**REPUBLIC OF GHANA**

MINISTRY OF SANITATION AND WATER RESOURCES

**LEDZOKUKU MUNICIPAL ASSEMBLY**

GREATER ACCRA METROPOLITAN AREA (GAMA) SANITATION AND WATER PROJECT

# CONSULTING SERVICES FOR COMMUNITY ENGAGEMENT/MOBILIZATION, DESIGN AND IMPLEMENTATION SUPERVISION FOR THE PROVISION OF IMPROVED SANITATION AND WATER SUPPLY IN TESHIE OLD TOWN COMMUNITY- PHASE II

# CONSTRUCTION OF SIMPLIFIED SEWERAGE NETWORK AND SEWAGE TREATMENT PLANT FOR TESHIE OLD TOWN.

## FINAL DESIGN REPORT


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# CONTENTS

# ACRONYMS

## B

| | | |
|---|---|---|
| BOD | - | Biochemical Oxygen Demand |

## C

| | | |
|---|---|---|
| CEMP | - | Construction Environmental Management Plan |
| CHRAJ | - | Commission of Human Rights and Administrative Justice |
| COD | - | Chemical Oxygen Demand |

## E

| | | |
|---|---|---|
| EHSD | - | Environmental Health and Sanitation Directorate |
| EIA | - | Environmental Impact Assessment |
| EMP | - | Environmental Management Plan |
| EPA | - | Environmental Protection Agency |
| ESMF | - | Environmental and Social Management Framework |

## F

| | | |
|---|---|---|
| FOMP | - | Facility Operation and Management Plans |

## G

| | | |
|---|---|---|
| GAMA | - | Greater Accra Metropolitan Area |
| GRM | - | Grievance Redress Mechanism |
| GWCL | - | Ghana Water Company Limited |

## H

| | | |
|---|---|---|
| HSE | - | Health Safety and Environment |

## L

| | | |
|---|---|---|
| LEKMA | - | Ledzokuku Municipal Assembly |
| LIUC | - | Low-Income Urban Community |

## M

| | | |
|---|---|---|
| MA | - | Municipal Assembly |
| MEHO | - | Municipal Environmental Health Officer |
| MLGRD | - | Ministry of Local Government and Rural Development |
| MMDA | - | Metropolitan, Municipal and District Assemblies |
| MSWR | - | Ministry of Sanitation and Water Resources |

**O**

O&M - Operation and Maintenance

**P**

PCU - Project Coordinating Unit
PAP - Project Affected Persons
PPE - Personal Protection Equipment

**R**

RAP - Resettlement Action Plan

**S**

SFD - Shit Flow Diagram
STP - Sewage Treatment Plant

**T**

TDS - Total Dissolved Solids
TOR- - Terms of Reference
TSS - Total Suspended Solids

**U**

UBF - Upflow Blanket Filter

**W**

WWTP - Wastewater Treatment Plant

# NON-TECHNICAL EXECUTIVE SUMMARY

The Government of Ghana, acting through the Ministry of Sanitation and Water Resources, is implementing the Greater Accra Metropolitan Area Sanitation and Water Project (GAMA SWP), funded through an International Development Agency (IDA) grant. The project seeks to increase access to improved sanitation and water supply in the Greater Accra Metropolitan Area (GAMA), with a special focus on low income urban communities (LIUCs), and to strengthen management of environmental sanitation across GAMA. The GAMA Project supports 22 Metropolitan and Municipal Assemblies in the Greater Accra Region, including the Ledzokuku Municipal Assembly (LEKMA).

LEKMA engaged Peoples Dialogue/WasteCare Associates Joint Venture (JV) to provide consulting services for community engagement/mobilization, design and implementation supervision for the provision of improved sanitation and water supply in Teshie Old Town, the target LIUC for improving sanitation and water supply services.

The Teshie Old Town community is located in the Ledzokuku Municipal Assembly. The community is bounded to north and south by the Accra-Tema Beach Road and the Sea (Gulf of Guinea) respectively. It stretches from the Kpeshie Lagoon (West) to First Junction Area (East). The community is made up of the Akro East and Akro West electoral Areas. From the baseline survey, the projected population of the community in 2015 is 20,145 with an average household size of 5. The total number of households by projection is estimated at 4,029.

Teshie Old Town lacks an efficient drainage system despite the existence of some concretized drains in the community. Most of the existing drains are silted limiting easy flow sullage and stormwater. The community has two major drainage/stormwater outfalls which meet at a point and drains into the Sangonaa Lagoon and finally into the sea. Most of existing drains are roadside drains.

The Teshie Old Town project area has been demarcated into eleven (11) main sewerage basins (labelled A, B, C, D, E, E1, F, G, H, J and K) as depicted in Figure ES1 below. The 11-main sewerage basins have been further demarcated into two hundred and eighty one (**281**) sewerage sub-basins.

The residential area which is situated adjacent to the WWTP site has been treated as a single sewerage basin of area **3.89Ha**. Further details of the sewer basins and corresponding network flows are discussed in Section 5.1 -5.3 of this report.

Analysis of hydraulic flows are presented in Annex C.

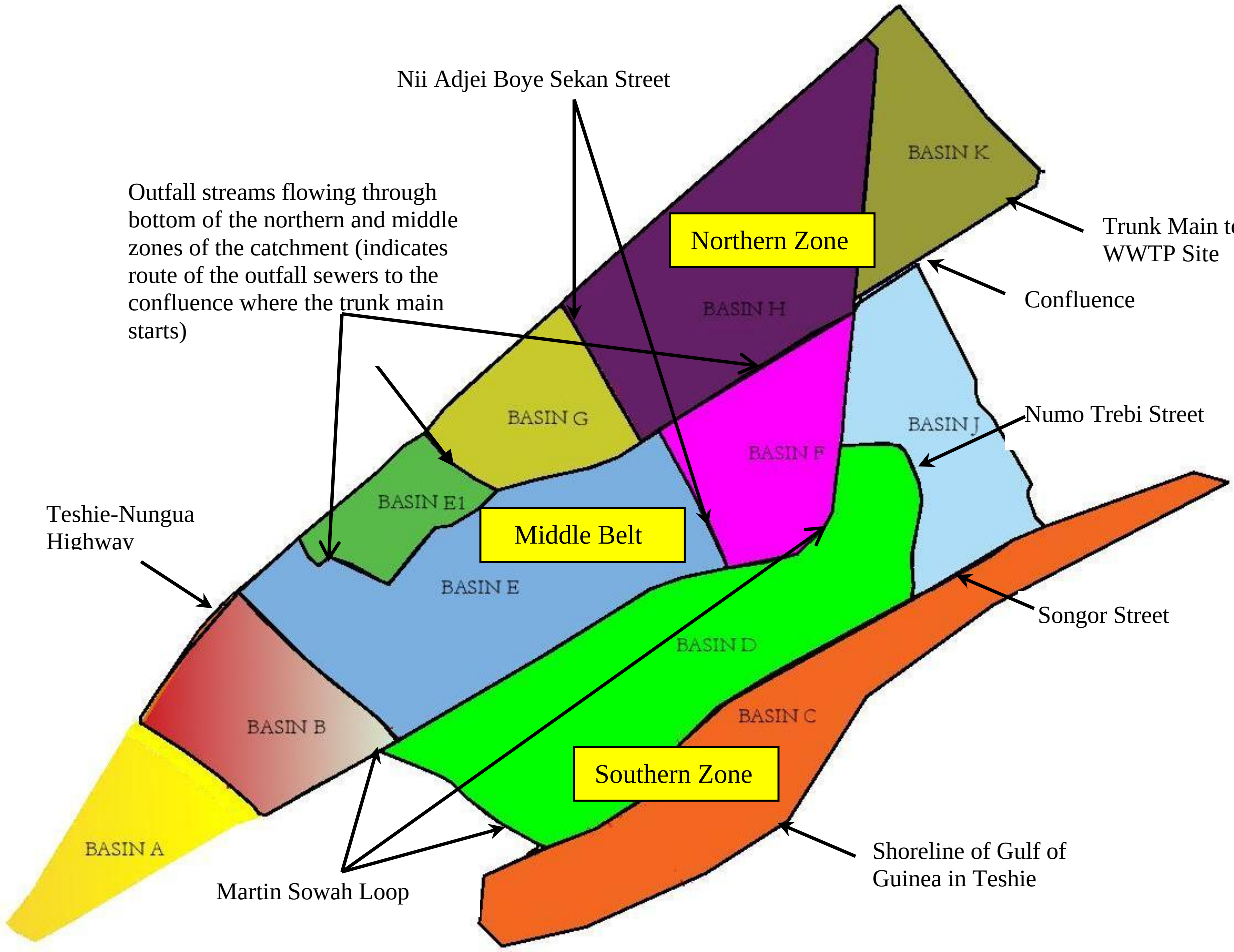



**Figure ES1: Eleven (11) Main Sewerage Basins in the Teshie Old Town catchment**

The intervention in Teshie Old Town has proceeded in two (2) phases of activities:

- Phase 1: Community Mapping, WASH Facilities Assessment and Hygiene Promotion
- Phase 2: Pre-Construction, Construction and Post-Construction Services Management

Upon completion of Phase 1 of the assignment, a simplified sewerage system (including a sewage treatment plant) was selected by the key stakeholders as the preferred intervention for improving access to sanitation in the Teshie Old Town community. The project also covers consideration of sewage flows generated by homes within the enclave adjacent to WWTP site, which if not considered as part of the design, may create imbalances/shocks in treatment processes of the designed WWTP.

The adoption of the simplified or condominial sewer network leads to a general drastic reduction in the total length of large public sewers and hence costs. In comparison to the conventional sewerage system, the condominial system is mostly made of condominial branches and only around (30–40) % of public sewers. The condominial branch is the pipeline that collects *all* the wastewater from households in houses within a block and conveys to the public sewer that passes along the boundary of the block. Houses are connected to the condominial/block sewers through house connection sewers (100 mm) and chambers or in some cases with uPVC elbows and cleanouts.

In order to lay condominal/block sewers along alleys and way-leaves makes *community engagement for consultations and agreement* among neighbouring households/households a critical element of successful project implementation.

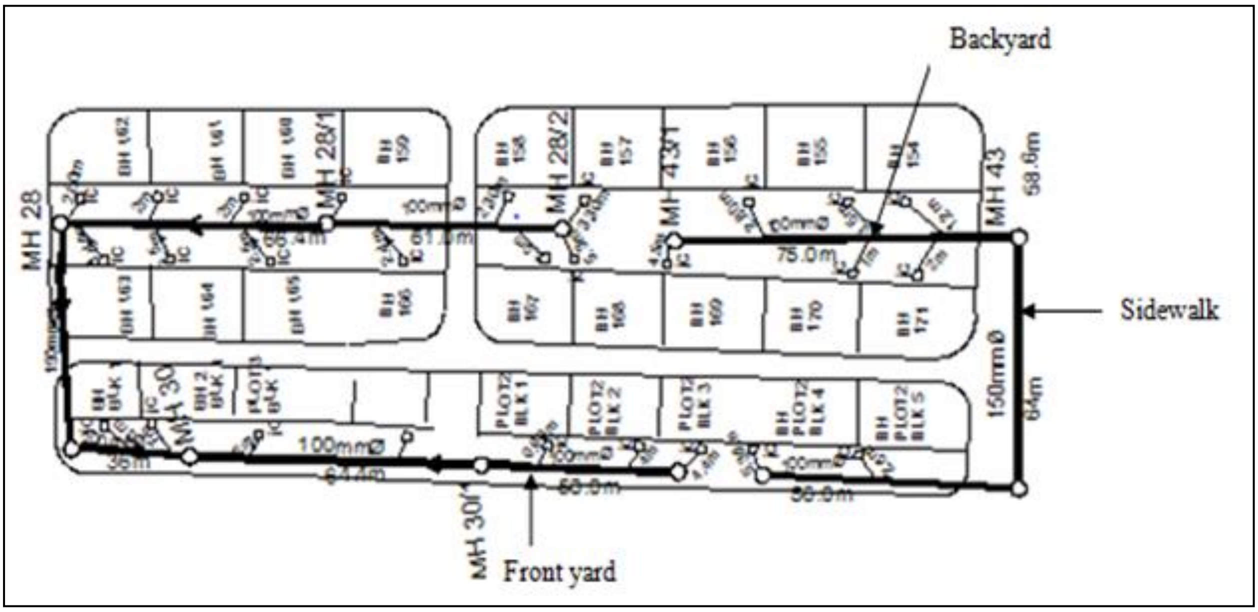



Figure ES2: Simplified sewer configurations for block of houses at Bimpe Hill, Asafo, Kumasi, Ghana

A project design period of 20 years is applied in the population projection for the Teshie Old Town sewerage systems with 56 litres per capita effluent discharge.

The major works for the Teshie Old Town simplified sewerage scheme is summarised as follows:

- Construction of a new simplified sewerage network covering Teshie Old Town and the enclave adjacent to the WWTP with a projected sewage flow of **1,695m$^3$/d**.
- Construction of wastewater treatment plant (WWTP) with a treatment capacity of **1,800m$^3$/d**.

Table ES1 summarises the sewer-pipe types and network lengths for carrying the projected sewage flows, while Table ES2 provides the influent wastewater and expected average treated effluent characteristics.

**Table ES1: Estimated sewer pipe lengths for Teshie Old Town**

| Pipe Diameter (mm) | Length (km) |
|---|---|
| 100 | 35.0 |
| 150 | 2.0 |
| 225 | 1.8 |
| 300 | 0.5 |
| 350 | 0.3 |
| 400 | 0.4 |

The new wastewater treatment plant to be constructed will include preliminary, primary, secondary and tertiary treatment units. Additionally, it will include sludge treatment and biogas utilization facilities.

Figure ES1 presents a schematic diagram of the unit operations and processes of the proposed WWTP.

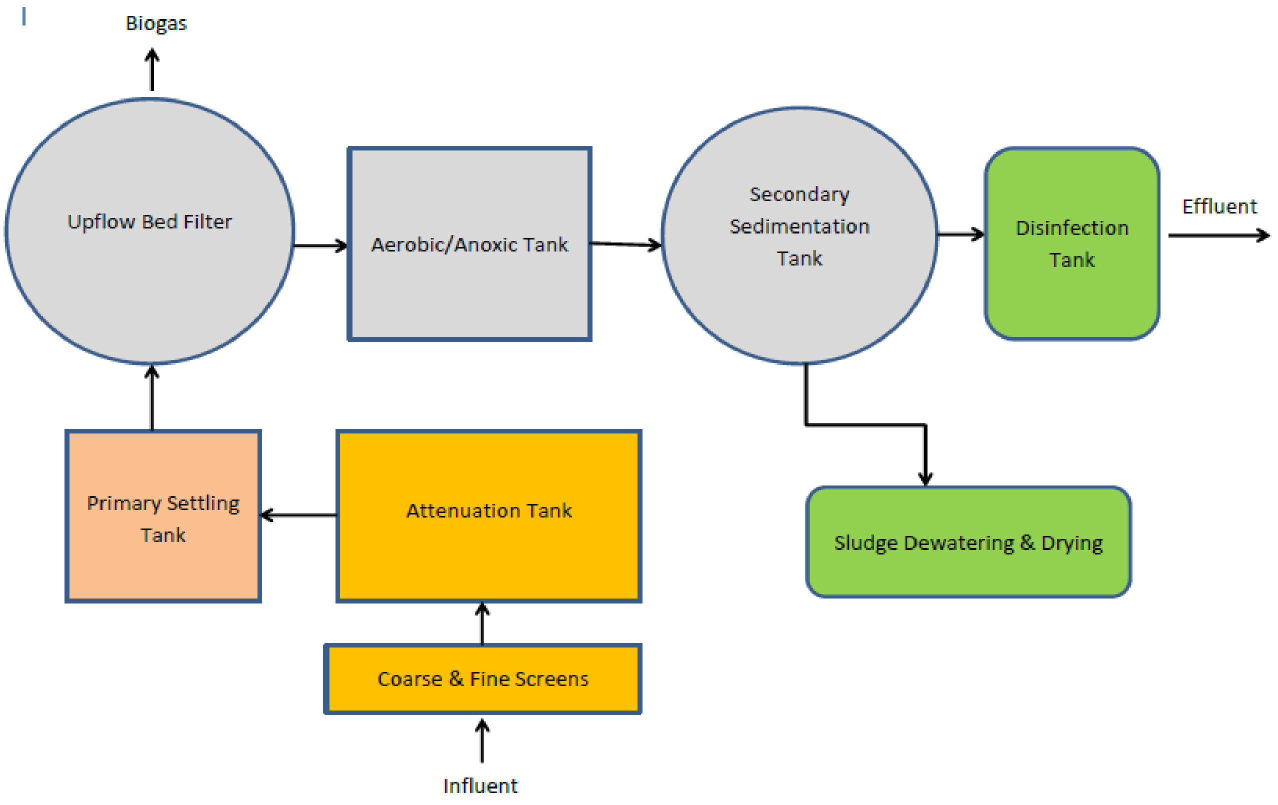



**Figure ES2: Schematic diagram of unit operations and processes for Teshie Old Town WWTP**

**Table ES2: Summary design flows, influent and effluent wastewater characteristics**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Capacity Design Flow, $Q_d$** | 1800m$^3$/day | | | | | |
| **Design Hourly Flow, $Q_h$** | 90m$^3$/h | | | | | |
| **Wastewater Quality Parameter** | **$COD_{Cr}$** | **$BOD_5$** | **Ammonia nitrogen** | **Suspended Solids (SS)** | **Total phosphorus** | **pH** |
| *Influent Wastewater* | 1000mg/L | 500 mg/L | 30mg/L | 400mg/L | 10mg/L | —— |
| *Effluent Wastewater* | 100mg/L | 25 mg/L | 10mg/L | 25mg/L | 2mg/L | 6.5~9.0 |

From the results of field sub-soil investigations carried out , the proposed location for the WWTP indicate that the site is underlain by saturated high plasticity dark silty clays and fine sand with low load bearing capacity up to a depth of 5m. This soil therefore requires improvement with approved well compacted non-plastic gravel fill material of up to minimum depth of 2.0m.

The summarised description of the unit operations and process units of the WWTP is presented in Table ES3. The corresponding Civil engineering works for the units, bulk earthworks and ancillary works are presented in Table ES4. Figure ES 3 shows a plan view of the proposed plant. Details of accompanying installations for electro-mechanical and instrumentation as well as electrical works are described under Section 6.4 – 6.6 of the main report.

**Table ES3: Treatment stages and associated unit processes**

| Treatment Stage | Unit Process/Facility | Description of Unit Process |
|---|---|---|
| Preliminary Treatment | Screening | Wastewater influent flows through coarse and fine screens under gravity to remove debris. |
| | Attenuation tank | Flow equalization provides a more constant hydraulic or organic loading of downstream treatment processes. The diurnal variation of wastewater inflows can have adverse effects on the efficiency, reliability, and control of unit process operations. |
| Primary Treatment | Primary sedimentation tank | This involves the separation and removal of suspended solids and floatables (scum) from wastewater by physico-chemical methods. This process also leads to reductions in TSS, COD and BOD loading of the influent. |
| Secondary Treatment | Upflow bed filter | The organic fraction of the wastewater (i.e. COD and BOD) is converted to biogas under anaerobic conditions in the reactor. Biogas will be harvested for generation of electricity. |
| | Aerobic/anoxic tank | Aerobic-anoxic treatment, which mimics activated sludge process, is applied to reduce the nutrient content of the wastewater effluent from the UBF as well as any leftover BOD and COD. |
| | Secondary sedimentation tank | This involves the removal of microorganisms (biological floc) and other solids after biological treatment. The sludge is recycled to the primary sedimentation tank. |
| Tertiary Treatment | Disinfection tank | This is an effluent polishing process that is intended to destroy pathogens. |
| Sludge Treatment | Sludge dewatering/drying | Sludge dewatering is basically the separation of liquid and solids. Dewatering can be done naturally by drying beds and solar energy or by mechanical and thermal units. |
| Biogas Utilization | Biogas recovery and cleaning | A biogas storage bag is used for safe and secure storage of biogas. The biogas produced by the anaerobic digestion process will partially be used for thermal drying of the solid fraction. |

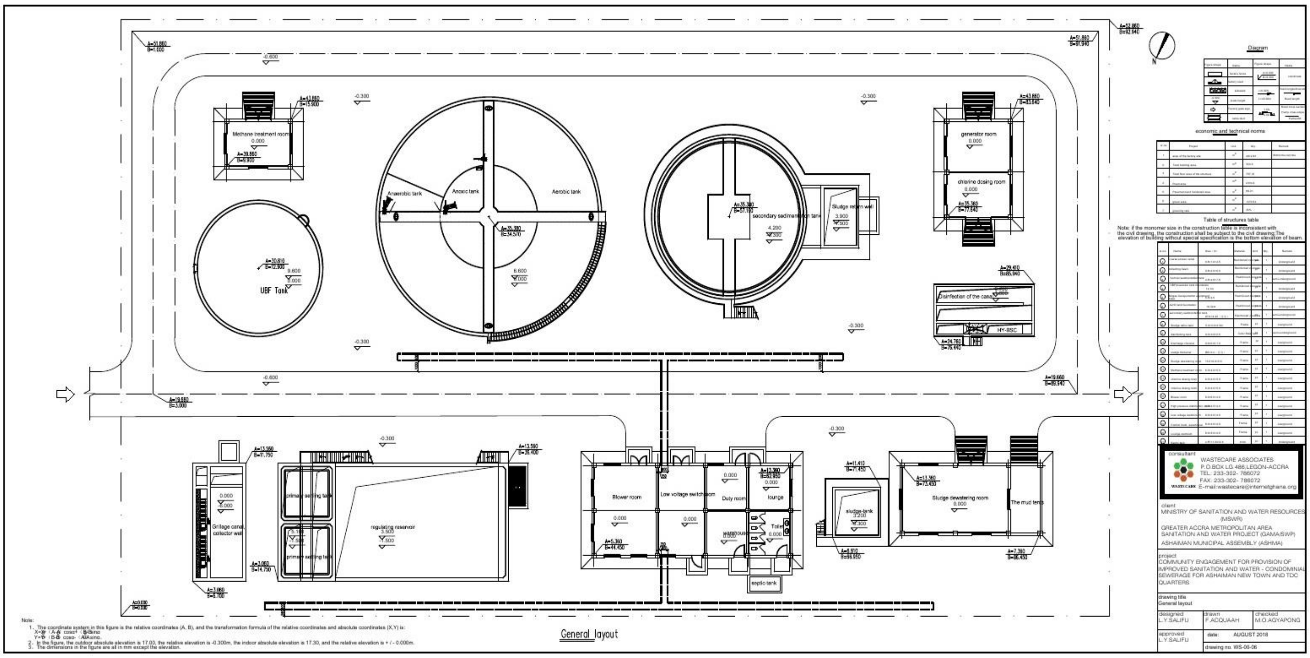


**Figure ES3: Schematic diagram of unit operations and processes for Teshie Old Town WWTP**

**Table ES4: Summarized Description of Civil works for WWTP**

| Item | Unit Process/Operation | Functional Size | Type of Facility | Unit | Qty | Remarks |
|---|---|---|---|---|---|---|
| 1 | Coarse/fine screen canal | 60 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Underground Tank |
| 2 | Collection basin | 235 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Underground Tank |
| 3 | Primary settling tank | 175 $m^3$ | Reinforced Concrete | No. | 2 | Rectangular Semi-Underground |
| 4 | Regulating tank/elevator pump room | 800 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Semi-Underground |
| 5 | UBF anaerobic tank with R.C foundation | 990 $m^3$ | Reinforced Concrete | No. | 1 | Cylindrical Underground |
| 6 | Biogas transportation equipment with R.C base | 19 $m^3$ | Reinforced Concrete | No. | 1 | Cylindrical Underground |
| 7 | A2/0 tank with R.C. foundation | 1865 $m^3$ | Reinforced Concrete | No. | 1 | Cylindrical Underground |
| 8 | Secondary sedimentation tank | 925 $m^3$ | Reinforced Concrete | No. | 1 | Underground |
| 9 | Sludge recirculation tank | 55 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Over-ground |
| 10 | Disinfection tank | 95 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Semi-underground |
| 11 | Outlet/PAP metering channel | 8 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Over-ground |
| 12 | Sludge dewatering room | 390 $m^3$ | Frame | No. | 1 | Rectangular Over-ground |

| Item | Unit Process/Operation | Functional Size | Type of Facility | Unit | Qty | Remarks |
|---|---|---|---|---|---|---|
| 14 | Methane treatment room | 120 $m^3$ | Frame | No. | 1 | Rectangular Over-ground |
| 15 | Chemical dosing room | 120 $m^3$ | Frame | No. | 1 | Rectangular Over-ground |
| 16 | Blower room | 260 $m^3$ | Frame | No. | 1 | Rectangular Over-ground |
| 17 | High pressure distribution room | 135 $m^3$ | Frame | No. | 1 | Rectangular Over-ground |
| 18 | Low voltage switch room | 130 $m^3$ | Frame | No. | 1 | Rectangular Over-ground |
| 19 | Control room, warehouse | 185 $m^3$ | Frame | No. | 1 | Rectangular Over-ground |
| 20 | Lounge, rout room | 185 m | Frame | No. | 1 | Rectangular Over-ground |
| 21 | Bio-digester | 10 $m^3$ | Precast Concrete | No. | 1 | Rectangular, partially Underground |
| 22 | WWTP site road works & side kerbs | 600 m | Bituminous | SET | 1 | Over-ground |
| 23 | WWTP site, paving of open areas | 2340 $m^2$ | Precast Blocks | SET | 1 | Over-ground |
| 24 | WWTP site, U-drainage works | 600 m | Precast Concrete | SET | 1 | Underground |
| 25 | WWTP site, earthworks & site grounds stabilization works | 8800 $m^2$ | Earthworks & Drainage | SET | 1 | Underground |

Detailed description of electro-mechanical, instrumentation equipment, electrical and ancillary works associated with each of the unit processes of the WWTP are described in Section 6.5 – 6.6 and the accompanying drawings of Annex III.

