		E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/8 (ft)	A (sft)	R=D/4 (ft)				$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V	Min Vel			
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)
32-	R-37	A31.1	A31.2	65	6	-	3.81	0.0024	0.0091	0.0457	-	1457.04	1453.73	1454.04	1450.73	0.0509	3	3	0.098	0.0625	0.000	0.000	4.06	0.40	OK	0.11	0.67	2.72	2	OK	0.23	0.69
33-	R-37	A31.2	A33	78	6	-	3.81	0.0000	0.0000	0.0457	-	1453.73	1453.56	1450.73	1449	0.0222	3	4.56	0.098	0.0625	0.000	0.000	2.68	0.26	OK	0.17	0.75	2.01	2	OK	0.29	0.87
34-	R-38	A32	A34.1	112	6	-	3.81	0.0096	0.0366	0.0366	-	1462.97	1456.61	1459.97	1452.85	0.0636	3	3.76	0.098	0.0625	0.000	0.000	4.54	0.45	OK	0.08	0.61	2.77	2	OK	0.2	0.60
35-	Through BL-11	A34	A34.1	163	6	-	3.81	0.0096	0.0366	0.0366	-	1460	1456.61	1457	1452.85	0.0255	3	3.76	0.098	0.0625	0.000	0.000	2.87	0.28	OK	0.13	0.70	2.01	2	OK	0.25	0.75
36-	R-38	A34.1	A33	81	6	-	3.81	0.0072	0.0274	0.1006	-	1456.61	1453.56	1452.85	1449	0.0475	3.76	4.56	0.098	0.0625	0.000	0.000	3.92	0.39	OK	0.26	0.84	3.30	2	OK	0.35	1.05
37-	R-37	A33	A39	23	6	-	3.81	0.0000	0.0000	0.1463	-	1453.56	1453	1449	1448.7	0.0130	4.56	4.3	0.098	0.0625	0.000	0.000	2.06	0.20	OK	0.73	0.99	2.04	2	OK	0.49	1.47
38-	R-37	A31.5	A31.4	128	0	-	3.81	0.0000	0.0000	0.0000	-	1461.74	1455.27	1459.66	1453.19	0.0505	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0	0.00
39-	R-37	A31.4	A39	48	0	-	3.81	0.0000	0.0000	0.0000	-	1455.27	1453	1453.19	1450.92	0.0473	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0	0.00
		Drop MH													1448.7																	
		Drop MH													1444.2																	
40-	G, BL-12	A40	A39	143	-	18	3.81	0.0048	0.0183	0.0183	-	1450	1453	1446	1444.2	0.0126	4	8.8	0.000	0.0000	1.766	0.3750	6.67	11.78	OK	0.00	0.30	2.00	2	OK	0.07	0.63
41-		A39	A39.1	131	-	18	3.81	0.0024	0.0091	0.1737	-	1453	1445	1444.2	1441	0.0244	8.8	4	0.000	0.0000	1.766	0.3750	9.29	16.41	OK	0.01	0.30	2.79	2	OK	0.07	0.63
42-		A39.1	A39.2	232	-	18	3.81	0.0072	0.0274	0.2012	-	1445	1450.13	1441	1438.05	0.0127	4	12.1	0.000	0.0000	1.766	0.3750	6.70	11.84	OK	0.02	0.30	2.01	2	OK	0.07	0.63
		Drop MH													1436.05																	
43-		A39.2	A39.3	212	-	18	3.81	0.0048	0.0183	0.2195	-	1450.13	1435.75	1436.05	1431.75	0.0203	14.1	4	0.000	0.0000	1.766	0.3750	8.47	14.95	OK	0.01	0.30	2.54	2	OK	0.07	0.63
44-	MR-01	A39.3	A39.4	353	6	-	3.81	0.0000	0.0000	0.2195	-	1435.75	1412.27	1431.75	1409.27	0.0637	4	3	0.098	0.0625	0.000	0.000	4.54	0.45	OK	0.49	0.93	4.22	2	OK	0.43	1.29
45-		A39.4	A12	82	6	-	3.81	0.0000	0.0000	0.2195	-	1412.27	1411.73	1409.27	1407.6	0.0204	3	4.13	0.098	0.0625	0.000	0.000	2.57	0.25	OK	0.87	1.07	2.75	2	OK	0.6	1.80

TABLE D3: Hydraulic Design Sheet of Dry weather Flow in Combined Sewer System (Zone-3).

S.1/2

		Cunette						Flow				FRL AT		I.L (ft)			Cover		Cunette		Pipe				Remarks from							
S/No	Section	From	To	Cu Sewer 'L' (ft)	Cu Sewer 'D' (in)	Circular Pipe 'D' (in)	P.F	Indivi.	Peak Indiv.	Commu.	Equal Flow Distri in two Pipes	E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)	Slope ft/ft	E-1 (ft)	E-2 (ft)	A (sft)	R=D/8 (ft)	A (sft)	R=D/4 (ft)	Vf	Qf	Q < Qf	$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V	Min Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)
														Zone-3																		
1-	BL-17	C1	C2	73	6	-	3.81	0.0072	0.0274	0.0274	-	1490	1488	1487	1484.7	0.0315	3	3.3	0.098	0.0625	0.000	0.000	3.20	0.31	OK	0.09	0.63	2.01	2	OK	0.21	0.63
2-		C2	C3	128	6	-	3.81	0.0048	0.0183	0.0457	-	1488	1480	1484.7	1477	0.0602	3.3	3	0.098	0.0625	0.000	0.000	4.42	0.43	OK	0.11	0.65	2.87	2	OK	0.22	0.66
		Drop MH													1474.7																	
3-	C.C	C3.1	C3	135	6	-	3.81	0.0174	0.0664	0.0664	-	1480	1480	1477	1474.7	0.0170	3	5.3	0.098	0.0625	0.000	0.000	2.35	0.23	OK	0.29	0.86	2.02	2	OK	0.37	1.11
4-	R-22	C3	C4	118	-	12	3.81	0.0048	0.0183	0.1304	-	1480	1487.5	1474.7	1473.8	0.0076	5.3	13.7	0.000	0.0000	0.785	0.2500	3.96	3.11	OK	0.04	0.51	2.02	2	OK	0.15	0.90
5-		C1.1	C2.1	45	6	-	3.81	0.0024	0.0091	0.0091	-	1495.98	1495.25	1492.98	1489.45	0.0784	3	5.8	0.098	0.0625	0.000	0.000	5.04	0.49	OK	0.02	0.40	2.02	2	OK	0.1	0.30
6-	R-23	C2.1	C3.2	50	6	-	3.81	0.0048	0.0183	0.0274	-	1495.25	1493.18	1489.45	1487.75	0.0340	5.8	5.43	0.098	0.0625	0.000	0.000	3.32	0.33	OK	0.08	0.61	2.02	2	OK	0.2	0.60
7-		C3.2	C4	110	6	-	3.81	0.0048	0.0183	0.0457	-	1493.18	1487.5	1487.75	1484.5	0.0295	5.43	3	0.098	0.0625	0.000	0.000	3.09	0.30	OK	0.15	0.73	2.26	2	OK	0.27	0.81
		Drop MH													1473.8																	
8-	R-23	C5.4	C5.1	35	0	-	3.81	0.0000	0.0000	0.0000	-	1496.06	1495.97	1493.98	1493.7	0.0080	2.08	2.27	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0	0.00
9-		C5.1	C5.2	46	0	-	3.81	0.0000	0.0000	0.0000	-	1495.97	1493.9	1493.7	1491.32	0.0517	2.27	2.58	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0	0.00
		Drop MH													1490.9																	
10-	R-23	C5.2	C5.3	50	6	-	3.81	0.0048	0.0183	0.0183	-	1493.9	1491.08	1490.9	1488.08	0.0564	3	3	0.098	0.0625	0.000	0.000	4.28	0.42	OK	0.04	0.51	2.18	2	OK	0.15	0.45
11-		C5.3	C6	133	6	-	3.81	0.0048	0.0183	0.0366	-	1491.08	1486.25	1488.08	1483.25	0.0363	3	3	0.098	0.0625	0.000	0.000	3.43	0.34	OK	0.11	0.67	2.30	2	OK	0.23	0.69
12-	R-22	C7	C10.1	118	0	-	3.81	0.0000	0.0000	0.0000	-	1504.23	1498.01	1502.15	1495.43	0.0569	2.08	2.58	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0	0.00
		Drop MH													1495.01																	
13-		C10.1	C6	226	6	-	3.81	0.0072	0.0274	0.0274	-	1498.01	1486.25	1495.01	1483.25	0.0520	3	3	0.098	0.0625	0.000	0.000	4.11	0.40	OK	0.07	0.59	2.42	2	OK	0.19	0.57
14-	R-22	C6	C8	190	6	-	3.81	0.0024	0.0091	0.0366	-	1486.25	1481.91	1483.25	1478.4	0.0255	3	3.51	0.098	0.0625	0.000	0.000	2.88	0.28	OK	0.13	0.70	2.01	2	OK	0.25	0.75
15-		C8	C8.1	70	6	-	3.81	0.0024	0.0091	0.0823	-	1481.91	1480.2	1478.4	1477.2	0.0171	3.51	3	0.098	0.0625	0.000	0.000	2.36	0.23	OK	0.36	0.92	2.17	2	OK	0.41	1.23
		Drop MH													1472.15																	
16-	R22 & R23	C4	C8.1	228	-	18	3.81	0.0024	0.0091	0.1853	-	1487.5	1480.2	1473.8	1472.15	0.0072	13.7	8.05	0.000	0.0000	1.766	0.3750	5.06	8.93	OK	0.02	0.40	2.02	2	OK	0.1	0.90
		Drop MH													1468.4																	
17-	R-22 & BL-14	C8.1	C9	216	-	18	3.81	0.0024	0.0091	0.1944	-	1480.2	1468	1468.4	1464	0.0204	11.8	4	0.000	0.0000	1.766	0.3750	8.48	14.98	OK	0.01	0.30	2.55	2	OK	0.07	0.63
18-	BL-14 & BL-13	C9	C9.1	324	9	-	3.81	0.0288	0.1097	0.3042	-	1468	1460	1464	1457	0.0216	4	3	0.221	0.0938	0.000	0.000	3.47	0.77	OK	0.40	0.93	3.22	2	OK	0.43	1.94
19-	BL-13	C9.1	C15.2	128	6	-	3.81	0.0072	0.0274	0.3316	-	1460	1450	1457	1447	0.0781	3	3	0.098	0.0625	0.000	0.000	5.03	0.49	OK	0.67	1.05	5.28	2	OK	0.57	1.71
20-		C15.2	C15.3	104	6	-	3.81	0.0029	0.0112	0.3427	-	1450	1450	1447	1443	0.0385	3	7	0.098	0.0625	0.000	0.000	3.53	0.35	OK	0.99	1.14	4.02	2	OK	0.81	2.43
21-	GREEN	C15.3	C15.4	98	6	-	3.81	0.0000	0.0000	0.3427	-	1450	1438	1443	1435	0.0816	7	3	0.098	0.0625	0.000	0.000	5.14	0.50	OK	0.68	1.07	5.50	2	OK	0.61	1.83
22-		C15.4	C15.5	83	6	-	3.81	0.0000	0.0000	0.3427	-	1438	1435	1435	1431.85	0.0380	3	3.15	0.098	0.0625	0.000	0.000	3.51	0.34	OK	1.00	1.14	4.00	2	OK	0.82	2.46
23-		C15.5	C14.2.1	317	6	-	3.81	0.0000	0.0000	0.3427	-	1435	1410	1431.85	1407	0.0784	3.15	3	0.098	0.0625	0.000	0.000	5.04	0.49	OK	0.69	1.08	5.44	2	OK	0.61	1.83
24-	G, & MR01	C14.2.1	C14.3	140	6	-	3.81	0.0000	0.0000	0.3427	-	1410	1408.13	1407	1401.7	0.0379	3	6.43	0.098	0.0625	0.000	0.000	3.50	0.34	OK	1.00	1.14	3.99	2	OK	0.82	2.46
		Drop MH													1401																	
25-	MR-01	C14.3	C34.1	83	-	24	3.81	0.0000	0.0000	0.3427	-	1408.13	1408.13	1401	1400.55	0.0054	7.13	7.58	0.000	0.0000	3.140	0.5000	5.30	16.65	OK	0.02	0.40	2.12	2	OK	0.1	1.20
		Drop MH													1389.8																	
26-	B-14 & G	C18	C5	126	-	9	3.81	0.0019	0.0072	0.0072	-	1475	1470	1471	1466	0.0397	4	4	0.000	0.0000	0.442	0.1875	7.46	3.29	OK	0.00	0.30	2.24	2	OK	0.07	0.32
		Drop MH													1457.55																	
27-	BL-14 & G	C5	C15	225	-	9	3.81	0.0072	0.0274	0.0346	-	1470	1450	1457.55	1446	0.0513	12.5	4	0.000	0.0000	0.442	0.1875	8.48	3.75	OK	0.01	0.30	2.55	2	OK	0.07	0.32
28-	GREEN	C15	C16	139	6	-	3.81	0.0000	0.0000	0.0346	-	1450	1440	1446	1437	0.0647	4	3	0.098	0.0625	0.000	0.000	4.58	0.45	OK	0.08	0.55	2.52	2	OK	0.17	0.51

S.2/2

S/No	Section	Cunette		Cu Sewer 'L' (ft)	Cu Sewer 'D' (in)	Circular Pipe 'D' (in)	P.F	Flow			Equal Flow Distri in two Pipes	FRL AT		I.L (ft)		Slope ft/ft	Cover		Cunette		Pipe		Vf	Qf	Q < Qf	Remarks from			Min Vel	Final Vel check	$\frac{d}{D}$	Flow Depth 'd' (inch)
		From	To					Indivi.	Peak Indiv.	Commu.		E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/8 (ft)	A (sft)	R=D/4 (ft)				$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)
29-	GREEN	C16	C17	215	6	-	3.81	0.0000	0.0000	0.0346	-	1440	1430	1437	1427	0.0465	3	3	0.098	0.0625	0.000	0.000	3.88	0.38	OK	0.09	0.63	2.45	2	OK	0.21	0.63
30-		C17	C19	115	9	-	3.81	0.0000	0.0000	0.0346	-	1430	1410	1427	1407	0.1739	3	3	0.221	0.0938	0.000	0.000	9.84	2.17	OK	0.02	0.40	3.94	2	OK	0.1	0.45
		Drop MH													1399.75																	
31-	R-22	C15.1	C16.1	156	0	-	3.81	0.0000	0.0000	0.0000	-	1445.31	1441.81	1443.23	1439.73	0.0224	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0	0.00
32-		C16.1	C23	127	0	-	3.81	0.0000	0.0000	0.0000	-	1441.81	1434.51	1439.73	1431.93	0.0614	2.08	2.58	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!	0.00	0.00	2	FALSE	0	0.00
		Drop MH													1431.51																	
33-	R-22	C23	C23.1	250	6	-	3.81	0.0057	0.0217	0.0217	-	1434.51	1419.85	1431.51	1416.85	0.0586	3	3	0.098	0.0625	0.000	0.000	4.36	0.43	OK	0.05	0.53	2.31	2	OK	0.16	0.48
34-		C23.1	C23.2	150	6	-	3.81	0.0000	0.0000	0.0217	-	1419.85	1410.47	1416.85	1407.47	0.0625	3	3	0.098	0.0625	0.000	0.000	4.50	0.44	OK	0.05	0.53	2.39	2	OK	0.16	0.48
35-		C23.2	C24.1	150	6	-	3.81	0.0000	0.0000	0.0217	-	1410.47	1406.21	1407.47	1401.3	0.0411	3	4.91	0.098	0.0625	0.000	0.000	3.65	0.36	OK	0.06	0.55	2.01	2	OK	0.17	0.51
36-		C24.1	C19	123	-	18	3.81	0.0000	0.0000	0.0217	-	1406.21	1410	1401.3	1399.75	0.0126	4.91	10.3	0.000	0.0000	1.766	0.3750	6.67	11.79	OK	0.00	0.30	2.00	2	OK	0.07	0.63
37-		C19	C20	172	-	18	3.81	0.0000	0.0000	0.0563	-	1410	1410	1399.75	1397.55	0.0128	10.3	12.5	0.000	0.0000	1.766	0.3750	6.72	11.87	OK	0.00	0.30	2.02	2	OK	0.07	0.63
38-	GREEN	C20	C22	220	-	24	3.81	0.0050	0.0189	0.0752	-	1410	1411.11	1397.55	1395.65	0.0086	12.5	15.5	0.000	0.0000	3.140	0.5000	6.69	21.01	OK	0.00	0.30	2.01	2	OK	0.07	0.84
39-	MR-01	C22	C25	88	-	24	3.81	0.0000	0.0000	0.0752	-	1411.11	1411.96	1395.65	1394.85	0.0091	15.5	17.1	0.000	0.0000	3.140	0.5000	6.87	21.56	OK	0.00	0.30	2.06	2	OK	0.07	0.84
40-	R-25	C24	C25	197	6		3.81	0.0160	0.0609	0.0609	-	1421.75	1411.96	1418.55	1408.96	0.0487	3.2	3	0.098	0.0625	0.000	0.000	3.97	0.39	OK	0.16	0.73	2.90	2	OK	0.27	0.81
		Drop MH													1394.85																	
41-	MR-01	C25	C27	255	-	18	3.81	0.0048	0.0183	0.1544	-	1411.96	1415.23	1394.85	1391.6	0.0127	17.1	23.6	0.000	0.0000	1.766	0.3750	6.71	11.85	OK	0.01	0.30	2.01	2	OK	0.07	0.63
42-	R-27	C33	C32	45	0	-	3.81	0.0000	0.0000	0.0000	-	1446.53	1445.79	1444.45	1443.71	0.0164	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!		0.00	2	FALSE	0	0.00
43-		C32	C31	50	0	-	3.81	0.0000	0.0000	0.0000	-	1445.79	1443.29	1443.71	1441.21	0.0500	2.08	2.08	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!		0.00	2	FALSE	0	0.00
		C31	C30.1	103	0	-	3.81	0.0000	0.0000	0.0000	-	1443.29	1436.48	1441.21	1433.9	0.0710	2.08	2.58	0.000	0.0000	0.000	0.000	0.00	0.00	FALSE	#DIV/0!		0.00	2	FALSE	0	0.00
		Drop MH													1433.48																	
		Drop MH													1432																	
44-	R-26	C28	C30.1	95	6		3.81	0.0057	0.0217	0.0217	-	1443.15	1436.48	1440.15	1433.48	0.0702	3	3	0.098	0.0625	0.000	0.000	4.77	0.47	OK	0.05	0.53	2.53	2	OK	0.16	0.48
45-		C30.1	C27	327	6		3.81	0.0144	0.0549	0.0766	-	1436.48	1415.23	1432	1410.75	0.0650	4.48	4.48	0.098	0.0625	0.000	0.000	4.59	0.45	OK	0.17	0.75	3.44	2	OK	0.29	0.87
		Drop MH													1391.6																	
46-	MR-01	C27	C30	121	-	24	3.81	0.0000	0.0000	0.2309	-	1415.23	1416.15	1391.6	1390.55	0.0087	23.6	25.6	0.000	0.0000	3.140	0.5000	6.71	21.06	OK	0.01	0.30	2.01	2	OK	0.07	0.84
47-	BL-2	C29	C30	164	9		3.81	0.0120	0.0457	0.2767	-	1420	1416.15	1416	1412.15	0.0235	4	4	0.221	0.0938	0.000	0.000	3.61	0.80	OK	0.35	0.91	3.29	2	OK	0.41	1.85
		Drop MH													1390.55																	
48-	MR-01	C30	C34.1	87	-	24	3.81	0.0000	0.0000	0.2767	-	1416.15	1408.13	1390.55	1389.8	0.0086	25.6	18.3	0.000	0.0000	3.140	0.5000	6.69	20.99	OK	0.01	0.30	2.01	2	OK	0.07	0.84
		A12													1407.6																	
		Drop MH													1388.25																	
49-	MR-01	C34.1	A12	235	-	30	3.81	0.0000	0.0000	0.6540	-	1408.13	1411.73	1389.8	1388.25	0.0066	18.3	23.5	0.000	0.0000	4.906	0.6250	6.79	33.29	OK	0.02	0.40	2.71	2	OK	0.1	1.50
50-	R-28	A12	A28.1	106	-	30	3.81	0.0024	0.0091	1.2090	0.6045	1411.73	1406.12	1388.25	1387.65	0.0057	23.5	18.5	0.000	0.0000	4.906	0.6250	6.29	30.84	OK	0.02	0.40	2.51	2	OK	0.1	1.50
						30		Dual Pipes			0.6045	1411.73	1406.12	1388.25	1387.65	0.0057	23.5	18.5	0.000	0.0000	4.906	0.6250	6.29	30.84	OK	0.02	0.40	2.51	2	OK	0.1	1.50
51-	R-28	A28.1	A28	124	-	30	3.81	0.0024	0.0091	1.2182	0.6091	1406.12	1398.96	1387.65	1386.9	0.0060	18.5	12.1	0.000	0.0000	4.906	0.6250	6.50	31.88	OK	0.02	0.40	2.60	2	OK	0.1	1.50
						30		Dual Pipes			0.6091	1406.12	1398.96	1387.65	1386.9	0.0060	18.5	12.1	0.000	0.0000	4.906	0.6250	6.50	31.88	OK	0.02	0.40	2.60	2	OK	0.1	1.50
52-	TO STP	A28	STP-1	85	-	30	3.81	0.0000	0.0000	1.3553	0.6777	1398.96	1390	1386.9	1386.25	0.0076	12.1	3.75	0.000	0.0000	4.906	0.6250	7.31	35.85	OK	0.02	0.40	2.92	2	OK	0.1	1.50
					-	30		Dual Pipes			0.6777	1398.96	1390	1386.9	1386.25	0.0076	12.1	3.75	0.000	0.0000	4.906	0.6250	7.31	35.85	OK	0.02	0.40	2.92	2	OK	0.1	1.50

Table D4: Rational Method Sheet for Combined Flow Design in Combined Sewer System (Zone-1, Zone-2, Zone-3 and separated portion of storm Drain).

RAINFALL INTENSITY FOR ISLAMABAD= 4 in/hr (0.000093 ft/sec)

VALUE OF WEIGHTED RUNOFF COEFFICIENT 'C' = 0.68 (Based on Table C-1 of Appendix C)

Annexure D

S.1/4

S.No	Section	Total R 'L' (ft)	Feeding 'L' (ft)	Drain 'L' (ft)	Drain Side	Nodes From	Nodes To	Total D 'L' = D 'L' + E. D 'L' (ft)	R 'W' (ft)	S 'W' on both sides (ft)	G 'A' Sh (sft)	CM 'W' (ft)	G 'A' CM (sft)	P 'W' of R (ft)	P 'A' R (sft)	G 'A' of 1 H/A (sft)	R 'A' of 1 H/A (sft)	No of H/A	Total G 'A' of H/A (sft)	Total R 'A' of H/A (sft)	Commer 'A' (sft)	Masjid (sft)	School 'R' (sft)	School 'G' (sft)	P.P.Pa (sft)	Parking (sft)	Park/PG 'G' (sft)	MLR 'G' (sft)	MLR 'R' (sft)	WW/P (sft)	P.B 'G' (sft)	P.B 'R' (sft)	Misc G 'A' (sft)	Total Paved 'A' (sft)	Total Green 'A' (sft)	Q=CIA (cusecs)	Sub-Catch No	Sub-Catch 'A' (sft)	Q from S-Basin (cusecs)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)
1-	R-01	187.79	187.79	185	L/S	B1	B2	185	40	20	3755.8	0	0	20	3755.8	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	11855.8	4655.8	1.04			
2-	R-02	409.91	308.91	303	R/S	B3	B9	303	40	20	6178.2	0	0	20	6178.2	112.5	1125	18	2025	18225	0	0	0	0	0	0	0	0	0	0	0	0	0	24403.2	8203.2	2.05			
3-	R-03	438.09	205	228	L/S	B10.1	B9	228	40	20	4100	0	0	20	4100	112.5	1125	14	1575	14175	0	0	0	0	0	0	0	0	0	0	0	0	0	18275	5675	1.51			
4-	R-02	409.91	102	116	R/S	B9	B4	116	40	20	2040	0	0	20	2040	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5077.5	2377.5	0.47			
5-	MR-02	3663.4	0	108	R/S	B2	B4	108	100	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
6-		3663.4	0	230	R/S	B4	B11	230	100	0	0	0	0	0	0	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7087.5	787.5	0.50			
7-	R-05	148.81	115	173	R/S	B6	B7	173	40	20	2300	0	0	20	2300	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	5100	0	0	0	0	0	0	7362.5	7962.5	0.96			
8-	R-04	438.09	100	100	R/S	B5	B7	100	40	20	2000	0	0	20	2000	112.5	1125	4	450	4050	0	0	0	0	0	0	0	0	0	0	0	0	0	6050	2450	0.54			
9-		438.09	100	100	R/S	B7	B8	100	40	20	2000	0	0	20	2000	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	5100	0	0	0	0	0	0	5037.5	7437.5	0.79			
10-	R-06	230.9	129.9	135	R/S	B8	B10	135	40	20	2598	0	0	20	2598	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2598	2598	0.33			
11-	R-03	438.09	177	214	R/S	B18	B10	214	40	20	3540	0	0	20	3540	112.5	1125	14	1575	14175	0	0	0	0	0	0	0	0	0	0	0	0	0	17715	5115	1.44			
12-	R-06	230.9	111	116	R/S	B10	B11	116	40	20	2220	0	0	20	2220	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2220	2220	0.28			
13-	R-04	438.09	100	93	R/S	B12	B14	93	40	20	2000	0	0	20	2000	112.5	1125	4	450	4050	0	0	0	0	0	0	5100	0	0	0	0	0	0	6050	7550	0.86			
14-	R-07	134.29	134.29	149	L/S	B13	B14	149	40	20	2685.8	0	0	20	2685.8	112.5	1125	4	450	4050	0	0	0	0	0	0	5100	0	0	0	0	0	0	6735.8	8235.8	0.94			
15-	R-04	438.09	128	143	R/S	B14	B15	143	40	20	2560	0	0	20	2560	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5597.5	2897.5	0.53			
16-	R-08	374.99	140	136	L/S	B16	B15	136	40	20	2800	0	0	20	2800	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11912.5	3812.5	0.99			
17-	R-08	374.99	235	238	L/S	B15	B19	238	40	20	4700	0	0	20	4700	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	13812.5	5712.5	1.23			
18-	MR-02	3663.4	0	255	R/S	B11	B19	255	100	0	0	0	0	0	0	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7087.5	787.5	0.50			
19-	MR-02	3663.4	0	104	R/S	B19	B21	104	100	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
20-	R-09	363.92	190	191	R/S	B20	B20.1	191	40	20	3800	0	0	20	3800	112.5	1125	8	900	8100	0	0	0	0	0	0	12158	0	0	0	0	0	0	11900	16858	1.81			
21-	R-09	363.92	163	179		B20.1	B21	179	40	20	3260	0		20	3260	112.5	1125	6	675	6075	0	0	0	0	0	0	0	0	0	0	0	0	0	9335	3935	0.84			
22-	MR-02	3663.4	0	254	R/S	B21	B27	254	100	0	0	0	0	0	0	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7087.5	787.5	0.50			
23-	R-12	244.5	125	127	L/S	B27	B26	127	40	20	2500	0	0	20	2500	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5537.5	2837.5	0.53			
24-	R-10	243.85	244	276	R/S	B25	B26	276	40	20	4880	0	0	20	4880	112.5	1125	8	900	8100	0	0	0	0	0	0	11604	0	0	0	0	0	0	12980	17384	1.91			
25-	R-12	244.5	133	175	L/S	B26	B23	175	40	20	2660	0	0	20	2660	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	9023	0	0	0	0	0	0	7722.5	12245.5	1.26			
26-	R-11	396.86	290	286	L/S	B22	B23	286	40	20	5800	0	0	20	5800	112.5	1125	12	1350	12150	0	0	0	0	0	0	0	0	0	0	0	0	0	17950	7150	1.58			
27-	R-11	396.86	107	115	L/S	B23	B24	115	40	20	2140	0	0	20	2140	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5177.5	2477.5	0.48			
28-	MR-01	4534.72	0	225	R/S	B28	B24	225	100	0	0	0	0	0	0	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	8100	900	0.57			
29-	MR-01	4534.72	0	109	R/S	B24	B30	109	100	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
30-	R-13	218.29	218.29	229	R/S	B29	B30	229	40	20	4365.8	0	0	20	4365.8	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	12465.8	5265.8	1.12			
31-	MR-01	4534.72	0	656	R/S	B30	B31	656	100	0	0	0	0	0	0	112.5	1125	0	0	0	11233	14466	41121	27414	0	0	44662	0	0	0	0	0	0	66820	72076	8.75			
32-	MR-01	4534.72	0	120	R/S	B32	B31	120	100	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	6552	0	0	0	0	0	0	0	0	6552	0	0.41			
33-	R-14	2052.94	478	474	R/S	B31	B33	474	60	24	11472	0	0	34	16252	112.5	1125	31	3487.5	31387.5	0	0	0	0	0	0	0	0	0	0	0	0	0	47639.5	14959.5	3.94	Z-2	1262786	81.92
34-	R-14	2052.94	159	159	R/S	B33	B39	159	60	24	3816	0	0	34	5406	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	12493.5	4603.5	1.08			
35-	R-15	364.01	180	175	R/S	B38	B38.1	175	40	20	3600	0	0	20	3600	112.5	1125	14	1575	14175	0	0	0	0	0	0	0	0	0	0	0	0	0	17775	5175	1.45			
36-	R-15	364.01	185	221	R/S	B38.1	B39	221	40	20	3700	0	0	20	3700	112.5	1125	13	1462.5	13162.5	0	0	0	0	0	0	0	0	0	0	0	0	0	16862.5	5162.5	1.39			
37-	R-14	2052.94	140	160	R/S	B39	B41	160	60	24	3360	0	0	34	4760	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	0	0	0	0	0	0	0	9822.5	3922.5	0.87			
38-	R-17	420.52	132	112	R/S	B40.1	B40.2	112	40	20	2640	0	0	20	2640	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7702.5	3202.5	0.69			
39-	R-17	420.52	175	175	R/S	B40.3	B40.4	175	40	20	3500	0	0	20	3500	112.5	1125	7	787.5	7087.5	0	0	0	0	0	0	0	0	0	0	0	0	0	10587.5	4287.5	0.94			
40-	R-17	420.52	109	88	R/S	B40.4	B40.2	88	40	20	2180	0	0	20	2180	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	5217.5	2517.5	0.49			
41-	R-18	335.25	200	220	R/S	B40.2	B42.1	220	40	20	4000	0	0	20	4000	112.5	1125	12	1350	12150	0	0	0	0	0	0	0	0	0	0	0	0	0	16150	5350	1.35			
42-	R-18	335.25	135.25	186	R/S	B42.1	B43.5	186	40	20	2705	0	0	20	2705	112.5	1125	12	1350	12150	0	0	0	0	0	0	0	0	0	0	0	0	0	14855	4055	1.19			
43-	R-19	272.37	142	137	R/S	B45	B45.1	137	40	20	2840	0	0	20	2840	112.5	1125	11	1237.5	11137.5	0	0	0	0	0	0	0	0	0	0	0	0	0	13977.5	4077.5	1.14			
44-	R-19	272.37	131	161	R/S	B45.1	B46.1	161	40	20	2620	0	0	20	2620	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11732.5	3632.5	0.97			
45-	R-20	569.83	120	111	L/S	B46	B46.1	111	40	20	2400	0	0	20	2400	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7462.5	2962.5	0.66			
46-	R-20	569.83	129	129	L/S	B46.1	B43.5	129	40	20	2580	0	0	20	2580	112.5	1125	5	562.5	5062.5	0	0	0	0	0	0	0	0	0	0	0	0	0	7642.5	3142.5	0.68			
47-	R-20	569.83	90	90	L/S	B43.5	B43.1	90	40	20	1800	0	0	20	1800	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	4837.5	2137.5	0.44			
48-	R-20	569.83	130	121	L/S	B44	B44.4	121	40	20	2600	0	0	20	2600	112.5	1125	6	675	6075	0	0	0	0	0	0	28514	0	0	0	0	0	0	8675	31789	2.55			
49-	R-20	569.83	75	75	L/S	B44.4	B43.1	75	40	20	1500	0	0	20	1500	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	28514	0	0	0	0	0	0	4537.5	30351.5	2.20			
50-	Link R20 & R21	105	105	105		B43.1	B43.2	105	10	0	0	0	0	10	1050	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1050	0	0.07			
51-	R-20	569.83	26	26	L/S	B43.2	B43.3	26	0	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
52-	R-21	625.66	170	153	L/S	B48	B48.1	153	40	20	3400	0	0	20	3400	112.5	1125	13	1462.5	13162.5	0	0	0	0	0	0	0	0	0	0	0	0	0	16562.5	4862.5	1.35			
53-	R-21	625.66	125	125	L/S	B48.1	B43.3	125	40	20	2500	0	0	20	2500	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	11612.5	3512.5	0.95			
54-	R-21	625.66	331	309	L/S	B49.1	B43.3	309	40	20	6620	0	0	20	6620	112.5	1125	24	2700	24300	0	0	0	0	0	0	0	0	0	0	0	0	0	30920	9320	2.53			
55-	Link R21 & R14	107	107	107		B43.3	B41.1	107	10	0	0	0	0	10	1070	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1070	0	0.07			
56-	R-14	2052.94	210	240	R/S	B41	B47	240	60	24	5040	0	0	34	7140	112.5	1125	15	1687.5	15187.5	0	0	0	0	0	0	0	0	0	0	0	0	0	22327.5	6727.5	1.83			
57-	R-14	2052.94	130	130	R/S	B47	B49	130	60	24	3120	0	0	34	4420	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13611	4420	16731	1.33			
58-	R-14	2052.94	111	111	R/S	B49	B50	111	60	24	2664	0	0	34	3774	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5183	3774	7847	0.73			
59-	R-14	2052.94	185	185	R/S	B50	B51	185	60	24	4440	0	0	34	6290	112.5	1125	11	1237.5	11137.5	0	0	0	0	0	0	0	0	0	0	0	0	0	17427.5	5677.5	1.45			
60-	R-16	1004.44	277	269	R/S	B36.1	B36.2	269	40	20	5540	0	0	20	5540	112.5	1125	11	1237.5	11137.5	0	0	0	0	0	0	0	0	0	0	0	0	0	16677.5	6777.5	1.48			
61-	R-16	1004.44	220	220	R/S	B36.2	B36.3	220	40	20	4400	0	0	20	4400	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	12500	5300	1.12			
62-	R-16	1004.44	508	508	R/S	B36.3	B37	508	40	20	10160	0	0	20	10160	112.5	1125	18	2025	18225	0	0	0	0	0	0	0	0	0	2848	0	0	0	31233	12185	2.73			
63-	MR-01	4534.72	0	246	R/S	B34	B34.1	246	100	0	0	0	0	0	0	112.5	1125	10	1125	10125	0	0	0	0	0	0	0	0	0	0	0	0	0	10125	1125	0.71			

S.2/4

S.No	Section	Total R 'L' (ft) (b)	Feeding 'L' (ft) (c)	Drain 'L'(ft) (d)	Drain Side (e)	Nodes From (f)	Nodes To (g)	Total D 'L'= D 'L '+ E. D 'L' (ft) (h)	R 'W'(ft) (i)	S 'W' on both sides (ft) (j)	G 'A' Sh(sft) (k)	CM 'W' (ft) (l)	G 'A' CM (sft) (m)	P 'W' of R (ft) (n)	P 'A' R (sft) (o)	G 'A' of 1 H/A (sft) (p)	R 'A' of 1 H/A (sft) (q)	No of H/A (r)	Total G 'A' of H/A (sft) (s)	Total R 'A' of H/A (sft) (t)	Commer 'A' (sft) (u)	Masjid (sft) (v)	School 'R' (sft) (w)	School 'G' (sft) (x)	P.P.Pa (sft) (y)	Parking (sft) (z)	Park/PG 'G' (Sft) (aa)	MI.R 'G' (Sft) (ab)	MI.R 'R' (Sft) (ac)	WW/ P (sft) (ad)	P.B 'G' (sft) (ae)	P.B 'R' (sft) (af)	Misc G 'A'(sft) (ag)	Total Paved 'A' (sft) (ah)	Total Green 'A' (sft) (ai)	Q=CIA (cusecs) (aj)	Sub-Catch No (ak)	Sub-Catch 'A' (sft) (al)	Q from S-Basin (cusecs) (am)
64-	MR-01	4534.72	0	130	R/S	B34.2	B34.1	130	100	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	6552	0	0	0	0	0	0	0	0	6552	0	0.41			
65-	MR-01	4534.72	0	204	R/S	B34.1	B34.3	204	100	0	0	0	0	0	0	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	9112.5	1012.5	0.64			
66-	MR-01	4534.72	0	250	R/S	B34.3	B34.4	250	100	0	0	0	0	0	0	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	8100	900	0.57			
67-	MR-01	4534.72	0	200	R/S	B34.4	B34.5	200	100	0	0	0	0	0	0	112.5	1125	8	900	8100	0	0	0	0	0	0	0	0	0	0	0	0	0	8100	900	0.57			
68-	MR-01	4534.72	0	134	R/S	B34.5	B35	134	100	0	0	0	0	0	0	112.5	1125	3	337.5	3037.5	0	0	0	0	0	0	0	0	0	0	0	0	0	3037.5	337.5	0.21			
69-	R-14	2052.94	140	125	R/S	B35	B37	125	60	24	3360	0	0	34	4760	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4760	3360	0.51			
70-	R-14	2052.94	100	100	R/S	B37	B43	100	60	24	2400	0	0	34	3400	112.5	1125	2	225	2025	0	0	0	0	0	0	0	0	0	0	0	0	0	5425	2625	0.51			
71-	R-14	2052.94	150	150	R/S	B43	B42	150	60	24	3600	0	0	34	5100	112.5	1125	9	1012.5	9112.5	0	0	0	0	0	0	0	0	0	0	0	0	0	14212.5	4612.5	1.19			
72-	R-14	2052.94	143	143	R/S	B42	B41.1	143	60	24	3432	0	0	34	4862	112.5	1125	10	1125	10125	0	0	0	0	0	0	0	0	0	0	0	0	0	14987	4557	1.23			
73-	R-14	2052.94	157	157	R/S	B41.1	B51	157	60	24	3768	0	0	34	5338	112.5	1125	1	112.5	1012.5	0	0	0	0	0	0	0	0	0	0	0	0	0	6350.5	3880.5	0.64			
74-	TO STP	-		162		B51	STP	162	0	0	0	0	0	0	0	112.5	1125	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
Zone-1																																							
75-	R-34	570.91	136	100	R/S	A1	A1.1	100	40	20	2720	0	0	20	2720	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	4251	2720	0.44			
76-	R-34	570.91	114	114	R/S	A1.1	A4	114	40	20	2280	0	0	20	2280	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	3811	2280	0.38			
77-	R-35	192.2	192.2	210	L/S	A4	A5	210	40	20	3844	0	0	20	3844	0	3062	1.5	0	4593	0	0	0	0	0	0	0	0	0	0	0	0	27710	8437	31554	2.52			
78-	R-36	243.81	230	199	L/S	A6	A7	199	40	20	4600	0	0	20	4600	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	7662	4600	0.77			
79-	R-32	603.72	100	80	L/S	A7	A7.1	80	40	20	2000	0	0	20	2000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	3531	2000	0.35			
80-	R-32	603.72	100	100	L/S	A7.1	A7.2	100	40	20	2000	0	0	20	2000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	3531	2000	0.35			
81-	R-32	603.72	64	64	L/S	A7.2	A5	64	40	20	1280	0	0	20	1280	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1280	1280	0.16			
82-	R-32	603.72	224	235	L/S	A5	A3	224	40	20	4480	0	0	20	4480	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	20806	7542	25286	2.07			
83-	R-34	570.91	155	155	L/S	A4.1	A1.2	155	40	20	3100	0	0	20	3100	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	6162	3100	0.58			
84-	R-34	570.91	140	116	L/S	A1.4	A1.3	116	40	20	2800	0	0	20	2800	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2800	2800	0.35			
85-	R-34	570.91	26	26	L/S	A1.3	A1.2	26	40	20	520	0	0	20	520	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	520	520	0.07			
86-	R-33	192.13	66	66	R/S	A1.2	A2	66	0	0	0	0	0	0	0	0	3062	0	0	0	3997	0	0	0	0	0	0	0	0	0	0	0	0	3997	0	0.25			
87-	R-33	192.13	84	84	R/S	A2	A2.1	84	40	20	1680	0	0	20	1680	0	3062	0.5	0	1531	7493	0	0	0	0	0	0	0	0	0	0	0	0	10704	1680	0.78			
88-	R-33	192.13	43	102	R/S	A2.1	A3	102	40	20	860	0	0	20	860	0	3062	0.5	0	1531	0	4429	0	0	0	0	0	0	0	0	0	0	0	6820	860	0.48			
89-	R-32	603.72	105	163	L/S	A3	A9	163	40	20	2100	0	0	20	2100	0	3062	0	0	0	0	5346	0	0	0	0	0	0	0	0	0	0	0	7446	2100	0.60			
90-	MR-01	4534.72	0	130	R/S	A8	A9	130	100	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
91-	MR-01	4534.72	0	160	R/S	A9	A10	160	100	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
92-	R-31	217.09	217.09	261	R/S	A14	A10	261	40	20	4341.8	0	0	20	4341.8	0	3062	1	0	3062	0	0	29910	19940	0	0	0	0	0	0	0	0	0	37313.8	24281.8	3.88			
93-	MR-01	4534.72	0	209	R/S	A10	A11	209	100	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	3062	0	0.19			
94-	R-30	362.73	362.73	373	L/S	A20	A11	407	40	20	7254.6	0	0	20	7254.6	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	14664	13378.6	21918.6	2.22			
95-	MR-01	4534.72	0	230	R/S	A11	A11.1	230	100	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	3062	0	0.19			
96-	WW-06	238.17	238.17	222	L/S	A25	A23.1	222	12	0	0	0	0	12	2858.04	0	3062	1.5	0	4593	0	0	0	0	0	0	0	0	0	0	0	0	8979	7451.04	8979	1.03			
97-	R-29	427.89	95	91	L/S	A23	A23.1	91	40	20	1900	0	0	20	1900	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	3431	1900	0.34			
98-	R-29	427.89	81	81	L/S	A23.1	A23.2	81	40	20	1620	0	0	20	1620	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	6988	3151	8608	0.74			
99-	R-29	427.89	172	170	L/S	A23.2	A23.3	170	40	20	3440	0	0	20	3440	0	3062	1.5	0	4593	0	0	0	0	0	0	0	0	0	0	0	0	20961	8033	24401	2.04	Z-1	542906	
100-	G, b/w R28 & R29	-	0	247		A23.3	A26	247	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	19352	3062	19352	1.41			
101-	R-28	534.33	130	126	L/S	A26	A28	126	40	20	2600	0	0	20	2600	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	7545	4131	10145	0.90			
102-	WW-03	227.77	227.77	211	L/S	A27	A28	211	12	0	0	0	0	12	2733.24	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	7001	5795.24	7001	0.81			
103-	MR-01	4534.72	0	246	R/S	A11.1	A12	246	100	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	3062	0	0.19			
104-	BL-10 & MR-01	-	0	207		A31.6	A31	207	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	7112	3062	7112	0.64			
105-	R-37	417.6	99	108	L/S	A31	A31.1	108	40	20	1980	0	0	20	1980	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	17451	3511	19431	1.44			
106-	R-37	417.6	65	65	L/S	A31.1	A31.2	65	40	20	1300	0	0	20	1300	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	10354	2831	11654	0.91			
107-	R-37	417.6	78	78	L/S	A31.2	A33	78	40	20	1560	0	0	20	1560	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3400	1560	4960	0.41			
108-	R-38	192.93	112	112	L/S	A32	A34.1	112	40	20	2240	0	0	20	2240	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	6947	5302	9187	0.91			
109-	Trough BL-11	-	0	163		A34	A34.1	163	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	6950	3062	6950	0.63			
110-	R-38	192.93	81	81	L/S	A34.1	A33	81	40	20	1620	0	0	20	1620	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	4682	1620	0.40			
111-	R-37	417.6	0	23	L/S	A33	A39	23	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
112-	R-37	417.6	128	128	L/S	A31.5	A31.4	128	40	20	2560	0	0	20	2560	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	6889	5622	9449	0.95			
113-	R-37	417.6	48	48	L/S	A31.4	A39	48	40	20	960	0	0	20	960	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5075	960	6035	0.44			
114-		-	0	143		A40	A39	143	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	6917	3062	6917	0.63			
115-	G, BL12	-	0	131		A39	A39.1	131	0	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	6884	1531	6884	0.53			
116-		-	0	232		A39.1	A39.2	232	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	7041	3062	7041	0.64			
117-		4534.72	0	212	L/S	A39.2	A39.3	212	100	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	10782	0	0	0	0	0	0	3062	10782	0.87			
118-	MR-01	4534.72	0	353	L/S	A39.3	A39.4	353	100	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	10782	0	0	0	0	0	0	0	10782	0.68			
119-		4534.72	0	82	L/S	A39.4	A12	82	100	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			

S.3/4

S.No	Section	Total R 'L' (ft)	Feeding 'L' (ft)	Drain 'L'(ft)	Drain Side	Nodes From	Nodes To	Total D 'L'= D 'L' '+ E. D 'L' (ft)	R 'W'(ft)	S 'W' on both sides (ft)	G 'A' Sh(sft)	CM 'W' (ft)	G 'A' CM (sft)	P 'W' of R (ft)	P 'A' R (sft)	G 'A' of 1 H/A (sft)	R 'A' of 1 H/A (sft)	No of H/A	Total G 'A' of H/A (sft)	Total R 'A' of H/A (sft)	Commer 'A' (sft)	Masjid (sft)	School 'R' (sft)	School 'G' (sft)	P.P.Pa (sft)	Parking (sft)	Park/PG 'G' (Sft)	MI.R 'G' (Sft)	MI.R 'R' (Sft)	WW/ P (sft)	P.B 'G' (sft)	P.B 'R' (sft)	Misc G 'A'(sft)	Total Paved 'A' (sft)	Total Green 'A' (sft)	Q=CIA (cusecs)	Sub-Catch No	Sub-Catch 'A' (sft)	Q from S-Basin (cusecs)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)
120-	BL-17	-	0	73		C1	C2	73	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	3530	3062	3530	0.42			
121-		-	0	128		C2	C3	128	0	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	7094	1531	7094	0.54			
122-	C.C	-	0	135		C3.1	C3	135	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2329	0	2329	0.15			
123-	R-22	3103.72	118	118	L/S	C3	C4	118	60	24	2832	0	0	34	4012	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	7074	2832	0.62			
124-		472.14	50	45	L/S	C1.1	C2.1	45	40	20	1000	0	0	20	1000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	2531	1000	0.22			
125-		472.14	50	50	L/S	C2.1	C3.1	50	40	20	1000	0	0	20	1000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	3272	2531	4272	0.43			
126-		472.14	110	110	L/S	C3.1	C4	110	40	20	2200	0	0	20	2200	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	5262	2200	0.47			
127-	R-23	472.14	56	54	L/S	C5.4	C5.1	54	40	20	1120	0	0	20	1120	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1120	1120	0.14			
128-		472.14	46	46	L/S	C5.1	C5.2	46	40	20	920	0	0	20	920	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3516	920	4436	0.34			
129-		472.14	50	50	L/S	C5.2	C5.3	50	40	20	1000	0	0	20	1000	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	3516	2531	4516	0.44			
130-		472.14	133	133	L/S	C5.3	C6	133	40	20	2660	0	0	20	2660	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	14027	5722	16687	1.41			
131-		3103.72	135	118	L/S	C7	C10.1	118	60	20	2700	0	0	20	2700	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	16136	5762	18836	1.55			
132-	R-22	3103.72	226	226	L/S	C10.1	C6	226	60	20	4520	0	0	20	4520	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	3479	7582	7999	0.98			
133-		3103.72	190	190	L/S	C6	C8	190	60	20	3800	0	0	20	3800	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	3498	6862	7298	0.89			
134-		3103.72	70	70	L/S	C8	C8.1	70	60	20	1400	0	0	20	1400	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	13751	2931	15151	1.14			
135-	R22 & R23	-	0	228		C4	C8.1	228	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	6478	3062	6478	0.60			
136-	R22 & BL14	-	0	216		C8.1	C9	216	0	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	1531	0	0.10			
137-	BL14 & B13	-	0	324		C9	C9.1	324	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20903	0	20903	1.32			
138-	BL-13	-	0	128		C9.1	C15.2	128	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7197	0	7197	0.45			
139-		-	0	104		C15.2	C15.3	104	0	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	7648	1531	7648	0.58			
140-	GREEN	-	0	98		C15.3	C15.4	98	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
141-		-	0	83		C15.4	C15.5	83	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9324	0	9324	0.59			
142-		-	0	317		C15.5	C14.2.1	317	0	0	0	0	0	0	0	0	3062	0	0	0	26381	0	0	0	0	0	0	0	0	0	0	0	5476	26381	5476	2.01			
143-	G, & MR01	-	0	140		C14.2.1	C14.3	140	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
144-	MR-01	-	0	83		C14.3	C34.1	83	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
145-	BL14 & G	-	0	126		C18	C5	126	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00	Z-3	766521	69.08
146-	BL14 & G	-	0	225		C5	C15	225	0	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	13903	3062	13903	1.07			
147-		-	0	139		C15	C16	139	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8716	0	8716	0.55			
148-	GREEN	-	0	215		C16	C17	215	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29344	0	29344	1.85			
149-		-	0	114		C17	C19	114	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
150-		3103.72	165	156	R/S	C15.1	C16.1	156	60	24	3960	0	0	34	5610	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	12198	5610	16158	1.37			
151-		3103.72	127	127	R/S	C16.1	C23	127	60	24	3048	0	0	34	4318	0	3062	0	0	0	0	0	8524	5683	0	0	0	0	0	0	0	0	0	12842	8731	1.36			
152-	R-22	3103.72	250	250	R/S	C23	C23.1	250	60	24	6000	0	0	34	8500	0	3062	0	0	0	0	0	8524	5683	0	0	0	0	0	0	0	0	0	17024	11683	1.81			
153-		3103.72	150	150	R/S	C23.1	C23.2	150	60	24	3600	0	0	34	5100	0	3062	0	0	0	0	0	8524	5683	0	0	0	0	0	0	0	0	0	13624	9283	1.44			
154-		3103.72	150	150	R/S	C23.2	C24.1	150	60	24	3600	0	0	34	5100	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5100	3600	0.55			
155-		3103.72	123	123		C24.1	C19	123	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
156-	GREEN	-	172	172		C19	C20	172	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11930	0	11930	0.75			
157-		-	0	220		C20	C22	220	0	0	0	0	0	0	0	0	3062	0	0	0	41080	0	0	0	0	0	0	0	0	0	0	0	19921	41080	19921	3.84			
158-	MR-01	4534.72	0	88	R/S	C22	C25	88	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
159-	R-25	191.9	192	197	L/S	C24	C25	197	40	20	3840	0	0	20	3840	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	20303	5371	24143	1.86			
160-	MR-01	4534.72	0	255	R/S	C25	C27	255	100	0	0	0	0	0	0	0	3062	1	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	3062	0	0.19			
161-		442.67	50	45	L/S	C33	C32	45	40	20	1000	0	0	20	1000	0	3062	0	0	0	0	0	6143	4096	0	0	0	0	0	0	0	0	0	7143	5096	0.77			
162-	R-27	442.67	50	50	L/S	C32	C31	50	40	20	1000	0	0	20	1000	0	3062	0	0	0	0	0	6143	4096	0	0	0	0	0	0	0	0	0	7143	5096	0.77			
163-		442.67	98	103	L/S	C31	C30.1	103	40	20	1960	0	0	20	1960	0	3062	0	0	0	0	0	6143	4096	0	0	0	0	0	0	0	0	0	8103	6056	0.89			
164-	R-26	418.87	95	95	L/S	C28	C30.1	95	40	20	1900	0	0	20	1900	0	3062	0	0	0	0	0	61473	4096	0	0	0	0	0	0	0	0	0	63373	5996	4.37			
165-		418.87	324	327	L/S	C30.1	C27	327	40	20	6480	0	0	20	6480	0	3062	1.5	0	4593	0	0	0	0	0	0	28780	0	0	0	0	0	23388	11073	58648	4.39			
166-	MR-01	4534.72	0	121	R/S	C27	C30	121	100	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	10889	1531	10889	0.78			
167-	BL-2	-	0	164		C29	C30	164	0	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	0	1531	0	0.10			
168-	MR-01	4534.72	0	87	R/S	C30	C34.1	87	100	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	11120	1531	11120	0.80			
169-	MR-01	4534.72	0	235	R/S	C34.1	A12	235	100	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	19149	0	0	0	0	0	0	0	20680	0	1.30			
170-	R-28	534.33	106	106	L/S	A12	A28.1	106	40	20	2120	0	0	20	2120	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	13829	3651	15949	1.23			
171-		534.33	124	124	L/S	A28.1	A28	124	40	20	2480	0	0	20	2480	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	6982	4011	9462	0.85			
172-	TO STP	-	0	85		A28	STP	85	0	0	0	0	0	0	0		3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			

S.No	Section	Total R 'L' (ft)	Feeding 'L' (ft)	Drain 'L'(ft)	Drain Side	Nodes From	Nodes To	Total D 'L'= D 'L '+ E. D 'L' (ft)	R 'W'(ft)	S 'W' on both sides (ft)	G 'A' Sh(sft)	CM 'W' (ft)	G 'A' CM (sft)	P 'W' of R (ft)	P 'A' R (sft)	G 'A' of 1 H/A (sft)	R 'A' of 1 H/A (sft)	No of H/A	Total G 'A' of H/A (sft)	Total R 'A' of H/A (sft)	Commer 'A' (sft)	Masjid (sft)	School 'R' (sft)	School 'G' (sft)	P.P.Pa (sft)	Parking (sft)	Park/PG 'G' (Sft)	MLR 'G' (Sft)	MLR 'R' (Sft)	WW/ P (sft)	P.B 'G' (sft)	P.B 'R' (sft)	Misc G 'A'(sft)	Total Paved 'A' (sft)	Total Green 'A' (sft)	Q=CIA (cusecs)	Sub-Catch No	Sub-Catch 'A' (sft)	Q from S-Basin (cusecs)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)
173-	MR-02	3663.4	230	230	R/S C.M	B19.2	B11.1	230	100	38	8740	10	2300	52	11960	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8020	11960	19060	1.95			
174-	MR-02	3663.4	238	238	R/S C.M	B11.1	B4.1	238	100	38	9044	10	2380	52	12376	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8079	12376	19503	2.01			
175-	MR-02	3663.4	123	123	R/S C.M	B4.1	B2.1.1	123	100	38	4674	10	1230	52	6396	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1555	6396	7459	0.87			
176-	MR-02	3663.4	712	712	R/S C.M	B2.1.1	B2.1	712	100	38	27056	10	7120	52	37024	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	49041	37024	83217	7.57			
177-	MR-02	3663.4	550	550	R/S C.M	B2.1	B2.2	550	100	38	20900	10	5500	52	28600	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	52106	28600	78506	6.74	S.C-1	525040	33.06
178-	MR-02	3663.4	550	550	R/S C.M	B2.2	B2.3	550	100	38	20900	10	5500	52	28600	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	32261	28600	58661	5.49			
179-	MR-02	3663.4	485	485	R/S C.M	B2.3	B2.4	485	100	38	18430	10	4850	52	25220	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31214	25220	54494	5.02			
180-	MR-02	3663.4	83.75	83.75	R/S C.M	B2.4	B2.5	83.75	100	38	3182.5	10	837.5	52	4355	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8710	4355	12730	1.08			
181-	MR-02	3663.4	231.25	231.3	R/S C.M	B2.5	B2.6	231.25	100	38	8787.5	10	2313	52	12025	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13754	12025	24854	2.32			
182-	MR-02	3663.4	131	131	R/S C.M	B19.1	B21.1	131	100	38	4978	10	1310	52	6812	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4694	6812	10982	1.12			
183-	MR-02	3663.4	222	222	R/S C.M	B21.1	B27.1	222	100	38	8436	10	2220	52	11544	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4034	11544	14690	1.65			
184-	MR-01	4534.72	260	260	R/S C.M	B24	B28.2	260	100	38	9880	10	2600	52	13520	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13520	12480	1.64	S.C-2	87860	5.53
185-	MR-02	3663.4	160.54	160.5	R/S C.M	B27.1	B28.2	160.54	100	38	6100.52	10	1605	52	8348.08	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1778	8348.08	9483.92	1.12			
186-	MR-01	4534.72	75	75	R/S C.M	B28.2	B28.1	75	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
187-	MR-01	4534.72	150	150	R/S C.M	B24.1	B24.2	150	100	38	5700	10	1500	52	7800	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7800	7200	0.94			
188-	MR-01	4534.72	250	250	R/S C.M	B24.2	B24.3	250	100	38	9500	10	2500	52	13000	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13000	12000	1.57			
189-	MR-01	4534.72	100	100	R/S C.M	B24.3	B24.4	100	100	38	3800	10	1000	52	5200	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5200	4800	0.63			
190-	MR-01	4534.72	118	118	R/S C.M	B31	B32	118	100	38	4484	10	1180	52	6136	0	3062	0	0	0	0	0	0	0	6552	0	0	0	0	0	0	0	0	12688	5664	1.16	S.C-3	96552	6.08
191-	MR-01	4534.72	32	32	R/S C.M	B32	B31.1	32	100	38	1216	10	320	52	1664	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1664	1536	0.20			
192-	MR-01	4534.72	150	150	R/S C.M	B31.1	B31.2	150	100	38	5700	10	1500	52	7800	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7800	7200	0.94			
193-	MR-01	4534.72	100	100	R/S C.M	B31.2	B24.4	100	100	38	3800	10	1000	52	5200	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5200	4800	0.63			
194-	MR-01	4534.72	0	128	R/S C.M	B24.4	B24.5	128	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
195-	MR-01	4534.72	148	148	R/S C.M	B32.1	B32.2	148	100	38	5624	10	1480	52	7696	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7696	7104	0.93			
196-	MR-01	4534.72	200	200	R/S C.M	B32.2	B32.3	200	100	38	7600	10	2000	52	10400	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10400	9600	1.26			
197-	MR-01	4534.72	150	150	R/S C.M	B32.3	B32.4	150	100	38	5700	10	1500	52	7800	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7800	7200	0.94			
198-	MR-01	4534.72	150	150	R/S C.M	B32.4	B32.5	150	100	38	5700	10	1500	52	7800	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7800	7200	0.94			
199-	MR-01	4534.72	150	150	R/S C.M	B32.5	B32.6	150	100	38	5700	10	1500	52	7800	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7800	7200	0.94	S.C-4	119400	7.52
200-	MR-01	4534.72	150	150	R/S C.M	B32.6	B32.7	150	100	38	5700	10	1500	52	7800	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7800	7200	0.94			
201-	MR-01	4534.72	100	100	R/S C.M	B32.7	B44.3	100	100	38	3800	10	1000	52	5200	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5200	4800	0.63			
202-	MR-01	4534.72	146	146	R/S C.M	B44.3	B32.8	146	100	38	5548	10	1460	52	7592	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7592	7008	0.92			
203-	MR-01	4534.72	0	81.4	R/S C.M	B32.8	B32.9	81.4	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
204-	R-22	3103.72	392	392	R/S C.M	C20.1	C21.1	392	60	24	9408	0	0	34	13328	0	3062	0	0	0	0	0	0	0	0	0	0	0	7387	0	0	0	0	20715	9408	1.90	S.C-5	30123	1.9
205-	MR-01	4534.72	124	124	R/S C.M	C29.1	C25.1	124	100	38	4712	10	1240	52	6448	0	3062	0	0	0	0	0	0	0	0	0	0	9253	4960	0	0	0	0	11408	15205	1.68			
206-	MR-01	4534.72	200	200	R/S C.M	C25.1	C43	200	100	38	7600	10	2000	52	10400	0	3062	0	0	0	0	0	0	0	0	0	0	9253	4960	0	8088	18872	0	34232	26941	3.85	S.C-6	87786	5.53
207-	MR-01	4534.72	0	133.8	R/S C.M	C43	C44	133.75	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
208-	MR-01	4534.72	102.23	102.2	R/S C.M	C28.1	C27.1	102.23	100	38	3884.74	10	1022	52	5315.96	0	3062	0	0	0	31469	0	0	0	0	0	0	0	0	0	0	0	0	36785	4907.04	2.63			
209-	MR-01	4534.72	165	165	R/S C.M	C27.1	C40	165	100	38	6270	10	1650	52	8580	0	3062	0	0	0	14539	0	0	0	0	0	0	0	0	0	0	0	0	23119	7920	1.95	S.C-7	77731	4.89
210-	MR-01	4534.72	50	50	R/S C.M	C40	C41	50	100	38	1900	10	500	52	2600	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2600	2400	0.31			
211-	MR-01	4534.72	0	150	R/S C.M	C41	C42	150	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
212-	MR-01	4534.72	257	252	R/S C.M	A8.1	A9.1	252	100	38	9766	10	2570	52	13364	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13364	12336	1.62			
213-	MR-01	4534.72	143	143	R/S C.M	A9.1	A10.1	143	100	38	5434	10	1430	52	7436	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7436	6864	0.90			
214-	MR-01	4534.72	209	209	R/S C.M	A10.1	A11.2	209	100	38	7942	10	2090	52	10868	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10868	10032	1.32	S.C-8	116400	7.33
215-	MR-01	4534.72	555	555	R/S C.M	A11.2	A35	555	100	38	21090	10	5550	52	28860	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	28860	26640	3.49			
216-	MR-01	4534.72	0	107	R/S C.M	A35	A35.1	107	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
217-	WW-14	512.29	512.29	504.6	R/S C.M	A29	A30	504.6	12	0	0	0	0	12	6147.48	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	11788	12271.5	11788	1.51	S.C-9	24059.5	1.51
218-	R-24	192.29	192.29	182.3	R/S C.M	C10	C10.2	201.84	40	20	3845.8	0	0	20	3845.8	0	3062	2	0	6124	0	0	0	0	0	0	0	0	0	0	0	0	0	9969.8	3845.8	0.87	S.C-10	13815.6	0.87
219-	R-22	3103.72	120	120	R/S C.M	C9.2	C4.2	120	60	24	2880	0	0	34	4080	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4080	2880	0.44			
220-	R-22	3103.72	230	230	R/S C.M	C4.2	C4.1	230	60	24	5520	0	0	34	7820	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7820	5520	0.84	S.C-11	20300	1.28
221-	R-22	3103.72	0	106	R/S C.M	C4.1	C8.2	106	0	0	0	0	0	0	0	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00			
222-	R-22	3103.72	145	145	R/S C.M	C11	C11.1	145	60	24	3480	0	0	34	4930	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4930	3480	0.53			
223-	R-22	3103.72	150	150	R/S C.M	C11.1	C11.2	150	60	24	3600	0	0	34	5100	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17950	5100	21550	1.68	S.C-12	112031	7.05
224-	R-22	3103.72	397	397	R/S C.M	C11.2	C12	397	60	24	9528	0	0	34	13498	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	0	52414	15029	61942	4.85			
225-	R-22	3103.72	172	172	R/S C.M	C13	C14	172	60	24	4128	0	0	34	5848	0	3062	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14144	5848	18272	1.52	S.C-13	24120	1.52
226-	b/w BL15,16 & 17	0	0	136	-	C22.1.1	C23.1.1	136	0	0	0	0	0	0	0	0	3062	0.5	0	1531	0	0	0	0	0	0	0	0	0	0	0	24129	15144	25660	15144	2.57	S.C-14	40804	2.57

Grand Total Area of three Zones &14 Sub-Basins = **3948235**

Total combined discharge from three Zones &14 Sub-Basins = **237.6**

Table D5: Hydraulic Design Sheet of Dry weather & Wet weather Flow jointly in Combined Sewer System (Zone-2).

S/No	Section (a)	D+Cu/Pipe From (b)	D+Cu/Pipe To (c)	D.Cu/Pipe 'L' (ft) (d)	Cu 'D' (in) (e)	Cir Pipe 'D' (in) (f)	Storm Flow Indivi. (cusec) (g)	Storm Flow Commu.(cusec) (h)	DWF Commu. (i)	Total Flow(DW+WW) (cusec) (j)	Equal Flow Distribution For dual Pipes (k)	FRL AT E-1 (ft) (l)	FRL AT E-2 (ft) (m)	I.L (ft) E-1 (ft) (n)	I.L (ft) E-2 (ft) (o)	Slope% or ft/ft (p)	Cover E-1 (ft) (q)	Cover E-2 (ft) (r)
1-	R-01	B1	B2	185	6	-	1.04	1.04	0.0134	1.05	-	1455	1443.73	1452	1440.73	6.09	3	3
		Drop MH													1439.73			
2-	R-02	B3	B9	303	6	-	2.05	2.05	0.0284	2.08	-	1470	1455.75	1467	1452.75	4.70	3	3
		Drop MH													1447.95			
3-	R-03	B10.1	B9	228	-	9	1.51	1.51	0.0234	1.53	-	1459.22	1455.75	1455.22	1447.95	0.0319	4	7.8
4-	R-02	B9	B4	116	-	12	0.47	4.03	0.0584	4.09	-	1455.75	1449.01	1447.95	1445	0.0254	7.8	4.01
		Drop MH													1436.3			
5-	MR-02	B2	B4	108	-	9	0.00	1.04	0.0134	1.05	-	1443.73	1449.01	1439.73	1436.3	0.0318	4.00	12.71
6-		B4	B11	230	-	18	0.50	5.57	0.0835	5.65	-	1449.01	1455.85	1436.3	1433.4	0.0126	12.71	22.45
7-	R-05	B6	B7	173	-	9	0.96	0.96	0.0083	0.97	-	1463.5	1462.79	1459.5	1454	0.0318	4	8.79
8-	R-04	B5	B7	100	-	9	0.54	0.54	0.0067	0.54	-	1462.91	1462.79	1458.91	1454	0.0491	4	8.79
9-		B7	B8	100	-	12	0.79	2.29	0.0200	2.31	-	1462.79	1462.69	1454	1451.8	0.0220	8.79	10.89
10-	R-06	B8	B10	135	-	12	0.33	2.61	0.0200	2.63	-	1462.69	1459.33	1451.8	1448.85	0.0219	10.89	10.48
11-	R-03	B18	B10	214	-	9	1.44	1.44	0.0234	1.46	-	1461.47	1459.33	1457.47	1450.65	0.0319	4	8.68
		Drop MH													1448.85			
12-	R-06	B10	B11	116	-	12	0.28	4.33	0.0434	4.37	-	1459.33	1455.85	1448.85	1446.3	0.0220	10.48	9.55
		Drop MH													1433.4			
13-	R-04	B12	B14	93	-	9	0.86	0.86	0.0067	0.86	-	1462.65	1462.55	1458.65	1455.7	0.0317	4	6.85
		Drop MH													1454.15			
14-	R-07	B13	B14	149	-	9	0.94	0.94	0.0067	0.95	-	1462.9	1462.55	1458.9	1454.15	0.0319	4	8.4
15-	R-04	B14	B15	143	-	12	0.53	2.33	0.0184	2.35	-	1462.55	1461.83	1454.15	1451.05	0.0217	8.4	10.78
16-	R-08	B16	B15	136	-	9	0.99	0.99	0.0150	1.01	-	1462.84	1461.83	1458.84	1454.5	0.0319	4	7.33
		Drop MH													1451.05			
17-	R-08	B15	B19	238	-	18	1.23	4.55	0.0484	4.60	-	1461.83	1460.14	1451.05	1448.05	0.0126	10.78	12.09
		Drop MH													1431.2			
18-	MR-02	B11	B19	255	-	24	0.50	10.39	0.1386	10.53	-	1455.85	1460.14	1433.4	1431.2	0.0086	22.45	28.94
19-	MR-02	B19	B21	104	-	24	0.00	14.94	0.1870	15.13	-	1460.14	1458.19	1431.2	1430.3	0.0087	28.94	27.89
20-	R-09	B20	B20.1	191	6	-	1.81	1.81	0.0134	1.82	-	1474.88	1462.38	1470.88	1459.38	6.02	4	3
21-	R-09	B20.1	B21	179	6	-	0.84	0.84	0.0234	0.86	-	1462.38	1458.19	1459.38	1453	3.56	3	5.19
		Drop MH													1430.3			
22-	MR-02	B21	B27	254	-	24	0.50	17.25	0.2220	17.47	-	1458.19	1455.13	1430.3	1428.1	0.0087	27.89	27.03
23-	R-12	B27	B26	127	-	24	0.53	17.78	0.2271	18.01	-	1455.13	1449.66	1428.1	1427	0.0087	27.03	22.66
24-	R-10	B25	B26	276	-	9	1.91	1.91	0.0134	1.93	-	1460.1	1449.66	1456.1	1445.6	0.0380	4	4.06
		Drop MH													1427			
25-	R-12	B26	B23	175	-	30	1.26	20.95	0.2488	21.20	-	1449.66	1454.35	1427	1425.85	0.0066	22.66	28.5
26-	R-11	B22	B23	286	6	-	1.58	1.58	0.0200	1.60	-	1470.11	1454.35	1467.11	1451.35	5.51	3	3
		Drop MH													1425.85			
27-	R-11	B23	B24	115	-	30	0.48	23.01	0.2755	23.29	-	1454.35	1448.28	1425.85	1425.1	0.0065	28.5	23.18
28-	MR-01	B28	B24	225	-	9	0.57	0.57	0.0134	0.58	-	1443.64	1448.28	1439.64	1432.5	0.0317	4	15.78
		Drop MH													1425.1			
29-	MR-01	B24	B30	109	-	30	0.00	23.58	0.2888	23.87	-	1448.28	1445.2	1425.1	1424.4	0.0064	23.18	20.8
30-	R-13	B29	B30	229	6	-	1.12	1.12	0.0134	1.13	-	1455.9	1445.2	1452.9	1439.45	5.87	3	5.75
		Drop MH													1424.4			
31-	MR-01	B30	B31	656	-	30	8.75	33.44	0.3284	33.77	-	1445.2	1439.54	1424.4	1419.85	0.0069	20.8	19.69
32-	MR-01	B32	B31	120	-	9	0.41	0.41	0.0017	0.41	-	1439.54	1439.54	1435.54	1431.7	0.0320	4	7.84
		Drop MH													1419.85			
33-	R-14	B31	B33	474	-	24	3.94	37.79	0.3818	38.17	19.09	1439.54	1430.21	1419.85	1415.75	0.0086	19.69	14.46
					-	24					19.09	1439.54	1430.21	1419.85	1415.75	0.0086	19.69	14.46
34-	R-14	B33	B39	159	-	24	1.08	38.87	0.3935	39.26	19.63	1430.21	1428.65	1415.75	1414.35	0.0088	14.46	14.3
					-	24					19.63	1430.21	1428.65	1415.75	1414.35	0.0088	14.46	14.3
35-	R-15	B38	B38.1	175	6	-	1.45	1.45	0.0234	1.47	-	1436.65	1430.66	1433.65	1427.4	3.57	3	3.26

S/No	Cunette Parameters A (sft) (s)	Cunette Parameters R=D/8 (ft) (t)	Storm Drain Size b (in) (u)	×	Storm Drain Size d (in) (v)	Drain Area (sft) (w)	Drain Wetted Perimeter (ft) (x)	Hydraulic Radius Drain = A/P (ft) (y)	Total Area D+Cu (sft) (z)	Total Rh D+Cu (ft) (aa)	Circular Pipe A (sft) (ab)	Circular Pipe R=D/4 (ft) (ac)	Vact (ad)	Vf (ae)	Qf (af)	Q < Qf (ag)	Remarks from Hydraulic Table $\frac{Q}{Qf}$ (ah)	Remarks from Hydraulic Table $\frac{V}{Vf}$ (ai)	Remarks from Hydraulic Table V (aj)	Min Speci. Vel (ak)	Final Vel check (al)	Max Speci. Vel (am)	Stepped or Not (an)	$\frac{d}{D}$ (ao)	Flow 'd' (inch) (ap)
1-	0.0981	0.0625	18	x	18	2.25	4.5	0.500	2.348	0.563	-	-	0.45	19.23	45.14	OK	0.02	0.40	7.69	3.00	-	8.50	FALSE	-	-
2-	0.0981	0.0625	18	x	18	2.25	4.5	0.500	2.348	0.563	-	-	0.89	16.89	39.66	OK	0.05	0.53	8.95	3.00	-	8.50	STEPPED	-	-
3-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.69	2.95	OK	0.52	1.01	6.75	2	OK	8.50	-	0.52	4.68
4-	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	7.23	5.68	OK	0.72	1.09	7.89	2	OK	8.50	-	0.63	7.56
5-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.67	2.95	OK	0.36	0.92	6.14	2	OK	8.50	-	0.42	3.78
6-	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.67	11.79	OK	0.48	0.99	6.61	2	OK	8.50	-	0.49	8.82
7-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.68	2.95	OK	0.33	0.90	6.01	2	OK	8.50	-	0.40	3.60
8-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	8.30	3.66	OK	0.15	0.73	6.06	2	OK	8.50	-	0.27	2.43
9-	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.73	5.28	OK	0.44	0.98	6.59	3	OK	8.50	-	0.47	5.64
10-	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.71	5.26	OK	0.50	1.00	6.71	2.00	OK	8.50	-	0.50	6.00
11-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.68	2.95	OK	0.49	0.99	6.62	2.00	OK	8.50	-	0.49	4.41
12-	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.73	5.28	OK	0.83	1.12	7.53	2.00	OK	8.50	-	0.70	8.40
13-											0.44	0.19	-	6.67	2.94	OK	0.29	0.87	5.80	2.00	OK	8.50	-	0.38	3.42
14-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.69	2.95	OK	0.32	0.89	5.95	2.00	OK	8.50	-	0.40	3.60
15-	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.68	5.24	OK	0.45	0.98	6.55	2.00	OK	8.50	-	0.47	5.64
16-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.69	2.95	OK	0.34	0.91	6.09	2.00	OK	8.50	-	0.41	3.69
17-	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.67	11.79	OK	0.39	0.94	6.27	2.00	OK	8.50	-	0.44	7.92
18-	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.69	21.00	OK	0.50	1.00	6.69	2.00	OK	8.50	-	0.50	12.00
19-	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.70	21.03	OK	0.72	1.09	7.30	2.00	OK	8.50	-	0.63	15.12
20-	0.0981	0.0625	18	x	18	2.25	4.5	0.500	2.348	0.563	-	-	0.78	19.11	44.88	OK	0.04	0.51	9.75	3.00	-	8.50	STEPPED	-	-
21-	0.0981	0.0625	18	x	18	2.25	4.5	0.500	2.348	0.563	-	-	0.37	14.71	34.53	OK	0.02	0.40	5.88	3.00	-	8.50	FALSE	-	-
22-	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.70	21.04	OK	0.83	1.12	7.51	2.00	OK	8.50	-	0.70	16.80
23-	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.70	21.04	OK	0.86	1.12	7.51	2.00	OK	8.50	-	0.72	17.28
24-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	7.30	3.23	OK	0.60	1.04	7.60	2.00	OK	8.50	-	0.56	5.04
25-	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.77	33.23	OK	0.64	1.06	7.18	2	OK	8.50	-	0.59	17.70
26-	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.68	18.28	42.93	OK	0.04	0.51	9.33	3.00	-	8.50	STEPPED	-	-
27-	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.75	33.11	OK	0.70	1.08	7.29	2.00	OK	8.50	-	0.62	18.60
28-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.67	2.95	OK	0.20	0.78	5.20	2.00	OK	8.50	-	0.31	2.79
29-	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.70	32.85	OK	0.73	1.09	7.30	2.00	OK	8.50	-	0.64	19.20
30-	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.48	18.88	44.33	OK	0.03	0.46	8.68	3.00	-	8.50	STEPPED	-	-
31-	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.96	34.14	OK	0.99	1.14	7.93	2.00	OK	8.50	-	0.81	24.30
32-	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.70	2.96	OK	0.14	0.71	4.76	2.00	OK	8.50	-	0.26	2.34
33-	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.70	21.03	OK	0.91	1.13	7.57	2.00	OK	8.50	-	0.75	18.00
	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.70	21.03	OK	0.91	1.13	7.57	2.00	OK	8.50	-	0.75	18.00
34-	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.76	21.22	OK	0.93	1.14	7.70	2.00	OK	8.50	-	0.77	18.48
	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.76	21.22	OK	0.93	1.14	7.70	2.00	OK	8.50	-	0.77	18.48
35-	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.63	14.72	34.56	OK	0.04	0.51	7.51	3.00	-	8.50	FALSE	-	-

S/No	Section	D+Cu/Pipe From	D+Cu/Pipe To	D.Cu/Pipe 'L' (ft)	Cu 'D' (in)	Cir Pipe 'D' (in)	Storm Flow Indivi. (cusec)	Storm Flow Commu.(cusec)	DWF Commu.	Total Flow(DW+WW) (cusec)	Equal Flow Distribution For dual Pipes	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope% or ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Cunette Parameters A (sft)	Cunette Parameters R=D/8 (ft)	Storm Drain Size b (in)	×	Storm Drain Size d (in)	Drain Area (sft)	Drain Wetted Perimeter (ft)	Hydraulic Radius Drain = A/P (ft)	Total Area D+Cu (sft)	Total Rh D+Cu (ft)	Circular Pipe A (sft)	Circular Pipe R=D/4 (ft)	Vact	Vf	Qf	Q < Qf	Remarks from Hydraulic Table $\frac{Q}{Qf}$	$\frac{V}{Vf}$	V	Min Speci. Vel	Final Vel check	Max Speci. Vel	Stepped or Not	$\frac{d}{D}$	Flow 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)		(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)	(an)	(ao)	(ap)
36-	R-15	B38.1	B39	221	6	-	1.39	2.83	£0.0451	2.88	-	1430.66	1428.65	1427.4	1422.5	2.22	3.26	6.15	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.23	11.60	27.23	OK	0.11	0.67	7.77	3.00	-	8.50	FALSE	-	-
		Drop MH													1414.35																												
37-	R-14	B39	B41	160	-	24	0.87	44.01	£0.4469	44.46	22.23	1428.65	1425.78	1414.35	1412.75	0.0100	14.3	13.03	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	7.20	22.61	OK	0.98	1.14	8.21	2.00	OK	8.50	-	0.80	19.20
					-	24					22.23	1428.65	1425.78	1414.35	1412.75	0.0100	14.3	13.03	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	7.20	22.61	OK	0.98	1.14	8.21	3.00	OK	8.50	-	0.80	19.20
38-	R-17	B40.1	B40.2	112	6	-	0.69	0.69	£0.0083	0.69	-	1427.2	1420.99	1424.2	1415.5	7.77	3	5.49	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.30	21.71	50.98	OK	0.01	0.30	6.51	3.00	-	8.50	FALSE	-	-
		Drop MH													1413.8																												
39-	R-17	B40.3	B40.4	175	-	9	0.94	0.94	0.0117	0.95	-	1426.15	1421.06	1422.15	1416.6	0.0317	4	4.46	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.67	2.94	OK	0.32	0.89	5.94	2.00	OK	8.50	-	0.40	3.60
40-	R-17	B40.4	B40.2	88	-	9	0.49	1.42	0.0167	1.44	-	1421.06	1420.99	1416.6	1413.8	0.0318	4.46	7.19	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.68	2.95	OK	0.49	0.99	6.61	2.00	OK	8.50	-	0.49	4.41
41-	R-18	B40.2	B42.1	220	-	12	1.35	4.40	0.0451	4.45	-	1420.99	1411.74	1413.8	1407.7	0.0277	7.19	4.04	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	7.55	5.93	OK	0.75	1.10	8.31	2.00	OK	8.50	-	0.65	7.80
42-	R-18	B42.1	B43.5	186	-	12	1.19	5.59	0.0651	5.66	-	1411.74	1407.17	1407.7	1403	0.0253	4.04	4.17	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	7.21	5.66	OK	1.00	1.14	8.22	2.00	OK	8.50	-	0.82	9.84
43-	R-19	B45	B45.1	137	6	-	1.14	1.14	0.0184	1.16	-	1423.06	1418.36	1420.06	1414	4.42	3	4.36	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.49	16.38	38.47	OK	0.03	0.46	7.54	3.00	-	8.50	FALSE	-	-
44-	R-19	B45.1	B46.1	161	6	-	0.97	2.10	0.0334	2.14	-	1418.36	1412.01	1414	1408	3.73	4.36	4.01	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.91	15.04	35.31	OK	0.06	0.55	8.27	3.00	-	8.50	FALSE	-	-
		Drop MH													1407.85																												
45-	R-20	B46	B46.1	111	-	9	0.66	0.66	0.0083	0.66	-	1415.4	1412.01	1411.4	1407.85	0.0320	4	4.16	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.70	2.96	OK	0.22	0.80	5.36	2.00	OK	8.5	-	0.33	2.97
46-	R-20	B46.1	B43.5	129	-	9	0.68	1.34	0.0501	1.39	-	1412.01	1407.17	1407.85	1403	0.0376	4.16	4.17	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	7.26	3.21	OK	0.43	0.97	7.04	2.00	OK	8.5	-	0.46	4.14
47-	R-20	B43.5	B43.1	90	6	-	0.44	9.47	0.1202	9.59	-	1407.17	1405.44	1403	1401.95	1.17	4.17	3.49	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	4.08	8.41	19.76	OK	0.49	0.99	8.33	3.00	-	8.50	FALSE	-	-
		Drop MH													1399																												
48-	R-20	B44	B44.4	121	6	-	2.55	2.55	0.0100	2.56	-	1415.07	1407.18	1412.07	1402.65	7.79	3	4.53	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.09	21.73	51.03	OK	0.05	0.53	11.52	3.00	-	8.50	STEPPED	-	-
49-	R-20	B44.4	B43.1	75	6	-	2.20	4.74	0.0150	4.76	-	1407.18	1405.44	1402.65	1399	4.87	4.53	6.44	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	2.03	17.18	40.35	OK	0.12	0.69	11.86	3.00	-	8.50	STEPPED	-	-
50-	Link R20 & R21	B43.1	B43.2	105	6	-	0.07	14.28	0.1352	14.42	-	1405.44	1401.02	1399	1397.7	1.24	6.44	3.32	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	6.14	8.67	20.35	OK	0.71	1.08	9.36	3.00	-	8.50	STEPPED	-	-
51-	R-20	B43.2	B43.3	26	6	-	0.00	14.28	0.1352	14.42	-	1401.02	1400.86	1397.7	1397.3	1.54	3.32	3.56	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	6.14	9.66	22.69	OK	0.64	1.06	10.24	3.00	-	8.50	STEPPED	-	-
		Drop MH													1396.3																												
52-	R-21	B48	B48.1	153	6	-	1.35	1.35	0.0217	1.37	-	1414.23	1404.51	1410.75	1401.03	6.35	3.48	3.48	0.0981	0.0625	18	x	18	2.25	4.5	0.50	2.348	0.563	-	-	0.58	19.63	46.10	OK	0.03	0.46	9.03	3.00	-	8.50	STEPPED	-	-
53-	R-21	B48.1	B43.3	125	6	-	0.95	2.30	0.0367	2.34	-	1404.51	1400.86	1401.03	1396.3	3.78	3.48	4.56	0.0981	0.0625	18	x	18	2.25	4.5	0.50	2.348	0.563	-	-	1.00	15.15	35.58	OK	0.07	0.59	8.94	3.00	-	8.50	STEPPED	-	-
54-	R-21	B49.1	B43.3	309	6	-	2.53	2.53	0.0417	2.58	-	1407.32	1400.86	1403.8	1396.3	2.43	3.52	4.56	0.0981	0.0625	18	x	18	2.25	4.5	0.50	2.348	0.563	-	-	1.10	12.14	28.49	OK	0.09	0.63	7.65	3.00	-	8.50	FALSE	-	-
	Link R21 & R14	B43.3	B41.1	107	6	-	0.07	19.18	0.2137	19.40	-	1400.86	1400.14	1396.3	1394.7	1.50	4.56	5.44	0.0981	0.0625	18	x	18	2.25	4.5	0.50	2.348	0.563	-	-	8.26	9.52	22.37	OK	0.87	1.12	10.67	3.00	-	8.50	STEPPED	-	-
55-	R-14	B41	B47	240	9	-	1.83	45.84	0.4736	46.31	-	1425.78	1413.34	1412.75	1410.34	1.00	13.03	3	0.2208	0.0938	30	x	30	6.25	7.5	0.83	6.471	0.927	-	-	7.16	10.89	70.47	OK	0.66	1.07	11.65	3.00	-	8.50	STEPPED	-	-
56-	R-14	B47	B49	130	9	-	1.33	47.17	0.4736	47.65	-	1413.34	1405.37	1410.34	1402.37	6.13	3	3	0.2208	0.0938	18	x	18	2.25	4.5	0.50	2.471	0.594	-	-	19.28	19.99	49.40	OK	0.96	1.14	22.79	3.00	-	8.50	STEPPED	-	-
57-	R-14	B49	B50	111	9	-	0.73	47.90	0.4736	48.38	-	1405.37	1400.68	1402.37	1397	4.84	3	3.68	0.2208	0.0938	24	x	24	4	6	0.67	4.221	0.760	-	-	11.46	20.95	88.41	OK	0.55	1.02	21.36	3.00	-	8.50	STEPPED	-	-
58-	R-14	B50	B51	185	9	-	1.45	49.36	0.4803	49.84	-	1400.68	1398.56	1397	1395	1.08	3.68	3.56	0.2208	0.0938	30	x	30	6.25	7.5	0.83	6.471	0.927	-	-	7.70	11.30	73.12	OK	0.68	1.07	12.09	3.00	-	8.50	STEPPED	-	-
		Drop MH													1393.8																												
59-	R-16	B36.1	B36.2	269	6	-	1.48	1.48	0.0184	1.50	-	1443.64	1427.17	1440.2	1423.73	6.12	3.44	3.44	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.64	19.27	45.26	OK	0.03	0.46	8.87	3.00	-	8.50	STEPPED	-	-
60-	R-16	B36.2	B36.3	220	6	-	1.12	2.60	0.0317	2.63	-	1427.17	1418.98	1423.73	1414.95	3.99	3.44	4.03	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.12	15.56	36.54	OK	0.07	0.59	9.18	3.00	-	8.50	STEPPED	-	-
61-	R-16	B36.3	B37	508	-	18	2.73	5.33	0.0634	5.39	-	1418.98	1414.74	1414.95	1408.55	0.0126	4.03	6.19	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.67	11.78	OK	0.46	0.98	6.54	2.00	OK	8.50	-	0.48	8.64
62-	MR-01	B34	B34.1	246	-	9	0.71	0.71	0.0184	0.73	-	1441.74	1438.79	1437.74	1429.9	0.0319	4	8.89	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.68	2.95	OK	0.25	0.84	5.62	2.00	OK	8.50	-	0.35	3.15
63-	MR-01	B34.2	B34.1	130	-	9	0.41	0.41	0.0017	0.41	-	1438.79	1438.79	1434.79	1430.65	0.0318	4	8.14	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.68	2.95	OK	0.14	0.71	4.74	2.00	OK	8.50	-	0.26	2.34
		Drop MH													1429.9																												
64-	MR-01	B34.1	B34.3	204	-	9	0.64	1.76	0.0351	1.79	-	1438.79	1430.26	1429.9	1423.4	0.0319	8.89	6.86	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.68	2.95	OK	0.61	1.05	7.02	2.00	OK	8.50	-	0.57	5.13
65-	MR-01	B34.3	B34.4	250	-	9	0.57	2.33	0.0484	2.37	-	1430.26	1422.76	1423.4	1417.9	0.0220	6.86	4.86	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	5.55	2.45	OK	0.97	1.14	6.33	2.00	OK	8.50	-	0.80	7.20
66-	MR-01	B34.4	B34.5	200	-	12	0.57	2.89	0.0618	2.95	-	1422.76	1418.64	1417.9	1413.55	0.0218	4.86	5.09	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.69	5.25	OK	0.56	1.03	6.89	2.00	OK	8.50	-	0.54	6.48
67-	MR-01	B34.5	B35	134	-	12	0.21	3.10	0.0668	3.17	-	1418.64	1414.58	1413.55	1410.5	0.0228	5.09	4.08	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.84	5.37	OK	0.59	1.04	7.12	2.00	OK	8.50	-	0.56	6.72
68-	R-14	B35	B37	125	-	18	0.51	3.62	0.0668	3.68	-	1414.58	1414.74	1410.5	1408.55	0.0156	4.08	6.19	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	7.42	13.11	OK	0.28	0.86	6.38	2.00	OK	8.50	-	0.37	6.66
69-	R-14	B37	B43	100	-	18	0.51	9.45	0.1336	9.59	-	1414.74	1411	1408.55	1406.95	0.0160	6.19	4.05	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	7.52	13.28	OK	0.72	1.09	8.20	2.00	OK	8.50	-	0.63	11.34
70-	R-14	B43	B42	150	6	-	1.19	10.64	0.1486	10.79	-	1411	1404.14	1406.95	1401.14	3.87	4.05	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	4.59	15.33	36.00	OK	0.30	0.88	13.49	3.00	-	8.50	STEPPED	-	-
71-	R-14	B42	B41.1	143	6	-	1.23	11.87	0.1653	12.03	-	1404.14	1400.14	1401.14	1395.7	3.80	3	4.44	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	5.13	15.19	35.67	OK	0.34	0.91	13.82	3.00	-	8.50	STEPPED	-	-
		Drop MH													1394.7																												
72-	R-14	B41.1	B51	157	9	-	0.64	31.70	0.3806	32.08	-	1400.14	1398.56	1394.7	1393.8	0.57325	5.44	4.76	0.2208	0.0938	30	x	30	6.25	7.5	0.83	6.471	0.927	-	-	4.96	8.23	53.25	OK	0.60	1.04	8.56	3.00	-	8.50	STEPPED	-	-
73-	TO STP	B51	STP-2	162	9	-	0.00	81.05	0.8609	**81.92**	-	1398.56	1396	1393.8	1389.35	2.74691	4.76	6.65	0.2208	0.0938	30	x	30	6.25	7.5	0.83	6.471	0.927	-	-	12.66	18.01	116.56	OK	0.70	1.08	19.45	3.00	-	8.50	STEPPED	-	-

Table D6: Hydraulic Design Sheet of Dry weather & Wet weather Flow jointly in Combined Sewer System (Zone-1).