In order to overcome the chronic poor operation and maintenance management practices that beset the running of wastewater treatments plants, the design of the proposed sewerage system in Teshie Old Town has derived lessons and experiences from Asafo simplified sewerage system regarding the reasons and factors of success and/or failure. It is proposed that a fees (tariff) schedule based on the category of premises (taking into account the number of users). Furthermore, it is proposed that a small-scale service provider (local operator) is embedded within Teshie Old Town to promote *community-private operator-partnership* for the maintenance of sewers. This is very critical not only to enhance household connections but also ensure rapid response to routine sewer complaints including blockage of grease traps and house connection chambers.

Lessons from the 2-years successful operation of the Mudor UASB plant has also been taken into account and therefore costs allowed for the test-running and O&M management of the proposed plant over a two-year period. Detailed O&M routines associated with the specific unit operations and processes of the WWTP are provided in Chapter 7.

Learning from international experience, especially implementation of simplified (condominium) sewerage in Brazil, prior to commencement of construction of sewers, engagements with representatives of the defined basins (sewer sheds) will be held to engender participation and reaching agreements on the location of sewer lines and their involvement in inspection of works. Representatives of basin organisations will complete terms of agreement for the construction of the sewers, operation and maintenance costs as well as the administration of fees to be charged for sewerage services.

The estimated cost of constructing the Teshie Old Town simplified sewers and construction of WWTP is Twenty nine million, six hundred and forty thousand, six hundred and sixty nine Ghana cedis (**GHS 29,640,669**)[1]; equivalent to US Dollars Five million, three hundred and eighty nine thousand, two hundred and twelve Dollars, sixty eight cents (**US$5,389,212.68**).

Table ES5 shows the itemised cost components for the implementation of the Teshie Old Town simplified sewerage system.

**Table ES5: Estimate of the GAMA-Teshie Old Town Sewerage Project**

| Bill | Description | Amount (Gh¢) |
|---|---|---|
| 01. | General Items | **1,253,750.00** |
| 02. | Gravity Sewerage Works Construction | **5,963,431.13** |
| 03. | Sewerage Manholes & Grease Traps | **2,836,234.63** |
| 04. | Sewage Treatment Plant Civil Works | **7,974,861.94** |
| 05. | Sewage Treatment Plant Electromechanical Works | **5,927,140.00** |
| 06. | Sewage Treatment Plant Pipework & Pipework Ancillaries | **864,003.80** |
| 07. | Sewage Treatment Plant Electrical Works | **1,135,157.81** |
| 08. | Sewage Treatment Plant Instrumentation | **64,837.00** |
| 09. | Operation And Maintenance Provisions | **553,755.00** |
| 10. | Environmental & Social Safeguards Implementation | **270,297.25** |
| 11. | GS & WWTP Systems Management Team Office | **468,989.00** |
| 12. | Wwtp Laboratory Building | **260,258.50** |
| **A** | **Sub-Total** | **27,572,716.05** |
| **B** | **Add 7.5% Of Sub-Total As Contingency** | **2,067,953.70** |
| **C** | **Total Tender Price (A+B)** | **29,640,669.75** |
| **D** | **Discount (……..)% If Any** | |
| **E** | **Total Tender Price Carried To Form Of Tender** | **29,640,669.75** |

The above estimated project cost also caters for incidental regulatory compliance costs including implementation of environmental and social safeguards as well as compensation for project affected persons (PAPs). Details of these are presented in Environmental Impact Statement and the Resettlement Action Plan (RAP) which have been submitted as separate reports. The RAP describes the compensation for PAPs and implementation issues.

It is expected that the Government of Ghana (GoG) through the Ministry of Finance will provide funds for direct compensation to project affected persons, and also bear the cost of RAP Implementation including grievance redress mechanism as well as monitoring and evaluation.

[1] US1=GHS5.50

The above project is to be funded as part of the International Development Agency (IDA) financed by Greater Accra Metropolitan Area (GAMA) Sanitation and Water Project, and will be implemented by the Ledzokuku Municipal Assembly (LEKMA) under direct facilitation support of the Ministry of Sanitation and Water Resources (MSWR).

The draft bid document for this project has been prepared and will be submitted as part of the submittal requirement for review and comments by the GAMA-PCU/LEKMA. The Consultant will assist LEKMA to invite and receive competitive bids at the national level.

It is expected that the review of draft final detailed designs and bid documents will be completed over the next three (3) months period leading to award of contract. Additional twelve (12) months will be required to execute physical construction of the project scope of works. A total of fifteen (15) months is proposed for the execution of the whole procurement process.

A further 12-months period of post-construction O&M activities of the facility has been proposed to lay the basis for improving the management of the sewerage system through a local private operator. It is planned that key community engagement activities leading to the engagement of local private operator will be carried out parallel to construction activities.

| | **Proposed Implementation Plan** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Activity** | **Months** | | | | | | | | | | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| Review of draft bid documents and draft detailed design report | | | | | | | | | | | | | | | | | | |
| Carry out the bidding process and award of Contract | | | | | | | | | | | | | | | | | | |
| Pre-contract start-up meeting | | | | | | | | | | | | | | | | | | |
| Engagement with utility agencies, Ghana standards board and the EPA. | | | | | | | | | | | | | | | | | | |
| Community sensitization for smooth project implementation | | | | | | | | | | | | | | | | | | |
| Mobilize personnel, equipment and materials to site | | | | | | | | | | | | | | | | | | |
| Construction works | | | | | | | | | | | | | | | | | | |

**Figure 9.1: Proposed Implementation Schedule**

From above discussions, it is concluded that the planned intervention of construction of the sewerage system is justified by the expected improvement in the containment of wastewater and faecal sludge flows within Teshie Old Town and the immediate environs, as well as ensuring that all stages of the faecal sludge value chain is managed in an environmentally sustainable manner.

The capacity building of staff through their involvement in managing the proposed intervention will contribute to achieving the objectives of the four (4) main components of the GAMA Sanitation and Water Project (SWP).

# 1 INTRODUCTION

## 1.1 BACKGROUND

The Government of Ghana, acting through the Ministry of Sanitation and Water Resources, is implementing the Greater Accra Metropolitan Area (GAMA) Sanitation and Water Project (GAMA SWP), financed by the World Bank through an IDA grant with the objective of increasing access to improved sanitation and improved water supply in the GAMA, with emphasis on low income urban communities, and to strengthen management of environmental sanitation across the GAMA. The GAMA Project supports eleven Metropolitan and Municipal Assemblies in the Greater Accra Region. The Project has four components:

- **Component 1**-Provision of water and environmental sanitation services to priority low income areas of GAMA
- **Component 2-** Improvement and expansion of the water distribution network in the GAMA
- **Component-3** Improvement and expansion of waste water and faecal sludge collection, transportation and treatment in GAMA, and
- **Component 4**- Institutional Strengthening.

An important component of this project is the upgrading of access to Water, Sanitation and Hygiene in selected communities in the Metropolitan and Municipal Assemblies in GAMA.
Liquid waste disposal practices in Teshie Old Town community are generally poor. There is lack of effective human excreta disposal system in the community. In the Teshie Old Town community, the community rely on public toilets for defecation which may not be closed in the night. Other methods for defaecation include tying the faeces in polythene bags and dumping it in refuse containers and dilute and pour indiscriminately around. The lack of effective disposal of human excreta in the community poses a critical challenge to environmental sanitation improvement efforts of the Assembly.

Peoples Dialogue/WasteCare Associates JV has been engaged to provide consulting services for community engagement/mobilization, design and implementation supervision for the provision of improved sanitation and water supply in Teshie Old Town community.

The assignment is being carried out in two phases. Specific activities under both phases include:

- Phase 1: Community Mapping, WASH Facilities Assessment and Hygiene Promotion
- Phase 2: Pre-Construction, Construction and Post-Construction Services Management

Specific activities under both phases include:

Phase 1: Community Mapping, WASH Facilities Assessment and Hygiene Promotion

1. *General Project Management and Quality Assurance of Outputs*
2. *Community Mapping and WASH Facilities and Service Assessment and Audit*
3. *Hygiene Promotion and Behavioral Change Communication (BCC)*
4. *Preparation of Community-Based Results-Based Monitoring and Evaluation System*
5. *Development of Service Delivery Models*
6. *Financing and Investment Packaging*

Phase 2: Pre-Construction, Construction and Post-Construction Services Management

7. *Update of WASH facilities and services*
8. *Field Investigations and Engineering Studies*
9. *Detail Architectural and Engineering Drawings*
10. *Preparation of Bill of Quantities and Tender Documents*
11. *Technical Assistance in Tendering and Bidding Process*
12. *Construction Supervision*
13. *Post Construction Services and Defects Liability Management*
14. *Preparation and Training on Facility Operation and Management Plans (FOMPs) & and Facilities Operation and Maintenance Handbooks (FOM-H)*
15. *Household endline survey and preparation of WASH community scorecard*

Upon completion of Phase One (1) of the assignment, a simplified sewerage system (including a sewage treatment plant) was selected by the key stakeholders as the preferred intervention for improving access to sanitation in the Teshie Old Town community.

## 1.2 PROJECT COMPONENTS

The proposed intervention which contributes to addressing the sewage and faecal sludge management challenges in the Ledzokuku Municipal Area will cover the following two (2) works components.

The Teshie Old Town simplified sewerage networks will include:

- Household sewer connections
- Laying of block or lateral sewer lines
- Laying of trunk or collector sewer lines
- Construction of house/block connection/main inspection/grit and screening chambers.

The wastewater treatment plant to be constructed to handle **1,800m3/day** will comprise of preliminary, primary, secondary and tertiary treatment units. Additionally, it will include sludge treatment and biogas utilization facilities. The main operation and process units to be constructed/ installed include the following:

- Screening chamber
- Sewage collection wells
- Primary sedimentation and attenuation tanks
- Upflow blanket filtration tank
- Anoxic-Anaerobic-Oxic (A2O) tank
- Secondary sedimentation tank
- Sludge treatment and storage tanks
- Construction of fence wall around the WWTP and treatment ponds site

A schematic drawing of the treatment plant is shown in Figure 1.1.

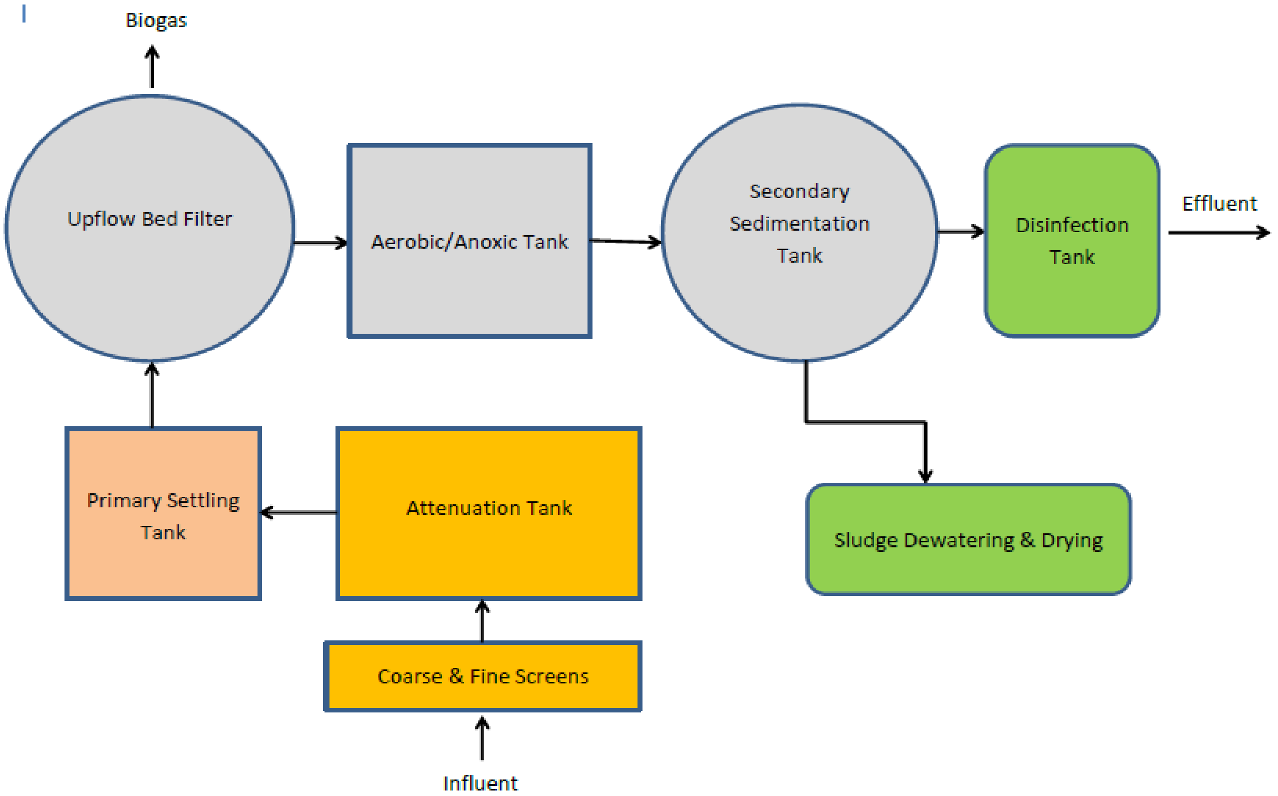



**Figure 1.1: Schematic diagram of unit processes for WWTP**

The estimated sewage flows from the Teshie Old Town sewer basins and the cumulative flow to be handled by the constructed WWTP are as follows:

- Construction of a new simplified sewerage network covering Teshie Old Town with a projected sewage flow of **1,695m$^3$/d**.
- Construction of sewage treatment ponds and a new plant to handle flows of **1800 m$^3$/d**.

## 1.3 PROJECT JUSTIFICATION

The wastewater and faecal sludge management value chain framework for urban communities typically consists of various stages including:

- U - User interface
- S - Storage/Containment
- C - Conveyance
- T - (Semi-) centralized treatment
- D - Use and/or disposal -Disposal/Reuse

Sewage and faecal sludge management in many urban settlements in Ghana is characterized by inadequate or non-functional sewage treatment facilities. The sanitation flow diagram (SFD) presented in Figure 1.1 depicts the status quo of the country with respect to the sources and flow paths of faecal sludge and sewage. The SFD suggests that about 98% of the total quantity of sewage and faecal sludge/septage generated is disposed of without treatment. The need to provide adequate treatment capacity is paramount.

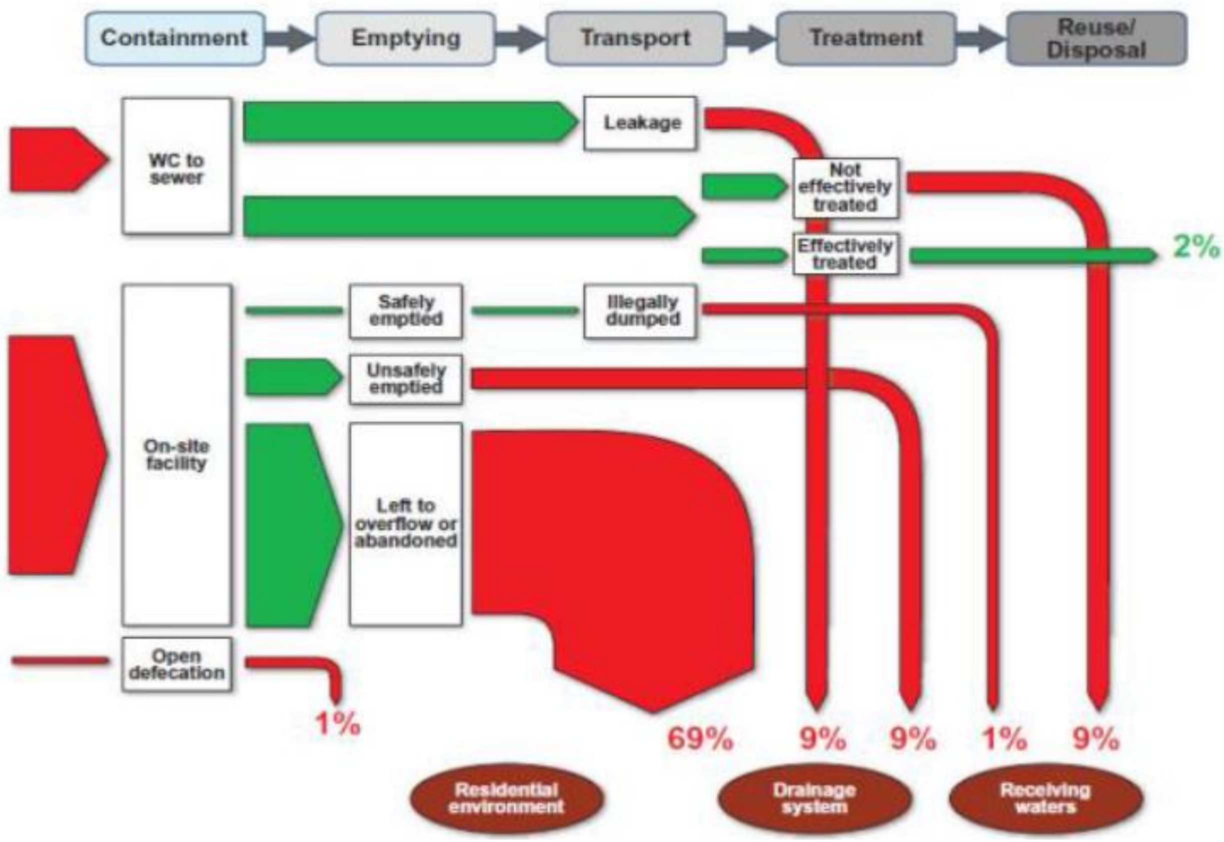



**Figure 1-2: Shit flow diagram for Ghana**

The existing method for collection of faecal sludge in Teshie Old Town involves the use of vacuum suction trucks mainly operated by private operators. The service providers are directly engaged by households and operators of public toilets according to prevailing service charges.
From the results of the baseline survey conducted in Phase 1 many households have serious complaints about the performance of service providers.

The prevailing conditions with respect to faecal sludge management in the Ledzokuku Municipal area do not ensure reliable containment and transfer of faecal sludge from the project area. The lack of treatment systems in the municipality also results in the discharge of raw sewage into the sea. Most significantly, the poor state of handling and/or treatment limits the opportunities for potential re-use of bio-solids and/or recovery of by-products that can be generated from improved faecal sludge handling and treatment processes. The provision of an improved faecal sludge management system will therefore ensure that all stages of the faecal sludge management value chain are managed in an environmentally sustainable manner.

In addition to the above direct benefits of the proposed intervention to households within the project areas it is envisaged that staff of LEKMA and MSWR who will be involved in project oversight will gain some practical knowledge of constructing sewerage schemes. Thus the intervention taken together with others including improvement of water supply reticulation within Teshie Old town will contribute to achieving objectives of Components 1, 2, 3, and 4 of GAMA Sanitation and Water Project (SWP).

## 1.4 STRUCTURE OF DESIGN REPORT

The detailed design report is made up of three separate volumes. This design report and the related annexes form Volume I. Volume II is the costing of all the works and associated services in the form of Bill of Quantities and the accompanying engineering drawings of the various civil engineering, electro-mechanical and electrical units and appurtenance make up Volume III. The content of the report is derived from baseline data collected from field surveys of the project area, special studies and reports including a geotechnical and geodetic surveys, as well as Resettlement Action Plan (RAP) and Environmental and Social Impact Assessment (ESIA) for the intervention.