S/No	Section	D+Cu/Pipe From	D+Cu/Pipe To	D.Cu/Pipe 'L' (ft)	Cu 'D' (in)	Cir Pipe 'D' (in)	Storm Flow Indivi. (cusec)	Storm Flow Commu.(cusec)	DWF Commu.	Total Flow(DW+WW) (cusec)	Equal Flow Distribution For dual Pipes	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope% or ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Cunette Parameters A (sft)	Cunette Parameters R=D/8 (ft)	Storm Drain Size b (in)	×	Storm Drain Size d (in)	Drain Area (sft)	Drain Wetted Perimeter (ft)	Hydraulic Radius Drain = A/P (ft)	Total Area D+Cu (sft)	Total Rh D+Cu (ft)	Circular Pipe A (sft)	Circular Pipe R=D/4 (ft)	Vact	Vf	Qf	Q < Qf	Remarks from Hydraulic Table $\frac{Q}{Qf}$	Remarks from Hydraulic Table $\frac{V}{Vf}$	Remarks from Hydraulic Table V	Min Speci. Vel	Final Vel check	Max Speci. Vel	Stepped or Not	$\frac{d}{D}$	Flow 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)		(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)	(an)	(ao)	(ap)
1-	R-34	A1	A1.1	100	6	-	0.44	0.44	0.0183	0.46	-	1485.12	1477.59	1482.12	1474.4	7.72	3	3.19	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.19	21.64	50.82	OK	0.01	0.30	6.49	3.00	-	8.50	FALSE	-	-
2-	R-34	A1.1	A4	114	6	-	0.38	0.82	0.0366	0.86	-	1477.59	1474.54	1474.4	1469.35	4.43	3.19	5.19	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.37	16.39	38.50	OK	0.02	0.40	6.56	3.00	-	8.50	FALSE	-	-
3-	R-35	A4	A5	210	6	-	2.52	3.34	0.0732	3.41	-	1474.54	1468	1469.35	1463.75	2.67	5.19	4.25	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.45	12.72	29.87	OK	0.11	0.67	8.52	3.00	-	8.50	STEPPED	-	-
4-	R-36	A6	A7	199	6	-	0.77	0.77	0.0183	0.79	-	1485.12	1479.99	1482.12	1473.3	4.43	3	6.69	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.34	16.40	38.51	OK	0.02	0.40	6.56	3.00	-	8.50	FALSE	-	-
5-	R-32	A7	A7.1	80	6	-	0.35	1.12	0.0274	1.15	-	1479.99	1473.41	1473.3	1470.41	3.61	6.69	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.49	14.80	34.76	OK	0.03	0.46	6.81	3.00	-	8.50	FALSE	-	-
6-	R-32	A7.1	A7.2	100	6	-	0.35	1.47	0.0366	1.51	-	1473.41	1468.49	1470.41	1465.49	4.92	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.64	17.28	40.57	OK	0.04	0.51	8.81	3.00	-	8.50	STEPPED	-	-
7-	R-32	A7.2	A5	69	6	-	0.16	1.63	0.0366	1.67	-	1468.49	1468	1465.49	1463.75	2.52	3	4.25	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.71	12.37	29.04	OK	0.06	0.55	6.80	3.00	-	8.50	FALSE	-	-
8-	R-32	A5	A3	224	6	-	2.07	7.04	0.1280	7.17	-	1468	1465.89	1463.75	1461	1.23	4.25	4.89	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	3.05	8.63	20.27	OK	0.35	0.92	7.94	3.00	-	8.50	FALSE	-	-
9-	R-34	A4.1	A1.2	155	6	-	0.58	0.58	0.0000	0.58	-	1474.54	1471.8	1472.46	1469.72	1.77	2.08	2.08	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.25	10.36	24.32	OK	0.02	0.40	4.14	3.00	-	8.50	FALSE	-	-
10-	R-34	A1.4	A1.3	116	6	-	0.35	0.35	0.0000	0.35	-	1480.2	1472.14	1478.12	1470.06	6.95	2.08	2.08	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.15	20.53	48.21	OK	0.01	0.30	6.16	3.00	-	8.50	FALSE	-	-
11-	R-34	A1.3	A1.2	26	6	-	0.07	0.42	0.0000	0.42	-	1472.14	1471.8	1470.06	1469.72	1.31	2.08	2.08	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.18	8.91	20.92	OK	0.02	0.40	3.56	3.00	-	8.50	FALSE	-	-
12-	R-33	A1.2	A2	66	6	-	0.25	1.25	0.0000	1.25	-	1471.8	1472.1	1469.72	1469.3	0.64	2.08	2.8	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.53	6.21	14.59	OK	0.09	0.63	3.91	3.00	-	8.50	FALSE	-	-
		Drop MH													1468.6																											-	-
13-	R-33	A2	A2.1	84	6	-	0.78	2.03	0.0183	2.05	-	1472.1	1467.43	1468.6	1464.2	5.24	3.5	3.23	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.87	17.83	41.86	OK	0.05	0.53	9.45	3.00	-	8.50	STEPPED	-	-
14-	R-33	A2.1	A3	102	6	-	0.48	2.52	0.0274	2.54	-	1467.43	1465.89	1464.2	1461	3.14	3.23	4.89	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.08	13.80	32.40	OK	0.08	0.61	8.42	3.00	-	8.50	FALSE	-	-
15-	R-32	A3	A9	163	6	-	0.60	10.15	0.1554	10.31	-	1465.89	1466.46	1461	1459.3	1.04	4.89	7.16	0.2208	0.0938	18	x	18	2.25	4.5	0.5	2.471	0.594	-	-	4.17	8.25	20.38	OK	0.51	1.01	8.33	3.00	-	8.50	FALSE	-	-
16-	MR-01	A8	A9	130	6	-	0.00	0.00	0.0072	0.01	-	1474.22	1466.46	1471.22	1460.75	8.05	3	5.71	0.2208	0.0938	18	x	18	2.25	4.5	0.5	2.471	0.594	-	-	0.00	22.92	56.62	OK	0.00	0.30	6.87	3.00	-	8.50	FALSE	-	-
		Drop MH													1459.3																												
17-	MR-01	A9	A10	160	6	-	0.00	10.15	0.1626	10.32	-	1466.46	1456	1459.3	1453	3.94	7.16	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	4.39	15.46	36.29	OK	0.28	0.86	13.29	3.00	-	8.50	STEPPED	-	-
		Drop MH													1448.25																												
		Drop MH													1441.15																												
18-	R-31	A14	A10	218	-	12	3.88	3.88	0.0358	3.91	-	1456.97	1456	1452.5	1448.25	0.0195	4.47	7.75	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.33	4.97	OK	0.79	1.10	6.97	2.00	OK	8.50	-	0.67	8.04
19-	MR-01	A10	A11	209	-	24	0.19	14.23	0.2167	14.44	-	1456	1442.23	1441.15	1438.23	0.0140	14.85	4	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	8.51	26.73	OK	0.54	1.02	8.68	2.00	OK	8.50	-	0.53	12.72
		Drop MH													1430.9																												
		Drop MH													1425.8																												
20-	R-30	A20	A11	373	-	12	2.22	2.22	0.0732	2.30	-	1442.96	1442.23	1438.96	1430.9	0.0216	4	11.33	-	-	-	-	-	-	-	-	-	-	0.79	0.25	-	6.67	5.23	OK	0.44	0.98	6.53	2.00	OK	8.50	-	0.47	5.64
21-	MR-01	A11	A11.1	230	-	24	0.19	16.64	0.3082	16.95	-	1442.23	1426.64	1425.8	1422.64	0.0137	16.43	4	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	8.44	26.50	OK	0.64	1.06	8.95	2.00	OK	8.50	-	0.59	14.16
22-	WW-06	A25	A23.1	222	6	-	1.03	1.03	0.0366	1.07	-	1436.99	1421.28	1433.99	1418	7.20	3	3.28	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.46	20.90	49.09	OK	0.02	0.40	8.36	3.00	-	8.50	FALSE	-	-
		Drop MH													1416.9																												
23-	R-29	A23	A23.1	91		9	0.34	0.34	0.0183	0.35	-	1423.81	1421.28	1419.81	1416.9	0.0320	4	4.38	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	6.70	2.96	OK	0.12	0.69	4.62	2.00	OK	8.50	-	0.24	2.16
24-	R-29	A23.1	A23.2	81		9	0.74	2.11	0.0640	2.17	-	1421.28	1417.02	1416.9	1413	0.0481	4.38	4.02	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	8.22	3.63	OK	0.60	1.04	8.55	2.00	OK	8.50	-	0.56	5.04
25-	R-29	A23.2	A23.3	170	6	-	2.04	4.15	0.0914	4.24	-	1417.02	1404.16	1413	1401.16	6.67	4.02	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.81	20.12	47.24	OK	0.09	0.63	12.67	3.00	-	8.50	STEPPED	-	-
26-	G, b/w R28 & R29	A23.3	A26	247	6	-	1.41	5.56	0.1097	5.67	-	1404.16	1395.19	1401.16	1392.19	3.63	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	2.42	14.84	34.85	OK	0.16	0.74	10.98	3.00	-	8.50	STEPPED	-	-
		Drop MH													1391.19																												
27-	R-28	A26	A28	126	-	18	0.90	6.46	0.1189	6.58	-	1395.19	1398.96	1391.19	1389.6	0.0126	4	9.36	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.6774	11.794	OK	0.558	1.03	6.8778	2	OK	8.50	-	0.54	9.72
28-	WW-03	A27	A28	211	6	-	0.81	0.81	0.0183	0.82	-	1418.3	1398.96	1413.8	1395.2	8.82	4.5	3.76	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.35	23.13	54.30	OK	0.02	0.40	9.25	3.00	-	8.50	STEPPED	-	-
		Drop MH													1389.6																												
		Drop MH													1386.9																												
29-	MR-01	A11.1	A12	246	6	-	0.19	16.83	0.3264	17.16	-	1426.64	1411.73	1422.64	1407.6	6.11	4	4.13	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	7.31	19.26	45.22	OK	0.38	0.95	18.30	3.00	-	8.50	STEPPED	-	-
30-	BL10 & MR-01	A31.6	A31	207	6	-	0.64	0.64	0.0274	0.67	-	1470	1463.92	1467	1460.5	3.14	3	3.42	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.28	13.80	32.41	OK	0.02	0.40	5.52	3.00	-	8.50	FALSE	-	-
31-	R-37	A31	A31.1	108	6	-	1.44	2.09	0.0366	2.12	-	1463.92	1457.04	1460.5	1454.04	5.98	3.42	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.90	19.05	44.73	OK	0.05	0.53	10.10	3.00	-	8.50	STEPPED	-	-
32-	R-37	A31.1	A31.2	65	6	-	0.91	3.00	0.0457	3.04	-	1457.04	1453.73	1454.04	1450.73	5.09	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.30	17.58	41.27	OK	0.07	0.59	10.37	3.00	-	8.50	STEPPED	-	-
33-	R-37	A31.2	A33	78	6	-	0.41	3.41	0.0457	3.45	-	1453.73	1453.56	1450.73	1449	2.22	3	4.56	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.47	11.60	27.24	OK	0.13	0.70	8.12	3.00	-	8.50	FALSE	-	-
34-	R-38	A32	A34.1	112	6	-	0.91	0.91	0.0366	0.95	-	1462.97	1456.61	1459.97	1452.85	6.36	3	3.76	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.40	19.64	46.12	OK	0.02	0.40	7.86	3.00	-	8.50	FALSE	-	-
35-	Trough BL11	A34	A34.1	81	6	-	0.63	0.63	0.0366	0.67	-	1460	1456.61	1457	1452.85	2.55	3	3.76	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.28	12.43	29.18	OK	0.02	0.40	4.97	3.00	-	8.50	FALSE	-	-
36-	R-38	A34.1	A33	23	6	-	0.40	1.94	0.1006	2.04	-	1456.61	1453.56	1452.85	1449	4.75	3.76	4.56	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.87	16.98	39.87	OK	0.05	0.53	9.00	3.00	-	8.50	STEPPED	-	-
37-	R-37	A33	A39	128	6	-	0.00	1.94	0.1463	2.09	-	1453.56	1453	1449	1448.7	1.30	4.56	4.3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.89	8.90	20.89	OK	0.10	0.65	5.78	3.00	-	8.50	FALSE	-	-
38-	R-37	A31.5	A31.4	48	6	-	0.95	0.95	0.0000	0.95	-	1461.74	1455.27	1459.66	1453.19	5.05	2.08	2.08	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.40	17.51	41.12	OK	0.02	0.40	7.00	3.00	-	8.50	FALSE	-	-
39-	R-37	A31.4	A39				0.44	1.39	0.0000	1.39	-	1455.27	1453	1453.19	1450.92	4.73	2.08	2.08	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.59	16.94	39.77	OK	0.03	0.46	7.79	3.00	-	8.50	FALSE	-	-
		Drop MH													1448.7																												
		Drop MH													1444.2																												

S/No	Section	D+Cu/Pipe From	D+Cu/Pipe To	D.Cu/Pipe 'L' (ft)	Cu 'D' (in)	Cir Pipe 'D' (in)	Storm Flow Indivi. (cusec)	Storm Flow Commu.(cusec)	DWF Commu.	Total Flow(DW+WW) (cusec)	Equal Flow Distribution For dual Pipes	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope% or ft/ft	Cover E-1 (ft)	Cover E-2 (ft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)
40-		A40	A39	143	-	18	0.63	7.36	0.0183	7.38	-	1450	1453	1446	1444.2	0.0126	4	8.8
41-	Green BL-12	A39	A39.1	131	-	18	0.53	7.89	0.1737	8.07	-	1453	1445	1444.2	1441	0.0244	8.8	4
42-		A39.1	A39.2	232	-	18	0.64	8.53	0.2012	8.73	-	1445	1450.13	1441	1438.05	0.0127	4	12.08
		Drop MH													1436.05			
43-		A39.2	A39.3	212	-	18	0.87	9.40	0.2195	9.62	-	1450.13	1435.75	1436.05	1431.75	0.0203	14.08	4
44-	MR-01	A39.3	A39.4	353	6	-	0.68	10.08	0.2195	10.30	-	1435.75	1412.27	1431.75	1409.27	6.37	4	3
45-		A39.4	A12	82	6	-	0.00	10.08	0.2195	10.30	-	1412.27	1411.73	1409.27	1407.6	2.04	3	4.13

S/No	Cunette Parameters A (sft)	Cunette Parameters R=D/8 (ft)	Storm Drain Size b (in)	×	Storm Drain Size d (in)	Drain Area (sft)	Drain Wetted Perimeter (ft)	Hydraulic Radius Drain = A/P (ft)	Total Area D+Cu (sft)	Total Rh D+Cu (ft)	Circular Pipe A (sft)	Circular Pipe R=D/4 (ft)	Vact	Vf	Qf	Q < Qf	Remarks from Hydraulic Table $\frac{Q}{Qf}$	Remarks from Hydraulic Table $\frac{V}{Vf}$	Remarks from Hydraulic Table V	Min Speci. Vel	Final Vel check	Max Speci. Vel	Stepped or Not	$\frac{d}{D}$	Flow 'd' (inch)
	(s)	(t)	(u)		(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)	(an)	(ao)	(ap)
40-	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.67	11.78	OK	0.63	1.05	7.00	2.00	OK	8.50	-	0.58	10.44
41-	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	9.29	16.41	OK	0.49	0.99	9.20	2.00	OK	8.50	-	0.49	8.82
42-	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.70	11.84	OK	0.74	1.09	7.31	2.00	OK	8.50	-	0.64	11.52
43-	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	8.47	14.95	OK	0.64	1.06	8.97	2.00	OK	8.50	-	0.59	10.62
44-	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	4.39	19.66	46.16	OK	0.22	0.80	15.73	3.00	-	8.50	STEPPED	-	-
45-	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	4.39	11.12	26.10	OK	0.39	0.94	10.45	3.00	-	8.50	STEPPED	-	-

Table D7: Hydraulic Design Sheet of Dry weather & Wet weather Flow jointly in Combined Sewer System (Zone-3).

S/No	Section	D+Cu/Pipe From	D+Cu/Pipe To	D.Cu/Pipe 'L' (ft)	Cu 'D' (in)	Cir Pipe 'D' (in)	Storm Flow Indivi. (cusec)	Storm Flow Commu.(cusec)	DWF Commu.	Total Flow(DW+WW) (cusec)	Equal Flow Distribution For dual Pipes	FRL AT E-1 (ft)	FRL AT E-2 (ft)	I.L (ft) E-1 (ft)	I.L (ft) E-2 (ft)	Slope% or ft/ft	Cover E-1 (ft)	Cover E-2 (ft)	Cunette Parameters A (sft)	Cunette Parameters R=D/8 (ft)	Storm Drain Size b (in)	×	Storm Drain Size d (in)	Drain Area (sft)	Drain Wetted Perimeter (ft)	Hydraulic Radius Drain = A/P (ft)	Total Area D+Cu (sft)	Total Rh D+Cu (ft)	Circular Pipe A (sft)	Circular Pipe R=D/4 (ft)	Vact	Vf	Qf	Q < Qf	Remarks from Hydraulic Table $\frac{Q}{Qf}$	Remarks from Hydraulic Table $\frac{V}{Vf}$	Remarks from Hydraulic Table V	Min Speci Vel	Final Vel check	Max Speci Vel	Stepped or Not	$\frac{d}{D}$	Flow 'd' (inch)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)		(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)	(an)	(ao)	(ap)
1-	BL-17	C1	C2	73	6	-	0.42	0.42	0.0274	0.44	-	1490	1488	1487	1484.7	3.15	3	3.3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.19	13.83	32.46	OK	0.01	0.30	4.15	3.00	-	8.50	FALSE	-	-
2-		C2	C3	128	6	-	0.54	0.96	0.0457	1.00	-	1488	1480	1484.7	1477	6.02	3.3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.43	19.10	44.86	OK	0.02	0.40	7.64	3.00	-	8.50	FALSE	-	-
		Drop MH													1474.7																												
3-	C.C	C3.1	C3	135	6	-	0.15	0.15	0.0664	0.21	-	1480	1480	1477	1474.7	1.70	3	5.3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.09	10.17	23.87	OK	0.01	0.30	3.05	3.00	-	8.50	FALSE	-	-
4-	R-22	C3	C4	118	6	-	0.62	1.73	0.1304	1.86	-	1480	1487.5	1474.7	1473.35	1.14	5.3	14.15	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.79	8.33	19.56	OK	0.10	0.63	5.25	3.00	-	8.50	FALSE	-	-
5-		C1.1	C2.1	45	6	-	0.22	0.22	0.0091	0.23	-	1495.98	1495.25	1492.98	1489.45	7.84	3	5.8	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.10	21.82	51.23	OK	0.00	0.30	6.54	3.00	-	8.50	FALSE	-	-
6-	R-23	C2.1	C3.2	50	6	-	0.43	0.65	0.0274	0.68	-	1495.25	1493.18	1489.45	1487.75	3.40	5.8	5.43	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.29	14.36	33.72	OK	0.02	0.40	5.74	3.00	-	8.50	FALSE	-	-
7-		C3.2	C4	110	6	-	0.47	1.12	0.0457	1.17	-	1493.18	1487.5	1487.75	1484.5	2.95	5.43	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.50	13.39	31.44	OK	0.04	0.51	6.83	3.00	-	8.50	FALSE	-	-
		Drop MH													1473.35																												
8-	R-23	C5.4	C5.1	35	6	-	0.14	0.14	0.0000	0.14	-	1496.06	1495.97	1493.98	1493.7	0.80	2.08	2.27	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.06	6.97	16.36	OK	0.01	0.30	2.09	3.00	-	8.50	FALSE	-	-
9-		C5.1	C5.2	46	6	-	0.34	0.34	0.0000	0.34	-	1495.97	1493.9	1493.7	1491.32	5.17	2.27	2.58	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.14	17.72	41.60	OK	0.01	0.30	5.32	3.00	-	8.50	FALSE	-	-
		Drop MH													1490.9																												
10-	R-23	C5.2	C5.3	50	6	-	0.44	0.78	0.0183	0.80	-	1493.9	1491.08	1490.9	1488.08	5.64	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.34	18.50	43.44	OK	0.02	0.40	7.40	3.00	-	8.50	FALSE	-	-
11-		C5.3	C6	133	6	-	1.41	2.19	0.0366	2.23	-	1491.08	1486.25	1488.08	1483.25	3.63	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.95	14.84	34.85	OK	0.06	0.55	8.16	3.00	-	8.50	FALSE	-	-
12-	R-22	C7	C10.1	118	6	-	1.55	1.55	0.0000	1.55	-	1504.23	1498.01	1502.15	1495.43	5.69	2.08	2.58	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.66	18.59	43.65	OK	0.04	0.51	9.48	3.00	-	8.50	STEPPED	-	-
		Drop MH													1495.01																												
13-		C10.1	C6	226	6	-	0.98	4.72	0.0274	4.75	-	1498.01	1486.25	1495.01	1483.25	5.20	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	2.02	17.77	41.72	OK	0.11	0.67	11.90	3.00	-	8.50	STEPPED	-	-
14-	R-22	C6	C8	190	6	-	0.89	5.61	0.0366	5.65	-	1486.25	1481.91	1483.25	1478.4	2.55	3	3.51	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	2.41	12.44	29.22	OK	0.19	0.77	9.58	3.00	-	8.50	STEPPED	-	-
15-		C8	C8.1	70	6	-	1.14	6.75	0.0823	6.83	-	1481.91	1480.2	1478.4	1477.2	1.71	3.51	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	2.91	10.20	23.95	OK	0.29	0.87	8.87	3.00	-	8.50	STEPPED	-	-
		Drop MH													1472.15																												
16-	R22, R23	C4	C8.1	228	-	18	0.60	3.45	0.1853	3.63	-	1487.5	1480.2	1473.8	1472.15	0.0072	13.7	8.05	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	5.06	8.93	OK	0.41	0.95	4.80	2.00	OK	8.50	-	0.45	8.10
		Drop MH													1468.4																												
17-	R22 & BL-14	C8.1	C9	216	-	18	0.10	10.30	0.1944	10.49	-	1480.2	1468	1468.4	1464	0.0204	11.8	4	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	8.48	14.98	OK	0.70	1.08	9.16	2.00	OK	8.50	-	0.62	11.16
18-	BL14 & BL13	C9	C9.1	324	9	-	1.32	11.61	0.3042	11.92	-	1468	1460	1464	1457	2.16	4	3	0.2208	0.0938	18	x	18	2.25	4.5	0.5	2.471	0.594	-	-	4.82	11.87	29.33	OK	0.41	0.95	11.28	3.00	-	8.50	STEPPED	-	-
19-	BL-13	C9.1	C15.2	128	6	-	0.45	12.07	0.3316	12.40	-	1460	1450	1457	1447	7.81	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	5.28	21.77	51.12	OK	0.24	0.83	18.07	3.00	-	8.50	STEPPED	-	-
20-		C15.2	C15.3	104	6	-	0.58	12.64	0.3427	12.99	-	1450	1450	1447	1443	3.85	3	7	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	5.53	15.28	35.87	OK	0.36	0.92	14.05	3.00	-	8.50	STEPPED	-	-
21-	GREEN	C15.3	C15.4	98	6	-	0.00	12.64	0.3427	12.99	-	1450	1438	1443	1435	8.16	7	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	5.53	22.25	52.26	OK	0.25	0.84	18.69	3.00	-	8.50	STEPPED	-	-
22-		C15.4	C15.5	83	6	-	0.59	13.23	0.3427	13.57	-	1438	1435	1435	1431.85	3.80	3	3.15	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	5.78	15.17	35.63	OK	0.38	0.93	14.11	3.00	-	8.50	STEPPED	-	-
23-		C15.5	C14.2.1	317	6	-	2.01	15.24	0.3427	15.58	-	1435	1410	1431.85	1407	7.84	3.15	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	6.64	21.81	51.21	OK	0.30	0.88	19.19	3.00	-	8.50	STEPPED	-	-
24-	Green & MR-01	C14.2.1	C14.3	140	6	-	0.00	15.24	0.3427	15.58	-	1410	1408.13	1407	1401.7	3.79	3	6.43	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	6.64	15.16	35.59	OK	0.44	0.98	14.85	3.00	-	8.50	STEPPED	-	-
		Drop MH													1401																												
25-	MR-01	C14.3	C34.1	83	-	24	0.00	15.24	0.3427	15.58	-	1408.13	1408.13	1401	1400.55	0.0054	7.13	7.58	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	5.30	16.65	OK	0.94	1.14	6.04	2.00	OK	8.50	-	0.77	18.48
		Drop MH													1389.8																												
26-	BL14 & Green	C18	C5	126	-	9	0.00	0.00	0.0072	0.01	-	1475	1470	1471	1466	0.0397	4	4	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	7.46	3.29	OK	0.00	0.30	2.24	2.00	OK	8.50	-	0.07	0.63
		Drop MH													1457.55																												
27-	BL14 & Green	C5	C15	225	-	9	1.07	1.07	0.0346	1.10	-	1470	1450	1457.55	1446	0.0513	12.45	4	-	-	-	-	-	-	-	-	-	-	0.44	0.19	-	8.48	3.75	OK	0.29	0.87	7.38	2.00	OK	8.50	-	0.38	3.42
28-		C15	C16	139	6	-	0.55	1.62	0.0346	1.65	-	1450	1440	1446	1437	6.47	4	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	0.70	19.82	46.54	OK	0.04	0.51	10.11	3.00	-	8.50	STEPPED	-	-
29-	GREEN	C16	C17	215	6	-	1.85	3.46	0.0346	3.50	-	1440	1430	1437	1427	4.65	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.49	16.80	39.45	OK	0.09	0.63	10.58	3.00	-	8.50	STEPPED	-	-
30-		C17	C19	115	9	-	0.00	3.46	0.0346	3.50	-	1430	1410	1427	1407	17.39	3	3	0.2208	0.0938	18	x	18	2.25	4.5	0.5	2.471	0.594	-	-	1.42	33.68	83.20	OK	0.04	0.51	17.17	3.00	-	8.50	STEPPED	-	-
		Drop MH													1399.75																												
31-	R-22	C15.1	C16.1	156	-	-	1.37	1.37	0.0000	1.37	-	1445.31	1441.81	1443.23	1439.73	2.24	2.08	2.08	0	0	18	x	18	2.25	4.5	0.5	2.25	0.5	-	-	0.61	10.79	24.27	OK	0.06	0.55	5.93	3.00	-	8.50	FALSE	-	-
32-		C16.1	C23	127	-	-	1.36	2.73	0.0000	2.73	-	1441.81	1434.51	1439.73	1431.93	6.14	2.08	2.58	0	0	18	x	18	2.25	4.5	0.5	2.25	0.5	-	-	1.21	17.85	40.15	OK	0.07	0.59	10.53	3.00	-	8.50	STEPPED	-	-
		Drop MH													1431.51																												
33-		C23	C23.1	250	6	-	1.81	4.54	0.0217	4.56	-	1434.51	1419.85	1431.51	1416.85	5.86	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.3481	0.5625	-	-	1.94	18.86	44.29	OK	0.10	0.65	12.26	3.00	-	8.50	STEPPED	-	-
34-	R-22	C23.1	C23.2	150	6	-	1.44	5.98	0.0217	6.00	-	1419.85	1410.47	1416.85	1407.47	6.25	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.3481	0.5625	-	-	2.56	19.48	45.74	OK	0.13	0.70	13.63	3.00	-	8.50	STEPPED	-	-
25-		C23.2	C24.1	150	6	-	0.55	6.53	0.0217	6.55	-	1410.47	1406.21	1407.47	1401.3	4.11	3	4.91	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.3481	0.5625	-	-	2.79	15.80	37.09	OK	0.18	0.76	12.01	3.00	-	8.50	STEPPED	-	-
36-		C24.1	C19	123	-	18	0.00	6.53	0.0217	6.55	-	1406.21	1410	1401.3	1399.75	0.0126	4.91	10.25	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.67	11.79	OK	0.56	1.03	6.87	2.00	OK	8.50	-	0.54	9.72
37-	GREEN	C19	C20	172	-	18	0.75	10.74	0.0563	10.80	-	1410	1410	1399.75	1397.55	0.0128	10.25	12.45	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.72	11.87	OK	0.91	1.13	7.60	2.00	OK	8.50	-	0.75	13.50
38-		C20	C22	220	-	24	3.84	14.58	0.0752	14.66	-	1410	1411.11	1397.55	1395.65	0.0086	12.45	15.46	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.69	21.01	OK	0.70	1.08	7.23	2.00	OK	8.50	-	0.62	14.88

S/No	Section	D+Cu/Pipe		D.Cu/Pipe 'L' (ft)	Cu 'D' (in)	Cir Pipe 'D' (in)	Storm Flow		DWF Commu.	Total Flow(DW+WW) (cusec)	Equal Flow Distribution For dual Pipes	FRL AT		I.L (ft)		Slope% or ft/ft	Cover		Cunette Parameters		Storm Drain Size			Drain Area (sft)	Drain Wetted Perimeter (ft)	Hydraulic Radius Drain = A/P (ft)	Total Area D+Cu (sft)	Total Rh D+Cu (ft)	Circular Pipe		Vact	Vf	Qf	Q < Qf	Remarks from Hydraulic Table			Min Speci. Vel	Final Vel check	Max Speci. Vel	Stepped or Not	$\frac{d}{D}$	Flow 'd' (inch)
		From	To				Indivi. (cusec)	Commu.(cusec)				E-1 (ft)	E-2 (ft)	E-1 (ft)	E-2 (ft)		E-1 (ft)	E-2 (ft)	A (sft)	R=D/8 (ft)	b (in)	×	d (in)						A (sft)	R=D/4 (ft)					$\frac{Q}{Qf}$	$\frac{V}{Vf}$	V						
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)		(v)	(w)	(x)	(y)	(z)	(aa)	(ab)	(ac)	(ad)	(ae)	(af)	(ag)	(ah)	(ai)	(aj)	(ak)	(al)	(am)	(an)	(ao)	(ap)
39-	MR-01	C22	C25	88	-	24	0.00	14.58	0.0752	14.66	-	1411.11	1411.96	1395.65	1394.85	0.0091	15.46	17.11	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.87	21.56	OK	0.68	1.07	7.35	2.00	OK	8.50	-	0.61	14.64
40-	R-25	C24	C25	197	6	-	1.86	1.86	0.0609	1.92	-	1421.75	1411.96	1418.55	1408.96	4.87	3.2	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.3481	0.5625	-	-	0.82	17.19	40.35	OK	0.05	0.53	9.11	3.00	-	8.50	STEPPED	-	-
		Drop MH													1394.85																												
41-	MR-01	C25	C27	255	-	18	0.19	2.05	0.1544	2.21	-	1411.96	1415.23	1394.85	1391.6	0.0127	17.11	23.63	-	-	-	-	-	-	-	-	-	-	1.77	0.38	-	6.71	11.85	OK	0.19	0.77	5.17	2.00	OK	8.50	-	0.30	5.40
42-	R-27	C33	C32	45	-	-	0.77	0.77	0.0000	0.77	-	1446.53	1445.79	1444.45	1443.71	1.64	2.08	2.08	0	0	18	x	18	2.25	4.5	0.5	2.25	0.5	-	-	0.34	9.23	20.78	OK	0.04	0.51	4.71	3.00	-	8.50	FALSE	-	-
43-		C32	C31	50	-	-	0.77	1.54	0.0000	1.54	-	1445.79	1443.29	1443.71	1441.21	5.00	2.08	2.08	0	0	18	x	18	2.25	4.5	0.5	2.25	0.5	-	-	0.68	16.10	36.23	OK	0.04	0.51	8.21	3.00	-	8.50	FALSE	-	-
44-		C31	C30.1	103	-	-	0.89	2.43	0.0000	2.43	-	1443.29	1436.48	1441.21	1433.9	7.10	2.08	2.58	0	0	18	x	18	2.25	4.5	0.5	2.25	0.5	-	-	1.08	19.18	43.16	OK	0.06	0.55	10.55	3.00	-	8.50	STEPPED	-	-
		Drop MH													1433.48																												
		Drop MH													1432																												
45-	R-26	C28	C30.1	95	6	-	4.37	4.37	0.0217	4.39	-	1443.15	1436.48	1440.15	1433.48	7.02	3	3	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	1.87	20.64	48.46	OK	0.09	0.63	13.00	3.00	-	8.50	STEPPED	-	-
46-		C30.1	C27	327	6	-	4.39	11.19	0.0766	11.27	-	1436.48	1415.23	1432	1410.75	6.50	4.48	4.48	0.0981	0.0625	18	x	18	2.25	4.5	0.5	2.348	0.563	-	-	4.80	19.86	46.62	OK	0.24	0.83	16.48	3.00	-	8.50	STEPPED	-	-
		Drop MH													1391.6																												
47-	MR-01	C27	C30	121	-	24	0.78	14.02	0.2309	14.25	-	1415.23	1416.15	1391.6	1390.55	0.0087	23.63	25.6	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.71	21.06	OK	0.68	1.07	7.18	2.00	OK	8.50	-	0.61	14.64
48-	BL-2	C29	C30	164	9	-	0.10	0.10	0.2767	0.37	-	1420	1416.15	1416	1412.15	2.35	4	4	0.2208	0.0938	18	x	18	2.25	4.5	0.5	2.471	0.594	-	-	0.15	12.37	30.57	OK	0.01	0.40	4.95	3.00	-	8.50	FALSE	-	-
		Drop MH													1390.55																												
49-	MR-01	C30	C34.1	87	-	24	0.80	14.92	0.2767	15.19		1416.15	1408.13	1390.55	1389.8	0.0086	25.6	18.33	-	-	-	-	-	-	-	-	-	-	3.14	0.50	-	6.69	20.99	OK	0.72	1.09	7.29	2.00	OK	8.50	-	0.63	15.12
50-		A12													1407.6																												
		Drop MH													1388.25																												
51-		C34.1	A12	235	-	30	1.30	31.46	0.6540	32.11		1408.13	1411.73	1389.8	1388.25	0.0066	18.33	23.48	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.79	33.29	OK	0.96	1.14	7.74	2.00	OK	8.50	-	0.79	23.70
52-	R-28	A12	A28.1	106	-	30	1.23	59.60	1.2090	60.81	30.41	1411.73	1406.12	1388.25	1387.65	0.0057	23.48	18.47	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.29	30.84	OK	0.99	1.14	7.17	2.00	OK	8.50	-	0.81	24.30
					-	30					30.41	1411.73	1406.12	1388.25	1387.65	0.0057	23.48	18.47	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.29	30.84	OK	0.99	1.14	7.17	2.00	OK	8.50	-	0.81	24.30
53-	R-28	A28.1	A28	124	-	30	0.85	60.45	1.2182	61.67	30.84	1406.12	1398.96	1387.65	1386.9	0.0060	18.47	12.06	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.50	31.88	OK	0.97	1.14	7.41	2.00	OK	8.50	-	0.80	24.00
					-	30					30.84	1406.12	1398.96	1387.65	1386.9	0.0060	18.47	12.06	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	6.50	31.88	OK	0.97	1.14	7.41	2.00	OK	8.50	-	0.80	24.00
54-	TO STP	A28	STP-1	85	-	30	0.00	67.72	1.3553	**69.08**	34.54	1398.96	1390	1386.9	1386.25	0.0076	12.06	3.75	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	7.31	35.85	OK	0.96	1.14	8.33	2.00	OK	8.50	-	0.79	23.70
					-	30					34.54	1398.96	1390	1386.9	1386.25	0.0076	12.06	3.75	-	-	-	-	-	-	-	-	-	-	4.91	0.63	-	7.31	35.85	OK	0.96	1.14	8.33	2.00	OK	8.50	-	0.79	23.70

Table D8: Design Sheet of Storm Drainage separated in Combined Sewer System.

S.No	Drain Nodes		Drain Length (ft)	FRL at		Invert Level at		Slope % age	Discharge		Drain Size			Drain 'A' (sft)	Wetted P= B+2Y (ft)	Hydraulic R=A/P (ft)	Vel actual (ft/sec)	Vel Max (ft/sec)	Capacity Max (cusec)	OK or NG	Remarks from Hydraulic Table			Min Spec Vel ft/sec	Final check for Vel	Max Speci Vel ft/sec	Stepped or Not
	From	To		End 1 (ft)	End 2 (ft)	End 1 (ft)	End 2 (ft)		Indivi. (cusec)	Commu. (cusec)	b (inch)	x	d (inch)								Q/Qf	V/Vf	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)		(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)
1-	B19.2	B11.1	227	1459.99	1456.1	1458.66	1454.77	1.714	1.95	1.95	12	x	12	1.00	3.00	0.33	1.95	7.19	7.19	OK	0.27	0.87	6.26	3.00	OK	8.50	FALSE
2-	B11.1	B4.1	228	1456.1	1448.65	1454.77	1447.32	3.268	2.01	3.96	12	x	12	1.00	3.00	0.33	3.96	9.93	9.93	OK	0.40	0.95	9.44	3.00	OK	8.50	STEPPED
3-	B4.1	B2.1.1	123	1448.65	1443.48	1447.32	1442.15	4.203	0.87	4.83	12	x	12	1.00	3.00	0.33	4.83	11.27	11.27	OK	0.43	0.98	11.04	3.00	OK	8.50	STEPPED
4-	B2.1.1	B2.1	712	1443.48	1413.95	1441.65	1412.12	4.147	7.57	12.40	12	x	18	1.50	3.50	0.43	8.27	12.11	18.16	OK	0.68	1.14	13.80	3.00	OK	8.50	STEPPED
5-	B2.1	B2.2	550	1413.95	1399.55	1412.12	1397.72	2.618	6.74	19.15	18	x	18	2.25	4.50	0.50	8.51	11.65	26.22	OK	0.73	1.10	12.82	3.00	OK	8.50	STEPPED
6-	B2.2	B2.3	550	1399.55	1383.97	1397.72	1382.14	2.833	5.49	24.64	18	x	18	2.25	4.50	0.50	10.95	12.12	27.27	OK	0.90	1.14	13.82	3.00	OK	8.50	STEPPED
7-	B2.3	B2.4	485	1383.97	1361.26	1382.14	1359.43	4.682	5.02	29.66	18	x	18	2.25	4.50	0.50	13.18	15.58	35.06	OK	0.85	1.13	17.61	3.00	OK	8.50	STEPPED
8-	B2.4	B2.5	83.75	1361.26	1359.29	1358.93	1356.96	2.352	1.08	30.74	24	x	24	4.00	6.00	0.67	7.68	13.38	53.52	OK	0.57	1.04	13.91	3.00	OK	8.50	STEPPED
9-	B2.5	B2.6	231.25	1359.29	1356.75	1356.96	1354.42	1.098	2.32	33.06	24	x	24	4.00	6.00	0.67	8.26	9.14	36.57	OK	0.90	1.14	10.42	3.00	OK	8.50	STEPPED
10-	B19.1	B21.1	126	1459.86	1457.21	1458.53	1455.88	2.103	1.12	1.12	12	x	12	1.00	3.00	0.33	1.12	7.97	7.97	OK	0.14	0.71	5.66	3.00	OK	8.50	FALSE
11-	B21.1	B27.1	222	1457.21	1444.88	1455.88	1443.55	5.554	1.65	2.77	12	x	12	1.00	3.00	0.33	2.77	12.95	12.95	OK	0.21	0.79	10.23	3.00	OK	8.50	STEPPED
12-	B24	B28.2	160.54	1448.21	1441.34	1446.88	1440.01	4.279	1.64	1.64	12	x	12	1.00	3.00	0.33	1.64	11.37	11.37	OK	0.14	0.71	8.07	3.00	OK	8.50	FALSE
13-	B27.1	B28.2	260	1444.88	1441.34	1443.55	1440.01	1.362	1.12	3.89	12	x	12	1.00	3.00	0.33	3.89	6.41	6.41	OK	0.61	1.05	6.73	3.00	OK	8.50	FALSE
14-	B28.2	B28.1	75	1441.34	1439.75	1440.01	1438.42	2.120	0.00	5.53	12	x	12	1.00	3.00	0.33	5.53	8.00	8.00	OK	0.69	1.08	8.64	3.00	OK	8.50	STEPPED
15-	B24.1	B24.2	150	1448.27	1443.45	1446.94	1442.12	3.213	0.94	0.94	12	x	12	1.00	3.00	0.33	0.94	9.85	9.85	OK	0.10	0.65	6.40	3.00	OK	8.50	FALSE
16-	B24.2	B24.3	250	1443.45	1431.03	1442.12	1429.7	4.968	1.57	2.52	12	x	12	1.00	3.00	0.33	2.52	12.25	12.25	OK	0.21	0.79	9.68	3.00	OK	8.50	STEPPED
17-	B24.3	B24.4	100	1431.03	1429.52	1429.7	1428.19	1.510	0.63	3.15	12	x	12	1.00	3.00	0.33	3.15	6.75	6.75	OK	0.47	0.99	6.69	3.00	OK	8.50	FALSE
18-	B31	B32	118	1442.51	1439.62	1441.18	1438.29	2.449	1.16	1.16	12	x	12	1.00	3.00	0.33	1.16	8.60	8.60	OK	0.13	0.70	6.02	3.00	OK	8.50	FALSE
19-	B32	B31.1	32	1439.62	1438.11	1438.29	1436.78	4.719	0.20	1.36	12	x	12	1.00	3.00	0.33	1.36	11.94	11.94	OK	0.11	0.67	8.00	3.00	OK	8.50	FALSE
20-	B31.1	B31.2	150	1438.11	1431.13	1436.78	1429.8	4.653	0.94	2.30	12	x	12	1.00	3.00	0.33	2.30	11.85	11.85	OK	0.19	0.77	9.13	3.00	OK	8.50	STEPPED
21-	B31.2	B24.4	100	1431.13	1429.52	1429.8	1428.19	1.610	0.63	2.93	12	x	12	1.00	3.00	0.33	2.93	6.97	6.97	OK	0.42	0.96	6.69	3.00	OK	8.50	FALSE
22-	B24.4	B24.5	128	1429.52	1419.75	1428.19	1418.42	7.633	0.00	6.08	12	x	12	1.00	3.00	0.33	6.08	15.18	15.18	OK	0.40	0.94	14.27	3.00	OK	8.50	STEPPED
23-	B32.1	B32.2	148	1442.49	1440.07	1441.16	1438.74	1.635	0.93	0.93	12	x	12	1.00	3.00	0.33	0.93	7.03	7.03	OK	0.13	0.70	4.92	3.00	OK	8.50	FALSE
24-	B32.2	B32.3	200	1440.07	1432.09	1438.74	1430.76	3.990	1.26	2.19	12	x	12	1.00	3.00	0.33	2.19	10.98	10.98	OK	0.20	0.78	8.56	3.00	OK	8.50	STEPPED
25-	B32.3	B32.4	150	1432.09	1426.4	1430.76	1425.07	3.793	0.94	3.14	12	x	12	1.00	3.00	0.33	3.14	10.70	10.70	OK	0.29	0.87	9.31	3.00	OK	8.50	STEPPED
26-	B32.4	B32.5	150	1426.4	1422.5	1425.07	1421.17	2.600	0.94	4.08	12	x	12	1.00	3.00	0.33	4.08	8.86	8.86	OK	0.46	0.98	8.68	3.00	OK	8.50	STEPPED
27-	B32.5	B32.6	150	1422.5	1419.57	1421.17	1418.24	1.953	0.94	5.02	12	x	12	1.00	3.00	0.33	5.02	7.68	7.68	OK	0.65	1.06	8.14	3.00	OK	8.50	FALSE
28-	B32.6	B32.7	150	1419.57	1415.51	1418.24	1414.18	2.707	0.94	5.97	12	x	12	1.00	3.00	0.33	5.97	9.04	9.04	OK	0.66	1.07	9.67	3.00	OK	8.50	STEPPED
29-	B32.7	B44.3	100	1415.51	1411.64	1414.18	1410.31	3.870	0.63	6.60	12	x	12	1.00	3.00	0.33	6.60	10.81	10.81	OK	0.61	1.05	11.35	3.00	OK	8.50	STEPPED
30-	B44.3	B32.8	146	1411.64	1404.92	1410.31	1403.59	4.603	0.92	7.52	12	x	12	1.00	3.00	0.33	7.52	11.79	11.79	OK	0.64	1.06	12.50	3.00	OK	8.50	STEPPED
31-	B32.8	B32.9	81.4	1404.92	1399.75	1403.59	1398.42	6.351	0.00	7.52	12	x	12	1.00	3.00	0.33	7.52	13.85	13.85	OK	0.54	1.02	14.13	3.00	OK	8.50	STEPPED
32-	C20.1	C21.1	392	1406.99	1405.36	1405.66	1404.03	0.416	1.90	1.90	12	x	12	1.00	3.00	0.33	1.90	3.54	3.54	OK	0.54	1.02	3.61	3.00	OK	8.50	FALSE
33-	C29.1	C25.1	124	1416.1	1412.98	1414.77	1411.65	2.516	1.68	1.68	12	x	12	1.00	3.00	0.33	1.68	8.72	8.72	OK	0.19	0.77	6.71	3.00	OK	8.50	FALSE
34-	C25.1	C43	200	1412.98	1404.22	1411.65	1402.89	4.380	3.85	5.53	12	x	12	1.00	3.00	0.33	5.53	11.50	11.50	OK	0.48	0.99	11.39	3.00	OK	8.50	STEPPED
35-	C43	C44	133.75	1404.22	1399.75	1402.89	1398.42	3.342	0.00	5.53	12	x	12	1.00	3.00	0.33	5.53	10.05	10.05	OK	0.55	1.02	10.25	3.00	OK	8.50	STEPPED
36-	C28.1	C27.1	102.23	1416.22	1414.33	1414.89	1413	1.849	2.63	2.63	12	x	12	1.00	3.00	0.33	2.63	7.47	7.47	OK	0.35	0.92	6.87	3.00	OK	8.50	FALSE
37-	C27.1	C40	165	1414.33	1408.57	1413	1407.24	3.491	1.95	4.58	12	x	12	1.00	3.00	0.33	4.58	10.27	10.27	OK	0.45	0.98	10.06	3.00	OK	8.50	STEPPED
38-	C40	C41	50	1408.57	1407.2	1407.24	1405.87	2.740	0.31	4.89	12	x	12	1.00	3.00	0.33	4.89	9.10	9.10	OK	0.54	1.02	9.28	3.00	OK	8.50	STEPPED
39-	C41	C42	150	1407.2	1399.75	1405.87	1398.42	4.967	0.00	4.89	12	x	12	1.00	3.00	0.33	4.89	12.25	12.25	OK	0.40	0.94	11.51	3.00	OK	8.50	STEPPED
40-	A8.1	A9.1	252	1482.41	1464.75	1481.08	1463.42	7.008	1.62	1.62	12	x	12	1.00	3.00	0.33	1.62	14.55	14.55	OK	0.11	0.67	9.75	3.00	OK	8.50	STEPPED
41-	A9.1	A10.1	143	1464.75	1455.75	1463.42	1454.42	6.294	0.90	2.52	12	x	12	1.00	3.00	0.33	2.52	13.79	13.79	OK	0.18	0.76	10.48	3.00	OK	8.50	STEPPED
42-	A10.1	A11.2	209	1455.75	1441.64	1454.42	1440.31	6.751	1.32	3.83	12	x	12	1.00	3.00	0.33	3.83	14.28	14.28	OK	0.27	0.85	12.14	3.00	OK	8.50	STEPPED
43-	A11.2	A35	555	1441.64	1408.13	1440.31	1406.8	6.038	3.49	7.33	12	x	12	1.00	3.00	0.33	7.33	13.50	13.50	OK	0.54	1.02	13.77	3.00	OK	8.50	STEPPED
44-	A35	A35.1	107	1408.13	1380.75	1406.8	1379.42	25.589	0.00	7.33	12		12	1.00	3.00	0.33	7.33	27.80	27.80	OK	0.26	0.84	23.35	3.00	OK	8.50	STEPPED

S.No	Drain Nodes		Drain Length (ft)	FRL at		Invert Level at		Slope % age	Discharge		Drain Size			Drain 'A' (sft)	Wetted P= B+2Y (ft)	Hydraulic R=A/P (ft)	Vel actual (ft/sec)	Vel Max (ft/sec)	Capacity Max (cusec)	OK or NG	Remarks from Hydraulic Table			Min Spec Vel ft/sec	Final check for Vel	Max Speci Vel ft/sec	Stepped or Not
	From	To		End 1 (ft)	End 2 (ft)	End 1 (ft)	End 2 (ft)		Indivi. (cusec)	Commu. (cusec)	b (inch)	x	d (inch)								Q/Qf	V/Vf	V				
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)		(l)	(m)	(n)	(o)	(p)	(q)	(r)	(s)	(t)	(u)	(v)	(w)	(x)	(y)	(z)
45-	A29	A30	504.6	1482.37	1452.75	1481.04	1451.42	5.870	1.51	1.51	12	x	12	1.00	3.00	0.33	1.51	13.31	13.31	OK	0.11	0.69	9.19	3.00	OK	8.50	STEPPED
46-	C10	C10.2	201.84	1487.72	1449.75	1486.39	1448.42	18.812	0.87	0.87	12	x	12	1.00	3.00	0.33	0.87	23.83	23.83	OK	0.04	0.51	12.16	3.00	OK	8.50	STEPPED
47-	C9.2	C4.2	120	1481.79	1480.75	1480.46	1479.42	0.867	0.44	0.44	12	x	12	1.00	3.00	0.33	0.44	5.12	5.12	OK	0.09	0.98	5.01	3.00	OK	8.50	FALSE
48-	C4.2	C4.1	230	1480.75	1479.85	1478.92	1478.02	0.391	0.84	1.28	12	x	18	1.50	3.50	0.43	0.85	3.72	5.58	OK	0.23	0.84	3.12	3.00	OK	8.50	FALSE
49-	C4.1	C8.2	106	1479.85	1459.75	1478.52	1458.42	18.962	0.00	1.28	12	x	12	1.00	3.00	0.33	1.28	23.93	23.93	OK	0.05	0.53	12.68	3.00	OK	8.50	STEPPED
50-	C11	C11.1	145	1481.67	1477.2	1480.34	1475.87	3.083	0.53	0.53	12	x	12	1.00	3.00	0.33	0.53	9.65	9.65	OK	0.05	0.53	5.11	3.00	OK	8.50	FALSE
51-	C11.1	C11.2	150	1477.2	1468.47	1475.87	1467.14	5.820	1.68	2.21	12	x	12	1.00	3.00	0.33	2.21	13.26	13.26	OK	0.17	0.75	9.94	3.00	OK	8.50	STEPPED
52-	C11.2	C12	397	1468.47	1444.09	1467.14	1442.76	6.141	4.85	7.05	12	x	12	1.00	3.00	0.33	7.05	13.62	13.62	OK	0.52	1.02	13.89	3.00	OK	8.50	STEPPED
53-	C13	C14	172	1444.97	1443.99	1443.64	1442.66	0.570	1.52	1.52	12	x	12	1.00	3.00	0.33	1.52	4.15	4.15	OK	0.37	0.93	3.86	3.00	OK	8.50	FALSE
54-	C22.1.1	C23.1.1	136	1479.75	1439.75	1478.42	1438.42	29.412	2.57	2.57	12	x	12	1.00	3.00	0.33	2.57	29.80	29.80	OK	0.09	0.63	18.78	3.00	OK	8.50	STEPPED

Table D9: Normal Depth of flow at outlet drains of 14 sub-catchments & three Zones using Newton's Method for combined system.

S.1/3

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	Q(act) (cusec)	Slope (ft/ft)	Selected Drain Size (B × D inch)	Manning's 'n'	Channel Width (ft)	Assumed (ft) y_j	$Q_j = \frac{1.49}{n} \times S^{1/2} \times \frac{(Bw \times yj)^{5/3}}{(Bw + 2yj)^{2/3}}$ (cusecs)	$y_{j+1} = yj - \frac{1 - Q/Qj}{\frac{5Bw + 6yj}{3yj(Bw + 2yj)}}$ (ft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
1-	B51	STP-2	162	81.91	0.02747	30 × 30	0.013	2.5	2	79.74069477	2.043305112
				81.91	0.02747		0.013	2.5	2.043305112	81.91302925	2.043244808
				81.91	0.02747		0.013	2.5	2.043244808	81.91000001	2.043244808
				81.91	0.02747		0.013	2.5	2.043244808	81.91	2.043244808
				81.91	0.02747		0.013	2.5	2.043244808	81.91	2.043244808
2-	B2.5	B2.6	231.25	33.06	0.01098	24 × 24	0.013	2	1.5	25.63103682	1.843234511
				33.06	0.01098		0.013	2	1.843234511	33.16397781	1.838553147
				33.06	0.01098		0.013	2	1.838553147	33.06001473	1.838552484
				33.06	0.01098		0.013	2	1.838552484	33.06	1.838552484
				33.06	0.01098		0.013	2	1.838552484	33.06	1.838552484
3-	B28.2	B28.1	75	5.53	0.0212	12 × 12	0.013	1	1	8.022874711	0.745773823
				5.53	0.0212		0.013	1	0.745773823	5.56899218	0.741654407
				5.53	0.0212		0.013	1	0.741654407	5.53001526	0.741652794
				5.53	0.0212		0.013	1	0.741652794	5.53	0.741652794
				5.53	0.0212		0.013	1	0.741652794	5.53	0.741652794
4-	B24.4	B24.5	126	6.08	0.07633	12 × 12	0.013	1	1	15.22333172	0.508589321
				6.08	0.07633		0.013	1	0.508589321	6.427464726	0.48792481
				6.08	0.07633		0.013	1	0.48792481	6.081482459	0.487835877
				6.08	0.07633		0.013	1	0.487835877	6.080000029	0.487835876
				6.08	0.07633		0.013	1	0.487835876	6.08	0.487835876
5-	B32.8	B32.9	81.4	7.52	0.0635	12 × 12	0.013	1	1	13.88509777	0.624935499
				7.52	0.0635		0.013	1	0.624935499	7.683929276	0.614650639
				7.52	0.0635		0.013	1	0.614650639	7.520230711	0.614636123
				7.52	0.0635		0.013	1	0.614636123	7.52	0.614636123
				7.52	0.0635		0.013	1	0.614636123	7.52	0.614636123
6-	C20.1	C21.1	392	1.90	0.0042	12 × 12	0.013	1	1	3.570974302	0.617146281
				1.90	0.0042		0.013	1	0.617146281	1.94426024	0.606325816
				1.90	0.0042		0.013	1	0.606325816	1.900067225	0.606309331
				1.90	0.0042		0.013	1	0.606309331	1.9	0.606309331
				1.90	0.0042		0.013	1	0.606309331	1.9	0.606309331
7-	C43	C44	133.75	5.53	0.0334	12 × 12	0.013	1	1	10.07013547	0.631121517
				5.53	0.0334		0.013	1	0.631121517	5.644319919	0.621248349
				5.53	0.0334		0.013	1	0.621248349	5.530151388	0.621235239

S.2/3

S.No	Drain Nodes From (a)	To (b)	Drain Length (ft) (c)	Q(act) (cusec) (d)	Slope (ft/ft) (e)	Selected Drain Size (B × D inch) (f)	Manning's 'n' (g)	Channel Width (ft) (h)	Assumed (ft) y_j (i)	$Q_j = \frac{1.49}{n} \times S^{1/2} \times \frac{(Bw \times yj)^{5/3}}{(Bw + 2yj)^{2/3}}$ (cusecs) (j)	$y_{j+1} = yj - \frac{1 - Q/Qj}{\frac{5Bw+6yj}{3yj(Bw+2yj)}}$ (ft) (k)
				5.53	0.0334		0.013	1	0.621235239	5.53	0.621235239
				5.53	0.0334		0.013	1	0.621235239	5.53	0.621235239
8-	C41	C42	150	4.89	0.0497	12 × 12	0.013	1	0.75	8.588089143	0.495035478
				4.89	0.0497		0.013	1	0.495035478	5.003062682	0.486655564
				4.89	0.0497		0.013	1	0.486655564	4.890203012	0.486640463
				4.89	0.0497		0.013	1	0.486640463	4.890000001	0.486640463
				4.89	0.0497		0.013	1	0.486640463	4.89	0.486640463
9-	A35	A35.1	107	7.33	0.2559	12 × 12	0.013	1	1	27.87386694	0.396975725
				7.33	0.2559		0.013	1	0.396975725	8.420622266	0.359490459
				7.33	0.2559		0.013	1	0.359490459	7.343610542	0.359010375
				7.33	0.2559		0.013	1	0.359010375	7.330002464	0.359010288
				7.33	0.2559		0.013	1	0.359010288	7.33	0.359010288
10-	A29	A30	504.6	1.51	0.0587	12 × 12	0.013	1	1	13.34999584	0.274361622
				1.51	0.0587		0.013	1	0.274361622	2.403172945	0.203076723
				1.51	0.0587		0.013	1	0.203076723	1.552293129	0.199323302
				1.51	0.0587		0.013	1	0.199323302	1.510150015	0.199309893
				1.51	0.0587		0.013	1	0.199309893	1.510000002	0.199309893
				1.51	0.0587		0.013	1	0.199309893	1.51	0.199309893
11-	C10	C10.2	201.84	0.87	0.1881	12 × 12	0.013	1	0.75	16.70754914	0.188727002
				0.87	0.1881		0.013	1	0.188727002	2.493308268	0.105927135
				0.87	0.1881		0.013	1	0.105927135	1.037088352	0.094917523
				0.87	0.1881		0.013	1	0.094917523	0.874359707	0.0946142
				0.87	0.1881		0.013	1	0.0946142	0.870003507	0.094613956
				0.87	0.1881		0.013	1	0.094613956	0.87	0.094613956
				0.87	0.1881		0.013	1	0.094613956	0.87	0.094613956
12-	C4.1	C8.2	106	1.28	0.1896	12 × 12	0.013	1	1	23.99281725	0.225467609
			106	1.28	0.1896		0.013	1	0.225467609	3.252397858	0.13178074
			106	1.28	0.1896		0.013	1	0.13178074	1.457195215	0.121290778
			106	1.28	0.1896		0.013	1	0.121290778	1.283290909	0.121088345
			106	1.28	0.1896		0.013	1	0.121088345	1.280001287	0.121088266
			106	1.28	0.1896		0.013	1	0.121088266	1.28	0.121088266
			106	1.28	0.1896		0.013	1	0.121088266	1.28	0.121088266
13-	C11.2	C12	397	7.05	0.0614	12 × 12	0.013	1	0.75	9.545584685	0.595200805
			397	7.05	0.0614		0.013	1	0.595200805	7.091701568	0.592517509
			397	7.05	0.0614		0.013	1	0.592517509	7.050016734	0.592516431
			397	7.05	0.0614		0.013	1	0.592516431	7.05	0.592516431
			397	7.05	0.0614		0.013	1	0.592516431	7.05	0.592516431

S.3/3

S.No	Drain Nodes From	Drain Nodes To	Drain Length (ft)	Q(act) (cusec)	Slope (ft/ft)	Selected Drain Size (B × D inch)	Manning's 'n'	Channel Width (ft)	Assumed (ft) y_j	$Q_j = \frac{1.49}{n} \times S^{1/2} \times \frac{(Bw \times yj)^{5/3}}{(Bw + 2yj)^{2/3}}$ (cusecs)	$y_{j+1} = yj - \frac{1 - Q/Qj}{\frac{5Bw+6yj}{3yj(Bw+2yj)}}$ (ft)
	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)
14-	C13	C14	172	1.52	0.0057	12 × 12	0.013	1	0.75	2.908410991	0.467342061
			172	1.52	0.0057		0.013	1	0.467342061	1.568550175	0.456583892
			172	1.52	0.0057		0.013	1	0.456583892	1.520124926	0.456556065
			172	1.52	0.0057		0.013	1	0.456556065	1.520000001	0.456556065
			172	1.52	0.0057		0.013	1	0.456556065	1.52	0.456556065
			172	1.52	0.0057		0.013	1	0.456556065	1.52	0.456556065
15-	C22.1.1	C23.1.1	136	2.57	0.2941	12 × 12	0.013	1	0.75	20.89131905	0.230734107
			136	2.57	0.2941		0.013	1	0.230734107	4.189387254	0.169484652
			136	2.57	0.2941		0.013	1	0.169484652	2.655791486	0.165829553
			136	2.57	0.2941		0.013	1	0.165829553	2.57038555	0.165812978
			136	2.57	0.2941		0.013	1	0.165812978	2.570000008	0.165812977
			136	2.57	0.2941		0.013	1	0.165812977	2.57	0.165812977
			136	2.57	0.2941		0.013	1	0.165812977	2.57	0.165812977

Appendix E

Quantity & Cost Estimation Spreadsheets for Separate & Combined Systems

ANNEXURE E: QUANTITY & COST ESTIMATION SPREADSHEETS FOR COMBINED, SEPARATE DRAINAGE NETWORKS

Table E1: Quantity and cost estimation spreadsheets for combined and separate systems based on PWD schedule of rates 2012

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
		SEPARATE SEWER SYSTEM (A)- SEWER PORTION						
1-	313-14	Excavation for pipes in common soil lift up to 5ft and lead up to one chain (100ft) including back filling	yes	100Cft	697.58	941.73	4,33,789 ft³	4,085,138
2-	313-15	Add for additional lift of every three feet	yes	Per 100Cft	77.35	–	–	–
3-	313-14+313-15(a)	5ft to 8ft depth	yes	100Cft	774.93	1,046.16	1,49,854 ft³	1,567,710
4-	313-14+313-15(b)	8ft to 11ft depth	yes	100Cft	852.28	1,150.58	80,620 ft³	9,27,596
5-	313-14+313-15(c)	11ft to 14ft depth	yes	100Cft	929.63	1,255.00	53,966 ft³	6,77,271
6-	313-14+313-15(d)	14ft to 17ft depth	yes	100Cft	1,006.98	1,359.42	26,899 ft³	3,65,681
7-	313-14+313-15(e)	17ft to 20ft depth	yes	100Cft	1,084.33	1,463.85	11,574 ft³	1,69,427
8-	313-14+313-15(f)	20ft to 23ft depth	yes	100Cft	1,161.68	1,568.27	8,422 ft³	1,32,091
9-	313-14+313-15(g)	23ft to 26ft depth	yes	100Cft	1,239.03	1,672.69	3,025 ft³	50,595
10-	313-6	Excavation for pipes in soft rock lift up to 5 ft and lead up to one chain (100ft) including back filling	yes	100Cft	1,477.56	1,994.71	2,13,657 ft³	42,61,839
11-	313-15	Add for additional lift of every three feet	yes	Per 100Cft	77.35	–	–	–
12-	313-6+313-15(a)	5ft to 8ft depth	yes	100Cft	1,554.91	2,099.13	73,809 ft³	15,49,343
13-	313-6+313-15(b)	8ft to 11ft depth	yes	100Cft	1,632.26	2,203.55	39,708 ft³	8,74,994
14-	313-6+313-15(c)	11ft to 14ft depth	yes	100Cft	1,709.61	2,307.97	26,580 ft³	6,13,463
15-	313-6+313-15(d)	14ft to 17ft depth	yes	100Cft	1,786.96	2,412.40	13,249 ft³	3,19,621
16-	313-6+313-15(e)	17ft to 20ft depth	yes	100Cft	1,864.31	2,516.82	5,701 ft³	1,43,475
17-	313-6+313-15(f)	20ft to 23ft depth	yes	100Cft	1,941.66	2,621.24	4,149 ft³	1,08,742
18-	313-6+313-15(g)	23ft to 26ft depth	yes	100Cft	2,019.01	2,725.66	1,490 ft³	40,607
19-	313-3	Laying of 9″ dia Class 'B' pipes including cutting, fitting, Jointing & back filling of trench	yes	RFT	250.26	337.85	25,368 ft	85,70,435

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
20-	109-4+109-13	Sand encasement of pipes including filling, ramming watering lift up to 5ft & 5ft to 8ft	yes	100Cft	2,287.86	3,088.61	2,93,696 ft³	90,71,134
		Circular Manholes						
21-	103-22	Excavation of circular manholes in common soil lift up to 5ft and lead up to one chain (100ft) with back filling	yes	100Cft	863.07	1,165.14	35,510 ft³	4,13,743
22-	103-28	Add for additional lift of every three feet	yes	Per 100Cft	77.35	–	–	–
23-	103-22 + 103-28(a)	5ft to 8ft depth	yes	100Cft	940.42	1,269.57	23,181 ft³	2,94,296
24-	103-22 + 103-28(b)	8ft to 11ft depth	yes	100Cft	1,017.77	1,373.99	21,490 ft³	2,95,266
25-	103-22 + 103-28(c)	11ft to 14ft depth	yes	100Cft	1,095.12	1,478.41	15,883 ft³	2,34,810
26-	103-22 + 103-28(d)	14ft to 17ft depth	yes	100Cft	1,172.47	1,582.83	1,1936 ft³	1,88,935
27-	103-22 + 103-28(e)	17ft to 20ft depth	yes	100Cft	1,249.82	1,687.26	9,566 ft³	1,61,399
28-	103-22 + 103-28(f)	20ft to 23ft depth	yes	100Cft	1,327.17	1,791.68	7,080 ft³	1,26,846
29-	103-22 + 103-28(g)	23ft to 26ft depth	yes	100Cft	1,404.52	1,896.10	4,252 ft³	80,630
30-	103-22 + 103-28(h)	26ft to 29ft depth	yes	100Cft	1,481.87	2,000.52	1,845 ft³	36,917
31-	103-25	Excavation for circular manholes in soft rock lift up to 5 ft and lead up to one chain (100ft) with back filling	yes	100Cft	1,092.48	1,474.85	17,490 ft³	2,57,951
32-	103-29	Add for additional lift of every three feet	yes	Per 100Cft	99.69	–	–	–
33-	103-25 + 103-29(a)	5ft to 8ft depth	yes	100Cft	1,192.17	1,609.43	11,417 ft³	1,83,756
33-	103-25 + 103-29(b)	8ft to 11ft depth	yes	100Cft	1,291.86	1,744.011	1,0584 ft³	1,84,595
34-	103-25 + 103-29(c)	11ft to 14ft depth	yes	100Cft	1,391.55	1,878.593	7,823 ft³	1,46,958
35-	103-25 + 103-29(d)	14ft to 17ft depth	yes	100Cft	1,491.24	2,013.174	5,879 ft³	1,18,358
36-	103-25 + 103-29(e)	17ft to 20ft depth	yes	100Cft	1,590.93	2,147.756	4,711 ft³	1,01,191
37-	103-25 + 103-29(f)	20ft to 23ft depth	yes	100Cft	1,690.62	2,282.337	3,487 ft³	79,586
38-	103-25 + 103-29(g)	23ft to 26ft depth	yes	100Cft	1,790.31	2,416.919	2,094 ft³	50,622
39-	103-25 + 103-29(h)	26ft to 29ft depth	yes	100Cft	1,890	2,551.5	909 ft³	23,191
40-	127-27	Stone Ballast in foundation of circular manholes	yes	100Cft	3,864.46	5,217.02	4,070 ft³	2,12,358
41-	105-14+105-27+105-39	P.C.C (1:4:8) in foundation of circular manholes	yes	100Cft	1,1402.13	15,392.88	2,829 ft³	4,35,535

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
42-	112-99	Brick Masonry 1st class for circular manholes with cement mortar(1:3) for 9″, 13.04″ thick walls including curing and scaffolding up to 10ft depth	yes	100Cft	23,742.29	32,052.09	15,535 ft³	49,79,169
43-	112-101	Add for additional depth of every 5ft	yes	Per 100Cft	422.62	–	–	–
44-	112-99 + 112-101(a)	10 to 15 ft depth	yes	100Cft	24,164.91	32,622.63	4,938 ft³	16,10,944
45-	112-99 + 112-101(b)	15 to 20 ft depth	yes	100Cft	24,587.53	33,193.17	3,432 ft³	1,139,320
46-	112-99 + 112-101(c)	20 to 25 ft depth	yes	100Cft	25,010.15	33,763.7	1,717 ft³	5,79,635
47-	112-99 + 112-101(d)	25 to 30 ft depth	yes	100Cft	25,432.77	34,334.24	257 ft³	88,284
48-	122-03	0.5 ″ thick cement plaster (1:3) at inside and outside walls of circular manholes	yes	100Sft	2,083.60	2,812.86	50,856 ft²	14,30,508
49-	108-12	Bitumen coating at outside walls of circular manholes	yes	100Sft	648.08	874.91	30,496 ft²	2,66,816
50-	109-107+109-123+109-48	Benching concrete (1:2:4) at inner bottom of circular manholes	yes	100Cft	17,693.43	23,886.13	1,736 ft³	4,14,694
51-	114-10+114-136+114-145	R.C.C (1:2:4) excluding cost of steel reinforcement for circular manhole covers resting area	yes	100Cft	23,343.77	31,514.09	594 ft³	1,87,128
52-	114-55 + 114-136 + 114-145	R.C.C (1:2:4) excluding cost of steel reinforcement for circular manhole covers	yes	100Cft	22,172.61	29,933.02	127 ft³	37,967
53-	144-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for circular manhole covers, steps	yes	Per Kg	103.29	139.44	2,726 kg	38,0048
54-	Non-Scheduled	MS Angle iron for circular manhole covers, rest area	no	Per Kg	200.00	270.00	3,585 kg	9,67,834
		Square Shape Manholes						
55-	103-04	Excavation of square shape manholes in common soil including back filling	yes	100Cft	911.40	1,230.39	52,258 ft³	6,42,979
56-	103-07	Excavation of square shape manholes in soft rock including back filling	yes	100Cft	1,212.23	1,636.51	25,739 ft³	4,21,222
57-	106-11+106-50	P.C.C (1:4:8) in foundation of square shape manholes	yes	100Cft	14,464.41	19,526.95	1,270 ft³	2,47,976
58-	109-12+109-120+109-146	P.C.C (1:3:6) for walls & base of square manholes	yes	100Cft	22,011.86	29,716.01	6,469 ft³	19,22,302

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**
59-	114-55+114-136+114-145	R.C.C (1:2:4) excluding cost of steel reinforcement for square manhole covers	yes	100Cft	22,172.61	29,933.02	494 ft³	1,47,795
60-	114-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for square manhole covers	yes	Per Kg	103.29	139.44	3,006 kg	4,19,183
61-	Non-Scheduled	Half circled MS Angle iron for square manhole cover	no	Per Kg	200.00	270.00	288 kg	77,690
62-	108-12	Bitumen coating at outside walls of square manholes	yes	100Sft	648.08	874.91	15,784 ft²	1,38,095
	–	**Total 'A'**	–	–	–	–	–	**5,32,55,694**
		(B) - STORM DRAIN PORTION						
63-	103-04	Excavation for P.C.C storm drains in common soil including back filling	yes	100Cft	911.40	1,230.39	2,44,253 ft³	30,05,262
64-	103-07	Excavation for P.C.C storm drains in soft rock including back filling	yes	100Cft	1,212.23	1,636.51	1,20,304 ft³	19,68,781
65-	106-11+106-50	P.C.C (1:4:8) in foundation of storm drains	yes	100Cft	14,464.41	19,526.95	18,816 ft³	36,74,226
66-	109-12+109-120+109-146	P.C.C (1:3:6) for walls & base of storm drains	yes	100Cft	22,011.86	29,716.01	49,266 ft³	1,46,39,839
67-	109-107 + 109-123 + 109-148	Benching concrete (1:2:4) at inner bottom of storm drains	yes	100Cft	17,693.43	23,886.13	8,412 ft³	20,09,299
68-	315-29	Precast R.C.C (1:2:4) slab covers including steel reinforcement for storm drains	yes	CFT	664.84	897.53	1,5231 ft³	1,36,70,559
69-	108-12	Bitumen coating at outside walls of storm drains	yes	100Sft	648.08	874.91	7,3541 ft²	6,43,415
70-	103-04	Excavation for P.C.C catch pits in common soil including back filling	yes	100Cft	911.40	1,230.39	34,500 ft³	4,24,482
71-	103-07	Excavation for P.C.C catch pits in soft rock including back filling	yes	100Cft	1,212.23	1,636.51	16,992 ft³	2,78,083
72-	106-11+106-50	P.C.C (1:4:8) in foundation of catch pits	yes	100Cft	14,464.41	19,526.95	2,323 ft³	4,53,692
73-	109-12 + 109-120 + 109-146	P.C.C (1:3:6) for walls & base of catch pits	yes	100Cft	22,011.86	29,716.01	5,117 ft³	15,20,549

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
74-	103-04	Excavation in common soil for 6 inch dia pipes to convey storm water from catch pits into storm drains with back filling	yes	100Cft	911.40	1,230.39	15,238 ft³	1,87,484
	103-07	Excavation in soft rock for 6 inch dia pipes to convey storm water from catch pits into storm drains with back filling	yes	100Cft	1,212.23	1,636.51	7,505 ft³	1,22,823
75-	311-2	Laying of 6 inch dia pipes to carry stormwater from catch pits	yes	RFT	186.09	251.22	4,332 ft	10,88,292
76-	108-12	Bitumen coating at outside walls of catch pits	yes	100Sft	648.08	874.91	12,444 ft³	1,08,874
77-	Non-Scheduled	MS Angle iron for manhole covers resting area of catch pits	no	Per Kg	200.00	270.00	19,819 kg	53,51,174
78-	Non-Scheduled	MS perforated manhole cover for catch pits	no	Per Kg	200.00	270.00	28,721 kg	77,54,752
79-	103-4	Excavation in common soil for trapezoidal shape open drains to convey surface water into catch pits	yes	100Cft	911.40	1,230.39	29,940 ft³	3,06,860
80-	103-7	Excavation in soft rock for trapezoidal shape open drains to convey surface water into catch pits	yes	100Cft	1,212.23	1,636.51	12,284 ft³	2,01,027
81-	109-107 + 109-123 + 109-148	Concrete 1:2:4 for Trapezoidal drain to feed storm water to catch pits	yes	100Cft	17,693.43	23,886.13	27,546 ft³	65,79,607
82-	114-10 + 114-136 + 114-145	R.C.C (1:2:4) for storm drains crossing roads(culverts) walls, base and top slabs excluding cost of steel reinforcement	yes	100Cft	23,343.77	31,514.09	9,018 ft³	28,41,783
83-	114-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for storm drains crossing roads (culverts) walls, base and top slabs	yes	Per Kg	103.29	139.44	13,667 kg	19,05,676
84-	103-04	Excavation in common soil for outfall drainage structures including back filling	yes	100Cft	911.40	1,230.39	2,300 ft³	28,304

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
85-	103-07	Excavation in soft rock for outfall drainage structures including back filling	yes	100Cft	1,212.23	1,636.51	1,133 ft³	18,542
86-	106-11+106-50	P.C.C (1:4:8) in foundation of outfall drainage structures	yes	100Cft	14,464.41	19,526.95	629 ft³	1,22,737
87-	127-164	Dry stone pitching for outfall drainage structures	yes	100Cft	3,960.48	5,346.65	1,875 ft³	1,00,226
88-	127-165	Cement pointing to dry stone pitching for outfall drainage structures	yes	Per 100Sft	991.97	1,339.16	1,855 ft²	24,843
89-	114-2+114-136+114-145	R.C.C (1:2:4) for outfall drainage structures excluding cost of steel reinforcement	yes	100Cft	15,860.40	2,1411.54	1,079 ft³	2,30,967
90-	114-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for outfall drainage structures wing walls, head walls & base	yes	Per Kg	103.29	139.44	1,241 kg	1,73,110
		Total ‘B’	–	–	–	–	–	**6,94,35,268**
		Total A + B (total of separate system)	–	–	–	–		**12,26,90,962**
		COMBINED SEWER SYSTEM						
		(A)-RECTANGULAR DRAIN + CUNETTE PORTION						
91-	103-04	Excavation for drain plus cunette in common soil including back filling lift up to 5ft and lead up to one chain (100ft)	yes	100Cft	911.40	1,230.39	3,25,599 ft³	40,06,135
92-	103-28	Add for additional lift of every three feet	yes	Per 100Cft	77.35	–	–	
93-	103-04 + 103-28(a)	5ft to 8ft depth	yes	100Cft	988.75	1,334.81	4,047 ft³	54,017
94-	103-04 + 103-28(b)	8ft to 11ft depth	yes	100Cft	1,066.10	1,439.24	7,253 ft³	1,04,380
95-	103-07	Excavation for drain plus cunette in soft rock including back filling lift up to 5ft and lead up to one chain (100ft)	yes	100Cft	1,212.23	1,636.51	1,60,370 ft³	26,24,465
96-	103-29	Add for additional lift of every three feet	yes	Per 100Cft	96.69	–		

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	**(b)**	**(c)**	**(d)**	**(e)**	**(f)**	**(g)**	**(h)**	**(i)**
97-	103-07 + 103-29(a)	5ft to 8ft depth	yes	100Cft	1,308.92	1,767.04	1,993 ft³	35,221
98-	103-07 + 103-29(b)	8ft to 11ft depth	yes	100Cft	1,405.61	1,897.57	3,572 ft³	67,784
99-	106-11+106-50	P.C.C (1:4:8) in foundation of drain plus cunette	yes	100Cft	14,464.41	19,526.95	11,101 ft³	21,67,663
100-	109-12 + 109-120 + 109-146	P.C.C (1:3:6) for walls & base of cunette & rectangular drain	yes	100Cft	22,011.86	29,716.01	43,269 ft³	1,28,57,738
101-	114-55 + 114-136 + 114-145	R.C.C (1:2:4) for drain plus cunette top lab excluding steel reinforcement	yes	100Cft	22,172.61	29,933.02	12,371 ft³	37,02,865
102-	114-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for drain plus cunette	yes	Per Kg	103.29	139.44	72,512 kg	1,01,11,186
103-	108-12	Bitumen coating at outside walls of drain plus cunette	yes	100Sft	648.08	874.91	45,055 ft³	3,94,189
		Total 'A'						**36125643**
		(B)-PIPE PORTION IN COMBINED SYSTEM						
103a-	313-14	Excavation for pipes in common soil lift up to 5ft and lead up to one chain (100ft) including back filling	yes	100Cft	697.58	941.73	3,40,384 ft³	32,05,508
104-	313-15	Add for additional lift of every three feet	yes	Per 100Cft	77.35	–	–	
105-	313-14+313-15(a)	5ft to 8ft depth	yes	100Cft	774.93	1,046.16	1,58,390 ft³	16,57,002
106-	313-14+313-15(b)	8ft to 11ft depth	yes	100Cft	852.28	1,150.58	2,05,023 ft³	23,58,946
107-	313-14+313-15(c)	11ft to 14ft depth	yes	100Cft	929.63	1,255.00	64,837 ft³	8,13,700
108-	313-14+313-15(d)	14ft to 17ft depth	yes	100Cft	1,006.98	1,359.42	38,001 ft³	5,16,595
109-	313-14+313-15(e)	17ft to 20ft depth	yes	100Cft	1,084.33	1,463.85	22,635 ft³	3,31,345
110-	313-14+313-15(f)	20ft to 23ft depth	yes	100Cft	1,161.68	1,568.27	12,589 ft³	1,97,424
111-	313-14+313-15(g)	23ft to 26ft depth	yes	100Cft	1,239.03	1,672.69	4,757 ft³	79,563
112-	313-14+313-15(h)	26ft to 29ft depth	yes	100Cft	1,316.38	1,777.11	141 ft³	2,504
113-	313-6	Excavation for pipes in soft rock lift up to 5ft and lead up to one chain (100ft) including back filling	yes	100Cft	1,477.56	1,994.71	1,67,652 ft³	33,44,161
114-	313-15	Add for additional lift of every three feet	yes	Per 100Cft	77.35	–	–	
115-	313-6 + 313-15(a)	5ft to 8ft depth	yes	100Cft	1,554.91	2,099.13	78,013 ft³	16,37,589

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
116-	313-6 + 313-15(b)	8ft to 11ft depth	yes	100Cft	1,632.26	2,203.55	1,00,981 ft³	22,25,175
117-	313-6 + 313-15(c)	11ft to 14ft depth	yes	100Cft	1,709.61	2,307.97	31,934 ft³	7,37,039
118-	313-6 + 313-15(d)	14ft to 17ft depth	yes	100Cft	1,786.96	2,412.40	18,717 ft³	4,51,527
119-	313-6 + 313-15(e)	17ft to 20ft depth	yes	100Cft	1,864.31	2,516.82	11,149 ft³	2,80,593
120-	313-6 + 313-15(f)	20ft to 23ft depth	yes	100Cft	1,941.66	2,621.24	6,200 ft³	1,62,527
121-	313-6 + 313-15(g)	23ft to 26ft depth	yes	100Cft	2,019.01	2,725.66	2,343 ft³	63,857
122-	313-6 + 313-15(h)	26ft to 29ft depth	yes	100Cft	2,096.36	2,830.09	69.40 ft³	1,964
123-	311-3	Laying of 9″ dia Class 'B' pipes including cutting, fitting, Jointing & back filling of trench	yes	RFT	250.26	337.85	4,293 ft	14,50,394
124-	311-4	Laying of 12″ dia Class 'B' pipes including cutting, fitting, Jointing & back filling of trench	yes	RFT	504.60	681.21	2,059 ft	14,02,611
125-	311-6	Laying of 18″ dia Class 'B' pipes including cutting, fitting, Jointing & back filling of trench	yes	RFT	833.90	1,125.77	2,321 ft	26,12,901
126-	311-8	Laying of 24″ dia Class 'B' pipes including cutting, fitting, Jointing & back filling of trench	yes	RFT	1,394.21	1,882.18	3,364 ft	63,31,665
127-	311-9	Laying of 30″ dia Class 'B' pipes including cutting, fitting, Jointing & back filling of trench	yes	RFT	1,785.98	2,411.07	1,920 ft	46,29,260
128-	104-9+104-13	Sand encasement of pipes including filling, ramming watering lift up to 5ft & 5ft to 8ft	yes	100Cft	2,287.86	3,088.61	2,20,393 ft³	68,07,080
		Circular Manholes						
129-	103-22	Excavation of circular manholes in common soil lift up to 5ft and lead up to one chain (100ft) with back filling	yes	100Cft	863.07	1,165.14	41,866 ft³	4,87,801
130-	103-28	Add for additional lift of every three feet	yes	Per 100Cft	77.35	–	–	–
131-	103-22 + 103-28(a)	5ft to 8ft depth	yes	100Cft	940.42	1,269.57	24,926 ft³	3,16,451
132-	103-22 + 103-28(b)	8ft to 11ft depth	yes	100Cft	1,017.77	1,373.99	24,226 ft³	3,32,869
133-	103-22 + 103-28(c)	11ft to 14ft depth	yes	100Cft	1,095.12	1,478.41	19,972 ft³	2,95,272
134-	103-22 + 103-28(d)	14ft to 17ft depth	yes	100Cft	1,172.47	1,582.83	15,849 ft³	2,50,868
135-	103-22 + 103-28(e)	17ft to 20ft depth	yes	100Cft	1,249.82	1,687.26	11,850 ft³	1,99,933
136-	103-22 + 103-28(f)	20ft to 23ft depth	yes	100Cft	1,327.17	1,791.68	8,528 ft³	1,52,794

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
137-	103-22 + 103-28(g)	23ft to 26ft depth	yes	100Cft	1,404.52	1,896.10	5,312 ft³	1,00,712
138-	103-22 + 103-28(h)	26ft to 29ft depth	yes	100Cft	1,481.87	2,000.52	3,453 ft³	69,083
139-	103-25	Excavation for circular manholes in soft rock lift up to 5 ft and lead up to one chain (100ft) with back filling	yes	100Cft	1,092.48	1,474.85	20,621 ft³	3,04,123
140-	103-29	Add for additional lift of every three feet	yes	Per 100Cft	99.69	–	–	–
141-	103-25 + 103-29(a)	5ft to 8ft depth	yes	100Cft	1,192.17	1,609.43	12,277 ft³	1,97,588
142-	103-25 + 103-29(b)	8ft to 11ft depth	yes	100Cft	1,291.86	1,744.01	11,932 ft³	2,08,103
143-	103-25 + 103-29(c)	11ft to 14ft depth	yes	100Cft	1,391.55	1,878.59	9,837 ft³	1,84,799
144-	103-25 + 103-29(d)	14ft to 17ft depth	yes	100Cft	1,491.24	2,013.17	7,806 ft³	1,57,156
145-	103-25 + 103-29(e)	17ft to 20ft depth	yes	100Cft	1,590.93	2,147.76	5,836 ft³	1,25,351
146-	103-25 + 103-29(f)	20ft to 23ft depth	yes	100Cft	1,690.62	2,282.34	4,200 ft³	95,866
147-	103-25 + 103-29(g)	23ft to 26ft depth	yes	100Cft	1,790.31	2,416.92	2,616 ft³	63,230
148-	103-25 + 103-29(h)	26ft to 29ft depth	yes	100Cft	1,890	2,551.50	1,701 ft³	43,397
149-	127-27	Stone Ballast in foundation of circular manholes	yes	100Cft	3,864.46	5,217.02	5,634 ft³	2,93,943
150-	105-14+105-27+105-39	P.C.C (1:4:8) in foundation of circular manholes	yes	100Cft	11,402.13	15,392.88	3,427 ft³	5,27,478
151-	112-99	Brick Masonry 1st class for circular manholes with cement mortar(1:3) for 9″, 13.04″ thick walls including curing and scaffolding up to 10ft depth	yes	100Cft	23,742.29	32,052.09	15,535 ft³	64,19,465
152-	112-101	Add for additional depth of every 5ft	yes	Per 100Cft	422.62	–	–	
153-	112-99 + 112-101(a)	10 to 15 ft depth	yes	100Cft	24,164.91	32,622.63	20,028 ft³	22,45,341
154-	112-99 + 112-101(b)	15 to 20 ft depth	yes	100Cft	24,587.53	33,193.17	6,883 ft³	14,03,525
155-	112-99 + 112-101(c)	20 to 25 ft depth	yes	100Cft	25,010.15	33,763.70	4,228 ft³	75,0911
156-	112-99 + 112-101(d)	25 to 30 ft depth	yes	100Cft	25,432.77	34,334.24	803 ft³	2,75,598
157-	122-03	0.5 ″ thick cement plaster (1:3) at inside and outside walls of circular manholes	yes	100Sft	2,083.60	2,812.86	6,1942 ft²	17,42,333
158-	108-12	Bitumen coating at outside walls of circular manholes	yes	100Sft	648.08	874.91	36,123 ft²	3,16,045

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
159-	109-107+109-123+109-48	Benching concrete (1:2:4) at inner bottom of circular manholes	yes	100Cft	17,693.43	23,886.13	1,033 ft³	2,46,835
160-	114-10+114-136+114-145	R.C.C (1:2:4) excluding cost of steel reinforcement for circular manhole covers resting area	yes	100Cft	23,343.77	31,514.09	576 ft³	1,81,455
161-	114-55 + 114-136 + 114-145	R.C.C (1:2:4) excluding cost of steel reinforcement for circular manhole covers	yes	100Cft	22,172.61	29,933.02	123 ft³	36,815
162-	144-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for circular manhole covers, steps	yes	Per Kg	103.29	139.44	2,042 kg	2,84,753
163-	Non-Scheduled	MS Angle iron for circular manhole covers, rest area	no	Per Kg	200.00	270.00	3,512 kg	9,48,240
		Square Shape Manholes						
164-	103-04	Excavation of square shape manholes in common soil including back filling	yes	100Cft	911.40	1,230.39	42,843 ft³	5,27,134
165-	103-07	Excavation of square shape manholes in soft rock including back filling	yes	100Cft	1,212.23	1,636.51	21,102 ft³	3,45,332
166-	106-11+106-50	P.C.C (1:4:8) in foundation of square shape manholes	yes	100Cft	14,464.41	19,526.95	1,054 ft³	2,05,717
167-	109-12+109-120+109-146	P.C.C (1:3:6) for walls & base of square manholes	yes	100Cft	22,011.86	29,716.01	5,223 ft³	15,52,205
168-	114-55+114-136+114-145	R.C.C (1:2:4) excluding cost of steel reinforcement for square manhole covers	yes	100Cft	22,172.61	29,933.02	485 ft³	1,45,301
169-	114-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for square manhole covers	yes	Per Kg	103.29	139.44	2,640 kg	3,68,107
170-	Non-Scheduled	Half circled MS Angle iron for square manhole cover	no	Per Kg	200.00	270.00	283 kg	76,378
171-	108-12	Bitumen coating at outside walls of square manholes	yes	100Sft	648.08	874.91	12,780 ft²	1,11,814
		Total 'B'						**63891051**
		(C)- STORM DRAIN PORTION IN COMBINED SYSTEM						
172-	103-04	Excavation for P.C.C storm drains in common soil including back filling	yes	100Cft	911.40	1,230.39	83,753 ft³	10,30,485

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
173-	103-07	Excavation for P.C.C storm drains in soft rock including back filling	yes	100Cft	1212.23	1,636.51	41,251 ft³	6,75,082
174-	106-11+106-50	P.C.C (1:4:8) in foundation of storm drains	yes	100Cft	14,464.41	19,526.95	6,756 ft³	13,19,284
173-	103-07	Excavation for P.C.C storm drains in soft rock including back filling	yes	100Cft	1,212.23	1,636.51	41,251 ft³	6,75,082
174-	106-11+106-50	P.C.C (1:4:8) in foundation of storm drains	yes	100Cft	14,464.41	19,526.95	6,756 ft³	13,19,284
175-	109-12+109-120+109-146	P.C.C (1:3:6) for walls & base of storm drains	yes	100Cft	22,011.86	29,716.01	20,390 ft³	60,59,224
176-	109-107 + 109-123 + 109-148	Benching concrete (1:2:4) at inner bottom of storm drains	yes	100Cft	17,693.43	23,886.13	2,960 ft³	7,06,951
177-	315-29	Precast R.C.C (1:2:4) slab covers including steel reinforcement for storm drains	yes	CFT	664.84	897.53	5,248 ft³	47,10,273
178-	108-12	Bitumen coating at outside walls of storm drains	yes	100Sft	648.08	874.91	25,358 ft²	2,21,857
179-	103-04	Excavation for P.C.C catch pits in common soil including back filling	yes	100Cft	911.40	1,230.39	45,658 ft³	5,61,767
180-	103-07	Excavation for P.C.C catch pits in soft rock including back filling	yes	100Cft	1,212.23	1,636.51	22,488 ft³	3,68,020
181-	106-11+106-50	P.C.C (1:4:8) in foundation of catch pits	yes	100Cft	14,464.41	19,526.95	1,192 ft³	2,32,826
182-	109-12 + 109-120 + 109-146	P.C.C (1:3:6) for walls & base of catch pits	yes	100Cft	22,011.86	29,716.01	6,370 ft³	18,92,773
183-	103-04	Excavation in common soil for 6 inch dia pipes to convey storm water from catch pits into storm drains with back filling	yes	100Cft	911.40	1,230.39	14,520 ft³	1,78,656
184-	103-07	Excavation in common soil for 6 inch dia pipes to convey storm water from catch pits into storm drains with back filling	yes	100Cft	1,212.23	1,636.51	7,152 ft³	1,17,039
185-	311-2	Laying of 6 inch dia pipes to carry stormwater from catch pits	yes	RFT	186.09	251.22	4,128 ft	10,37,042
186-	108-12	Bitumen coating at outside walls of catch pits	yes	100Sft	648.08	874.91	1,6537 ft³	1,44,684
187-	Non-Scheduled	MS Angle iron for manhole covers resting area of catch pits	no	Per Kg	200.00	270.00	17,137 kg	46,27,026

S.No	PWD Ref No	Description	Sched or not	Unit	Unit Rates 2012	35% premium	Qty	Total Amount (Rs)
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
188-	Non-Scheduled	MS perforated manhole cover for catch pits	no	Per Kg	200.00	270.00	24,835 kg	67,05,339
189-	103-4	Excavation in common soil for trapezoidal shape open drains to convey surface water into catch pits	yes	100Cft	911.40	1,230.39	31,788 ft^3	3,91,116
190-	103-7	Excavation in soft rock for trapezoidal shape open drains to convey surface water into catch pits	yes	100Cft	1,212.23	1,636.51	15,657 ft^3	2,56,225
191-	109-107 + 109-123 + 109-148	Concrete 1:2:4 for Trapezoidal drain to feed storm water to catch pits	yes	100Cft	17,693.43	23,886.13	34,020 ft^3	81,26,030
192-	103-04	Excavation in common soil for outfall drainage structures including back filling	yes	100Cft	911.40	1,230.39	1,852 ft^3	22,793
193-	103-07	Excavation in soft rock for outfall drainage structures including back filling	yes	100Cft	1,212.23	1,636.51	912 ft^3	14,932
194-	106-11+106-50	P.C.C (1:4:8) in foundation of outfall drainage structures	yes	100Cft	14,464.41	19,526.95	514 ft^3	1,00,420
195-	127-164	Dry stone pitching for outfall drainage structures	yes	100Cft	3,960.48	5,346.65	1,541 ft^3	82,382
196-	127-165	Cement pointing to dry stone pitching for outfall drainage structures	yes	Per 100Sft	991.97	1,339.16	1,525 ft^2	20,421
197-	114-2+114-136+114-145	R.C.C (1:2:4) for outfall drainage structures excluding cost of steel reinforcement	yes	100Cft	15,860.40	21,411.54	859 ft^3	1,83,880
198-	114-167	Steel reinforcement with yield stress of 40,000 psi including cutting bending and wastage for outfall drainage structures wing walls, head walls & base	yes	Per Kg	103.29	139.44	1000 kg	1,39,383
		Total ‘C’						**3,99,25,910**
		Total A + B + C (total of combined system)						**13,99,42,604**

Appendix F

Key Plan & Detailed Drawings of Sewers in Separate Network

ANNEXURE F: SEWER LAYOUT PLAN FOR SEPARATE SEWER SYSTEM

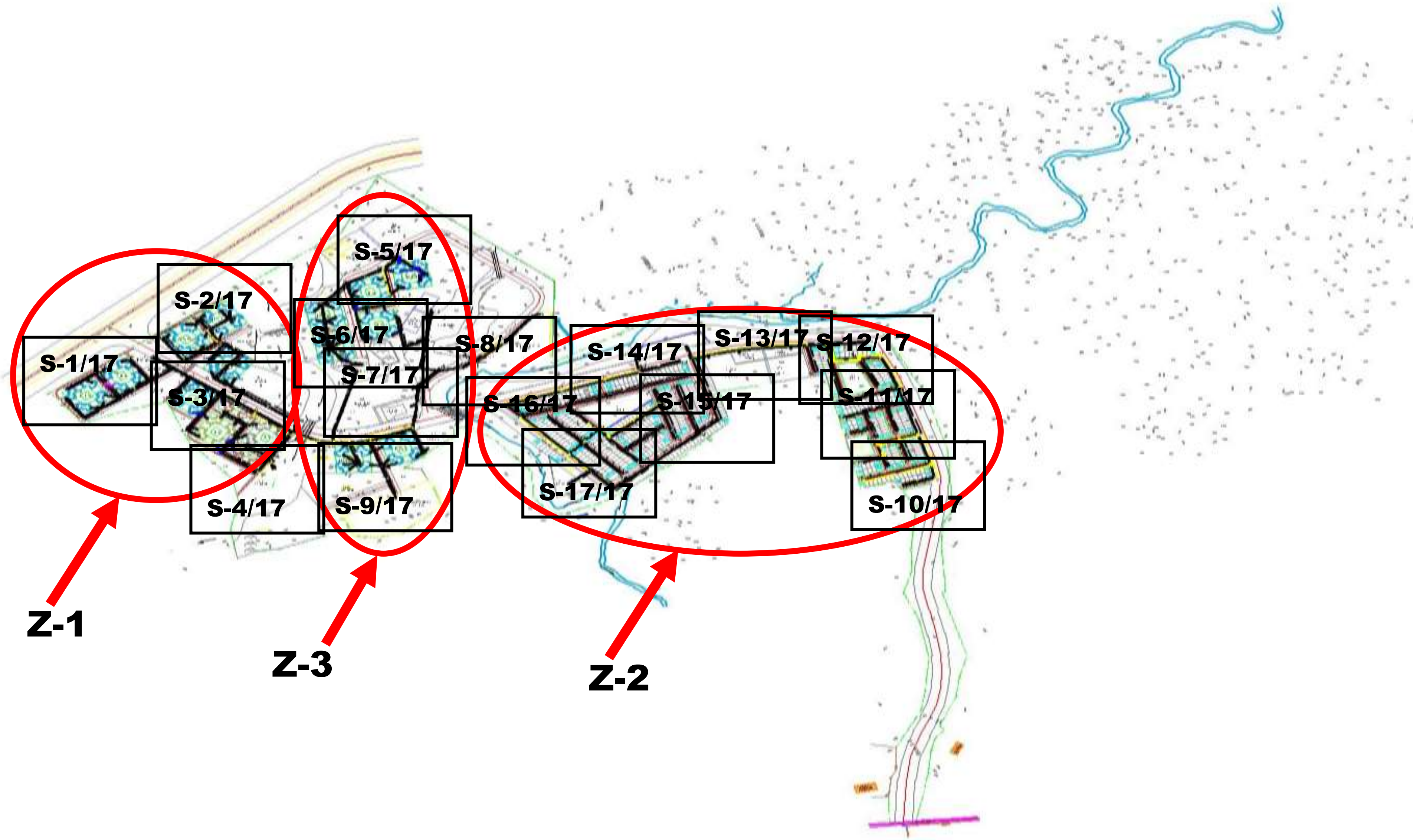
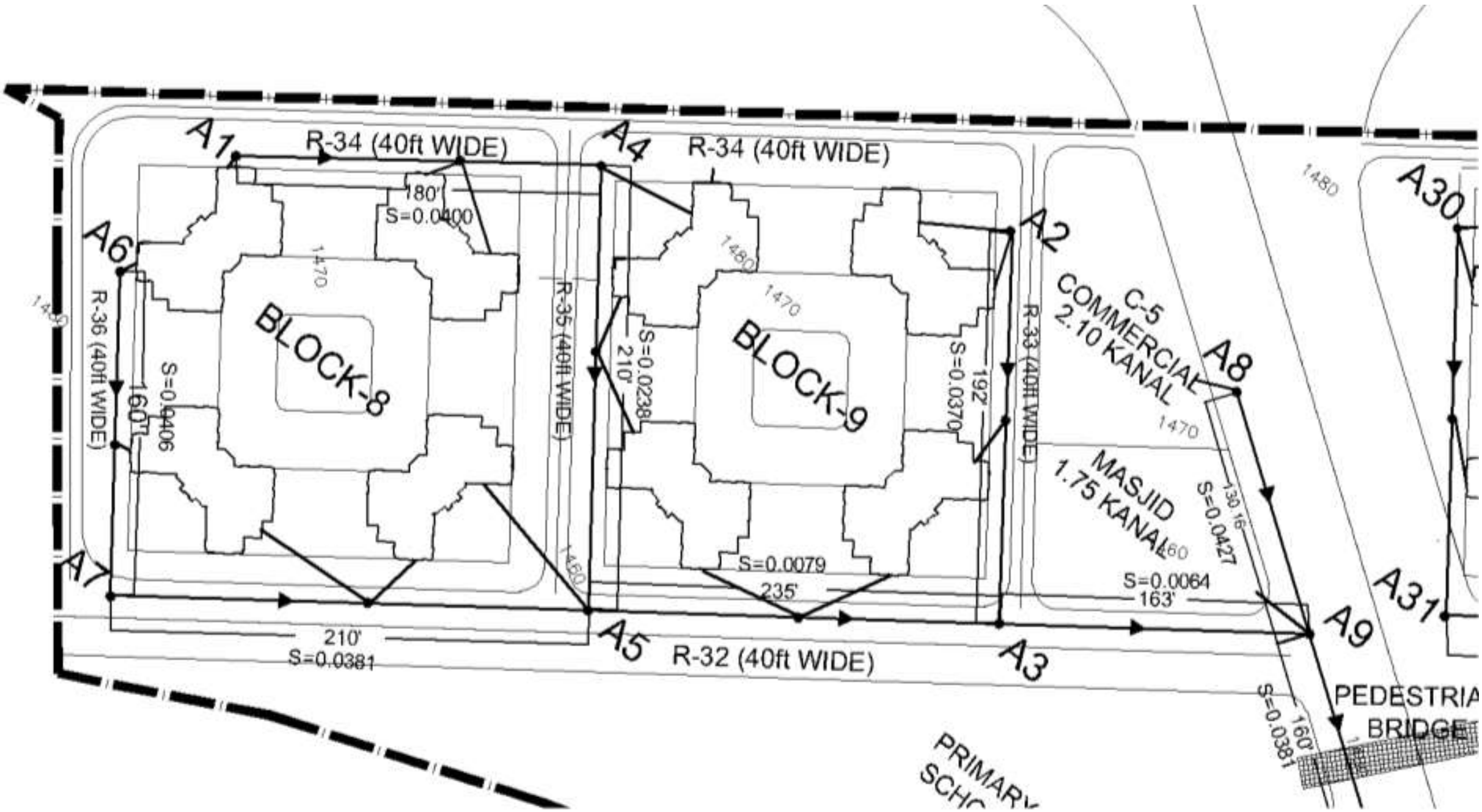


Fig F1: Sewer layout plan for searate system showing 3 zones and legened for detail drawings



Sheet 1 of 17

Fig F2: Sewer layout plan of Zone-1 at R/S of MR-01 showing nodes and flow direction

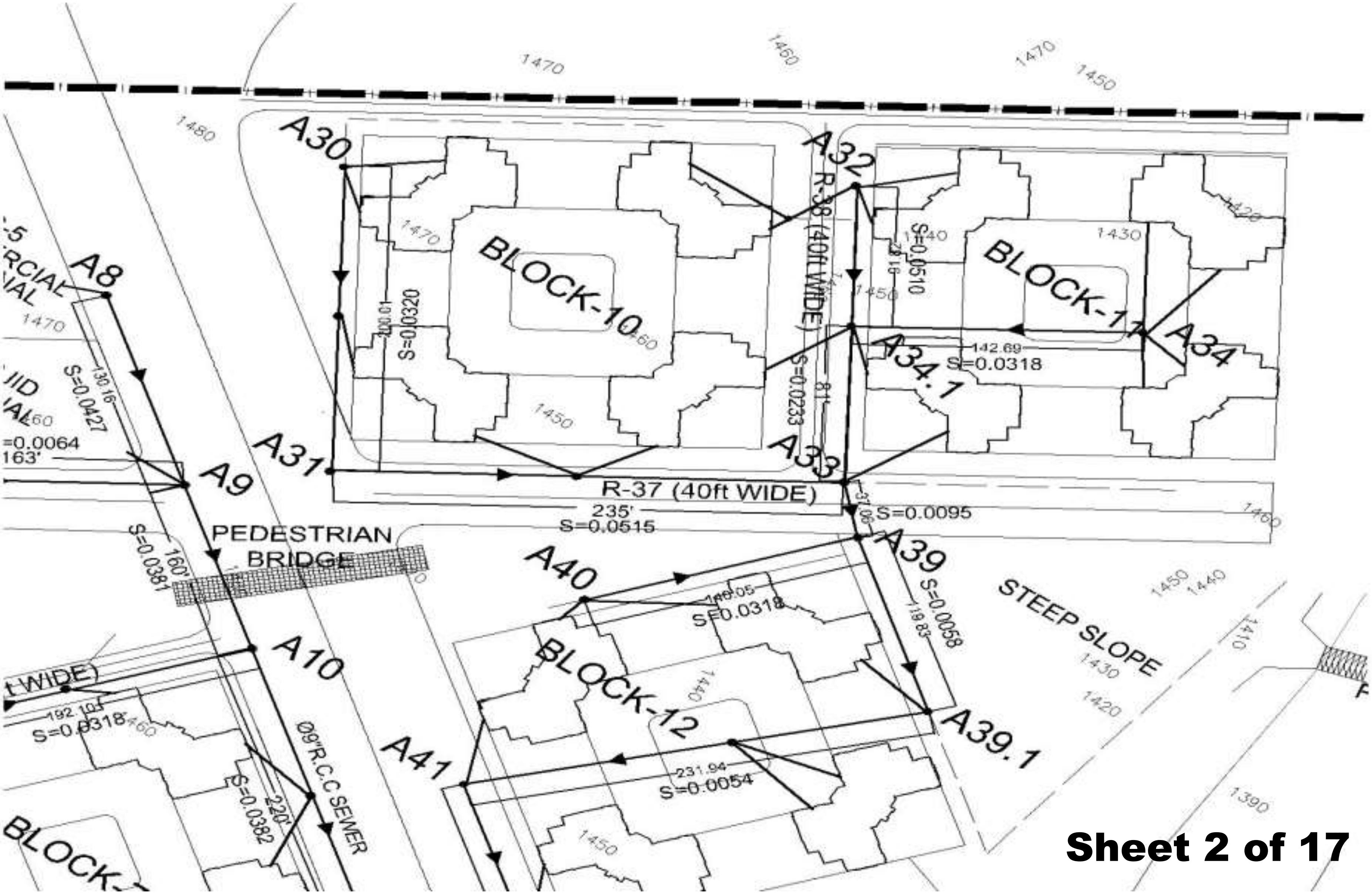


Fig F3: Sewer layout plan of Zone-1 at L/S of MR-01 showing nodes and flow direction

Fig F4: Sewer layout plan of Zone-1 at R/S of MR-01 near STP-1 showing nodes and flow direction

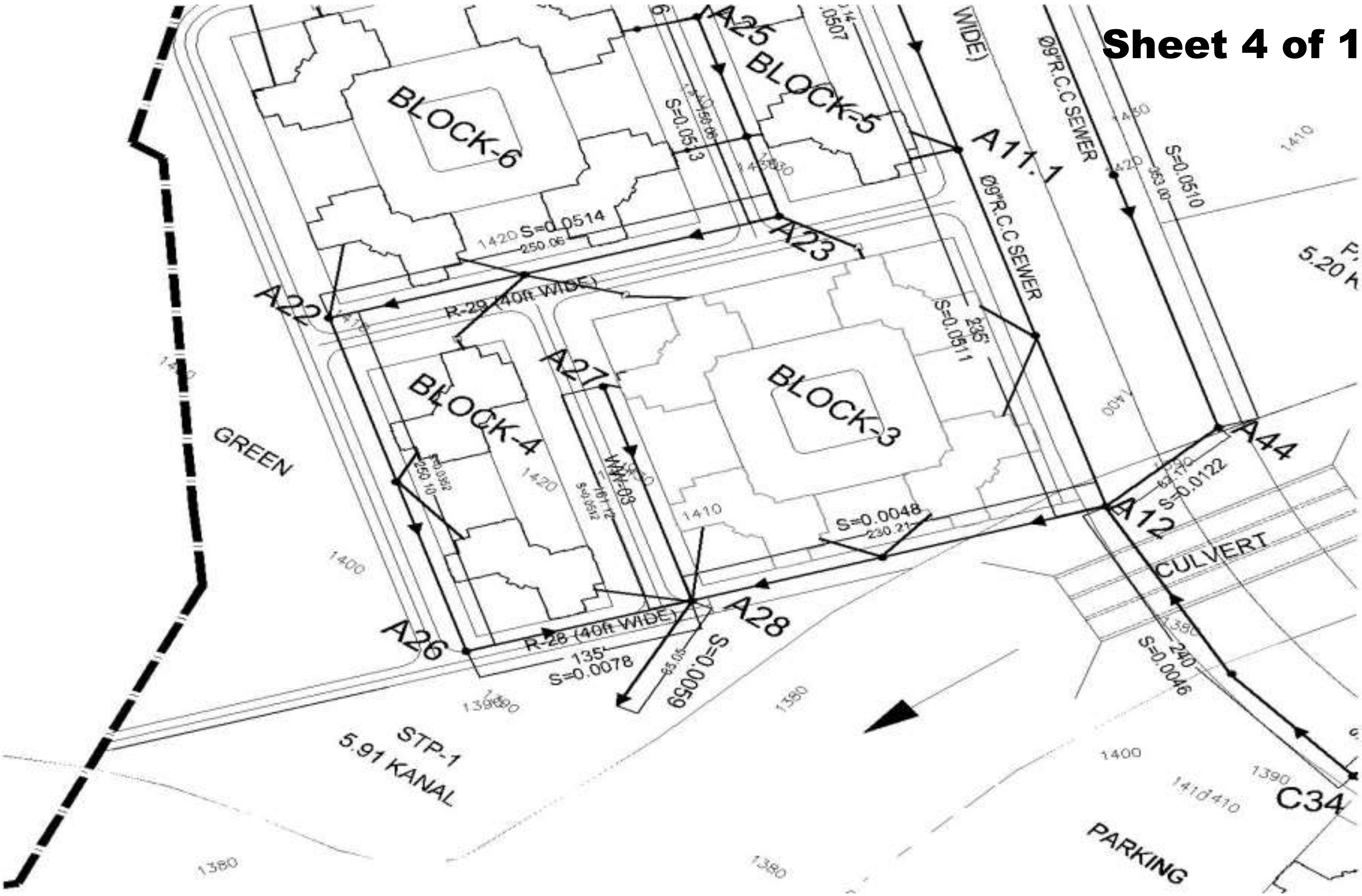


Fig F5: Sewer layout plan of Zone-1 at R/S of MR-01 also showing node A12 which is confluence point of Z-1, Z-3 for didposal to STP-1

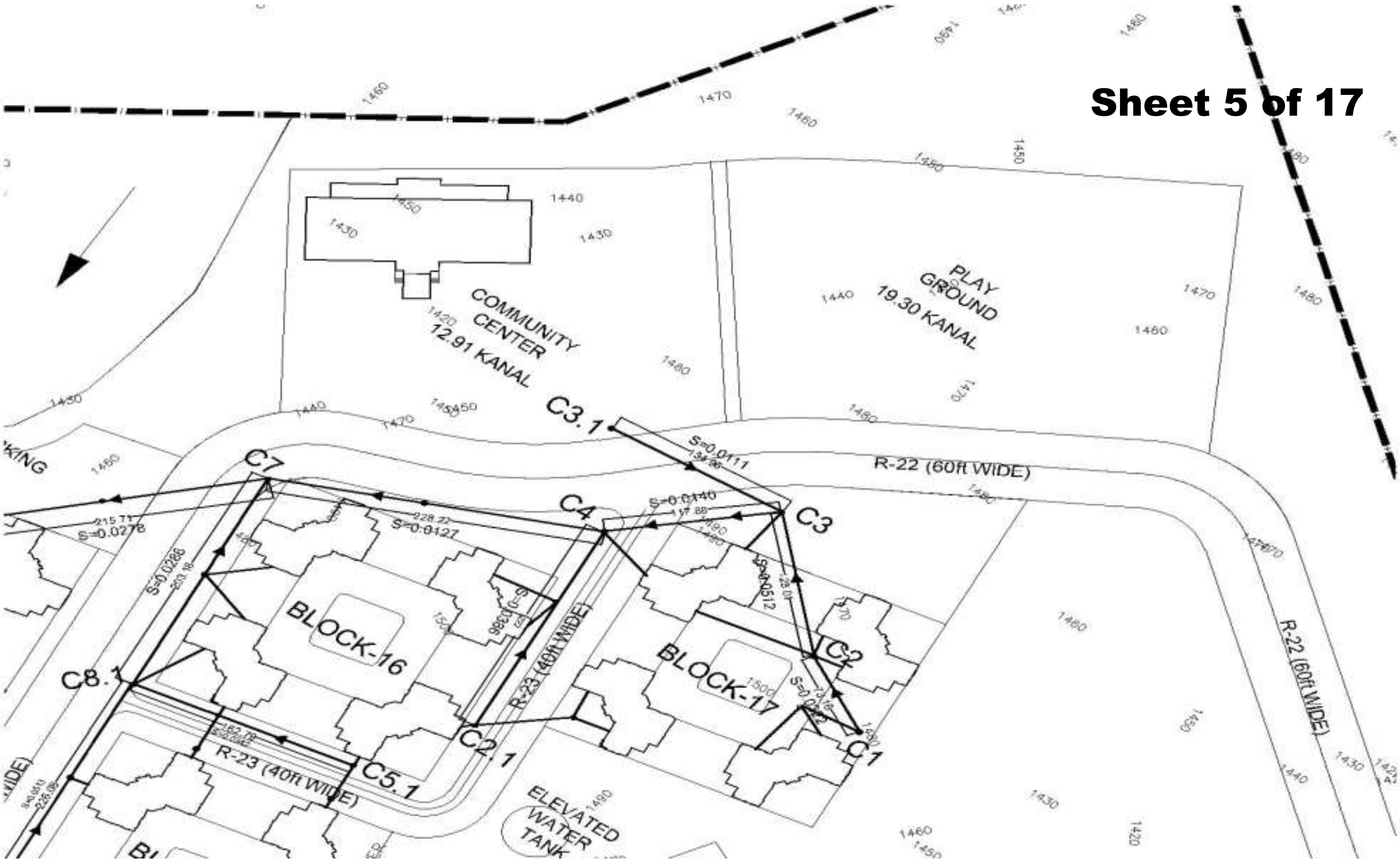


Fig F6: Sewer layout plan of Zone-3 at L/S of MR-01 showing nodes and flow direction

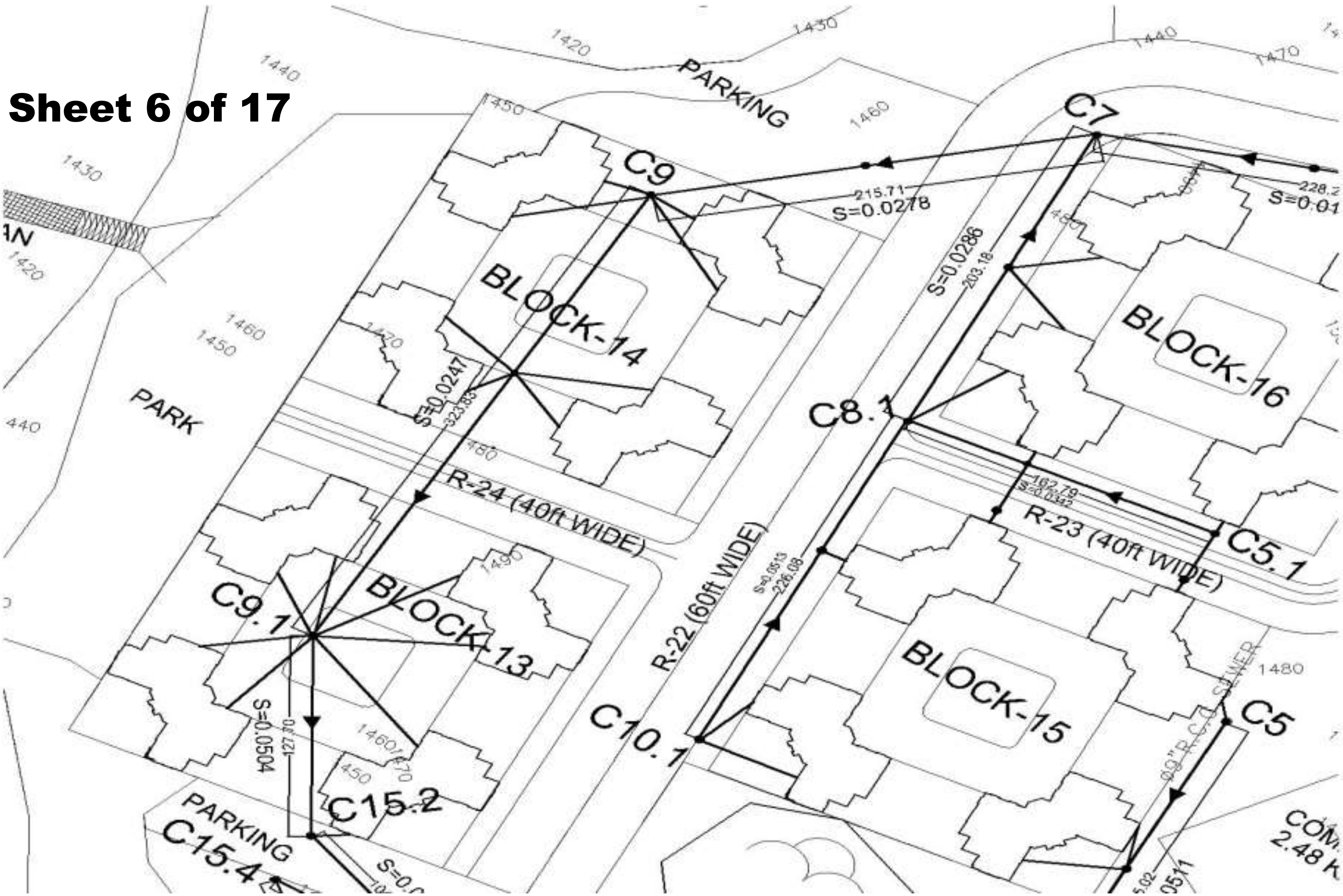


Fig F7: Sewer layout plan of Zone-3 at L/S of MR-01 showing nodes and flow direction

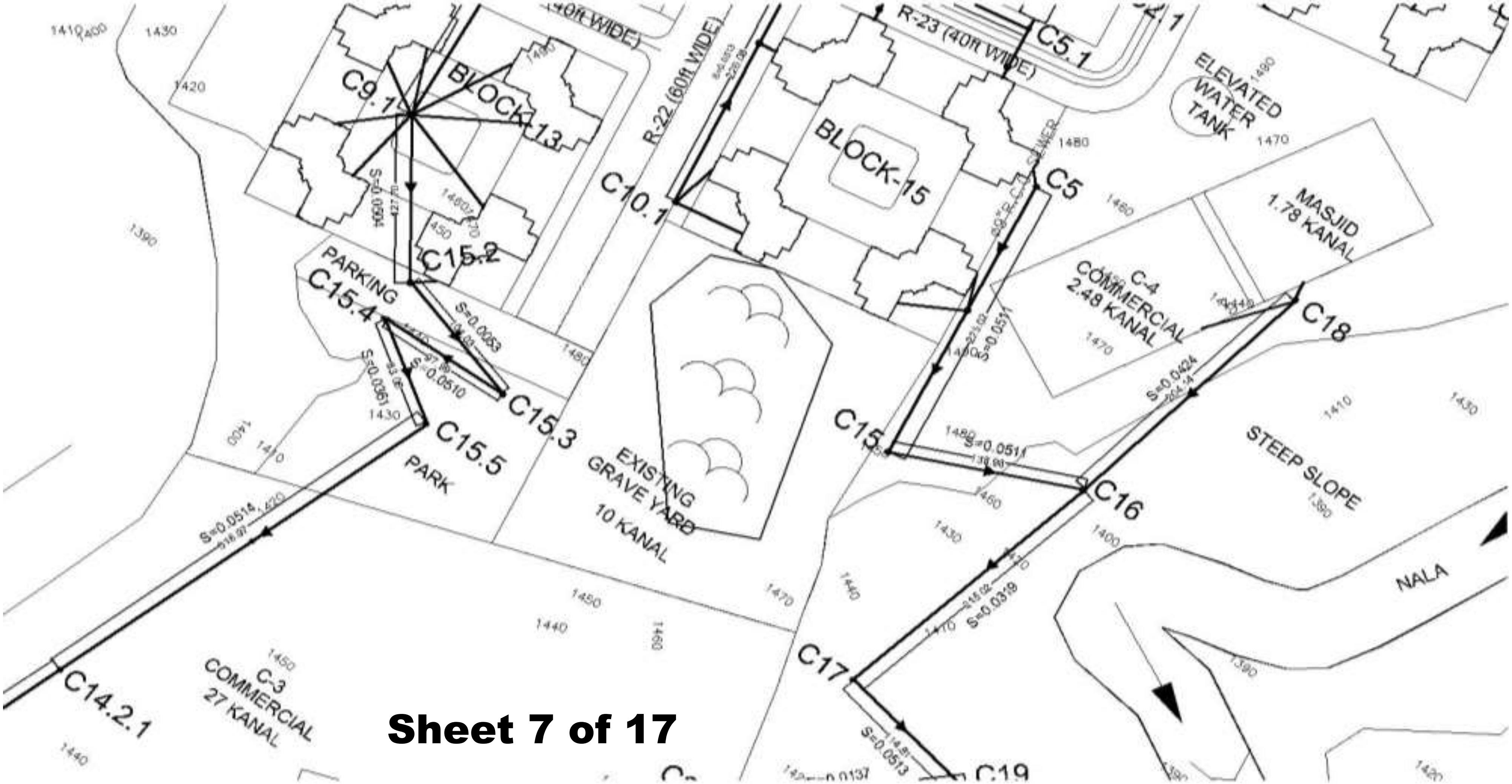


Fig F8: Sewer layout plan of Zone-3 at L/S of MR-01 showing nodes and flow direction

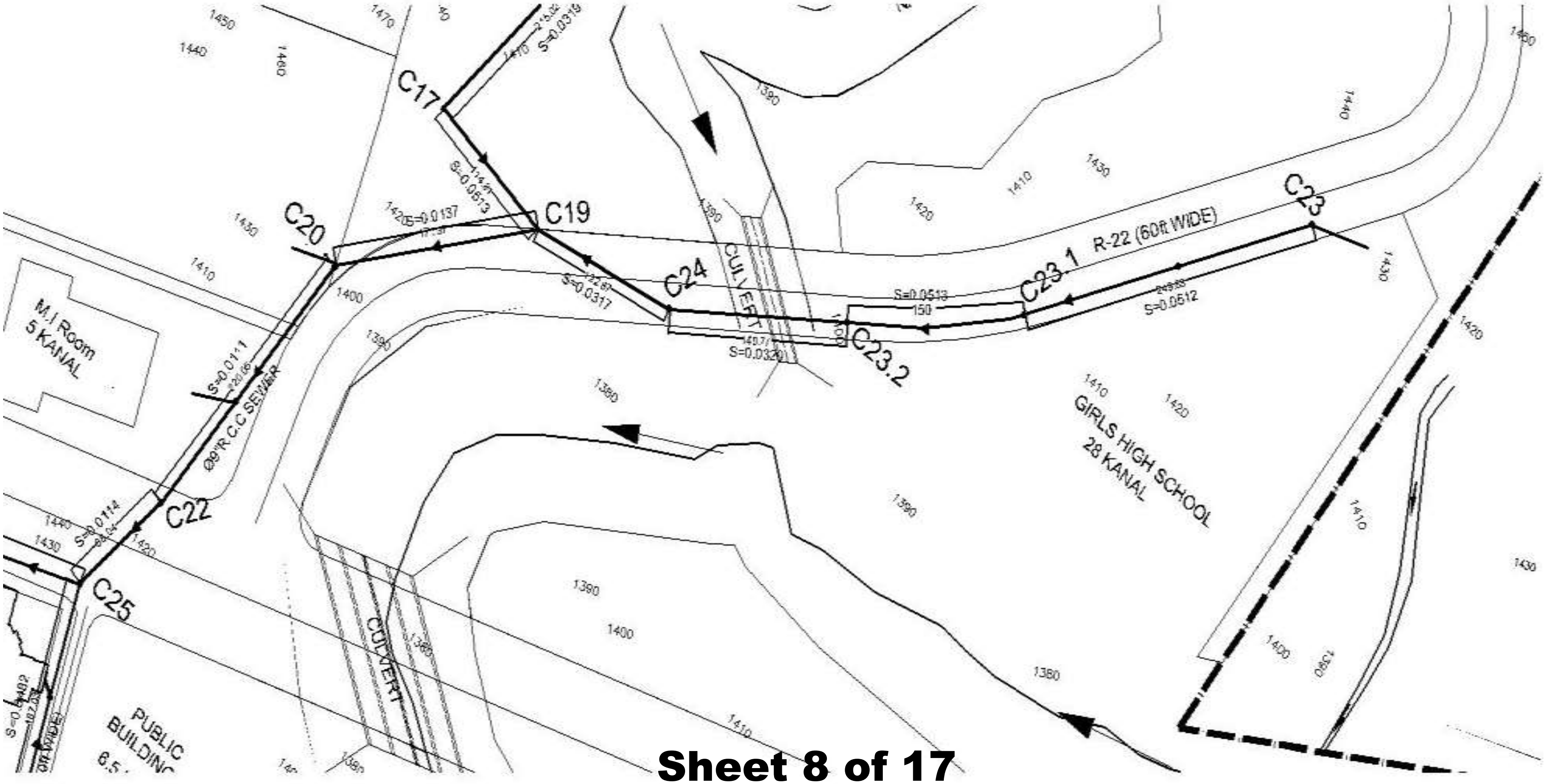


Fig F9: Sewer layout plan of Zone-3 at L/S of MR-01 showing nodes and flow direction

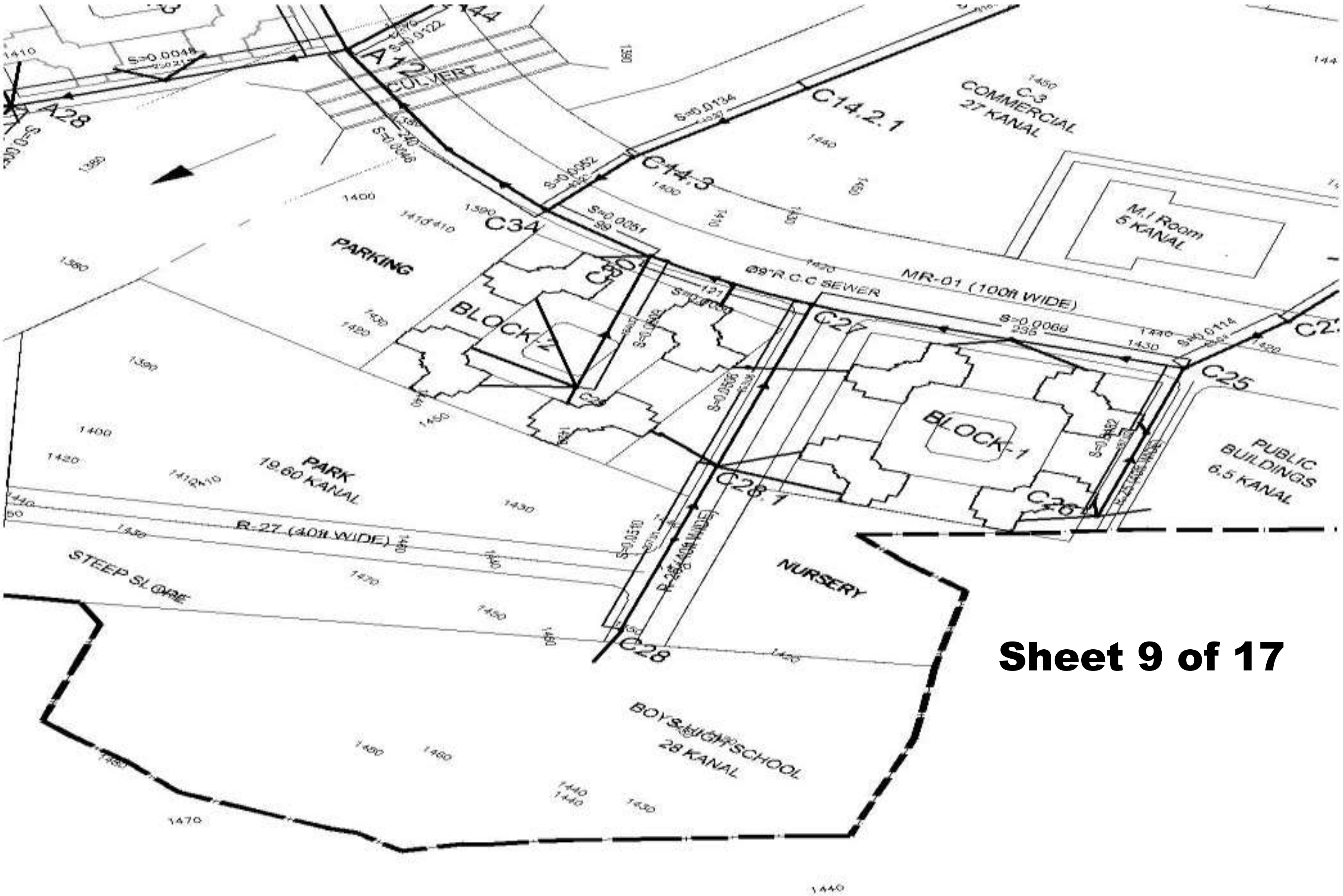


Fig F10: Sewer layout plan at R/S of MR-01 showing confulence node A12 of Zone-1and Zone-3

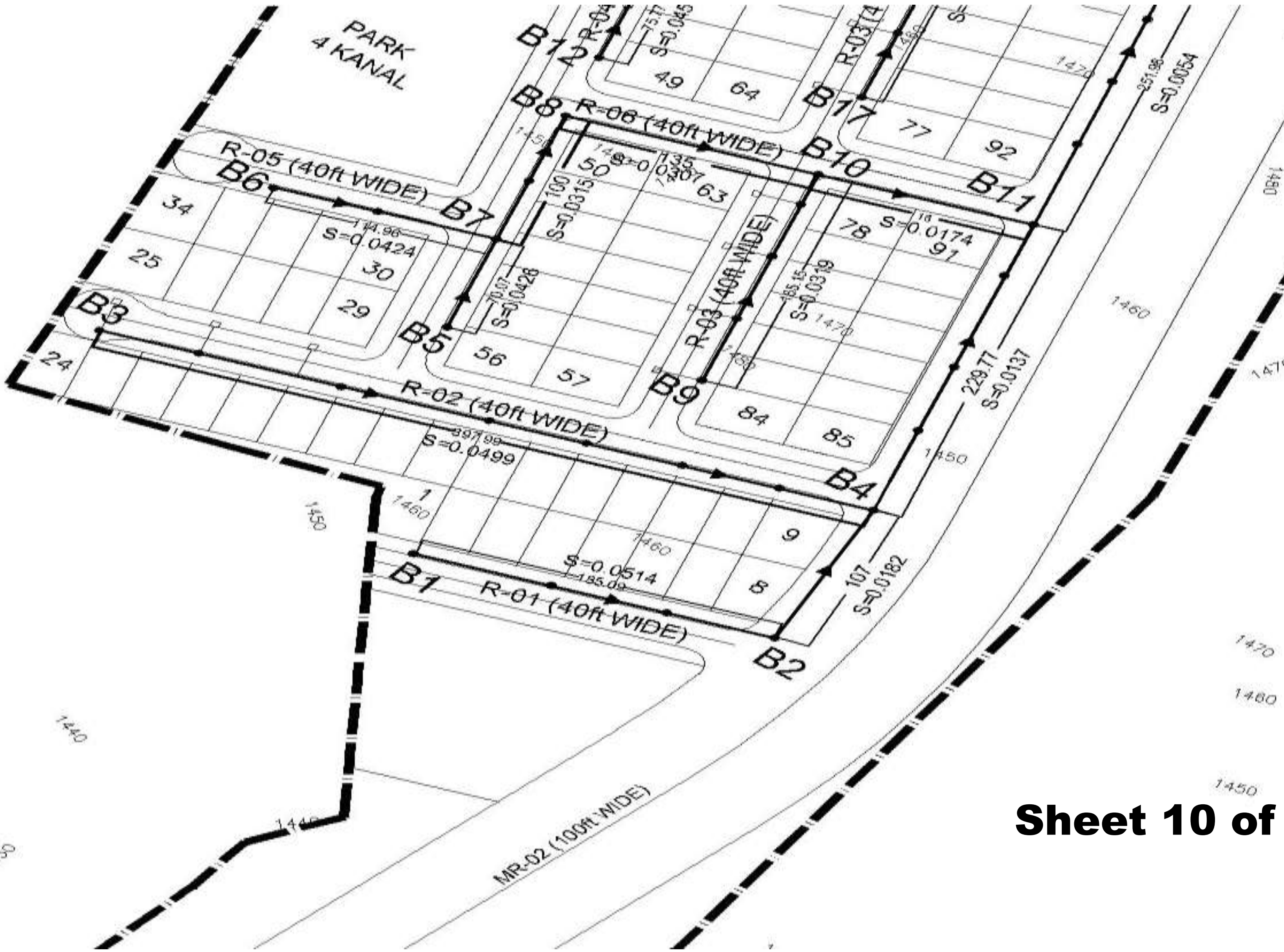


Fig F11: Sewer layout plan of Zone-2 for black water disposal of houses at R/S of MR-02

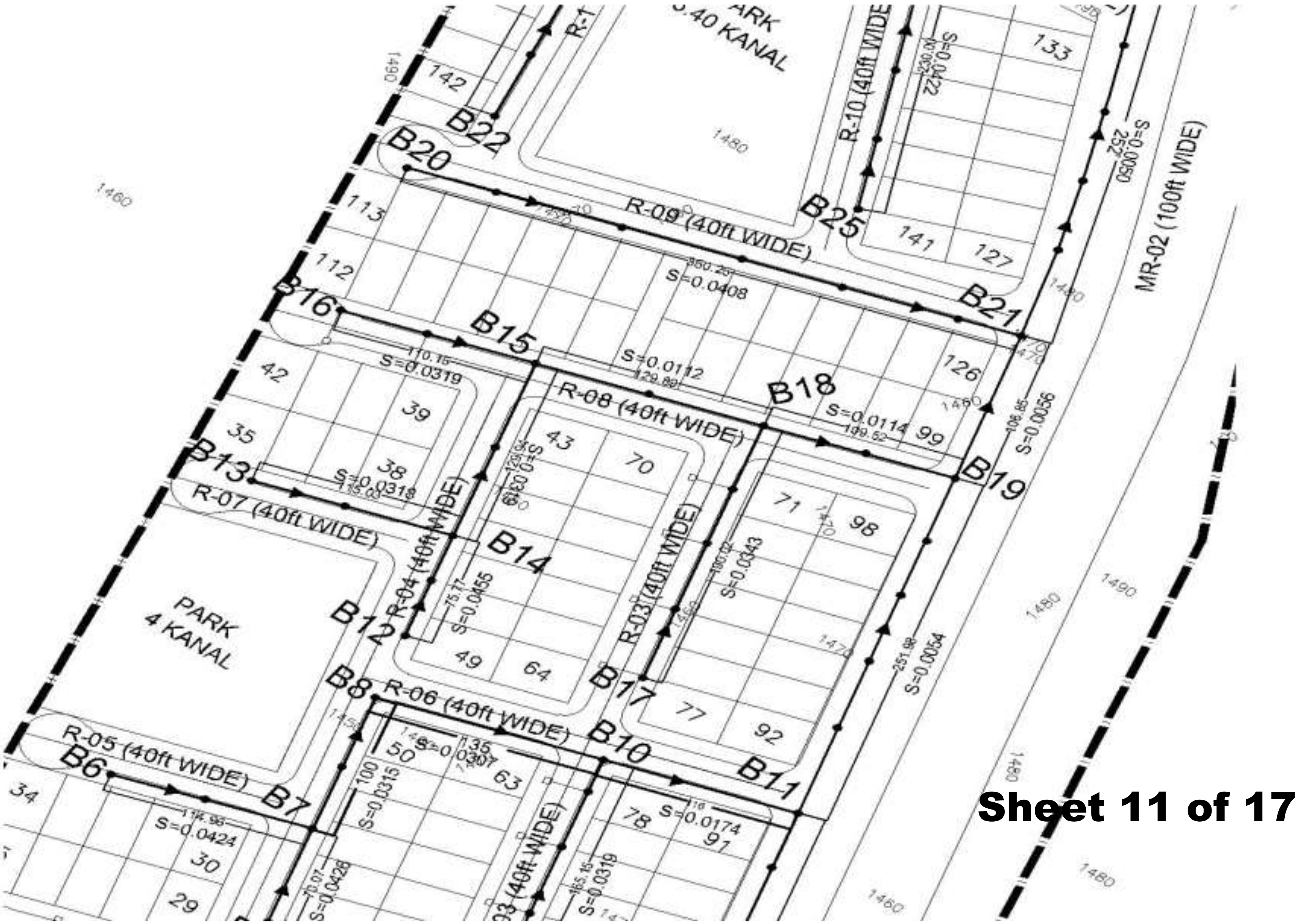


Fig F12: Sewer layout plan of Zone-2 at R/S of MR-02 and just before start point MR-02

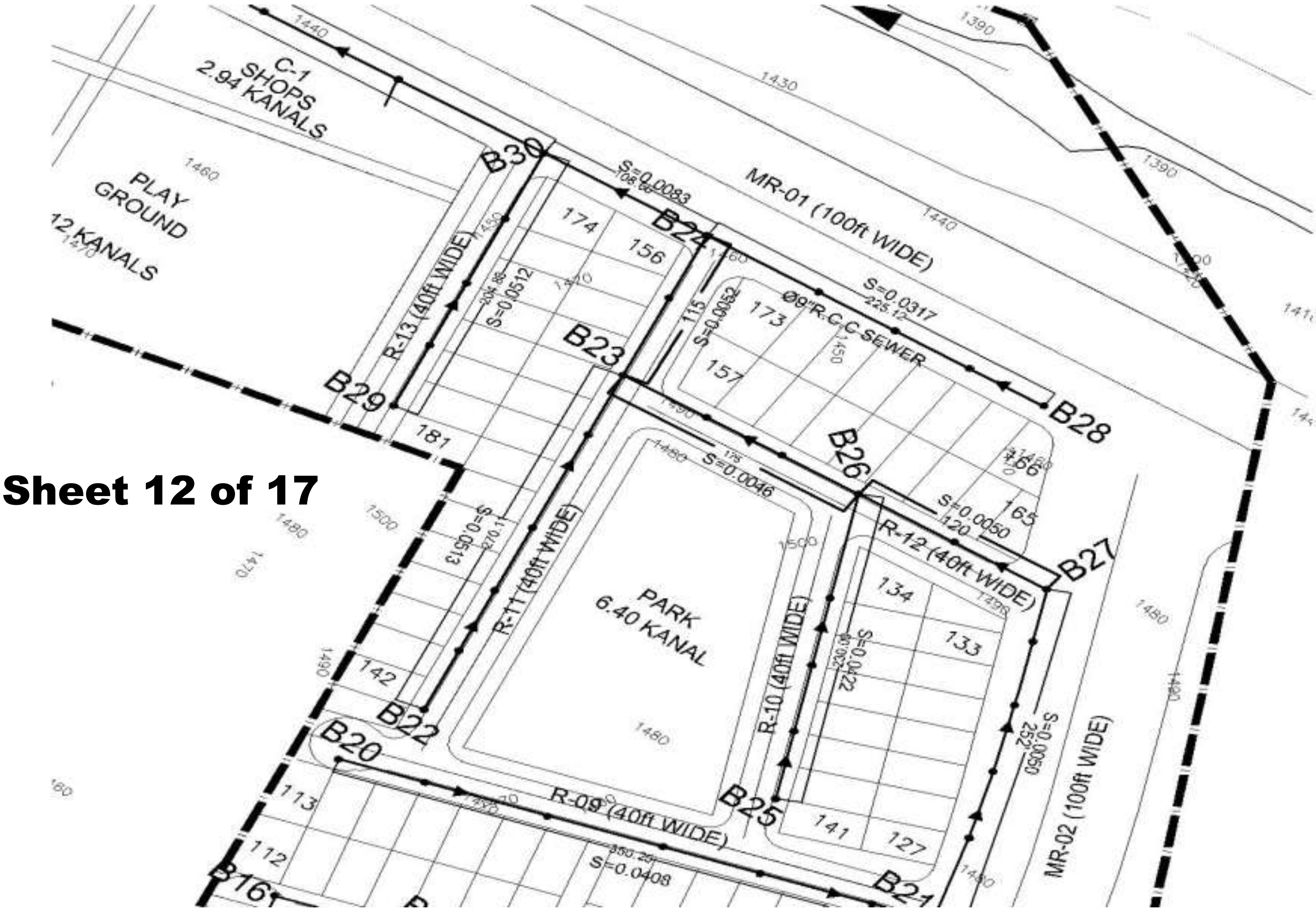


Fig F13: Sewer layout plan of Zone-2 at juction of MR-02 and MR-01

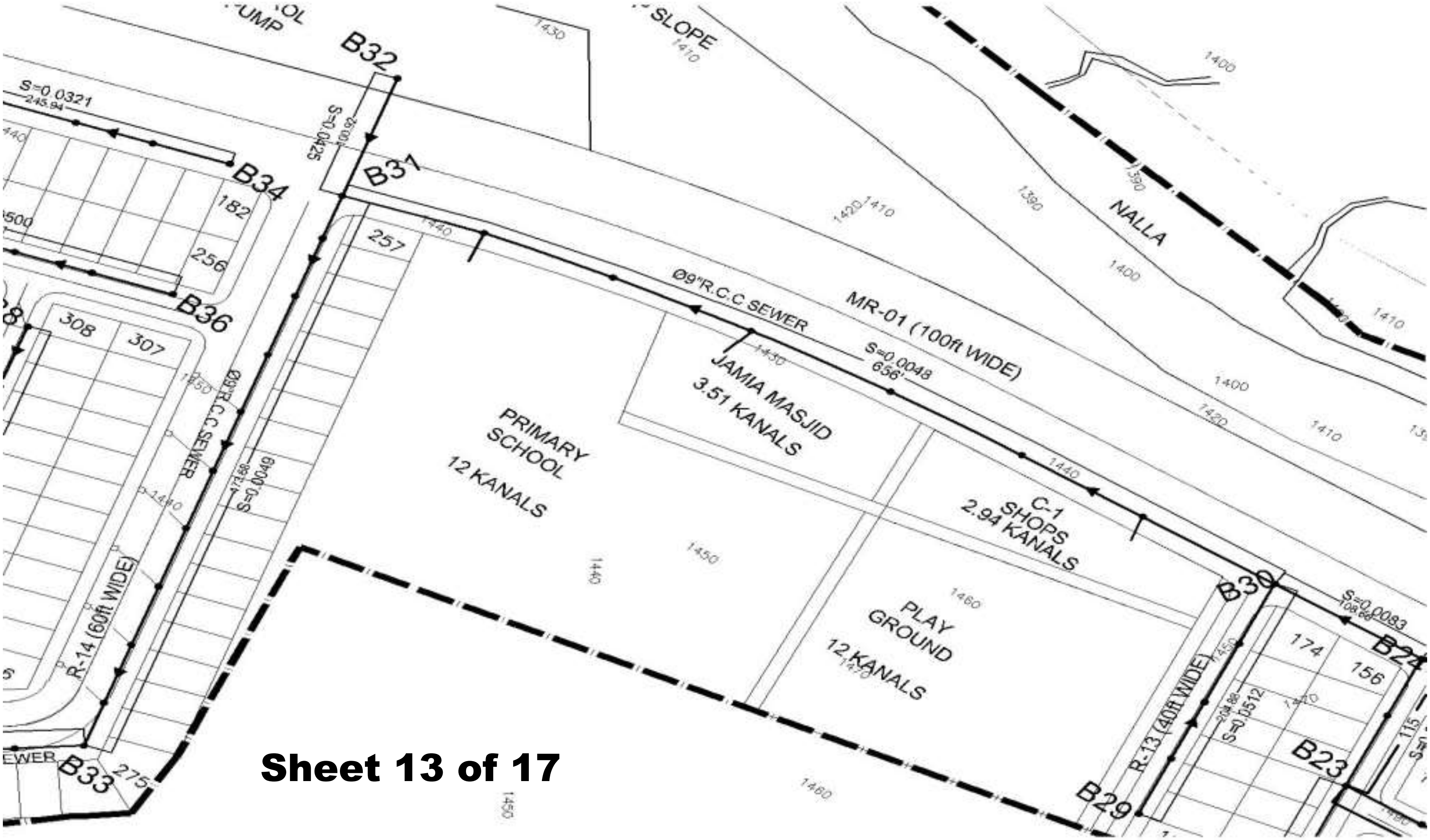


Fig F14: Sewer layout plan of Zone-2 at R/S of MR-01

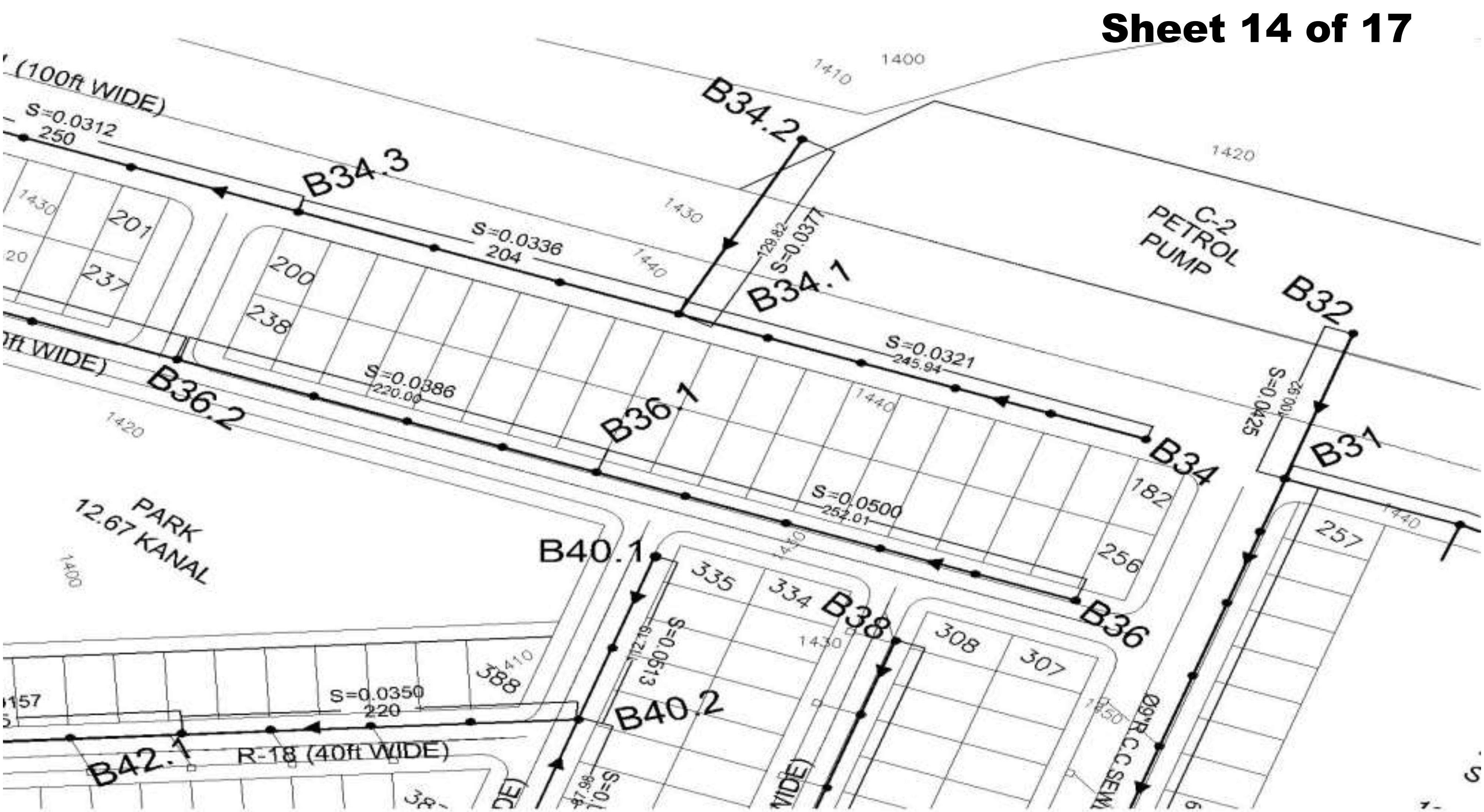


Fig F15: Sewer layout plan of Zone-2 at R/S of MR-01

Fig F16: Sewer layout plan of Zone-2 at R/S of R-14

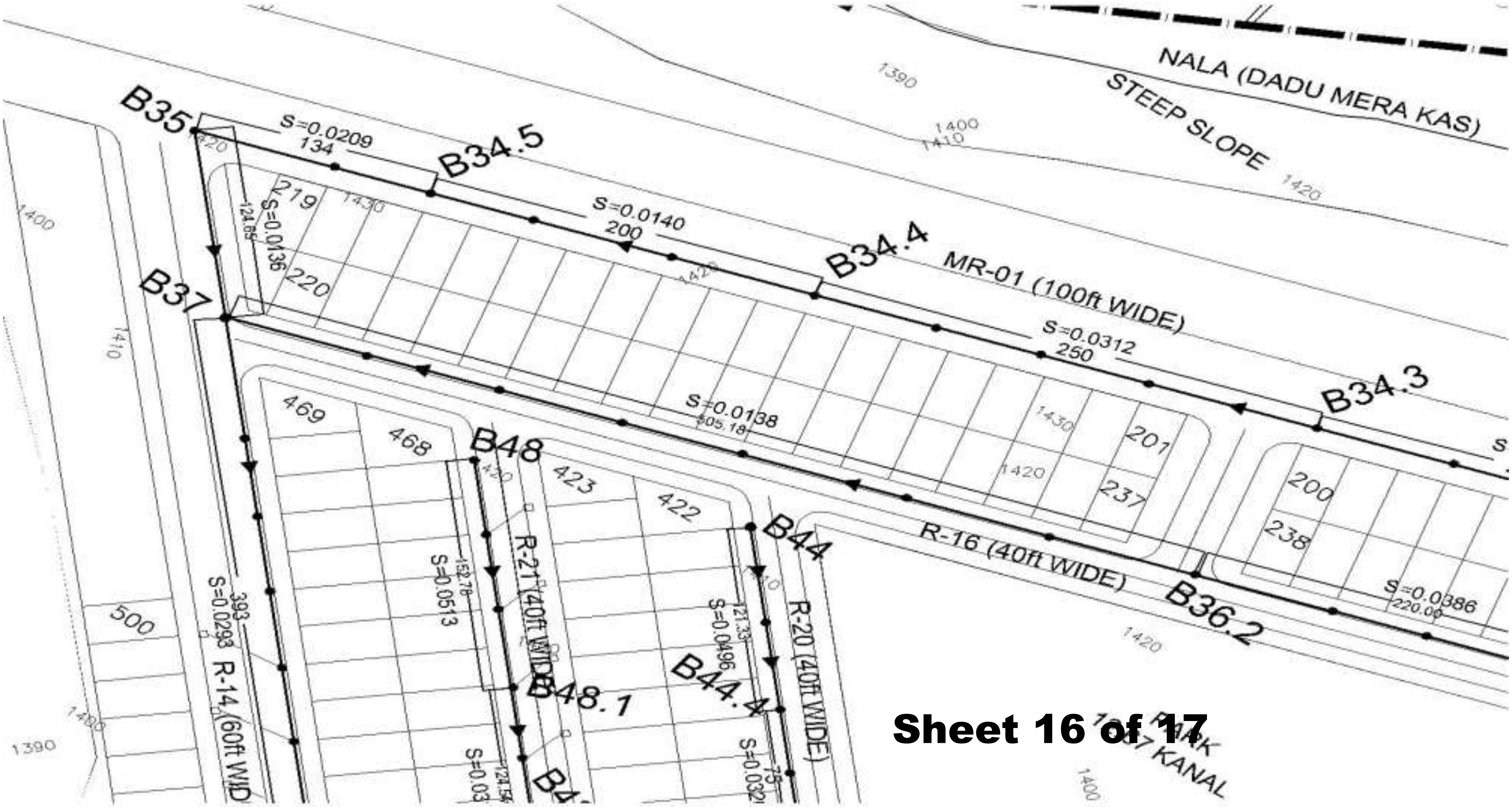


Fig F17: Sewer layout plan of Zone-2 at R/S of R-14

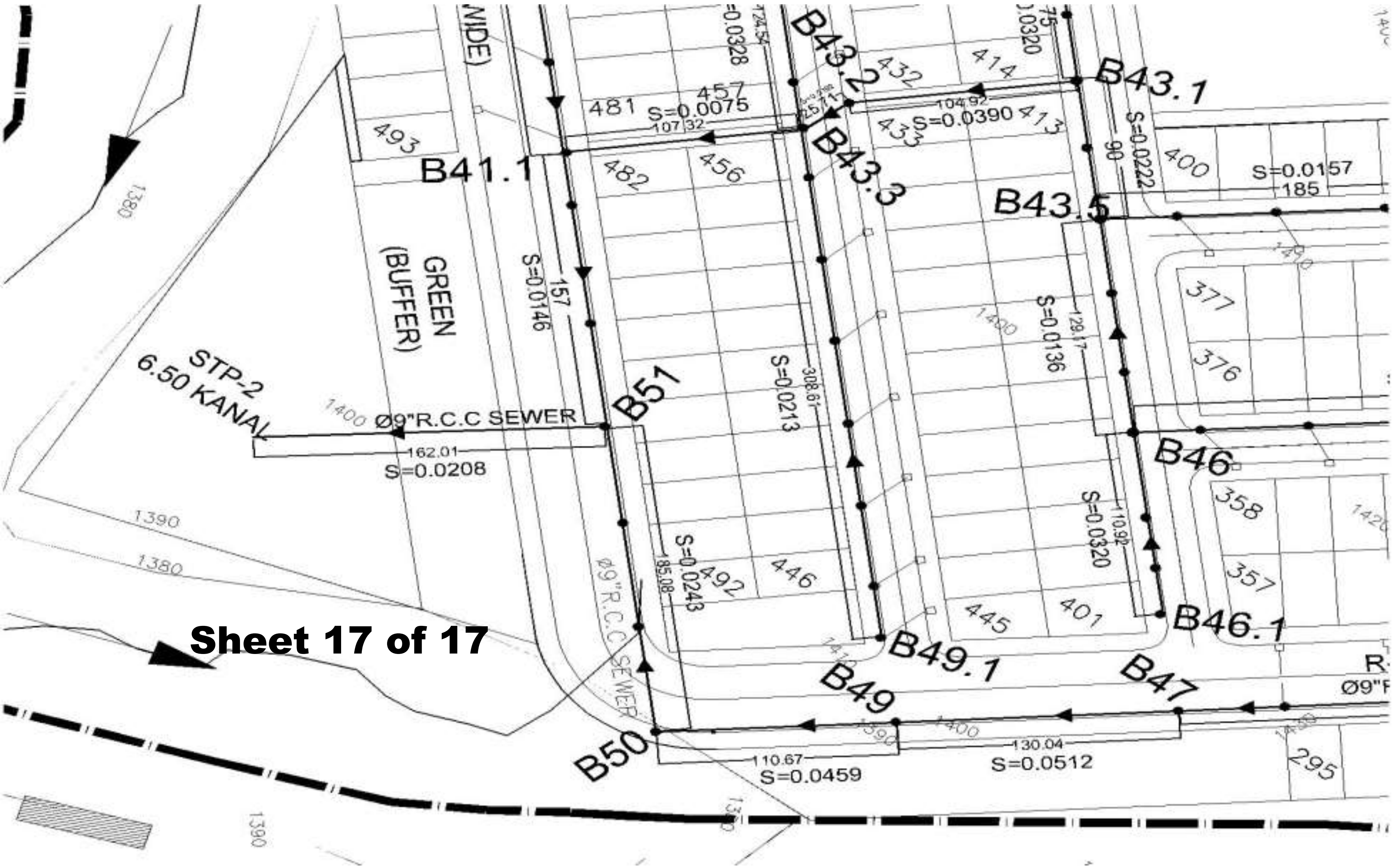


Fig F18: Sewer layout plan of Zone-2 terminal at STP-2

Appendix G

Key Plan & Detailed Drawings of Storm Drainage in Separate Network

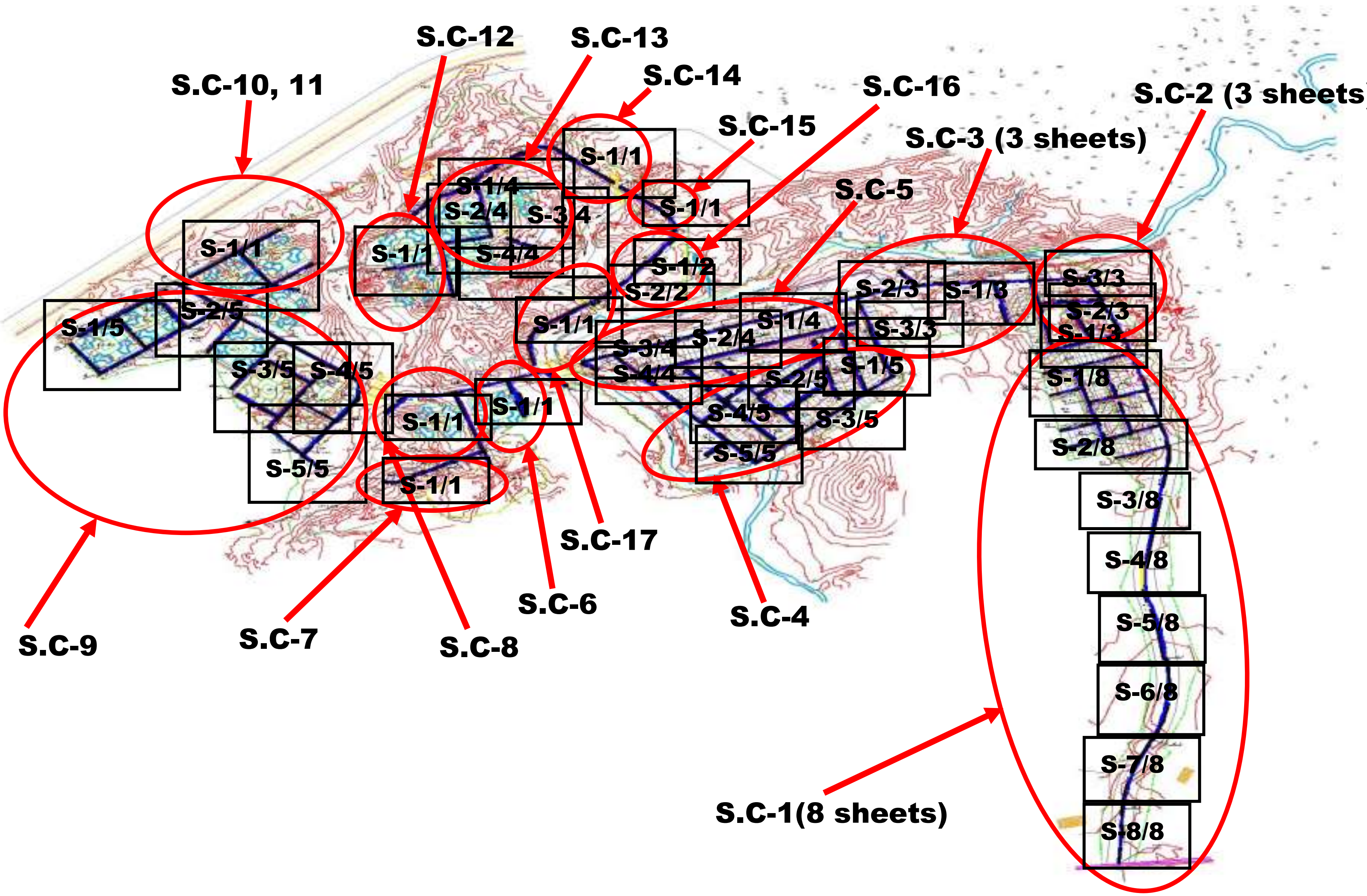


Fig G1: Storm drainage layout plan of entire residential colony showing 17 sub-catchments & legened for detail drawings