The detailed design report includes the *executive summary* which presents a brief of the project background, profile of the Teshie Old Town LIUC, justification, results of socio-economic and engineering surveys and the methods employed, the design criteria, process and operation units adopted for the desired treatment effectiveness, the related infrastructure works and cost estimation as well as project implementation plan and operations and maintenance (O&M) management requirements.

This *chapter 1* introduces the background of the GAMA SWP project, components, justifications and need for the project and how the whole design report is organized. The profile of the Teshie Old Town LIUC is presented in *Chapter 2* and covers description of the project-area and aspects of the physical environment (i.e. geographical location, demographics and socio-economics, surface water and groundwater hydrology, geology, soils and vegetation including existing infrastructure and municipal services). *Chapter 3* covers both geodectic surveys and geotechnical investigations.
The topographical surveys provided maps of locations of the project area, layouts with all existing infrastructures, spot heights/contours including important features and landmarks along the sewer routes and the treatment plant site. Geo-technical investigations provided data of the subsurface properties of the rocks at treatment plant site. The details of important design criteria, assumptions, and formulae, methods of sewerage systems design based on international best practices, standards and specifications that apply to designing unit operations and processes, cost estimation of sewer network and treatment plant, as well as other appurtenances are presented in *Chapter 4*.
The planning horizon for population and flow estimations from the sewerage basins of Teshie Old Town, sizing and hydraulic parameters of related sewers and manholes are captured under *Chapter 5*. The design of unit operations and processes and other ancillary works which taken together make up the wastewater treatment plan (WWTP) is the subject of *Chapter 6*. The results of the two (2) preceding chapter leads to cost estimation of the project in *Chapter 7*, which also provides financial analysis and bulk costs of the civil engineering, electro-mechanical, electrical and pipe works as well as incidental costs for implementing key mechanisms of RAP and ESIA. *Chapter 8* covers proje0ct funding and implementation plan and schedule for the proposed project. *Chapter 9* covers operation and maintenance (O&M) management and proposed manpower, machinery and funding for sustaining the operations of the sewerage system.

# 2 LIUC PROFILE

## 2.1 GEOGRAPHICAL LOCATION

The Teshie Old Town community is located in the Ledzokuku Municipal Assembly (LEKMA). The community is bounded to north and south by the Accra-Tema Beach Road and the Sea (Gulf of Guinea) respectively. It stretches from the Kpeshie Lagoon (West) to First Junction Area (East). The proposed simplified sewerage will cover the inhabited area shown in Figure 2.1. The community is made up of the Akro East and Akro West electoral areas with an estimated land size of 2.097 $km^2$. The population and housing densities are estimated at 215.3 persons/ha and 14.42 houses/ha respectively


**Figure 2-1: Google Earth imagery of project area**

## 2.2 DEMOGRAPHIC AND SOCIO-ECONOMIC CHARACTERISTICS

Teshie Old Town has an estimated population of **21,288**. Teshie Old Town has an estimated **4,805** households. Majority of residents in Teshie Old Town are Ga-Dangme (85.47% of the households are headed by Ga-Dangme). The Akans follow next with 9.1% and the Ewes 2.9%. Other ethnic groups in the community include Mole-Dagbani, Guans and Gurma.

The results from a community baseline survey undertaken in Teshie Old Town during Phase 1, indicates that only 4% of household heads are employed in the formal sector (teaching, banking, and public service) as a sole occupation. Majority (37.5%) of the household heads are into petty trading as their main income source.

Household heads into only farming (livestock and crop) constituted 1.9% of the household heads in the community. This may be a reflection how urbanized (highly built-up and densely populated) the community is. Heads with multiple occupations (two or more occupations) constituted 9% while those who plied other occupations (e.g. fishing, fish mongering, lottery operator, pastoring, driving or pensioner, etc.) constituted 22.4% of the household heads. 10.1% of the household heads were artisans while household heads into labour work accounted for 8.3%.

## 2.3 CLIMATE

The Ledzokuku Municipal Area falls within the dry equatorial climate zone which exhibits seasonality in the rainfall distribution. The seasonality in the precipitation patterns is brought about by the movement of the inter-tropical convergence zone (ITCZ). Figure 2.2 shows the monthly rainfall pattern. Temperatures are high all around the year with daily variations higher than seasonal variations. The average monthly temperature has a range of only 4ºC throughout the year. Daily temperatures range from 19ºC to 32ºC from December to June. Between July and November the days are cooler and temperatures range from 18ºC to 29ºC.

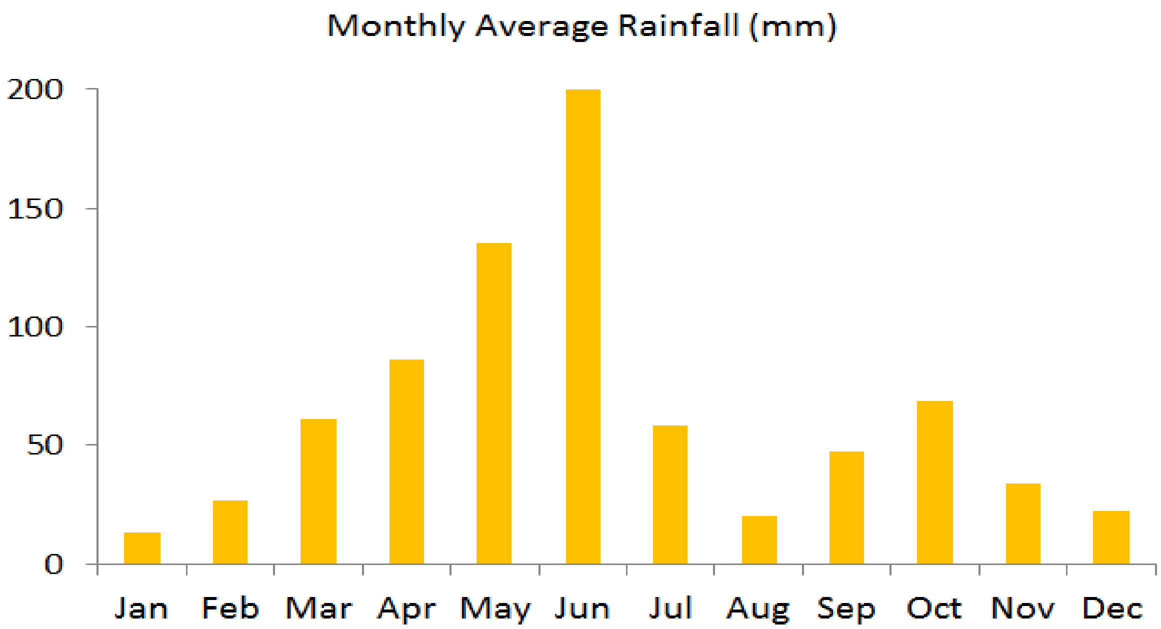



**Figure 2-2: Monthly variation of rainfall**

## 2.4 SURFACE WATER AND GROUNDWATER HYDROLOGY

The Ledzokuku Municipal Area Municipal Area lies within the Kpeshie and Songo-Mokwe Basins. Streams in these catchments generally flow in north to south direction, emptying directly into the principal outlets to the sea at Kpeshie, Songo and Mokwoe Lagoons. The Old Teshie LIUC lies within the Songo drainage basin as shown in Figure 2.3.

The main lithological group is the Dahomeyan Paragneiss which consists of ortho and paa gneisses and schists and migmatites, many of which are rich in garnet, hornblende and biotite. Primary porosity as well as fracturing of the massive paragneiss is very low.

The lower weathered zone builds a low yielding aquifer. The depth to groundwater table is between 5-15m. Groundwater yield and recharge rates are low.

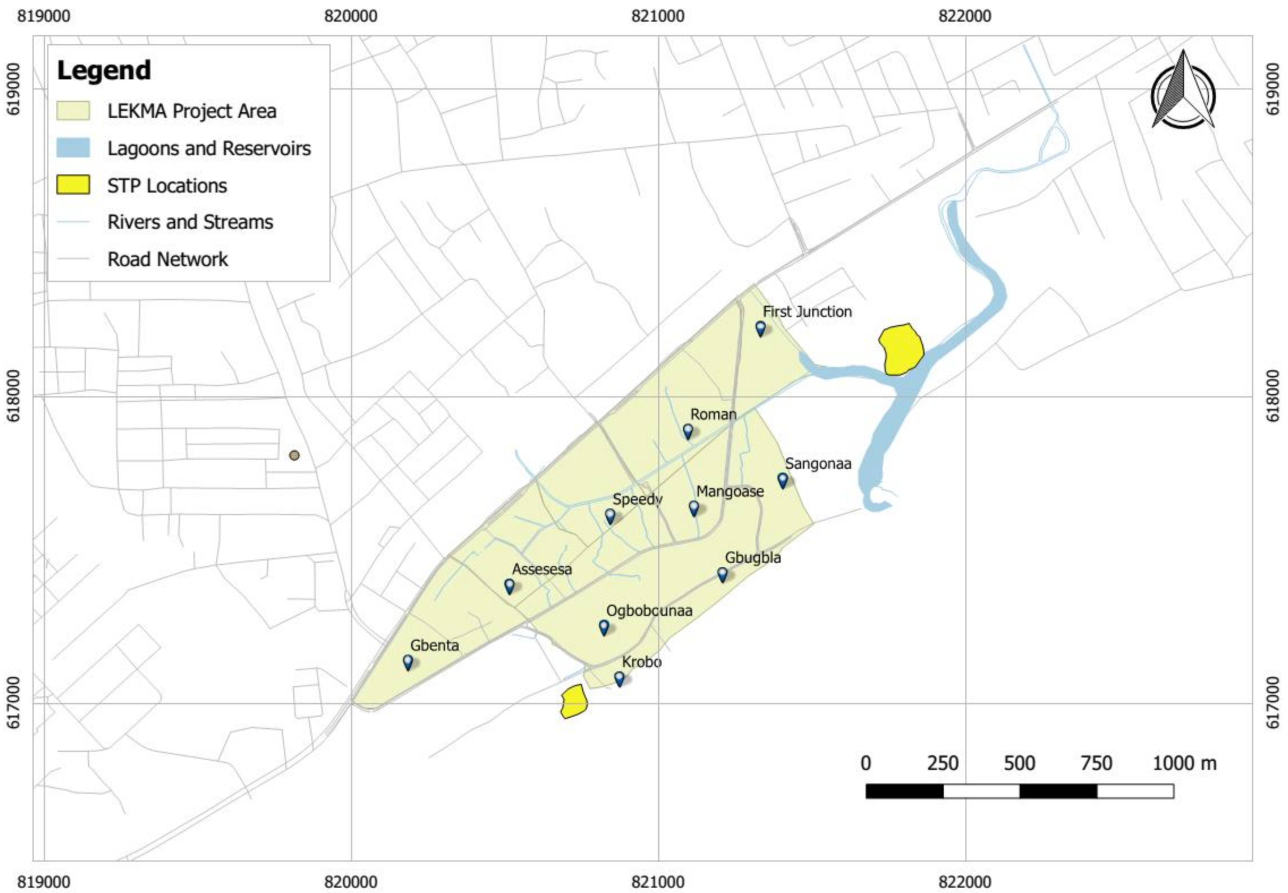



**Figure 2-3: Surface water hydrology in project area**

## 2.5 GEOLOGY, SOILS AND VEGETATION

The soils in the municipal area fall into two major classifications i.e. Savannah Ochrosols and Regosolic Groundwater Laterites. The Savannah Ochrosols are shallow to very shallow, reddish brown and brown, concretionary, medium to light textured soils. The Regosolic Groundwater Laterites consist of few centimeters to several meters of pale-coloured sands overlying mottled, gravelly, sandy clays underlain by weathered acidic gneiss or granite. The local soil series in this geographical area include the Simpa-Agawtaw, Oyibi-Muni association and Toje Consociation

Soils found in the area are categorized into four main groups: drift materials resulting from deposits by wind-blown erosion; alluvial and marine mottled clays of comparatively recent origin derived from underlying shales; residual clays and gravels derived from weathered quartzite, gneiss and schist rocks, and lateritic sandy clay soils.

The sandy beach/coastline is characterized at some portions by a series of resistant rock outcrops and platforms. There is also severe coastal erosion along some portions of coastline. These soil types are likely to retain the ground water and therefore contributing to high water table.

The vegetation comprises of coastal scrub, grasslands and strand and mangrove. The coastal scrub and grasslands consists of dense clusters of small trees and shrubs which grow to an average height of 5m. The grasses are a mixture of species found in the undergrowth of forests. The mangrove forests are found in the coastal lagoon areas where the soil is waterlogged and salty. The mangrove trees grow to a height of between 12m and 15m and are green in appearance throughout the year

## 2.6 INFRASTRUCTURE AND MUNICIPAL SERVICES

The Teshie Old Town has all link roads within the community tarred. This LIUC lacks an efficient drainage system despite the existence of some concretized drains in the community. Most of the existing drains are silted or choked with refuse limiting free flow of sullage and stormwater. The community has two major drainage/stormwater outfalls which meet at a point and drains into the Sangonaa Lagoon and finally into the sea. Most of existing drains are roadside drains. Incidence of flooding in the community is quite low.

**Figure 2-4: Sullage disposal in Teshie Old Town**

# 3 ENGINEERING SURVEYS AND INVESTIGATIONS

## 3.1 TOPOGRAPHICAL SURVEYS

### 3.1.1 Scope and Objectives

A detailed topographic survey of the project area was undertaken. The objective of the survey was to:

- Conduct a detailed topographic survey of Teshie Old Town
- Capture adequate data necessary to generate an elevation model for the selection and design of sewer lines and manholes.

### 3.1.2 Field Reconnaissance

The survey started with a comprehensive field reconnaissance around the perimeter of the project area to define and demarcate all the locations to be covered by the sewer network area. The treatment plant area was also visited. A sewer walk was conducted within the area to pre-identify possible locations for pipes and manholes. Figure 3.1 depicts the survey activities.


Figure 3.1 Rover receiver capturing data along the proposed trunk sewer route

### 3.1.3 Establishment of Control Points

Primary controls were established using the RTK GPS for the project. These points were set in the Ghana National Grid. All existing features (roads, buildings, walls, drains, and utilities) were surveyed with an RTK GPS. General topography of the land was surveyed by picking spot heights. The RTK GPS consists of a base and rover which all receives information from satellites in space. The base station is set on a known point (Control point). The base station sends correction data to the surveyor who is operating the receiver (Rover). Real-time positions on the rover receiver are calculated as fast as 20 times per second or as little as once per second. Figure 3.3 illustrates the basic operation of the RTK GPS.

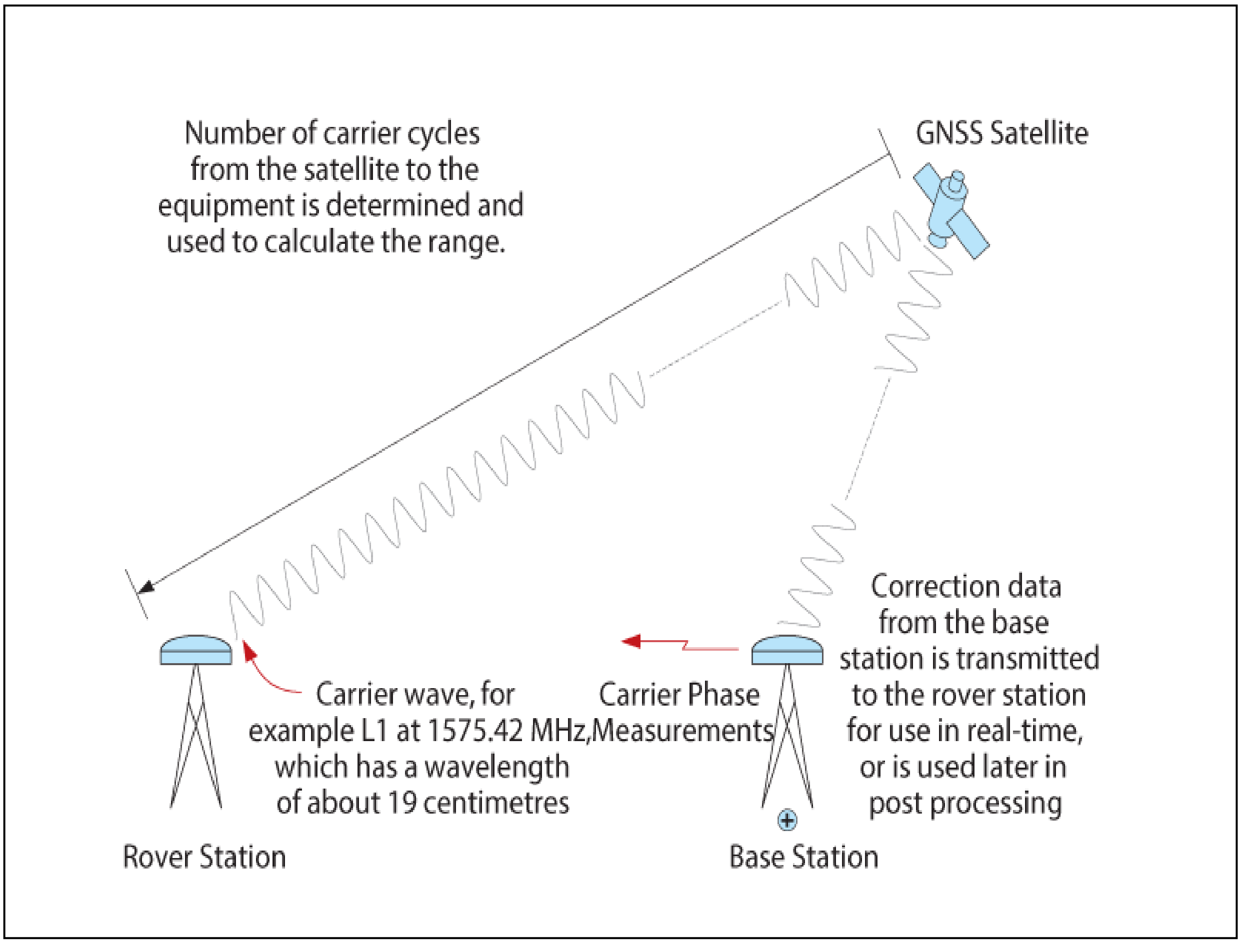



Figure 3.3 Rover receiver capturing data along the proposed trunk sewer route

### 3.1.5 Data Processing and Plan Drafting

Positions and locations of features are captured in the form of coordinates. Microsoft Excel is used to organize the coordinates and AutoCAD used for drafting. A ground model is established for the area and longitudinal profiles of sewer lines also generated.

## 3.2 GEOTECHNICAL INVESTIGATIONS

### 3.2.1 Scope and Objectives

Geotechnical investigation at the proposed site was conducted for the decentralised wastewater treatment facility to study the strength characteristics of the sub-soils and assess the suitability of ground conditions to accommodate the proposed construction.

The specific objectives of the site investigation were to:

- Ascertain the general capability of the subsoils at the site to support the typical loads to be imposed by the proposed buildings;
- Determine any ground conditions at the site that could adversely affect the performance of the foundation and affect use of the site for the intended purposes; and
- Recommend allowable foundation bearing pressure values and footing placement depths.

### 3.2.2 Field Testing (Dynamic Probing) and Sampling

The sub-soil investigation was undertaken in accordance with BS 5930: Code of Practice for Site Investigations. The Heavy Dynamic Probing (DPH) technique as specified by BS EN ISO 22476-2:2005, was used to assess the strength of the site sub-soils under field conditions. Dynamic Probing is the process of continuously driving sounding rods fitted with a closed point cone of specified dimensions into the ground by means of a drop weight at a constant drop height.

The number of blows that affect each 10cm penetration drop is recorded to assess the resistance of the soil layers to penetration. For this particular test site, a motorised heavy-duty dynamic penetrometer with drop-weight of 50kg was employed to probe the sub-soil at each test point till the depth of investigative interest or 'refusal' was reached.

The equipment specifications of the heavy-weight DCP machine deployed at the site are based on the German Standard DIN 4094 and are stated below:

- Equipment model: Nordmeyer R50 Heavy Duty Dynamic Cone Penetrometer
- Drop Weight: 50kg, Height of fall: 50 cm
- Sounding rods: 32 mm dia, 1m long
- Drive point area: 15cm2 Drive point diameter: 43.7mm
- Apex cone angle: $90^o$

The percussion mechanism is fully automatic and minimizes probability of operator error.

### 3.2.3 Test Point Locations and Penetration Depths

Four probing test locations were investigated. Table 3.2 presents the geographical coordinates of the test locations.

Table 3.2 Geographic coordinates of test points

| **Test Point ID** | **Northings** | **Westings** |
|---|---|---|
| TP1 | $05^{0}$ 35.140’ | $00^{0}$ 05.728’ |
| TP2 | $05^{0}$ 35.114’ | $00^{0}$ 05.748’ |
| TP3 | $05^{0}$ 35.089’ | $00^{0}$ 0.746’ |
| TP4 | $05^{0}$ 35.142’ | $00^{0}$ 05.763’ |

The tests were terminated at depths which indicated change in subsoil profile with sufficiently high bearing capacity potential. A window sampler was driven into the ground and used to recover disturbed samples of sub-soil materials at different depths for observation and testing. No undisturbed samples could be recovered due to the sandy nature of the site soils. It was noticed that the sides of exploration holes collapsed immediately the test rods were withdrawn from the holes. Figure 3.5 shows sampling activities at TP3.


Figure 3.5 Ground investigation team at TP3

### 3.2.4 Findings and Recommendations

*Findings*

Based on the results of the investigative studies the following findings have been concluded for the site;

- The site sub-soils, down to 6.0m depth, are fine-grained, loose and saturated, and exist in a semi-solid/semi-liquid state with very low shear strength incapable of directly supporting any building loads. Minimum bearing capacity values in the range of 1 to 3kN/m2 were assessed for this depth zone. The low-strength sub-soil conditions are consistent across the site.
- Total and differential settlements will be very significant for any structures directly founded in the site sub-soils.
- Groundwater occurs within the 0.20m depth below ground surface and will pose serious challenges for excavation stability during construction.
- The site is underlain at depth, below 6m, by competent weathering products of the Accraian Sandstone bedrock system.

Existing buildings within vicinity of site are founded in imported fill material placed on existing ground surface to average heights of 1.0m.

*Recommendations*

Following from the above-stated findings at site the following recommendations are made for the design and construction of foundations at the proposed sewage treatment facility site.

- An engineered earth fill should be designed and constructed over the site soils to improve the foundation soil strength.
- To accelerate consolidation, vertical sand drains should be inserted into the in-situ soil before placement of fill soils.
- The fill should be compacted in layers with heavy vibratory roller compactors.
- The bearing capacity of the improved ground should be determined after completion of the earth fill works.
- Foundation footing pressures for the sewage treatment plant structures should not exceed half of the bearing capacity determined for the improved ground conditions.