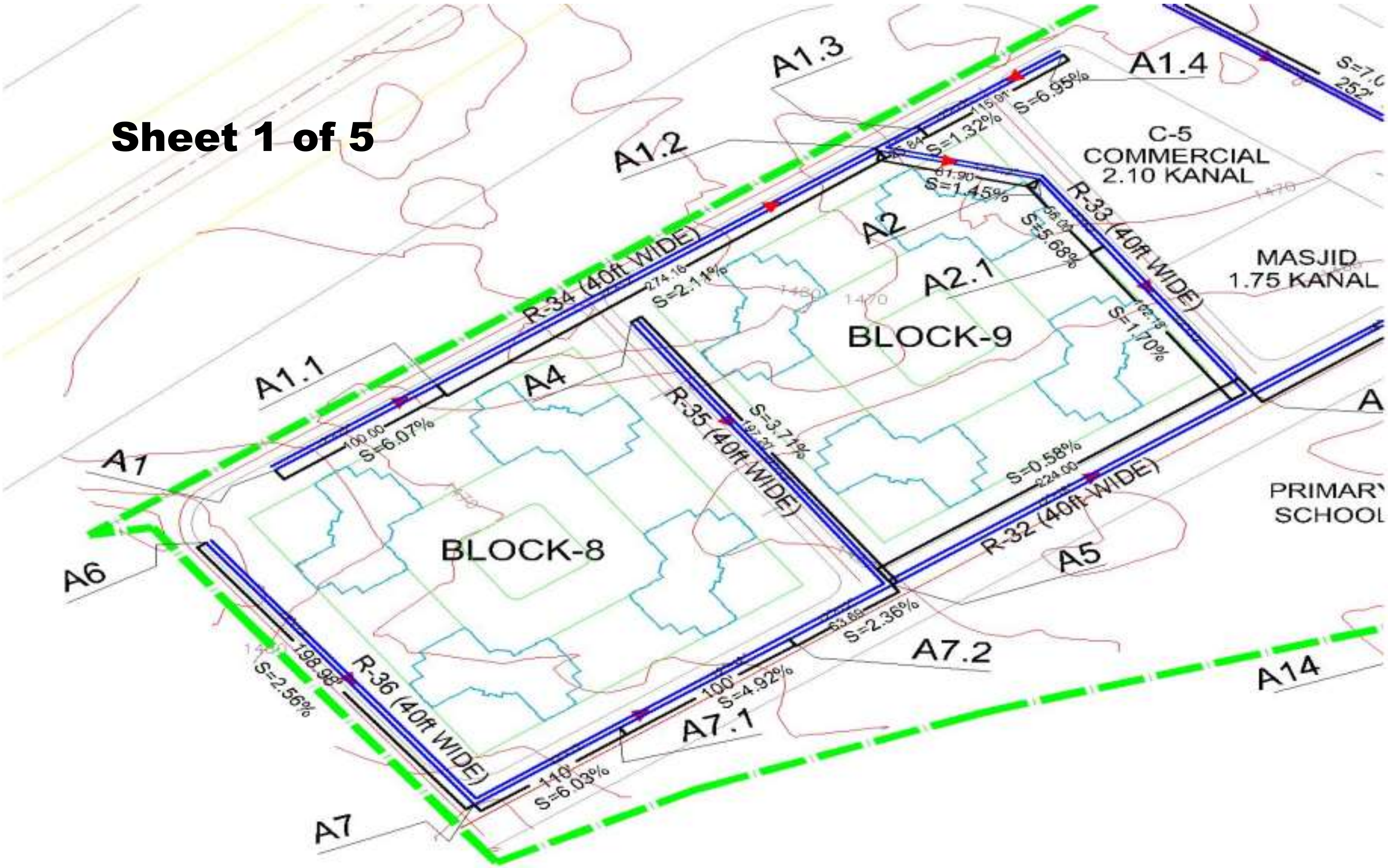


Fig G2: Storm drainage layout plan of Sub-catchment-9 part one at R/S of MR-01

Annexure G

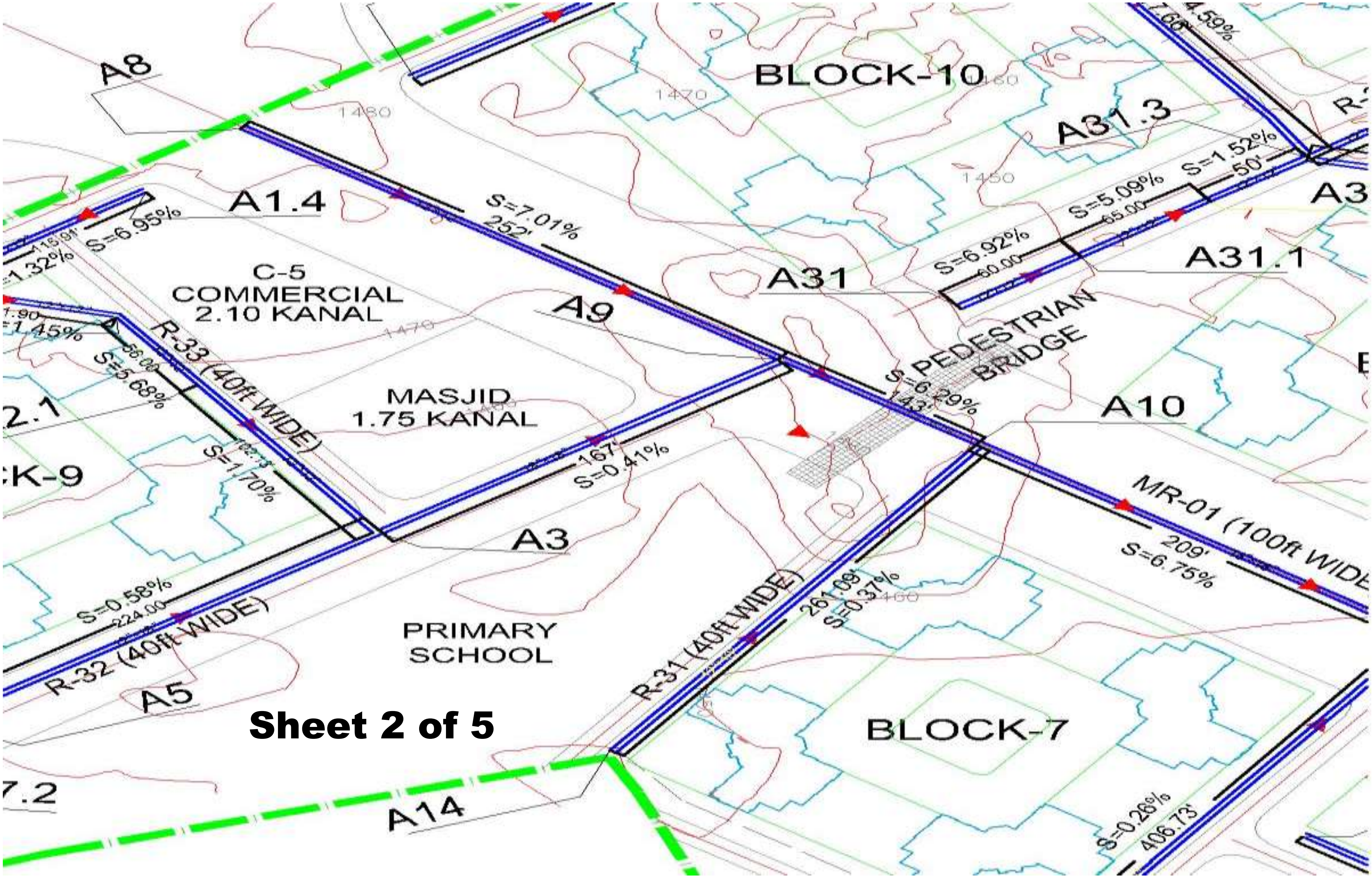


Fig G3: Storm drainage layout plan of Sub-catchment-9 part two at R/S of MR-01

Annexure G

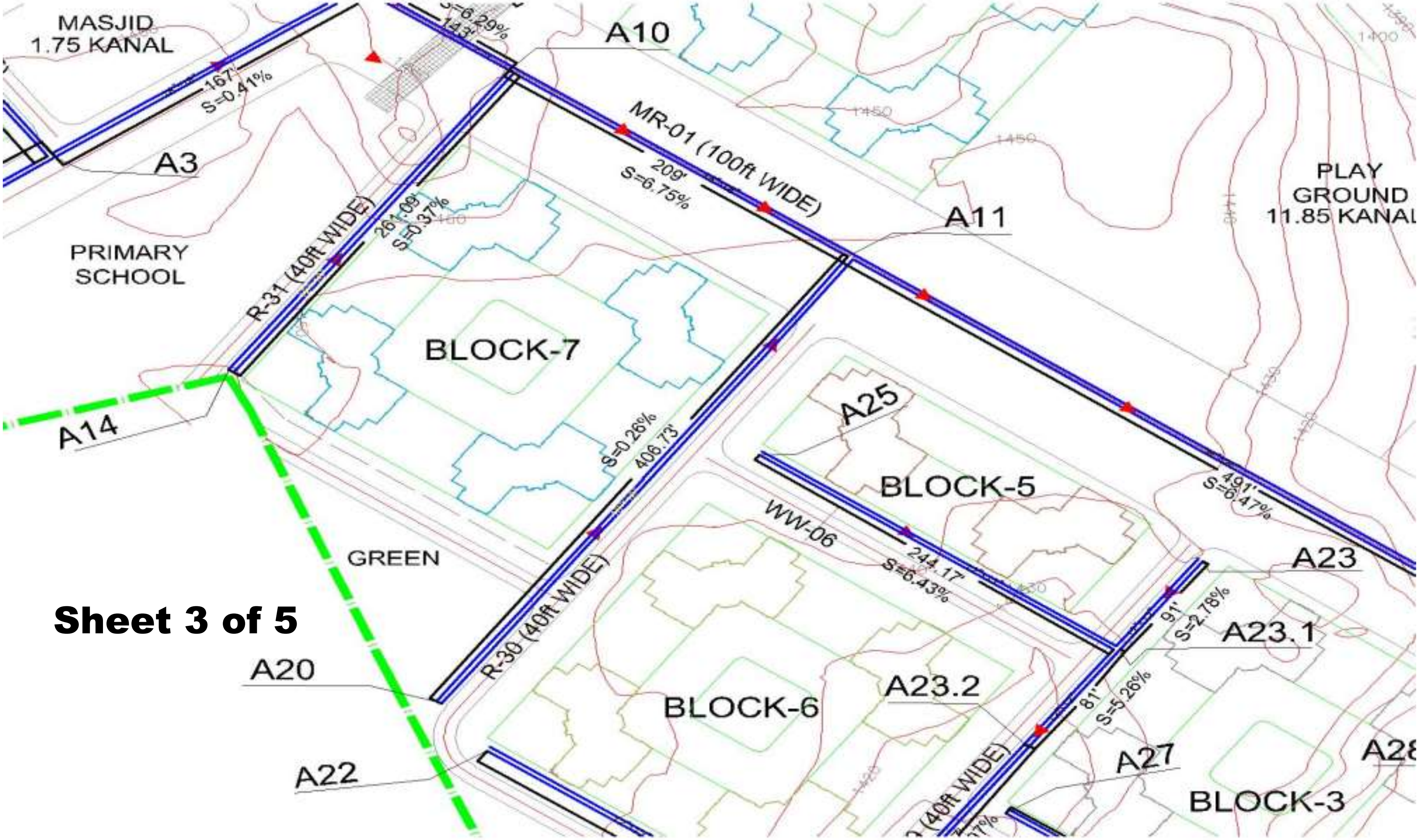


Fig G4: Storm drainage layout plan of Sub-catchment-9 part three at R/S of MR-01

Annexure G

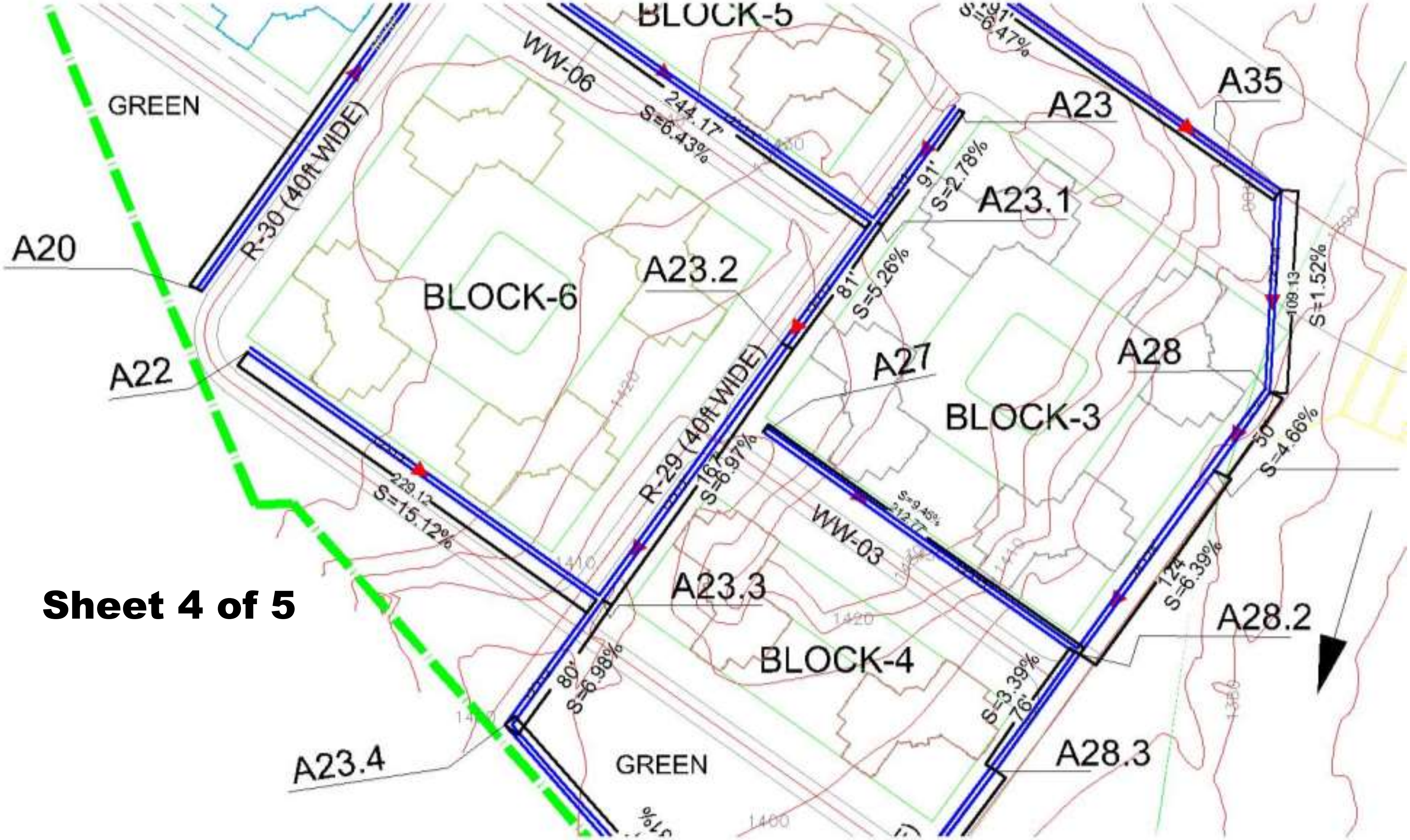


Fig G5: Storm drainage layout plan of Sub-catchment-9 part four at R/S of MR-01

Annexure G

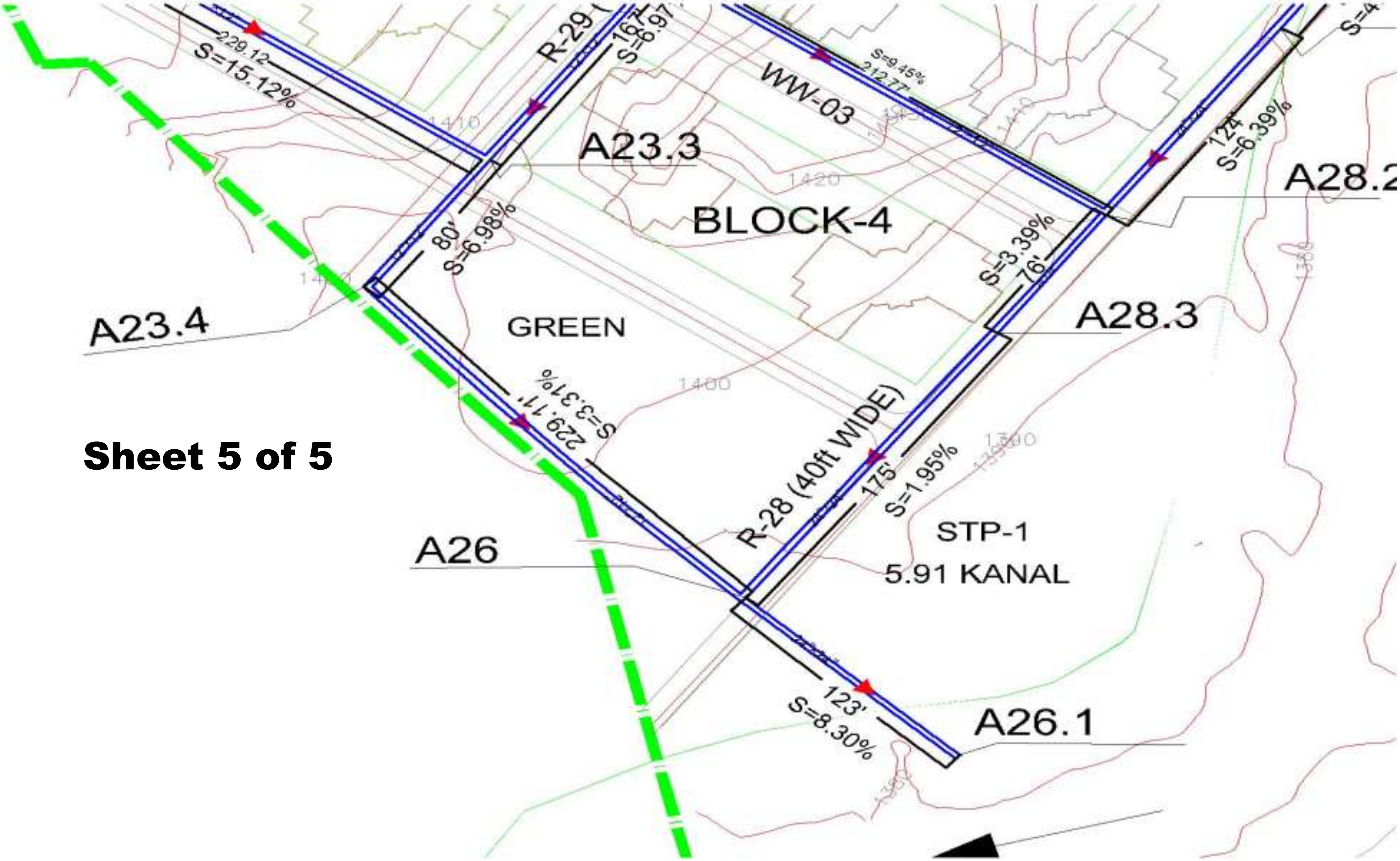


Fig G6: Storm drainage layout plan of Sub-catchment-9 showing final disposal node A26.1 into Nullah

Annexure G

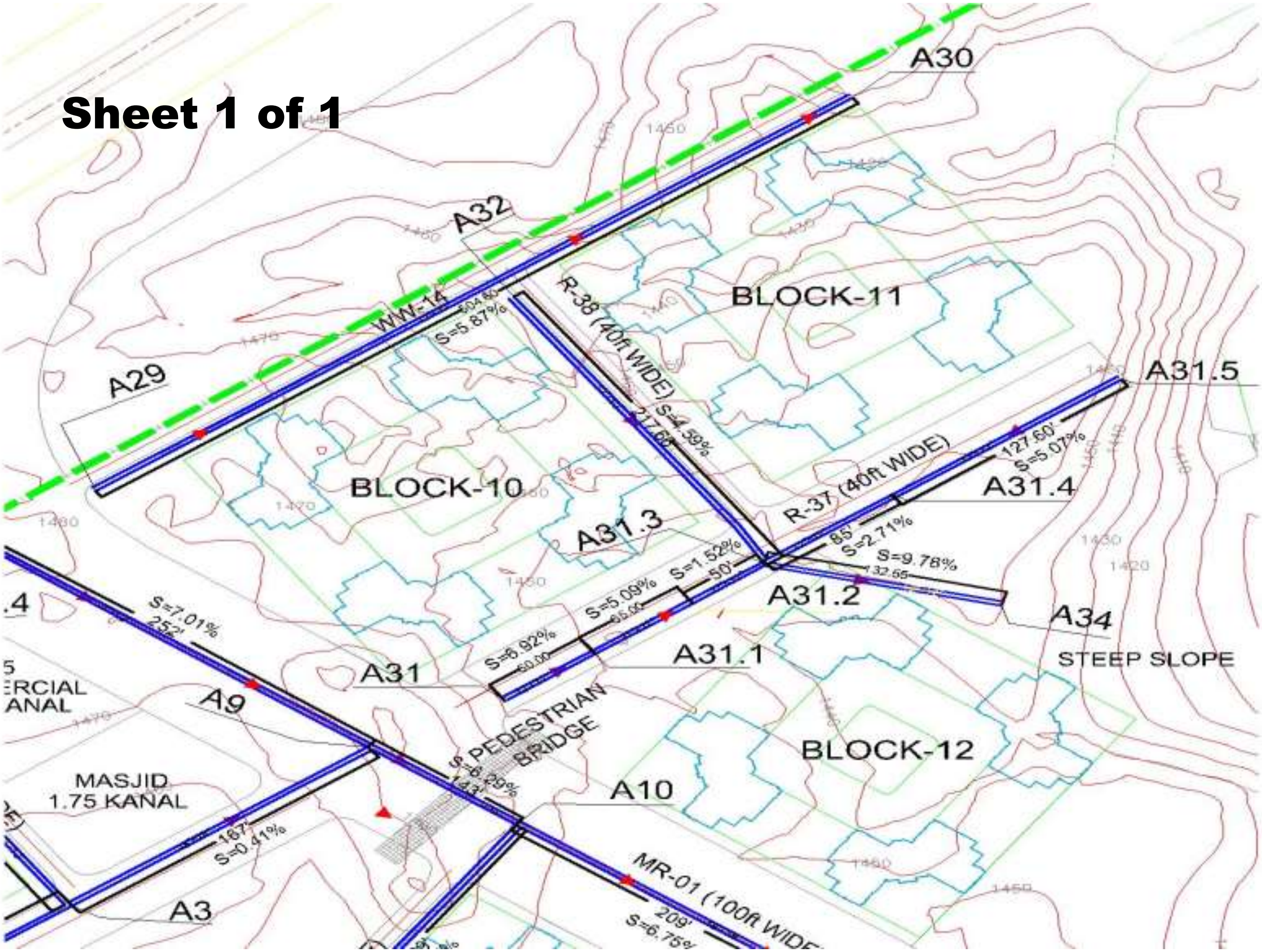


Fig G7: Storm drainage layout plan of Sub-catchment-10, 11 showing final disposal nodes A30 & A34

Annexure G

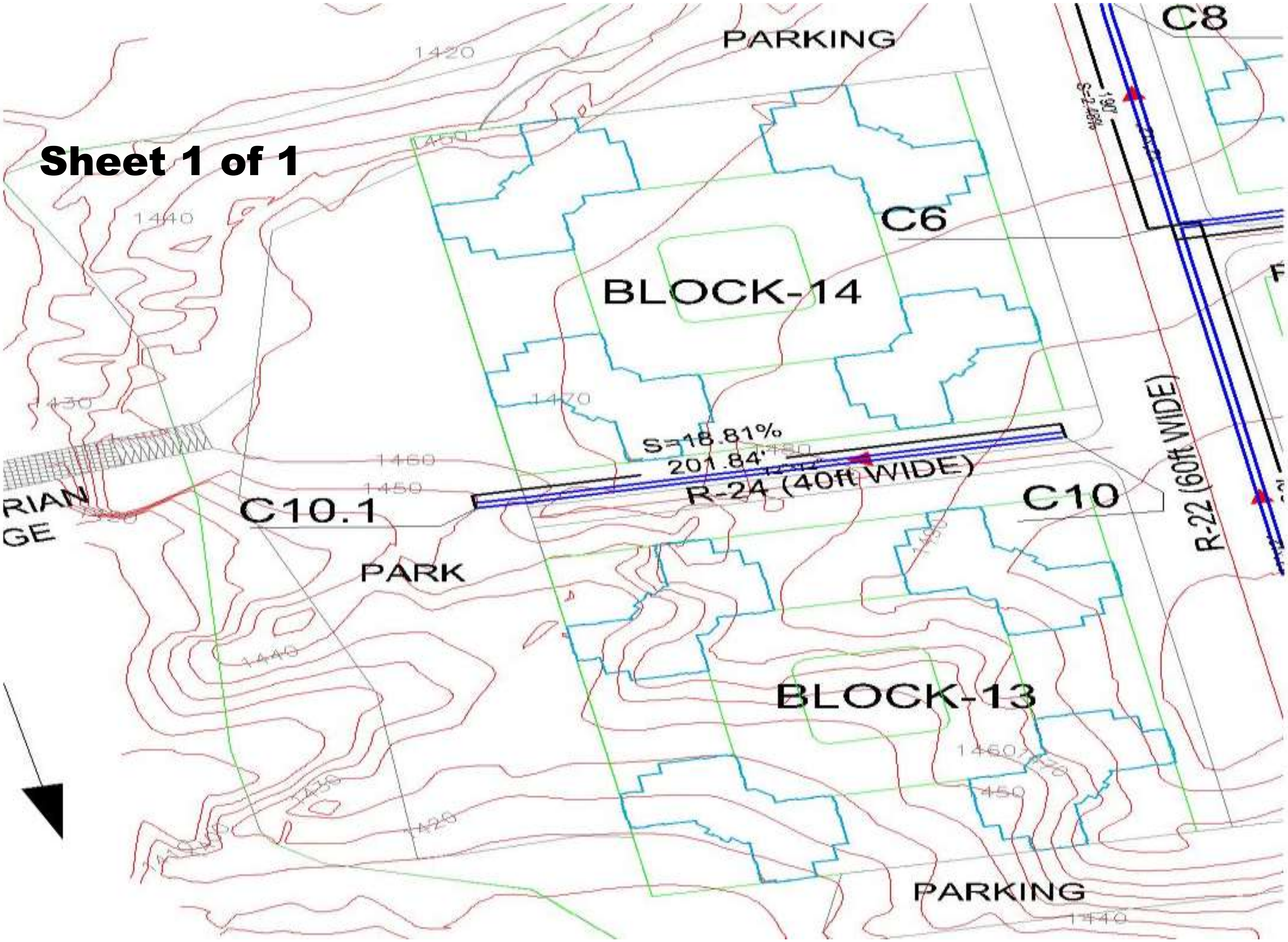


Fig G8: Storm drainage layout plan of Sub-catchment-12 showing final disposal nodes C10.1

Annexure G

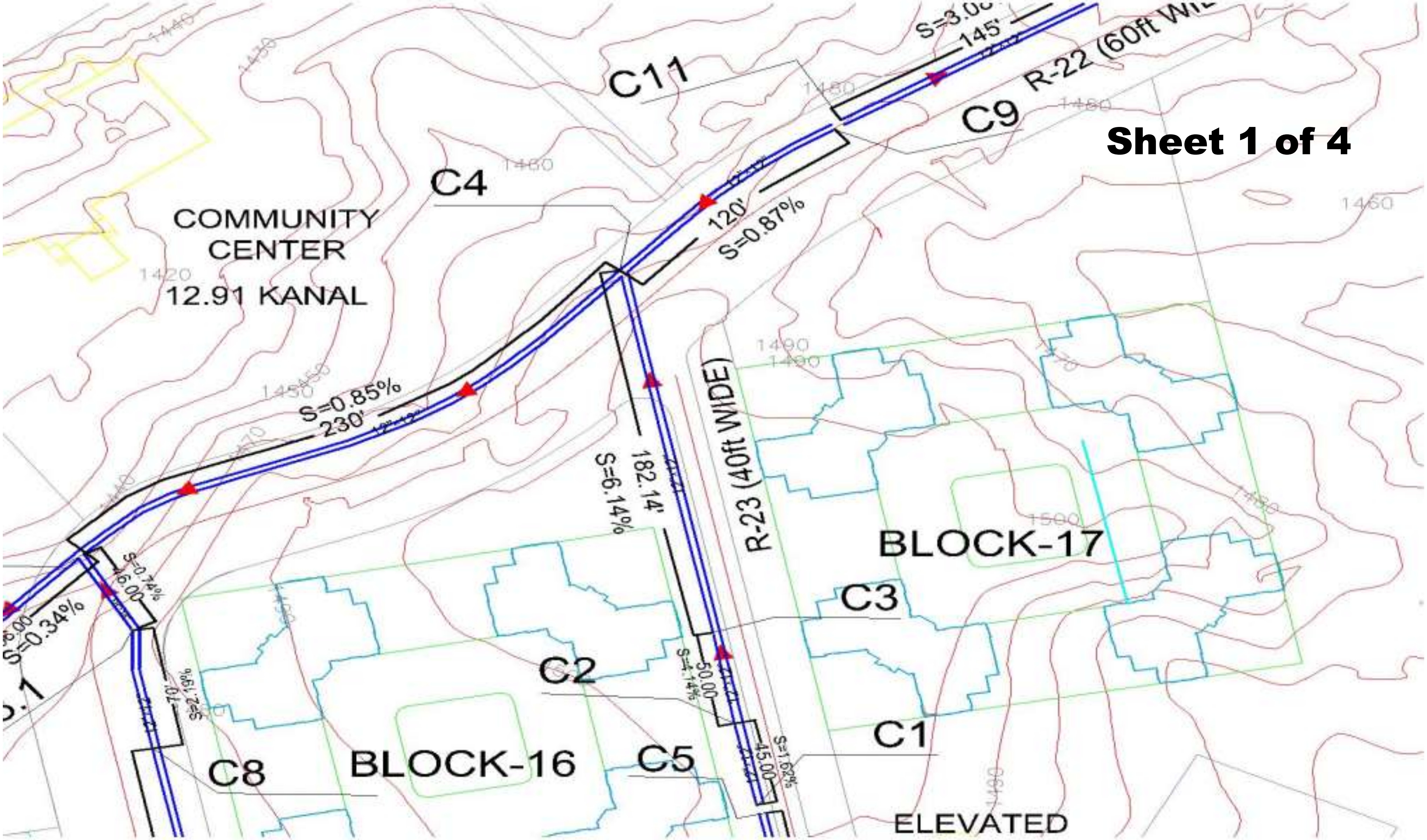
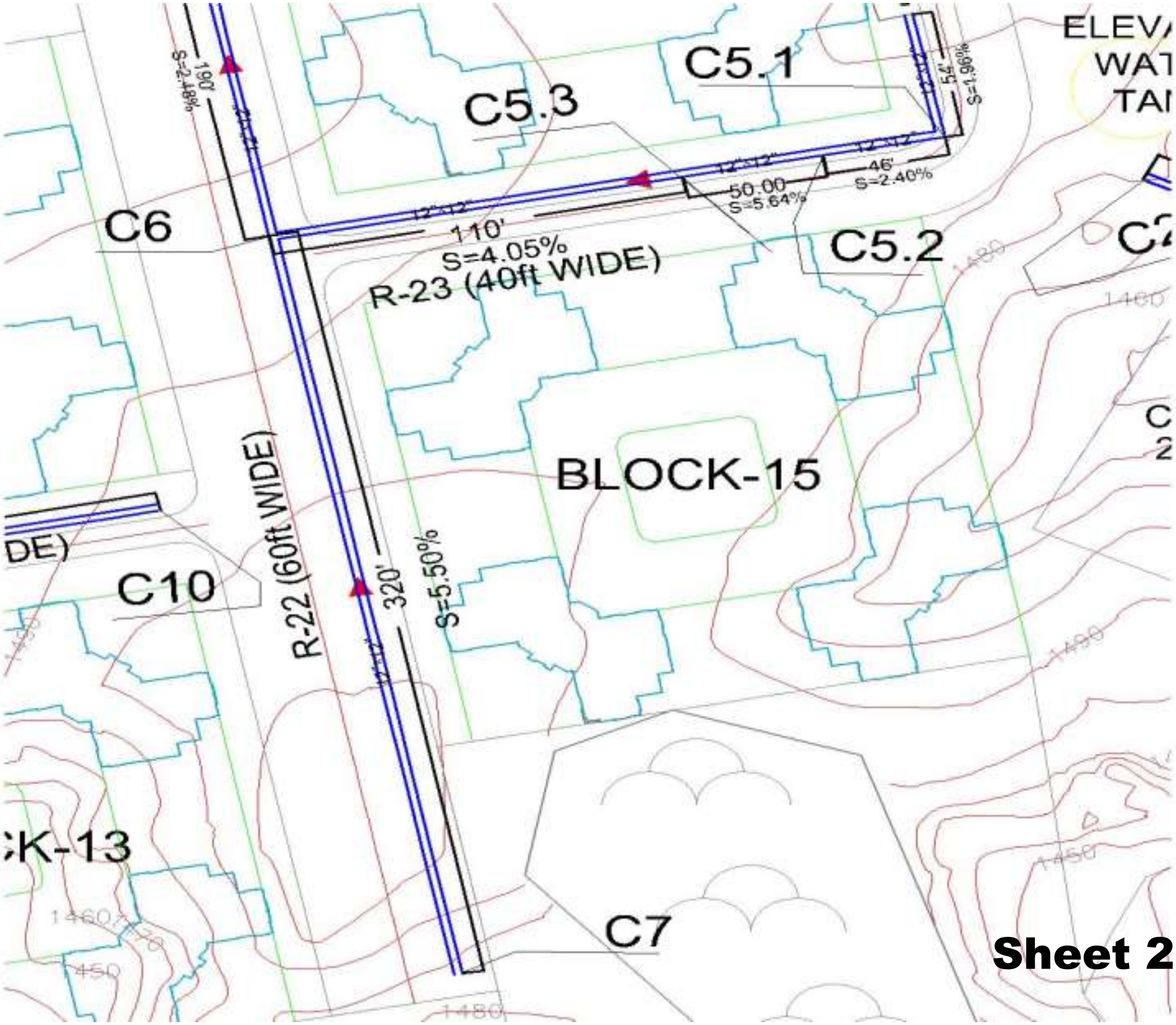


Fig G9: Storm drainage layout plan of Sub-catchment-13 showing initial nodes C9,C1 & C5

Annexure G



Sheet 2 of 4

Fig G10: Storm drainage layout plan of Sub-catchment-13 showing initial nodes C7

Annexure G

Sheet 3 of 4

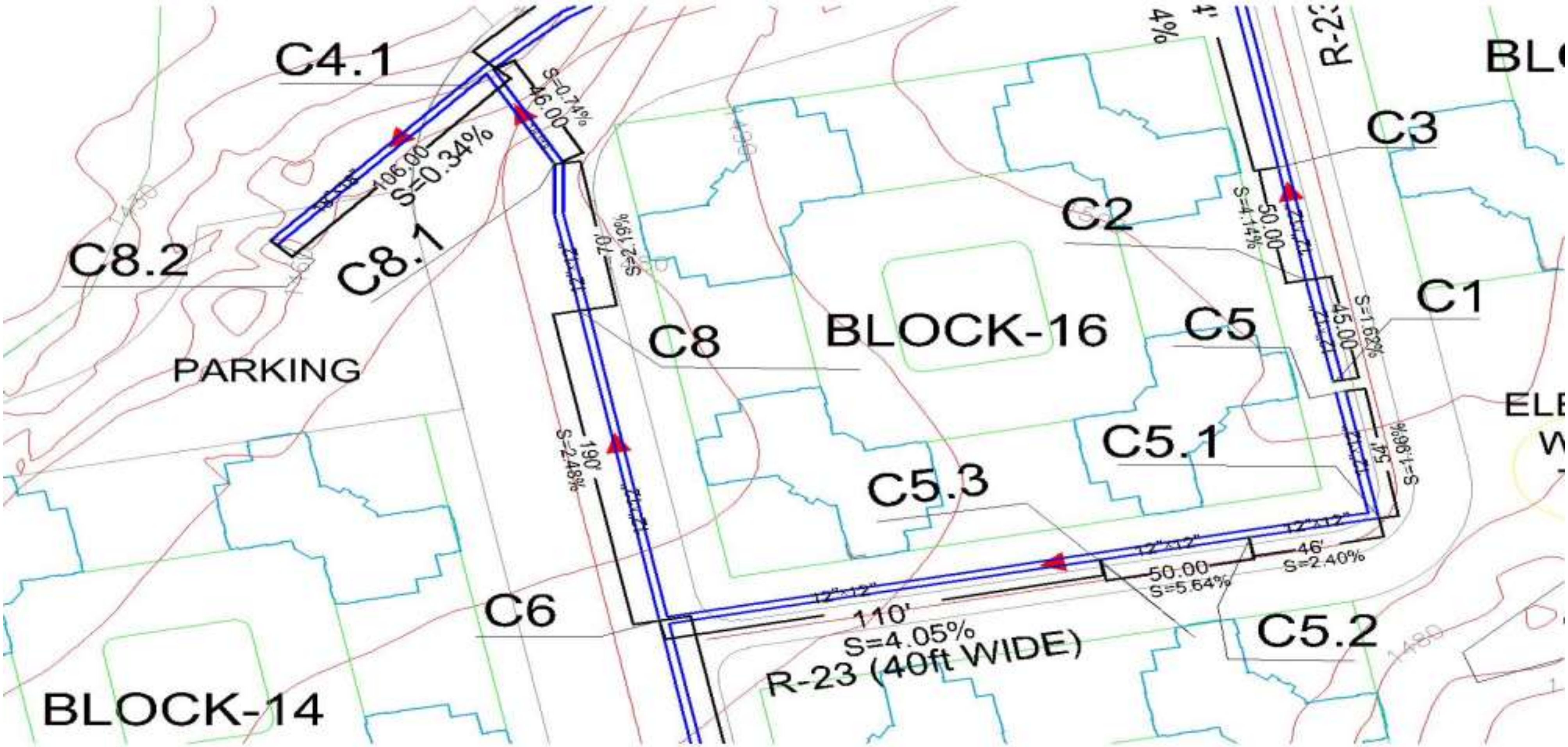


Fig G11: Storm drainage layout plan of Sub-catchment-13 showing final disposal node C8.2

Annexure G

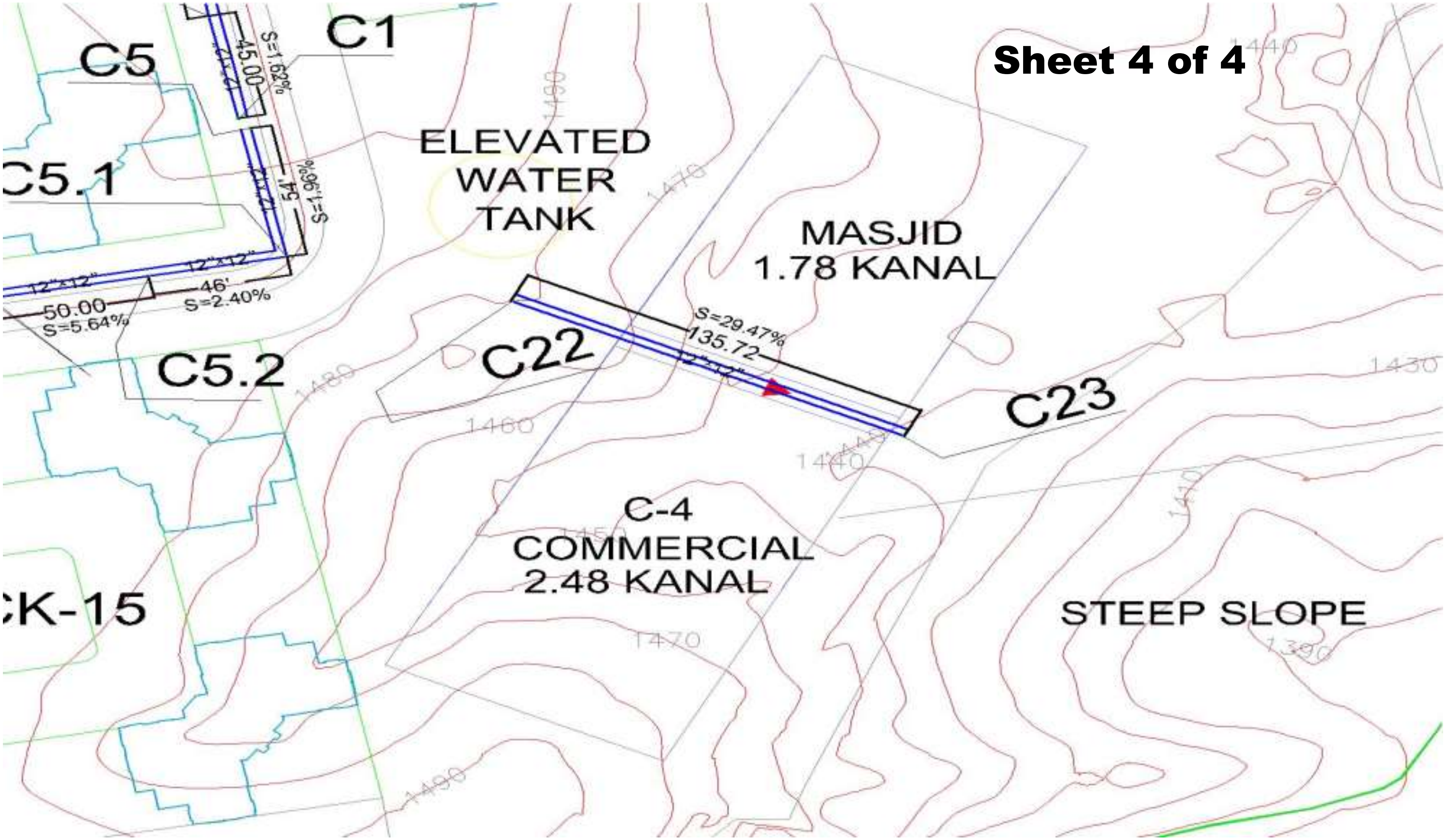


Fig G12: Storm drainage layout plan of Sub-catchment-13 showing final disposal node C23

Annexure G

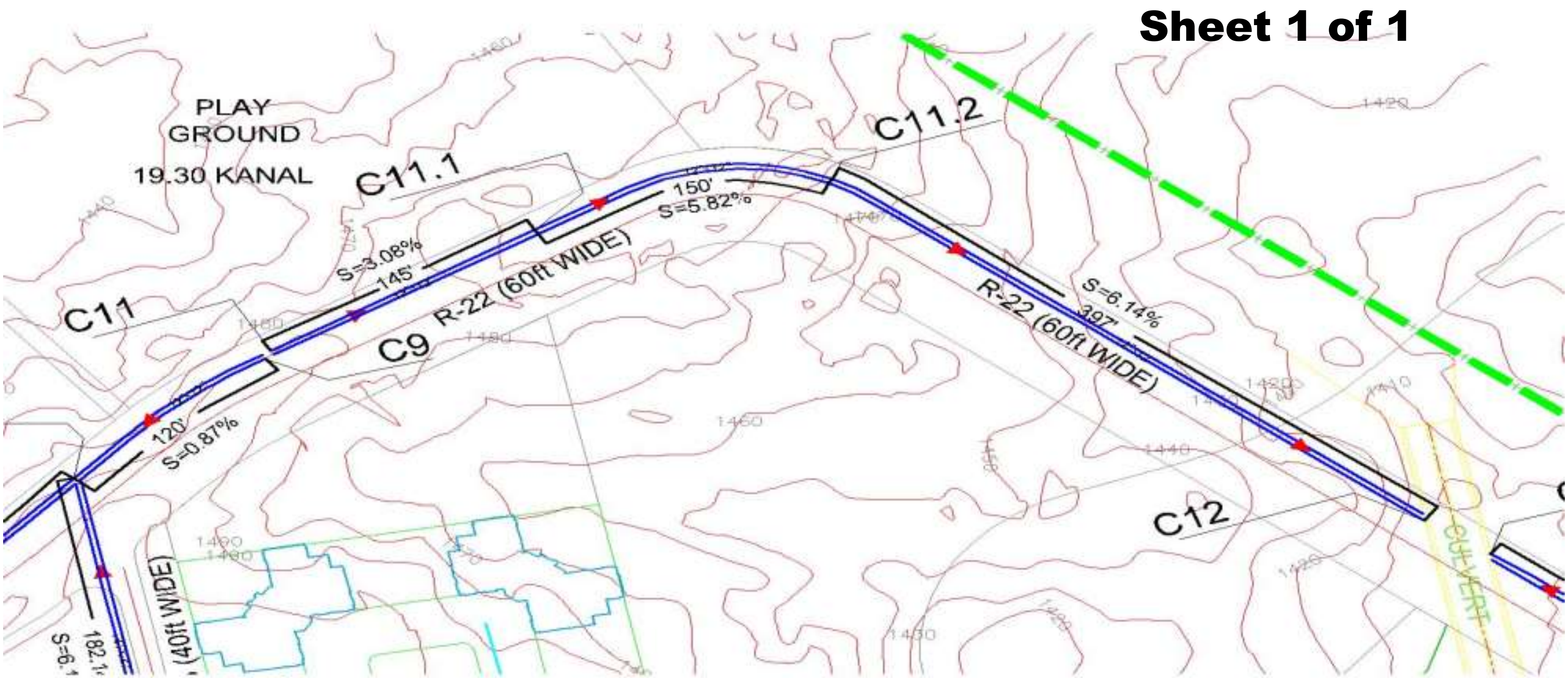


Fig G13: Storm drainage layout plan of Sub-catchment-14 showing final disposal node C124

Annexure G

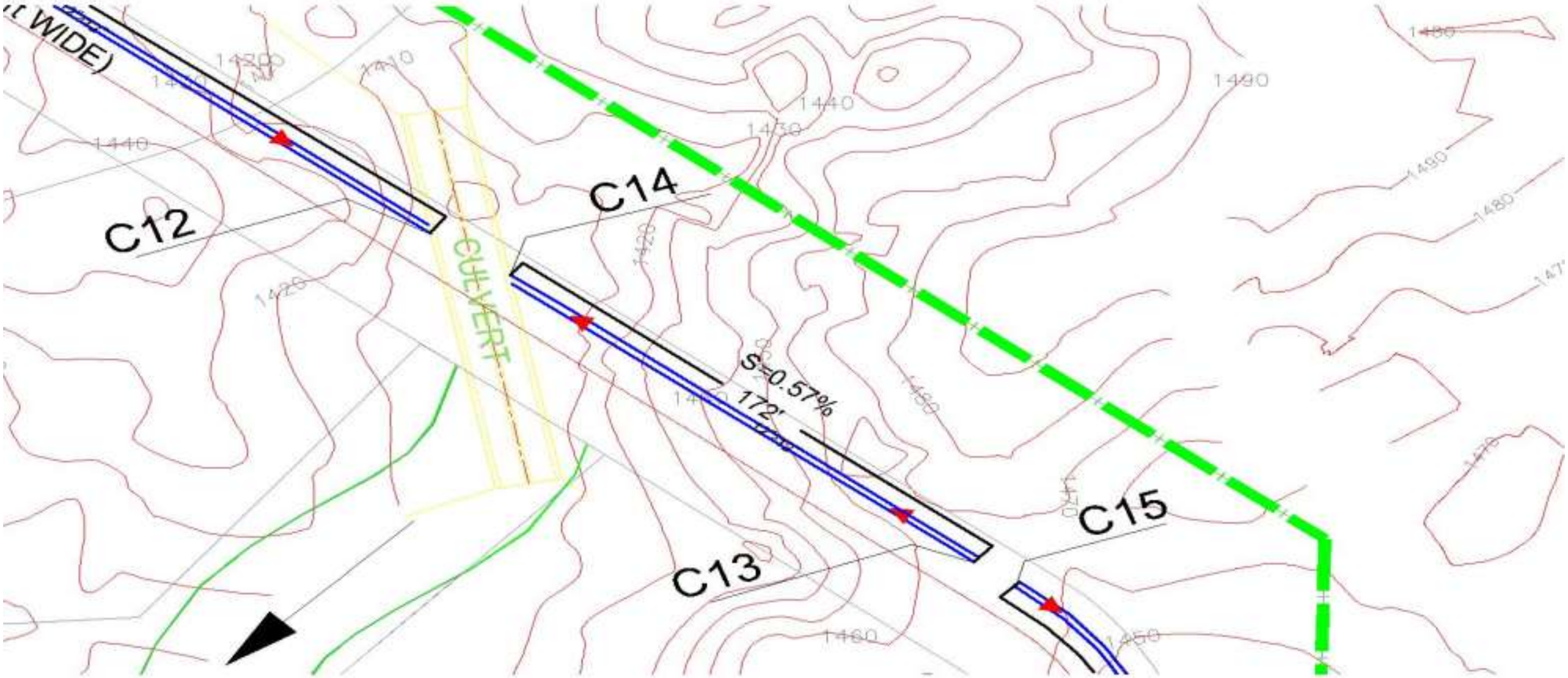


Fig G14: Storm drainage layout plan of Sub-catchment-15 showing final disposal node C14

Annexure G

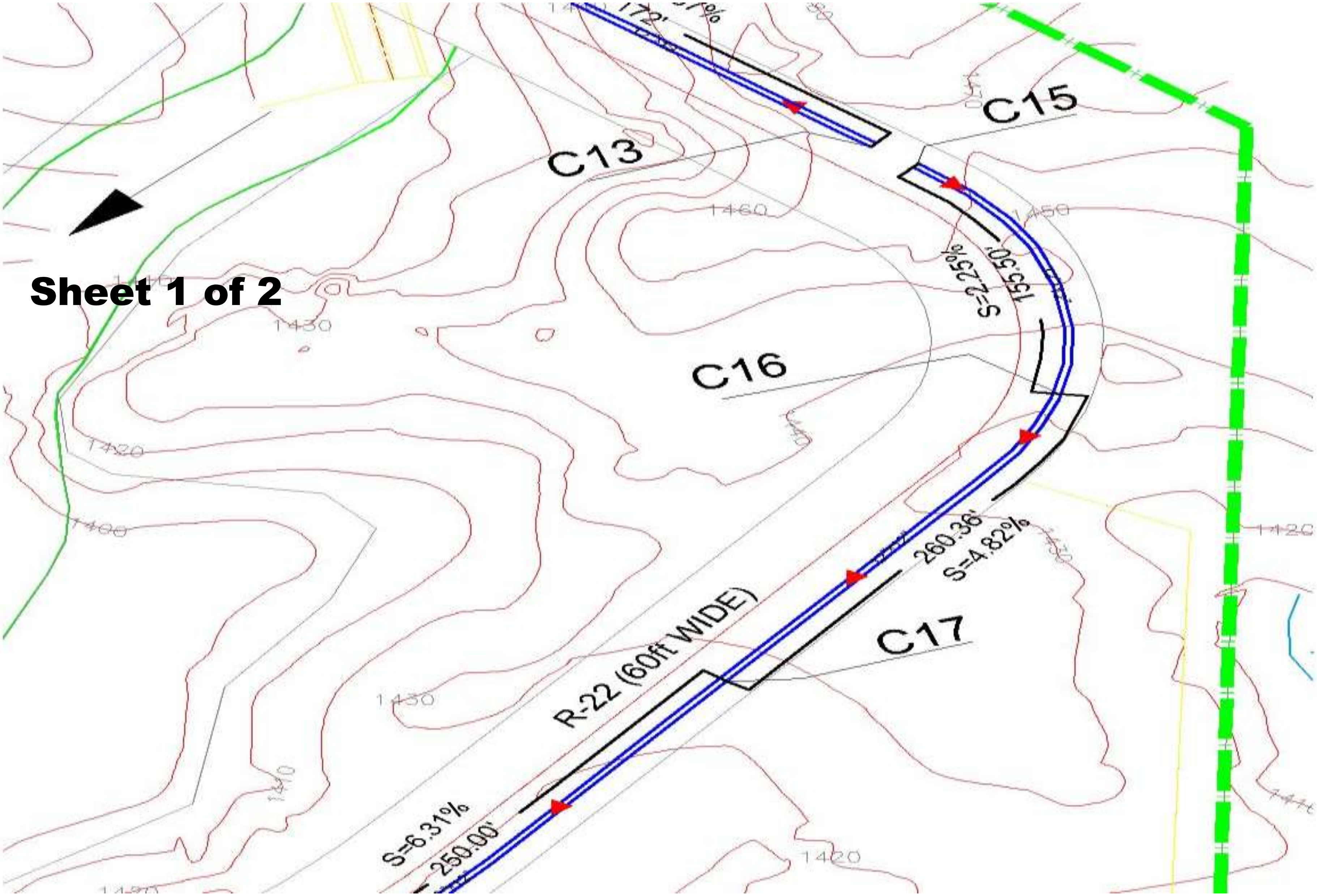


Fig G15: Storm drainage layout plan of Sub-catchment-16 showing initial node C15

Annexure G

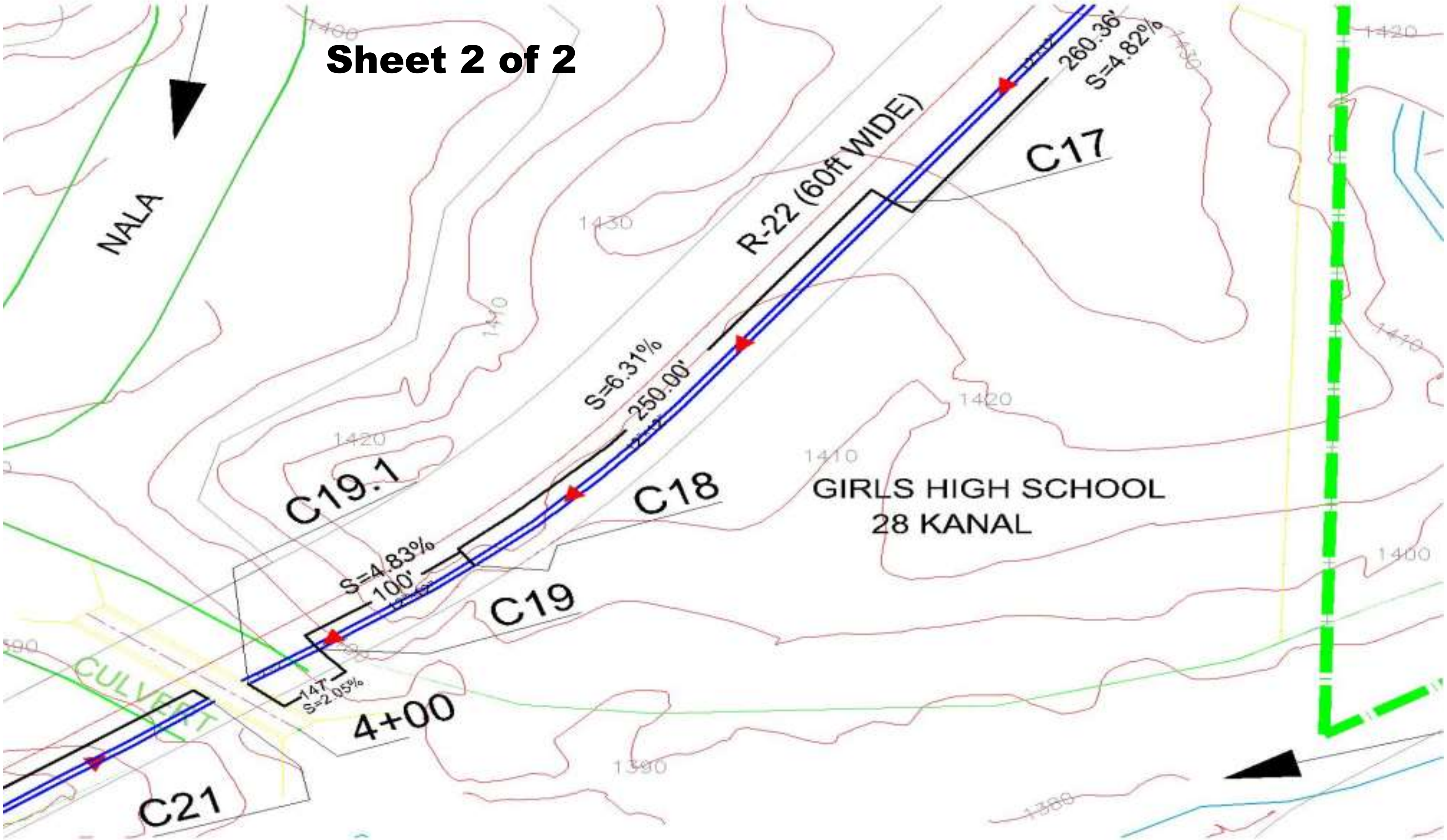


Fig G16: Storm drainage layout plan of Sub-catchment-16 showing final disposal node C19.1

Annexure G

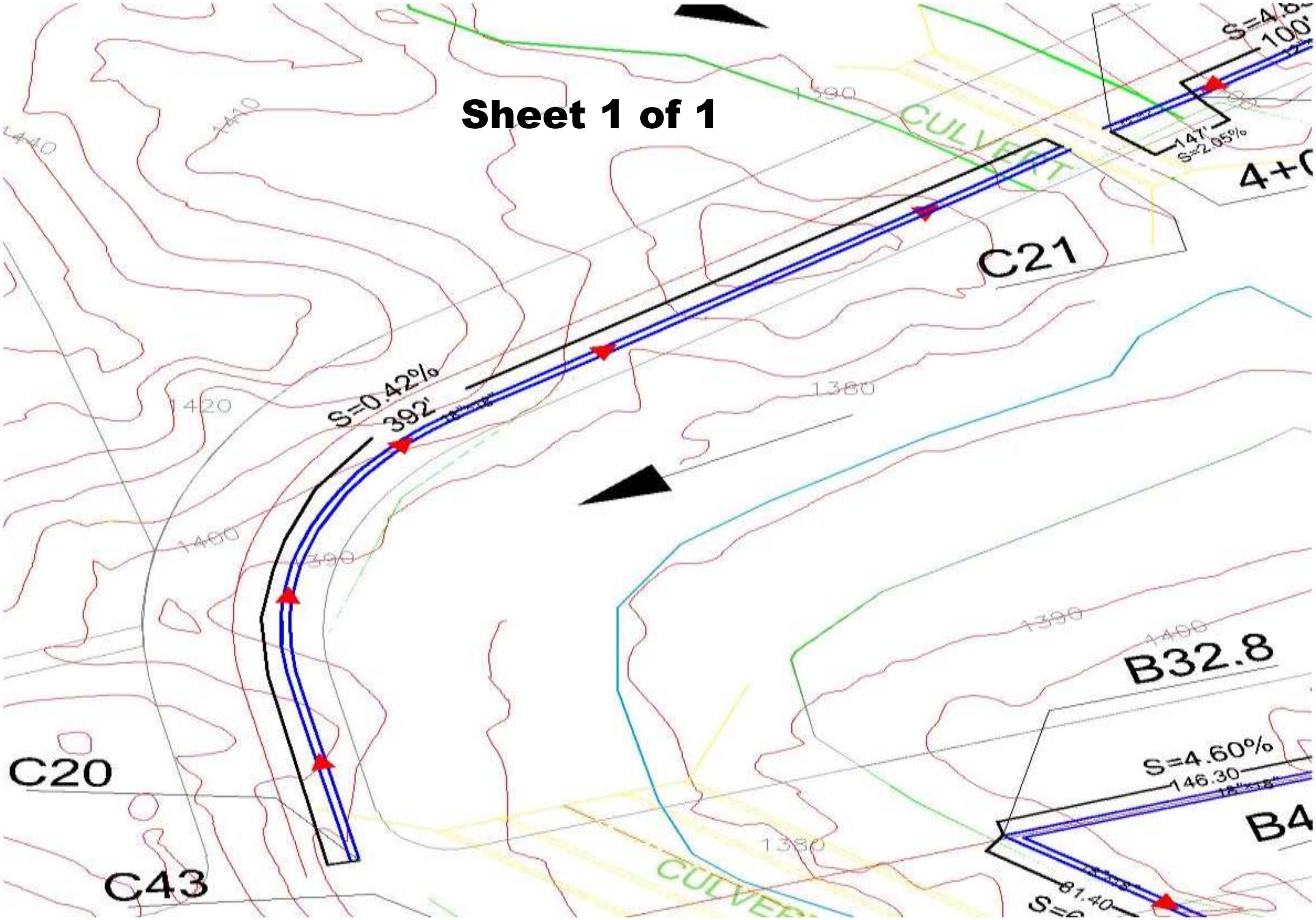


Fig G17: Storm drainage layout plan of Sub-catchment-17 showing initial node C20 & final disposal node C21

Annexure G

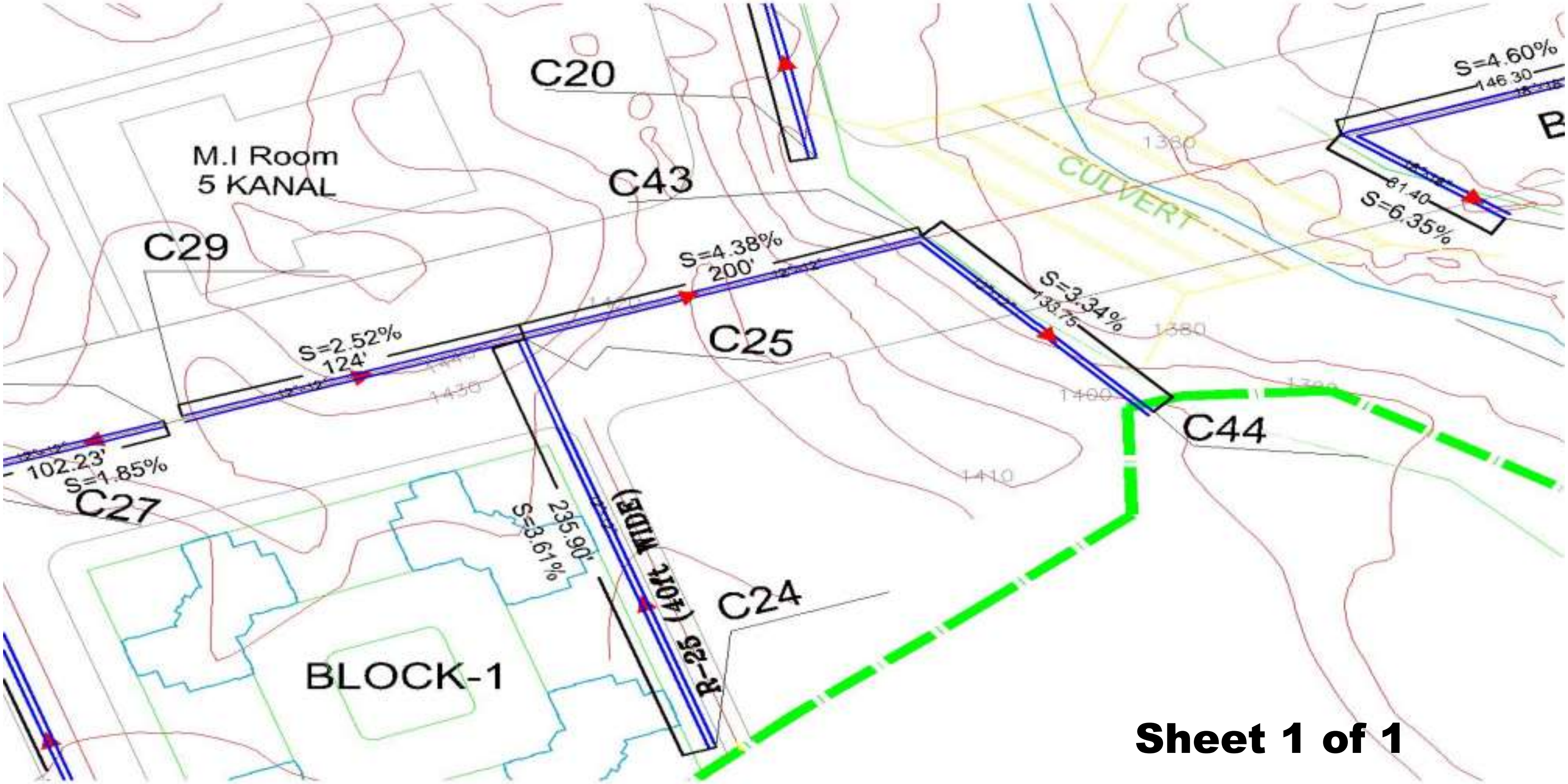


Fig G18: Storm drainage layout plan of Sub-catchment-6 showing initial node C24, C29 & final disposal node C44

Annexure G

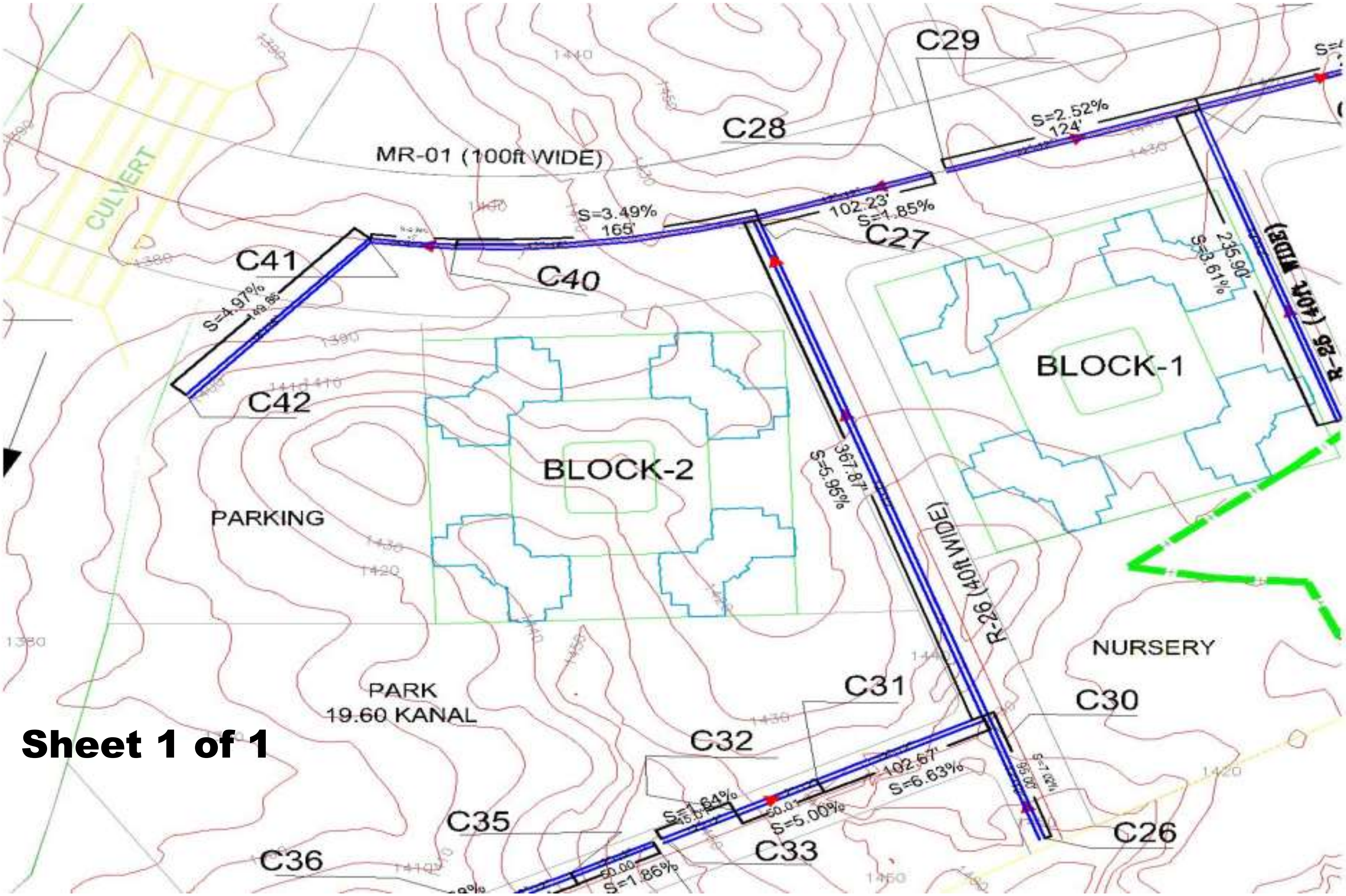


Fig G19: Storm drainage layout plan of Sub-catchment-8 showing initial node C33, C26 & final disposal node C42

Annexure G

Sheet 1 of 1

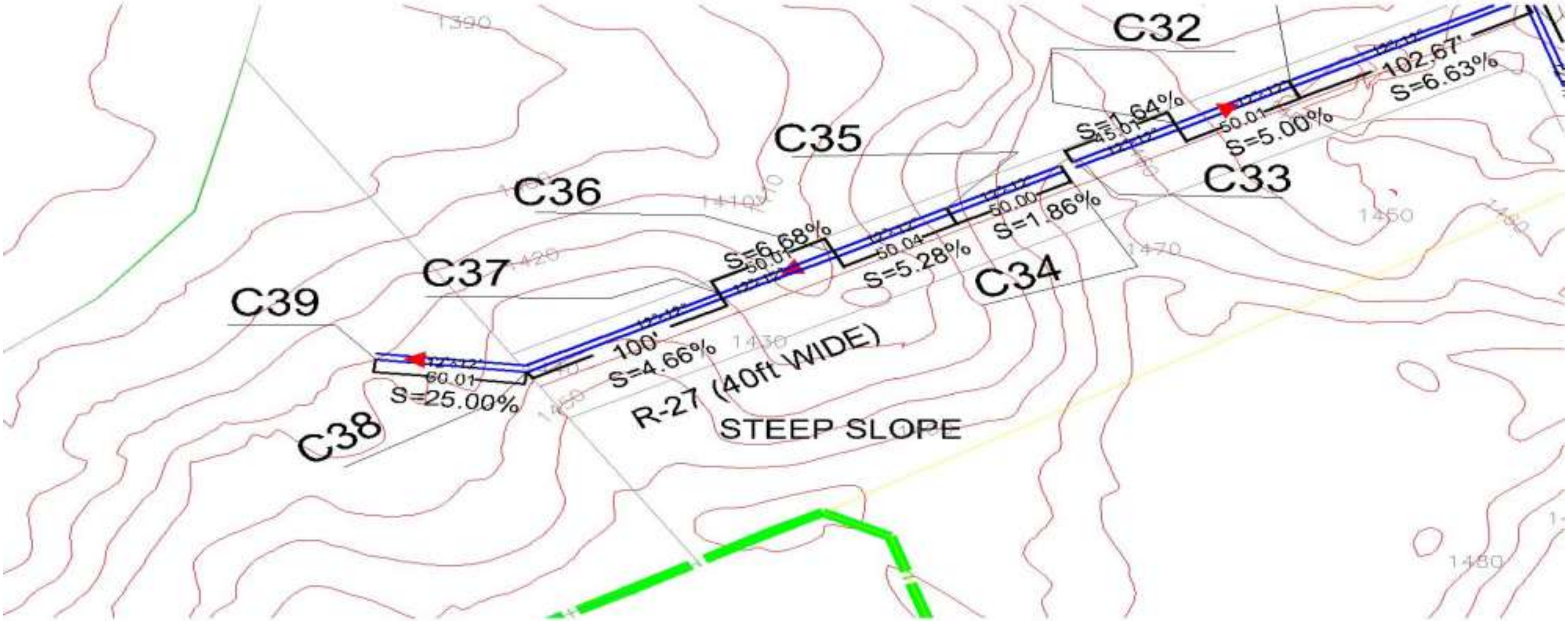


Fig G20: Storm drainage layout plan of Sub-catchment-7 showing initial node C35 & final disposal node C39

Annexure G

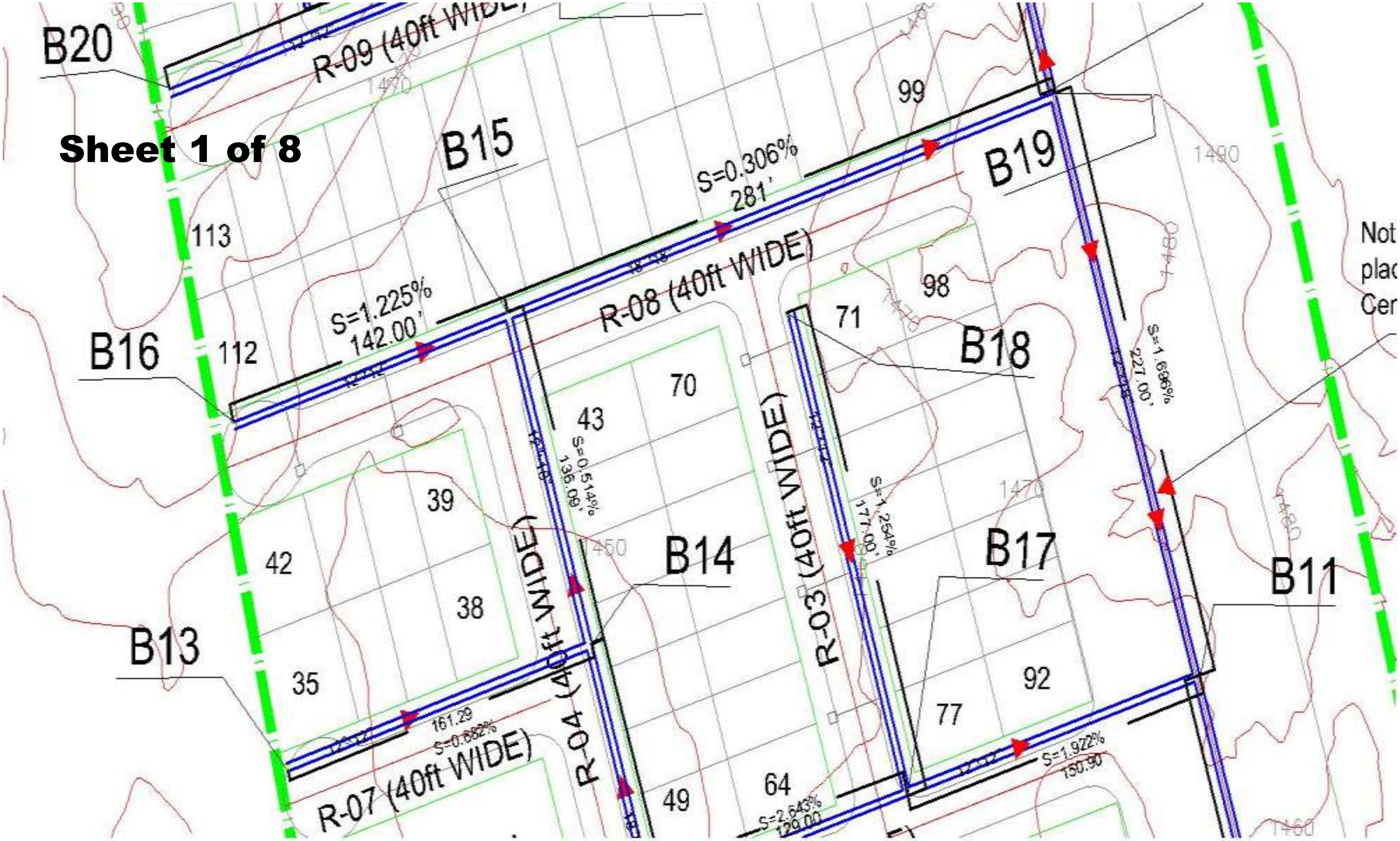


Fig G21: Storm drainage layout plan of Sub-catchment-1 showing initial nodes B16 & B19

Annexure G

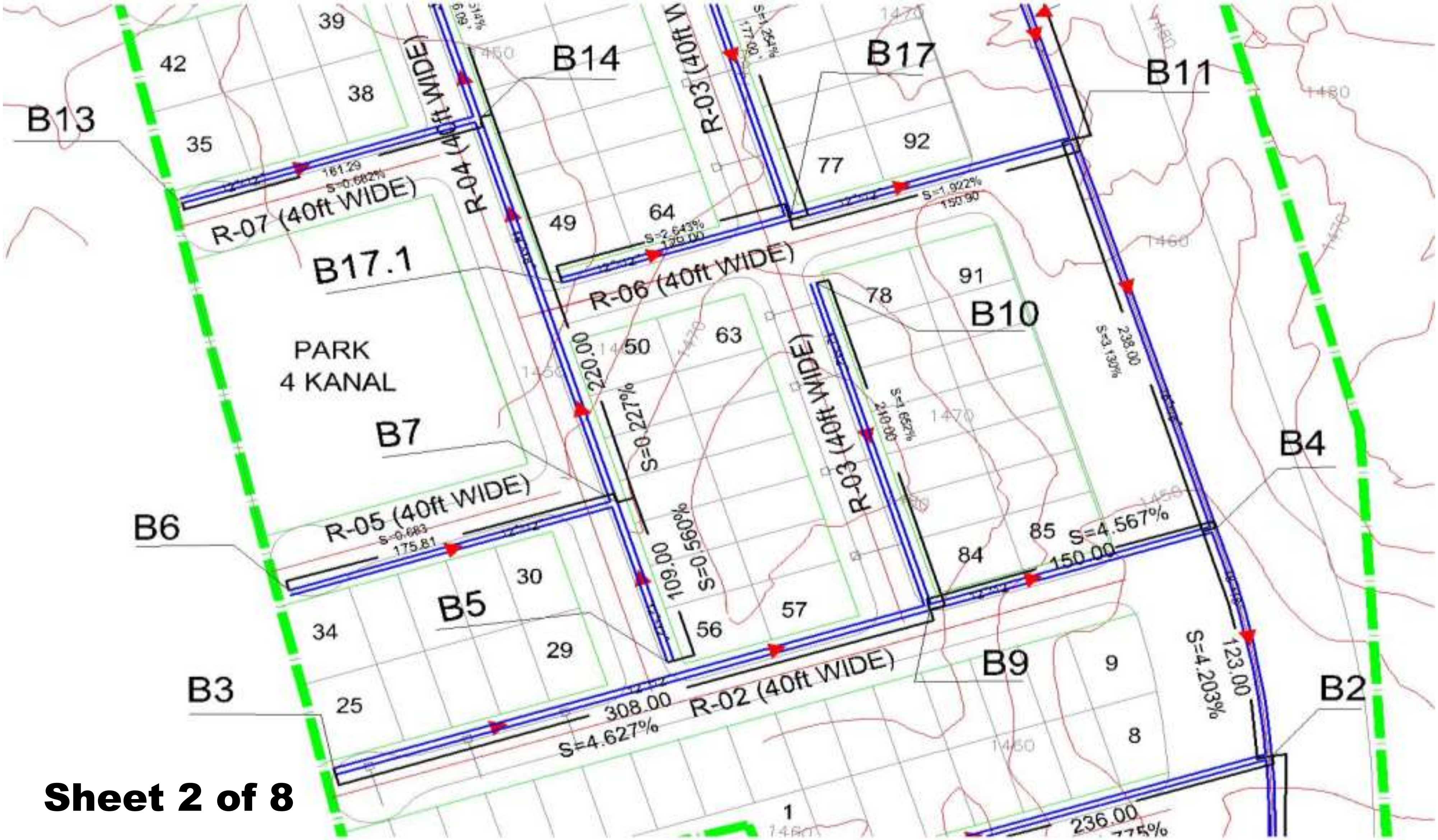


Fig G22: Storm drainage layout plan of Sub-catchment-1 part two

Annexure G

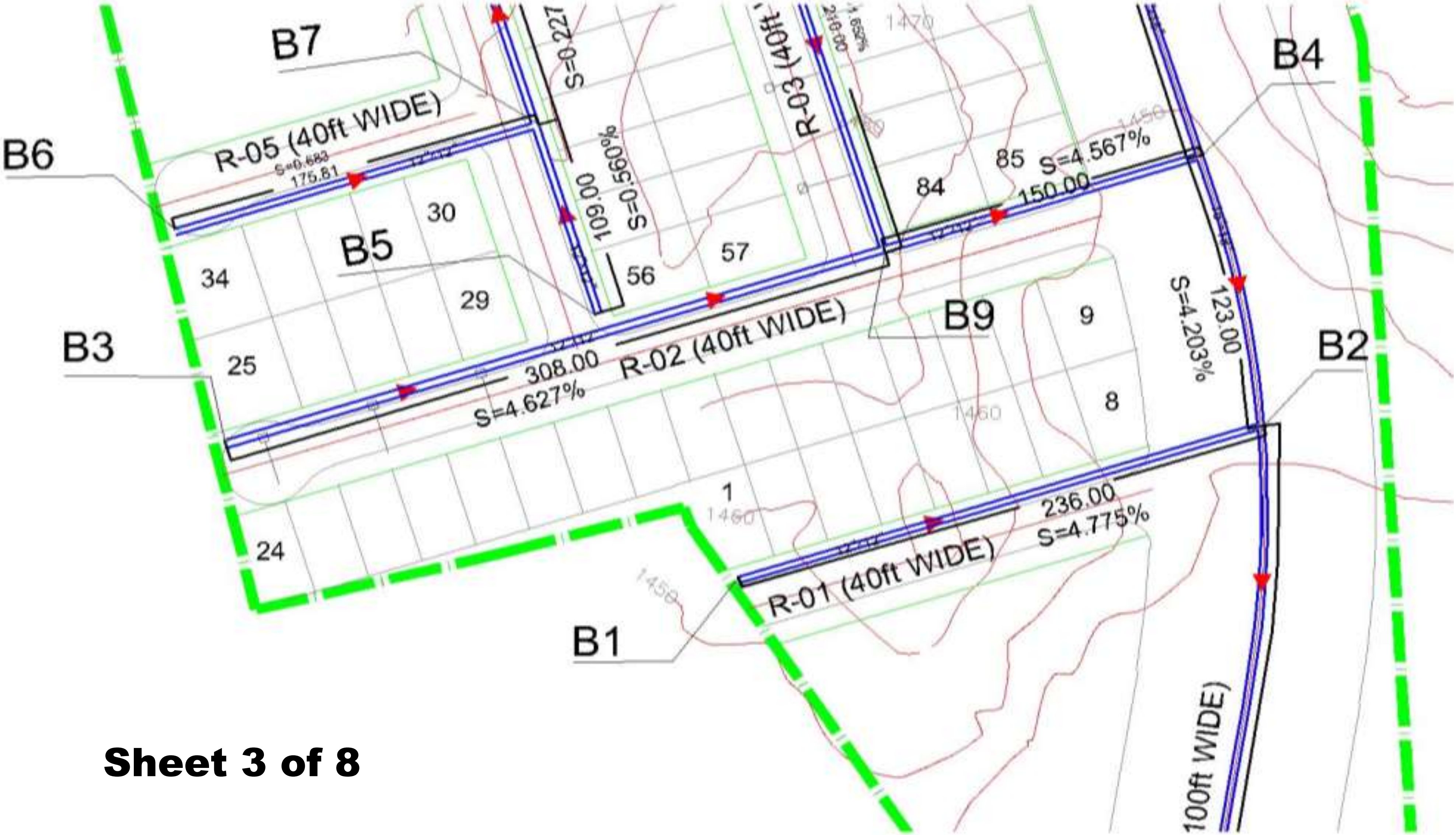


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Fig G23: Storm drainage layout plan of Sub-catchment-1 part three

Annexure G

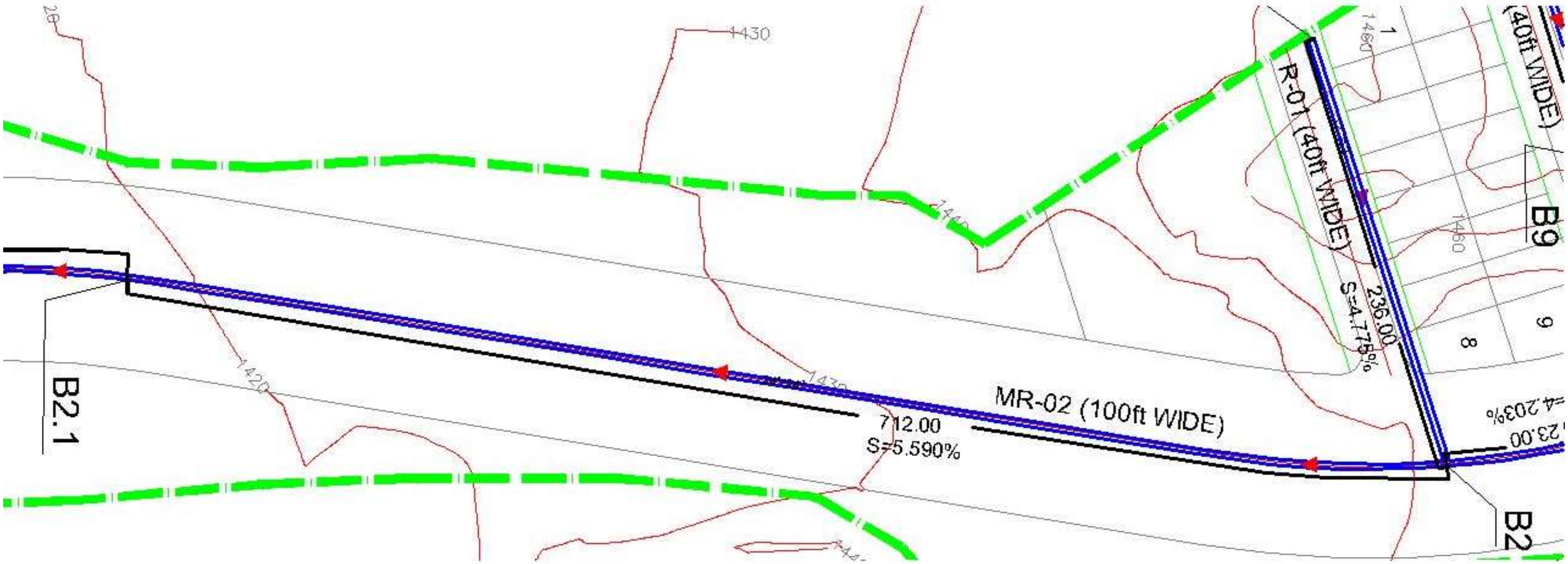

Fig G24: Storm drainage layout plan of Sub-catchment-1 part four (B2 to B2.1)

Annexure G

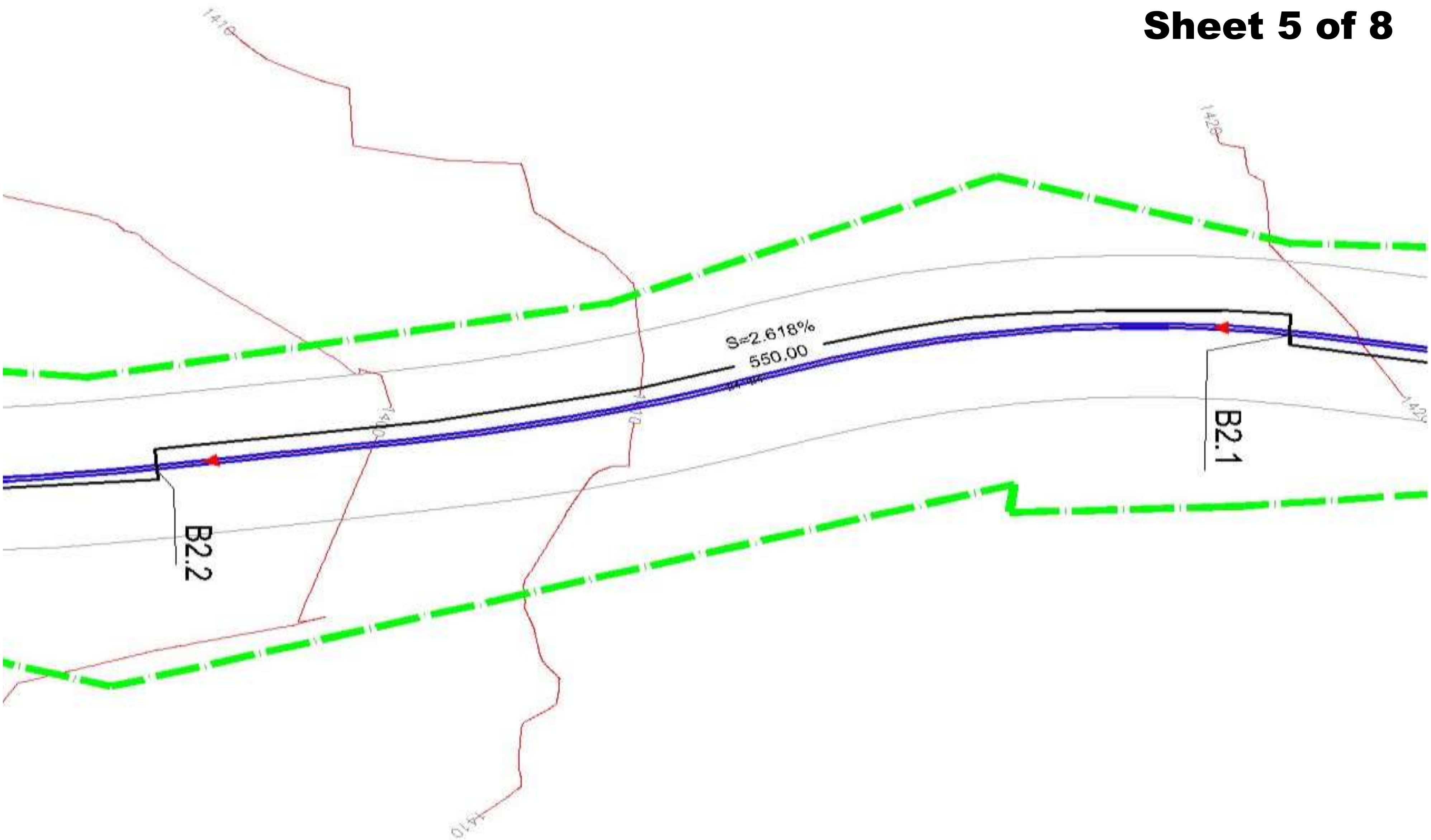

Fig G25: Storm drainage layout plan of Sub-catchment-1 part five(B2.1 to B2.2)

Sheet 6 of 8

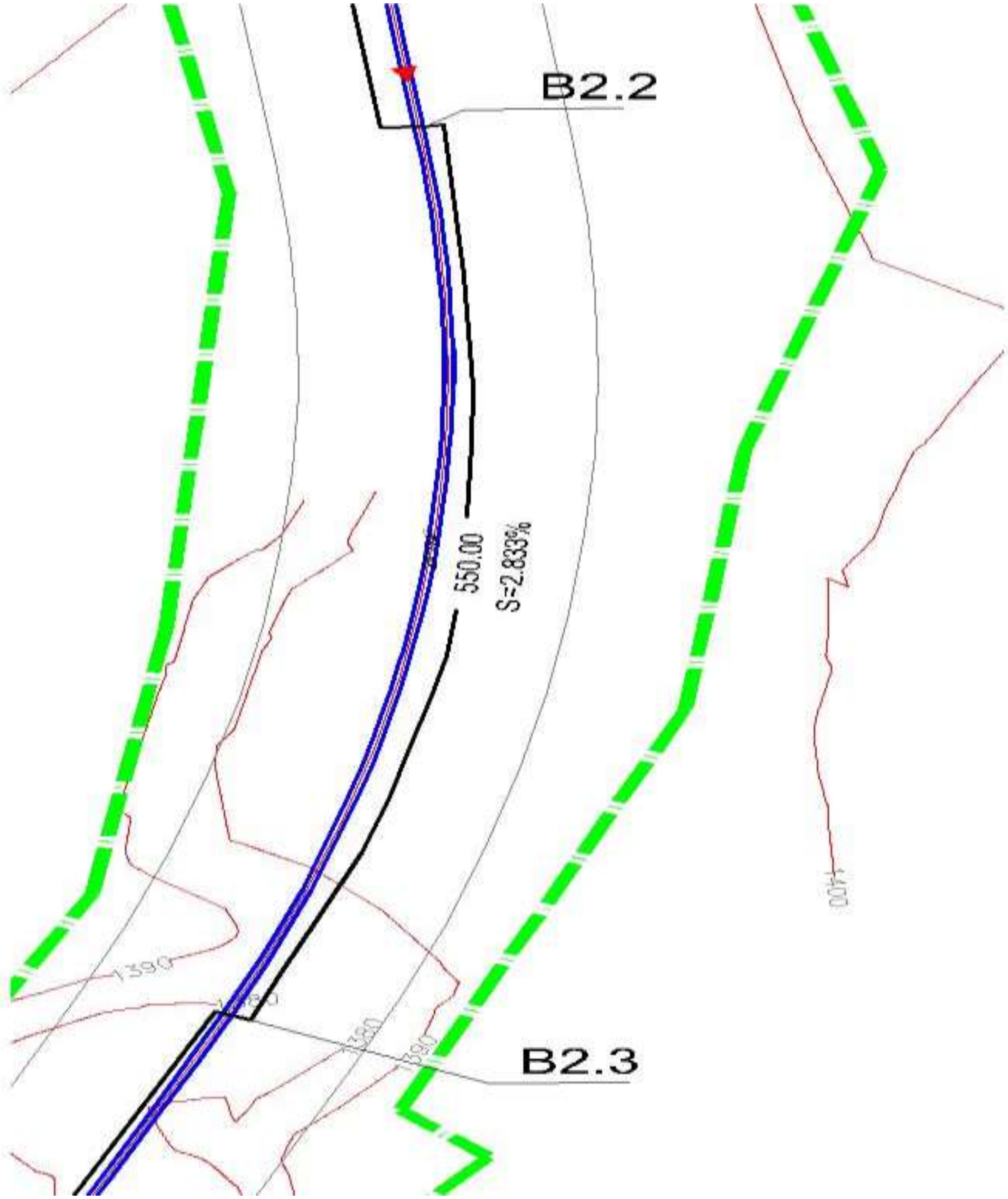

Fig G26: Storm drainage layout plan of Sub-catchment-1 part six

Annexure G

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Fig G27: Storm drainage layout plan of Sub-catchment-1 part seven

Annexure G

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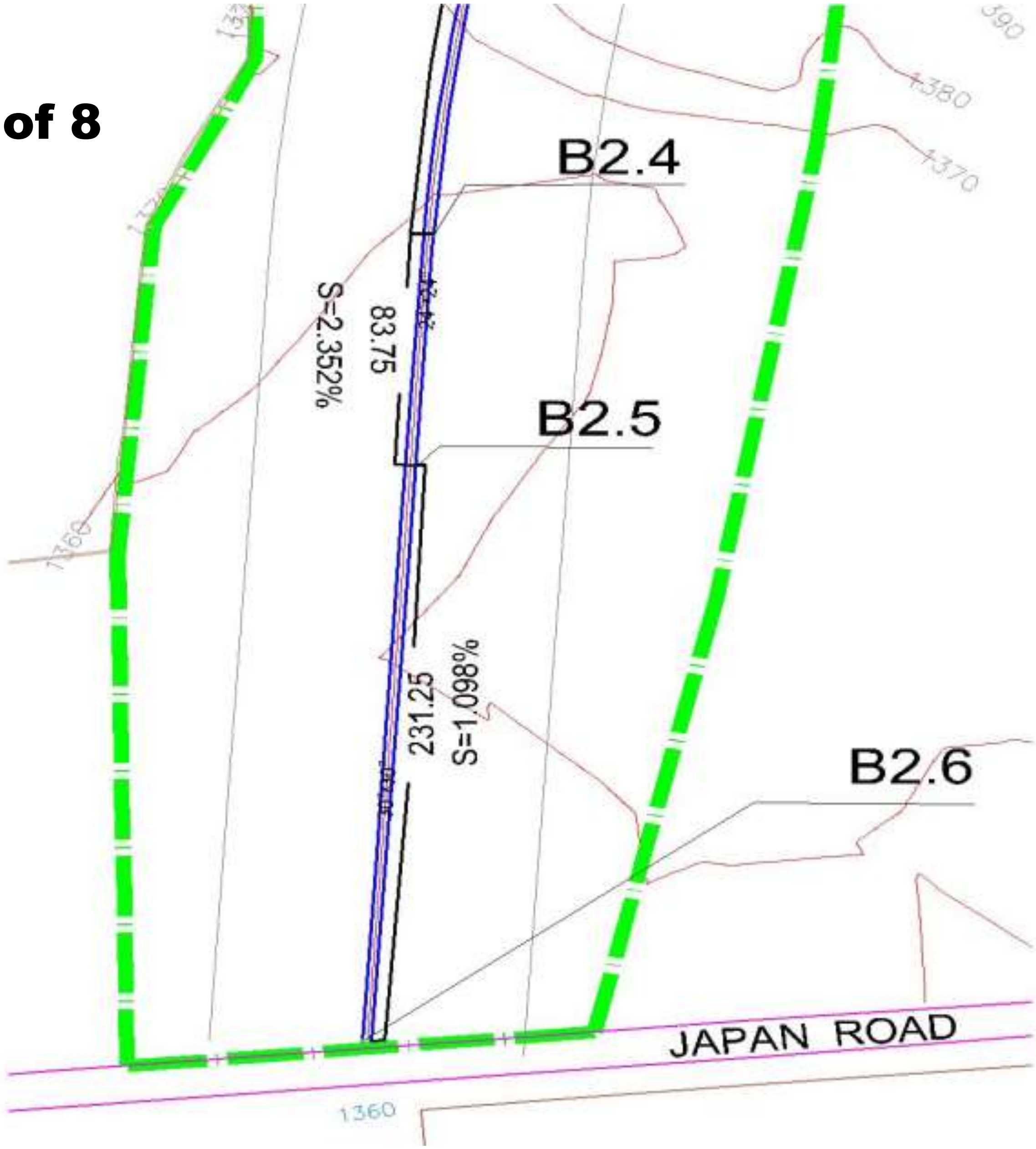

Fig G28: Storm drainage layout plan of Sub-catchment-1 showing final disposal node B2.6

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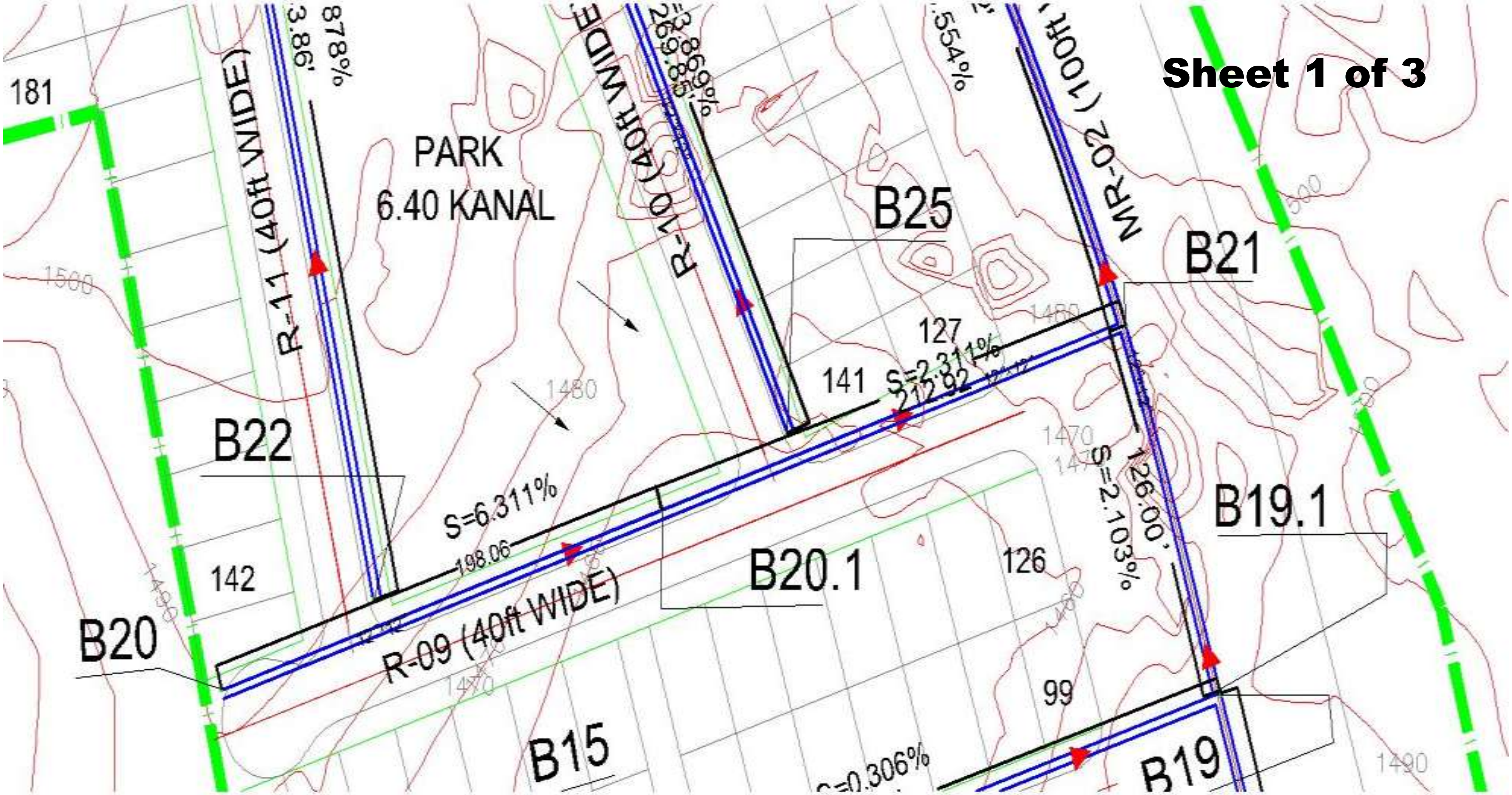

Fig G29: Storm drainage layout plan of Sub-catchment-2 showing initial nodes B20 & B19.1

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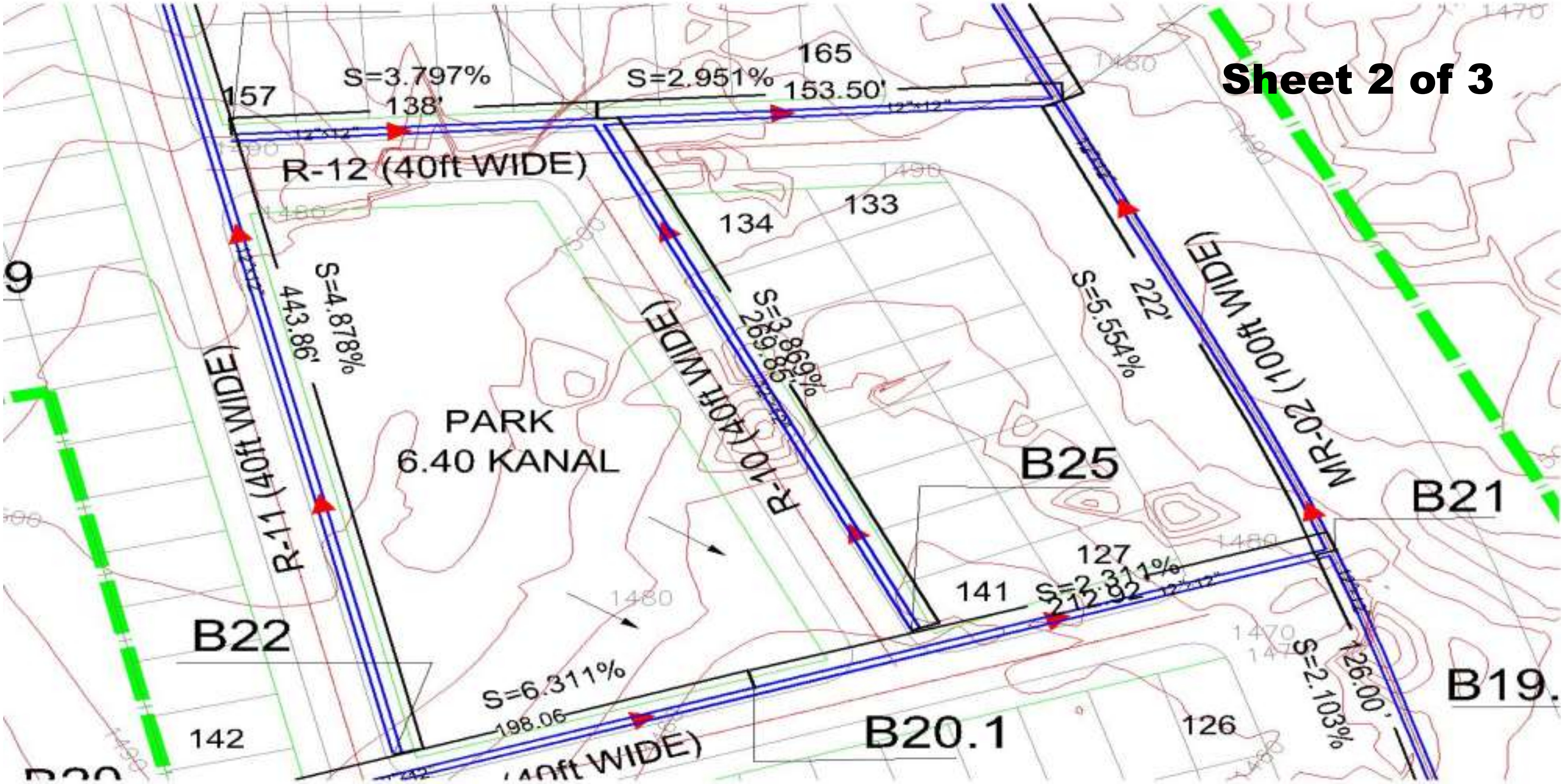
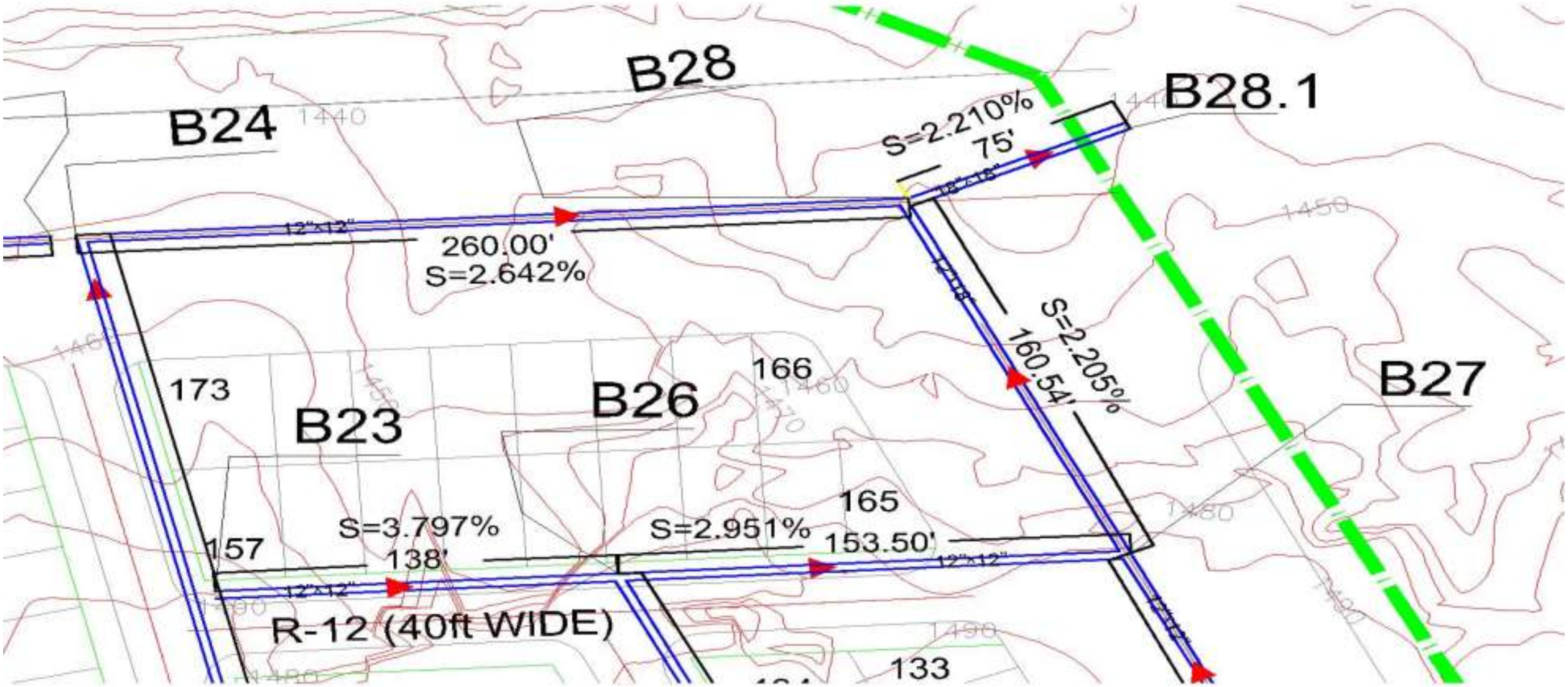


Fig G30: Storm drainage layout plan of Sub-catchment-2 part two

Annexure G



Sheet 3 of 3

Fig G31: Storm drainage layout plan of Sub-catchment-2 showing final disposal node B28.1

Annexure G

Sheet 1 of 3

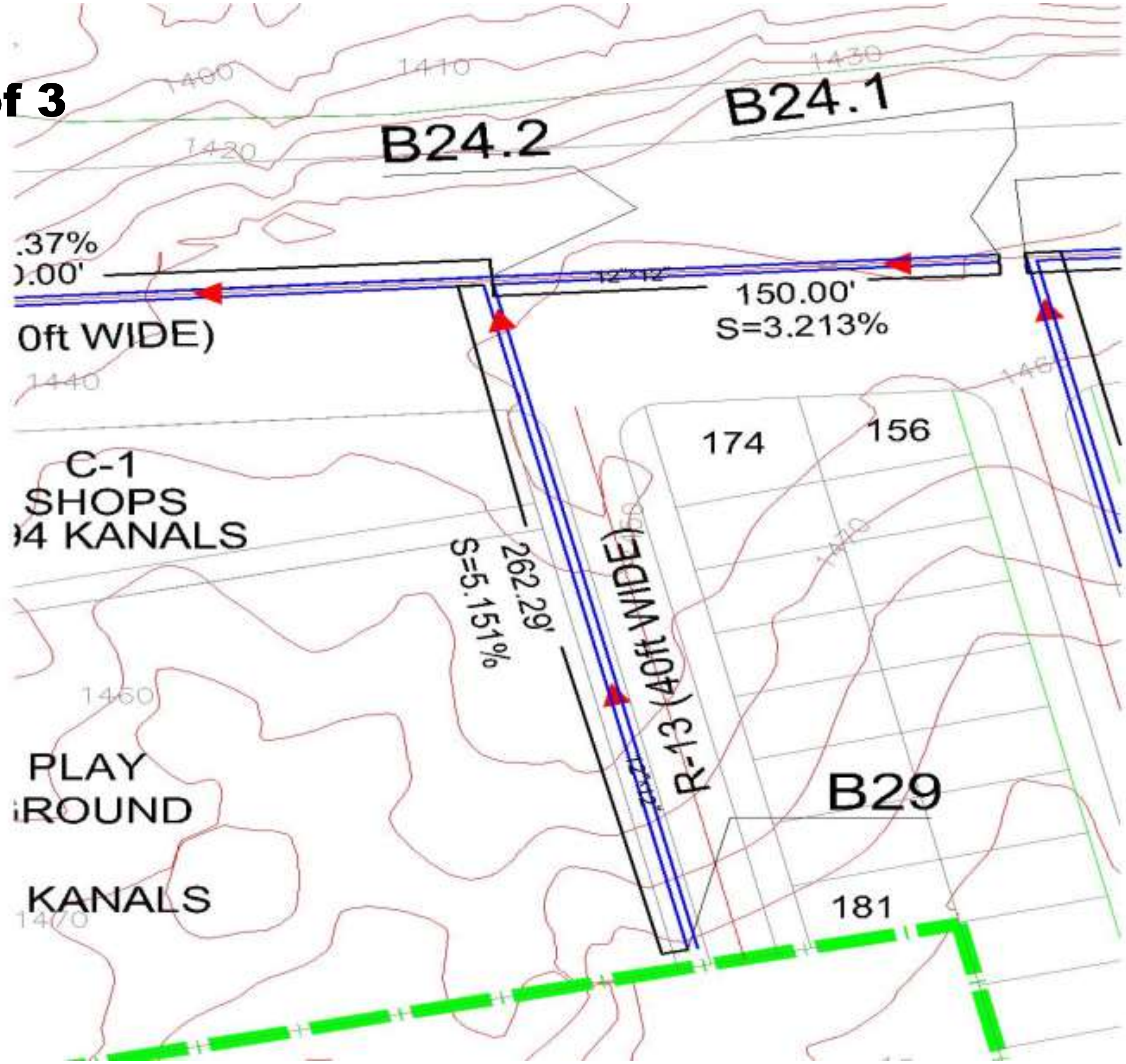


Fig G32: Storm drainage layout plan of Sub-catchment-3 showing initial nodes B29 & B24.2

Annexure G

Sheet 2 of 3

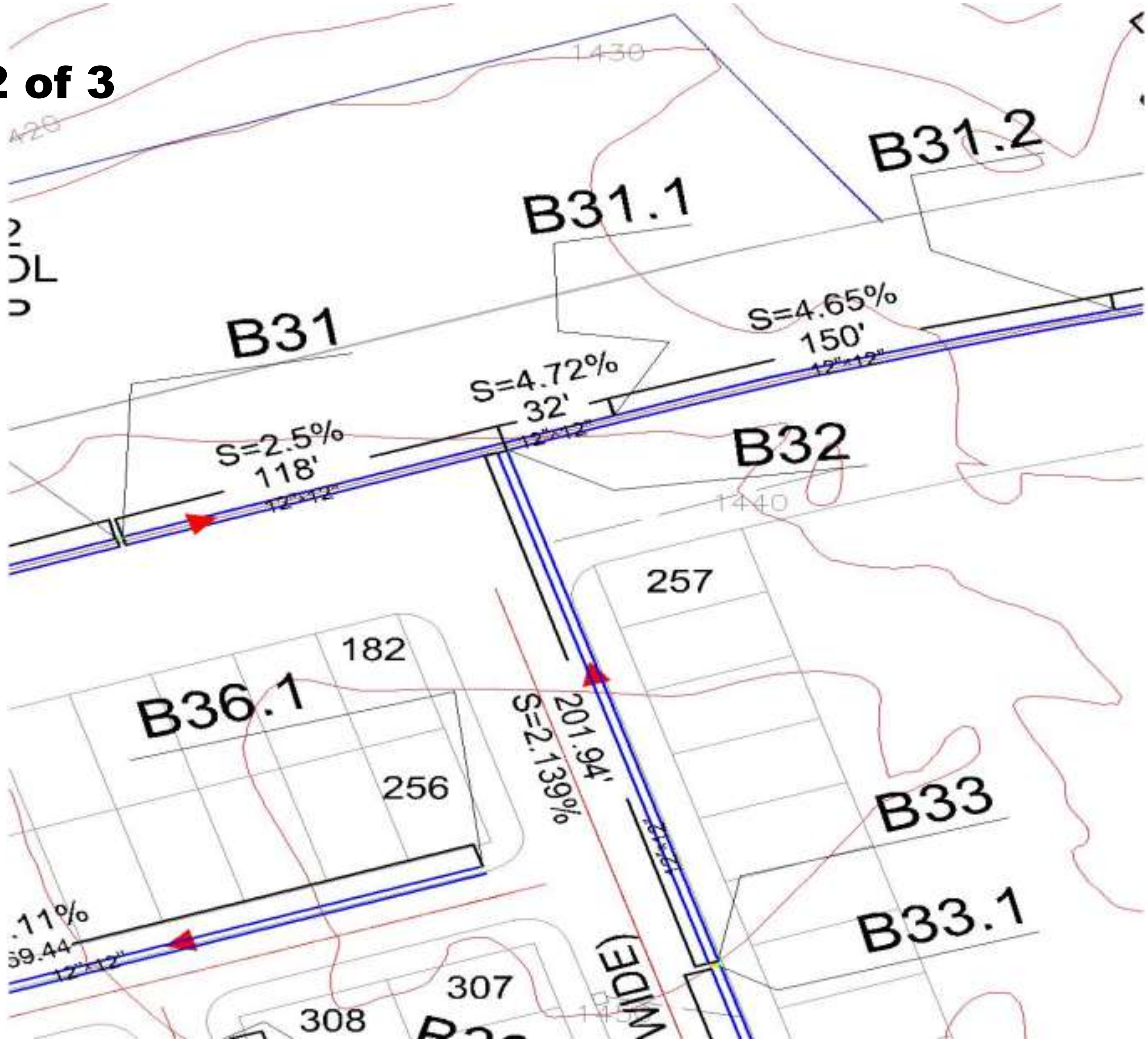


Fig G33: Storm drainage layout plan of Sub-catchment-3 showing initial nodes B33 & B31

Annexure G

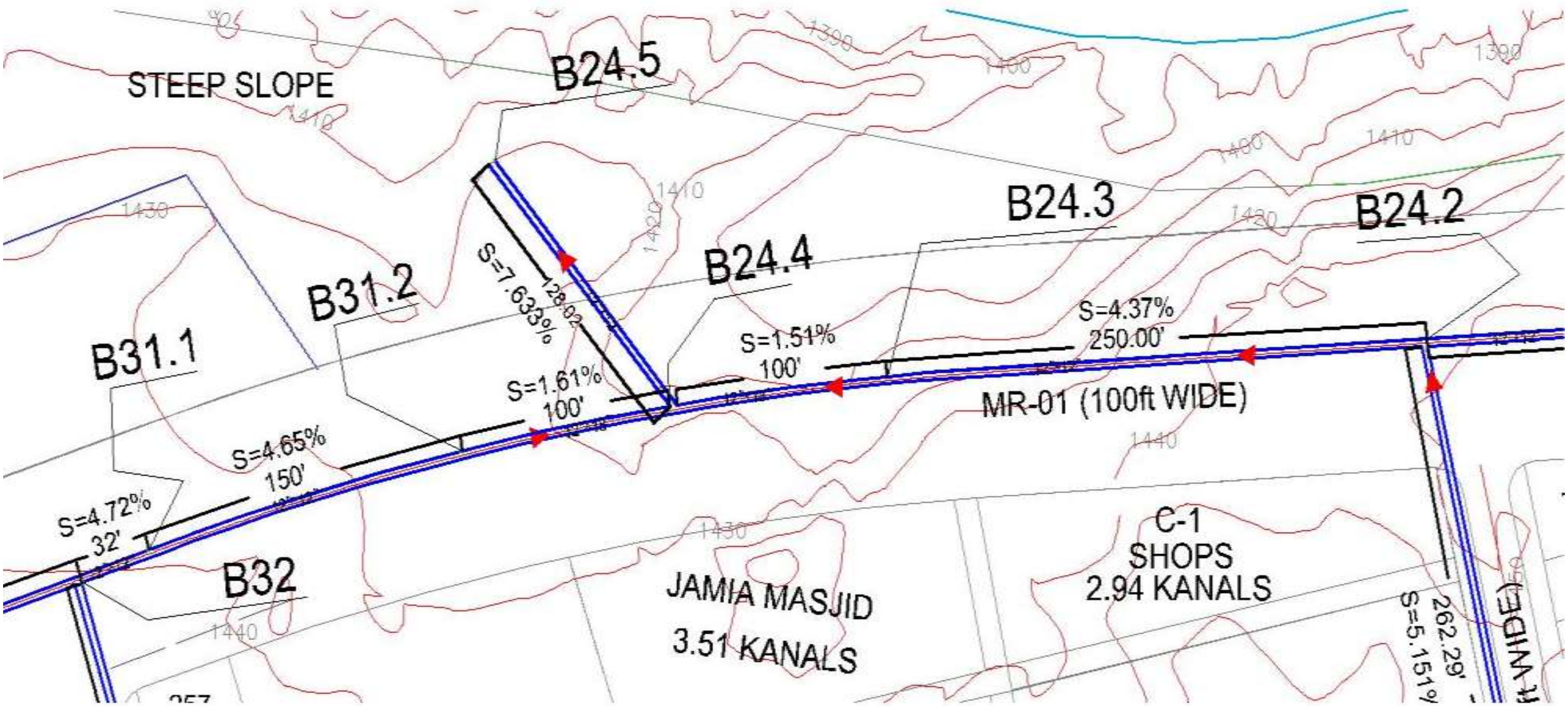


Fig G34: Storm drainage layout plan of Sub-catchment-3 showing final disposal node B24.5

Annexure G

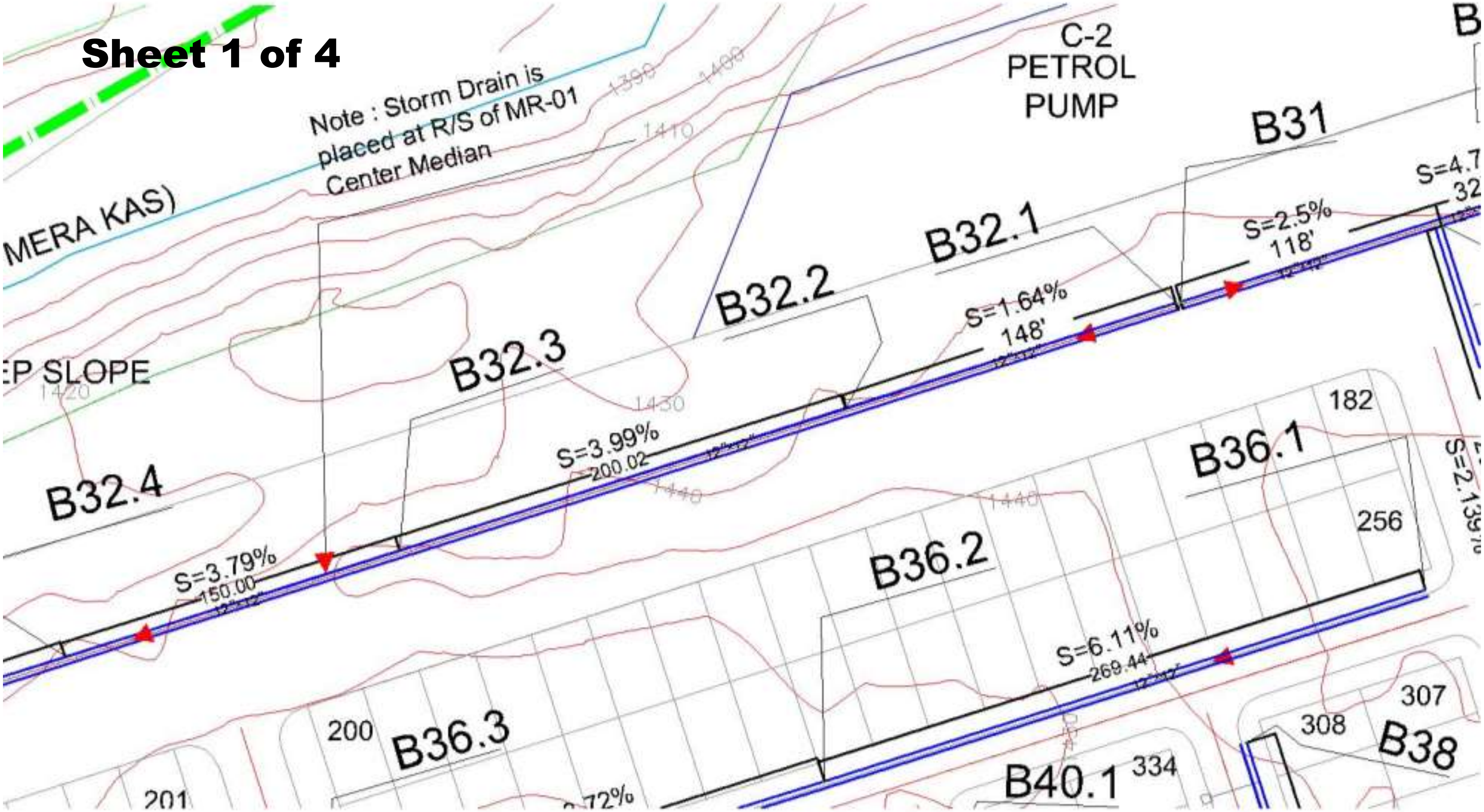


Fig G35: Storm drainage layout plan of Sub-catchment-5 showing initial nodes B36.1 & B32.1

Annexure G

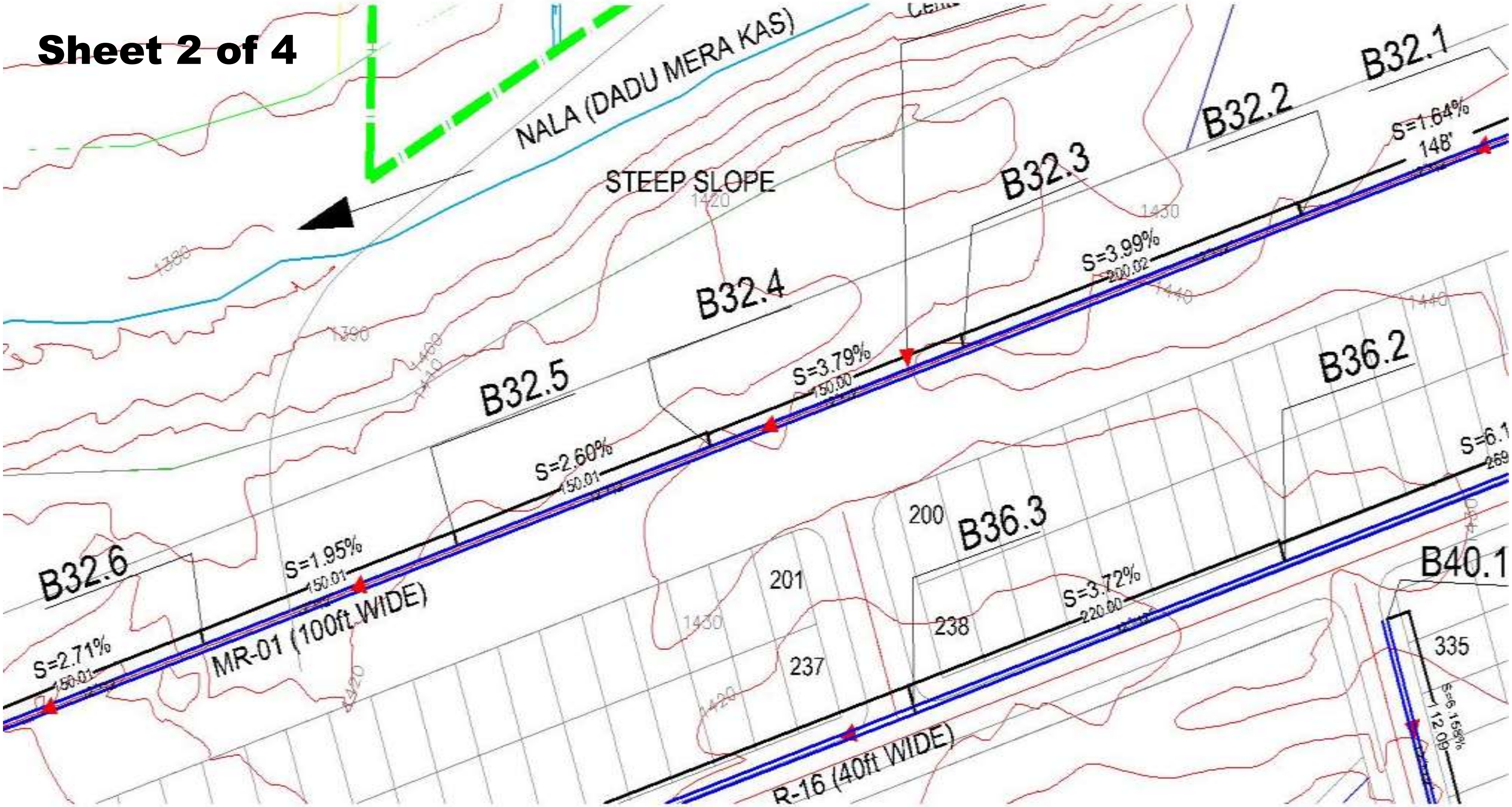


Fig G36: Storm drainage layout plan of Sub-catchment-5 part two

Annexure G

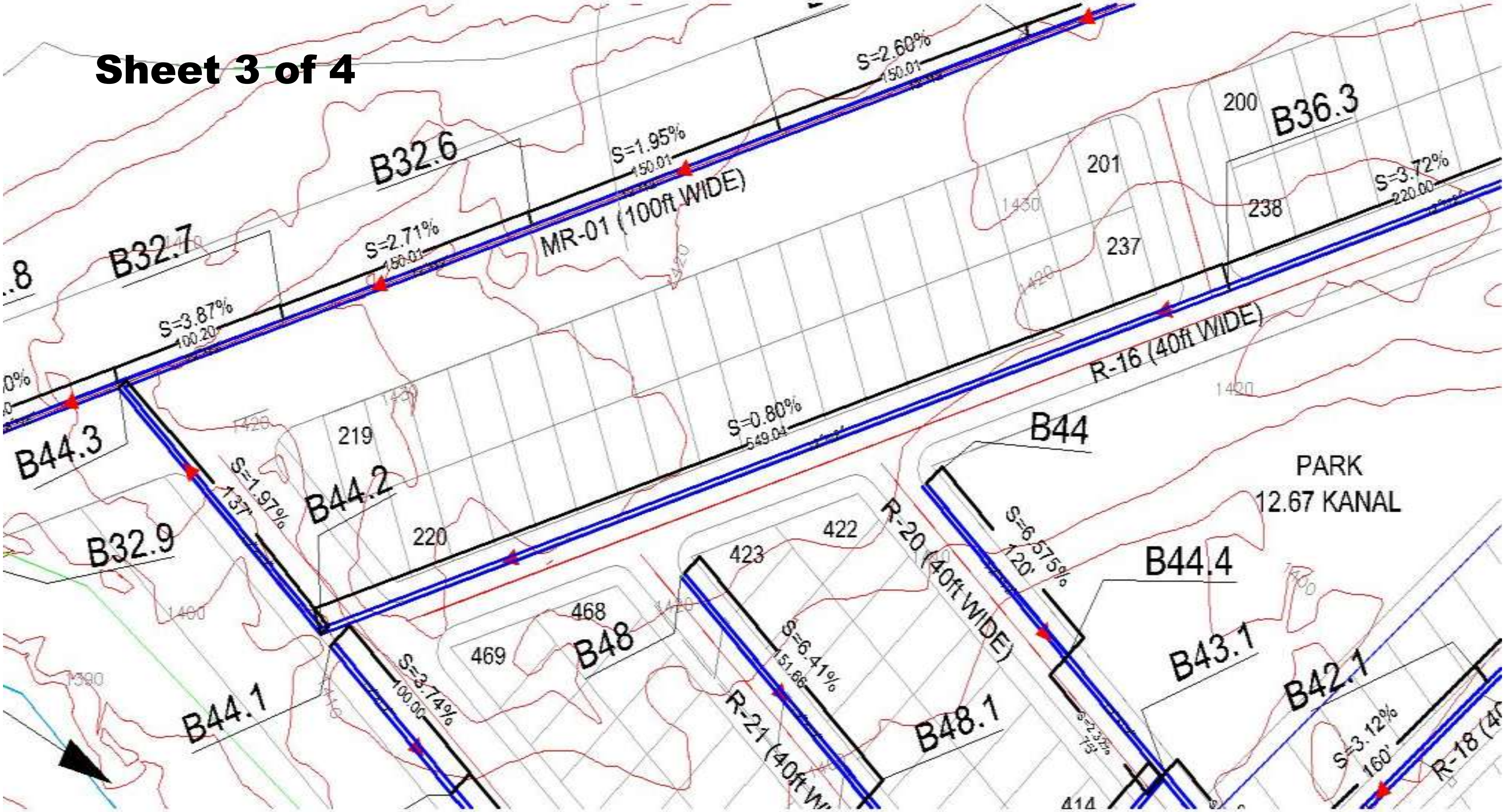


Fig G37: Storm drainage layout plan of Sub-catchment-5 part three

Annexure G

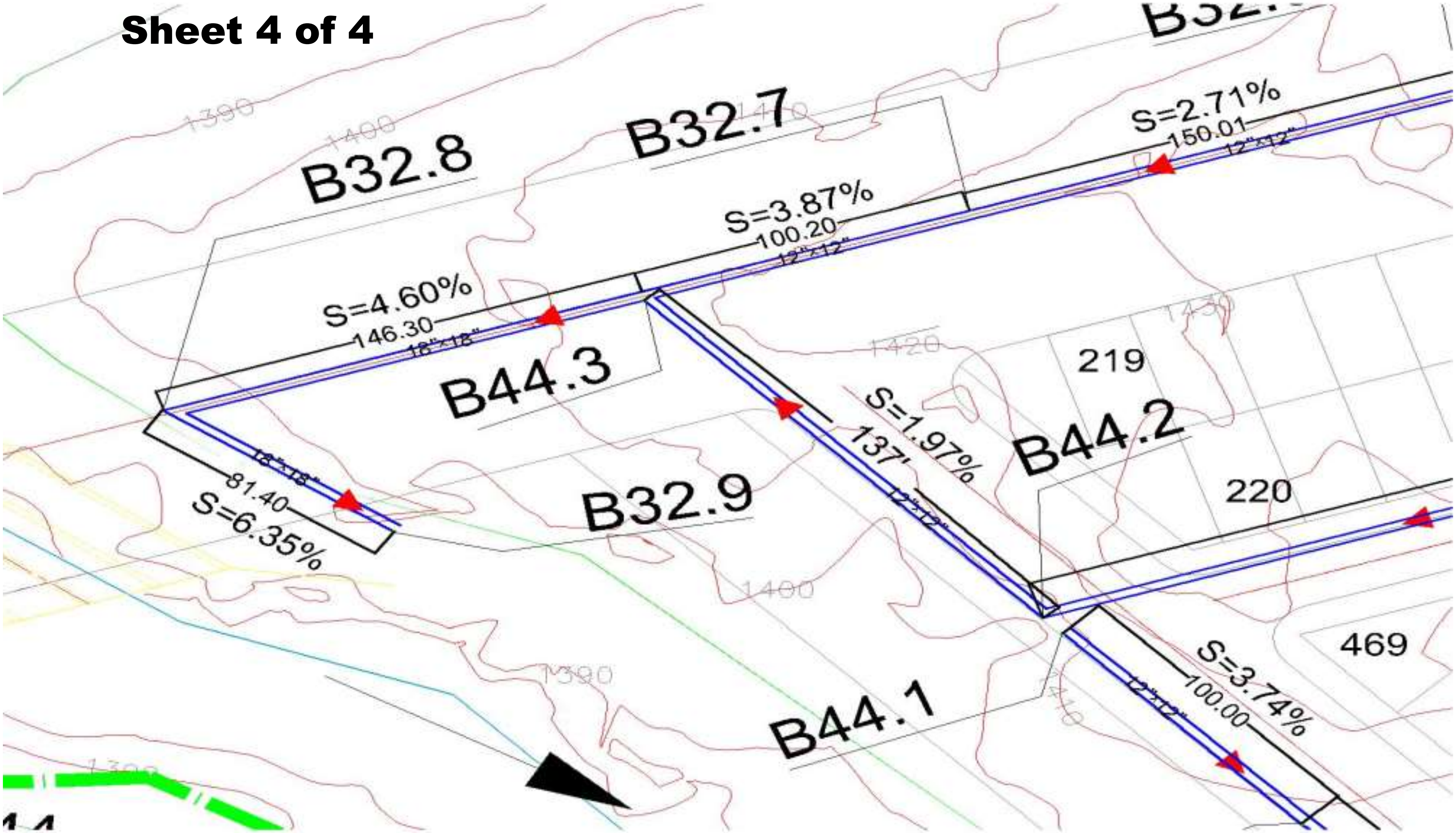


Fig G38: Storm drainage layout plan of Sub-catchment-5 showing final disposal node B44.1

Annexure G

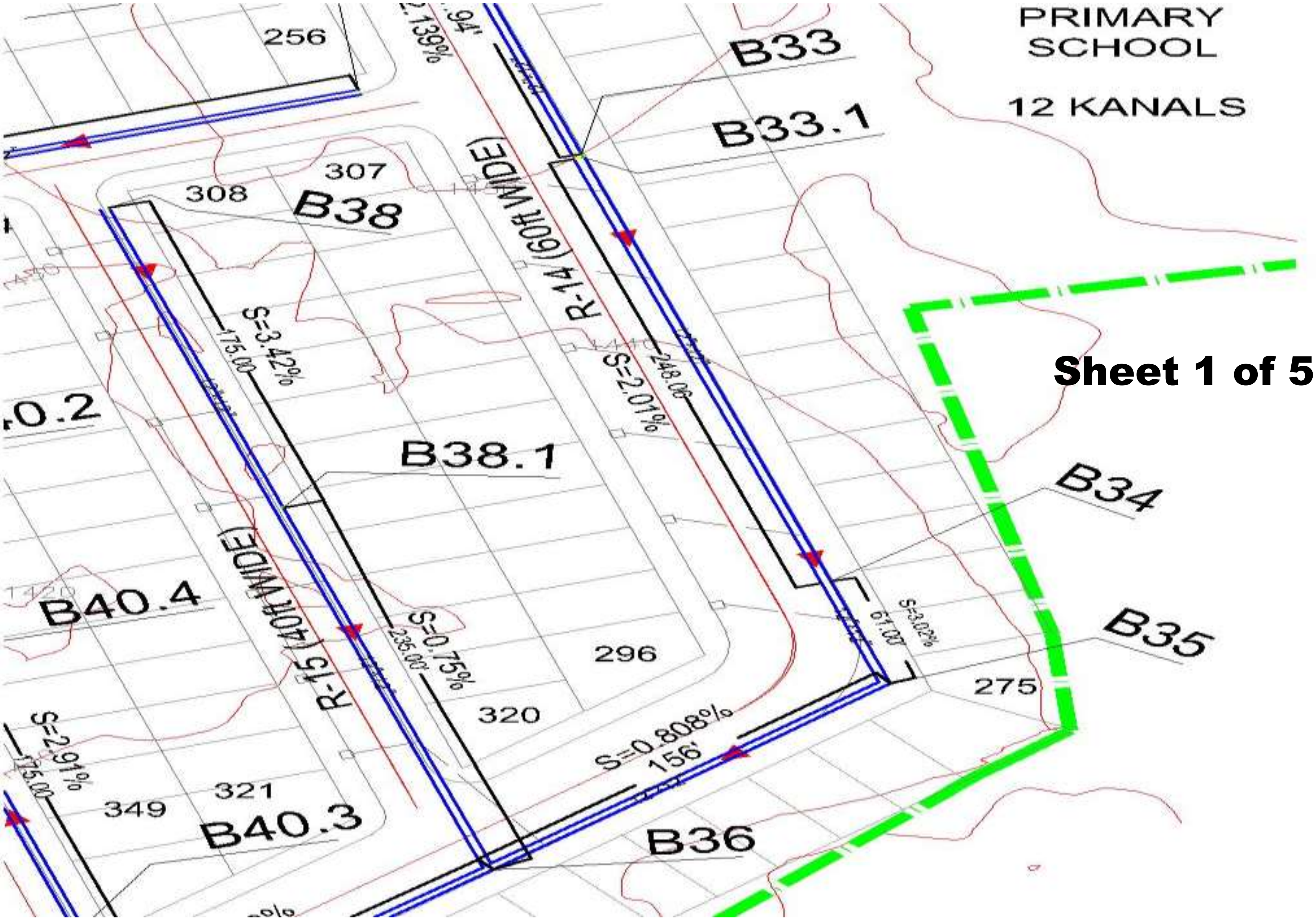


Fig G39: Storm drainage layout plan of Sub-catchment-4 showing initial nodes node B33.1 & B38

Annexure G

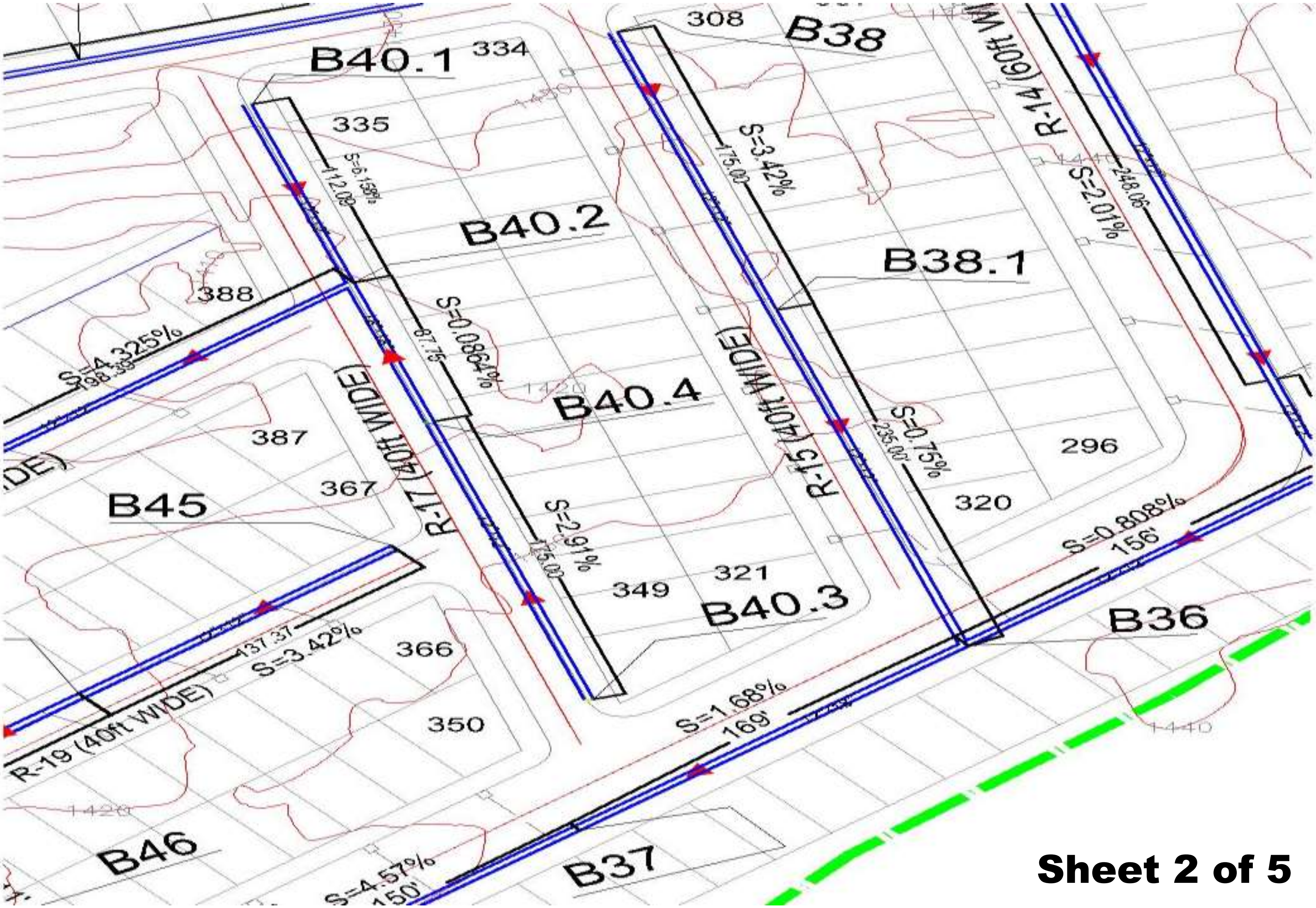


Fig G40: Storm drainage layout plan of Sub-catchment-4 part two

Annexure G

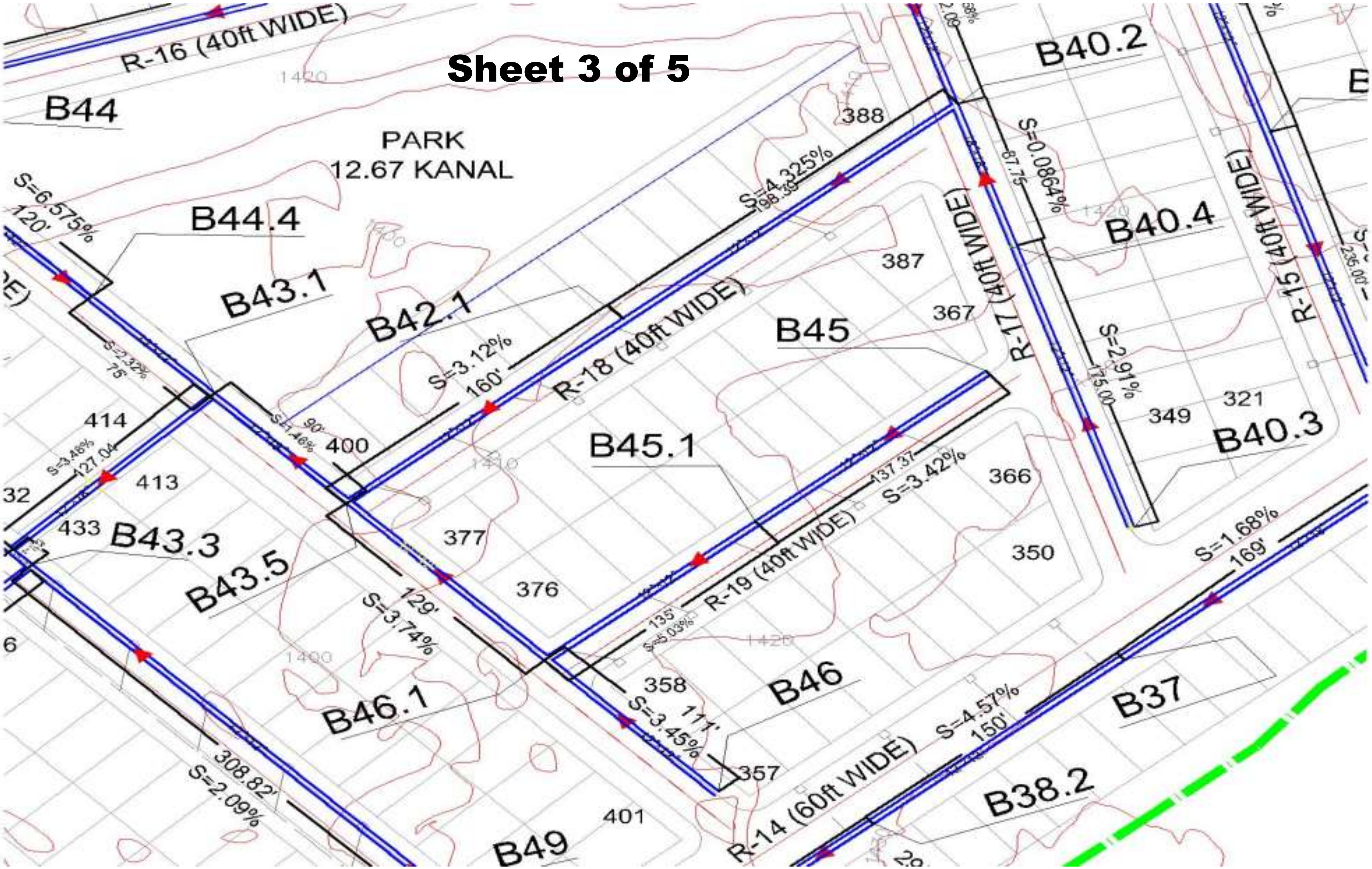


Fig G41: Storm drainage layout plan of Sub-catchment-4 part three

Annexure G

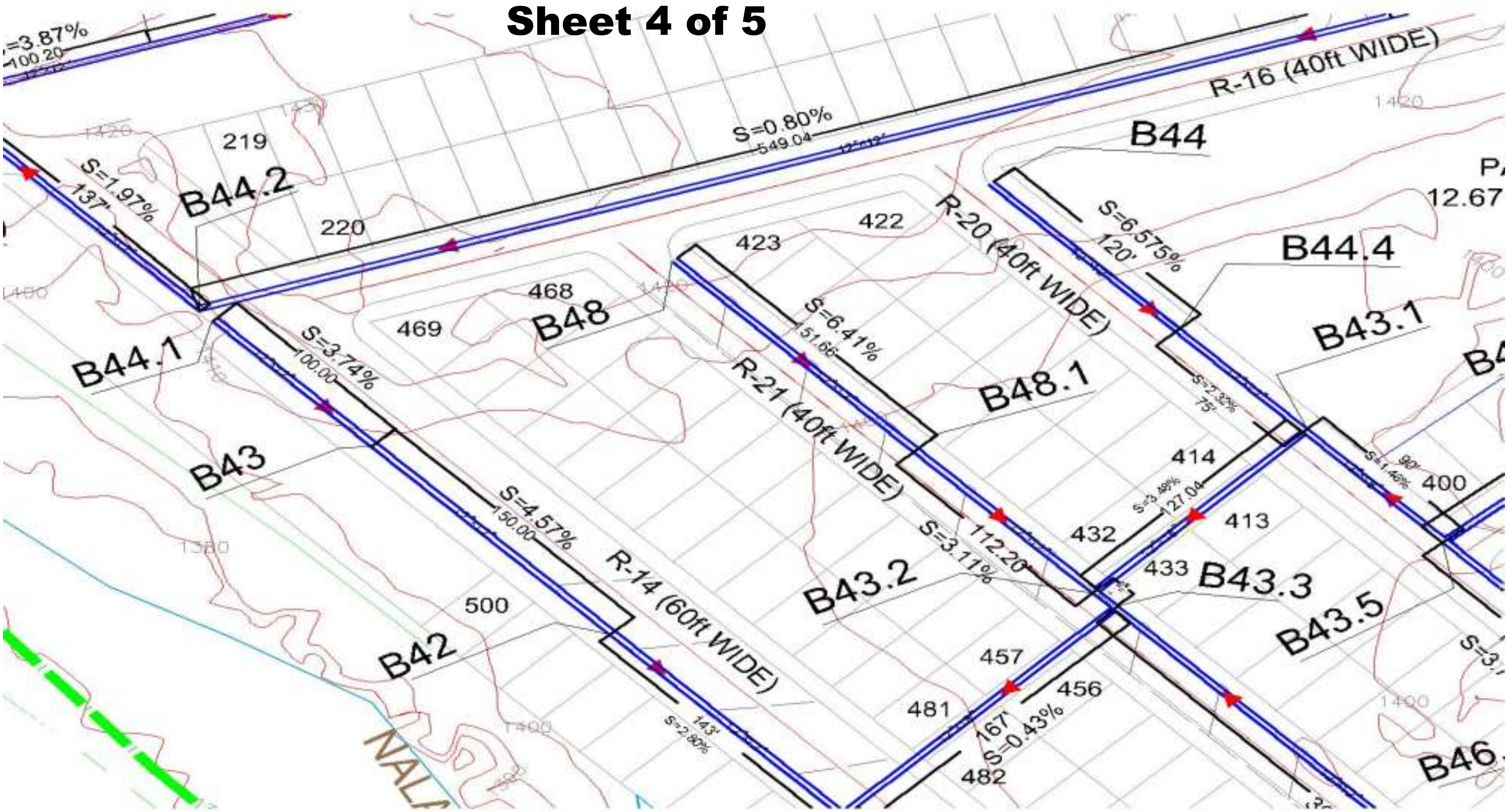


Fig G42: Storm drainage layout plan of Sub-catchment-4 part four

Annexure G

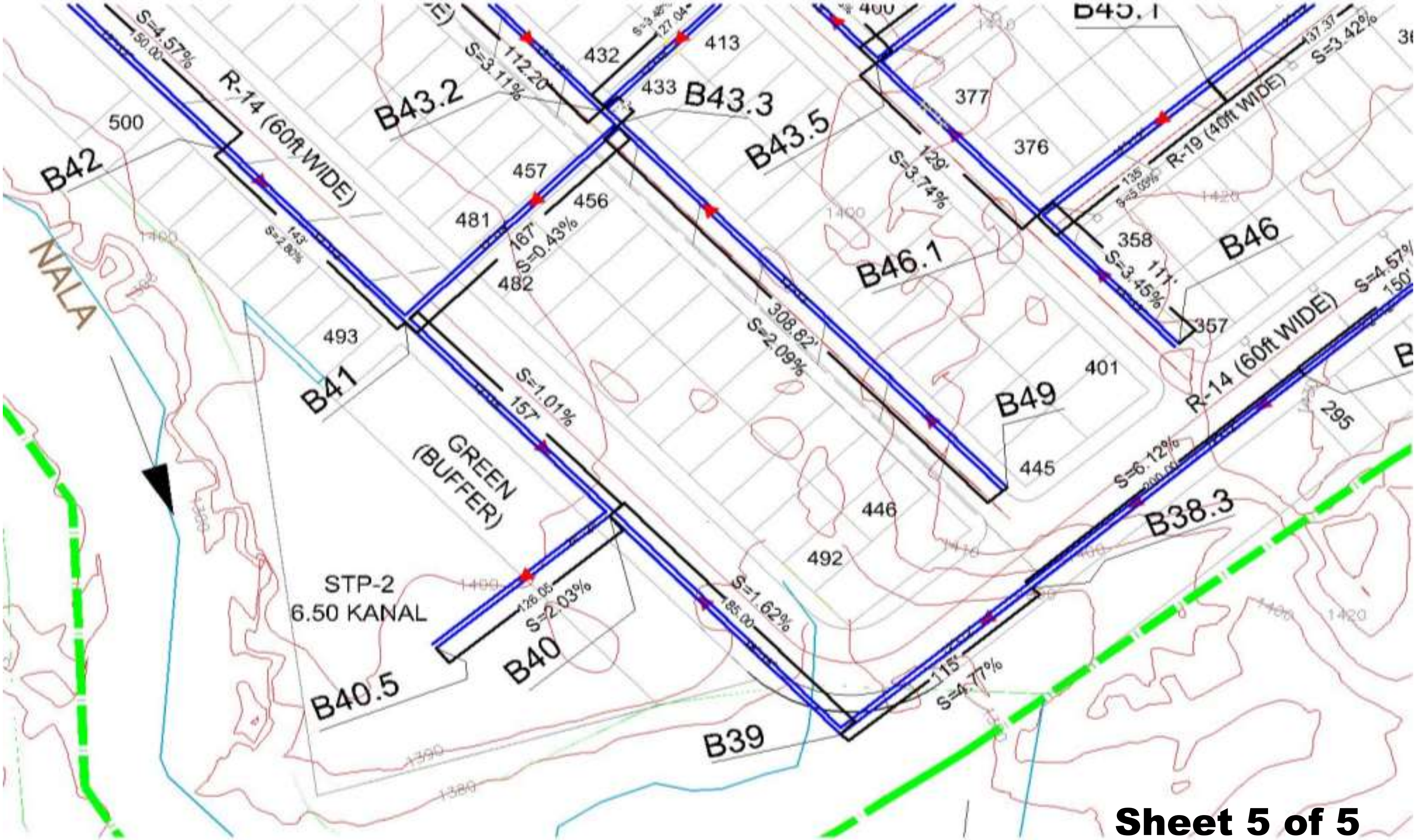


Fig G43: Storm drainage layout plan of Sub-catchment-4 showing final disposal node B40.5

Appendix H

Key Plan & Detailed Drawings of Combined Network

ANNEXURE H: DRY AND WET WEATHER MIXED FOW LAYOUT FOR COMBINED SEWER SYSTEM

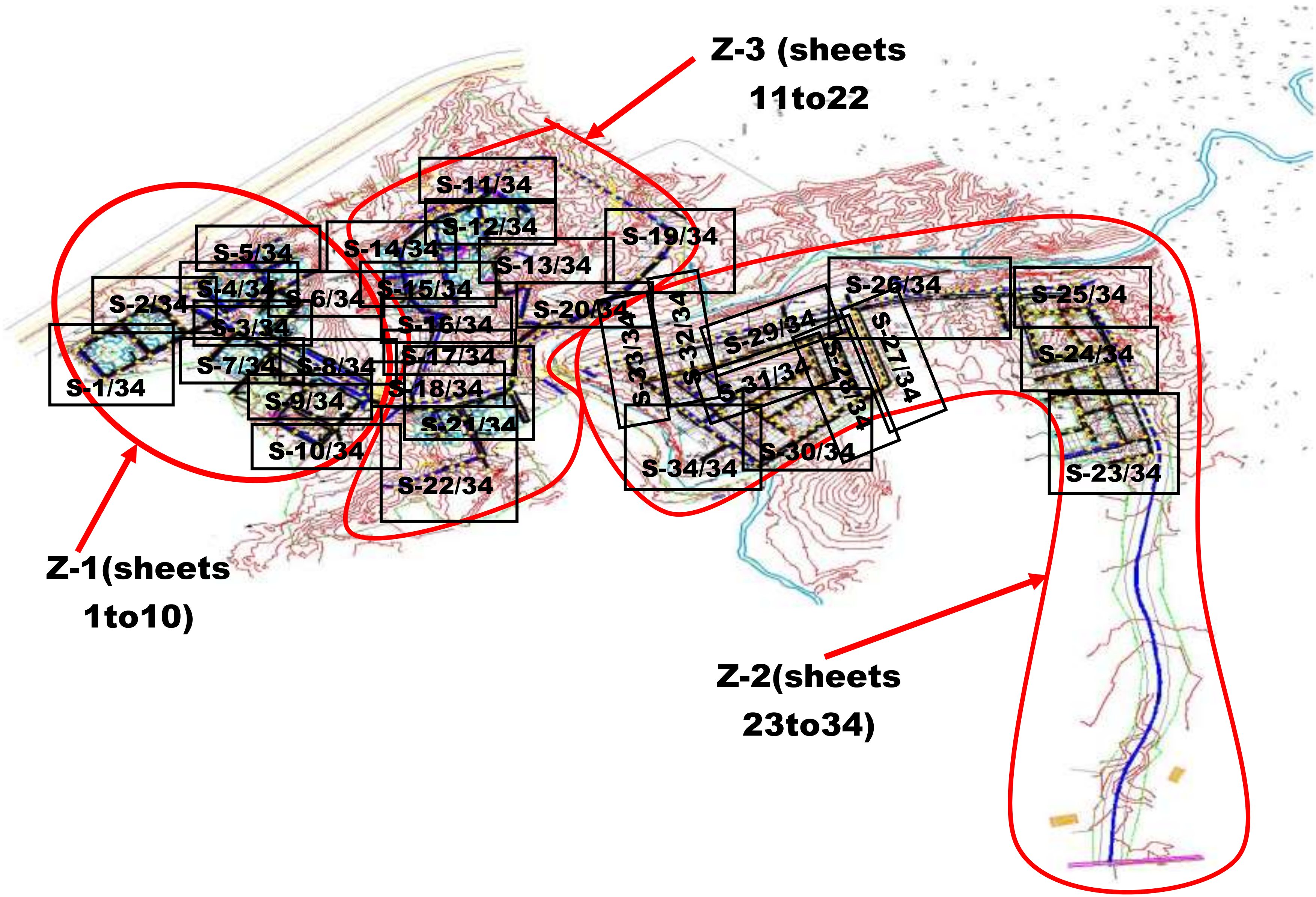


Fig H1: Combined drainage layout plan of entire residential colony and legened for detailed drawing

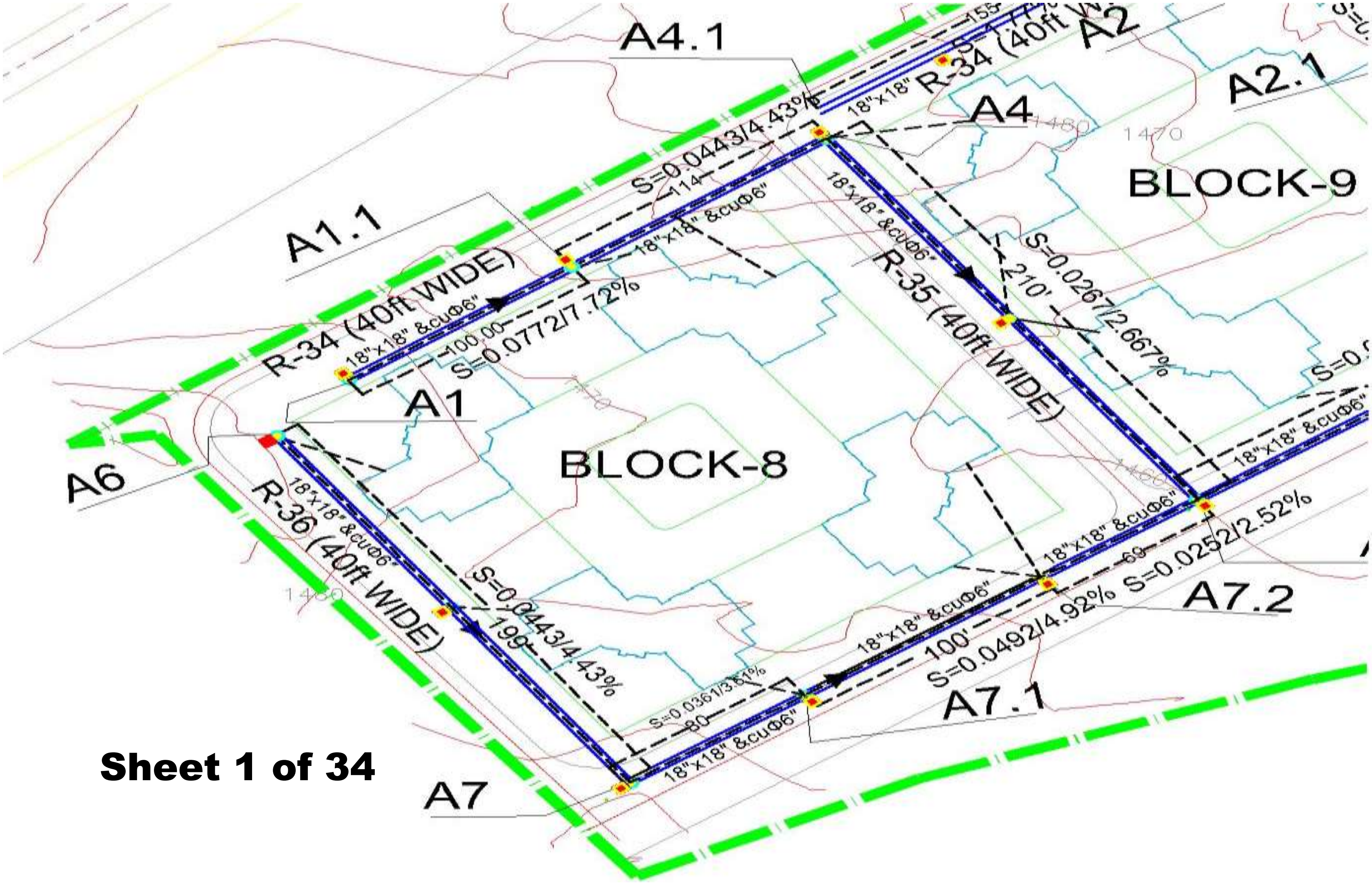


Fig H2: Combined drainage layout plan of Zone-1 at R/S of MR-01, here red spots indicate catchpits connected to manhole nodes