# 4. DESIGN CRITERIA AND APPROACH

This chapter provides an overview of the design criteria used for the Teshie Old Town simplified sewerage system. A literature review of international best practices for simplified sewer design and construction was undertaken in order to adopt applicable design parameters and methods. The construction criteria adopted for the Asafo simplified sewerage in Asafo, Kumasi, Ghana which has been in operation for the past twenty-four (24) years were also used for comparison and application where appropriate.

## 4.1 SEWER SYSTEM CONFIGURATION AND LAYOUT

### 4.1.1 General

The simplified sewerage network is divided in two parts, the public sewer constituted by the main and trunk networks, and the condominial branches which are considered the collective connection to the public sewer and include the block and house connection sewers (Neder, 2000: Bakalian et al., 1994). Figure 4.1 shows a generalised connectivity between the two components. Figure 4.2 shows the simplified sewer network connections for a block of houses in Asafo, Kumasi, Ghana.

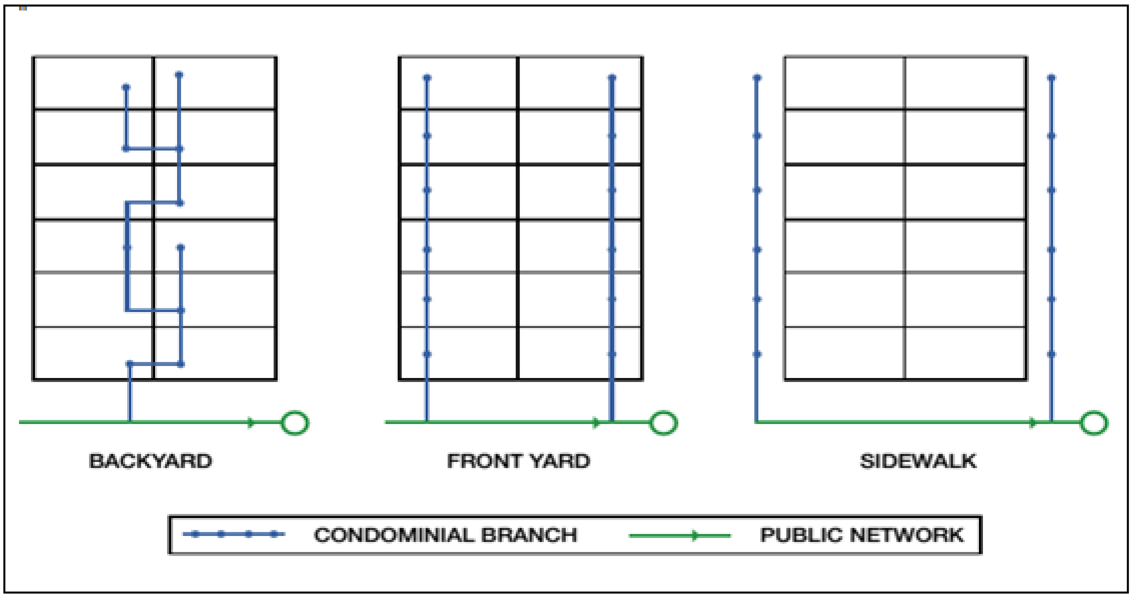



Figure 4.1 Alternative configurations for options for public and condominial sewers

The public sewer collects the wastewater from the block and condominial branches. This pipeline is always in the public area of the community. It follows the last inspection box of each block/condominial branch, and is installed, if possible on the side walk/pavements of streets. When this is not possible it will be installed at the road edge. When the public sewer passes along the face of a block, no condominial branches are needed at this side of the block and connection are done directly into the public sewer.

The use of the condominial system leads to a drastic reduction in the total length of the public sewers. In comparison to the conventional sewerage system, the condominial system is mostly made of condominial branches and only around (30–40) % of public sewers.

It must be emphasized that less sewers in the public areas of the project locality means less risks of obstruction or damage to the system. The block and condominial branches constructed mostly in non-vehicle traffic areas are protected from external heavy loads.

The condominial branch is the pipeline that collects *all* the wastewater from households in houses within a block and conveys to the public sewer that passes along the boundary of the block. Houses are connected to the condominial/block sewers through house connection sewers (100 mm) and chambers. The final routing of the condominial branches should be according to strict technical recommendations to allow gravity flow. In order to lay condominaal/block sewers along alleys and way-leaves makes *community engagement for consultations and agreement* among neighbours a critical element of successful project implementation.

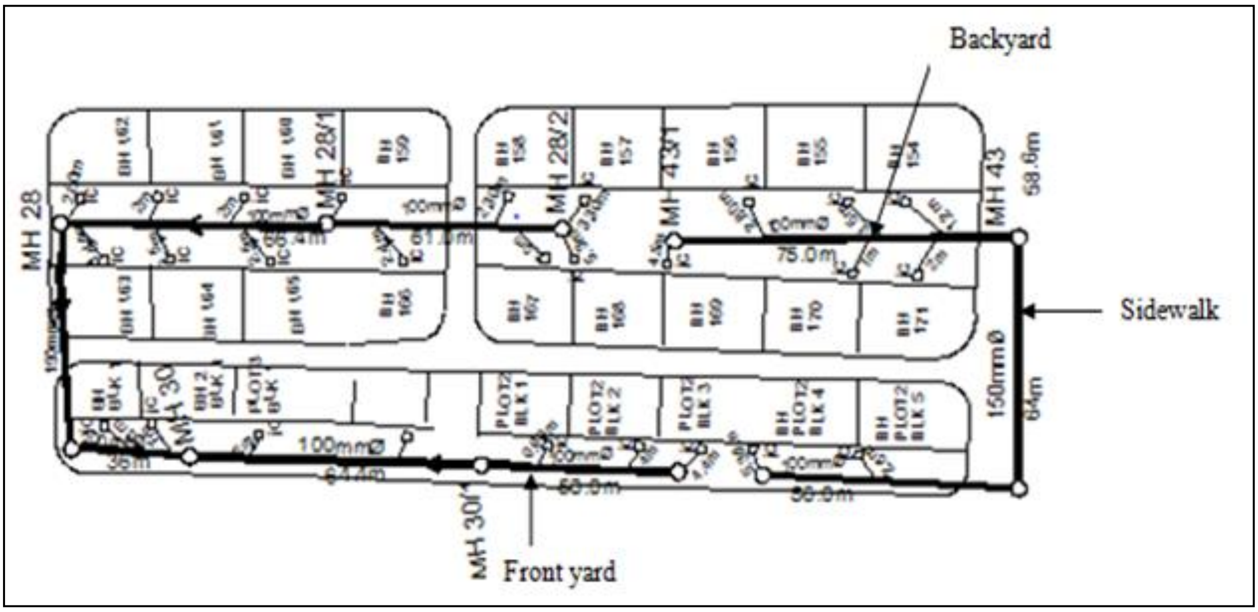



Figure 4.2: Simplified sewer configurations for block of houses at Bimpe Hill, Asafo, Kumasi, Ghana

### 4.1.2 Pipe Material

Three (3) types of pipes have mostly been used for conveyance of wastewater. These are precast concrete (PC), Vitrified Clay (VC) and plastic pipes. Plastic pipes are currently the preferred material for sewer networking. All pipes for wastewater conveyance shall be to the relevant international manufacturing standards. A market survey shall be carried to ensure quality of pipes before ordering and accepting for delivery. The quality of pipes affect jointing and hence prevention of leakage of sewage to pollute underground sources of water.

**A. <u>PRECAST CONCRETE (PC) PIPES:</u>**

Precast concrete pipes manufactured for sewerage works are reinforced concrete pipes with rubber ring, spigot and socket joints (Duncan, Mara et al, 2000).

PC Pipes are manufactured in diameters from 80 to 2600 mm in accordance with *ASTM C14 & C14M* standards, and are supplied with rubber ring gaskets. The joining of PC pipes with rubber rings offers the potential for a water-tight and flexible joint which is easy to make in a trench. The pipes are manufactured in 2.0 m lengths for diameters up to 250 mm, and 2.5 m lengths for diameters above 250 mm.

Disadvantages of concrete pipes include limited range of fittings, risk of corrosion from hydrogen sulphide formation in sewers, need for good quality control and supervision over manufacture and installation.

Nevertheless, they have generally proved to be durable and have been used extensively in sewerage work with sewer sizes greater than 450 mm. They are also relatively cheap. They are therefore recommended with the precaution that the standards and specifications for manufacture and installation will be stringently followed.

**B. <u>VITRIFIED CLAY (VC) PIPES:</u>**

*ASTM C700-18* provides standards for production of vitrified clay pipes of internal diameters from 100 mm to 600 mm. Pipes are manufactured in 0.6m, 0.75m & 0.9m lengths with spigot and socket or cement mortar type joints. Nowadays, rubber ring joints are also being used for vitrified clay pipes of diameter more than 150 mm.

The main disadvantage of stoneware pipes compared with concrete pipes is the greater number of joints that are required because of the short lengths that are manufactured.
This increases the cost of laying and increases the potential for infiltration through badly made joints if strong supervision is lacking during the construction phase. In addition, VC pipes are brittle rigid pipes which are susceptible to breakages during transport and handling. Nevertheless, they are cheap, durable, and suitable for use with corrosive liquids (i.e. sulphide corrosion) and in aggressive ground conditions. (VC) pipes have been used extensively for in house drains, house connections and for main sewers up to about 300 mm diameter in aggressive ground conditions.

**C. <u>PLASTIC PIPES:</u>**

Un-plasticized polyvinylchloride (uPVC) pressure pipes for sewerage works are manufactured in accordance with *BS EN1401-Part 1*, in diameters from 100 mm up to 1000 mm. The pipes are delivered in 5 or 6 m lengths and can be joined by either rubber gaskets or by solvent welding. Normally, rubber gaskets are used for pipes larger than 100 mm.

uPVC is an inert material, and is suitable for carrying many corrosive effluents and for laying in aggressive ground conditions. However, the pipes are susceptible to poor workmanship; it is also recommended that very careful attention is given during installation to pipe stacking, handling, trench bedding and backfilling procedures. High density polyethylene (HDPE) pipes of 160 mm are proposed to be used in narrow lanes, highly traffic streets and connected to main sewers using chambers.

### 4.1.3 Selection of Sewer Type & Fittings

The following factors recommended by (Duncan, Mara et al, 2000) have been considered in selecting the most appropriate pipe material and fittings for the sewerage network:

- Availability of sizes and fittings, when required - pipes and fittings must be readily available in the local market.
- Cost of materials and installation – pipes and fittings must be cheap items of pipe cost, transport to site and installation to make the sewerage scheme economical.
- Durability – pipes must have long life expectancy.

- Resistance to corrosion – pipe material must be resistant to chemical and biological attack in aggressive ground conditions.
- Resistance to abrasion - selected pipe must have very smooth interior surface to ensure strong resistance to abrasion.
- Strength – pipe material must have the required strength to withstand laying, bedding and considerable external loads of backfill material and vehicular traffic.
- Weight of pipe - pipe must be made with material of less specific weight for easy handling and transport.
- Imperviousness - pipe must be impervious and must have well secured joints to prevent sewage seepage and its negative environmental impacts.

Table 4.1 below presents the type of pipe materials that will be utilized at different sections of the LIUC sewerage network in accordance with (Neder, 2000: Bakalian et al., 1994).
Although the PVC pipes are usually expensive than the ceramic ones, it is possible to compensate this disadvantage during the construction, due that the PVC pipes are easier and quicker to install.

Table 4.1 Sewer pipe material

| **Sewer Type** | **Material Choice** |
|---|---|
| Sidewalk Condominial Branch | uPVC/PVC Reinforced |
| Inside of the lot Condominial Branch | uPVC/PVC Reinforced |
| Public Sewer $\varphi \leq 400$mm | HDPE/uPVC |
| Public Sewer $\varphi > 600$mm | Precast Concrete |

Table 4.2 below presents the nominal outside diameter of uPVC pipes used for gravity sewerage networks in accordance with (**BS EN 1401-Part 1**).

Table 4.2 Nominal and Mean outside Diameter of uPVC Pipes in (mm)

| **Nominal Size DN/OD*(mm)*** | **Nominal Outside Diameter*(mm)*** | **Mean Outside Diameter *(mm*** | |
|---|---|---|---|
| | | Min | Max |
| 110 | 110 | 110.0 | 110.3 |
| 125 | 125 | 125.0 | 125.3 |
| 160 | 160 | 160.0 | 160.4 |
| 200 | 200 | 200.0 | 200.5 |
| 250 | 250 | 250.0 | 250.5 |
| 315 | 315 | 315.0 | 315.6 |
| 400 | 400 | 400.0 | 400.7 |
| 500 | 500 | 500.0 | 500.9 |
| 630 | 630 | 630.0 | 631.1 |
| 800 | 800 | 800.0 | 801.3 |
| 1000 | 1000 | 1000.0 | 1001.6 |

### 4.1.4 Minimum Pipe Diameters

Table 4.3 presents the minimum diameter for the various simplified sewer components (Neder, 2000: Bakalian et al., 1994). The use of small diameters especially in low flow conditions, permit a better transport condition for the solids that are present at the wastewater. The Asafo simplified sewer network employed 100mm diameter pipes for house connections and condominials.

Table 4.3 Minimum diameter

| Sewer Type | Minimum Diameter |
|---|---|
| Condominial Branch | 100 mm |
| Public Sewer | 100 mm |

### 4.1.5 Structural Design of Sewers

Sewers have been designed structurally so that when buried they can withstand all the external forces to which they are likely to be subjected. Providing bedding, hunching and surrounds, which may be of concrete, sand or gravel, are important ways of strengthening a pipeline to withstand higher loading.

The basic data on which the need of additional support is determined are the actual strengths of the pipes used, the depths of the laid pipeline and its location (whether in a main road with fast moving traffic, or in a plot with pedestrian traffic only, etc.). The computation of loads on buried pipelines established by the work of (Martston, Spangle et al., 2008) has been utilized for the structural design.

To allow for settlement and soil movement, sewers with flexible joints and self centering properties have been selected. These joints will be formed using pipe spigots and sockets with smooth and sound interiors made to tolerances which allow this type of jointing.

### 4.1.6 Minimum Depth of Sewers

Minimum depths of cover over sewers are often given as 1200 mm in roads and a reduction of up to 600 mm in alleys. Normal current practice is to have at least 1 m cover above the top of the sewer to permit the pipe to be protected against damage according to the minimum desired coverage.

A shallow sewer at a depth of 0.6 m, with adequate protection against damage by proper concrete shrouding, will be considered acceptable when this is justified economically and is not technically detrimental. It is recommended to adopt a minimum depth of sewer as 1.0 m in general and 0.6m for shallow sewers. Recommended minimum depths of sewers applied are provided in Table 4.4 (Neder, 2000: Bakalian et al., 1994).

The minimum depth of sewer pipes for Asafo simplified sewers, in alleys and pavement not subjected to vehicular traffic was 0.5m and areas subjected to traffic 0.8m with concrete sleeving for protection.

**Table 4.4 Minimum pipe depths**

| Sewer Type | Minimum Depth |
|---|---|
| Side walk condominial branch | 0.60 m |
| Front lot condominial branch | 0.40 m |
| Back lot condominial branch | 0.40 m |
| Side walk public sewer | 0.80 m |
| Traffic road sewer | 1.20 m |

### 4.1.7 Sewer Manholes

Sewer Manholes have been designed in accordance with the following standards/conventions recommended by (Duncan & Mara et al, 2000). Manholes shall be located:

1) At changes in direction;
2) At changes in slope;
3) At pipe junctions with the exception of building connections;
4) At the upper end and ends of all laterals for cleansing and flushing of the lines
5) At intervals of 90m to 120 m, as required

All manholes shall be given specific identification number that will be embossed on their covers.

## 4.2 WASTEWATER FLOW ESTIMATION

### 4.2.1 Design Period

The design period or horizon of the project establishes the time in which the constructed system should be able to support the growth of the population of the area up to the period. Short to medium horizons may result in less expensive installations, but could lead to periodic increments in investments to match population growth. On the other hand, a project with a long horizon will cost more in upfront implementation phase, but would serve to absorb increased flows due to increasing future populations up to the design horizon.

Since condominial systems are usually designed in low income areas, where the demand on services is larger than the resources available to attend them, is a good strategy to shorten the horizon of the project. A project horizon of 15 -20 years is recommended (Neder, 2000; Bakalian et al., 1994).

### 4.2.2 Population Projection

The design period or horizon of the project establishes the time in which the constructed system should be able to support the growth of the population within the sewer area. The design period adopted for the Teshie Old Town sewerage system is 20 years.

### 4.2.2 Per Capita Water Consumption

The per-capita water consumption of a population depends on several factors, including cultural tradition, level of local economy, urban characteristics, climate, et cetera. The choice of the per person daily water demand should be based on extensive evaluation of the conditions that exist in the beneficiary low-income communities.

In the low income areas that the condominial system is usually implemented, there is likelihood of having a low value for the water demand (Neder, 2000; Bakalian et al., 1994). From the community baseline survey undertaken in Teshie Old Town, 98.5% of households rely on in-house and public stand pipe water supplies for general uses such as cleaning and personal hygiene. Flow condition to communal standpipes is continuous and hence availability of water for household use besides drinking is high. Densification of reticulation has been carried out in Teshie Old Town based on results of the baseline survey.

The projected water demand for 2040 (i.e. design life of Teshie Old Town Simplified Sewer Network) for shared connections as per the GAMA SWP Master Plan indicate values ranging from 50lcpd for shared and 120lpcd for house connections. GWCL field studies (e.g. Lamptey, 2010) indicate per capita consumption for low income communities where flow is intermittently good as 56lcpd. A value of 56 lpcd was used for the Asafo simplified sewerage scheme and has been adopted for low income areas in the Greater Accra metropolitan area.

### 4.2.3 Wastewater Return and Flow Coefficients

The wastewater return-coefficient represents the relationship between the water consumed in a household and its correspondent wastewater production. The value of the wastewater return coefficient is usually less than one, and a traditional value of 0.8 is adopted (Neder, 2000; Bakalian et al., 1994). A return value of 0.75 was employed in the design of the Asafo simplified sewerage scheme.

As the flows determined by the water consumed is an average value, the actual design of the system takes into account *flow coefficients* that approximate design flows to those that will occur during the operation of the system. The flow coefficients used to calculate the maximum and minimum flows that will occur in sewer pipes are:

- ***Coefficient k1*** - Represents the relationship between the minimum flow of the day of larger contribution and the annual daily medium flow (corresponding to the coefficient of daily variation)
- ***Coefficient k2*** - Represents the relationship between the hourly maximum flow and the medium flow of the day of larger contribution (corresponding to the coefficient of hourly variation)
- ***Coefficient k3*** - Represents the relationship between the minimum flow of the day and the medium flow of the day of medium contribution (corresponding to the coefficient of minimum hourly variation)

### 4.2.4 Peak Flow Estimation

For the determination of the flow to be used to design the sewer, the following formula is used for residential areas (Neder, 2000; Bakalian et al., 1994):

$$Qd = \frac{N \times D \times q \times C \times k1 \times k2}{86.400}$$

Where:

Qd = Flow (litres / second)

N = Number of households attended by the sewer, including those of upstream branches (units)

D = Occupancy density (inhabitants/household)

q = “per capita’” water demand. (litres /inhabitant. day)

C = wastewater return coefficient.

k1 = Day of largest consume coefficient.

k2 = Hour of largest consume coefficient.

For the determination of the design flow for the system, two values of contribution should be considered:

- The initial flow (Qi): determined from baseline data and studies of current consumption of water, from which verification of the minimum flow is carried out.
- The final flow (Qf): based on estimation of the population at end of the project horizon period.

These values should be calculated for the residential areas of the project and added to the concentrated flows produced by industries, commercial buildings, schools and other facilities that present higher levels of water consumption when compared with the domestic dwellings. These contributions should have their flows quantified and considered as point sources in effective design of sewers. Table 4.4 presents flow coefficient values whereas Table 4.5 provides corresponding values for non-residential premises.

**Table 4.4 Flow coefficients**

| **Parameter** | ***Value*** |
|---|---|
| K1 | 1.2 |
| K2 | 0.5 |
| K3 | 0.5 |

**Table 4.5 Non-residential flow values**

| Type of Utility | Wastewater flow (l/s) |
|---|---|
| Police station | 0.045 |
| Regional Administration | 0.117 |
| Supermarket | 0.316 |
| Church | 0.077 |
| Bank | 1.620 |
| Military station | 0.769 |
| Kindergarten | 0.088 |
| Regional activity center | 0.053 |
| Professional school | 0.220 |
| Commerce unit | 0.048 |
| Post office | 0.089 |
| Gas station | 0.120 |

### 4.2.5 Infiltration Rates

The infiltration rate is generally dependent on the type of pipes used for construction, the general soil condition, the ground water level and the types of inspection devices. The suggested values for the infiltration rate range between 0.05 to 1.0 l/s. Table 4.6 presents recommended infiltration rates for various sewer materials (Neder, 2000; Bakalian et al., 1994).

**Table 4.6 Infiltration rates**

| Sewer Material | Infiltration Rate |
|---|---|
| Ceramic or concrete | 0.2 l/s. km |
| PVC | 0.0 l/s. km |

## 4.3 HYDRAULIC ANALYSIS

### 4.3.1 Manning Formula

The Manning formula is the preferred method used for designing sewer pipes due to its simplicity and the availability of large quantity of operational data.

$$V = \frac{1}{n} \times \frac{R^{2/3} \times I^{1/2}}{H}$$

Where:

V = velocity m/s.

n = roughness coefficient, usually set as 0.013 for sewer pipes

R = hydraulic radius (m).

I = slope of the segment (m/m).

### 4.3.2 Limiting Velocities

The sewer should be designed with a flow velocity that is able to carry all the solids that usually are present in domestic wastewater. The minimum velocity is the one that guarantees that the sewer has a self-cleansing flow that occurs at least one time in a day. The self-cleansing capacity is related to a minimum water level in the pipe, meaning that for same flow values, smaller diameters sewers can have better self-cleansing velocities. The recommended minimum velocity is 0.6 m/s.

The best parameter to measure the self-cleansing ability of a flow in a pipe is to determine the traction tension that the flow generates. This tension is defined as the tangential force that is applied to the pipes wall by the flowing liquid. The minimum value for the traction tension is 1.0 Pa (0.10 $kg/cm^2$). This value must be achieved for the initial flow condition, adopting a Manning roughness coefficient of n = 0.013.

Excessive flow velocities may cause the pipe wall to erode, due to the solid particles that are present in the wastewater. Table 4.7 presents the recommended maximum velocities achievable in three (3) types of pipes (Neder, 2000).

**Table 4.7 Maximum velocities for sewer pipes**

| Sewer Material | Maximum velocity |
|---|---|
| Ceramic | 5 m/s |
| Concrete | 4 m/s |
| PVC | 6 m/s |

### 4.3.3 Pipe Slopes

The minimum slope that should be adopted for the design of the system is given by the following formula (Neder, 2000):

$$I_{MIN.} = 0{,}0055 \text{ x } Q^{-0{,}47}$$

Where

Q is the flow (l/s)

$I_{min}$ is the minimum slope (m/m)

For construction purposes the adopted minimum slope for the condominial branches is 0.5% (0.005 m/m).

The maximum slope is determined by the maximum velocity that should be achieved in the sewer. Assuming a maximum velocity of 5.0 m/s and a Manning's coefficient of 0.013 the maximum slope can be computed using the following formula (Neder, 2000):

$$Imax = 4{,}50\ Qf^{-0{,}67}$$

Where

Qf is the flow (l/s)

$I_{max}$ is the minimum slope (m/m)

In Asafo, Kumasi, simplified sewers were laid along flat natural gradients in back-alleys of tenement buildings to slopes of 1 in 100 for house connections and 1/167 for block collections.

### 4.3.4 Minimum Flow

The daily flows for condominial branches that are typically computed for low sloped pipes using the Manning equation are generally too small to ensure adequate solids transport capacity.

In practice, however, verified empirical evidence suggests that a single toilet flush is able to produce a flow of about 1.5 l/ s, which is enough to have the sewer washed.  In this way, the minimum flow to be considered when designing the system is 1.5 l/s (Neder, 2000).

## 4.4 SEWAGE TREATMENT PROCESSES

### 4.4.1 Design Sewage Characterization

The influent flow and quality are presented in Table 4.8 and Table 4.9 respectively.

**Table 4.8 Input flow**

| Parameter | Value |
|---|---|
| Design daily flow ($Q_d$) | 1800m$^3$/d |
| Design hourly flow ($Q_h$) | 90m$^3$/h |

**Table 4.9 Influent quality**

| Parameter | Value |
|---|---|
| $COD_{Cr}$ | 1000 mg/l |
| $BOD_5$ | 500 mg/l |
| Ammonia nitrogen | 30mg/l |
| SS | 400mg/l |
| Total phosphorus | 10mg/l |
| pH | - |

### 4.4.2 Selection of Process and Operation Units for the WWTP

Sewage contains both particulate and dissolved material that is largely of biological origin and biodegradable. Fundamentally, sewage treatment techniques involve catalyzing natural self-cleansing processes in a manner that reduce or contain undesirable impacts on the natural environment.

The treatment of municipal sewage involves the use of technology in a series of operation and process steps for the removal of pollutants from the raw sewage by use of physical, mechanical and biochemical methods. An important aspect of the hygienization of sewage to make it fit for disposal into a receiving water body is the death and/or permanent deactivation of pathogens and other organisms that are indicative of faecal contamination.

The influent characteristics of sewage to be treated as gauged against the discharge consents of relevant authorizing agencies, such as the Environmental Protection Agency (EPA) and the National Standards Authority (NSA) are therefore applied in the selection of the operation and process units that taken together will achieve the discharge consent limit.

The selection is therefore dependent on important physical characteristics (e.g. total solids (TS), suspended solids (SS), temperature, conductivity, turbidity), the distribution of inorganic chemical compounds that impact on alkalinity (including inorganic compounds as Total Nitrogen (TN), Organic Nitrogen ($NO_3$-), Total Phosporous (TP), and heavy metals) and organic compounds that impact on oxygen depleting properties (as $BOD_5$, COD etc) and biological characteristics based on the presence of pathogenic materials (expressed as total coliform bacteria, and other toxicity thresholds).

While there are different configurations for the many unit processes that can be applied for removing the above contaminants, the commonly targeted contaminants include suspended solids (SS), nutrients in the form of TOC, TN, TP, refractory organic matter such as waste oils, heavy metals and soluble inorganics (TDS). The removal processes to be used for the commonly targeted contaminants are discussed in the following paragraphs.

*Removal of Suspended Solids*

The removal of suspended solids (SS) in sewage mainly depends on settling of inorganic non-colloidal solids and to some extent microbial degradation of organic particles. Small colloidal and sub-colloidal particles can also be adsorbed through flocculation in activated sludge process and precipitation of sludge flocs as well as flocculation due to a barrier like netting.

*Reduction of $BOD_5$ and COD*

The removal of $BOD_5$ is carried out by adsorption and microbial metabolism of organic nutrients by microorganisms.

The input flow $BOD_5$ of 500 mg/l is to be reduced to 25mg/l or less by the selection of appropriate biological treatment, mainly aerobic processes that enhance synthesis of organic matter for cell growth and release of energy. COD is manifested as suspended and soluble solids and the mechanisms for reducing COD follow that of SS removal.

The reduction of the bio-degradable portion of COD also follows that of $BOD_5$ removal. The removal of non-degradable component of the COD is rather difficult and may require process units beyond primary physical and secondary biological processes. Nevertheless the ratio of $BOD_5$:COD of 2 is indicative of achievable biodegradability.

*Denitrification (Removal of Nitrogen)*

The presence of adequate dissolved oxygen (DO) $\geq$ 2mg/l in conditions with temperature above $20^oC$, together with an adequate carbon source in the form of sludge enhances nitrification. The process units provide conditions for nitrogen-containing organic matter in sewage to degrade (ammonification) under anaerobic conditions into ammonia-nitrogen, and then, under aerobic conditions, nitrifying bacteria partially oxidize nitrate nitrogen ($NO_2$- and $NO_3$-).

Under anoxic conditions, denitrifying bacteria with additional carbon sources provide energy to make nitrate nitrogen breakdown with release of nitrogen gas ($N_2$). The latter condition is characterized by the presence of nitrate, sufficient carbon substrate and anoxic conditions of less than 0.2 mg/l. The proper balance and sequencing of anaerobic, anoxic and aerobic processes will lead to a reduction of influent $NH_3$-N of 30 mg/l to 10 mg/l or less.

*Removal of Phosphorous as (Total P)*

Phosphorous accumulating bacteria release phosphate under anaerobic conditions and in the process, energy is produced for the biodegradation of organic matter which the by-product is polyhydroxybutyric acid (PHB). In aerobic conditions the energy stored in PHB is used to synthesize and absorb phosphorus in bacteria cells with resultant sludge of high concentration of phosphorus and surplus sludge.

The technique of biological phosphorus removal is that polyphosphate bacteria must grow in anaerobic conditions and then enter an aerobic stage to increase phosphorus uptake in order to achieve 80% removal rate of Total Phosphorus (TP) from 10mg/l to less than 2 mg/l.

This is a critical consideration in the selection of the types and sequence of process unit(s) to ensure adequate removal of phosphorus and ammonia nitrogen.

*Target Moisture Content of Treated Sludge*
Sludge from treatment units to be condensed and dehydrated to moisture content of not more than 75% to enhance handling and disposal.

### 4.4.3 Sustainable Installation, Operation and Maintenance of the WWTP

Important considerations for the construction, installation and ultimately sustainable operation and maintenance (O&M) of the proposed WWTP include the following:

- Final effluent discharge should meet the minimum requirements of the Environmental Protection Agency (EPA) Ghana and National Standards Authority (NSA);
- Land for installation of the plant should be within allowable limits around the existing treatment plan area;
- Value-for-money regarding capital costs, operation and maintenance management, and period of construction within the GAMA SWP progammed outputs.
- Process and operations units should be based on technologies that have seen operational use locally and internationally; and
- Local hydro-geological and climatic conditions favour the year-round operation of the selected treatment process and operation units.

### 4.4.4 Effluent Discharge Guidelines

Because no specific effluent standards for domestic wastewater are available the Ghana EPA standards for industries provided in Table 4.11 are used as reference values.

Table 4.12 also presents World Bank EHS guidelines for effluent discharge applicable to sanitary wastewater treatment.

**Table 4.11 Ghana EPA effluent quality**

| Parameter | Unit | Value |
|---|---|---|
| pH | - | 6 – 9 |
| Turbidity | mg/l | 75 |
| COD | mg/l | 250 |
| $BOD_5$ | mg/l | 50 |
| Total coliforms | MPN/100 ml | 400 |
| Faecal coliforms | MPN/100 ml | 10 – 100 |
| TSS | mg/l | 50 |
| Nitrate – nitrogen ($NO_3$) | mg/l | 0.1 |
| Phosphate - phosphorus ($P0_3$) | mg/l | 2 |
| Ammonia - nitrogen ($NH_4$) | mg/l | 1.5 |

.

**Table 4.12 World Bank effluent quality guidelines**

| Parameter | Unit | Value |
|---|---|---|
| pH | - | 6 - 9 |
| COD | mg/l | 125 |
| $BOD_5$ | mg/l | 30 |
| Total coliforms | MPN/100 ml | 400 |
| Total nitrogen | mg/l | 10 |
| Total phosphorus | mg/l | 2 |
| Oil and grease | mg/l | 10 |

# 5. DESIGN OF SEWER NETWORK

## 5.1 SEWERAGE BASINS

### 5.1.1 Teshie Old Town

The Teshie Old Town project area has been demarcated into eleven (11) main sewerage basins (labelled A,B,C,D,E,E1,F,G,H,J and K) as depicted in Figure 5.1 below. The 11-main sewerage basins have been further demarcated into two hundred and eighty one (281) sewerage sub-basins shown in Figure 5.2 below.

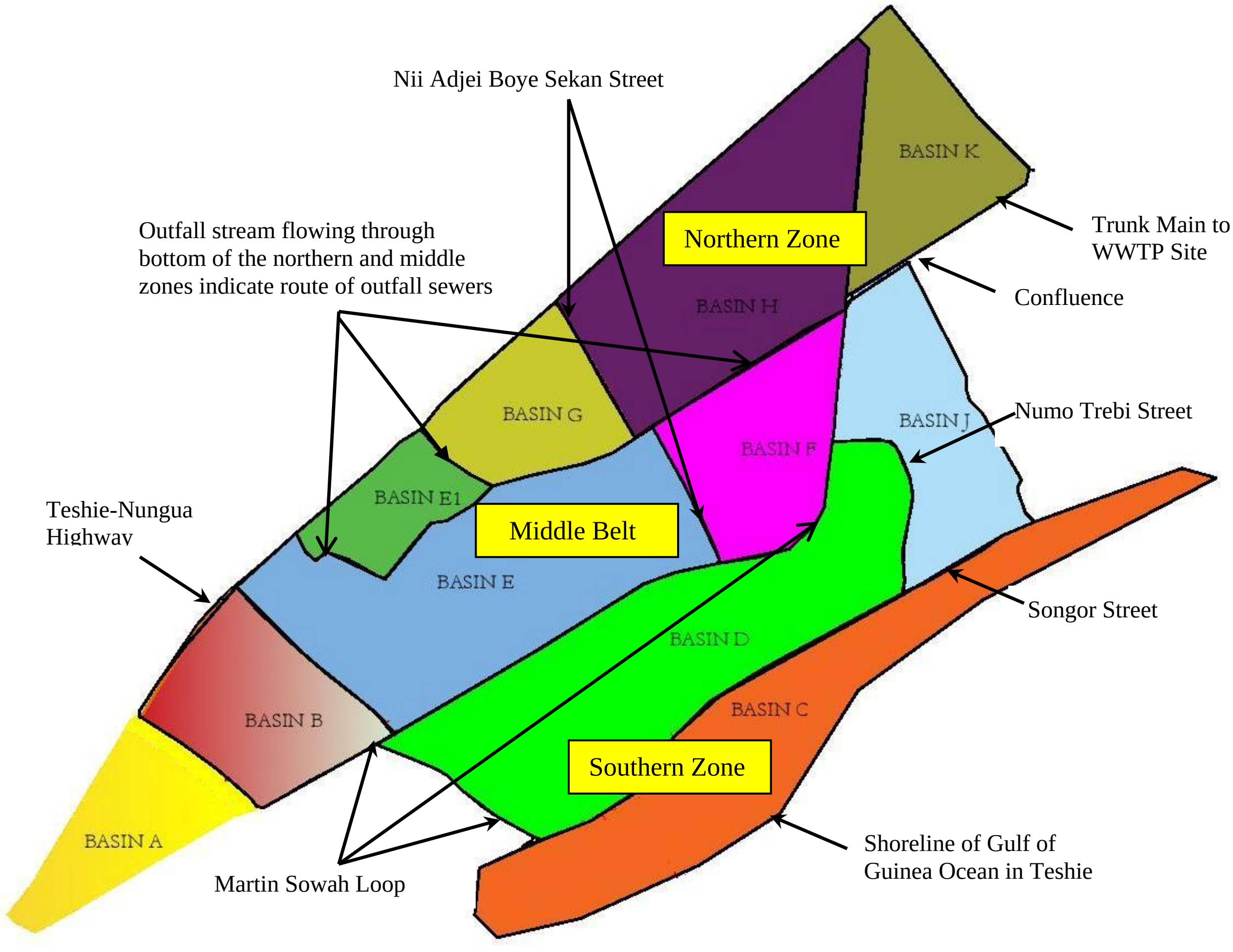



Figure 5.1 Eleven (11) Main Sewerage Basins in the Teshie Old Town catchment

The arrows shown in Figure 5.1 provide important landmarks of the Teshie Old Town LIUC. The Martin Sowah street and the main outfall stream channel divides the catchment into three zones (i.e the northern and southern zones and middle belt. The northern zone is made up of four (4) basins namely (E1, G, H and K) respectively. The middle belt consists of four basins as well which are (A, B, E and F). The southern zone has three (3) basins namely C, D and J.

The confluence shown above is where all the sub-mains of the various basins meet to discharge total flow of the catchment into the trunk sewer and that is tip of the arrow shown in basin J. It is when the flow is collected at this point that the trunk main carries it to the sewage treatment plant. The outfall stream channel shown above runs along bottom of the northern and middle zones to the confluence and from the confluence the channel continues to the sewage treatment plant site into a natural drainage mangrove where the final effluent of the WWTP is expected to be discharged for effective replenishment of aquatic life.

Table 5.1 below presents the characteristics of the respective main basins and their natural drainage patterns described above. Flows from all the sewer sheds is carried by gravity through the confluence to the wastewater treatment plant (WWTP) which is located outside the boundaries of the LIUC. The total area of the LIUC catchment is **98.87Ha**.

**Table 5.1: Characteristics of New Town based on 9-Main Sewerage Basins**

| Basin | Area (ha) | Major Suburbs/Landmarks |
|---|---|---|
| A | 4.03 | St. Johns Schools |
| B | 5.79 | Advans Ghana, Ashfoam & Lords Tabernacle Church |
| C | 8.89 | Teshie Mantse Palace |
| D | 19.70 | Bokoshie Modern Public Toilet |
| E | 18.02 | Jordan Methodist Church |
| E1 | 3.50 | Adoemli Market |
| F | 5.70 | Lizzy's Pub & Pablow Winery |
| G | 3.63 | Holy Apostolic Reform Church/Premier Bet,Com |
| H | 19.81 | Total Filling Station// St. Anne & Joachim Catholic Church & Schools |
| J | 5.21 | Songor Street /Teshie Mangoase/Apostolic Primary & JHS |
| K | 4.59 | Manglad Roofing Systems/ Latter Days Saints Church |
| TOTAL | **98.87** | |

### 5.1.2 WWTP Enclave

The area that lies adjacent to the Teshie Old Town wastewater treatment plant site which is depicted in Figure 5.2 covers an area of about **3.98 ha**.

Major landmarks in this quarter include the two guest houses, new residential developments, Church of Pentecost, and vehicle fitting and spray shops, old refuse dump sitting close to the proposed WWTP site and a large natural drainage mangrove south of the WWTP site.

Flows from this single sewerage basin will be sent by gravity to the WWTP which is located to the south west of the project area.

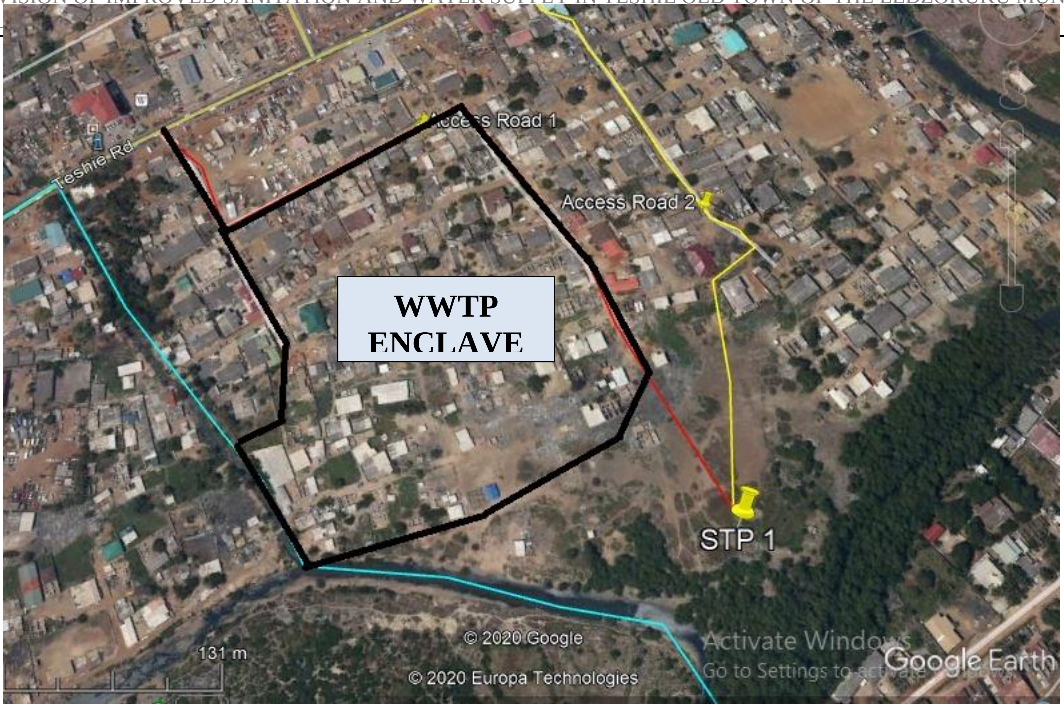



**Figure 5.2 Insertion of Sewerage basin for Enclave near WWTP site**

## 5.2 LIUC LAYOUT DESCRIPTION

Sewer lines on the LIUC layout presented in Figure 5.3 below were planned using different line colour configurations in digitized 2-D AutoCAD. The coloured lines indicate proposed condominium sewers, public/street sewers, main collectors and trunk mains. The designed sewerage layout also depicts the following gravity flow functions:

1) Condominial sewers have been planned to collect wastewater from homes/residences into the public sewers placed along existing streets and alleys within the basins.

2) The public/street sewers have been planned to collect and direct wastewater flow by gravity from the upstream sections of planned sewerage basins towards downstream sections into outfall sewers located along outfall channels of the Old Teshie drainage shed/catchment.

3) The outfall sewers have also been planned strategically to collect aggregated sewage flows from sections of the basins through the middle belt and other natural channels of the Old Teshie drainage basin towards the entrance of the trunk main at the common point called the confluence. At the confluence, the truck main will collect the total flow discharged from the various basins and transport it to the WWTP site for treatment. By this, the total wastewater of the entire catchment will be effectively and completely conveyed to the WWTP site.

In conclusion wastewater collected by condominial and street sewers will flow and aggregate through well planned outfall sewers to the collective point of disposal by the most direct (and, consequently; the shortest) route with the prime aim of achieving a cost-effective design.

Spot heights on the proposed LIUC layout presented above confirm the total feasible nature of gravity flow regime of the catchment. Consequently there is no need for provision of any pumping facility within any of the ten (10) basins of catchment described above.

Sewer manholes presented on the layout have been planned in accordance with the standards and best practice conventions presented in item 4.1.7 above. Design calculations/analysis and results were based on input data from the layout, design criteria, parameters and equations in Chapter 4.0.

Annex B of this report presents a better-quality layout which shows more clearly all the necessary details described (1)-(3) above. Longitudinal profiles of some main sewer lines of the layout have been added.

**Figure 5.3 Teshie Old Town Gravity Sewerage Network**

## 5.3 DESIGN POPULATION AND SEWAGE FLOWS

### 5.3.1 Basin Flows (Old Teshie)

Tables 5.2A, 5.2B, 5.2D, 5.2E, 5.2E1, 5.2F, 5.2G, 5.2H, 5.2J and 5.2K below respectively present the initial and final populations and their corresponding average and peak sewage flows for two hundred and eighty one (281) sub-basins of the Old Teshie catchment (sewer shed).