Annexure H

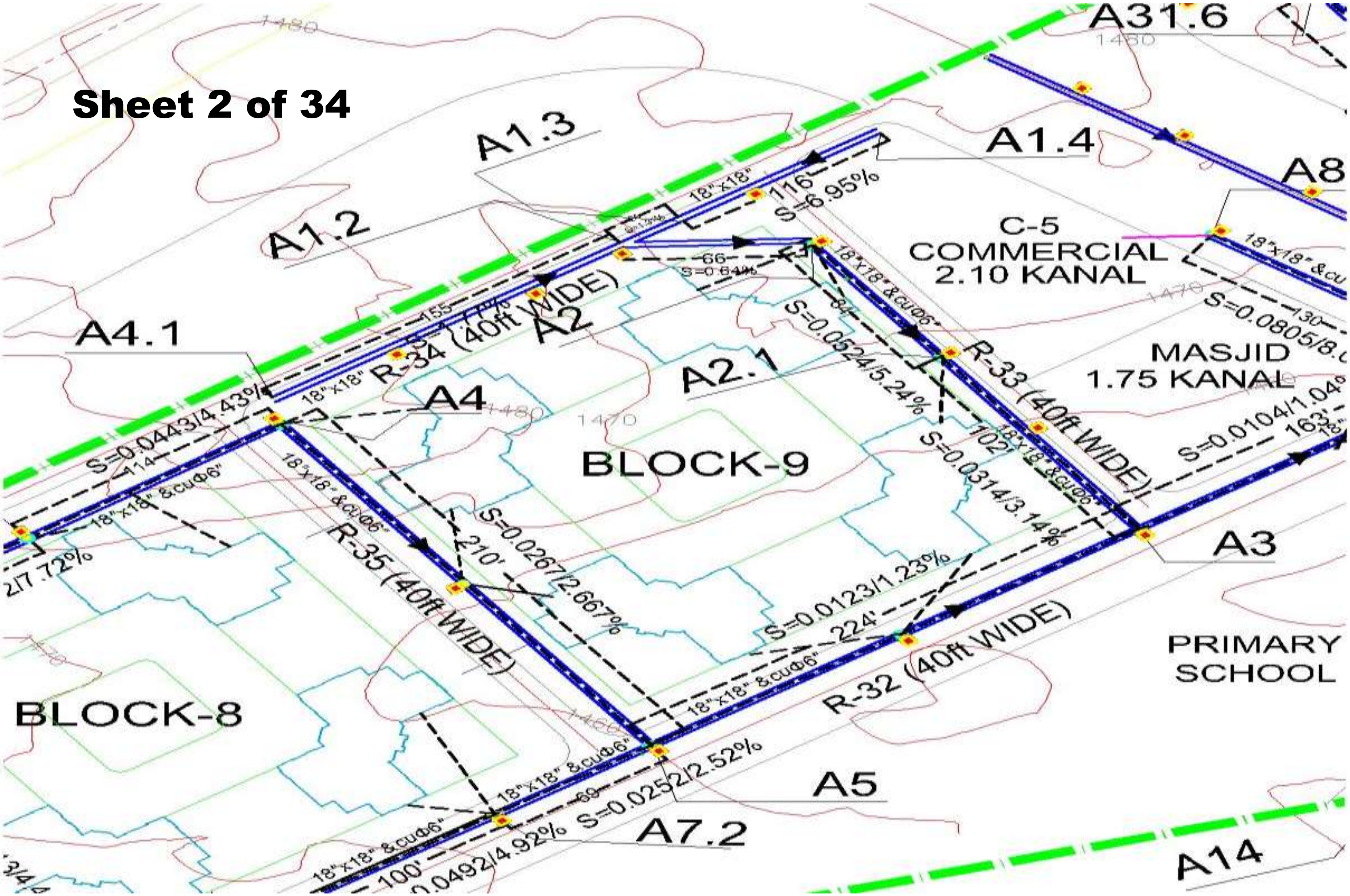


Fig H3: Combined drainage layout plan of Zone-1 at R/S of MR-01

Annexure H

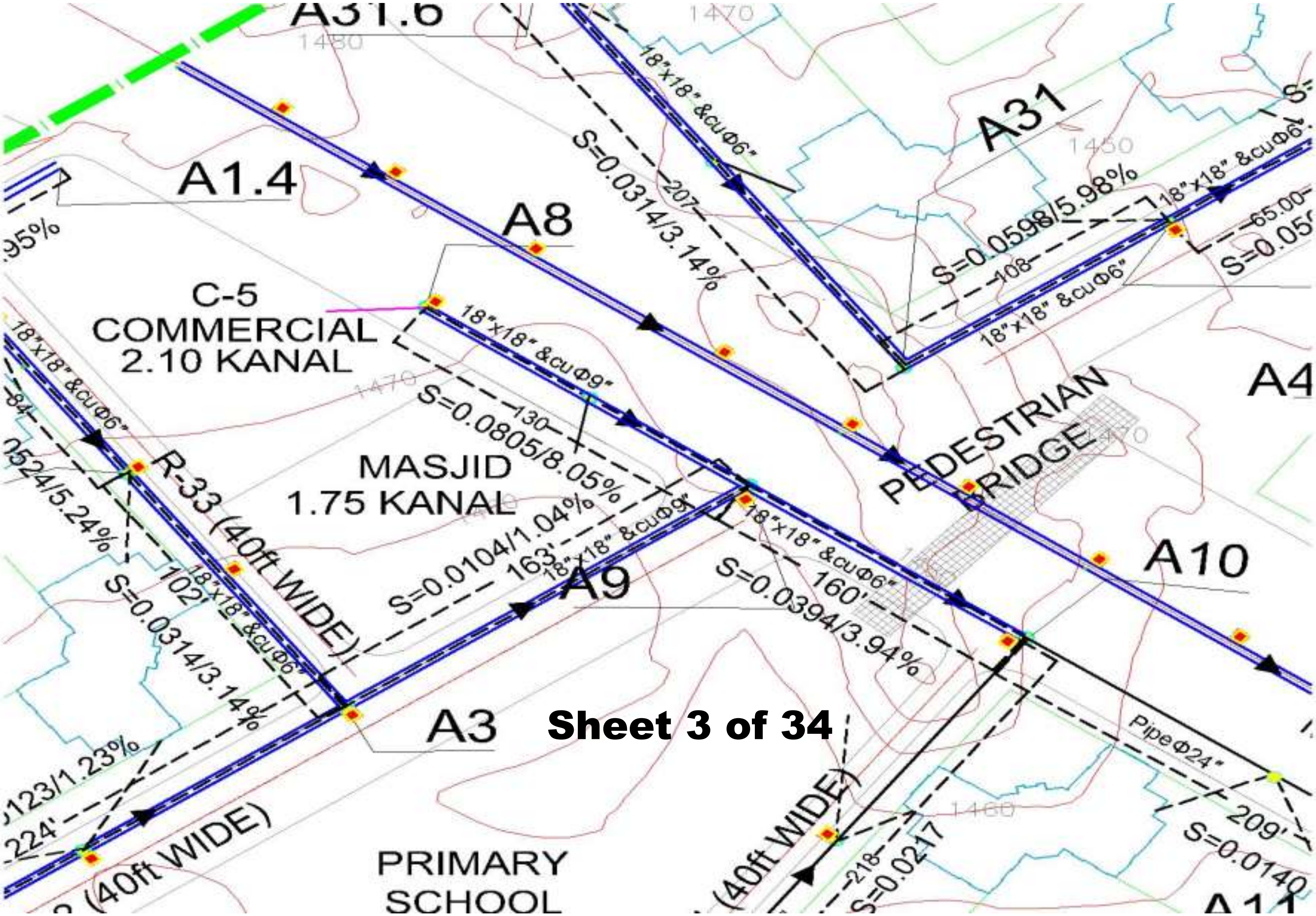


Fig H4: Combined drainage layout plan of Zone-1 at R/S of MR-01

Annexure H

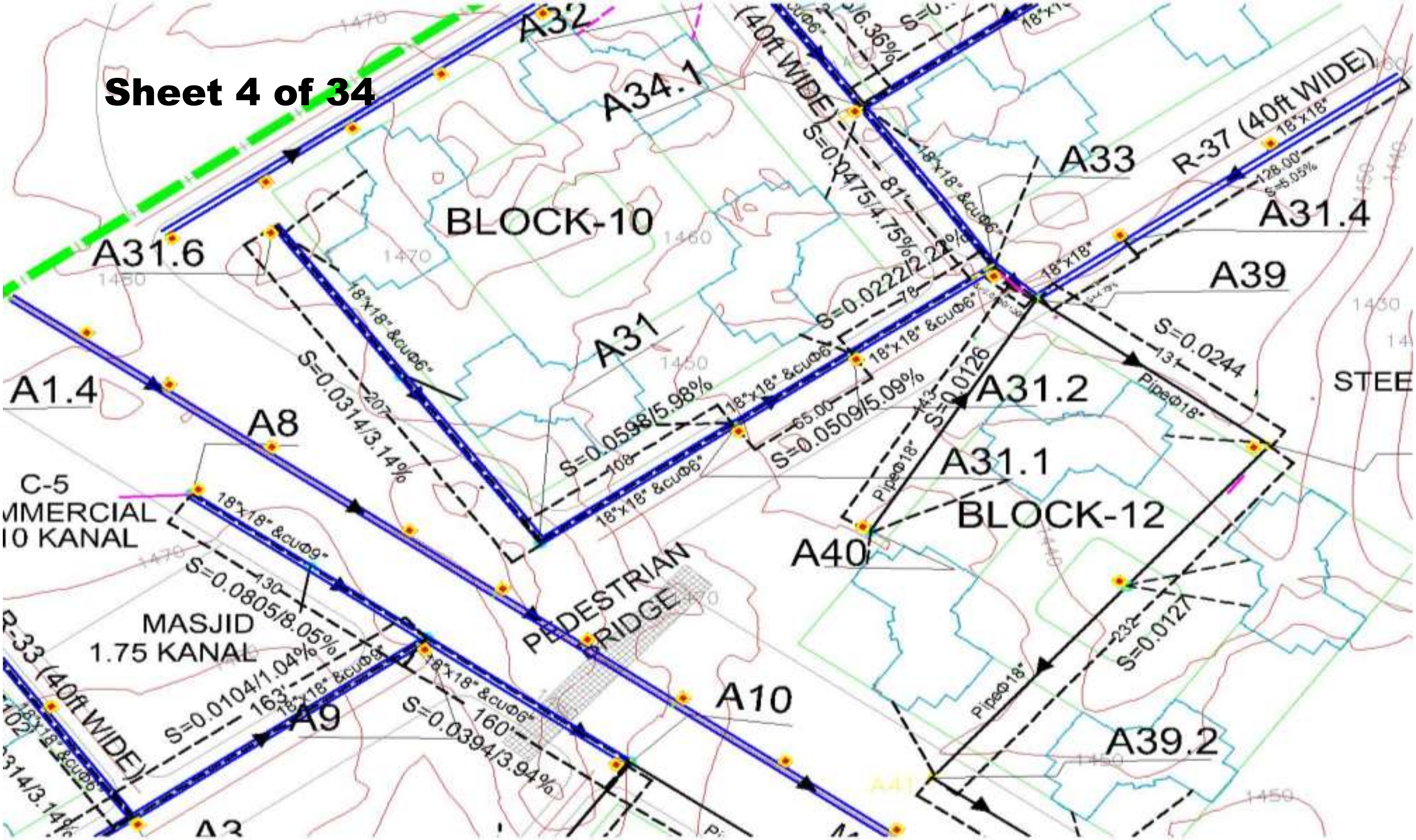


Fig H5: Combined drainage layout plan of Zone-1 at L/S of MR-01

Annexure H

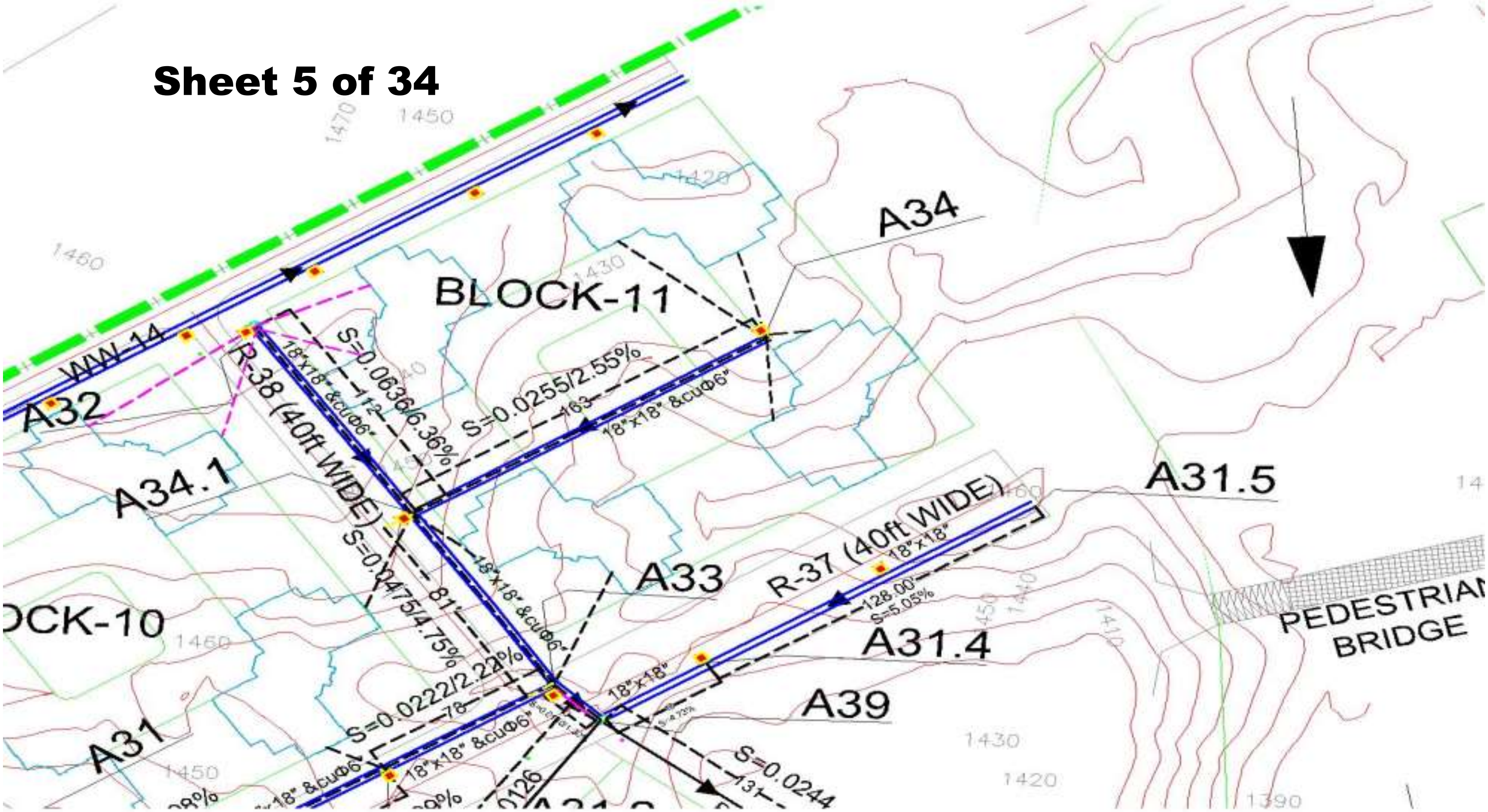


Fig H6: Combined drainage layout plan of Zone-1 at L/S of MR-01

Annexure H

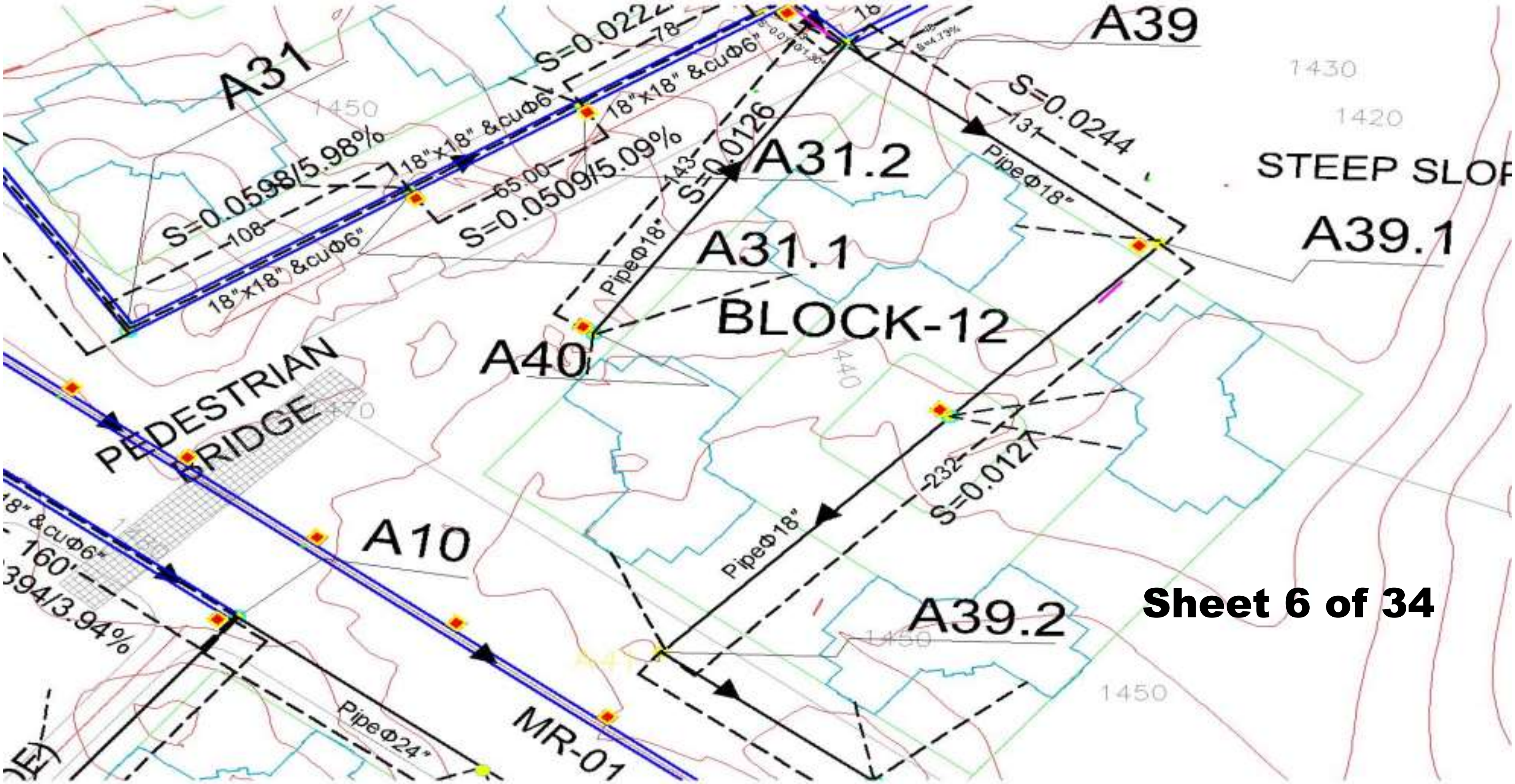


Fig H7: Combined drainage layout plan of Zone-1 at L/S of MR-01

Annexure H

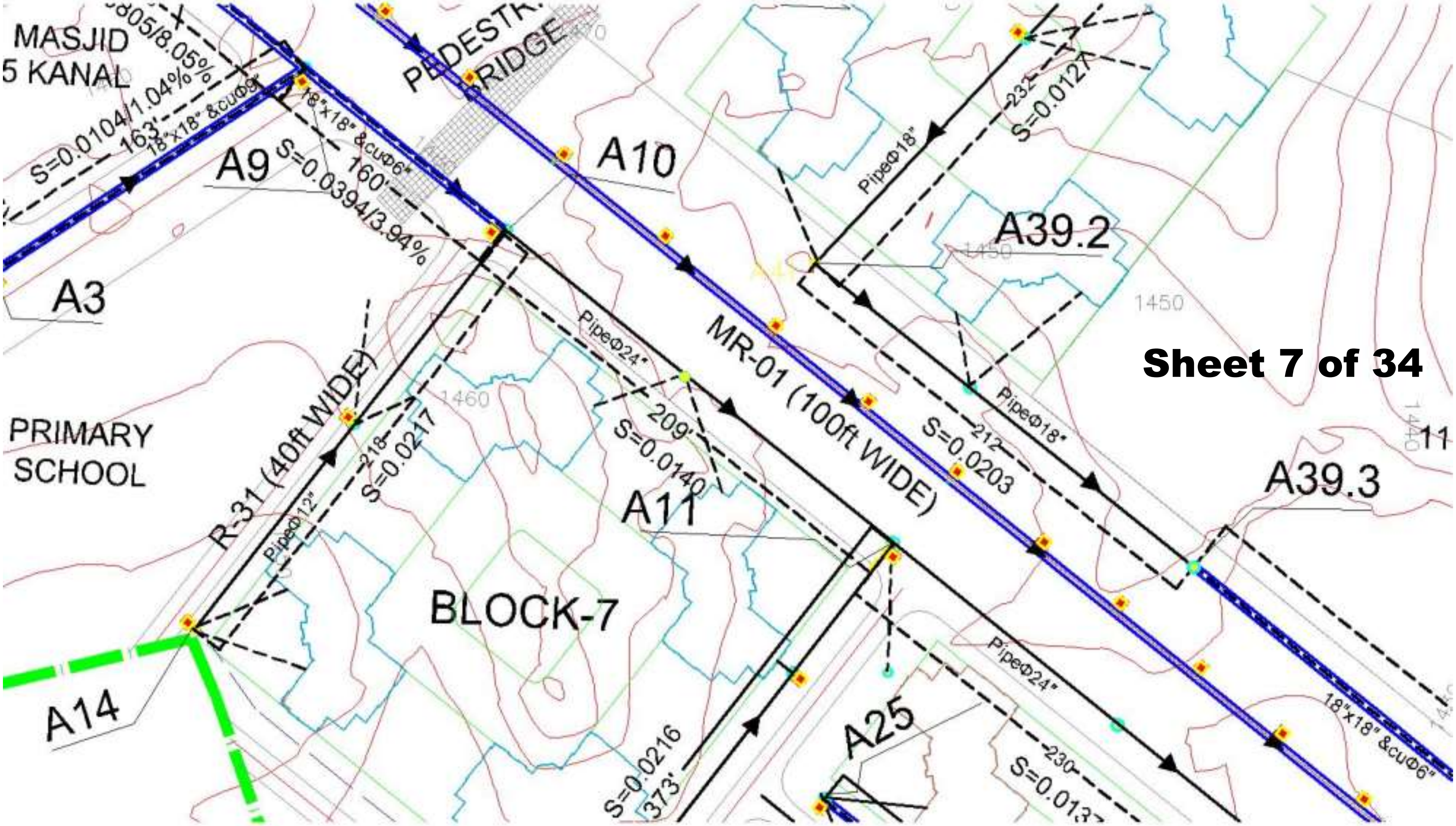


Fig H8: Combined drainage layout plan of Zone-1 at L/S & R/S of MR-01

Annexure H

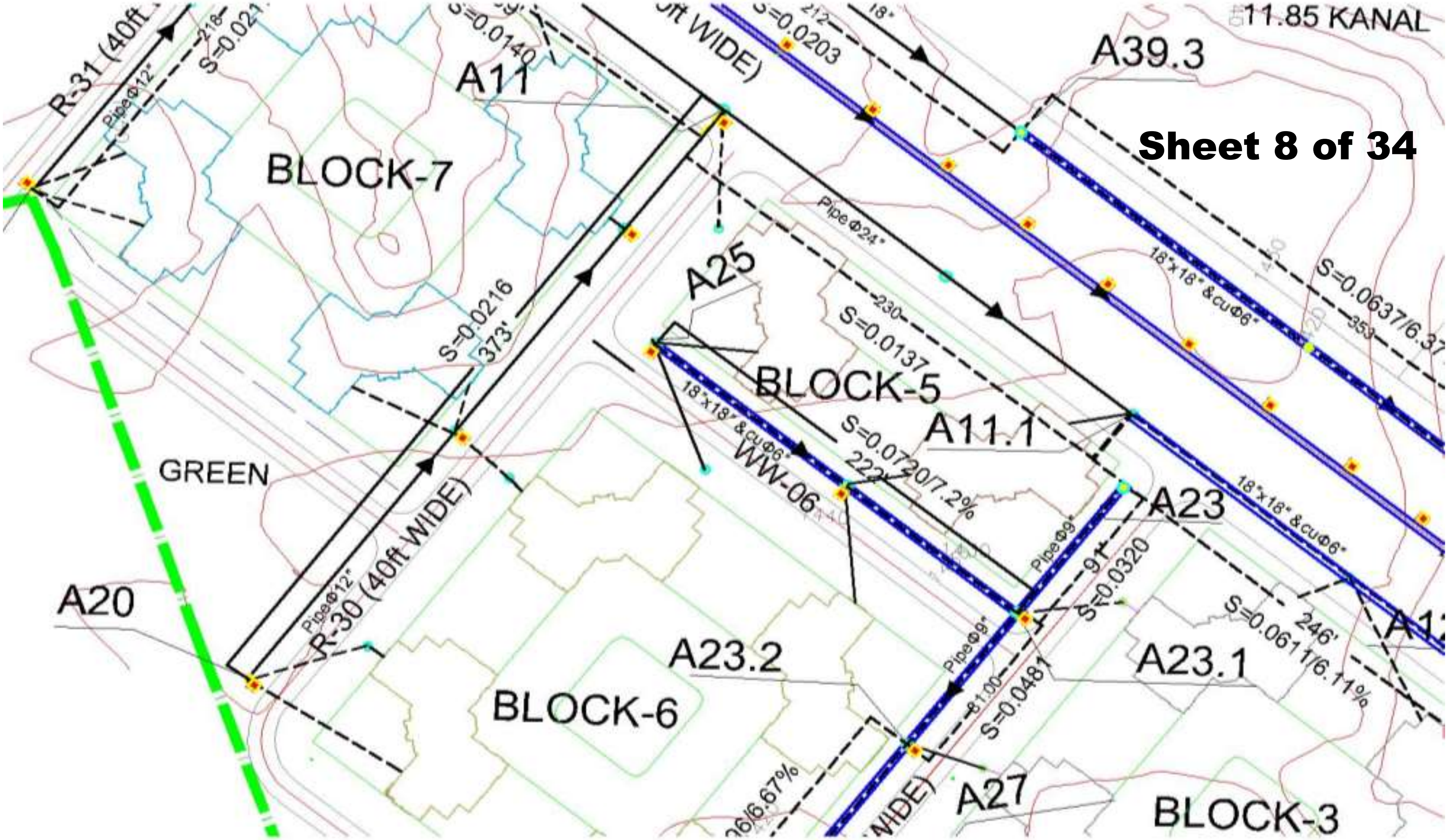


Fig H9: Combined drainage layout plan of Zone-1 at L/S & R/S of MR-01

Annexure H

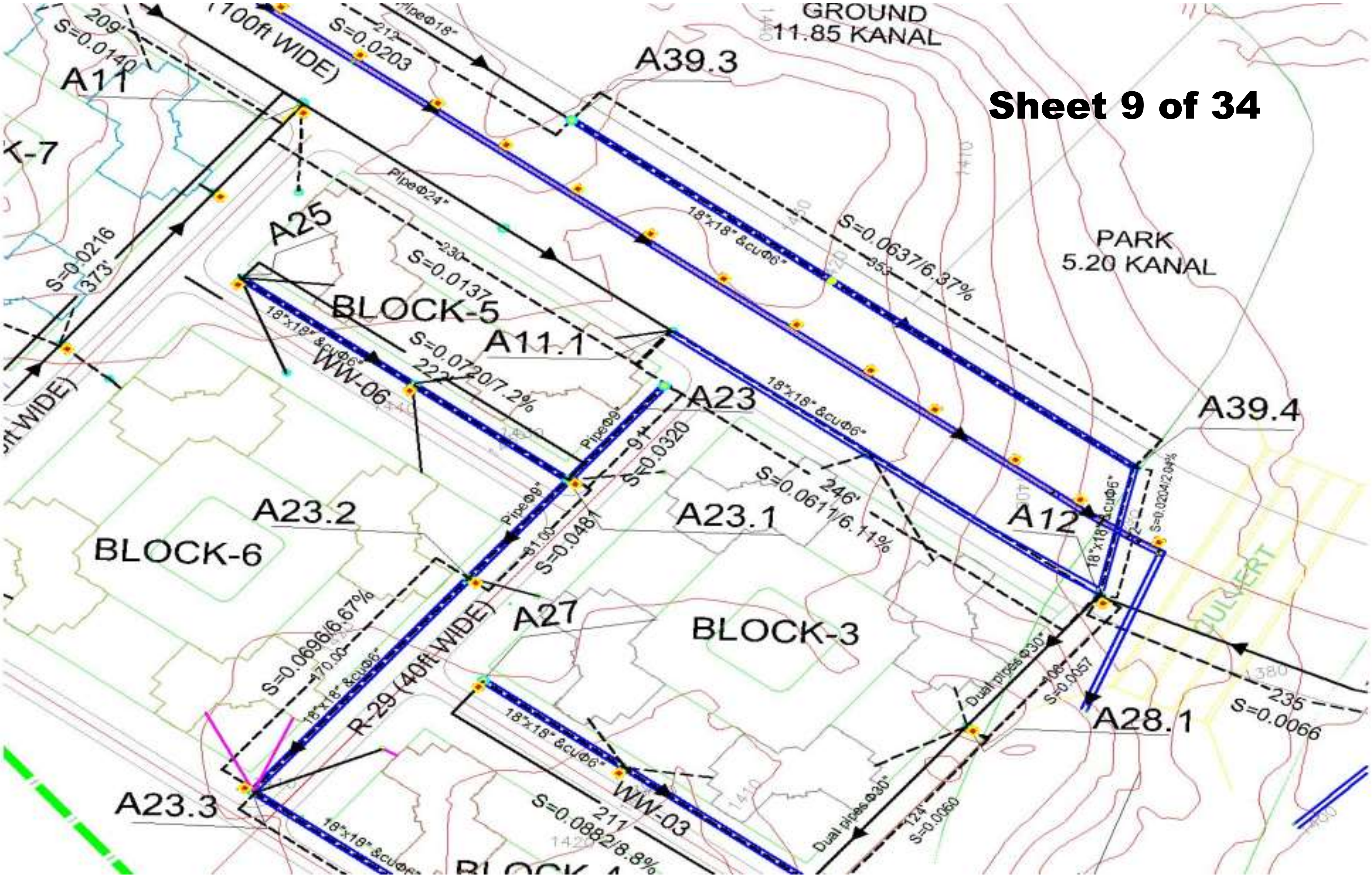


Fig H10: Combined drainage layout plan of Zone-1 at L/S & R/S of MR-01

Annexure H

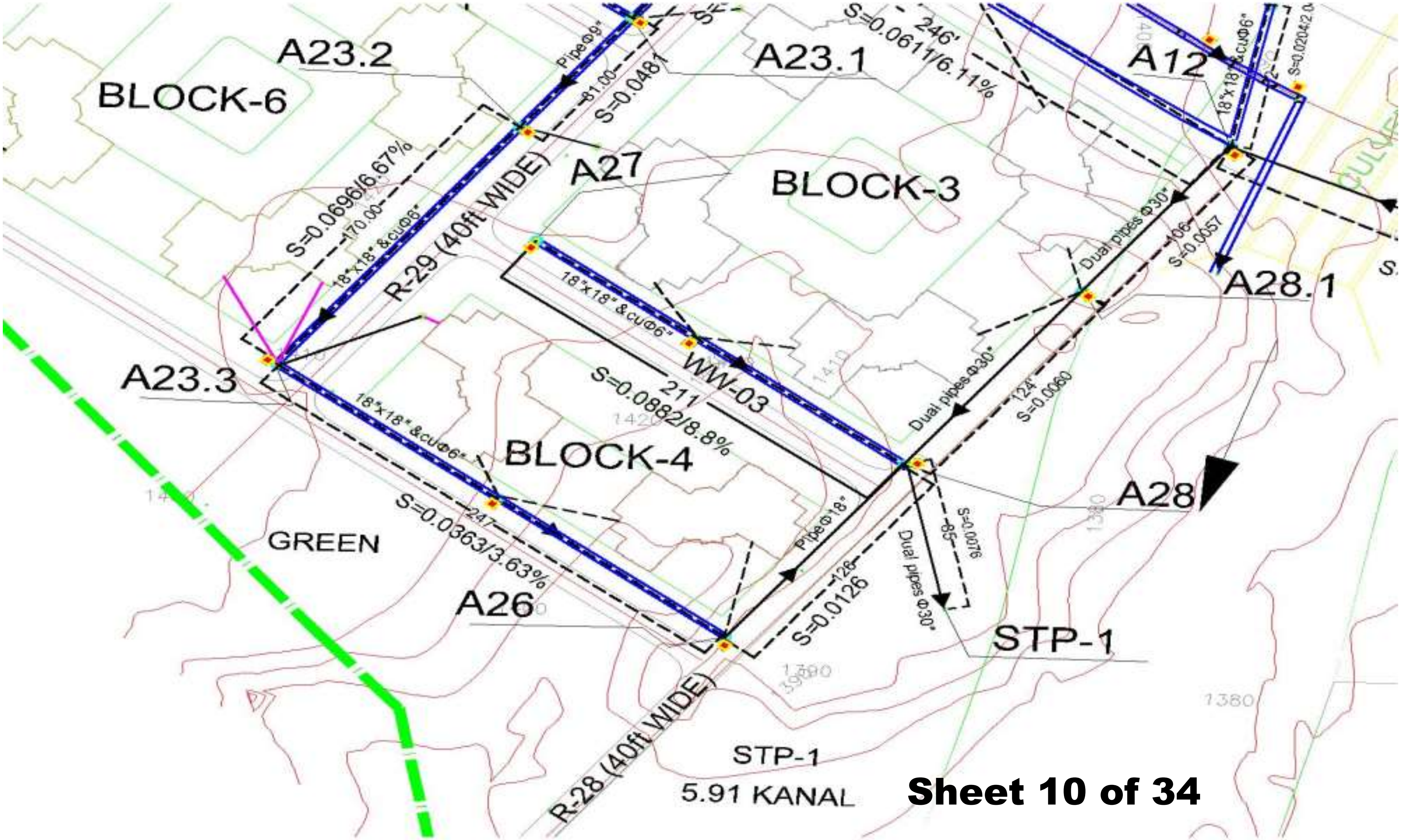


Fig H11: Combined drainage layout plan of Zone-1 showing node A12 which is comfluence point of Z-1, Z-3 and STP-1

Annexure H

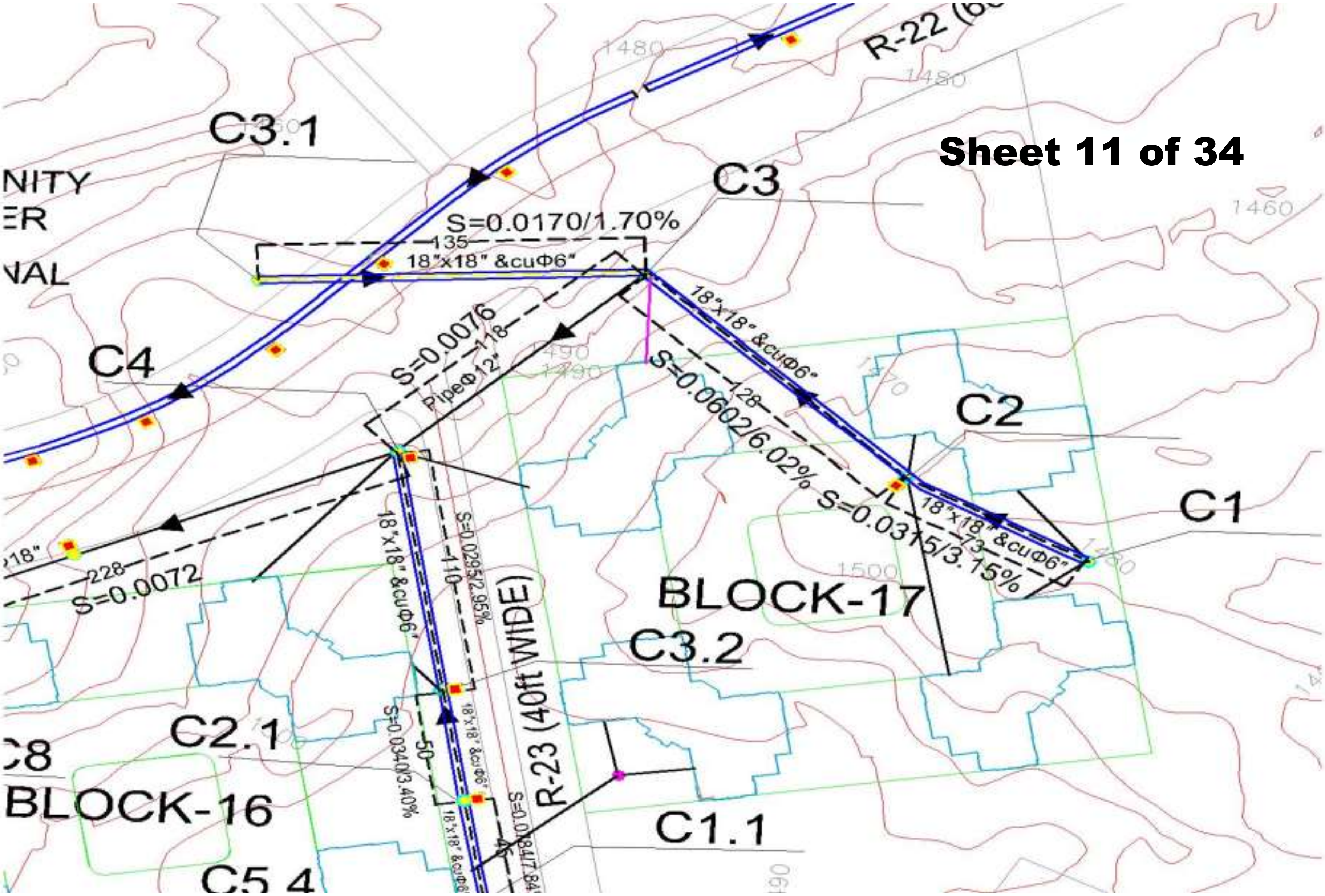


Fig H12: Combined drainage layout plan of Zone-3 showing intial node C1, C3.1 & separated storm drain along R-22

Annexure H

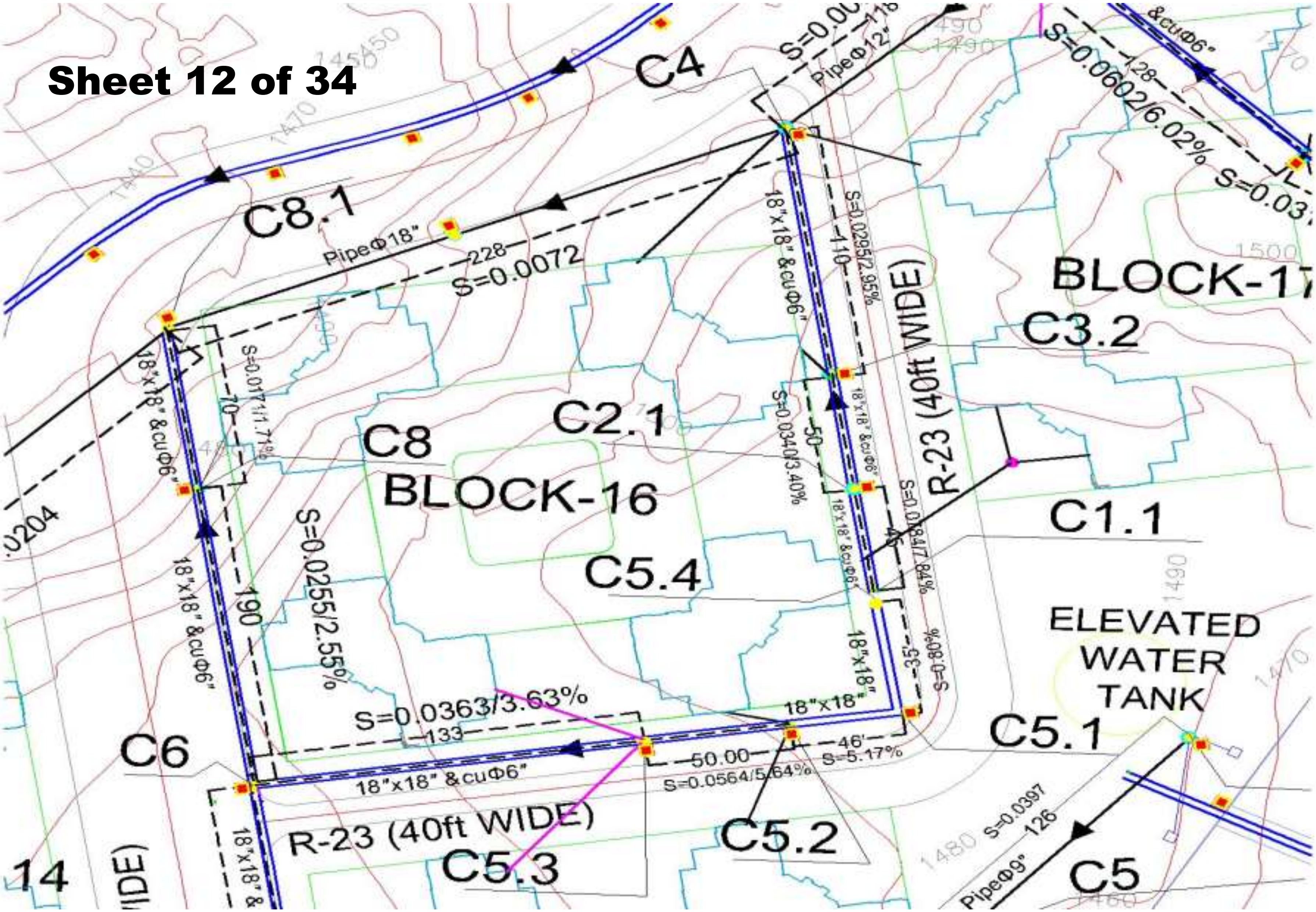


Fig H13: Combined drainage layout plan of Zone-3 along R-22 & R-23

Annexure H

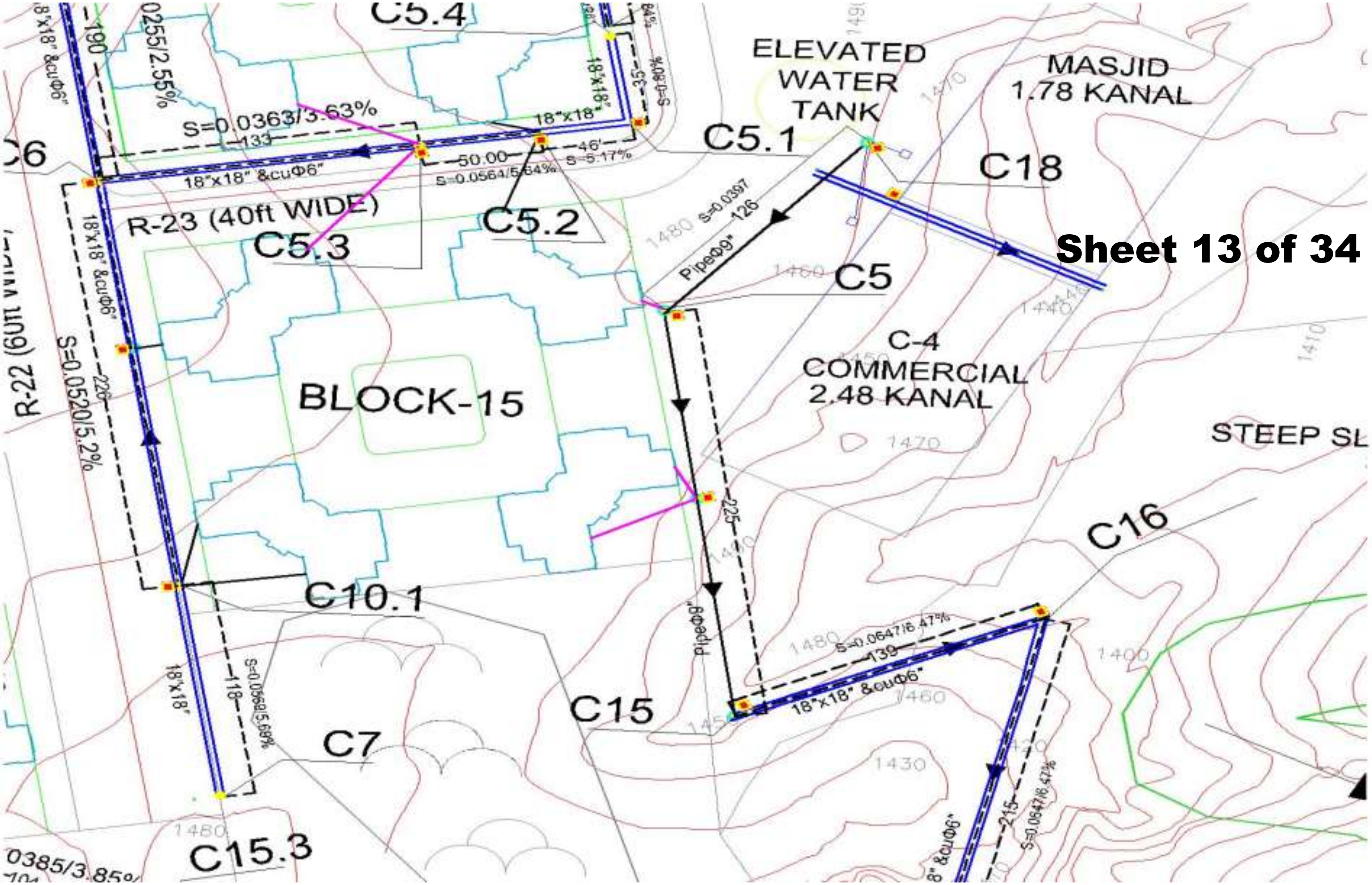


Fig H14: Combined drainage layout plan of Zone-3 near Block-15 & Green

Annexure H

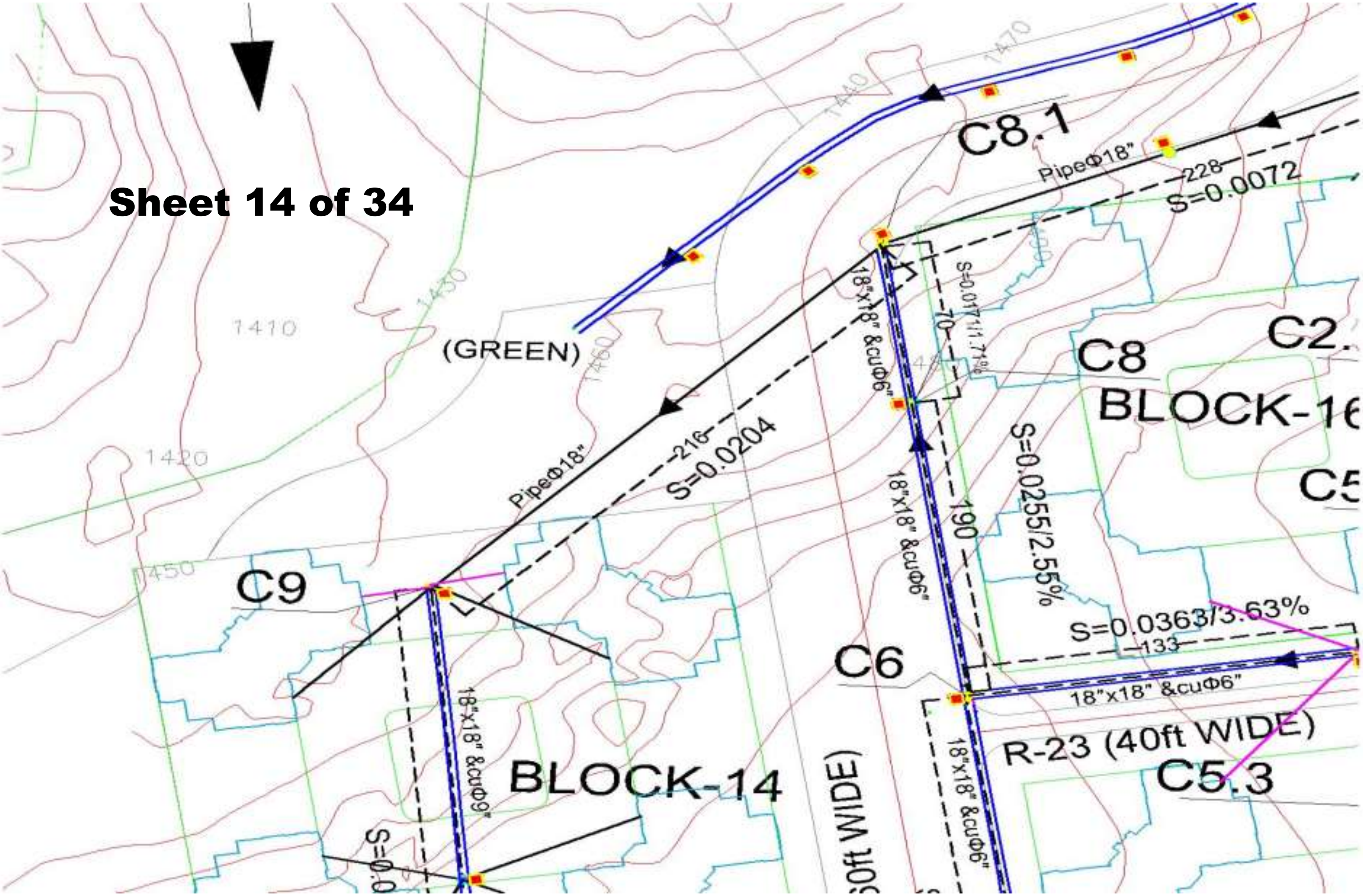


Fig H15: Combined drainage layout plan of Zone-3 near Block-16 & crossing R-22

Annexure H

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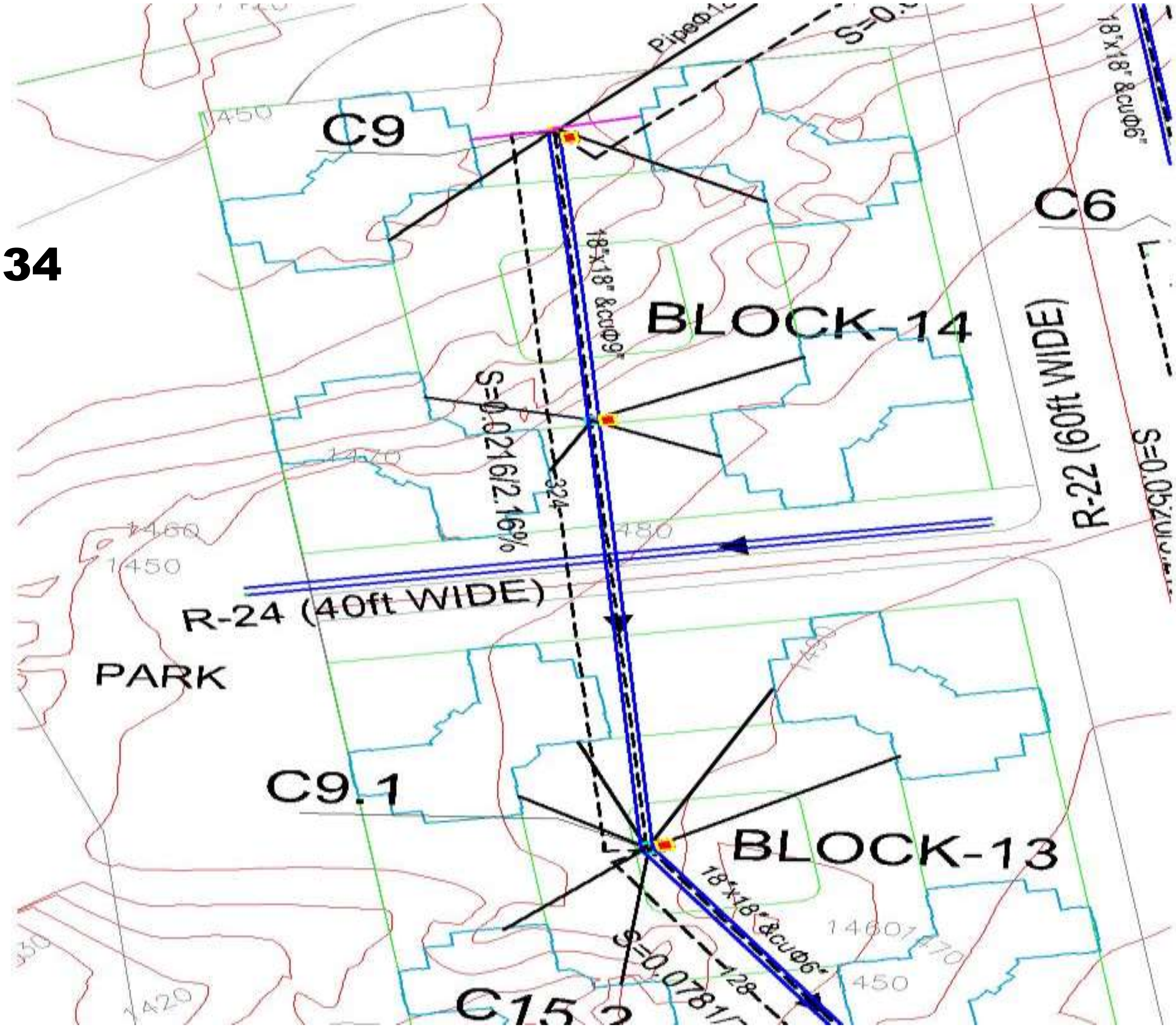


Fig H16: Combined drainage layout plan of Zone-3 through Block-13 & 14

Annexure H

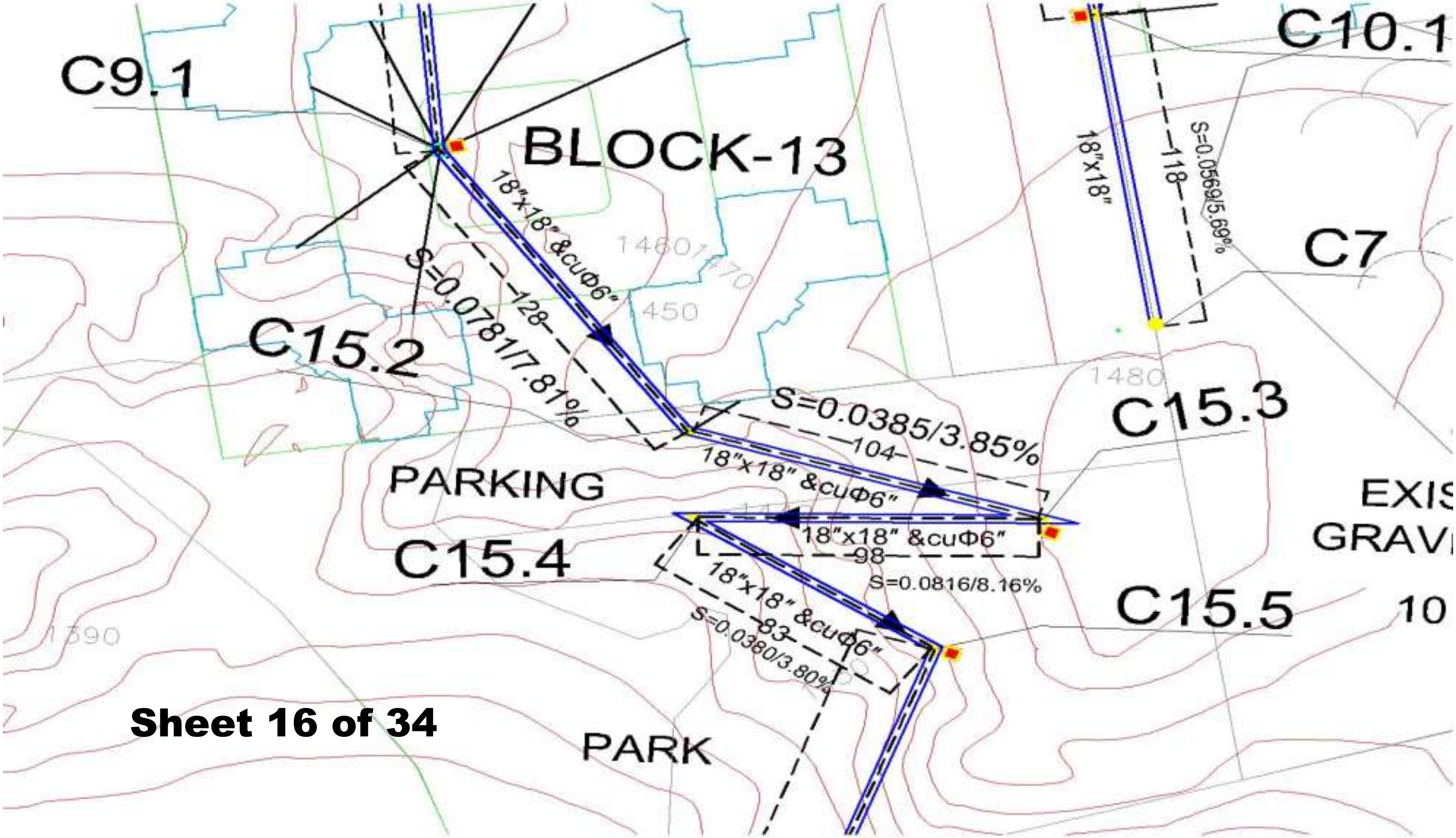
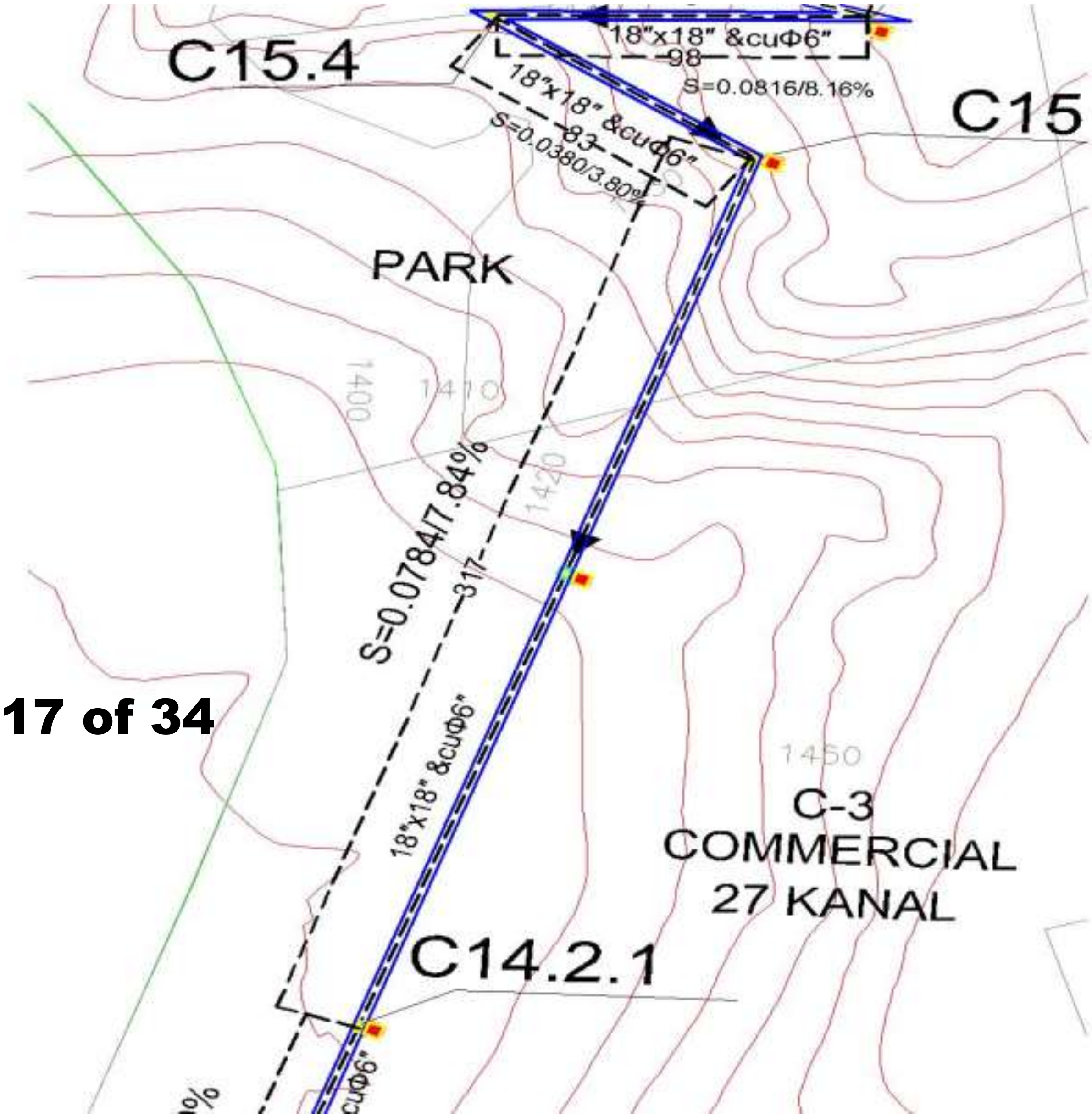


Fig H17: Combined drainage layout plan of Zone-3 exit from Block-13 & 14

Annexure H



Sheet 17 of 34

Fig H18: Combined drainage layout plan of Zone-3 from back side of commercial & M.I Room

Annexure H

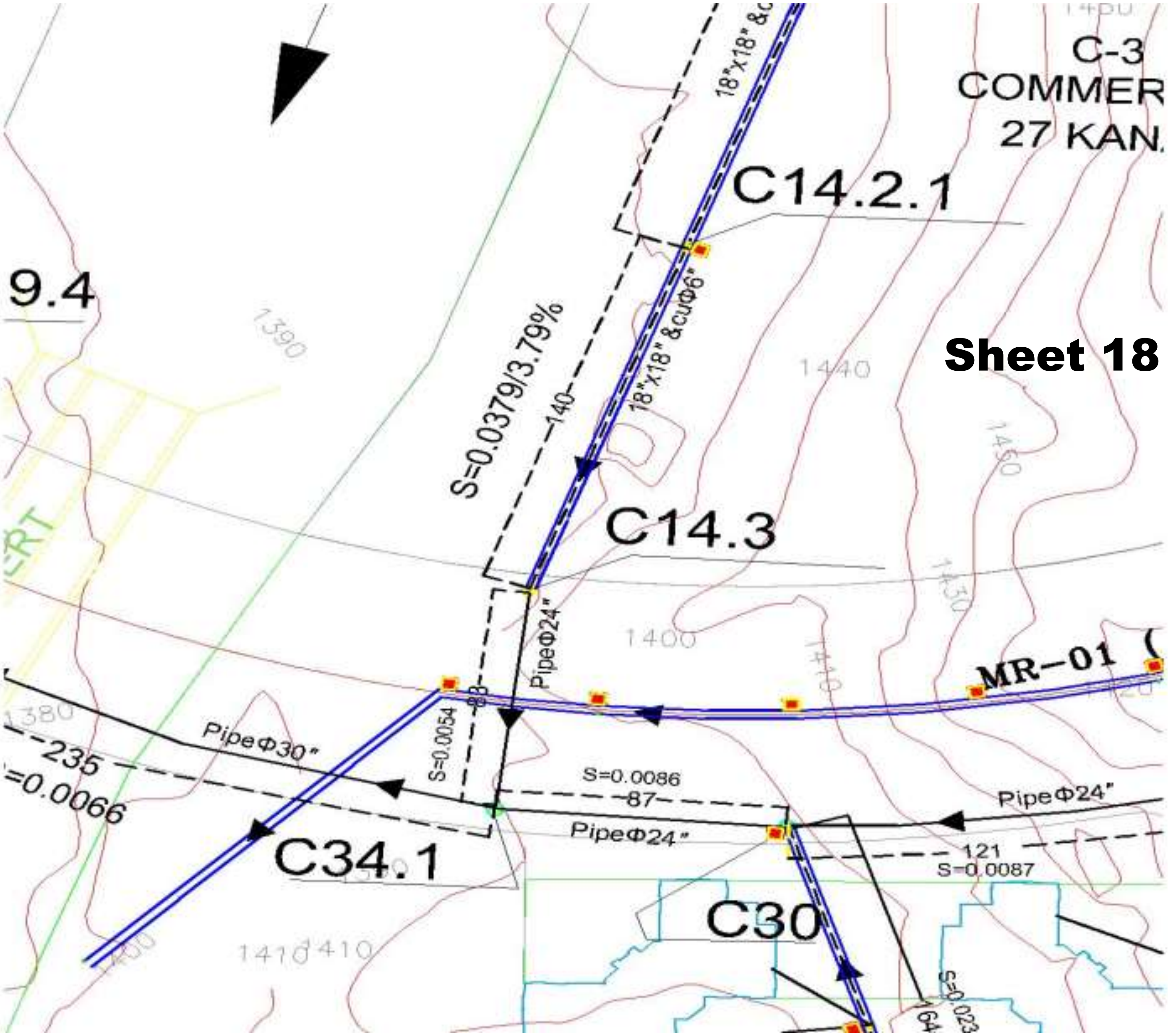


Fig H19: Combined drainage layout plan of Zone-3 entrance at MR-01

Annexure H

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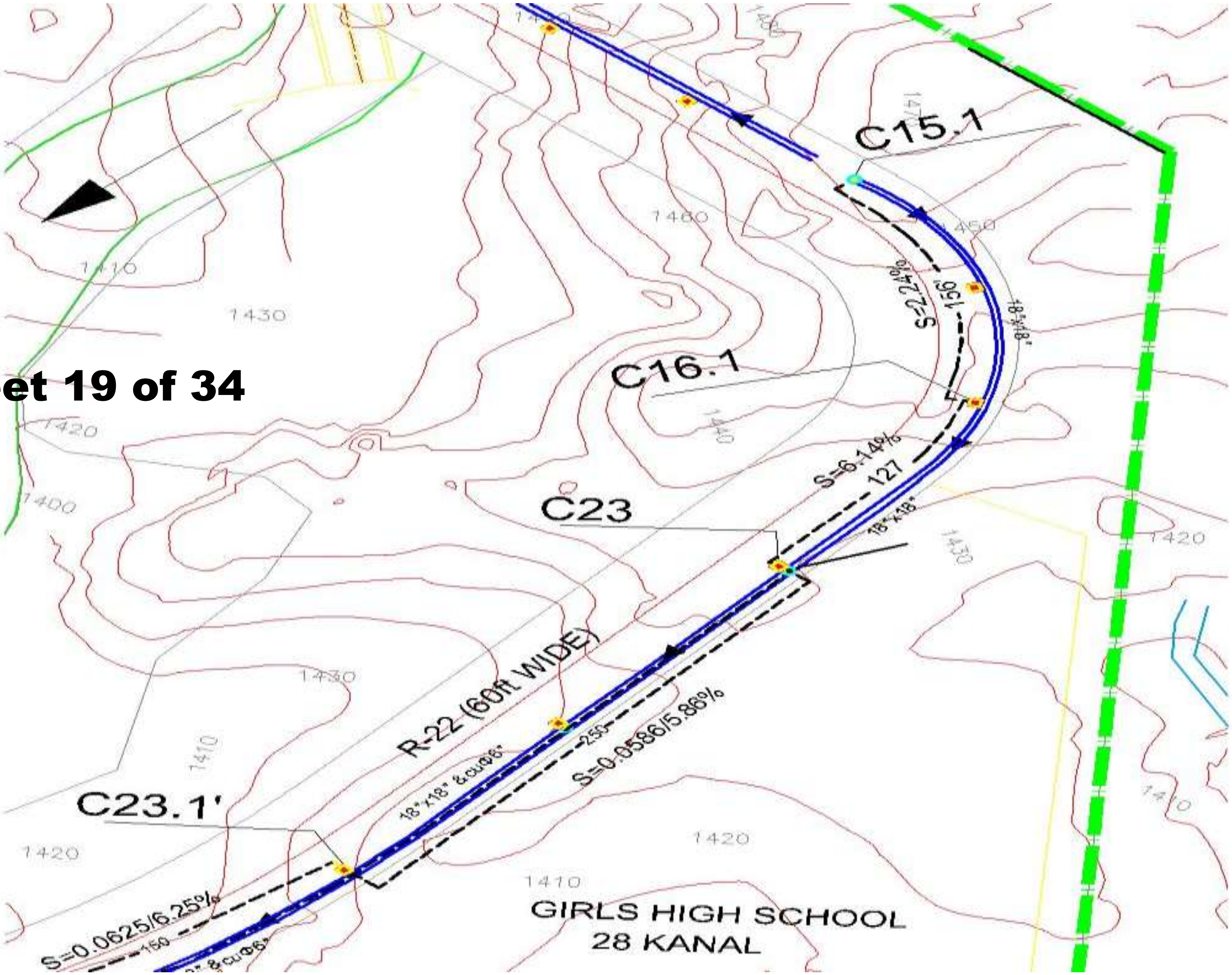

Fig H20: Combined drainage layout plan of Zone-3 at R-22 near girls high school

Annexure H

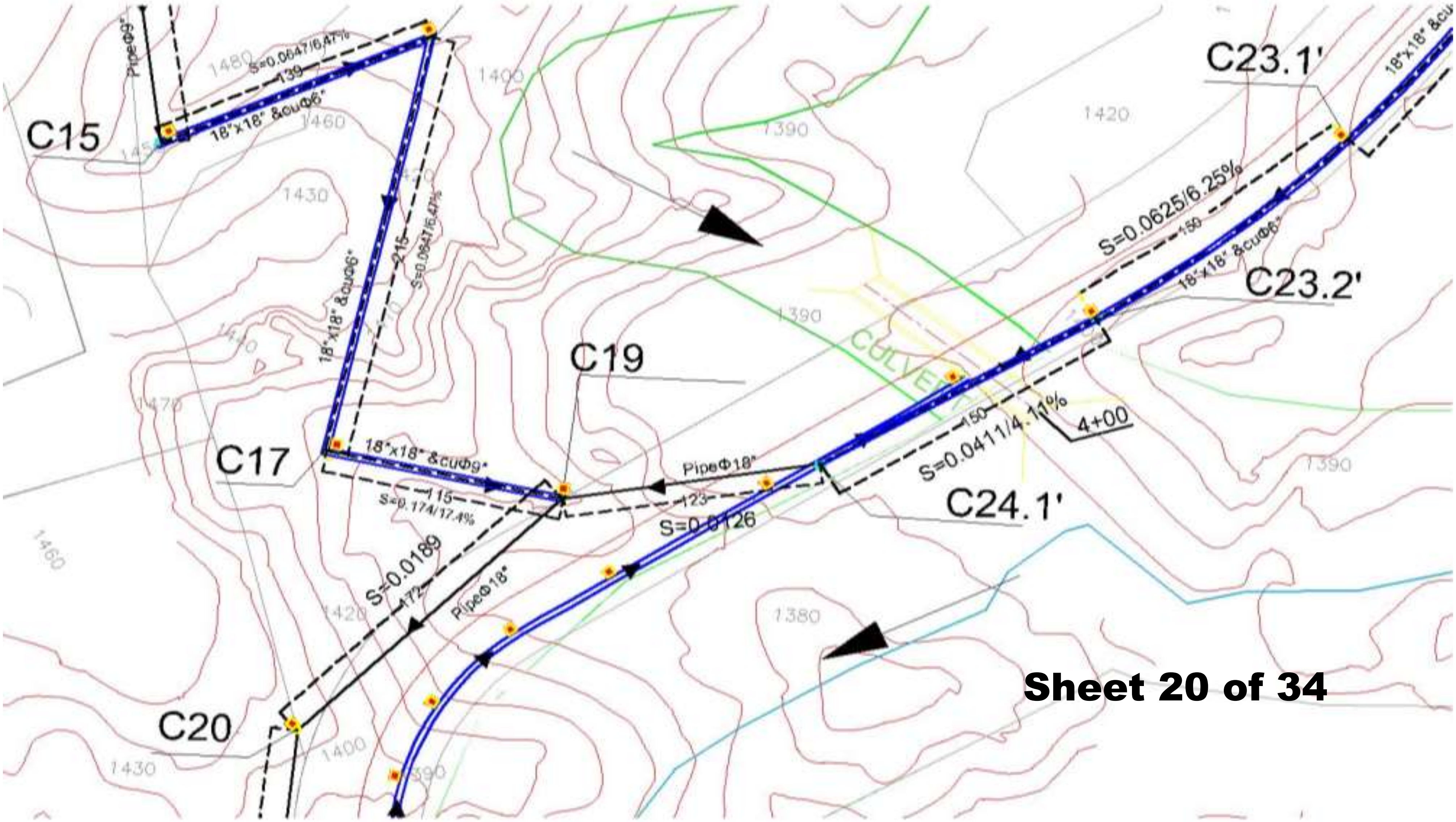

Fig H21: Combined drainage layout plan of Zone-3 showing node C19 junction of lines from R-22 and Block-15

Annexure H

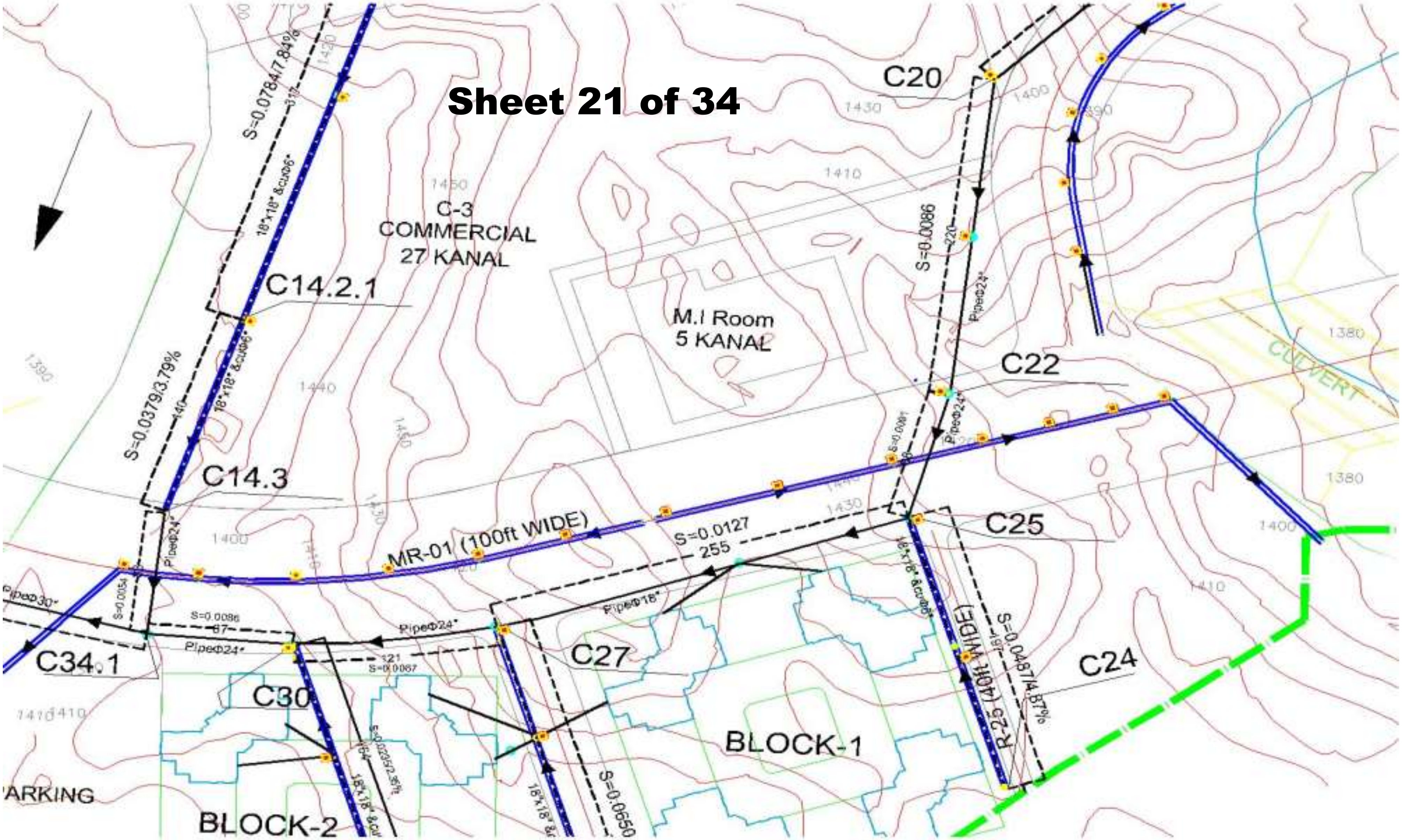

Fig H22: Combined drainage layout plan of Zone-3 showing node C34.1 & C25 intake from R-22 and Blocks-13,14,15,16

Annexure H

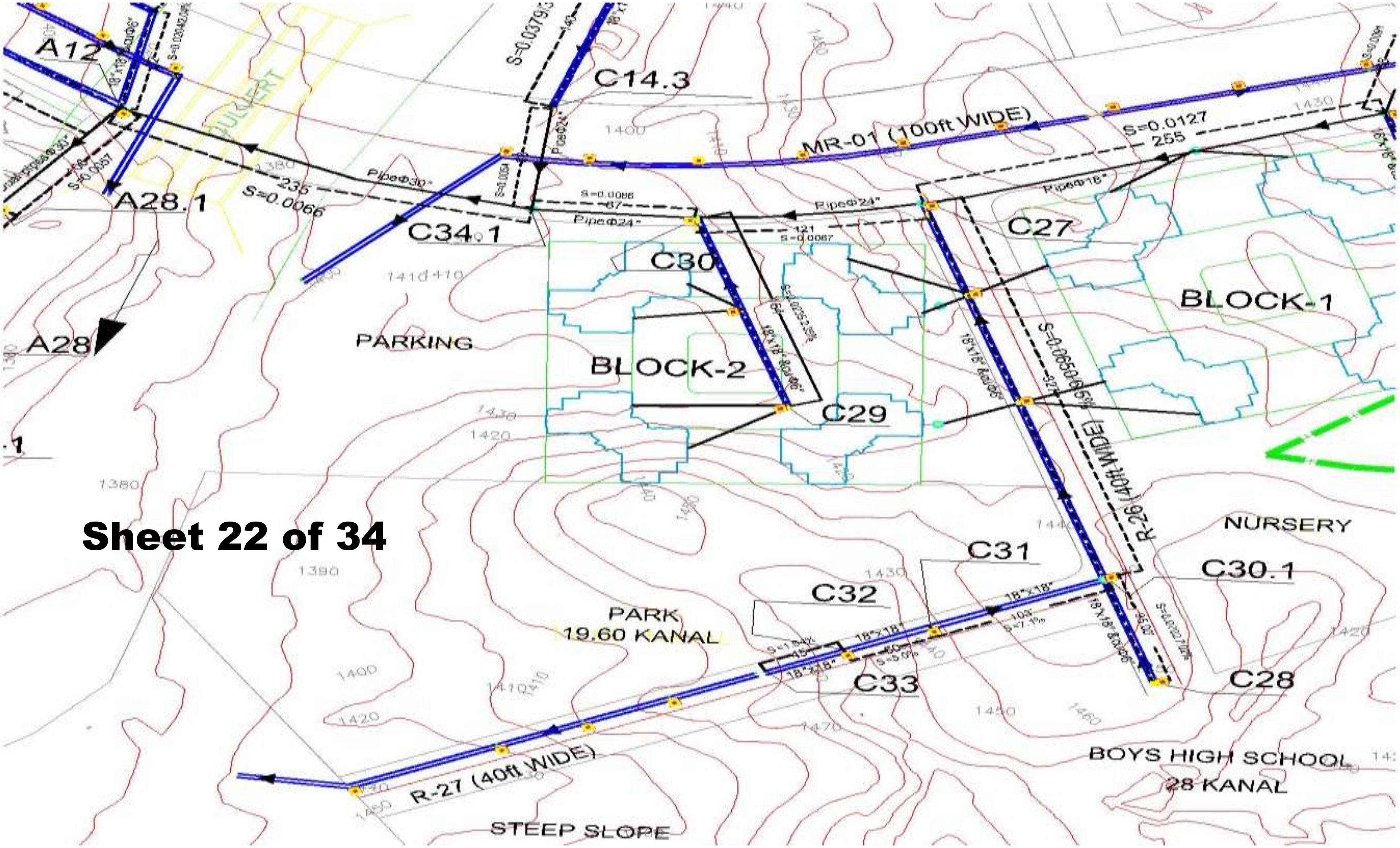

Fig H23: Layout plan showing node C34.1 transfering combined flows of Zone-3 into Zone-1 at node A12 for disposal at STP-1

Annexure H

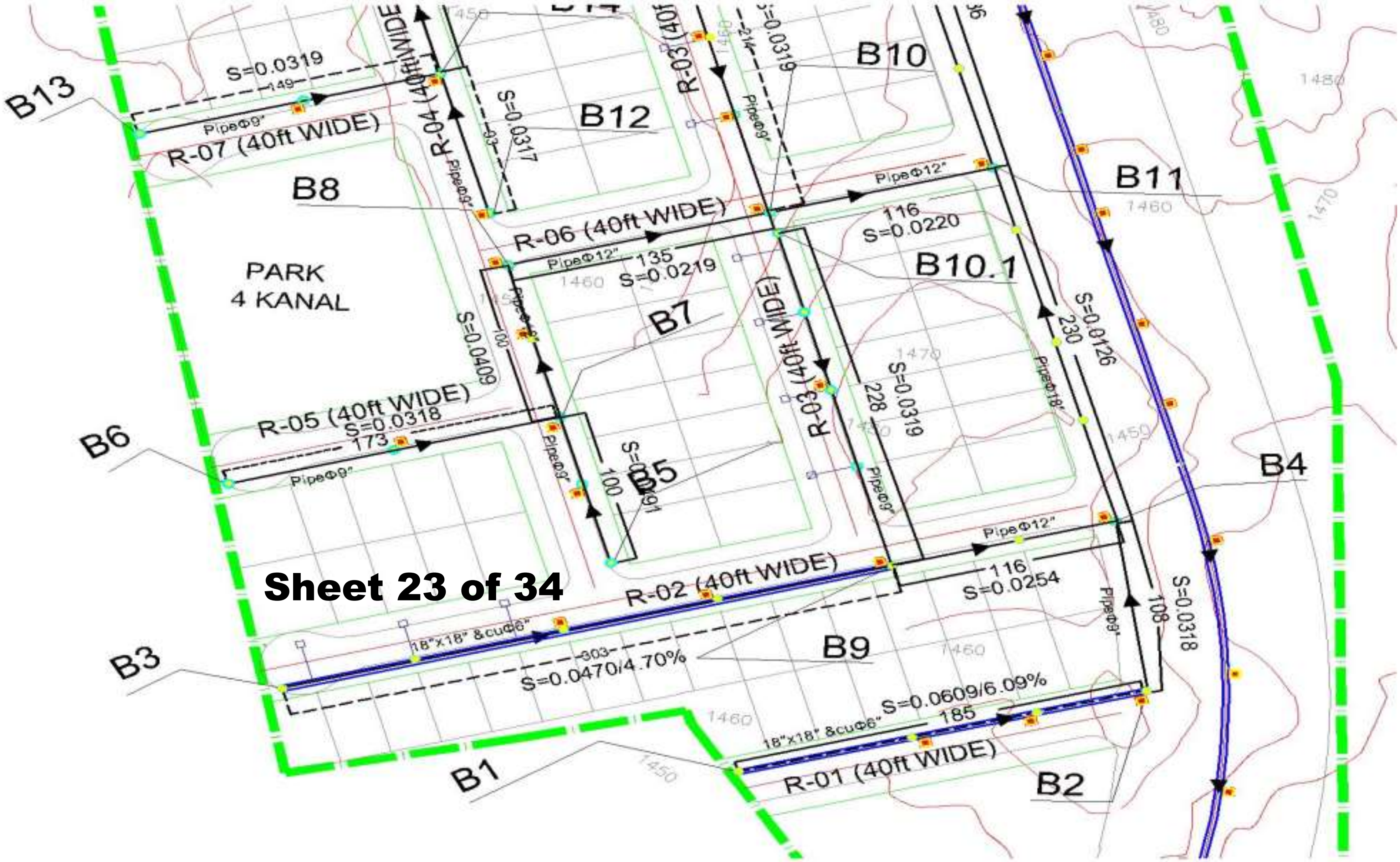

Fig H24: Layout plan of Zome-2 deside MR-02 showing initial node B1

Annexure H

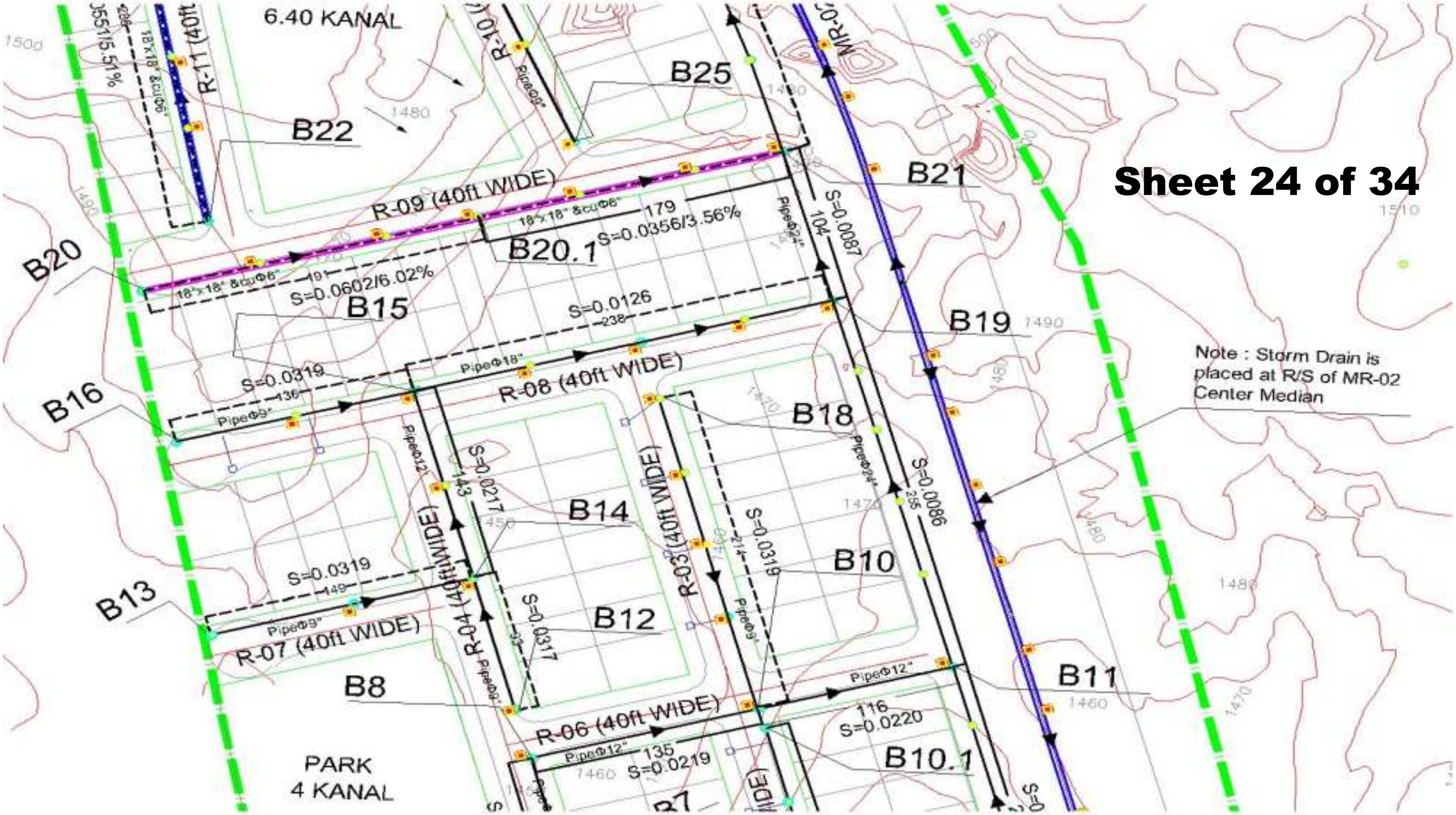

Fig H25: Layout plan of Zome-2 part two

Annexure H

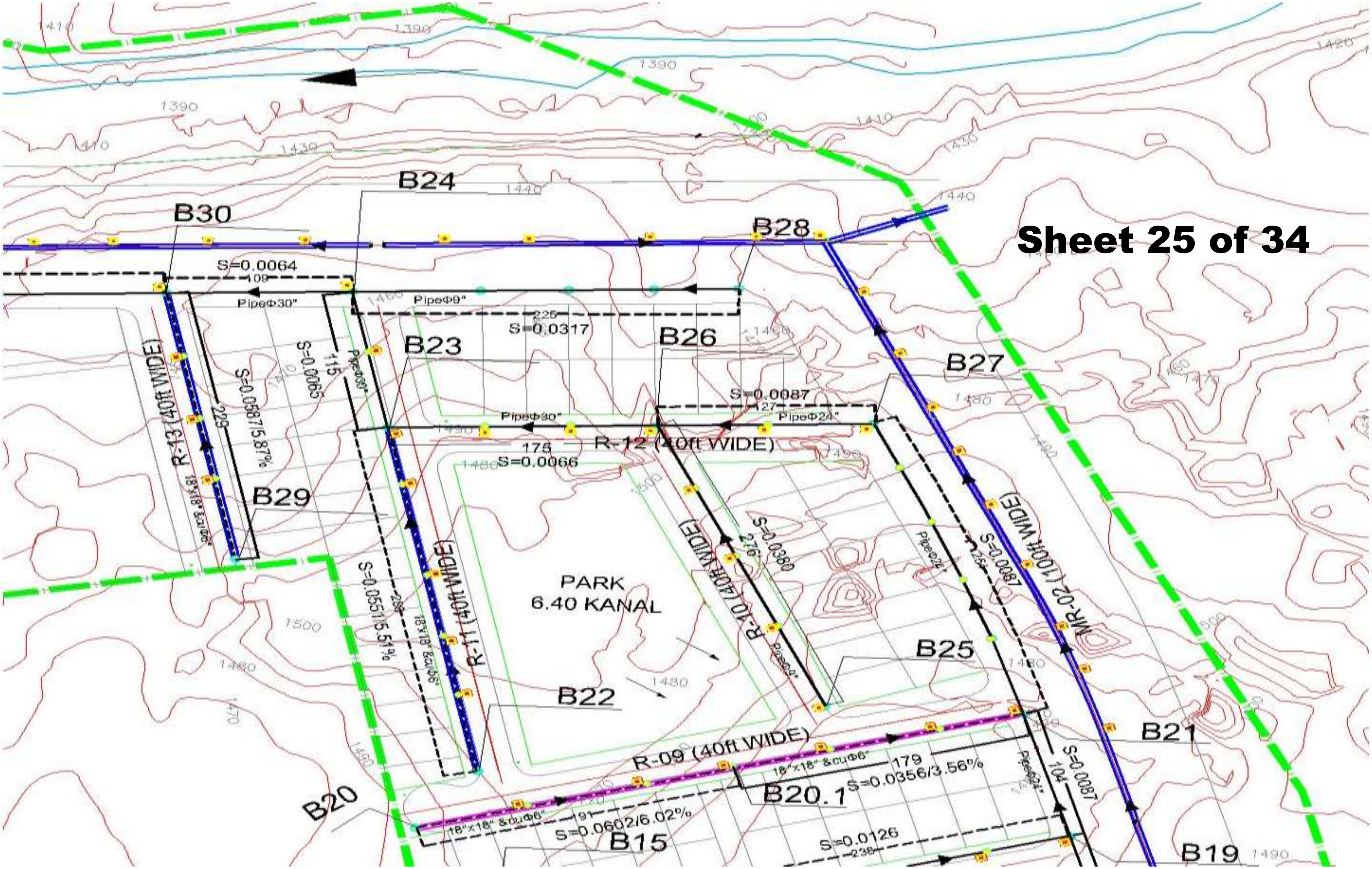

Fig H26: Layout plan of Zome-2 junction of MR-01& MR-02

Annexure H

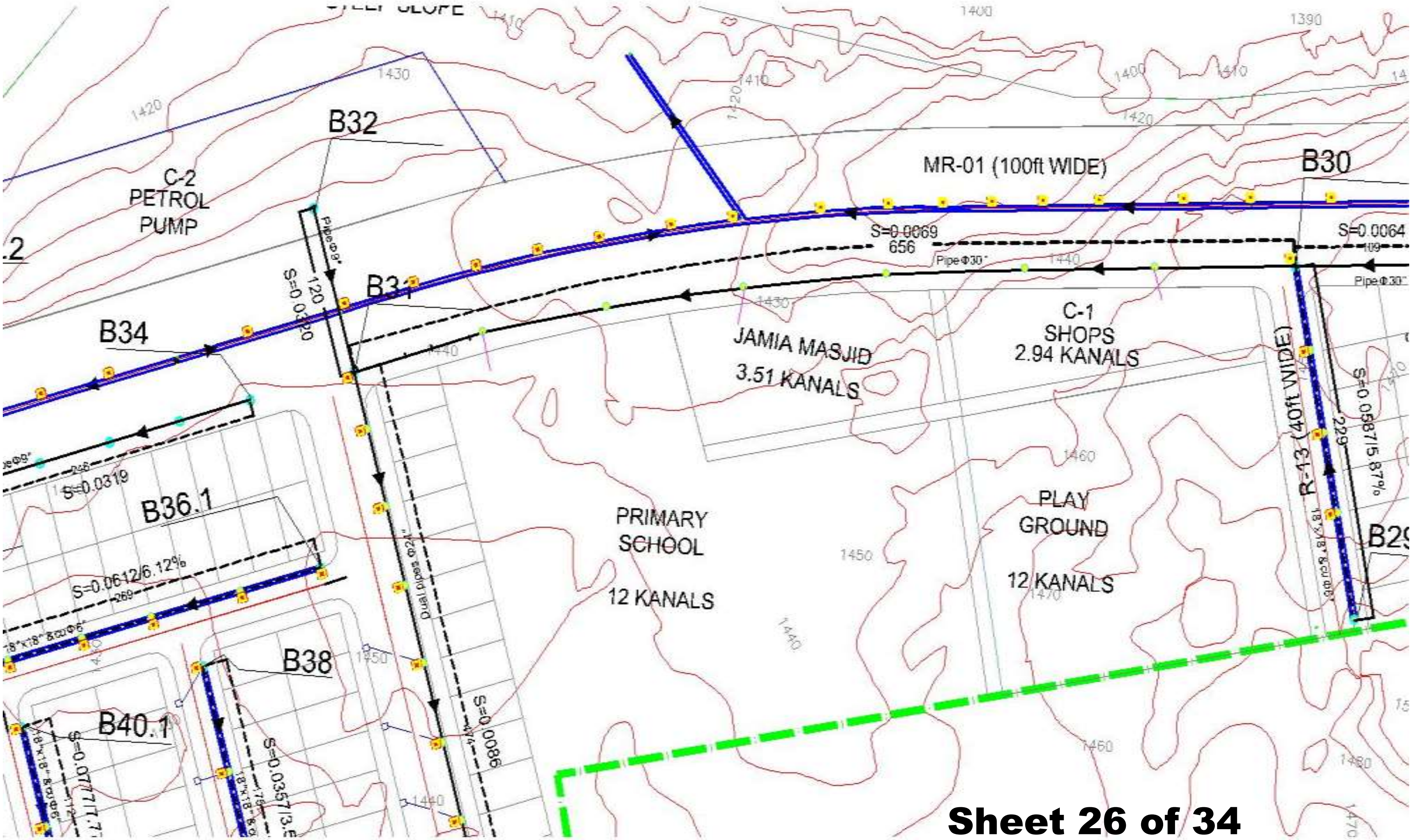

Fig H27: Layout plan of Zome-2 part four

Annexure H

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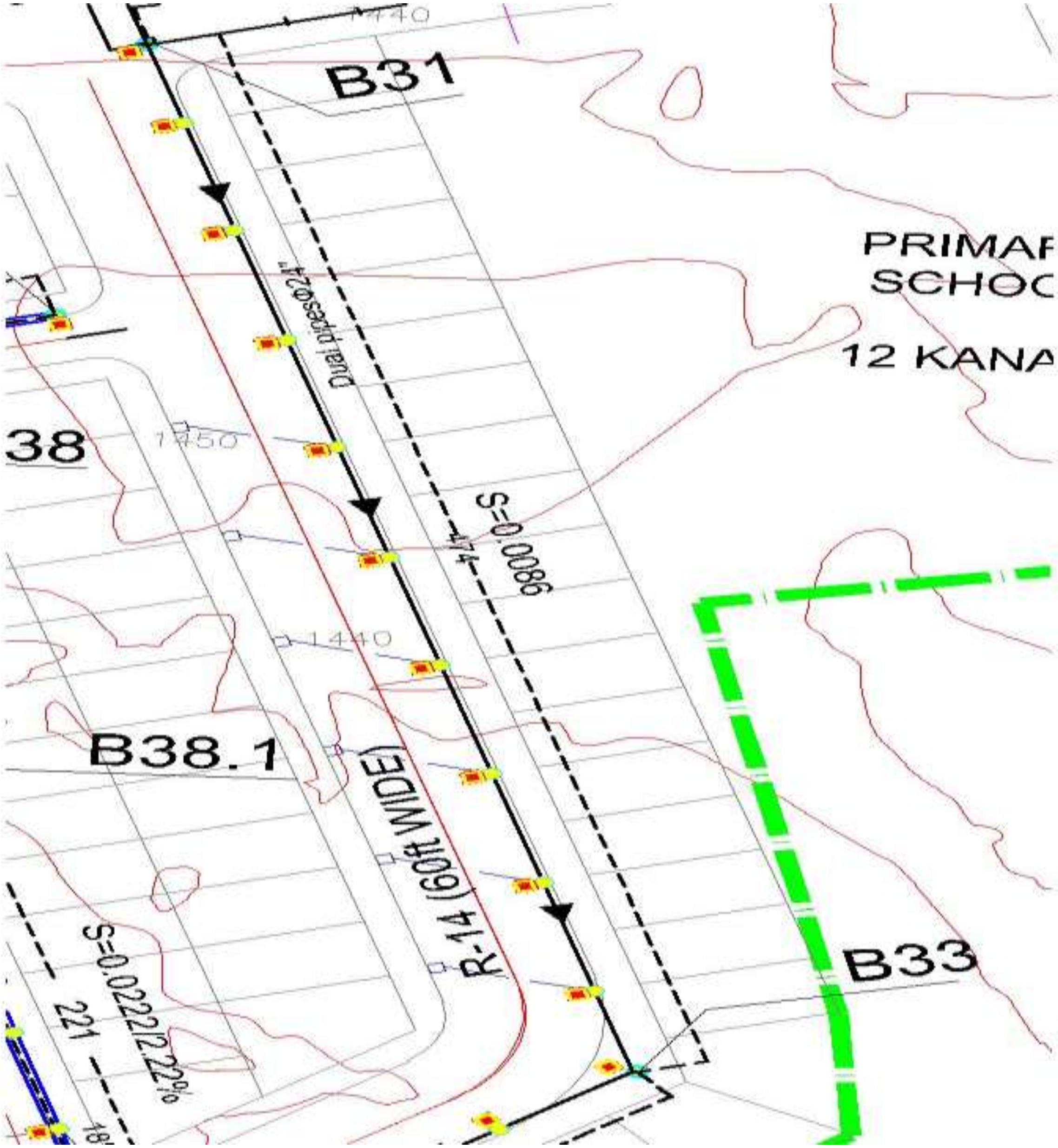
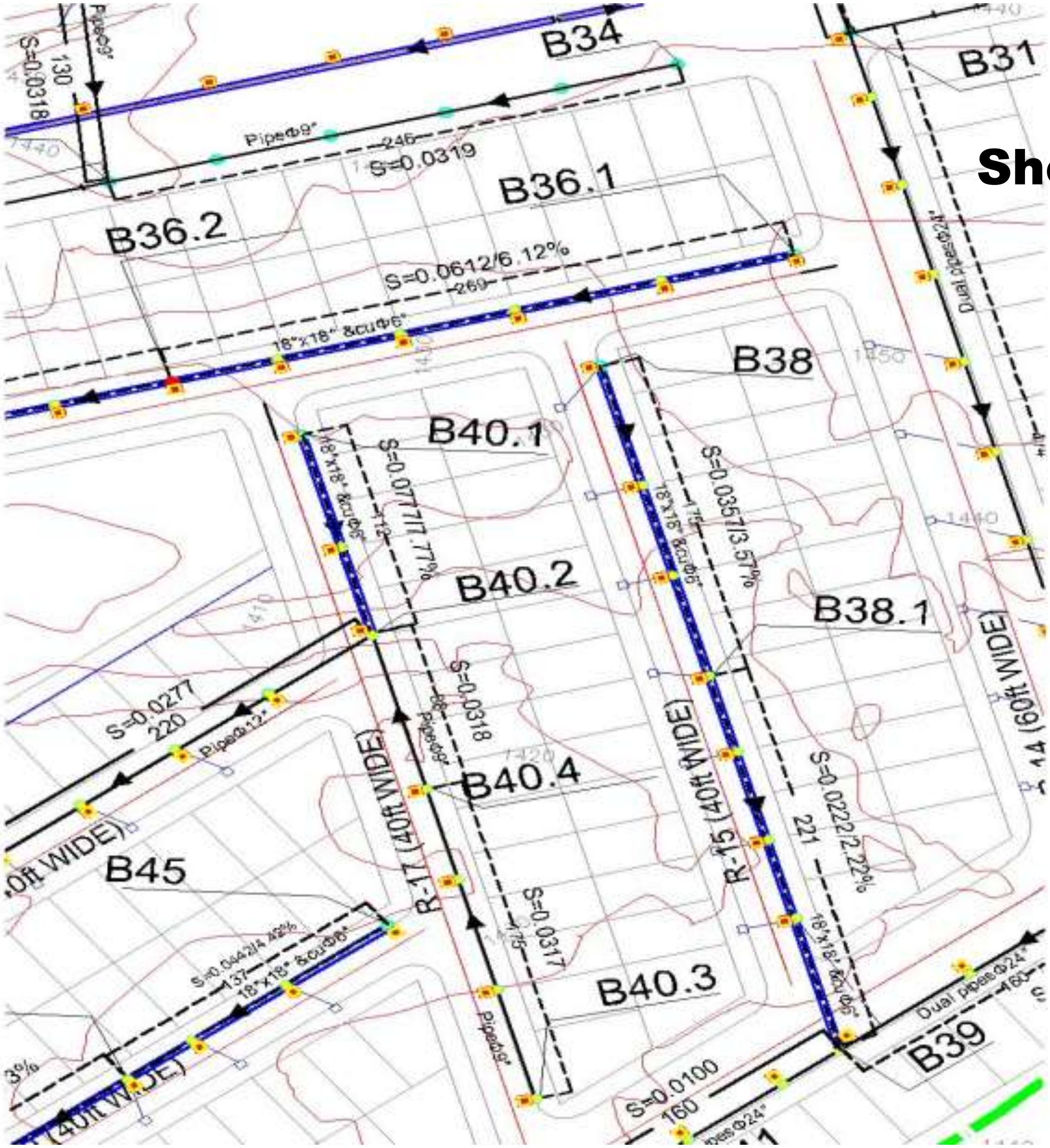


Fig H28: Layout plan of Zome-2 part five

Annexure H



Sheet 28 of 34

Fig H29: Layout plan of Zome-2 part six

Annexure H

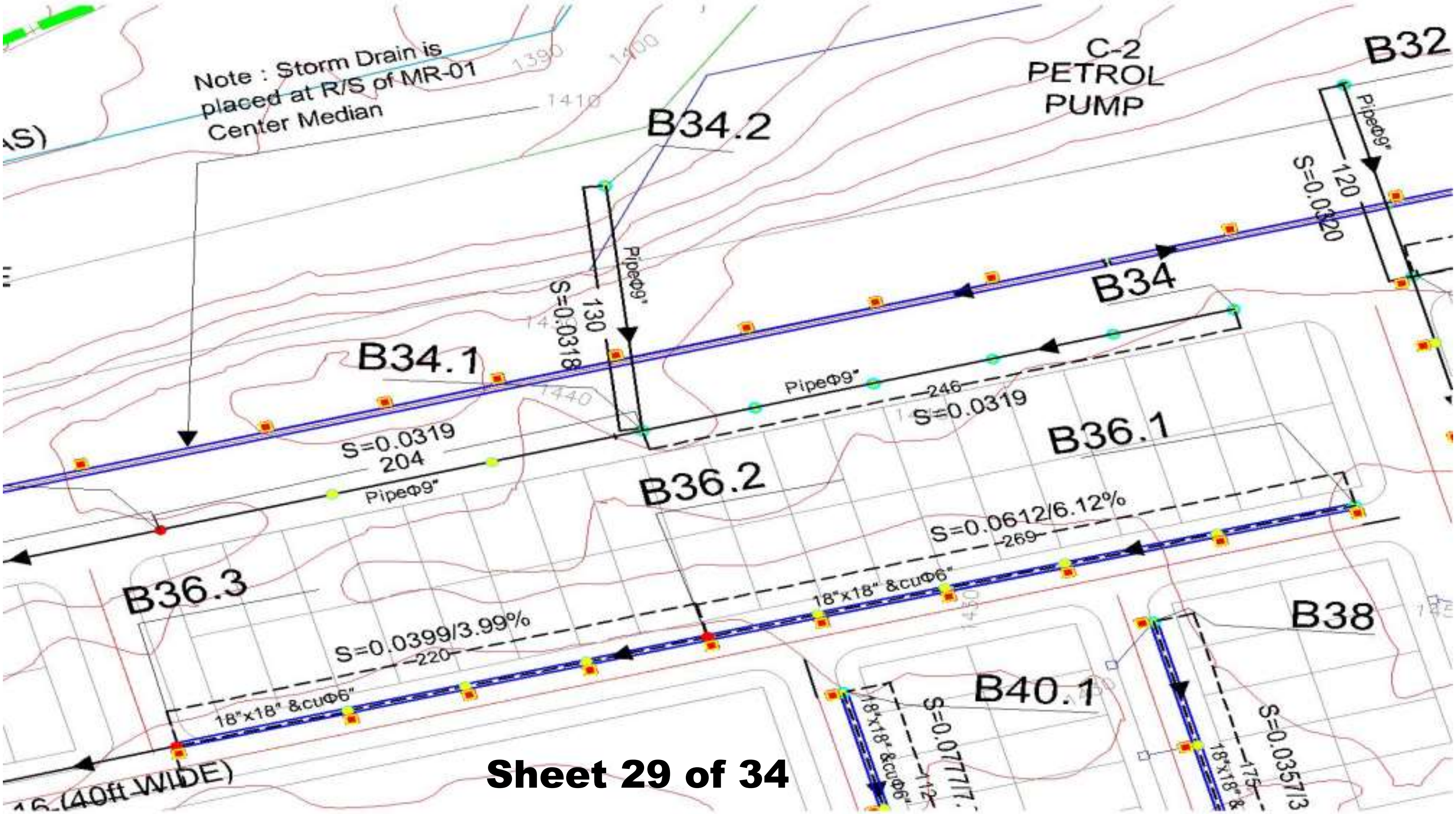


Fig H30: Layout plan of Zome-2 part seven

Annexure H

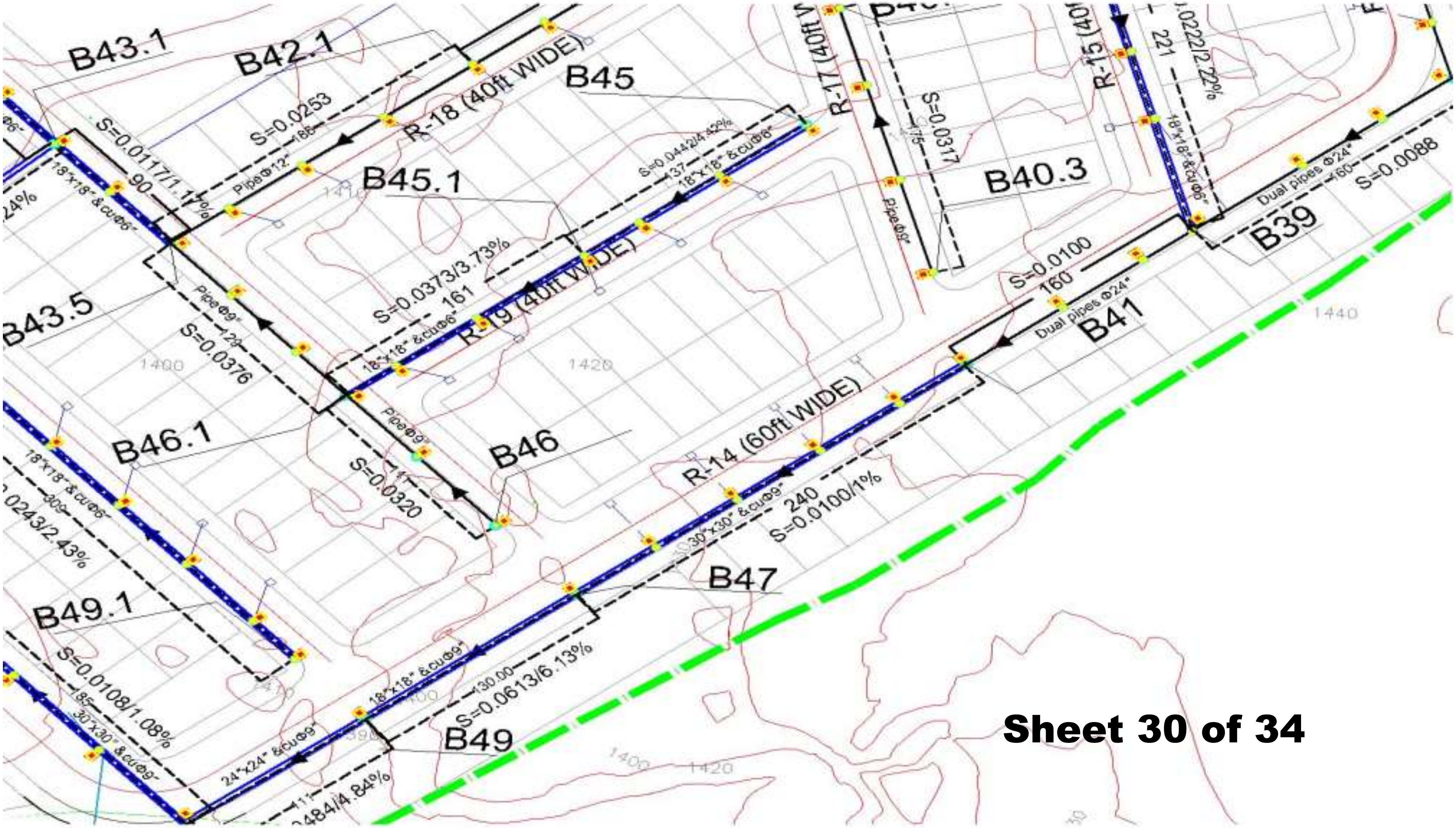


Fig H31: Layout plan of Zome-2 part eight

Annexure H

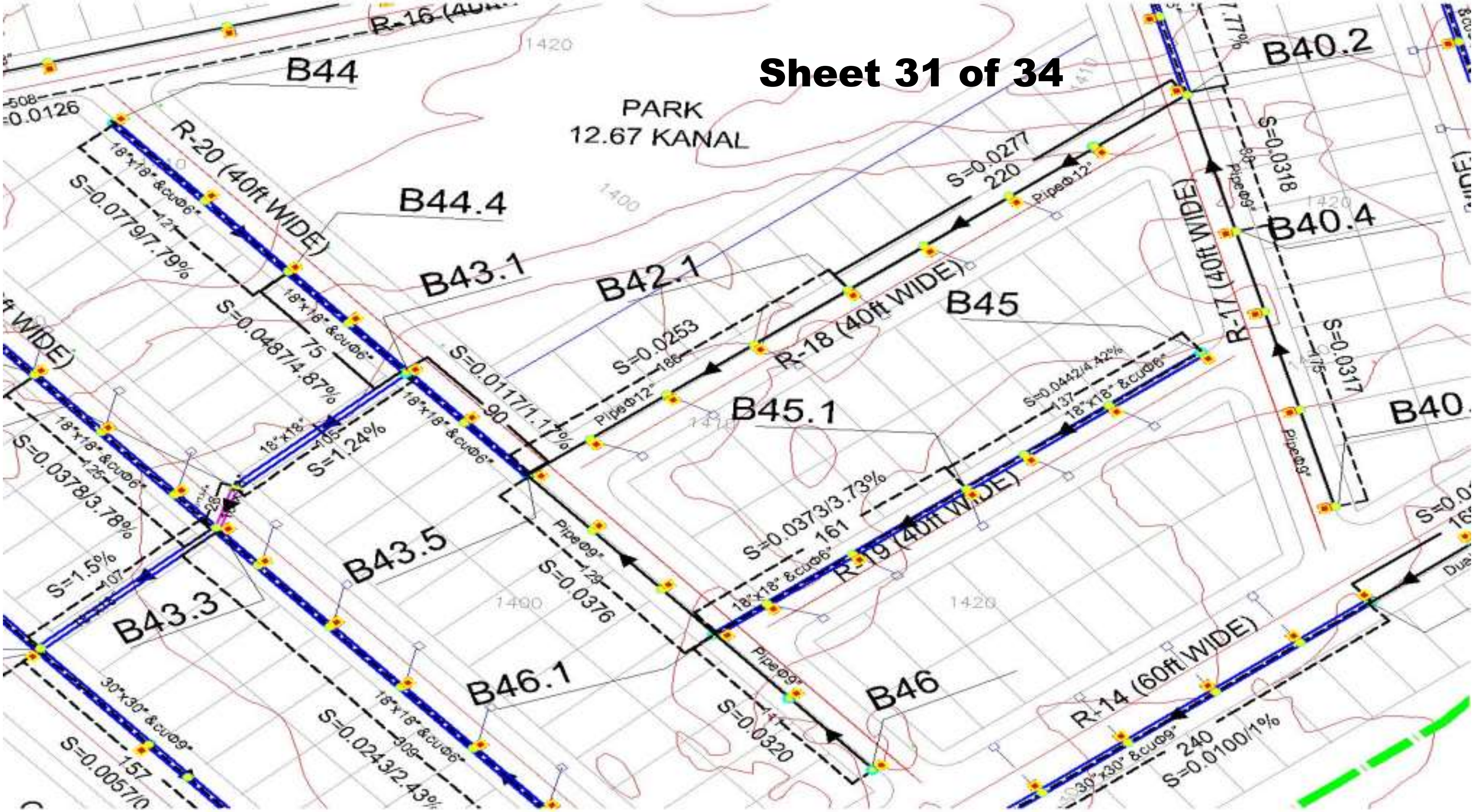


Fig H32: Layout plan of Zome-2 part nine

Annexure H

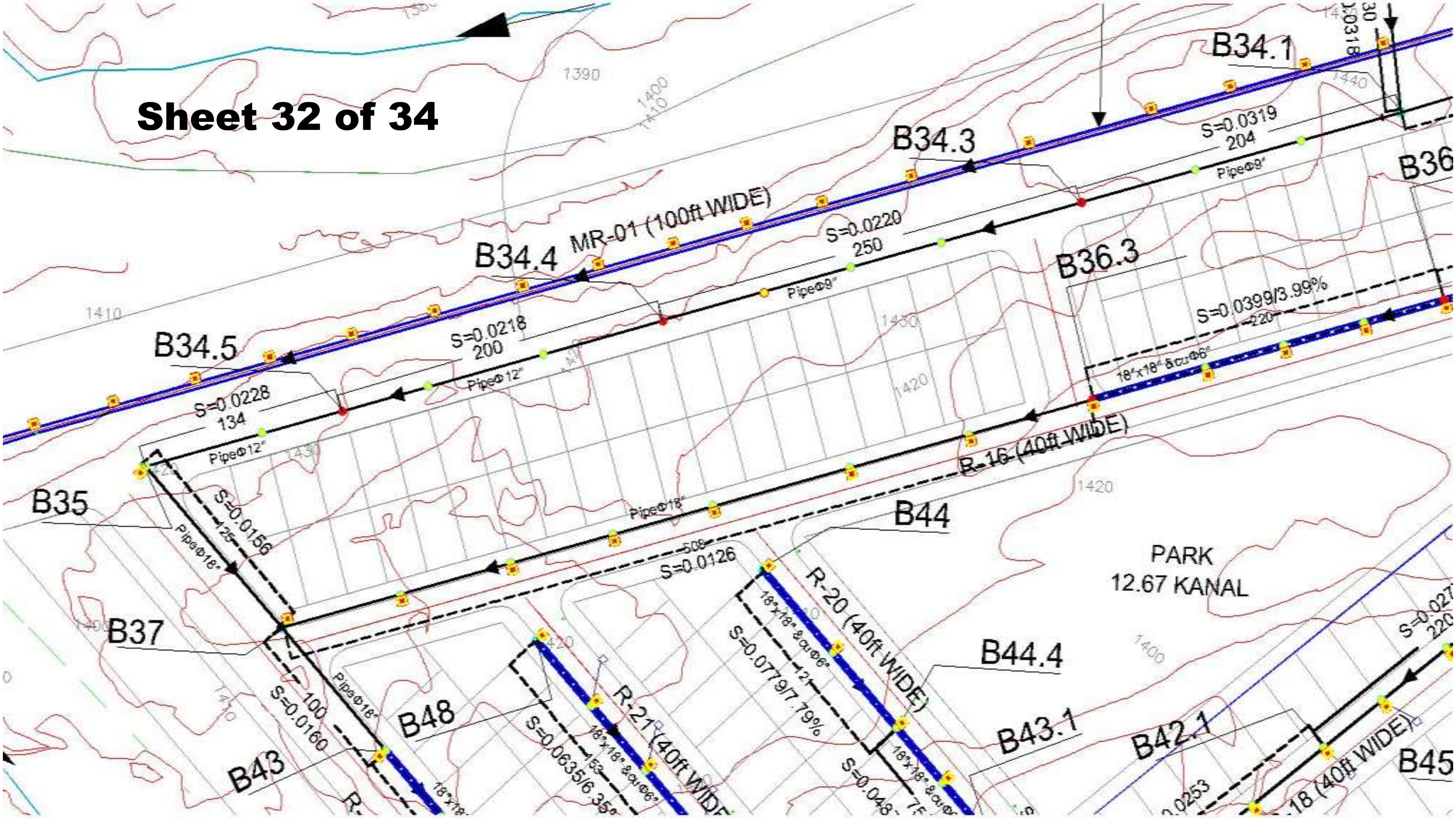


Fig H33: Layout plan of Zome-2 part ten

Annexure H

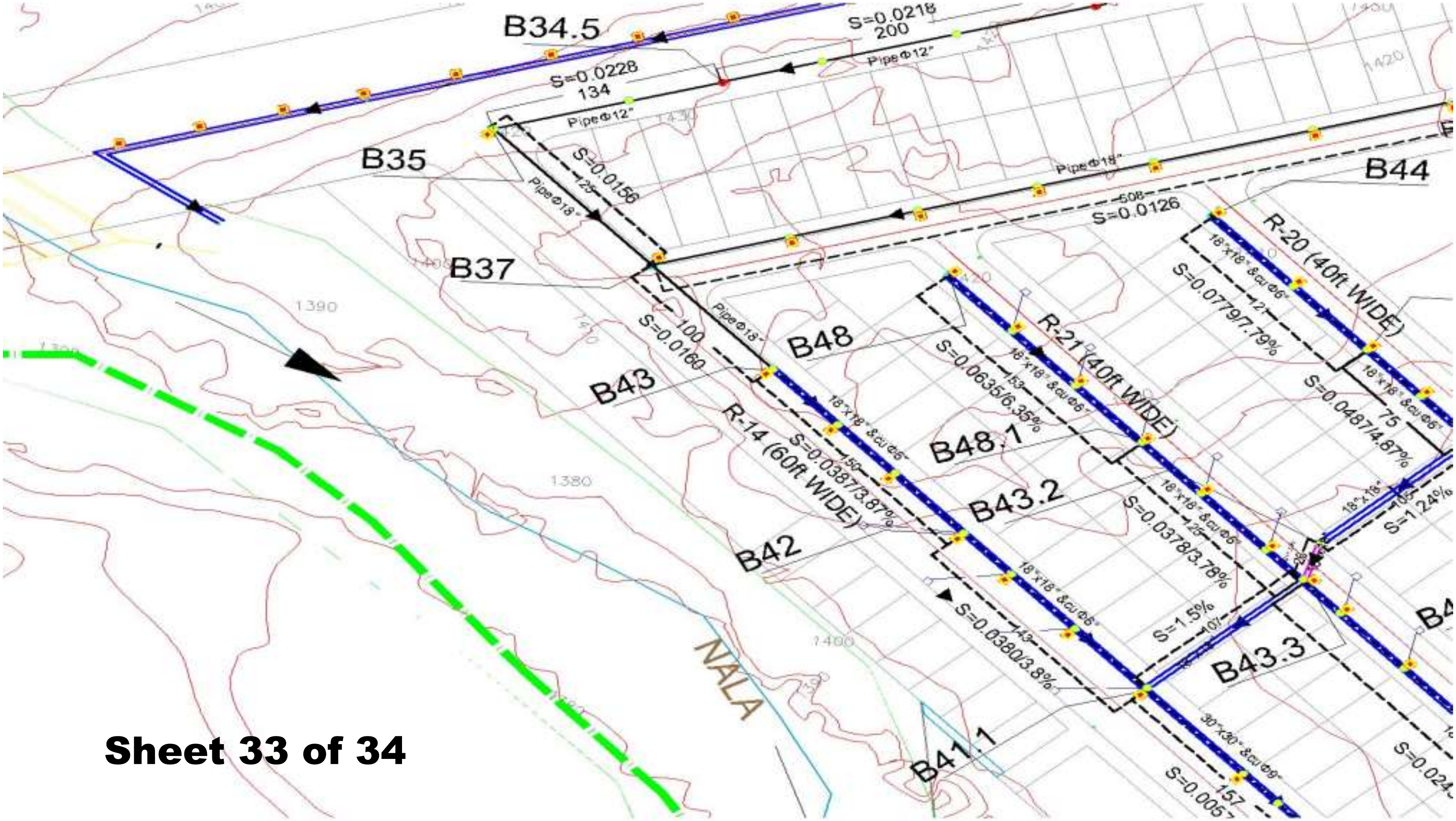


Fig H34: Layout plan of Zome-2 part eleven

Annexure H

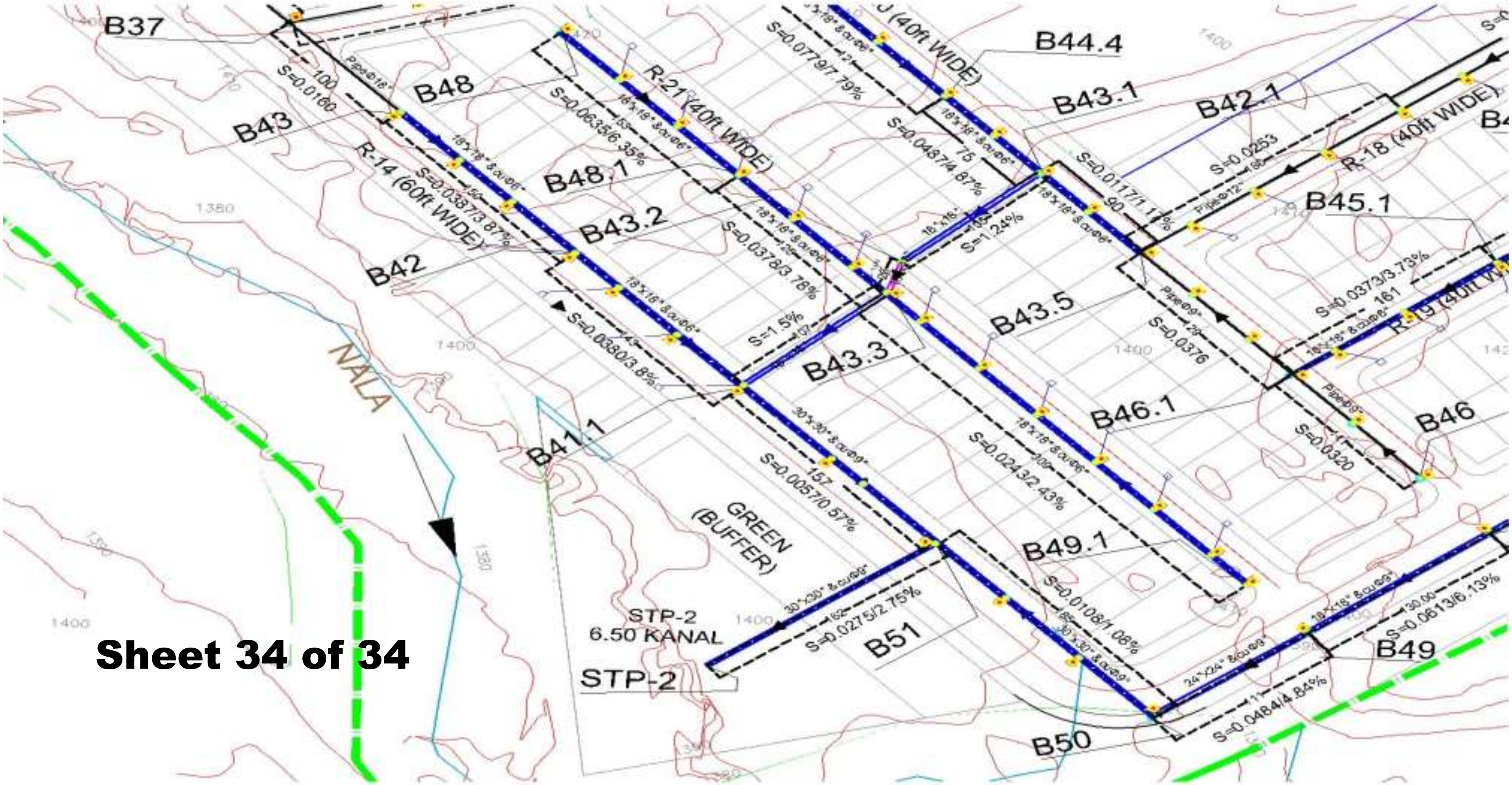


Fig H35: Layout plan showing final disposal of combined flows at nodes B51 to STP-2 of Zone-3

Appendix I

Multi Dia R.C.C Pipes Section Drawing

ANNEXURE I: DIFFERENT R.C.C CIRCULAR PIPE SECTIONS USED FOR COMBINED & SEPARATE SYSTEMS

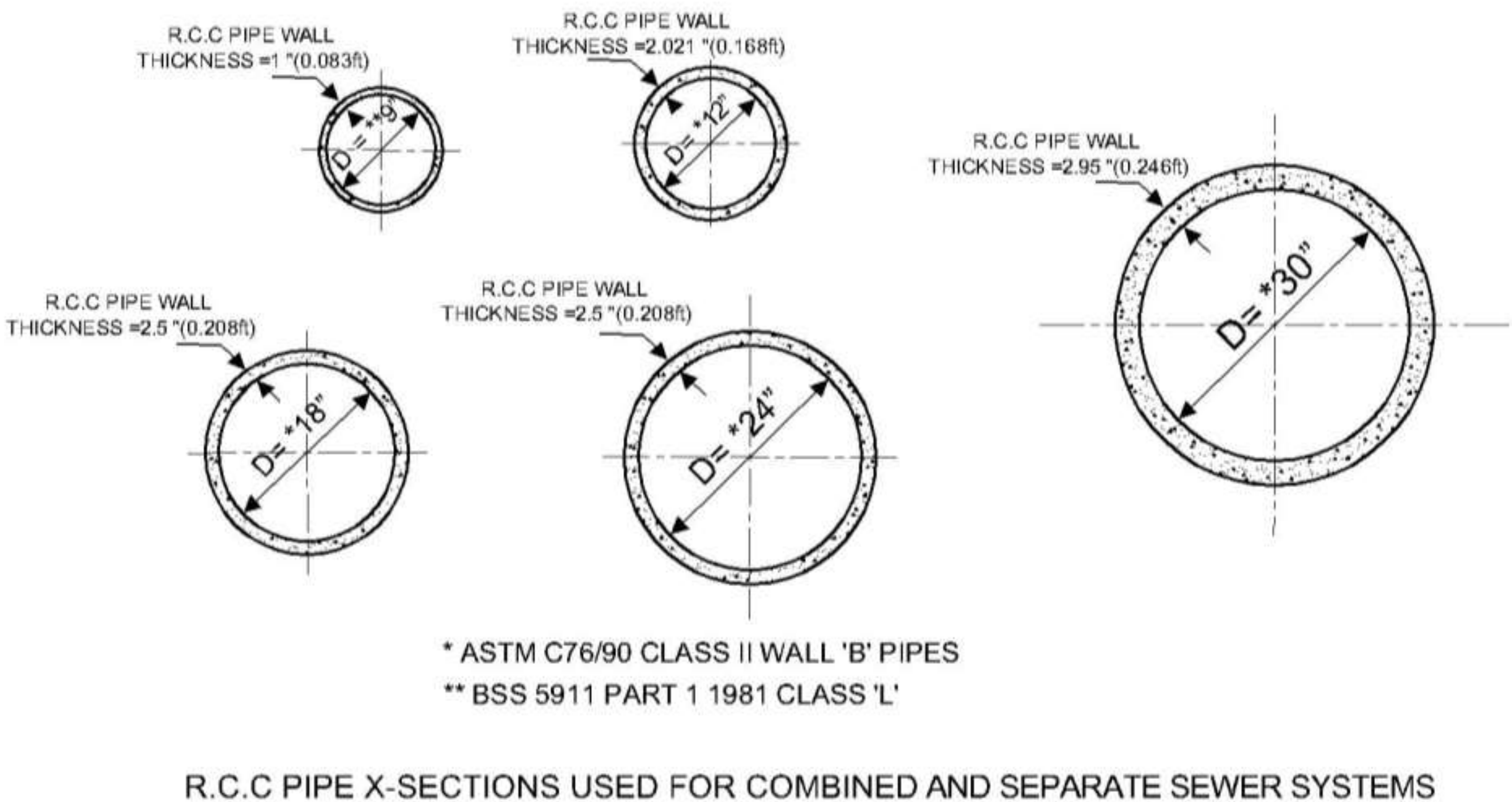
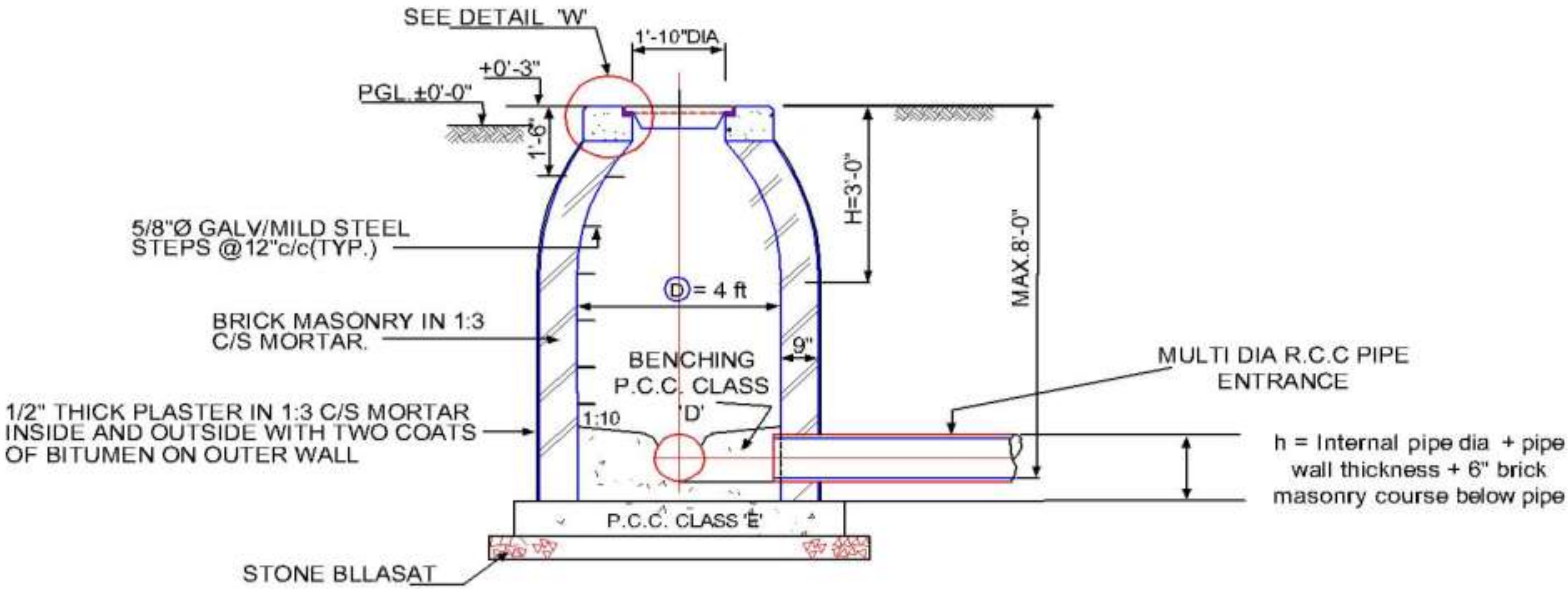


Fig I1: Cross sections of multi diameter R.C.C pipes used for both drainage networks

Appendix J

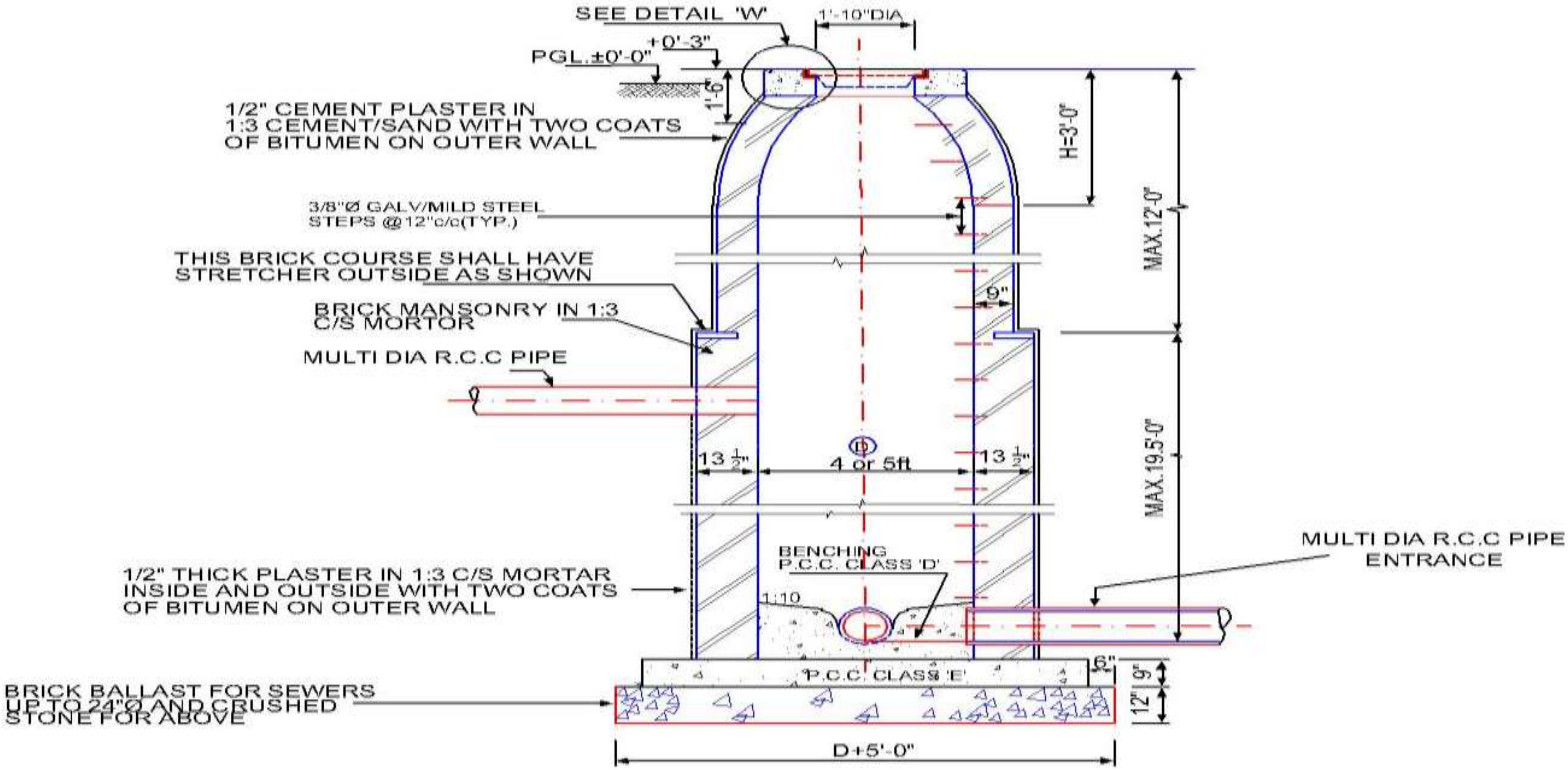
Shallow & Deep Manholes Drawings

ANNEXURE J: SHALLOW & DEEP MANHOLES CROSSECTIONAL DRAWINGS USED FOR BOTH SYSTEMS



X-SECTION OF SHALLOW CIRCULAR BRICK MASONRY MANHOLES USED FOR COMBINED & SEPARATE SYSTEMS

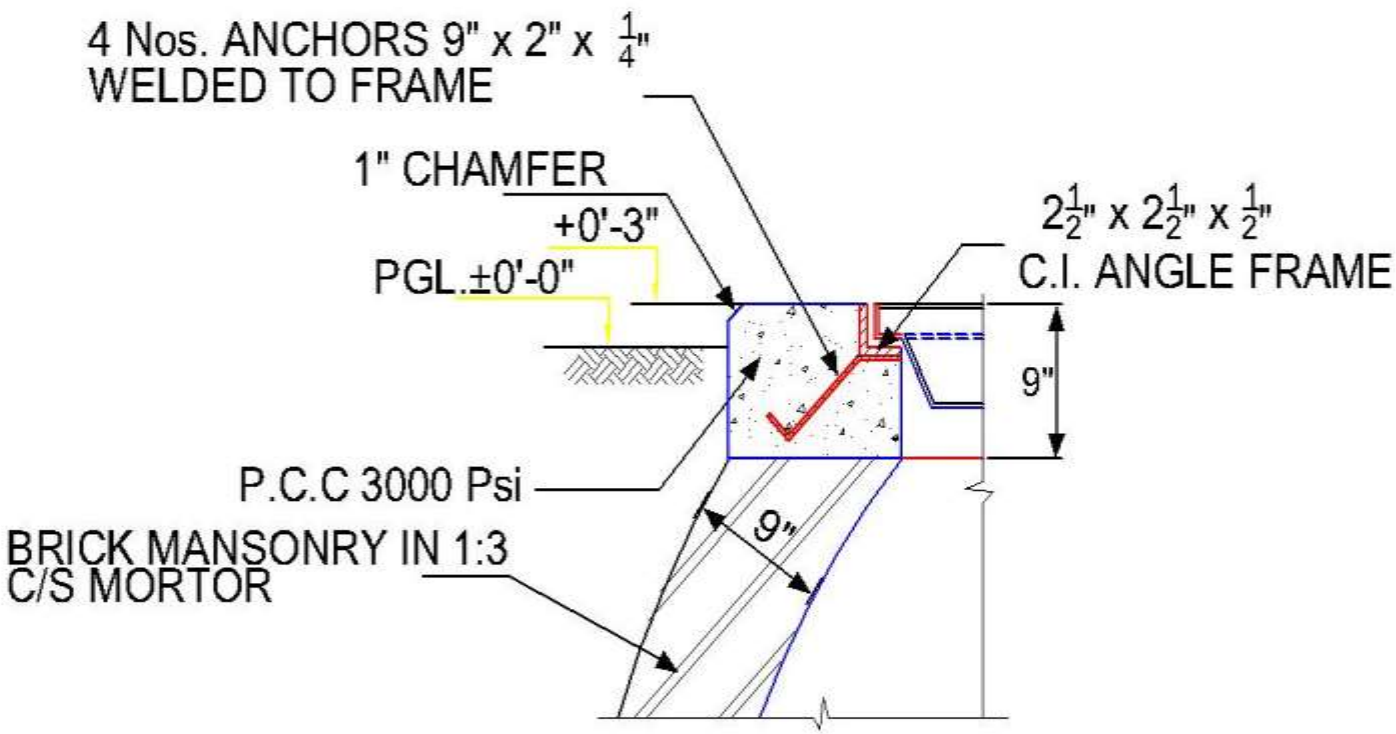
Fig J1: Cross section of shallow circular type brick masonry manholes used for combined and separate sewer systems



X-SECTION OF DEEP CIRCULAR BRICK MASONRY MANHOLES USED FOR COMBINED & SEPARATE SYSTEMS

Fig J2: Cross section of deep circular type brick masonry manholes used for combined and separate sewer systems

Annexure J



DETAIL -W FOR DEEP & SHALLOW CIRCULAR MANHOLE COVERS REST AREA

Fig J3: Detail-W for shallow and deep circular manhole covers rest area

Annexure J

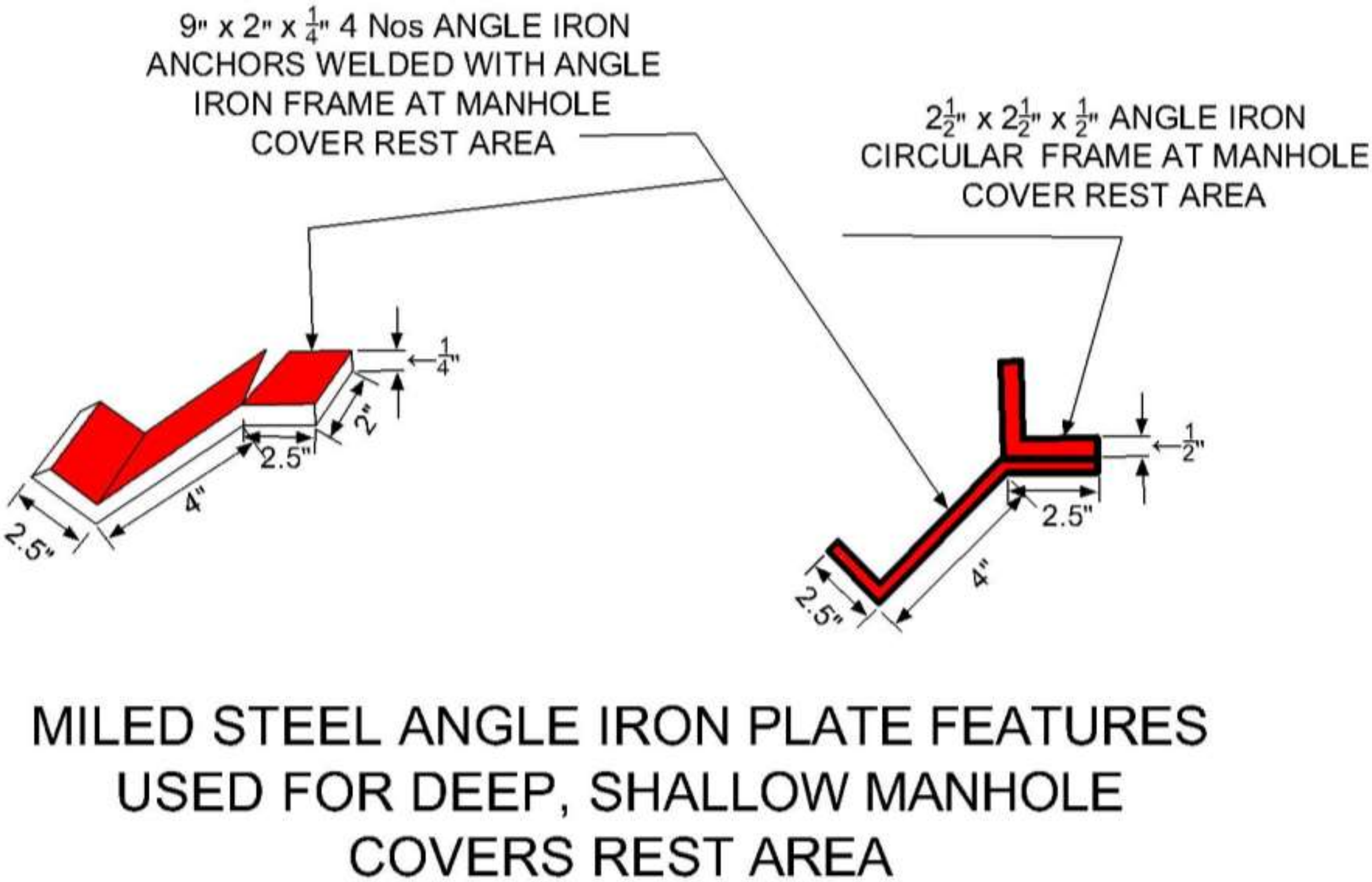


Fig J4: Features of mild steel angle iron used for shallow and deep circular manhole covers rest area

Annexure J

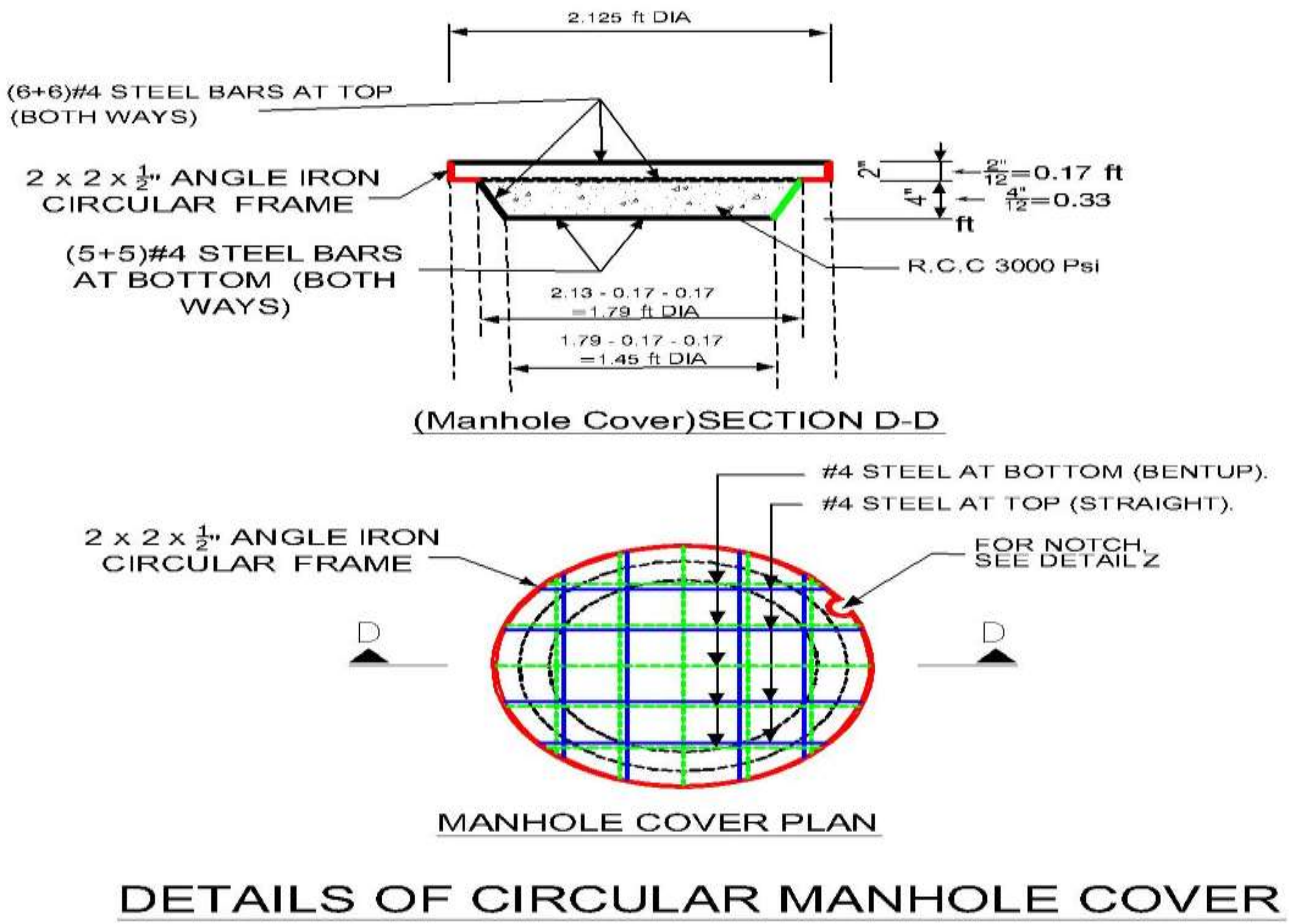


Fig J5: Circular manhole cover plan, crossection including steel reinforcment and M.S angle iron ring detail around manhole cover outer edge

Annexure J

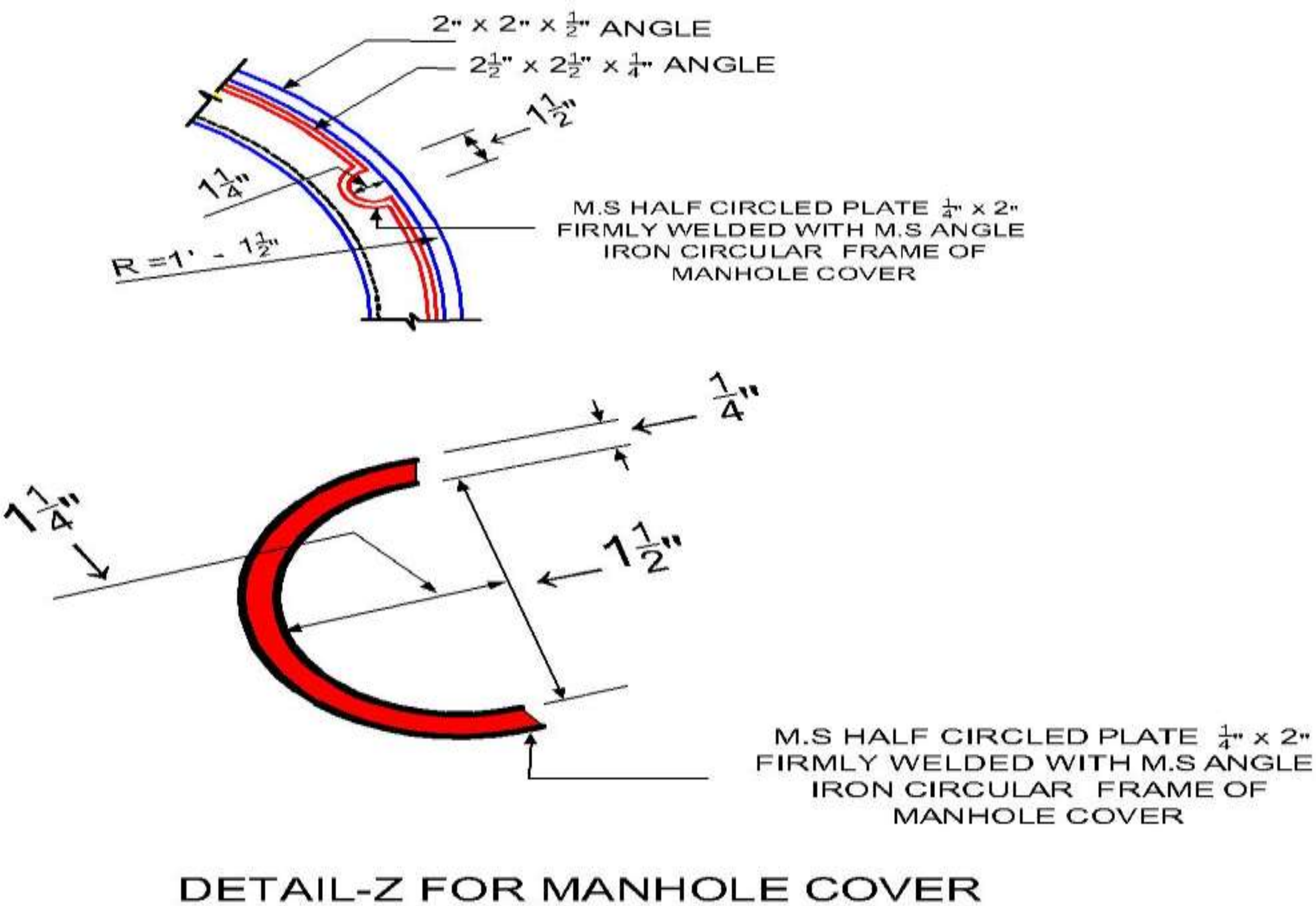


Fig J6: Detal-Z for circular manhole cover

Annexure J

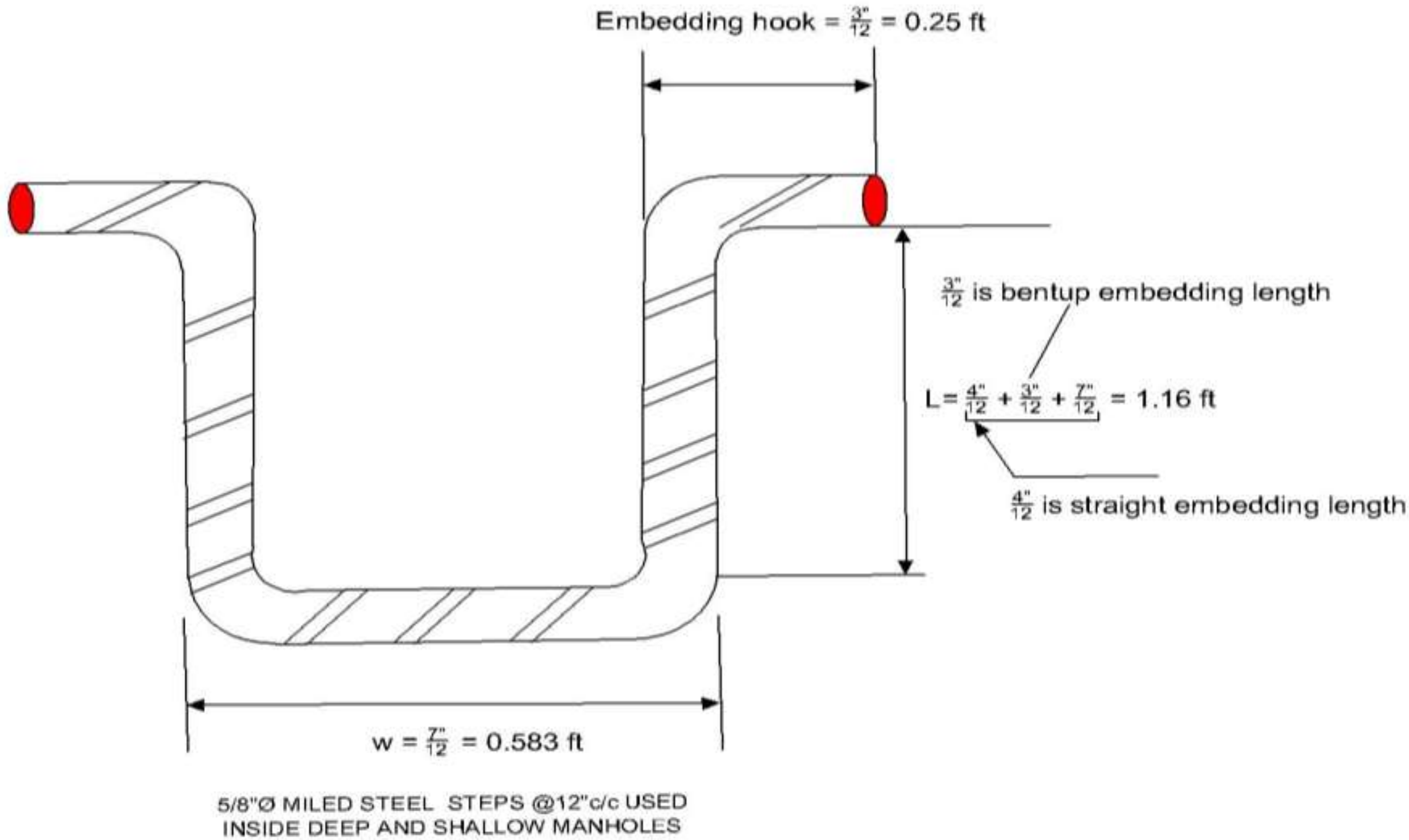


Fig J7: Mild steel steps used inside shallow and deep manholes to be used as ladder rungs

Annexure J

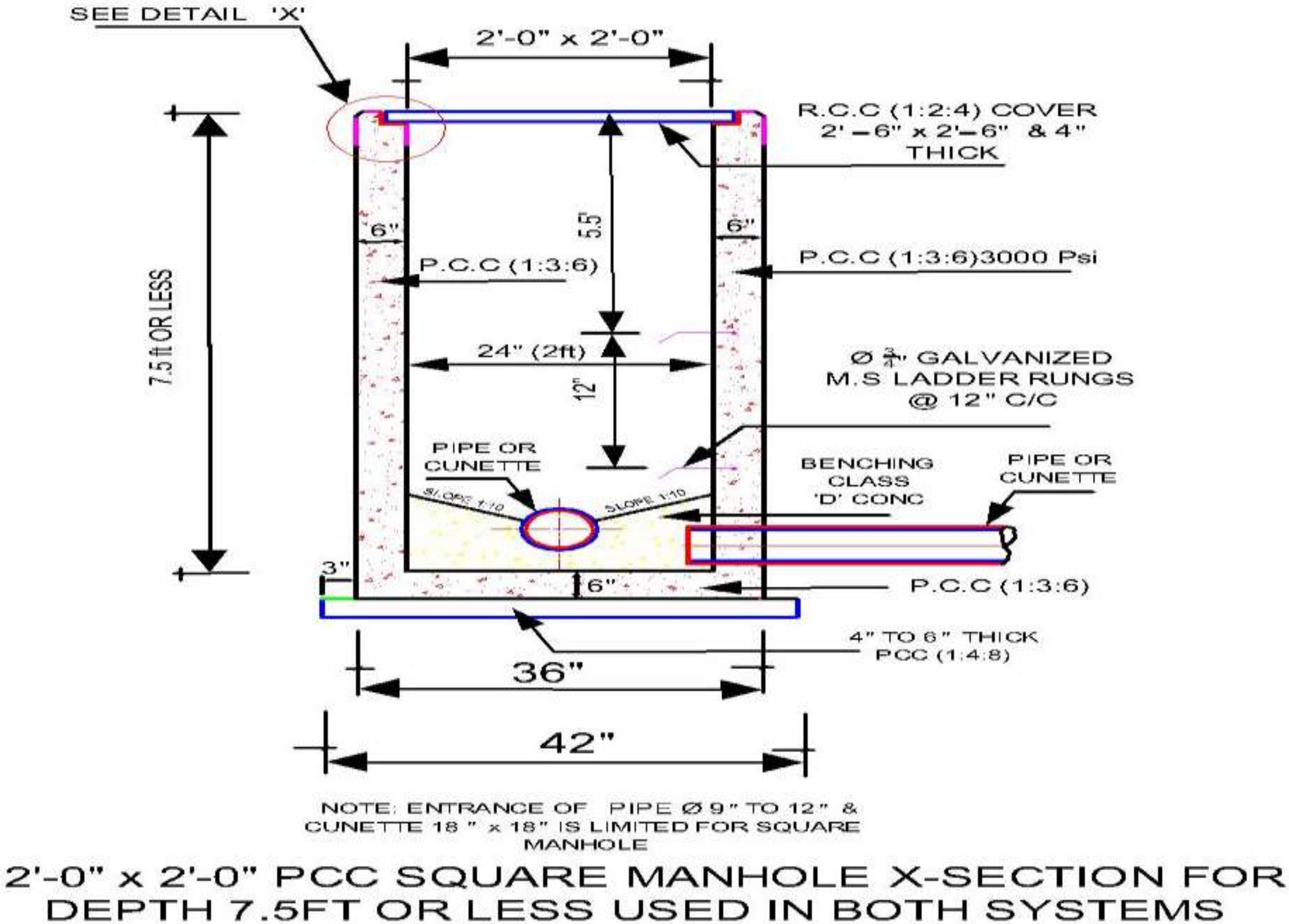


Fig J8: R.C.C square shape shallow manhole corssectional drawing used for combined and separate sewer systems

Annexure J

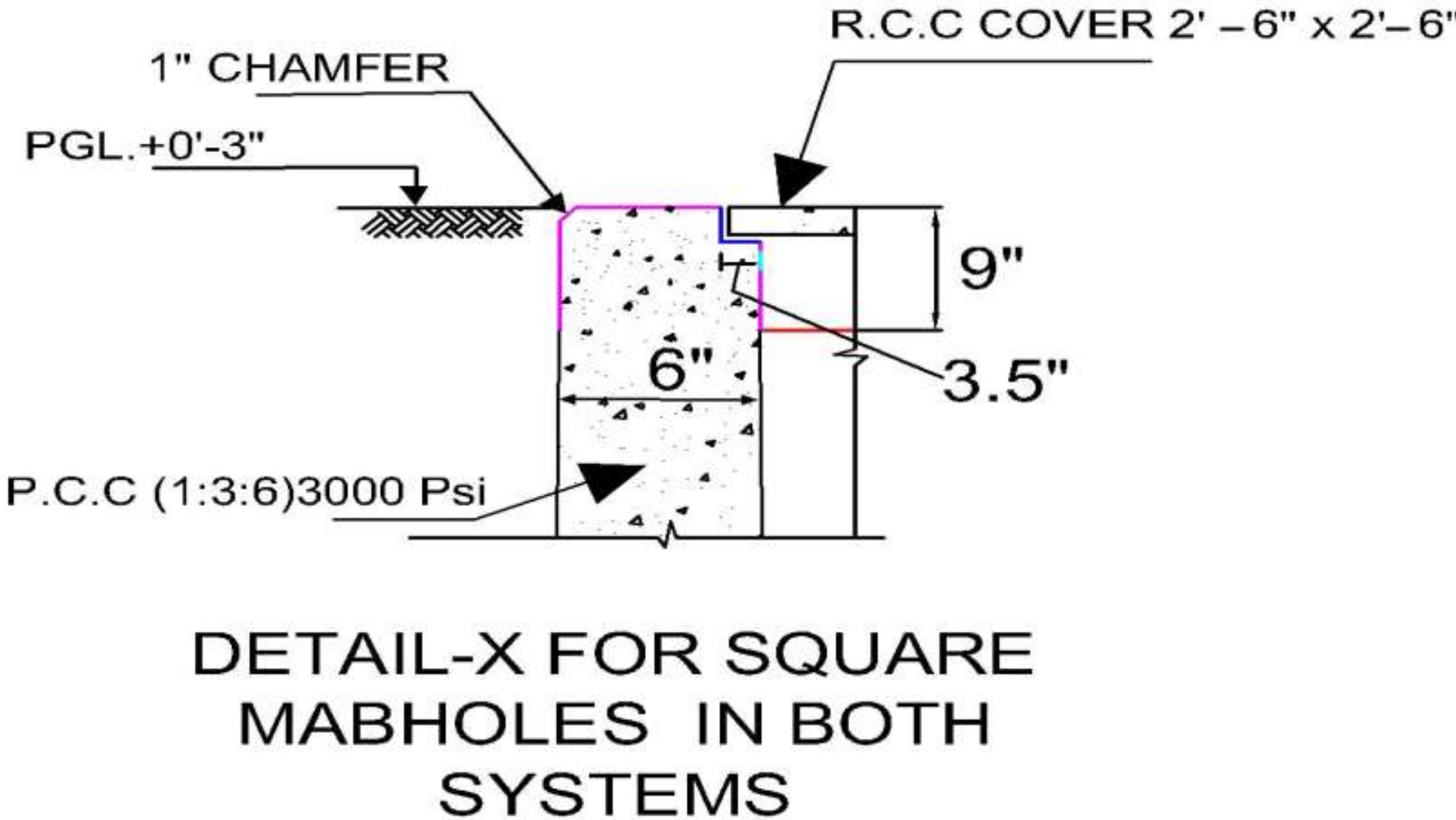


Fig J9: Detail-X for R.C.C square shape manhole cover rest area used for combined and separate sewer systems

Annexre J

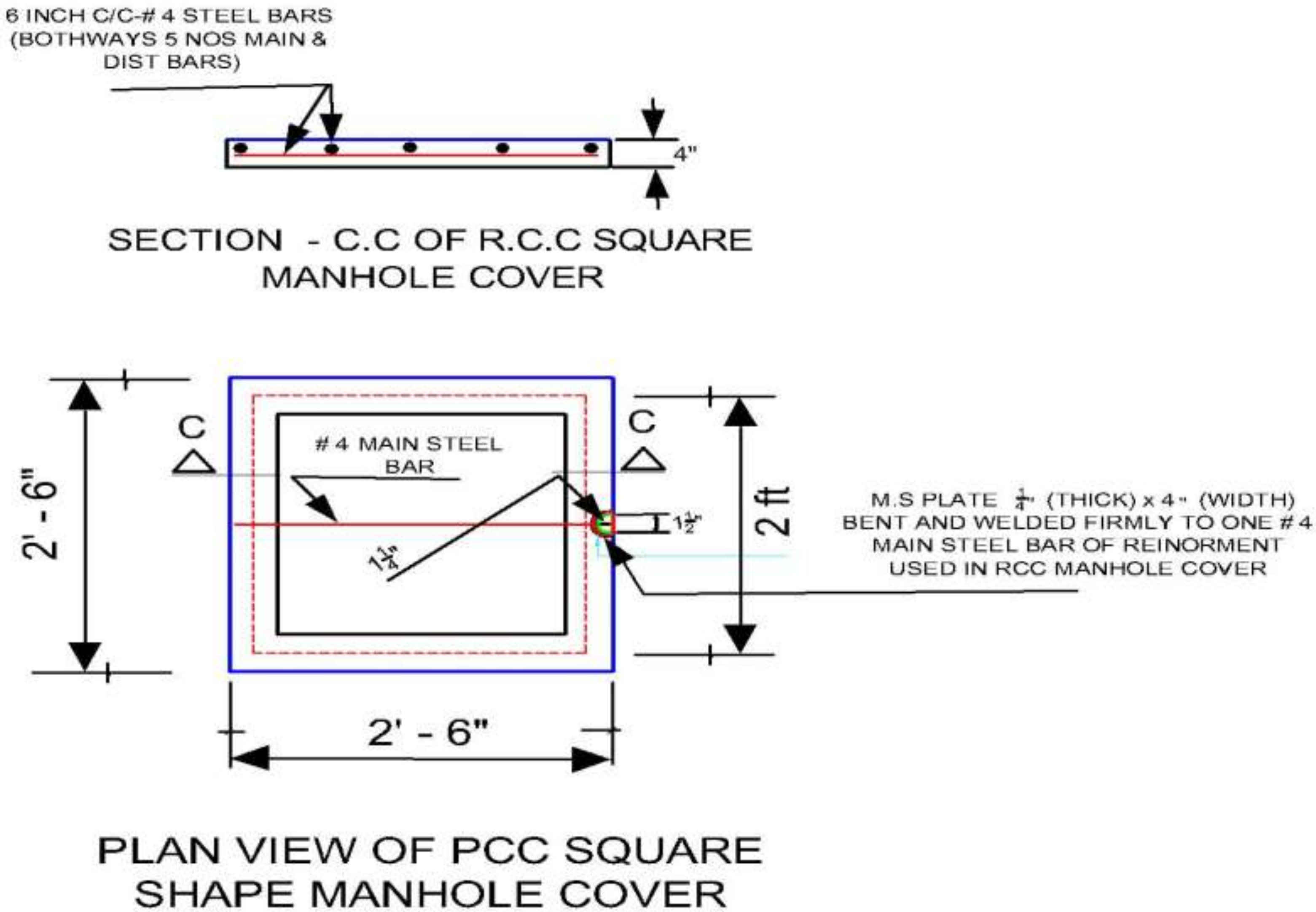


Fig J10: R.C.C square shape manhole cover plan and x-section including steel reinforcment detail

Appendix K

Storm Drains Sectional Drawing

ANNEXURE K: X-SCTIONAL DRAWINGS OF STORM DRANS SEPARATED IN BOTH DRAINAGE SYSTEMS

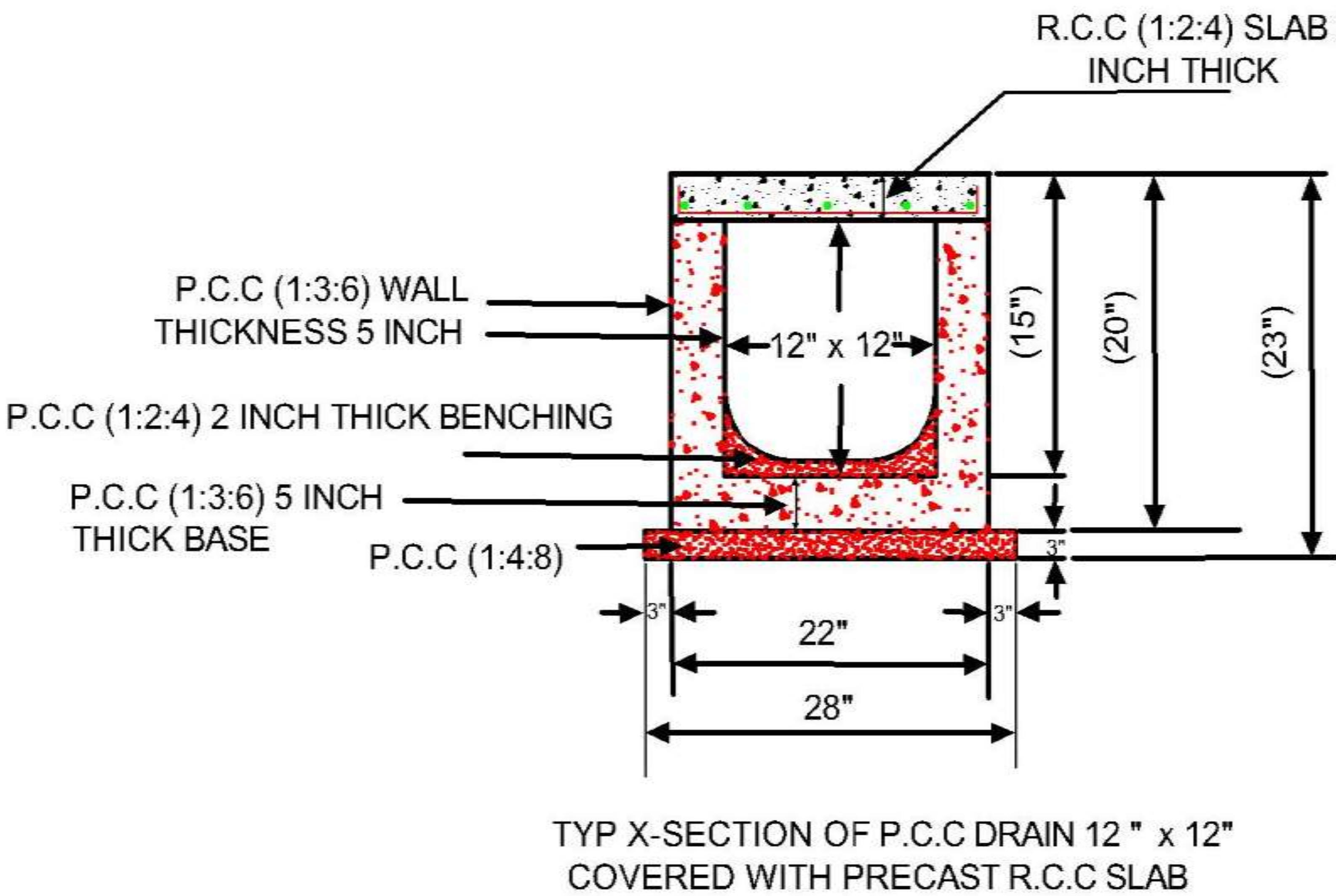


Fig K1: P.C.C Storm Drain X-section of internal size 12inch × 12inch used for separated storm drains in both systems

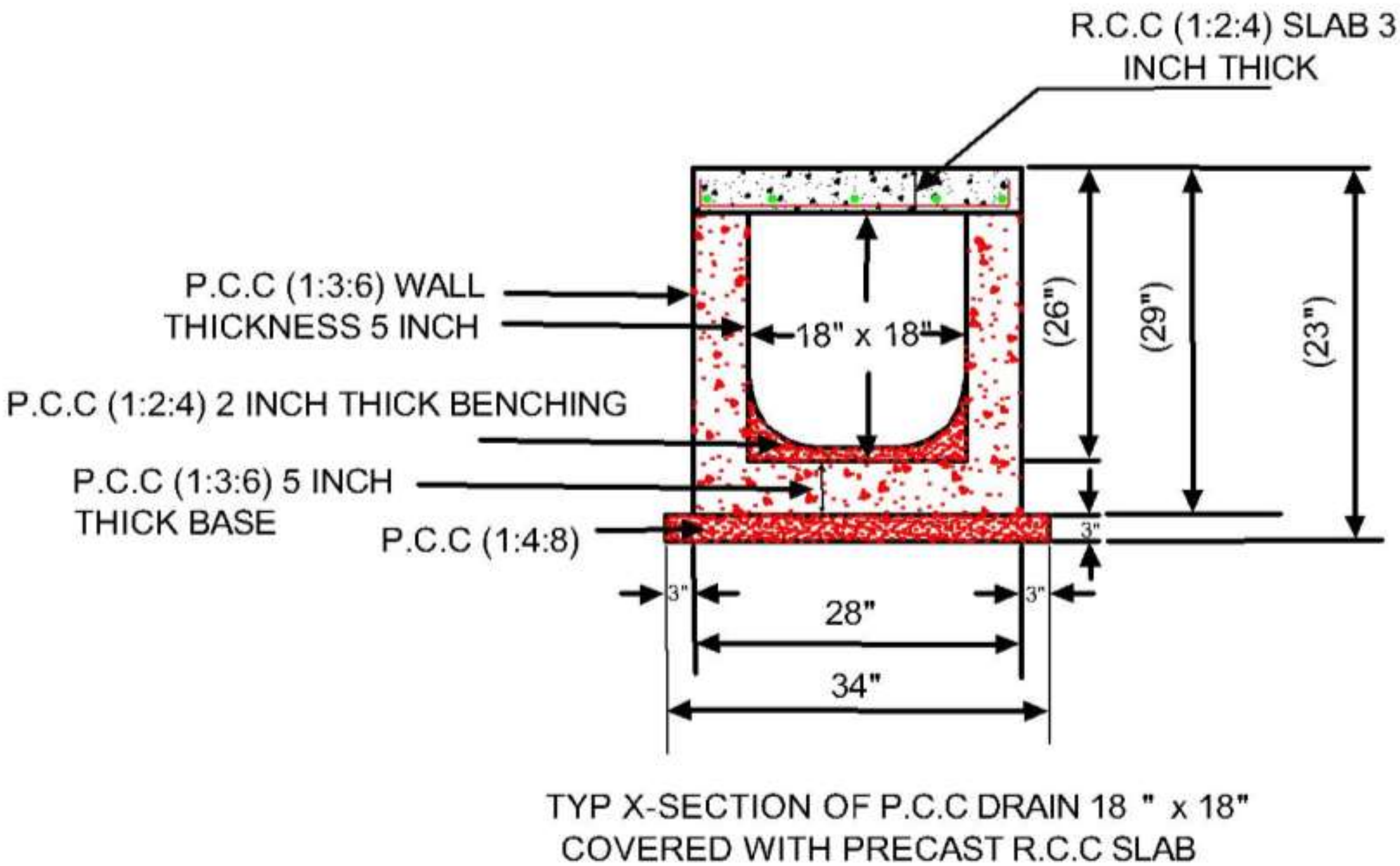


Fig K2: P.C.C Storm Drain X-section of internal size 18inch × 18inch used for separated storm drains in both systems

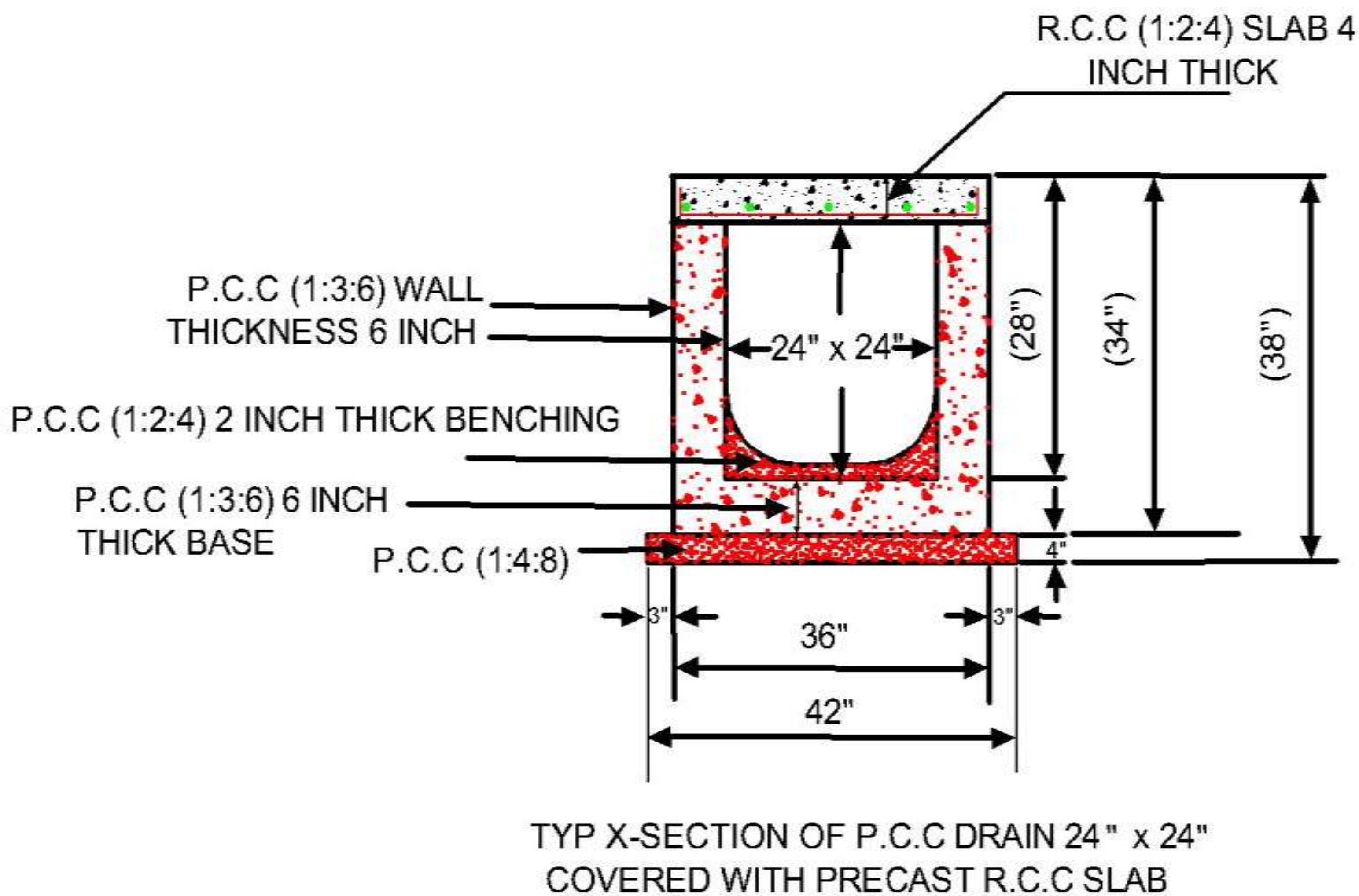


Fig K3: P.C.C Storm Drain X-section of internal size 24inch × 24inch used for separated storm drains in both systems

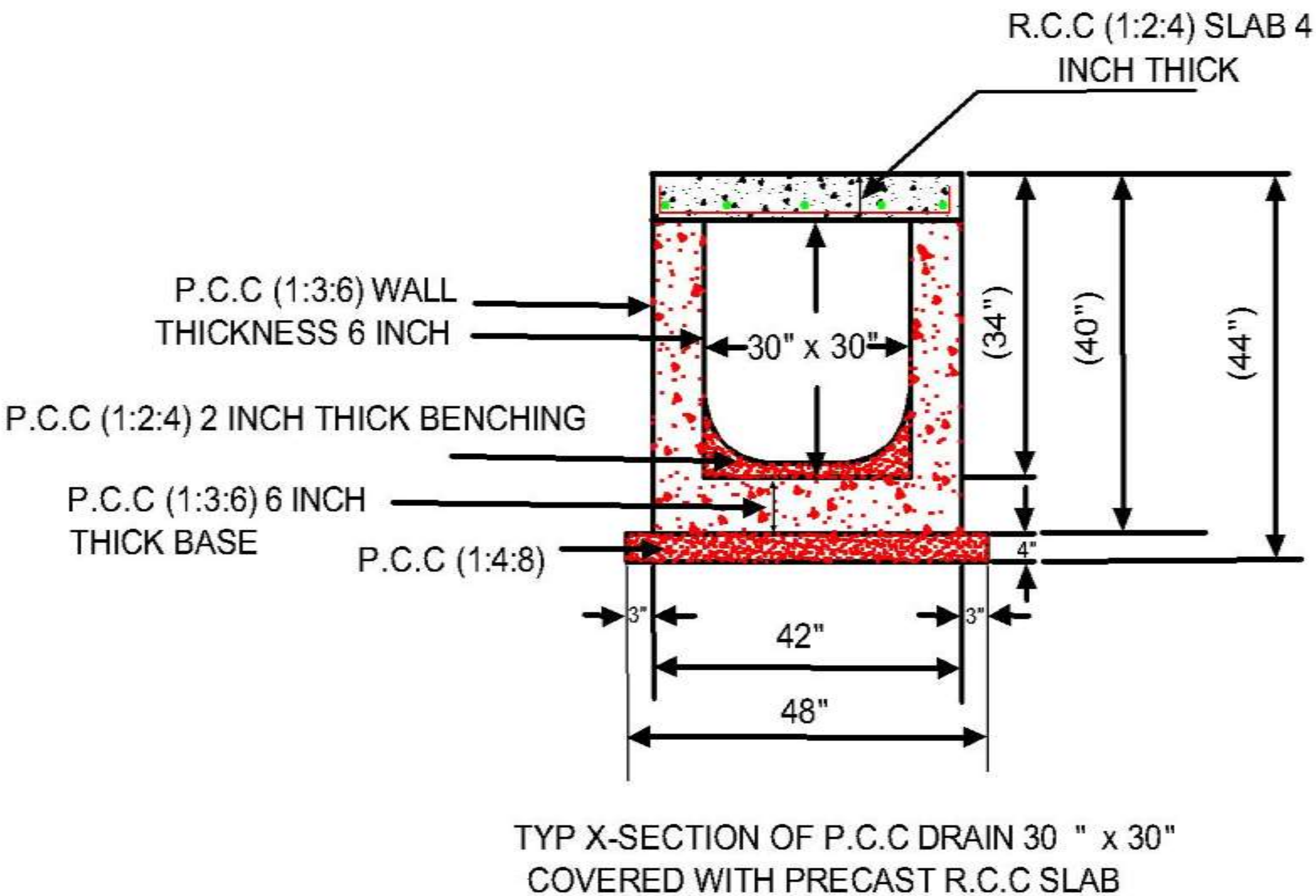


Fig K4: P.C.C Storm Drain X-section of internal size 30inch × 30inch used for separated storm drains in both systems