**TABLE 5.2A, INITIAL AND FINAL SEWAGE FLOW, BASIN A**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-A1 | 0.25 | 53 | **2.39** | **0.017** | 91 | **4.07** | **0.028** |
| SB-A2 | 0.42 | 91 | **4.09** | **0.028** | 156 | **6.97** | **0.048** |
| SB-A3 | 0.97 | 210 | **9.39** | **0.065** | 357 | **16.00** | **0.111** |
| SB-A4 | 0.63 | 135 | **6.06** | **0.042** | 231 | **10.33** | **0.072** |
| SB-A5 | 0.35 | 76 | **3.41** | **0.024** | 130 | **5.81** | **0.040** |
| SB-A6 | 0.34 | 73 | **3.27** | **0.023** | 125 | **5.58** | **0.039** |
| SB-A7 | 0.32 | 68 | **3.05** | **0.021** | 116 | **5.20** | **0.036** |
| SB-A8 | 0.74 | 160 | **7.17** | **0.050** | 273 | **12.22** | **0.085** |
| **TOTAL** | **4.03** | **867** | **38.84** | **0.270** | **1477** | **66.17** | **0.460** |

**TABLE 5.2B, INITIAL AND FINAL SEWAGE FLOW, BASIN B**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-B1 | 0.24 | 52 | **2.33** | **0.02** | 89 | **3.97** | **0.03** |
| SB-B2 | 0.39 | 83 | **3.74** | **0.03** | 142 | **6.36** | **0.04** |
| SB-B3 | 0.20 | 43 | **1.95** | **0.01** | 74 | **3.32** | **0.02** |
| SB-B4 | 0.16 | 33 | **1.50** | **0.01** | 57 | **2.55** | **0.02** |
| SB-B5 | 0.23 | 49 | **2.20** | **0.02** | 84 | **3.74** | **0.03** |
| SB-B6 | 0.27 | 57 | **2.56** | **0.02** | 97 | **4.36** | **0.03** |
| SB-B7 | 0.23 | 50 | **2.25** | **0.02** | 86 | **3.84** | **0.03** |
| SB-B8 | 0.12 | 26 | **1.15** | **0.01** | 44 | **1.96** | **0.01** |

**TABLE 5.2B, INITIAL AND FINAL SEWAGE FLOW, BASIN B**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3$/d) | Peak Flow (l/s) | Initial Population | Average Flow ($m^3$/d) | Peak Flow (l/s) |
| SB-B9 | 0.22 | 48 | **2.16** | **0.01** | 82 | **3.67** | **0.03** |
| SB-B10 | 0.27 | 59 | **2.65** | **0.02** | 101 | **4.51** | **0.03** |
| SB-B11 | 0.27 | 58 | **2.62** | **0.02** | 100 | **4.46** | **0.03** |
| SB-B12 | 0.34 | 72 | **3.24** | **0.02** | 123 | **5.53** | **0.04** |
| SB-B13 | 0.19 | 42 | **1.87** | **0.01** | 71 | **3.18** | **0.02** |
| SB-B14 | 0.17 | 36 | **1.60** | **0.01** | 61 | **2.73** | **0.02** |
| SB-B15 | 0.18 | 39 | **1.73** | **0.01** | 66 | **2.95** | **0.02** |
| SB-B16 | 0.27 | 58 | **2.60** | **0.02** | 99 | **4.43** | **0.03** |
| SB-B17 | 0.19 | 42 | **1.88** | **0.01** | 71 | **3.20** | **0.02** |
| SB-B18 | 0.50 | 107 | **4.79** | **0.03** | 182 | **8.17** | **0.06** |
| SB-B19 | 0.69 | 148 | **6.64** | **0.05** | 253 | **11.32** | **0.08** |
| SB-B20 | 0.24 | 52 | **2.34** | **0.02** | 89 | **3.99** | **0.03** |
| SB-B21 | 0.42 | 89 | **4.01** | **0.03** | 152 | **6.83** | **0.05** |
| **TOTAL** | **5.79** | **1246** | **55.80** | **0.39** | **2122** | **95.07** | **0.66** |

**TABLE 5.2C, INITIAL AND FINAL SEWAGE FLOW, BASIN C**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3$/d) | Peak Flow (l/s) | Final Population | Average Flow ($m^3$/d) | Peak Flow (l/s) |
| SB-C1 | 0.51 | 110 | **4.91** | **0.03** | 187 | **8.36** | **0.06** |
| SB-C2 | 0.58 | 124 | **5.57** | **0.04** | 212 | **9.49** | **0.07** |
| SB-C3 | 0.47 | 102 | **4.57** | **0.03** | 174 | **7.79** | **0.05** |
| SB-C4 | 0.63 | 136 | **6.10** | **0.04** | 232 | **10.40** | **0.07** |
| SB-C5 | 0.63 | 135 | **6.04** | **0.04** | 230 | **10.29** | **0.07** |
| SB-C6 | 0.51 | 109 | **4.88** | **0.03** | 186 | **8.32** | **0.06** |
| SB-C7 | 0.59 | 127 | **5.68** | **0.04** | 216 | **9.68** | **0.07** |
| SB-C8 | 1.33 | 286 | **12.79** | **0.09** | 486 | **21.79** | **0.15** |

**TABLE 5.2C, INITIAL AND FINAL SEWAGE FLOW, BASIN C**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-C9 | 0.72 | 155 | **6.93** | **0.05** | 264 | **11.81** | **0.08** |
| SB-C10 | 0.46 | 99 | **4.43** | **0.03** | 169 | **7.55** | **0.05** |
| SB-C11 | 0.54 | 116 | **5.20** | **0.04** | 198 | **8.87** | **0.06** |
| SB-C12 | 0.38 | 82 | **3.65** | **0.03** | 139 | **6.22** | **0.04** |
| SB-C13 | 0.35 | 75 | **3.34** | **0.02** | 127 | **5.70** | **0.04** |
| SB-C14 | 0.24 | 52 | **2.31** | **0.02** | 88 | **3.94** | **0.03** |
| SB-C15 | 0.26 | 55 | **2.47** | **0.02** | 94 | **4.21** | **0.03** |
| SB-C16 | 0.72 | 155 | **6.95** | **0.05** | 264 | **11.83** | **0.08** |
| TOTAL | **8.90** | **1200.11** | **53.77** | **0.37** | **2044.71** | **91.60** | **0.64** |

**TABLE 5.2D, INITIAL AND FINAL SEWAGE FLOW, BASIN D**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-D1 | 0.08 | 17 | **0.78** | **0.01** | 30 | **1.33** | **0.01** |
| SB-D2 | 0.16 | 34 | **1.54** | **0.01** | 59 | **2.63** | **0.02** |
| SB-D3 | 0.14 | 31 | **1.38** | **0.01** | 53 | **2.36** | **0.02** |
| SB-D4 | 0.11 | 23 | **1.01** | **0.01** | 39 | **1.73** | **0.01** |
| SB-D5 | 0.37 | 80 | **3.57** | **0.02** | 136 | **6.08** | **0.04** |
| SB-D6 | 0.97 | 209 | **9.35** | **0.06** | 356 | **15.93** | **0.11** |
| SB-D7 | 4.49 | 967 | **43.33** | **0.30** | 1648 | **73.83** | **0.51** |
| SB-D8 | 0.30 | 64 | **2.87** | **0.02** | 109 | **4.89** | **0.03** |
| SB-D9 | 0.09 | 20 | **0.89** | **0.01** | 34 | **1.52** | **0.01** |
| SB-D10 | 0.22 | 48 | **2.17** | **0.02** | 82 | **3.70** | **0.03** |
| SB-D11 | 0.16 | 35 | **1.56** | **0.01** | 59 | **2.66** | **0.02** |
| SB-D12 | 0.10 | 22 | **1.00** | **0.01** | 38 | **1.70** | **0.01** |

**TABLE 5.2D, INITIAL AND FINAL SEWAGE FLOW, BASIN D**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-D13 | 0.17 | 37 | **1.67** | **0.01** | 64 | **2.85** | **0.02** |
| SB-D14 | 0.31 | 66 | **2.95** | **0.02** | 112 | **5.02** | **0.03** |
| SB-D15 | 0.19 | 40 | **1.79** | **0.01** | 68 | **3.04** | **0.02** |
| SB-D16 | 0.72 | 155 | **6.97** | **0.05** | 265 | **11.87** | **0.08** |
| SB-D17 | 0.42 | 91 | **4.06** | **0.03** | 154 | **6.92** | **0.05** |
| SB-D18 | 0.11 | 23 | **1.03** | **0.01** | 39 | **1.76** | **0.01** |
| SB-D19 | 0.21 | 46 | **2.06** | **0.01** | 78 | **3.51** | **0.02** |
| SB-D20 | 0.20 | 44 | **1.96** | **0.01** | 75 | **3.34** | **0.02** |
| SB-D21 | 0.26 | 56 | **2.49** | **0.02** | 95 | **4.25** | **0.03** |
| SB-D22 | 0.24 | 53 | **2.35** | **0.02** | 89 | **4.01** | **0.03** |
| SB-D22A | 0.08 | 16 | **0.73** | **0.01** | 28 | **1.24** | **0.01** |
| SB-D23 | 0.10 | 22 | **1.00** | **0.01** | 38 | **1.70** | **0.01** |
| SB-D24 | 0.09 | 19 | **0.85** | **0.01** | 32 | **1.44** | **0.01** |
| SB-D25 | 0.33 | 71 | **3.17** | **0.02** | 121 | **5.41** | **0.04** |
| SB-D26 | 0.60 | 129 | **5.78** | **0.04** | 220 | **9.84** | **0.07** |
| SB-D27 | 0.17 | 37 | **1.64** | **0.01** | 62 | **2.79** | **0.02** |
| SB-D28 | 0.68 | 147 | **6.58** | **0.05** | 250 | **11.21** | **0.08** |
| SB-D29 | 0.26 | 57 | **2.54** | **0.02** | 97 | **4.33** | **0.03** |
| SB-D30 | 0.32 | 70 | **3.13** | **0.02** | 119 | **5.33** | **0.04** |
| SB-D31 | 0.21 | 44 | **1.99** | **0.01** | 76 | **3.39** | **0.02** |
| SB-D32 | 0.30 | 65 | **2.91** | **0.02** | 111 | **4.96** | **0.03** |
| SB-D33 | 0.51 | 110 | **4.93** | **0.03** | 188 | **8.40** | **0.06** |
| SB-D34 | 0.11 | 25 | **1.11** | **0.01** | 42 | **1.89** | **0.01** |
| SB-D35 | 0.06 | 13 | **0.58** | **0.00** | 22 | **0.99** | **0.01** |
| SB-D36 | 0.11 | 24 | **1.06** | **0.01** | 40 | **1.80** | **0.01** |
| SB-D37 | 0.10 | 22 | **0.97** | **0.01** | 37 | **1.65** | **0.01** |
| SB-D38 | 0.19 | 42 | **1.87** | **0.01** | 71 | **3.18** | **0.02** |
| SB-D39 | 0.23 | 50 | **2.23** | **0.02** | 85 | **3.79** | **0.03** |

**TABLE 5.2D, INITIAL AND FINAL SEWAGE FLOW, BASIN D**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-D40 | 0.16 | 34 | **1.54** | **0.01** | 59 | **2.63** | **0.02** |
| SB-D41 | 0.18 | 38 | **1.69** | **0.01** | 64 | **2.88** | **0.02** |
| SB-D42 | 0.25 | 54 | **2.40** | **0.02** | 91 | **4.08** | **0.03** |
| SB-D43 | 0.14 | 30 | **1.35** | **0.01** | 51 | **2.30** | **0.02** |
| SB-D44 | 0.33 | 71 | **3.17** | **0.02** | 121 | **5.40** | **0.04** |
| SB-D45 | 0.12 | 25 | **1.12** | **0.01** | 43 | **1.91** | **0.01** |
| SB-D46 | 0.16 | 35 | **1.57** | **0.01** | 60 | **2.67** | **0.02** |
| SB-D47 | 0.23 | 49 | **2.17** | **0.02** | 83 | **3.71** | **0.03** |
| SB-D48 | 0.13 | 29 | **1.30** | **0.01** | 49 | **2.22** | **0.02** |
| SB-D49 | 0.23 | 50 | **2.24** | **0.02** | 85 | **3.81** | **0.03** |
| SB-D50 | 0.16 | 34 | **1.53** | **0.01** | 58 | **2.60** | **0.02** |
| SB-D51 | 0.12 | 25 | **1.14** | **0.01** | 43 | **1.94** | **0.01** |
| SB-D52 | 0.08 | 17 | **0.76** | **0.01** | 29 | **1.30** | **0.01** |
| SB-D53 | 0.08 | 18 | **0.79** | **0.01** | 30 | **1.35** | **0.01** |
| SB-D54 | 0.24 | 52 | **2.35** | **0.02** | 89 | **4.00** | **0.03** |
| SB-D55 | 0.14 | 30 | **1.34** | **0.01** | 51 | **2.28** | **0.02** |
| SB-D56 | 0.71 | 153 | **6.84** | **0.05** | 260 | **11.66** | **0.08** |
| SB-D57 | 0.13 | 28 | **1.24** | **0.01** | 47 | **2.12** | **0.01** |
| SB-D58 | 0.28 | 61 | **2.72** | **0.02** | 103 | **4.63** | **0.03** |
| SB-D59 | 0.31 | 67 | **3.02** | **0.02** | 115 | **5.15** | **0.04** |
| SB-D60 | 0.28 | 59 | **2.66** | **0.02** | 101 | **4.53** | **0.03** |
| SB-D61 | 0.18 | 39 | **1.74** | **0.01** | 66 | **2.96** | **0.02** |
| SB-D62 | 0.15 | 33 | **1.49** | **0.01** | 57 | **2.54** | **0.02** |
| SB-D63 | 0.15 | 32 | **1.42** | **0.01** | 54 | **2.42** | **0.02** |
| SB-D64 | 0.05 | 10 | **0.47** | **0.00** | 18 | **0.80** | **0.01** |
| SB-D65 | 0.22 | 48 | **2.15** | **0.01** | 82 | **3.67** | **0.03** |
| **TOTAL** | **19.70** | **4242** | **190.05** | **1.32** | **7228** | **323.79** | **2.25** |

| TABLE 5.2E, INITIAL AND FINAL SEWAGE FLOW, BASIN E | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sub-Basin Code** | **Basin Area (Ha)** | **Initial Sewage Flow** | | | **Final Sewage Flow** | | |
| | | **Initial Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** | **Final Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** |
| SB-E1 | 0.19 | 41 | **1.84** | **0.01** | 70 | **3.14** | **0.02** |
| SB-E2 | 0.19 | 41 | **1.84** | **0.01** | 70 | **3.13** | **0.02** |
| SB-E3 | 0.45 | 97 | **4.32** | **0.03** | 164 | **7.37** | **0.05** |
| SB-E4 | 0.32 | 69 | **3.09** | **0.02** | 117 | **5.26** | **0.04** |
| SB-E5 | 0.08 | 16 | **0.73** | **0.01** | 28 | **1.24** | **0.01** |
| SB-E6 | 0.08 | 18 | **0.79** | **0.01** | 30 | **1.35** | **0.01** |
| SB-E6A | 0.07 | 14 | **0.65** | **0.00** | 25 | **1.10** | **0.01** |
| SB-E6B | 0.08 | 16 | **0.73** | **0.01** | 28 | **1.24** | **0.01** |
| SB-E7 | 0.20 | 44 | **1.96** | **0.01** | 75 | **3.34** | **0.02** |
| SB-E8 | 0.23 | 49 | **2.21** | **0.02** | 84 | **3.76** | **0.03** |
| SB-E9 | 0.15 | 32 | **1.41** | **0.01** | 54 | **2.41** | **0.02** |
| SB-E10 | 0.25 | 54 | **2.40** | **0.02** | 91 | **4.09** | **0.03** |
| SB-E11 | 0.19 | 40 | **1.79** | **0.01** | 68 | **3.06** | **0.02** |
| SB-E12 | 0.44 | 95 | **4.27** | **0.03** | 162 | **7.27** | **0.05** |
| SB-E13 | 0.26 | 56 | **2.53** | **0.02** | 96 | **4.31** | **0.03** |
| SB-E14 | 0.25 | 55 | **2.46** | **0.02** | 93 | **4.18** | **0.03** |
| SB-E15 | 0.08 | 17 | **0.76** | **0.01** | 29 | **1.30** | **0.01** |
| SB-E16 | 1.22 | 262 | **11.73** | **0.08** | 446 | **19.99** | **0.14** |
| SB-E18 | 0.21 | 44 | **1.98** | **0.01** | 75 | **3.37** | **0.02** |
| SB-E19 | 0.15 | 32 | **1.45** | **0.01** | 55 | **2.47** | **0.02** |
| SB-E20 | 0.28 | 60 | **2.69** | **0.02** | 102 | **4.58** | **0.03** |
| SB-E21 | 0.33 | 72 | **3.21** | **0.02** | 122 | **5.47** | **0.04** |
| SB-E22 | 0.17 | 36 | **1.62** | **0.01** | 62 | **2.76** | **0.02** |
| SB-E23 | 0.27 | 59 | **2.64** | **0.02** | 100 | **4.50** | **0.03** |
| SB-E24 | 0.08 | 17 | **0.75** | **0.01** | 28 | **1.27** | **0.01** |
| SB-E25 | 0.09 | 20 | **0.87** | **0.01** | 33 | **1.49** | **0.01** |
| SB-E26 | 0.13 | 27 | **1.21** | **0.01** | 46 | **2.07** | **0.01** |
| SB-E27 | 0.12 | 26 | **1.18** | **0.01** | 45 | **2.01** | **0.01** |
| SB-E28 | 0.53 | 114 | **5.10** | **0.04** | 194 | **8.70** | **0.06** |

| TABLE 5.2E, INITIAL AND FINAL SEWAGE FLOW, BASIN E | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sub-Basin Code** | **Basin Area (Ha)** | **Initial Sewage Flow** | | | **Final Sewage Flow** | | |
| | | **Initial Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** | **Initial Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** |
| SB-E29 | 0.28 | 61 | **2.72** | **0.02** | 103 | **4.63** | **0.03** |
| SB-E30 | 0.23 | 50 | **2.25** | **0.02** | 86 | **3.84** | **0.03** |
| SB-E31 | 0.07 | 16 | **0.70** | **0.00** | 26 | **1.19** | **0.01** |
| SB-E32 | 0.51 | 109 | **4.90** | **0.03** | 186 | **8.36** | **0.06** |
| SB-E33 | 0.37 | 79 | **3.52** | **0.02** | 134 | **6.00** | **0.04** |
| SB-E34 | 0.12 | 25 | **1.13** | **0.01** | 43 | **1.93** | **0.01** |
| SB-E35 | 0.40 | 86 | **3.85** | **0.03** | 146 | **6.55** | **0.05** |
| SB-E36 | 0.49 | 105 | **4.69** | **0.03** | 178 | **7.99** | **0.06** |
| SB-E37 | 0.25 | 55 | **2.45** | **0.02** | 93 | **4.18** | **0.03** |
| SB-E38 | 0.09 | 19 | **0.87** | **0.01** | 33 | **1.48** | **0.01** |
| SB-E40 | 0.08 | 17 | **0.75** | **0.01** | 29 | **1.28** | **0.01** |
| SB-E41 | 0.14 | 30 | **1.36** | **0.01** | 52 | **2.31** | **0.02** |
| SB-E42 | 0.11 | 25 | **1.10** | **0.01** | 42 | **1.88** | **0.01** |
| SB-E28 | 0.53 | 114 | **5.10** | **0.04** | 194 | **8.70** | **0.06** |
| SB-E29 | 0.28 | 61 | **2.72** | **0.02** | 103 | **4.63** | **0.03** |
| SB-E30 | 0.23 | 50 | **2.25** | **0.02** | 86 | **3.84** | **0.03** |
| SB-E31 | 0.07 | 16 | **0.70** | **0.00** | 26 | **1.19** | **0.01** |
| SB-E32 | 0.51 | 109 | **4.90** | **0.03** | 186 | **8.36** | **0.06** |
| SB-E33 | 0.37 | 79 | **3.52** | **0.02** | 134 | **6.00** | **0.04** |
| SB-E34 | 0.12 | 25 | **1.13** | **0.01** | 43 | **1.93** | **0.01** |
| SB-E35 | 0.40 | 86 | **3.85** | **0.03** | 146 | **6.55** | **0.05** |
| SB-E36 | 0.49 | 105 | **4.69** | **0.03** | 178 | **7.99** | **0.06** |
| SB-E37 | 0.25 | 55 | **2.45** | **0.02** | 93 | **4.18** | **0.03** |
| SB-E38 | 0.09 | 19 | **0.87** | **0.01** | 33 | **1.48** | **0.01** |
| SB-E40 | 0.08 | 17 | **0.75** | **0.01** | 29 | **1.28** | **0.01** |
| SB-E41 | 0.14 | 30 | **1.36** | **0.01** | 52 | **2.31** | **0.02** |
| SB-E42 | 0.11 | 25 | **1.10** | **0.01** | 42 | **1.88** | **0.01** |
| SB-E43 | 0.36 | 77 | **3.43** | **0.02** | 131 | **5.85** | **0.04** |
| SB-E44 | 0.58 | 126 | **5.63** | **0.04** | 214 | **9.59** | **0.07** |

**TABLE 5.2E, INITIAL AND FINAL SEWAGE FLOW, BASIN E**

| Sub-Basin Code | Basin Area | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-E45 | 0.34 | 74 | **3.31** | **0.02** | 126 | **5.64** | **0.04** |
| SB-E46 | 0.77 | 166 | **7.43** | **0.05** | 283 | **12.66** | **0.09** |
| SB-E47 | 0.36 | 77 | **3.44** | **0.02** | 131 | **5.87** | **0.04** |
| SB-E48 | 0.12 | 25 | **1.13** | **0.01** | 43 | **1.93** | **0.01** |
| SB-E49 | 0.11 | 24 | **1.05** | **0.01** | 40 | **1.80** | **0.01** |
| SB-E50 | 0.34 | 72 | **3.24** | **0.02** | 123 | **5.52** | **0.04** |
| SB-E51 | 0.32 | 69 | **3.08** | **0.02** | 117 | **5.24** | **0.04** |
| SB-E52 | 0.40 | 87 | **3.88** | **0.03** | 147 | **6.61** | **0.05** |
| SB-E53 | 0.14 | 31 | **1.38** | **0.01** | 53 | **2.35** | **0.02** |
| SBE54 | 0.30 | 65 | **2.91** | **0.02** | 111 | **4.96** | **0.03** |
| **TOTAL** | **18.02** | **3880** | **173.84** | **1.21** | **6611** | **296.18** | **2.06** |