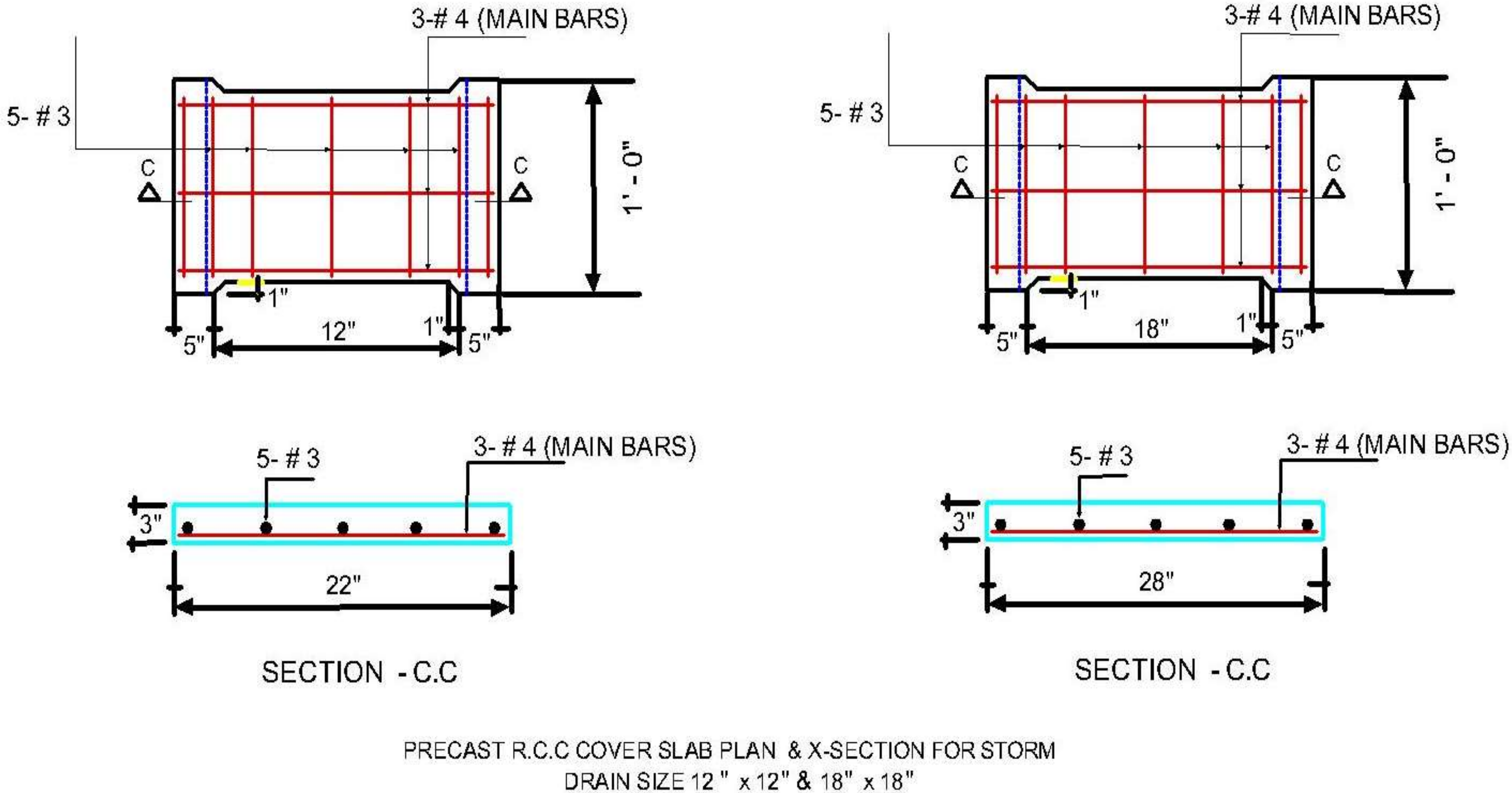


Fig K5: R.C.C cover slab plan, x-section for storm drain sizes 12inch × 12inch & 18inch × 18inch used for separated storm drains in both systems

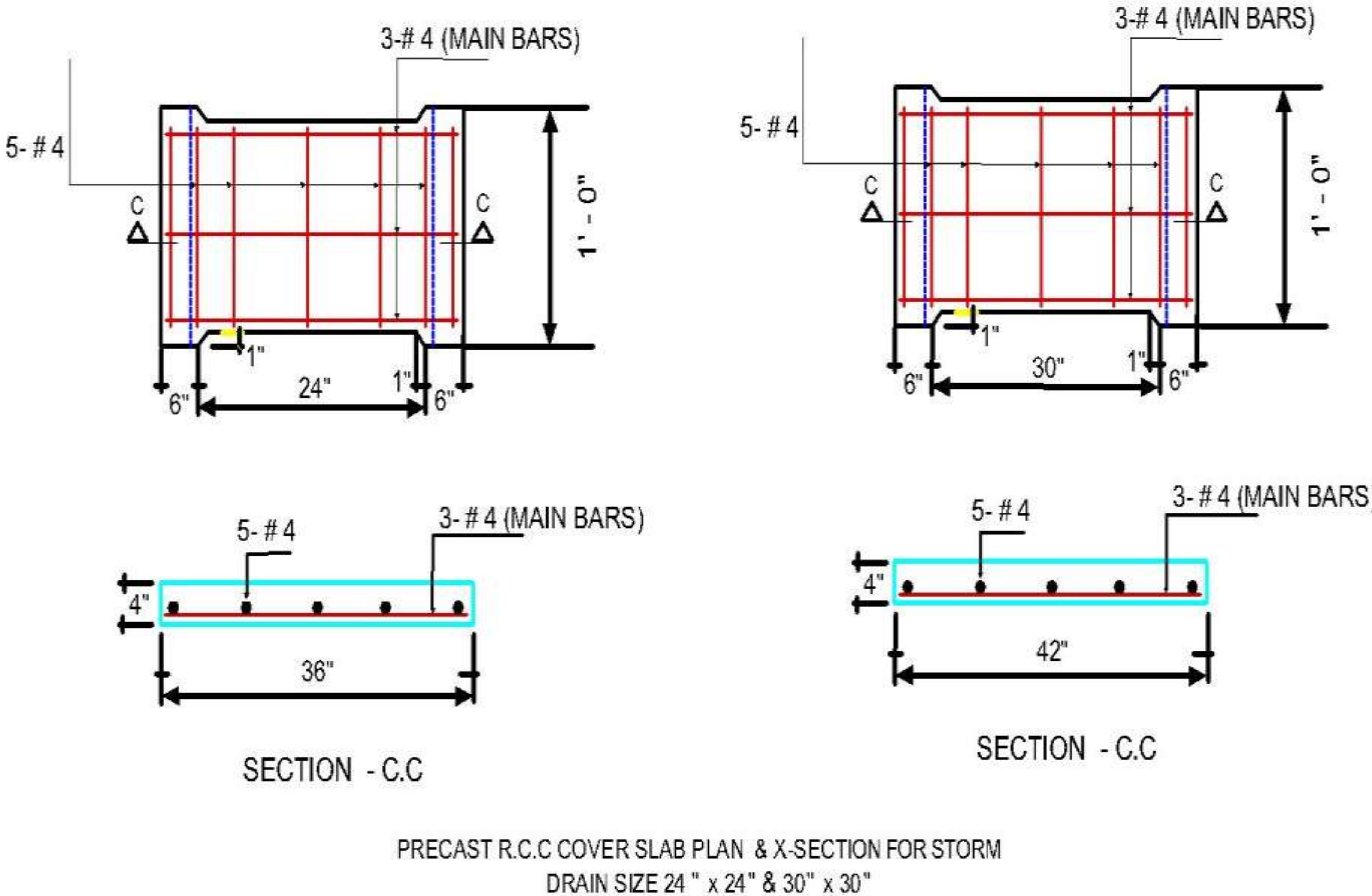


Fig K6: R.C.C cover slab plan, x-section for storm drain sizes 24inch × 24inch & 30inch × 30inch used for separated storm drains in both systems

Appendix L

Catch Pit Crossectional Drawings

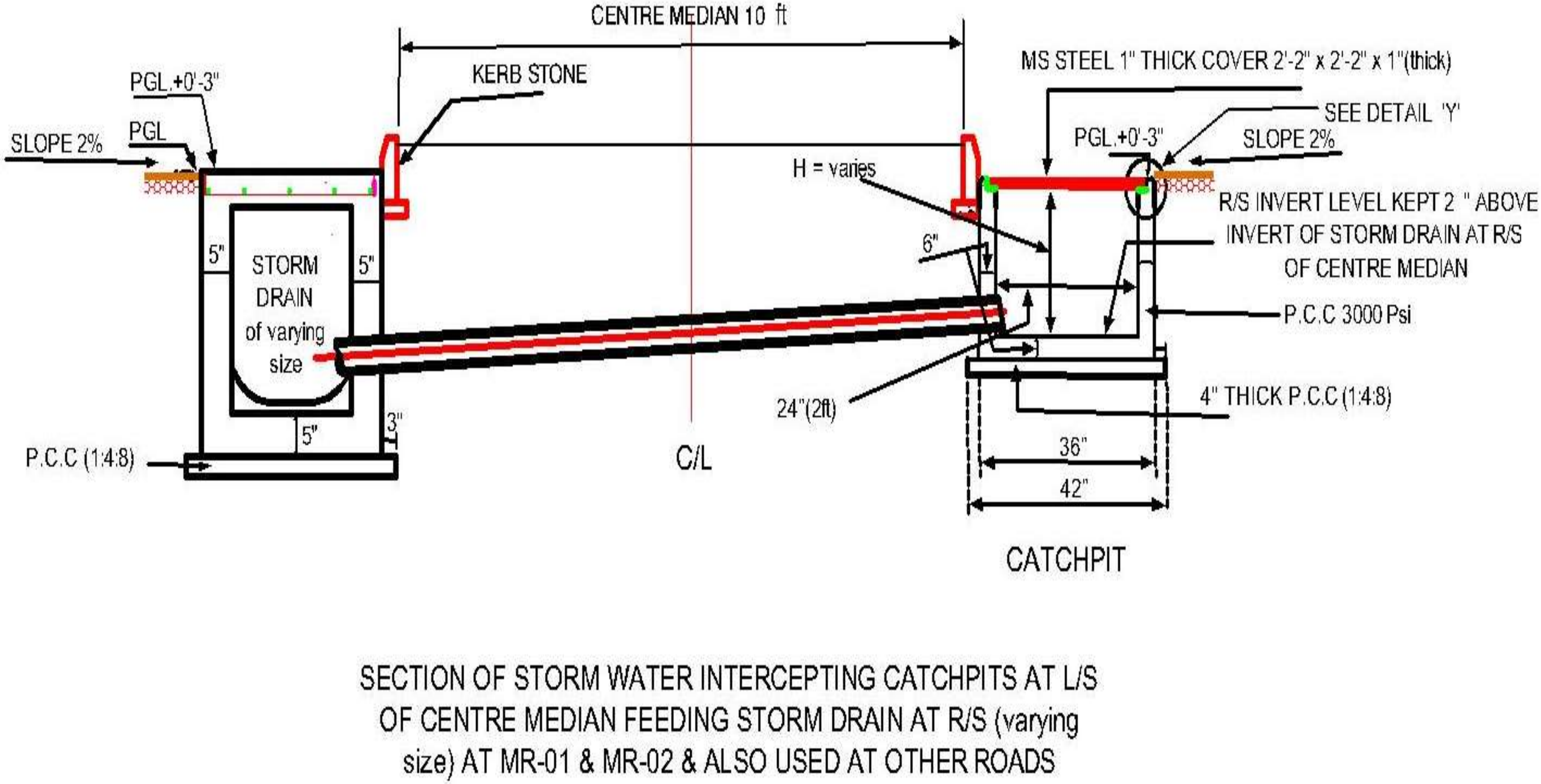


Fig L1: P.C.C catch pits of internal size varying height and 24inch width feeding storm water to drain of varying size

Annexure L

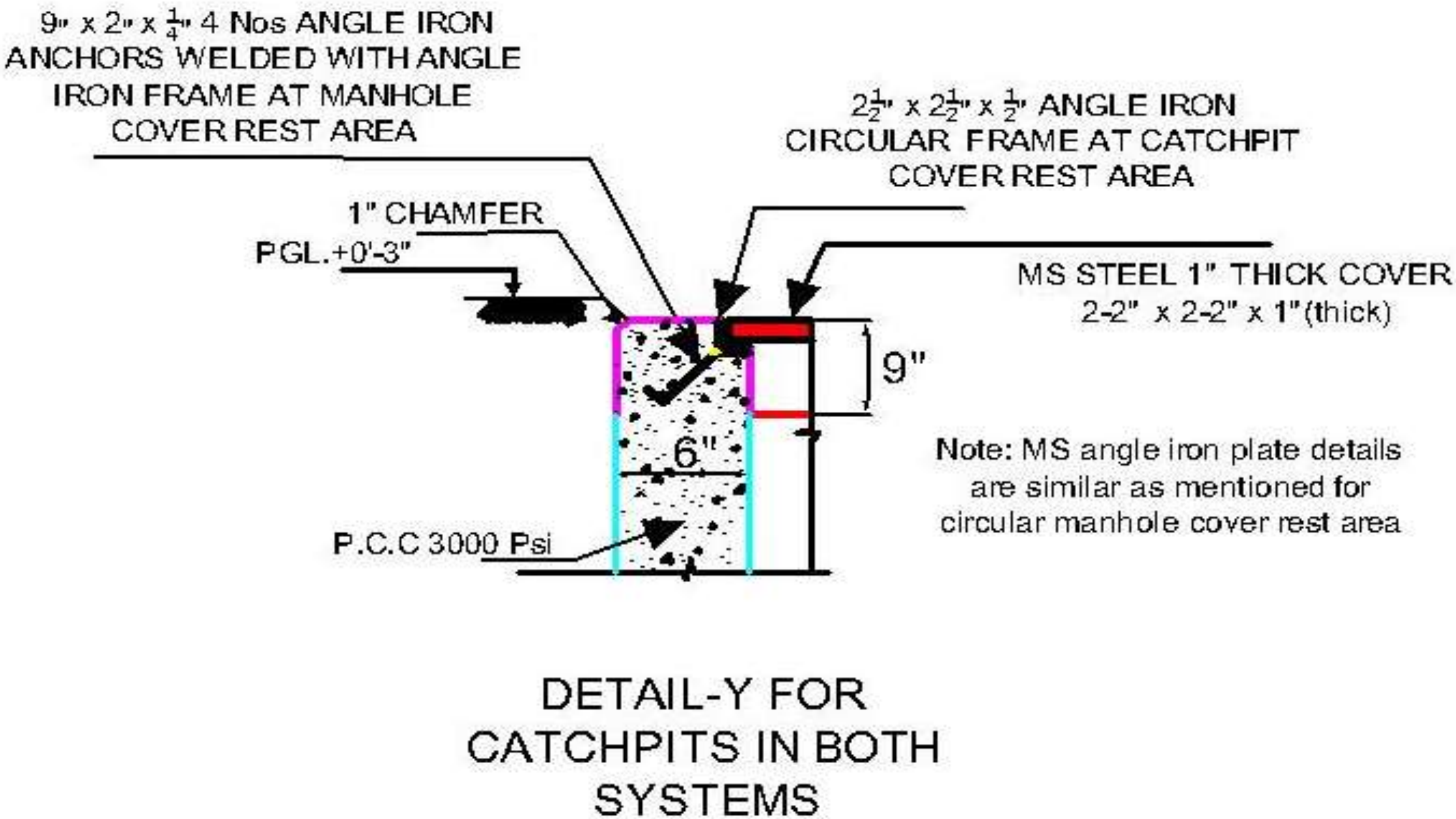
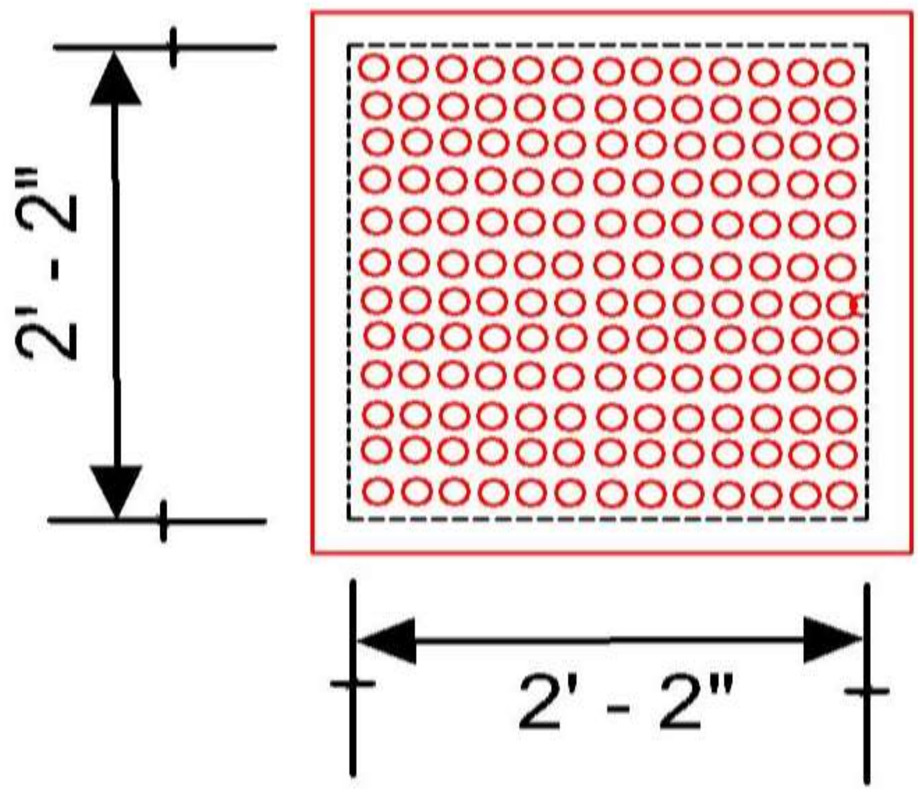


Fig L2: Detail-Y for P.C.C catch pits 1inch thick mild steel cover rest area while angle iron details are simlar as mentiioned in Fig J4

Annexure L



PLAN VIEW OF MS STEEL 1 INCH THICK PERFORATED CATCHPIT COVER FOR BOTH SYSTEMS

Fig L3: Plan view of 1inch thich mild steel perforated catch pit cover used for both drainage systems

Appendix M

Drain Plus Cunette Drawings

ANNEXURE M: DRAWINGS OF MULTI SIZES STORM DRAINS PLUS CUNETTE DIA USED FOR COMBINED SYSTEM

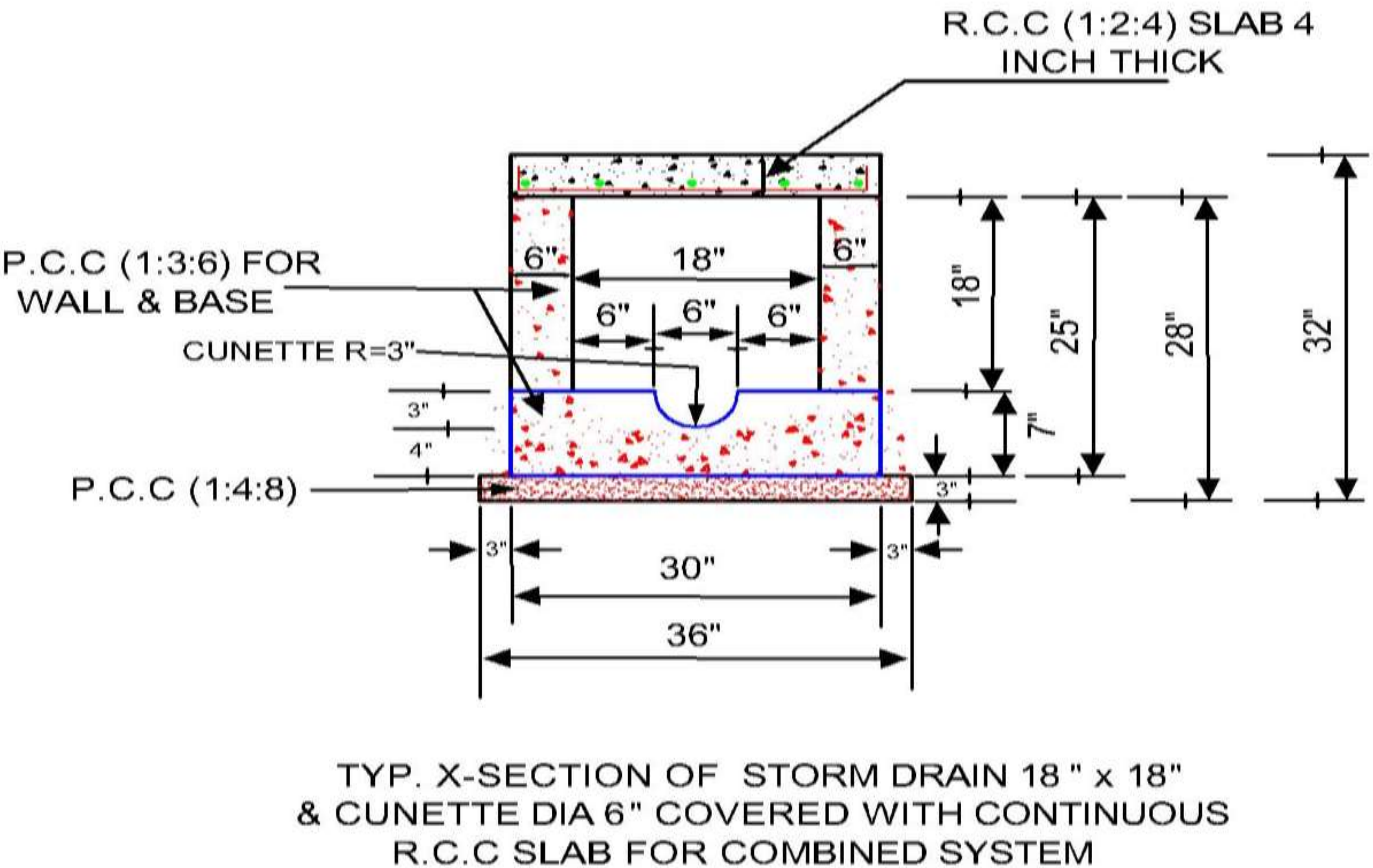


Fig M1: Typical x-section of storm drain of size 18inch × 18inch plus cunette diameter 6inch used for combined system

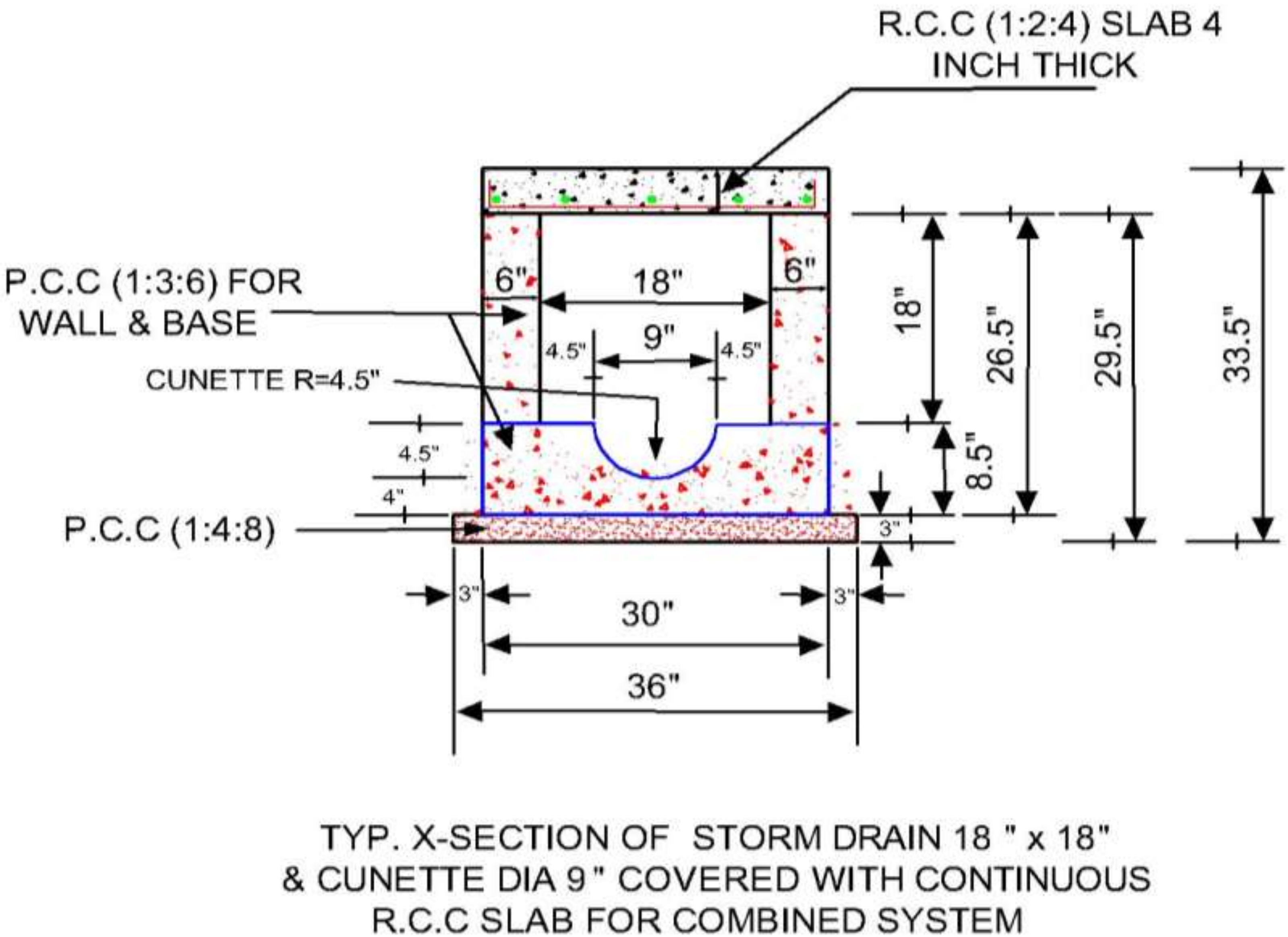


Fig M2: Typical x-section of storm drain of size 18inch × 18inch plus cunette diameter 9inch used for combined system

Annexure M

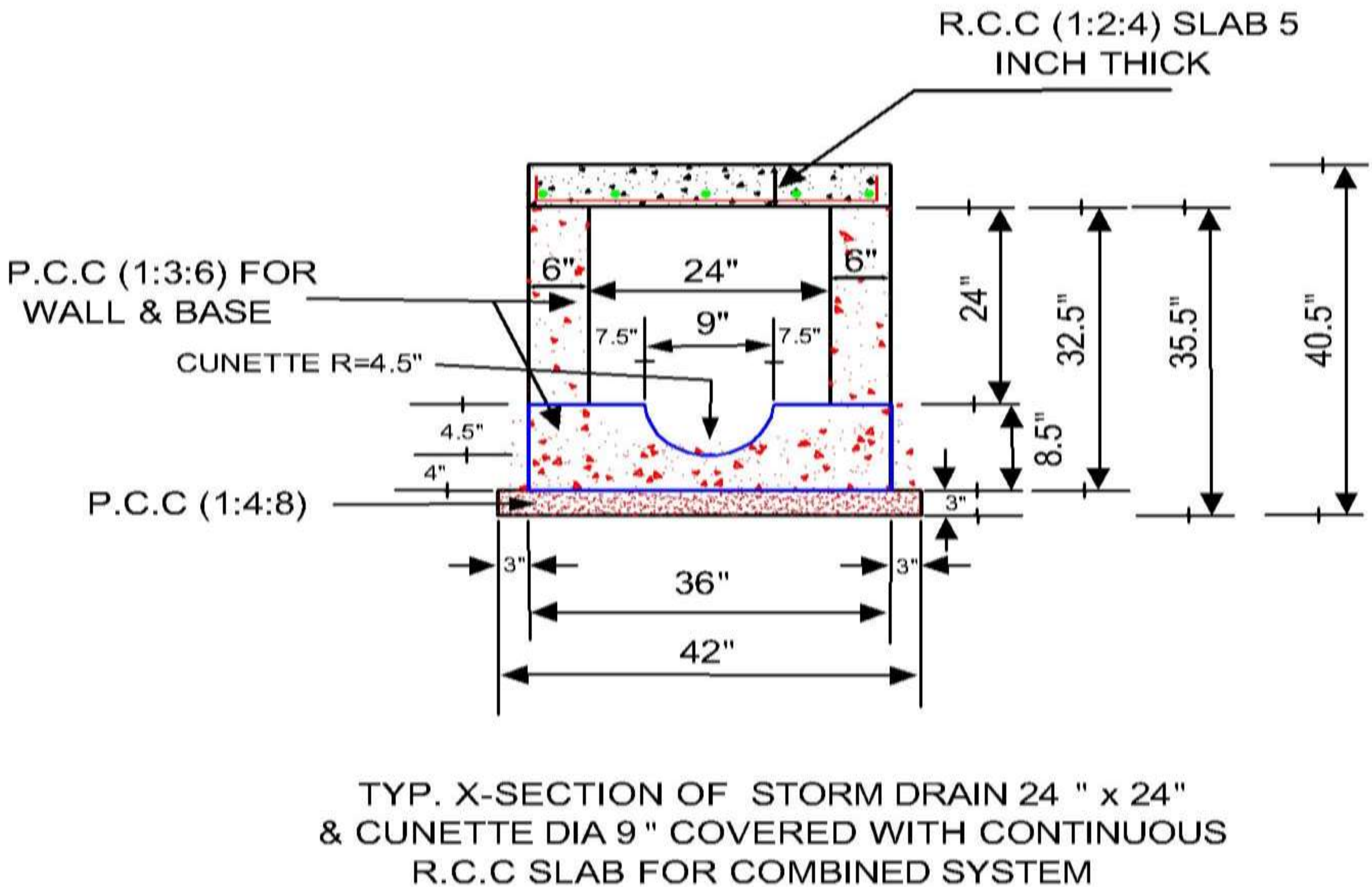


Fig M3: Typical x-section of storm drain of size 24inch × 24inch plus cunette diameter 9inch used for combined system

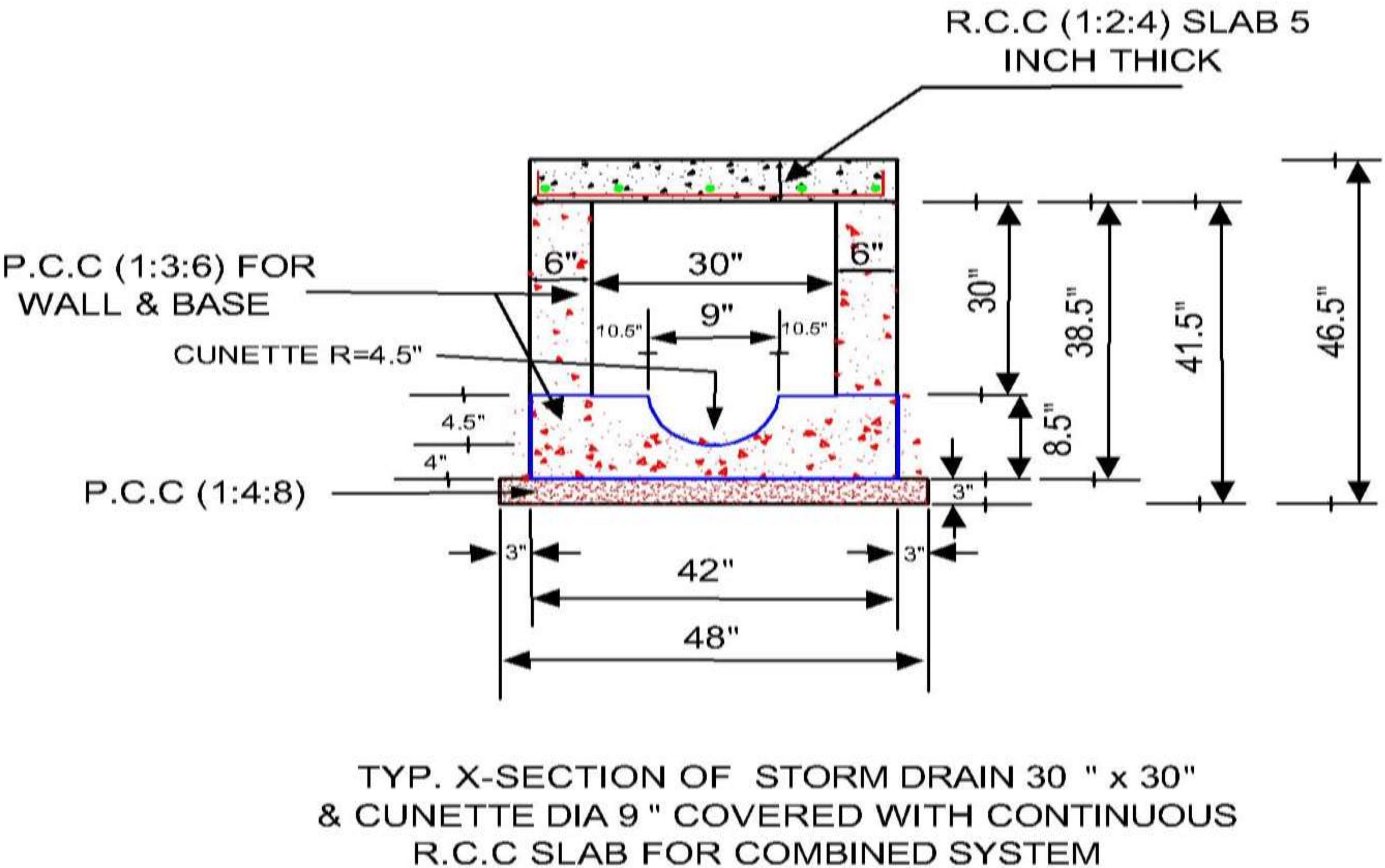


Fig M4: Typical x-section of storm drain of size 30inch × 30inch plus cunette diameter 9inch used for combined system

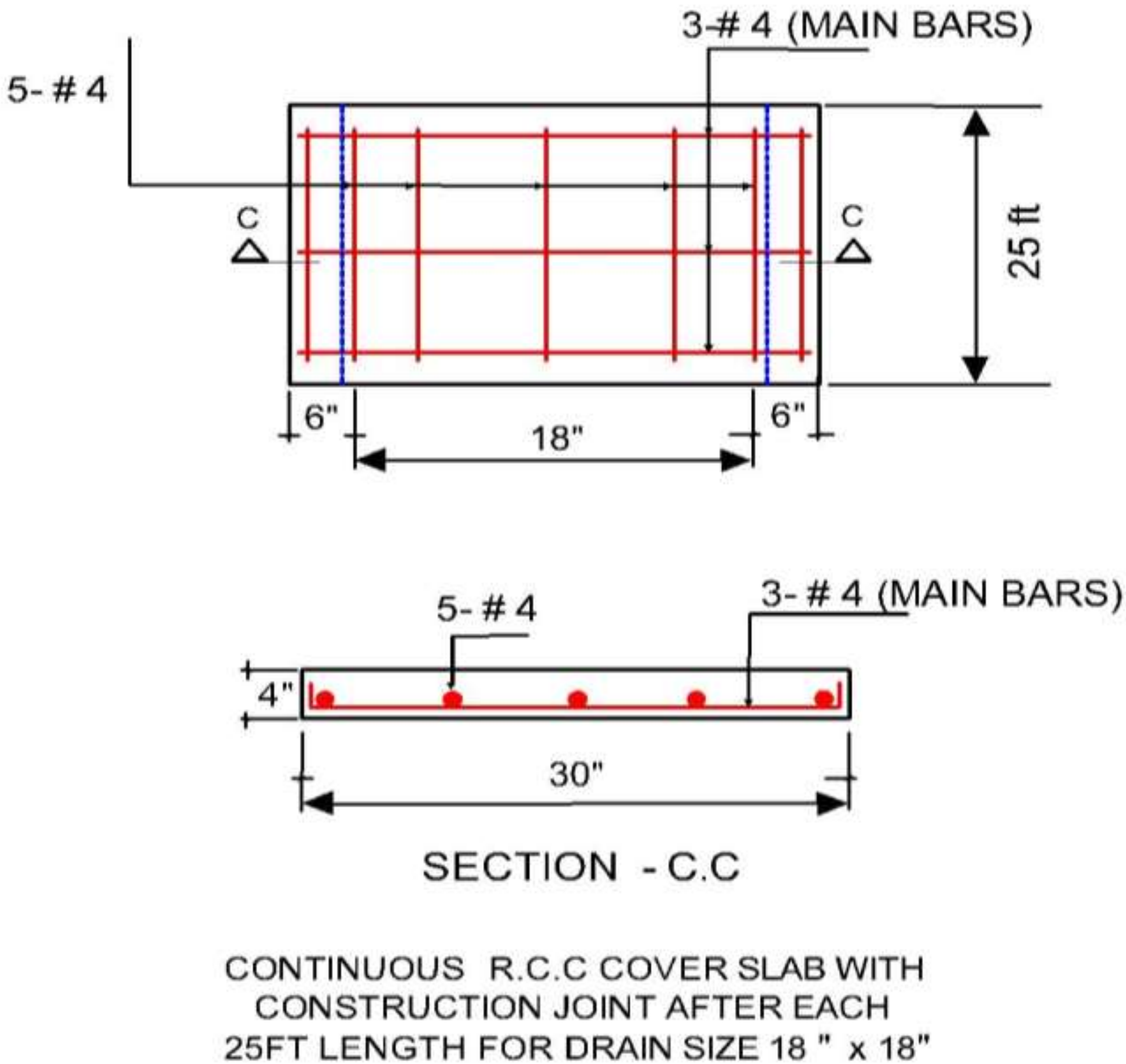


Fig M5: Plan and x-section of R.C.C cover slab including reinforcement details for drain size 18inch × 18inch used in combined system

Annexure M

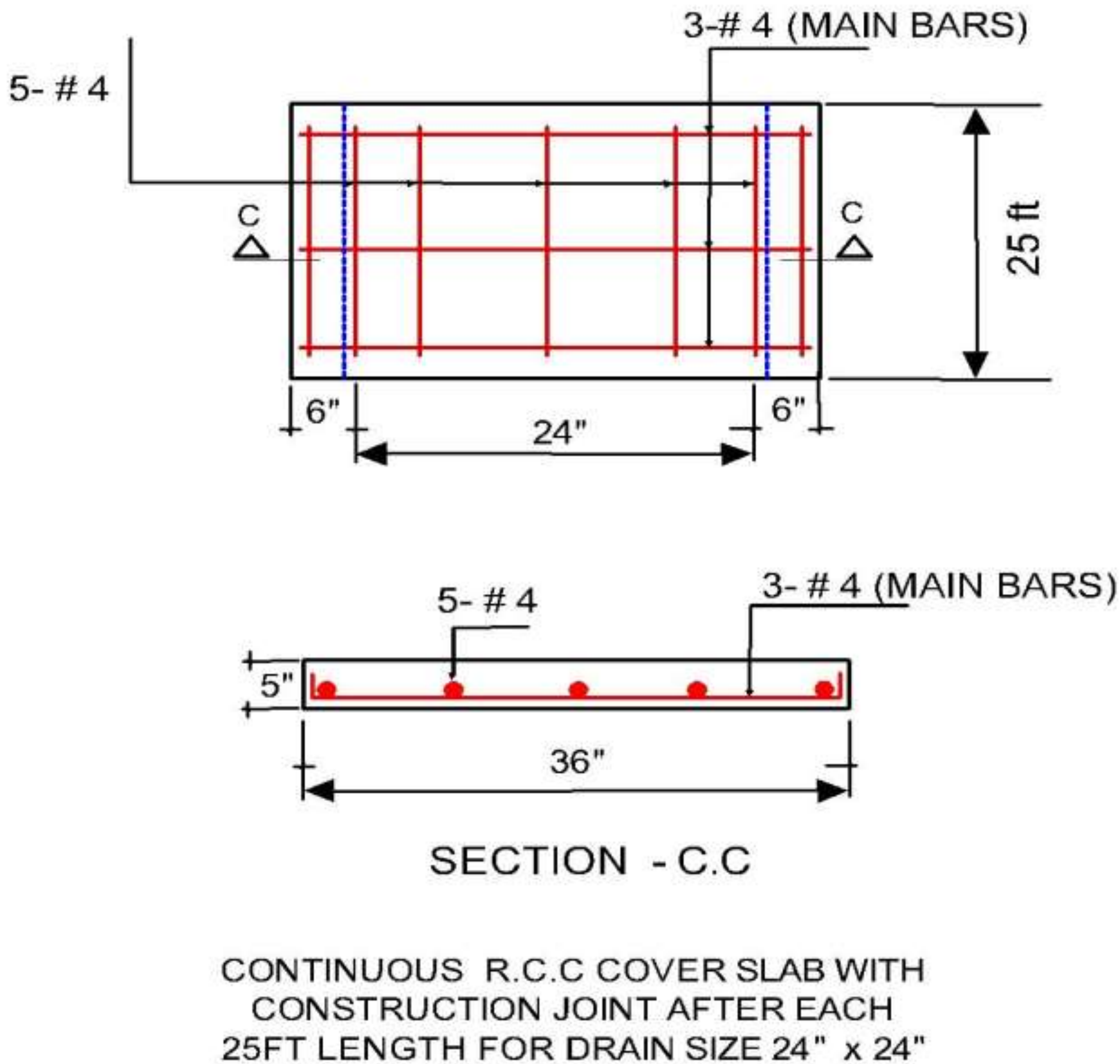


Fig M6: Plan and x-section of R.C.C cover slab including reinforcement details for drain size 24inch × 24inch used in combined system

Annexure M

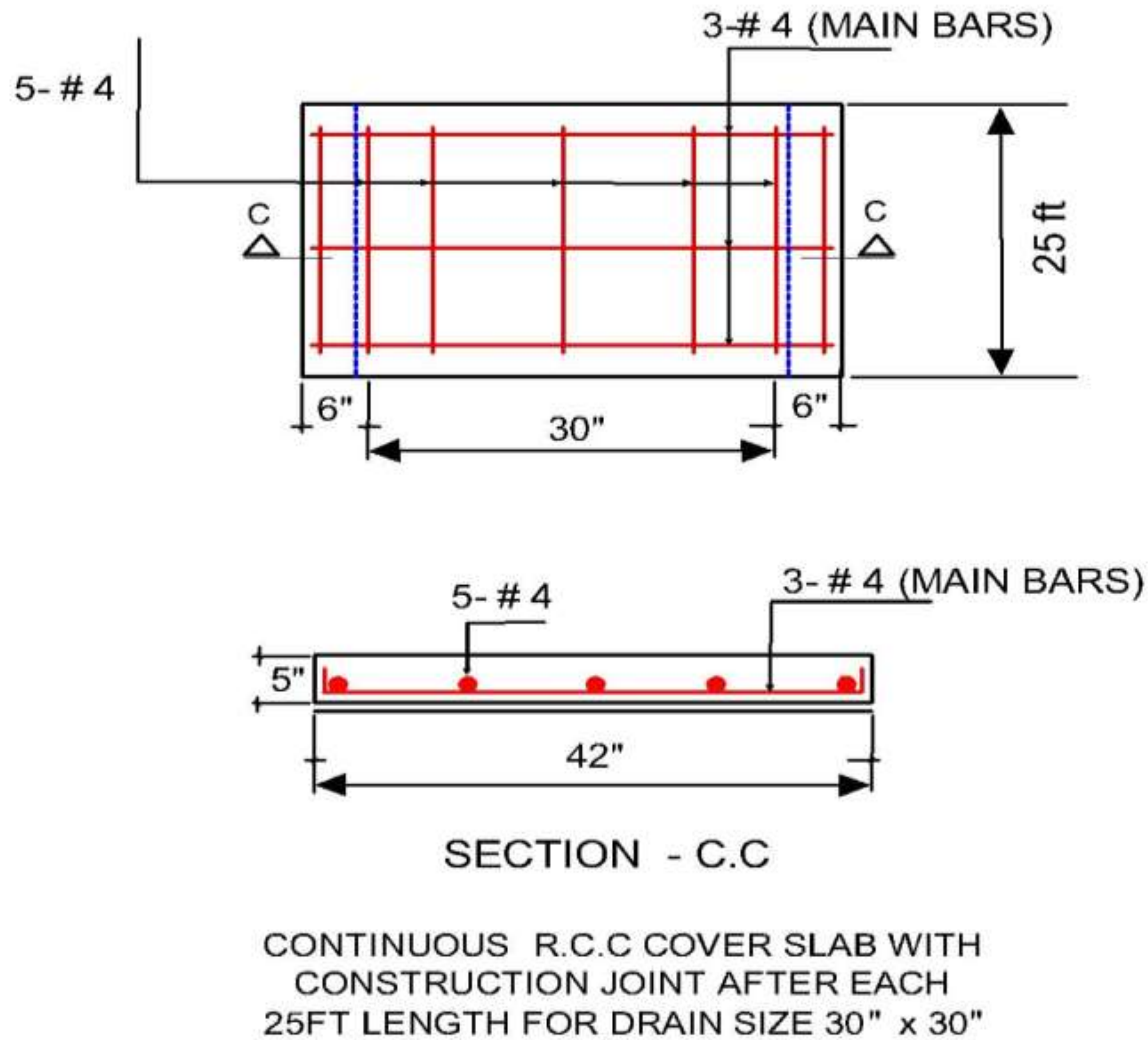


Fig M7: Plan and x-section of R.C.C cover slab including reinforcement details for drain size 24inch × 24inch used in combined system

Appendix N

Outfall Drainage Structures Drawings

ANNEXURE N: DRAWINGS OF OUTFALL DRAINAGE STRUCTURES AT OULETS OF SEPARATED STORM DRAINS

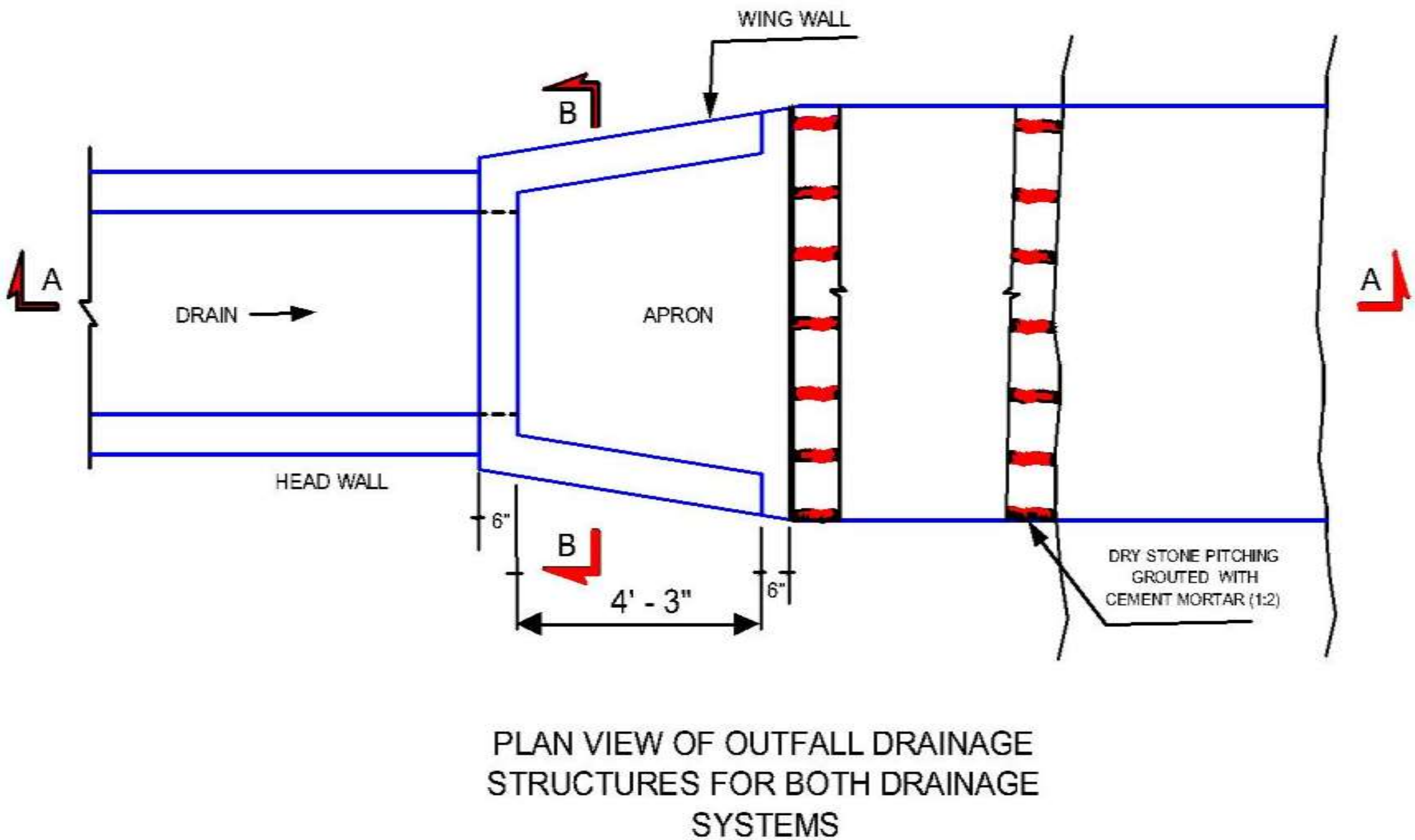
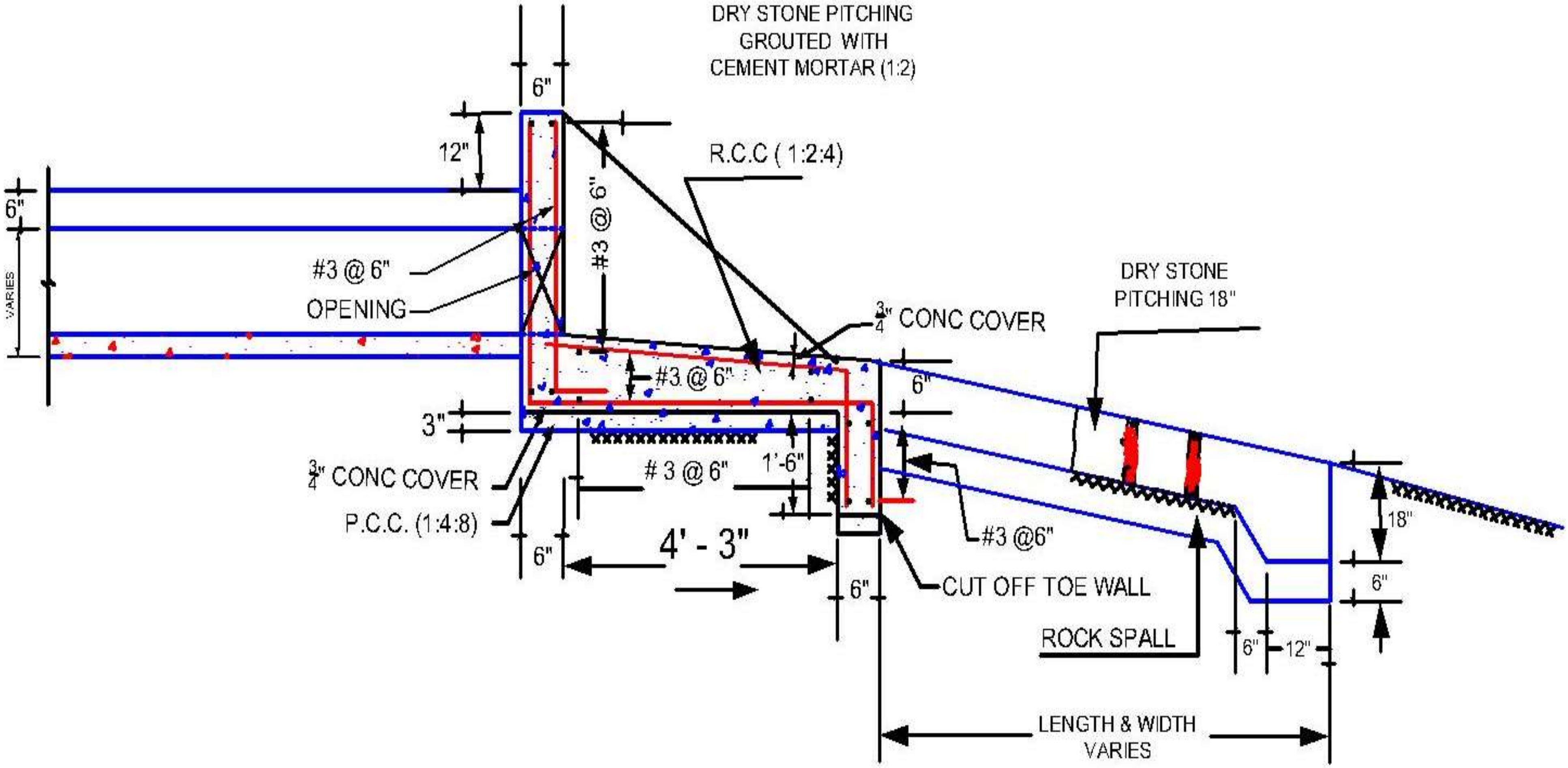


Fig N1: Plan view of outfall drainage structures at outlets of separated storm drains used in both systems



SECTION - A.A OF OUTFALL DRAINAGE STRUCTURE

Fig N2: Longitudinal section-AA of outfall drainage structures at outlets of separated storm drains including steel reinforcement details

Annexure N

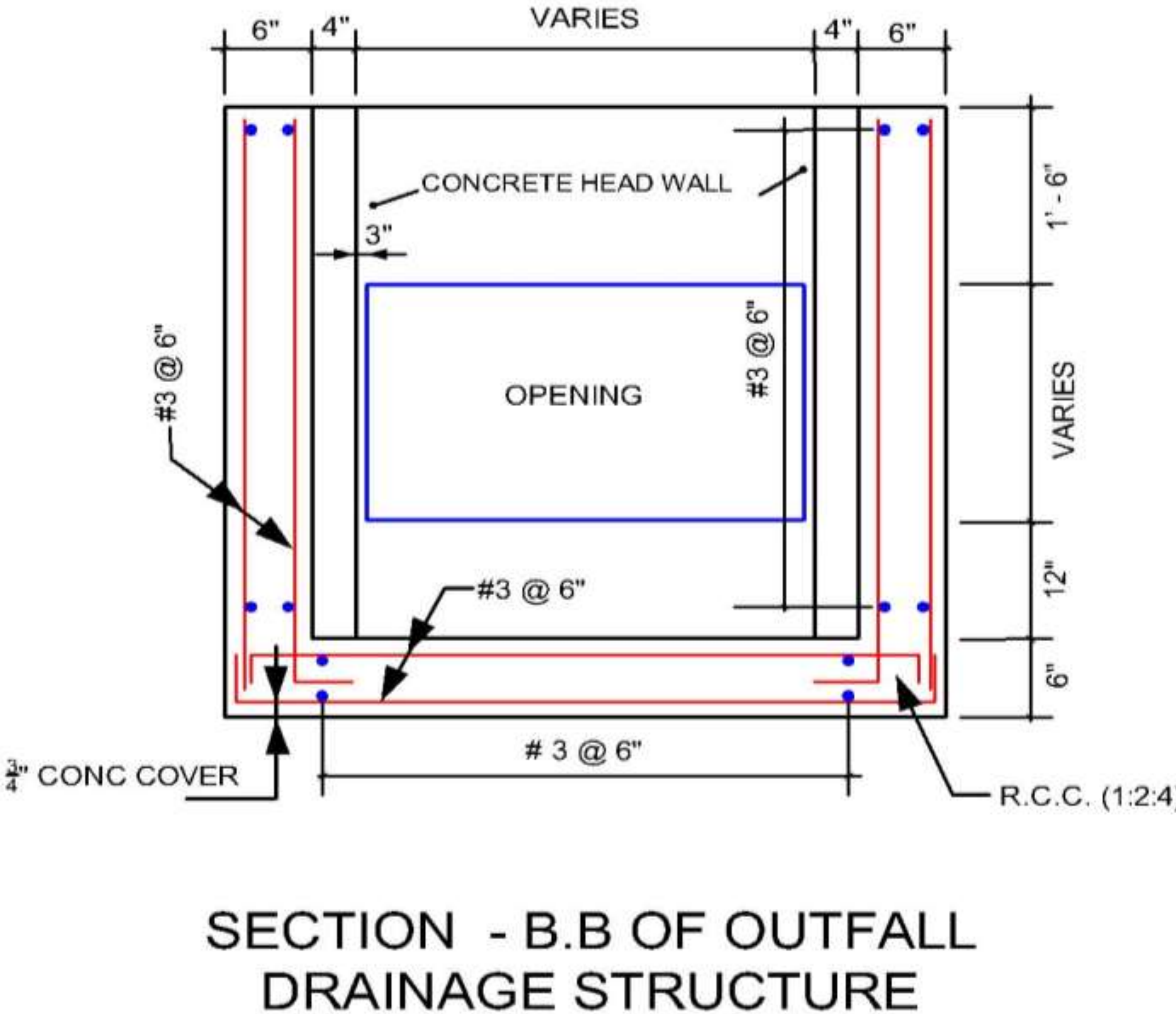


Fig N3: X- sectiontional view-BB of outfall drainage structures including steel reinforcement details

Appendix O

High Velocity Reduction Steps Drawing

ANNEXURE O: LONGITUDINAL X-SECTION DRAWING FOR PROVISION OF STEPS IN STORM DRAINS

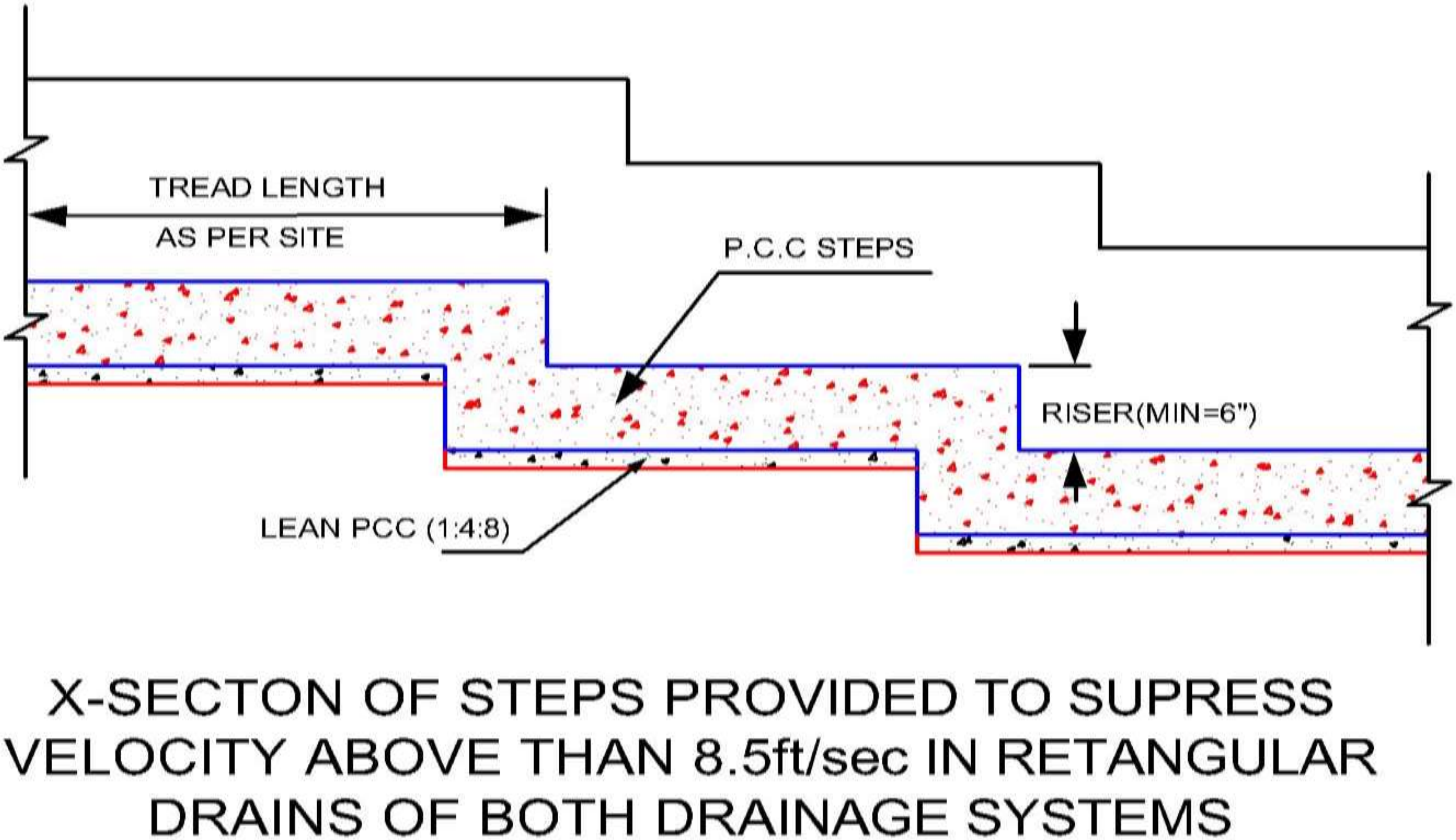


Fig O1: Longitudinal x-sectiontional view of steps provided in storm drains of both systems where maximum velocity excedds 8.5ft/sec

Appendix P

Trapezoidal Cunette Drawing & Photographs

ANNEXURE P: X-SECTIONAL DRAWING OF TRAPEZOIDAL SHAPE OPEN DRAINS USED FOR BOTH SYSTEMS

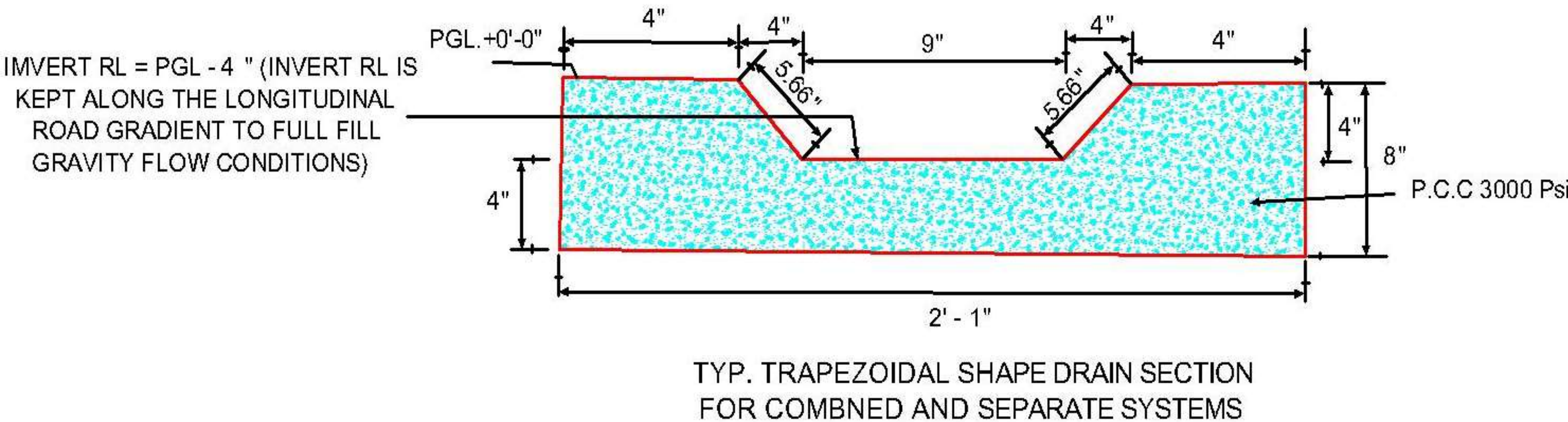


Fig P1: X-sectiontional view of cunette to convey surface storm to catchpits used in both systems

Fig P2: Photograph of Trapezoidal shape drain and perforated mild steel catchpit cover used for both systems

Annexure P

Fig P3: Photograph of Trapezoidal shape drain and perforated mild steel catchpit cover

Annexure P

Fig P4: Close Photograph of mild stell perforated mild steel catchpit cover

Appendix Q

Individual Peak Flow & Peak Factor Calulation Sheets

Table Q1: Peak Factor and sewage flow calculations based on formulas given in [9, 16, 46, 58- 60].

Flow Type	Peak Factor & Peak Sewage flow Calculations	Flow Type	Peak Factor & Peak Sewage flow Calculations
	Plots		**Flats**
Domestic	No of persons/plot = 6 Water required per person = 50 gpcd Total water required for one plot = 50 × 6 = 300 gpd Covert gpd requirement into gpm = $\frac{300}{24 \times 60}$ = 0.208 gpm One imperial gallon = 0.0027 ft³/sec(cusec) Convert gpm to cusec = 0.208 × 0.0027 = 0.001 cusec Individual sewage flow = 80% of water required Individual sewage flow/ plot = $\frac{80 \times 0.001}{100}$ = **0.00045 cusec** P.F for total population = $\frac{5}{P^{0.16}} = \frac{5}{8120^{0.16}}$ = 1.11 Peak Indivi. sewage flow 0.00045 × 1.11 = **0.0005 cusec** Peak Factor for plot population = $\frac{5}{P^{0.16}} = \frac{5}{6^{0.16}}$ = 3.71	Domestic	No of persons/plot = 5 Water required per person = 40 gpcd Total water required for one plot = 40 × 5 = 200 gpd Covert gpd requirement into gpm = $\frac{200}{24 \times 60}$ = 0.139 gpm One imperial gallon = 0.0027 ft³/sec(cusec) Convert gpm to cusec = 0.139 × 0.0027 = 0.0004 cusec Individual sewage flow = 80% of water required Individual sewage flow/ plot = $\frac{80 \times 0.0004}{100}$ = 0.0003 cusec P.F for total population = $\frac{5}{P^{0.16}} = \frac{5}{8120^{0.16}}$ = 1.11 Peak Indivi. sewage flow 0.0003 × 1.11 = **0.0003 cusec** Peak Factor for plot population = $\frac{5}{P^{0.16}} = \frac{5}{5^{0.16}}$ = 3.81
	School		**Mosque**
Non-Domestic	No of persons(15% of total population) = $\frac{15 \times 8120}{100}$ = 1218 Water required per person = 8 gpcd Total water required for school = 1218 × 8 = 9744 gpd Covert gpd requirement into gpm = $\frac{9744}{24 \times 60}$ = 6.767 gpm One imperial gallon = 0.0027 ft³/sec(cusec) Convert gpm to cusec = 6.767 × 0.0027 = 0.018 cusec Individual sewage flow = 80% of water required Indivi. sewage flow/school = $\frac{80 \times 0.018}{100}$ = **0.0146 cusec** Peak Factor = 1.11	Non-Domestic	No of persons(20% of total population) = $\frac{20 \times 8120}{100}$ = 1624 Water required per person = 3 gpcd Total water required for mosque = 1624 × 3 = 4872 gpd Covert gpd requirement into gpm = $\frac{4872}{24 \times 60}$ = 3.383 gpm One imperial gallon = 0.0027 ft³/sec(cusec) Convert gpm to cusec = 3.383 × 0.0027 = 0.009 cusec Individual sewage flow = 80% of water required Indivi. sewage flow/ school = $\frac{80 \times 0.009}{100}$ = **0.0073 cusec** Peak Factor = 1.11 **S.1/3**

Flow Type	Peak Factor & Peak Sewage flow Calculations	Flow Type	Peak Factor & Peak Sewage flow Calculations

School

Peak Indivi. sewage flow 0.0146 × 1.11 = **0.0162 cusec**

Mosque

Peak Indivi. sewage flow 0.0073 × 1.11 = **0.0081 cusec**

Peak sewage flows for 2 high schools @ 35% each $= \frac{35 \times 0.0162}{100}$ = 0.0057 cusec and average flow $= \frac{35 \times 0.0146}{100}$ = 0.0051 cusec

Peak sewage flows for 2 primary schools @ 15% each $= \frac{15 \times 0.0162}{100}$ = 0.0024 cusec and average flow $= \frac{15 \times 0.0146}{100}$ = 0.0022 cusec

Peak sewage flows for jamia mosque @ 60% each $= \frac{60 \times 0.0081}{100}$ = 0.0049 cusec and average flow $= \frac{60 \times 0.0073}{100}$ = 0.0044 cusec

Peak sewage flows for other two mosques @ 20% each $= \frac{20 \times 0.0081}{100}$ = 0.0016 cusec and average flow $= \frac{20 \times 0.0073}{100}$ = 0.0015 cusec

Community Centre

Non-Domestic

Area = 58095 sft

Water required = 200 gal/1000sft/day

Total water required $= \frac{58095 \times 200}{1000}$ = 11619 gpd

Covert gpd requirement into gpm $= \frac{11619}{24 \times 60}$ = 8.069 gpm

One imperial gallon = 0.0027 ft³/sec(cusec)

Convert gpm to cusec = 8.069 × 0.0027 = 0.022 cusec

Individual sewage flow = 80% of water required

Indivi. sewage flow $= \frac{80 \times 0.022}{100}$ = **0.01743 cusec**

Peak Factor = 1.11

Peak Indivi. sewage flow 0.01743 × 1.11 = **0.0193 cusec**

M.I Room

Non-Domestic

Area 22500 sft

Water required = 1000 gal/acre/day

Total water required $= \frac{22500 \times 1000}{43560}$ = 517 gpd

Covert gpd requirement into gpm $= \frac{517}{24 \times 60}$ = 0.359 gpm

One imperial gallon = 0.0027 ft³/sec(cusec)

Convert gpm to cusec = 0.359 × 0.0027 = 0.001 cusec

Individual sewage flow = 80% of water required

Indivi. sewage flow $= \frac{80 \times 0.001}{100}$ = **0.00077 cusec**

Peak Factor = 1.11

Peak Indivi. sewage flow 0.00077 × 1.11 = **0.0009 cusec**

Commercial (C-4,C-5)

Non-Domestic

Area = 11160 sft

Water required = 1000 gal/acre/day

Total water required $= \frac{11160 \times 1000}{43560}$ = 256 gpd

Covert gpd requirement into gpm $= \frac{256}{24 \times 60}$ = 0.178 gpm

One imperial gallon = 0.0027 ft³/sec(cusec)

Commercial (C-3)

Non-Domestic

Area = 121500 sft

Water required = 1000 gal/acre/day

Total water required $= \frac{121500 \times 1000}{43560}$ = 2789 gpd

Covert gpd requirement into gpm $= \frac{2789}{24 \times 60}$ = 1.937 gpm

One imperial gallon = 0.0027 ft³/sec(cusec)

S.2/3

Flow Type	Peak Factor & Peak Sewage flow Calculations	Flow Type	Peak Factor & Peak Sewage flow Calculations
Non-Domestic	**Commercial (C-4,C-5)** Convert gpm to cusec = 0.178 × 0.0027 = 0.00048 cusec Individual sewage flow = 80% of water required Indivi. sewage flow = $\frac{80 \times 0.00048}{100}$ = **0.00038 cusec** Peak Factor = 1.11 Peak Indivi. sewage flow 0.00038 × 1.11 = **0.0004 cusec** **Shops** Area = 13230 sft Water required = 1000 gal/acre/day Total water required = $\frac{13230 \times 1000}{43560}$ = 304 gpd Covert gpd requirement into gpm = $\frac{304}{24 \times 60}$ = 0.211 gpm One imperial gallon = 0.0027 ft^3/sec(cusec) Convert gpm to cusec = 0.211 × 0.0027 = 0.00057 cusec Individual sewage flow = 80% of water required Indivi. sewage flow = $\frac{80 \times 0.00057}{100}$ = **0.00046 cusec** Peak Factor = 1.11 Peak Indivi. sewage flow 0.00046 × 1.11 = **0.0005 cusec**	Non-Domestic	**Commercial (C-3)** Convert gpm to cusec = 1.937 × 0.0027 = 0.005 cusec Individual sewage flow = 80% of water required Indivi. sewage flow = $\frac{80 \times 0.005}{100}$ = **0.00418 cusec** Peak Factor = 1.11 Peak Indivi. sewage flow 0.00418 × 1.11 = **0.0046 cusec** **Public Buildings** Area = 29250 sft Water required = 200 gal/1000sft/day Total water required = $\frac{29250 \times 200}{1000}$ = 5850 gpd Covert gpd requirement into gpm = $\frac{5850}{24 \times 60}$ = 4.063 gpm One imperial gallon = 0.0027 ft^3/sec(cusec) Convert gpm to cusec = 4.063 × 0.0027 = 0.01097 cusec Individual sewage flow = 80% of water required Indivi. sewage flow = $\frac{80 \times 0.01097}{100}$ = **0.00878 cusec** Peak Factor = 1.11 Peak Indivi. sewage flow 0.00878 × 1.11 = **0.0097 cusec**

S.3/3

Appendix R

X-Sectional Drawings of Multi ROW Roads and Walkways

ANNEXURE R: CROSS SECTIONAL DRAWINGS OF MULTI ROW (RIGHT OF WAY) ROADS & WALKWAYS

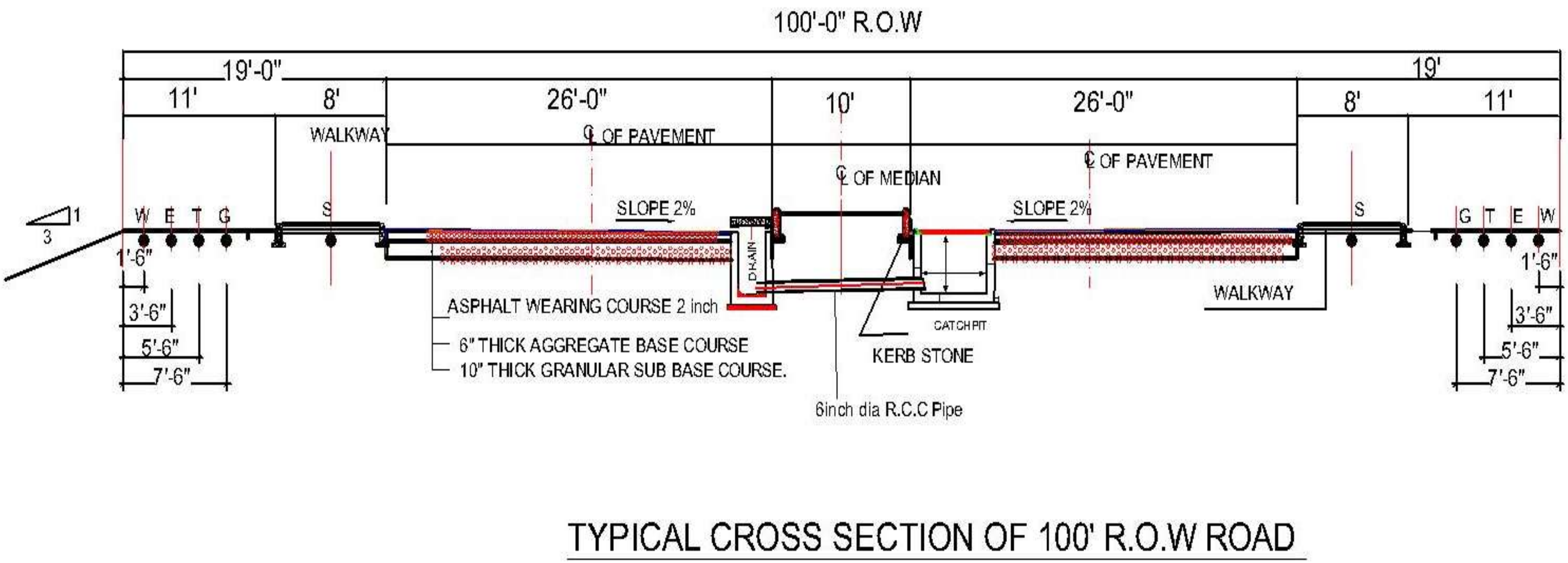


Fig R1: X-Section for MR-01 , MR-02 having right of way 100 ft along with placement of storm drain at R/S & catchpit at L/S

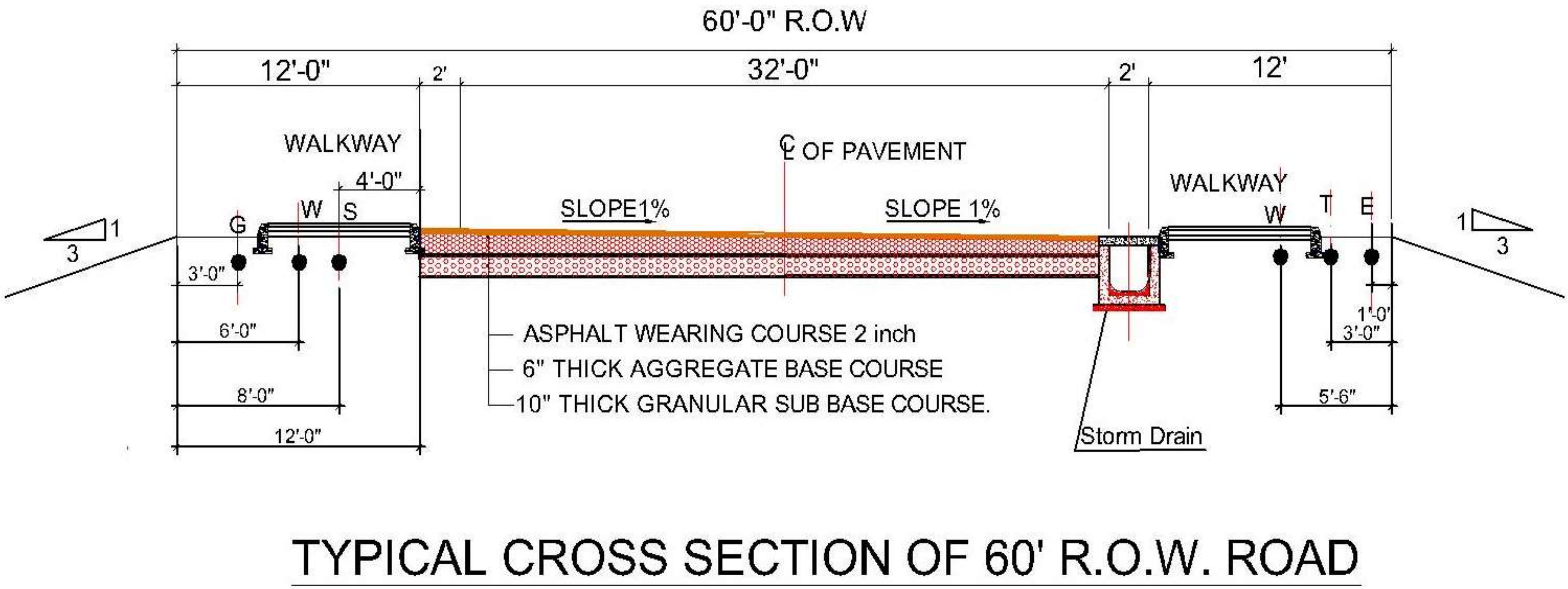


Fig R2: X-Section for Road No 14 and 22 having right of way 60 ft along with placement of storm drain, sewer line

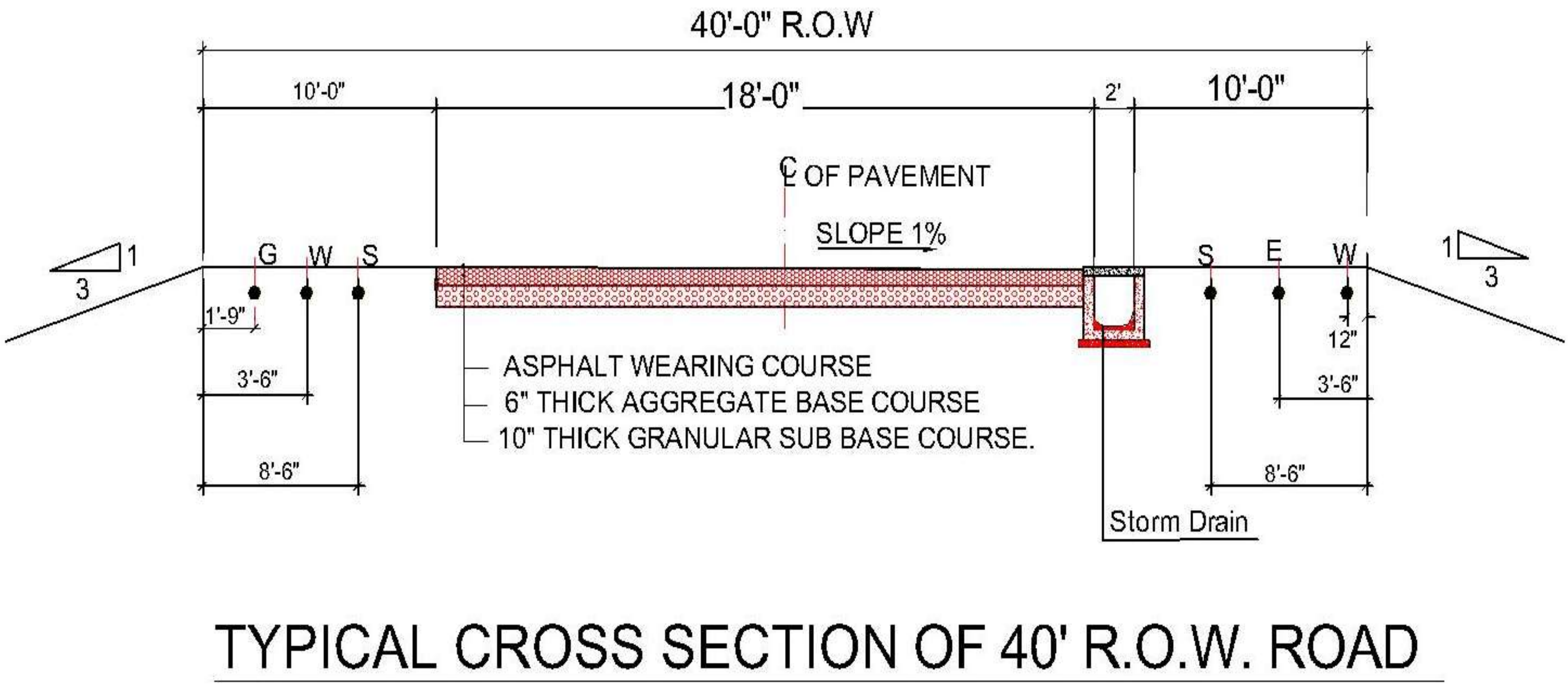


Fig R3: X-Section for Roads having right of way 40 ft along with placement of storm drain, sewer line

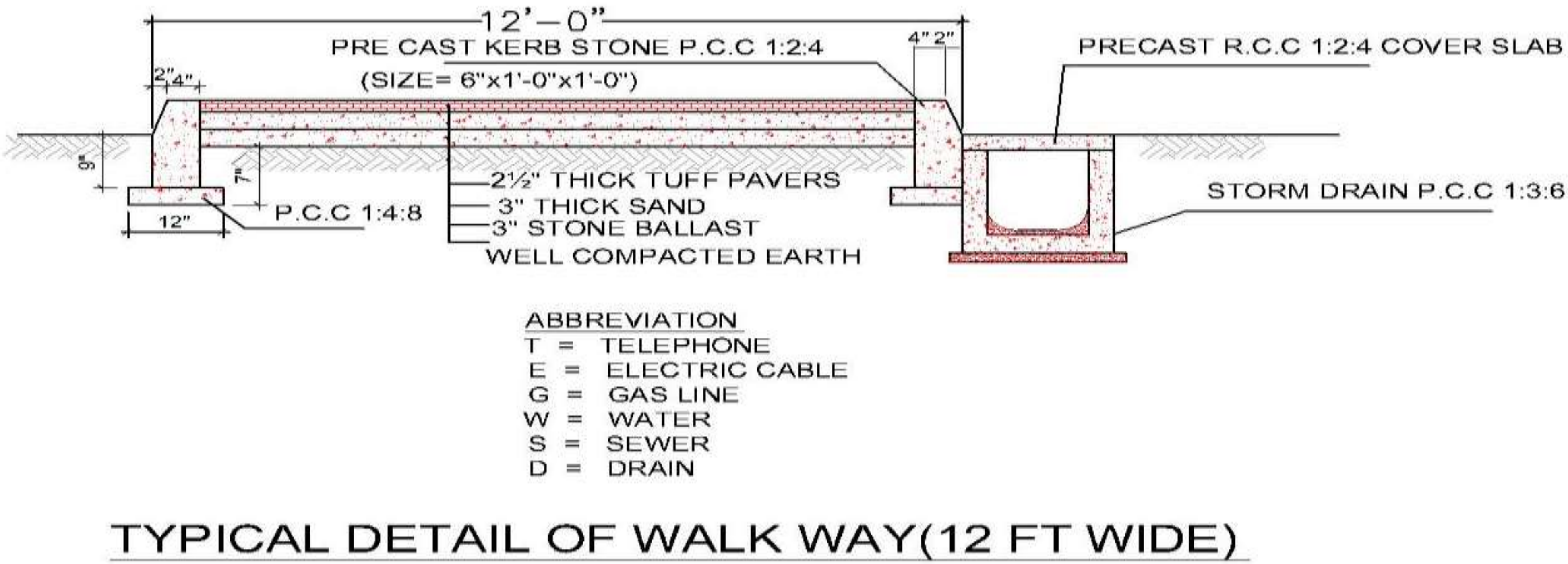


Fig R4: X-Section for Walkways 12 ft wide along with placement of storm drain or sewer line