**TABLE 5.2E1, INITIAL AND FINAL SEWAGE FLOW, BASIN E1**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-E1-1 | 1.28 | 275 | **12.32** | **0.09** | 468 | **20.99** | **0.15** |
| SB-E1-2 | 0.14 | 30 | **1.34** | **0.01** | 51 | **2.27** | **0.02** |
| SB-E1-3 | 0.15 | 33 | **1.48** | **0.01** | 56 | **2.53** | **0.02** |
| SB-E1-4 | 0.11 | 25 | **1.11** | **0.01** | 42 | **1.88** | **0.01** |
| SB-E1-5 | 0.07 | 15 | **0.68** | **0.00** | 26 | **1.16** | **0.01** |
| SB-E1-6 | 0.18 | 38 | **1.71** | **0.01** | 65 | **2.92** | **0.02** |
| SB-E1-7 | 0.20 | 43 | **1.93** | **0.01** | 73 | **3.29** | **0.02** |
| SB-E1-8 | 0.21 | 45 | **2.03** | **0.01** | 77 | **3.45** | **0.02** |
| SB-E1-9 | 0.12 | 26 | **1.15** | **0.01** | 44 | **1.96** | **0.01** |
| SB-E1-10 | 0.18 | 40 | **1.78** | **0.01** | 68 | **3.03** | **0.02** |
| SB-E1-11 | 0.21 | 46 | **2.06** | **0.01** | 78 | **3.52** | **0.02** |
| SB-E1-12 | 0.08 | 17 | **0.75** | **0.01** | 29 | **1.28** | **0.01** |

| TABLE 5.2E1, INITIAL AND FINAL SEWAGE FLOW, BASIN E1 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-E1-13 | 0.32 | 69 | **3.09** | **0.02** | 117 | **5.26** | **0.04** |
| SB-E1-14 | 0.13 | 27 | **1.22** | **0.01** | 47 | **2.08** | **0.01** |
| SB-E1-15 | 0.12 | 25 | **1.11** | **0.01** | 42 | **1.89** | **0.01** |
| **TOTAL** | **3.50** | **754** | **33.76** | **0.23** | **1284** | **57.52** | **0.40** |

| TABLE 5.2F, INITIAL AND FINAL SEWAGE FLOW, BASIN F | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-F1 | 0.10 | 22 | **1.00** | **0.01** | 38 | **1.70** | **0.01** |
| SB-F2 | 0.12 | 25 | **1.12** | **0.01** | 43 | **1.91** | **0.01** |
| SB-F3 | 0.06 | 13 | **0.58** | **0.00** | 22 | **0.99** | **0.01** |
| SB-F4 | 0.10 | 22 | **0.97** | **0.01** | 37 | **1.64** | **0.01** |
| SB-F5 | 0.23 | 49 | **2.19** | **0.02** | 83 | **3.73** | **0.03** |
| SB-F6 | 0.09 | 19 | **0.83** | **0.01** | 32 | **1.42** | **0.01** |
| SB-F7 | 0.20 | 43 | **1.95** | **0.01** | 74 | **3.32** | **0.02** |
| SB-F8 | 0.14 | 29 | **1.31** | **0.01** | 50 | **2.24** | **0.02** |
| SB-F9 | 0.32 | 68 | **3.06** | **0.02** | 116 | **5.21** | **0.04** |
| SB-F10 | 0.15 | 31 | **1.41** | **0.01** | 53 | **2.39** | **0.02** |
| SB-F11 | 0.24 | 52 | **2.33** | **0.02** | 89 | **3.97** | **0.03** |
| SB-F12 | 0.25 | 54 | **2.41** | **0.02** | 92 | **4.11** | **0.03** |
| SB-F13 | 0.17 | 37 | **1.64** | **0.01** | 63 | **2.80** | **0.02** |
| SB-F14 | 0.15 | 33 | **1.49** | **0.01** | 57 | **2.54** | **0.02** |
| SB-F17 | 0.22 | 48 | **2.17** | **0.02** | 82 | **3.70** | **0.03** |
| SB-F18 | 0.10 | 20 | **0.92** | **0.01** | 35 | **1.56** | **0.01** |
| SB-F19 | 0.07 | 15 | **0.66** | **0.00** | 25 | **1.12** | **0.01** |
| SB-F20 | 0.16 | 35 | **1.57** | **0.01** | 60 | **2.68** | **0.02** |
| SB-F21 | 0.21 | 44 | **1.98** | **0.01** | 75 | **3.37** | **0.02** |
| SB-F22 | 0.24 | 52 | **2.34** | **0.02** | 89 | **3.98** | **0.03** |
| SB-F23 | 0.36 | 77 | **3.43** | **0.02** | 131 | **5.85** | **0.04** |

| TABLE 5.2F, INITIAL AND FINAL SEWAGE FLOW, BASIN F | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sub-Basin Code** | | **Initial Sewage Flow** | | | **Final Sewage Flow** | | |
| | | | | | | | |
| SB-F24 | 0.08 | 18 | **0.79** | **0.01** | 30 | **1.34** | **0.01** |
| SB-F25 | 0.09 | 18 | **0.83** | **0.01** | 31 | **1.41** | **0.01** |
| SB-F26 | 0.09 | 18 | **0.83** | **0.01** | 31 | **1.41** | **0.01** |
| SB-F27 | 0.09 | 20 | **0.88** | **0.01** | 34 | **1.50** | **0.01** |
| SB-F28 | 0.12 | 25 | **1.13** | **0.01** | 43 | **1.92** | **0.01** |
| SB-F29 | 0.10 | 21 | **0.93** | **0.01** | 35 | **1.58** | **0.01** |
| SB-F30 | 0.07 | 15 | **0.68** | **0.00** | 26 | **1.16** | **0.01** |
| SB-F31 | 0.11 | 24 | **1.08** | **0.01** | 41 | **1.85** | **0.01** |
| SB-F32 | 0.18 | 40 | **1.77** | **0.01** | 67 | **3.02** | **0.02** |
| SB-F33 | 0.15 | 32 | **1.44** | **0.01** | 55 | **2.45** | **0.02** |
| SB-F34 | 0.27 | 59 | **2.65** | **0.02** | 101 | **4.51** | **0.03** |
| SB-F35 | 0.29 | 63 | **2.84** | **0.02** | 108 | **4.85** | **0.03** |
| SB-F36 | 0.07 | 15 | **0.69** | **0.00** | 26 | **1.18** | **0.01** |
| SB-F37 | **0.32** | **69** | **3.09** | **0.02** | **118** | **5.27** | **0.04** |
| **TOTAL** | **5.70** | **1227** | **54.98** | **0.38** | **2091** | **93.68** | **0.65** |

| TABLE 5.2G, INITIAL AND FINAL SEWAGE FLOW, BASIN G | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sub-Basin Code** | **Basin Area (Ha)** | **Initial Sewage Flow** | | | **Final Sewage Flow** | | |
| | | **Initial Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** | **Final Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** |
| SB-G1 | 0.53 | 114 | **5.12** | **0.04** | 195 | **8.72** | **0.06** |
| SB-G2 | 0.14 | 29 | **1.31** | **0.01** | 50 | **2.23** | **0.02** |
| SB-G2A | 0.13 | 28 | **1.26** | **0.01** | 48 | **2.14** | **0.01** |
| SB-G3 | 0.36 | 77 | **3.44** | **0.02** | 131 | **5.87** | **0.04** |
| SB-G4 | 0.18 | 38 | **1.70** | **0.01** | 64 | **2.89** | **0.02** |
| SB-G5 | 0.26 | 55 | **2.47** | **0.02** | 94 | **4.20** | **0.03** |
| SB-G6 | 0.47 | 101 | **4.53** | **0.03** | 172 | **7.72** | **0.05** |
| SB-G7 | 0.33 | 71 | **3.18** | **0.02** | 121 | **5.41** | **0.04** |
| SB-G8 | 0.11 | 24 | **1.07** | **0.01** | 41 | **1.82** | **0.01** |
| SB-G9 | 0.26 | 56 | **2.50** | **0.02** | 95 | **4.25** | **0.03** |

| TABLE 5.2G, INITIAL AND FINAL SEWAGE FLOW, BASIN G | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sub-Basin Code | | Initial Sewage Flow | | | Final Sewage Flow | | |
| | | | | | | | |
| SB-G10 | 0.19 | 42 | **1.87** | **0.01** | 71 | **3.19** | **0.02** |
| SB-G11 | 0.11 | 24 | **1.08** | **0.01** | 41 | **1.84** | **0.01** |
| SB-G12 | 0.12 | 25 | **1.14** | **0.01** | 43 | **1.94** | **0.01** |
| SB-G13 | 0.25 | 54 | **2.41** | **0.02** | 92 | **4.11** | **0.03** |
| SB-G14 | 0.20 | 44 | **1.96** | **0.01** | 75 | **3.34** | **0.02** |
| **TOTAL** | **3.63** | **781.65** | **35.02** | **0.24** | **1331.75** | **59.66** | **0.41** |

| TABLE 5.2H, INITIAL AND FINAL SEWAGE FLOW, BASIN H | | | | | | | |
|---|---|---|---|---|---|---|---|
| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-H1 | 0.11 | 24 | **1.07** | **0.01** | 41 | **1.83** | **0.01** |
| SB-H2 | 0.05 | 11 | **0.50** | **0.00** | 19 | **0.86** | **0.01** |
| SB-H3 | 0.10 | 22 | **0.98** | **0.01** | 37 | **1.66** | **0.01** |
| SB-H4 | 0.17 | 37 | **1.68** | **0.01** | 64 | **2.86** | **0.02** |
| SB-H5 | 0.28 | 60 | **2.69** | **0.02** | 102 | **4.58** | **0.03** |
| SB-H6 | 0.41 | 88 | **3.96** | **0.03** | 151 | **6.75** | **0.05** |
| SB-H7 | 0.13 | 28 | **1.23** | **0.01** | 47 | **2.10** | **0.01** |
| SB-H8 | 0.14 | 30 | **1.33** | **0.01** | 50 | **2.26** | **0.02** |
| SB-H9 | 0.18 | 39 | **1.75** | **0.01** | 66 | **2.97** | **0.02** |
| SB-H10 | 0.13 | 28 | **1.26** | **0.01** | 48 | **2.15** | **0.01** |
| SB-H11 | 0.60 | 128 | **5.75** | **0.04** | 219 | **9.79** | **0.07** |
| SB-H12 | 0.31 | 66 | **2.95** | **0.02** | 112 | **5.03** | **0.03** |
| SB-H13 | 0.27 | 59 | **2.63** | **0.02** | 100 | **4.48** | **0.03** |
| SB-H14 | 0.49 | 105 | **4.72** | **0.03** | 179 | **8.03** | **0.06** |
| SB-H14A | 0.50 | 107 | **4.78** | **0.03** | 182 | **8.15** | **0.06** |
| SB-H15 | 0.29 | 62 | **2.76** | **0.02** | 105 | **4.71** | **0.03** |

**TABLE 5.2H, INITIAL AND FINAL SEWAGE FLOW, BASIN H**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3$/d) | Peak Flow (l/s) | Initial Population | Average Flow ($m^3$/d) | Peak Flow (l/s) |
| SB-H16 | 0.56 | 122 | **5.44** | **0.04** | 207 | **9.28** | **0.06** |
| SB-H16A | 0.24 | 52 | **2.32** | **0.02** | 88 | **3.96** | **0.03** |
| SB-H17 | 0.16 | 34 | **1.54** | **0.01** | 59 | **2.63** | **0.02** |
| SB-H18 | 0.21 | 45 | **2.00** | **0.01** | 76 | **3.41** | **0.02** |
| SB-H19 | 0.29 | 63 | **2.80** | **0.02** | 107 | **4.78** | **0.03** |
| SB-H20 | 0.19 | 41 | **1.83** | **0.01** | 69 | **3.11** | **0.02** |
| SB-H21 | 2.61 | 562 | **25.19** | **0.17** | 958 | **42.92** | **0.30** |
| SB-H22 | 2.82 | 606 | **27.16** | **0.19** | 1033 | **46.28** | **0.32** |
| SB-H23 | 4.67 | 1005 | **45.04** | **0.31** | 1713 | **76.73** | **0.53** |
| SB-H24 | 0.09 | 20 | **0.91** | **0.01** | 35 | **1.55** | **0.01** |
| SB-H25 | 0.29 | 62 | **2.76** | **0.02** | 105 | **4.70** | **0.03** |
| SB-H26 | 0.21 | 44 | **1.98** | **0.01** | 75 | **3.37** | **0.02** |
| SB-H27 | 0.46 | 99 | **4.41** | **0.03** | 168 | **7.52** | **0.05** |
| SB-H28 | 0.86 | 186 | **8.34** | **0.06** | 317 | **14.21** | **0.10** |
| SB-H29 | 0.15 | 33 | **1.46** | **0.01** | 56 | **2.49** | **0.02** |
| SB-H30 | 0.37 | 79 | **3.54** | **0.02** | 135 | **6.03** | **0.04** |
| SB-H31 | 0.70 | 151 | **6.79** | **0.05** | 258 | **11.56** | **0.08** |
| SB-H32 | 0.42 | 90 | **4.02** | **0.03** | 153 | **6.85** | **0.05** |
| SB-H33 | 0.18 | 38 | **1.69** | **0.01** | 64 | **2.88** | **0.02** |
| SB-H34 | 0.19 | 41 | **1.84** | **0.01** | 70 | **3.14** | **0.02** |
| **TOTAL** | **19.81** | **4266** | **191.12** | **1.33** | **7268** | **325.62** | **2.26** |

**TABLE 5.2J, INITIAL AND FINAL SEWAGE FLOW, BASIN J**

| Sub-Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Final Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| SB-J1 | 0.29 | 63 | **2.84** | **0.02** | 108 | **4.84** | **0.03** |
| SB-J2 | 0.08 | 17 | **0.78** | **0.01** | 30 | **1.33** | **0.01** |
| SB-J3 | 0.35 | 76 | **3.41** | **0.02** | 130 | **5.80** | **0.04** |
| SB-J4 | 0.41 | 88 | **3.93** | **0.03** | 149 | **6.69** | **0.05** |
| SB-J5 | 0.16 | 33 | **1.50** | **0.01** | 57 | **2.55** | **0.02** |
| SB-J6 | 0.12 | 26 | **1.18** | **0.01** | 45 | **2.02** | **0.01** |
| SB-J7 | 0.13 | 28 | **1.26** | **0.01** | 48 | **2.15** | **0.01** |
| SB-J8 | 0.09 | 18 | **0.82** | **0.01** | 31 | **1.40** | **0.01** |
| SB-J9 | 0.24 | 53 | **2.35** | **0.02** | 90 | **4.01** | **0.03** |
| SB-J10 | 0.28 | 60 | **2.68** | **0.02** | 102 | **4.56** | **0.03** |
| SB-J11 | 0.17 | 36 | **1.62** | **0.01** | 62 | **2.76** | **0.02** |
| SB-J12 | 0.33 | 70 | **3.16** | **0.02** | 120 | **5.38** | **0.04** |
| SB-J13 | 0.38 | 82 | **3.68** | **0.03** | 140 | **6.27** | **0.04** |
| SB-J14 | 0.41 | 88 | **3.94** | **0.03** | 150 | **6.72** | **0.05** |
| SB-J15 | 0.28 | 59 | **2.66** | **0.02** | 101 | **4.53** | **0.03** |
| SB-J16 | 0.28 | 60 | **2.71** | **0.02** | 103 | **4.61** | **0.03** |
| SB-J17 | 0.48 | 103 | **4.63** | **0.03** | 176 | **7.89** | **0.05** |
| SB-J18 | 0.33 | 70 | **3.14** | **0.02** | 119 | **5.35** | **0.04** |
| SB-J19 | 0.42 | 89 | **4.01** | **0.03** | 152 | **6.83** | **0.05** |
| **TOTAL** | **5.21** | **1123** | **50.29** | **0.35** | **1912** | **85.68** | **0.59** |

| TABLE 5.2K, INITIAL AND FINAL SEWAGE FLOW, BASIN K | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Sub-Basin Code** | **Basin Area (Ha)** | **Initial Sewage Flow** | | | **Final Sewage Flow** | | |
| | | **Initial Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** | **Final Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** |
| SB-K1 | 0.13 | 28 | **1.26** | **0.01** | 48 | **2.14** | **0.01** |
| SB-K2 | 0.59 | 127 | **5.68** | **0.04** | 216 | **9.68** | **0.07** |
| SB-K3 | 0.19 | 42 | **1.86** | **0.01** | 71 | **3.17** | **0.02** |
| SB-K4 | 1.26 | 271 | **12.15** | **0.08** | 462 | **20.70** | **0.14** |
| SB-K5 | 0.40 | 87 | **3.90** | **0.03** | 148 | **6.65** | **0.05** |
| SB-K6 | 0.60 | 130 | **5.83** | **0.04** | 222 | **9.93** | **0.07** |
| SB-K7 | 0.23 | 50 | **2.22** | **0.02** | 84 | **3.78** | **0.03** |
| SB-K8 | 0.38 | 81 | **3.65** | **0.03** | 139 | **6.22** | **0.04** |
| SB-K9 | 0.38 | 81 | **3.65** | **0.03** | 139 | **6.22** | **0.04** |
| SB-K10 | 0.42 | 91 | **4.09** | **0.03** | 156 | **6.97** | **0.05** |
| **TOTAL** | **4.59** | **988.47** | **44.28** | **0.31** | **1684.13** | **75.45** | **0.52** |

### 5.3.2 Summarized Results (Teshie Old Town)

Table 5.3 provides the summarized results of design population, average and peak sewage flow analysis of the Teshie Old Town catchment.

| TABLE 5.3, SUMMARIZED RESULTS OF BASIN FLOWS | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Basin Code** | **Basin Area (Ha)** | **Initial Sewage Flow** | | | **Final Sewage Flow** | | |
| | | **Initial Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** | **Final Population** | **Average Flow ($m^3$/d)** | **Peak Flow (l/s)** |
| A | 4.03 | 867 | 38.84 | 0.27 | 1477 | 66.17 | 0.46 |
| B | 5.79 | 1246 | 55.80 | 0.39 | 2122 | 95.07 | 0.66 |
| C | 8.89 | 1914 | 85.75 | 0.60 | 3261 | 146.09 | 1.01 |
| D | 19.70 | 4242 | 190.05 | 1.32 | 7228 | 323.79 | 2.25 |
| E | 18.02 | 3880 | 173.84 | 1.21 | 6611 | 296.18 | 2.06 |

**TABLE 5.3, SUMMARIZED RESULTS OF DESIGN POPOLATION AND BASIN FLOWS**

| Basin Code | Basin Area (Ha) | Initial Sewage Flow | | | Final Sewage Flow | | |
|---|---|---|---|---|---|---|---|
| | | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) | Initial Population | Average Flow ($m^3/d$) | Peak Flow (l/s) |
| E1 | 3.50 | 754 | 33.76 | 0.23 | 1284 | 57.52 | 0.40 |
| F | 5.70 | 1227 | 54.98 | 0.38 | 2091 | 93.68 | 0.65 |
| G | 3.63 | 782 | 35.02 | 0.24 | 1331.7 | 59.66 | 0.41 |
| H | 19.81 | 4266 | 191.12 | 1.33 | 7268.3 | 325.62 | 2.26 |
| J | 5.21 | 1123 | 50.29 | 0.35 | 1912.5 | 85.68 | 0.59 |
| K | 4.59 | 988 | 44.28 | 0.31 | 1684.1 | 75.45 | 0.52 |
| **TOTAL** | **98.88** | **21288** | **953.72** | **6.62** | **36270** | **1624.92** | **11.28** |

### 5.3.2 Basin Flows for WWTP Enclave

The sewage flows determined for the initial and final periods for WWTP plant residential enclave are presented in Table 5.4.

**Table 5.4 Wastewater flows for WWTP Enclave**

| Period | Est. Population | Avg. Flow ($m^3/d$) | Peak Flow (l/s) |
|---|---|---|---|
| Initial | 838 | 37.52 | 0.26 |
| Final | 1,427 | 69.93 | 0.44 |

### 5.3.3 Summarized Results (Basin Flows)

Table 5.4 provides the summarized results of average and peak sewage flow analysis of the Teshie Old Teshie and WWTP sewerage catchment areas.

**Table 5.5 Summarized Results of Basin Flows**

| Period | Est. Population | Avg. Flow ($m^3/d$) | Peak Flow (l/s) |
|---|---|---|---|
| Initial | 21,288 | 991.24 | 6.88 |
| Final | 36,270 | 1,694.85 | 11.72 |

## 5.4 DESIGN OF SEWERAGE NETWORK

### 5.4.1 Old Teshie

Tables 5.6, 5.7 and 5.8 below present results of the sewerage network design analysis for the community. The results show sewer codes, manholes connecting sewers indicated on the layout, as well as calculated initial and final peak flows of sewers and lengths of sewers. Table 5.6 presents design results of 100 mm condominials and street sewers.

**Table 5.6A1 Design Results of 100mm Condominials in Basin A**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-01 | MH-03 | MH-02 | 20.95 | **0.008** | **0.014** | **100** |
| S-02 | MH-01 | MH-02 | 65.05 | **0.140** | **0.239** | **100** |
| S-03 | MH-02 | MH-04 | 33.26 | **0.028** | **0.048** | **100** |
| S-04 | MH-05 | MH-04 | 60.60 | **0.028** | **0.048** | **100** |
| S-05 | MH-06A | MH-06 | 18.86 | **0.108** | **0.184** | **100** |
| S-06 | MH-06 | MH-05 | 41.11 | **0.108** | **0.184** | **100** |
| S-07 | MH-05 | MH-04 | 41.70 | **0.108** | **0.184** | **100** |
| S-08 | MH-06A | MH-07 | 16.93 | **0.079** | **0.135** | **100** |
| S-09 | MH-07 | MH-21 | 27.39 | **0.079** | **0.135** | **100** |
| S-10 | MH-21 | MH-20 | 38.86 | **0.079** | **0.135** | **100** |
| S-11 | MH-04 | MH-09 | 44.65 | **0.201** | **0.343** | **100** |
| S-12 | MH-09 | MH-10 | 61.88 | **0.201** | **0.343** | **100** |
| S-13 | MH-10 | MH-12 | 70.56 | **0.351** | **0.598** | **100** |
| S-14 | MH-12 | MH-19 | 27.74 | **0.351** | **0.598** | **100** |
| S-15 | MH-20 | MH-19 | 29.60 | **0.155** | **0.264** | **100** |
| S-16 | MH-17 | MH-10 | 85.60 | **0.042** | **0.072** | **100** |
| S-17 | MH-19 | MH-18A | 24.07 | **0.598** | **1.018** | **100** |
| S-18 | MH-18A | MH-18 | 32.58 | **0.598** | **1.018** | **100** |
| S-19 | MH-17 | MH-16 | 31.10 | **0.065** | **0.110** | **100** |
| S-20 | MH-16 | MH-15 | 8.96 | **0.098** | **0.167** | **100** |
| S-21 | MH-15 | MH-14 | 14.86 | **0.098** | **0.167** | **100** |
| S-22 | MH-14 | MH-13 | **13.21** | **0.098** | **0.167** | **100** |
| S-23 | MH-13 | MH-18 | **32.45** | **0.098** | **0.167** | **100** |
| S-24 | MH-17 | MH-24 | 45.28 | **0.011** | **0.019** | **100** |
| S-25 | MH-24 | MH-25 | 38.41 | **0.011** | **0.019** | **100** |
| S-26 | MH-25 | MH-26 | 13.48 | **0.011** | **0.019** | **100** |
| S-27 | MH-26 | MH--27 | 27.38 | **0.011** | **0.019** | **100** |
| S-28 | MH-34 | MH-16 | 30.93 | **0.150** | **0.256** | **100** |

**Table 5.6A1 Design Results of 100mm Condominials in Basin A**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-29 | MH-33 | MH-34 | 16.95 | **0.150** | **0.256** | **100** |
| S-30 | MH-32 | MH-33 | 14.45 | **0.150** | **0.256** | **100** |
| S-31 | MH-29 | MH-30 | 19.79 | **0.044** | **0.075** | **100** |
| S-32 | MH-30 | MH-32 | 5.43 | **0.044** | **0.075** | **100** |
| S-33 | MH-29 | MH-28 | 11.63 | **0.044** | **0.075** | **100** |
| S-34 | MH-28 | MH-27 | 38.41 | **0.044** | **0.075** | **100** |
| S-35 | MH-27 | MH-35 | 90.74 | **0.149** | **0.254** | **100** |
| S-36 | MH-32 | MH-42 | 16.40 | **0.305** | **0.519** | **100** |
| S-37 | MH-42A | MH-42 | 15.98 | **0.305** | **0.519** | **100** |
| S-38 | MH-42A | MH-23B | **35.97** | **0.305** | **0.519** | **100** |
| S-39 | MH-23B | MH-23A | 5.71 | **0.305** | **0.519** | **100** |
| S-40 | MH-18 | MH-22 | 28.23 | **0.769** | **1.310** | **100** |
| S-41 | MH-22 | MH-23 | 21.18 | **0.769** | **1.310** | **100** |
| S-42 | MH-23 | MH-23A | 7.70 | **0.769** | **1.310** | **100** |
| S-43 | MH-23A | MH-35A | 14.45 | **1.732** | **2.952** | **100** |
| S-43A | MH-23A | MH-35 | 21.18 | **1.732** | **2.952** | **100** |
| S-46 | MH-20 | MH-41 | 32.4 | **0.065** | **0.110** | **100** |
| S-47 | MH-41 | MH-40 | 56.61 | **0.065** | **0.110** | **100** |
| S-48 | MH-40 | MH-39 | 12.25 | **0.065** | **0.110** | **100** |
| S-49 | MH-39 | MH-38 | 10.63 | **0.065** | **0.110** | **100** |
| S-50 | MH-38 | MH-37 | 29.35 | **0.065** | **0.110** | **100** |
| **TOTAL LEN GTH (m)** | | | **1502.89** | | | |

**Table 5.6A2 Design Results of 150mm Street Sewers/Collectors in Basin A**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-01 | MH-03 | MH-02 | 20.95 | **0.008** | **0.014** | **100** |
| S-45 | MH-36 | MH-37 | 25.3 | **2.066** | **3.521** | **150** |
| S-46 | MH-20 | MH-41 | 32.4 | **0.065** | **0.110** | **150** |
| S-51 | MH-37 | MH-77 | 33.13 | **2.131** | **3.631** | **150** |
| **TOTAL LEN GTH (m)** | | | **90.83** | | | |

**Table 5.6B1 Design Results of 100mm Condominials in Basin B**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-52 | MH-61 | MH-62 | 28.54 | **0.016** | **0.028** | **100** |
| S-53 | MH-60 | MH-59 | 16.61 | **0.099** | **0.168** | **100** |
| S-54 | MH-59 | MH-58 | 23.21 | **0.099** | **0.168** | **100** |
| S-55 | MH-57 | MH-56 | 69.43 | **0.257** | **0.439** | **100** |
| S-56 | MH-56 | MH-58 | 5.27 | **0.284** | **0.485** | **100** |
| S-57 | MH-56 | MH-55 | 38.33 | **0.220** | **0.376** | **100** |
| S-58 | MH-53 | MH-52 | 45.52 | **0.152** | **0.258** | **100** |
| S-59 | MH-52 | MH-54 | 33.42 | **0.186** | **0.316** | **100** |
| S-60 | MH-54 | MH-55 | 32.52 | **0.186** | **0.316** | **100** |
| S-61 | MH-49 | MH-48 | 43.09 | **0.111** | **0.188** | **100** |
| S-62 | MH-50 | MH-48 | 6.51 | **0.296** | **0.549** | **100** |
| S-63 | MH-52 | MH-50 | 40.21 | **0.235** | **0.488** | **100** |
| S-64 | MH-47 | MH-46 | 38.47 | **0.152** | **0.260** | **100** |
| S-65 | MH-48 | MH-46 | 37.96 | **0.582** | **1.037** | **100** |
| S-66 | MH-42A | MH-42 | 51.85 | **0.015** | **0.026** | **100** |
| S-67 | MH-42 | MH-45 | 27.86 | **0.015** | **0.026** | **100** |
| S-68 | MH-46 | MH-43 | 30.56 | **0.819** | **1.439** | **100** |
| S-69 | MH-43 | MH-44 | 23.94 | **0.819** | **1.439** | **100** |
| S-69A | MH-44 | MH-45 | 13.39 | **0.819** | **1.439** | **100** |
| S-70 | MH-45 | MH-102 | 18.94 | **0.853** | **1.496** | **100** |
| S-71 | MH-50 | MH-51 | 41.64 | **0.282** | **0.522** | **100** |
| S-72 | MH-51 | MH-99 | 15.24 | **0.567** | **0.972** | **100** |
| S-73 | MH-99 | MH-100 | 17.82 | **0.567** | **0.972** | **100** |
| S-74 | MH-100 | MH-101 | 30.71 | **0.567** | **0.972** | **100** |
| S-75 | MH-101 | MH-102 | 13.09 | **0.567** | **0.972** | **100** |
| S-76 | MH-55 | MH-78 | 38.33 | **0.390** | **0.665** | **100** |
| S-77 | MH-51 | MH-78 | 42.16 | **0.379** | **0.647** | **100** |
| S-78 | MH-60 | MH-64 | 27.50 | **0.008** | **0.014** | **100** |
| S-79 | MH-64 | MH-63 | 33.21 | **0.322** | **0.548** | **100** |
| S-79A | MH-58 | MH-61 | 27.50 | **0.569** | **0.969** | **100** |
| S-80 | MH-61 | MH-62 | 10.85 | **0.569** | **0.969** | **100** |
| S-81 | MH-62 | MH-63 | 2.81 | **0.569** | **0.969** | **100** |
| S-82 | MH-63 | MH-65 | 24.15 | **0.912** | **1.553** | **100** |
| S-83 | MH-65 | MH-66 | 15.11 | **0.912** | **1.553** | **100** |
| S-84 | MH-66 | MH-67 | 35.44 | **0.912** | **1.553** | **100** |

**Table 5.6B1 Design Results of 100mm Condominials in Basin B**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-85 | MH-55 | MH-67 | 44.36 | **0.592** | **1.010** | **100** |
| S-86 | MH-68 | MH-83 | **21.69** | **1.055** | **1.800** | **100** |
| S-87 | MH-83 | MH-82A | 25.94 | **0.714** | **1.217** | **100** |
| S-88 | MH-78 | MH-79 | 8.86 | **0.373** | **0.636** | **100** |
| S-89 | MH-79 | MH-80 | 12.71 | **0.373** | **0.636** | **100** |
| S-90 | MH-80 | MH-72 | 25.36 | **0.373** | **0.636** | **100** |
| S-91 | MH-72 | MH-81 | 14.51 | **0.373** | **0.636** | **100** |
| S-92 | MH-81 | MH-82 | 22.92 | **0.373** | **0.636** | **100** |
| S-93 | MH-82 | MH-95 | 29.73 | **0.326** | **0.555** | **100** |
| S-94 | MH-51 | MH-97 | 32.19 | **0.567** | **0.988** | **100** |
| S-95 | MH-97 | MH-98 | 12.84 | **0.567** | **0.988** | **100** |
| S-96 | MH-98 | MH-95 | 22.87 | **0.567** | **0.988** | **100** |
| S-97 | MH-102 | MH-96 | 75.94 | **0.023** | **0.038** | **100** |
| S-98 | MH-95 | MH-96 | 40.36 | **1.036** | **1.787** | **100** |
| S-99 | MH-94 | MH-96 | 40.04 | **0.013** | **0.022** | **100** |
| S-100 | MH-82 | MH-82A | 25.81 | **0.370** | **0.632** | **100** |
| S-101 | MH-82A | MH-92 | 20.94 | **0.637** | **1.083** | **100** |
| S-101A | MH-92 | MH-93 | 16.00 | **0.637** | **1.083** | **100** |
| S-102 | MH-93 | MH-94 | 35.85 | **0.637** | **1.083** | **100** |
| S-102 | MH-93 | MH-94 | 35.85 | **0.652** | **1.110** | **100** |
| S-103 | MH-94 | MH-89 | 33.92 | **0.011** | **0.019** | **100** |
| S-104 | MH-82A | MH-84 | 47.25 | **0.699** | **1.190** | **100** |
| S-105 | MH-84 | MH-89 | 36.13 | **0.995** | **1.608** | **100** |
| S-106 | MH-89 | MH-90 | 42.15 | **0.180** | **0.306** | **100** |
| S-107 | MH-85 | MH-86 | 24.96 | **0.180** | **0.306** | **100** |
| S-110 | MH-83 | MH-83A | 24.61 | **0.709** | **1.208** | **100** |
| S-111 | MH-83 | MH-88 | 37.44 | **0.709** | **1.208** | **100** |
| S-112 | MH-88 | MH-87 | 19.8 | **0.709** | **1.208** | **100** |
| S-115E | MH-87A | MH-87B | 41.94 | **0.016** | **0.028** | **100** |
| S-119 | MH-73 | MH-69 | 58.36 | **0.356** | **0.607** | **100** |
| S-120 | MH-69 | MH-70 | 11.60 | **0.356** | **0.607** | **100** |
| S-121 | MH-70 | MH-71 | 16.69 | **0.356** | **0.607** | **100** |
| S-122 | MH-71 | MH-72 | 23.64 | **0.356** | **0.607** | **100** |
| **TOTAL LEN GTH (m)** | | | **1984.45** | | | |

**Table 5.6B2 Design Results of 150mm Street Sewers/Collectors in Basin B**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-85A | MH-67 | MH-68 | 31.23 | **1.832** | **3.122** | **150** |
| S-108 | MH-86 | MH-91 | 34.59 | **3.740** | **6.497** | **150** |
| S-109 | MH-91 | MH-90 | 21.23 | **3.740** | **6.497** | **150** |
| S-113 | MH-87 | MH-86 | 30.18 | **3.610** | **6.275** | **150** |
| S-114 | MH-68 | MH-72 | 28.00 | **1.239** | **2.111** | **150** |
| S-115 | MH-72 | MH-73 | 35.74 | **1.929** | **3.289** | **150** |
| S-115A | MH-74 | MH-73 | 28.57 | **2.131** | **3.631** | **150** |
| S-115B | MH-75 | MH-74 | 25.45 | **2.131** | **3.631** | **150** |
| S-115C | MH-76 | MH-75 | 24.84 | **2.131** | **3.631** | **150** |
| S-115D | MH-77 | MH-76 | 56.81 | **2.131** | **3.631** | **150** |
| S-116 | MH-73 | MH-87A | 19.14 | **3.374** | **5.892** | **150** |
| S-117 | MH-87A | MH-87 | 14.93 | **3.374** | **5.892** | **150** |
| **TOTAL LEN GTH (m)** | | | **350.71** | | | |

**Table 5.6C1 Design Results of 100mm Condominials in Basin C**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1485A | MH-C1 | MH-C2 | 34.06 | **0.073** | **0.058** | **100** |
| S-1486A | MH-C2 | MH-C3 | 45.22 | **0.034** | **0.058** | **100** |
| S-1487A | MH-C3 | MH-C4 | 16.48 | **0.034** | **0.058** | **100** |
| S-1488A | MH-C5 | MH-C4 | 72.85 | **1.037** | **1.767** | **100** |
| S-1489A | MH-C6 | MH-C5 | 16.12 | **0.066** | **0.112** | **100** |
| S-1490A | MH-C7 | MH-C6 | 22.47 | **0.066** | **0.112** | **100** |
| S-1491A | MH-C8 | MH-C7 | 16.56 | **0.066** | **0.112** | **100** |
| S-1492A | MH-C9 | MH-C8 | 34.05 | **0.073** | **0.124** | **100** |
| S-1493A | MH-C10 | MH-C9 | 15.21 | **0.073** | **0.124** | **100** |
| S-1494A | MH-C11 | MH-C10 | 15.81 | **0.073** | **0.124** | **100** |
| S-1495A | MH-C12 | MH-C13 | 33.16 | **0.070** | **0.120** | **100** |
| S-1496A | MH-C13 | MH-C8 | 37.41 | **0.070** | **0.120** | **100** |
| S-1497A | MH-C14 | MH-C5 | 21.99 | **0.937** | **1.597** | **100** |
| S-1498A | MH-C15 | MH-C14 | 32.21 | **0.074** | **0.126** | **100** |
| S-1499A | MH-C16 | MH-C15 | 34.60 | **0.074** | **0.126** | **100** |

**Table 5.6C1 Design Results of 100mm Condominials in Basin C**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1500 | MH-C17 | MH-C16 | 18.34 | **0.074** | **0.126** | **100** |
| S-1501 | MH-C18 | MH-C17 | 3.60 | **0.074** | **0.126** | **100** |
| S-1502 | MH-C19 | MH-C18 | 21.10 | **0.074** | **0.126** | **100** |
| S-1503 | MH-C20 | MH-C14 | 66.94 | **0.824** | **1.404** | **100** |
| S-1504 | MH-C21 | MH-C20 | 40.35 | **0.084** | **0.144** | **100** |
| S-1505 | MH-C22 | MH-C21 | 34.43 | **0.084** | **0.144** | **100** |
| S-1506 | MH-C23 | MH-C22 | 34.23 | **0.084** | **0.144** | **100** |
| S-1507 | MH-C24 | MH-C20 | 45.08 | **0.698** | **1.189** | **100** |
| S-1508 | MH-C25 | MH-C24 | 15.92 | **0.698** | **1.189** | **100** |
| S-1509 | MH-C26 | MH-C25 | 12.51 | **0.076** | **0.129** | **100** |
| S-1510 | MH-C27 | MH-C26 | 6.04 | **0.076** | **0.129** | **100** |
| S-1511 | MH-C28 | MH-C27 | 26.74 | **0.076** | **0.129** | **100** |
| S-1514 | MH-C31 | MH-C25 | 52.79 | **0.580** | **0.988** | **100** |
| S-1515 | MH-C32 | MH-C31 | 79.94 | **0.073** | **0.125** | **100** |
| S-1516 | MH-C33 | MH-C32 | 22.35 | **0.073** | **0.125** | **100** |
| S-1517 | MH-C34 | MH-C31 | 59.60 | **0.472** | **0.805** | **100** |
| S-1518 | MH-C35 | MH-C34 | 87.26 | **0.128** | **0.219** | **100** |
| S-1519 | MH-C36 | MH-C35 | 33.47 | **0.128** | **0.219** | **100** |
| S-1520 | MH-C37 | MH-C36 | 5.83 | **0.128** | **0.219** | **100** |
| S-1521 | MH-C38 | MH-C34 | 44.03 | **0.305** | **0.519** | **100** |
| S-1522 | MH-C39 | MH-C38 | 18.89 | **0.305** | **0.519** | **100** |
| S-1523 | MH-C40 | MH-C39 | 76.24 | **0.305** | **0.519** | **100** |
| S-1524 | MH-C41 | MH-C40 | 7.91 | **0.305** | **0.519** | **100** |
| S-1525 | MH-C42 | MH-C41 | 98.65 | **0.137** | **0.233** | **100** |
| S-1526 | MH-C43 | MH-C42 | 30.09 | **0.137** | **0.233** | **100** |
| S-1527 | MH-C44A | MH-C44 | 66.85 | **0.079** | **0.134** | **100** |
| S-1527A | MH-C44 | MH-C41 | 76.24 | **0.292** | **0.497** | **100** |
| S-1528 | MH-C45 | MH-C44 | 44.69 | **0.165** | **0.280** | **100** |
| S-1529 | MH-C46 | MH-C45 | 57.07 | **0.067** | **0.114** | **100** |
| S-1530 | MH-C47 | MH-C46 | 36.62 | **0.067** | **0.114** | **100** |
| S-1531 | MH-C48 | MH-C45 | 54.42 | **0.067** | **0.114** | **100** |
| S-1532 | MH-C49 | MH-C48 | 56.03 | **0.062** | **0.105** | **100** |
| S-1533 | MH-C48 | MH-C50 | 48.81 | **0.056** | **0.096** | **100** |
| S-1534 | MH-C51 | MH-C50 | 27.45 | **0.049** | **0.083** | **100** |
| S-1535 | MH-C52 | MH-C51 | 12.16 | **0.049** | **0.083** | **100** |
| S-1536 | MH-C53 | MH-C52 | 22.17 | **0.049** | **0.083** | **100** |

**Table 5.6C1 Design Results of 100mm Condominials in Basin C**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1537 | MH-C50 | MH-C54 | 60.57 | **0.128** | **0.218** | **100** |
| S-1538 | MH-C55 | MH-C54 | 20.84 | **0.039** | **0.067** | **100** |
| S-1539 | MH-C56 | MH-C55 | 12.60 | **0.039** | **0.067** | **100** |
| S-1540 | MH-C57 | MH-C56 | 22.39 | **0.039** | **0.067** | **100** |
| S-1541 | MH-C54 | MH-C58 | 26.61 | **0.183** | **0.312** | **100** |
| S-1542 | MH-C59 | MH-C58 | 41.65 | **0.033** | **0.057** | **100** |
| S-1543 | MH-C58 | MH-C59 | 46.81 | **0.065** | **0.111** | **100** |
| S-1543A | MH-C60 | MH-C59 | 13.06 | **0.234** | **0.398** | **100** |
| S-1544 | MH-C61 | MH-C60 | 16.77 | **0.065** | **0.111** | **100** |
| S-1545 | MH-C62 | MH-C61 | 16.39 | **0.065** | **0.111** | **100** |
| **TOTAL LEN GTH (m)** | | | **2170.73** | | | |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-538A | MH-513 | MH-514 | 13.86 | **0.031** | **0.052** | **100** |
| S-538A | MH-513 | MH-514 | 13.86 | **0.031** | **0.052** | **100** |
| S-539 | MH-514 | MH-515 | 10.48 | **0.031** | **0.052** | **100** |
| S-540 | MH-515 | MH-516 | 28.42 | **0.031** | **0.052** | **100** |
| S-541 | MH-502 | MH-503 | 32.71 | **0.016** | **0.027** | **100** |
| S-542 | MH-502 | MH-504 | 29.77 | **0.025** | **0.043** | **100** |
| S-543 | MH-504 | MH-513 | 7.00 | **0.025** | **0.043** | **100** |
| S-544 | MH-503 | MH-496 | 16.85 | **0.058** | **0.098** | **100** |
| S-545 | MH-495 | MH-496 | 30.57 | **0.036** | **0.061** | **100** |
| S-546 | MH-498 | MH-495 | 33.36 | **0.031** | **0.053** | **100** |
| S-547 | MH-499 | MH-498 | 11.15 | **0.031** | **0.053** | **100** |
| S-548 | MH-500 | MH-499 | 22.19 | **0.123** | **0.209** | **100** |
| S-549 | MH-501 | MH-500 | 20.73 | **0.031** | **0.052** | **100** |
| S-550 | MH-502 | MH-501 | 16.51 | **0.031** | **0.052** | **100** |
| S-550A | MH-495 | MH-494 | 17.64 | **0.040** | **0.069** | **100** |
| S-551 | mh-497 | mh-486 | 30.79 | **0.147** | **0.250** | **100** |
| S-552 | MH-480 | mh-486 | 12.76 | **0.053** | **0.090** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-553 | mh-487 | mh-480 | 15.08. | **0.053** | **0.090** | **100** |
| S-554 | mh-488 | mh-487 | 9.47 | **0.053** | **0.090** | **100** |
| S-555 | mh-490 | mh-488 | 5.01 | **0.053** | **0.090** | **100** |
| S-556 | mh-491 | mh-490 | 14.98 | **0.053** | **0.090** | **100** |
| S-557 | mh-492 | mh-491 | 3.72 | **0.042** | **0.072** | **100** |
| S-558 | mh-486 | mh-481 | **30.97** | **0.225** | **0.383** | **100** |
| S-559 | mh-478 | mh-481 | **9.87** | **0.150** | **0.256** | **100** |
| S-560 | MH-477 | MH-478 | 15.67 | **0.150** | **0.256** | **100** |
| S-561 | MH-476 | MH-477 | 16.08 | **0.150** | **0.256** | **100** |
| S-562 | MH-532 | MH-476 | 22.14 | **0.121** | **0.206** | **100** |
| S-563 | MH-531 | MH-532 | 12.67 | **0.121** | **0.206** | **100** |
| S-564 | MH-530 | MH-531 | 18.32 | **0.169** | **0.288** | **100** |
| S-565 | MH-529 | MH-530 | 9.87 | **0.169** | **0.288** | **100** |
| S-566 | MH-528 | MH-529 | 22.01 | **0.169** | **0.288** | **100** |
| S-567 | MH-527 | MH-528 | 7.27 | **0.169** | **0.288** | **100** |
| S-568 | MH-526 | MH-527 | 6.15 | **0.274** | **0.467** | **100** |
| S-569 | MH-518 | MH-526 | 21.86 | **0.274** | **0.467** | **100** |
| S-570 | MH-517 | MH-518 | 14.91 | **0.061** | **0.104** | **100** |
| S-571 | MH-491 | MH-517 | 34.78 | **0.061** | **0.104** | **100** |
| S-572 | MH-481 | MH-474 | 38.45 | **0.440** | **0.749** | **100** |
| S-573 | MH-473 | MH-474 | 16.84 | **0.434** | **0.740** | **100** |
| S-574 | MH-471 | MH-473 | 29.19 | **0.434** | **0.740** | **100** |
| S-575 | MH-472 | MH-471 | 17.74 | **0.137** | **0.233** | **100** |
| S-576 | MH-475 | MH-472 | 18.91 | **0.137** | **0.233** | **100** |
| S-577 | MH-476 | MH-475 | 28.02 | **0.137** | **0.233** | **100** |
| S-578 | MH-474 | MH-482 | 40.34 | **1.175** | **2.001** | **100** |
| S-579 | MH-482 | MH-483 | 19.03 | **1.175** | **2.001** | **100** |
| S-580 | MH-483 | MH-484 | 25.48 | **1.175** | **2.001** | **100** |
| S-581 | MH-485 | MH-484 | 21.00 | **0.301** | **0.513** | **100** |
| S-582 | MH-479 | MH-485 | 37.75 | **0.301** | **0.513** | **100** |
| S-583 | MH-484 | MH-462 | 19.37 | **1.175** | **2.001** | **100** |
| S-584 | MH-462 | MH-463 | 22.81 | **1.175** | **2.001** | **100** |
| S-585 | MH-463 | MH-464 | 10.40 | **1.175** | **2.001** | **100** |
| S-586 | MH-464 | MH-465 | 30.91 | **1.175** | **2.001** | **100** |
| S-587 | MH-465 | MH-466 | 17.67 | **1.175** | **2.001** | **100** |
| S-588 | MH-468 | MH-466 | 20.90 | **0.774** | **1.319** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-589 | MH-469 | MH-468 | 17.65 | **0.774** | **1.319** | **100** |
| S-589 | MH-469 | MH-468 | 17.65 | **0.774** | **1.319** | **100** |
| S-590 | MH-470 | MH-469 | 19.76 | **0.381** | **0.649** | **100** |
| S-591 | MH-471 | MH-470 | 23.62 | **0.381** | **0.649** | **100** |
| S-592 | MH-512 | MH-513 | 20.82 | **0.142** | **0.241** | **100** |
| S-593 | MH-511 | MH-512 | 17.17 | **0.142** | **0.241** | **100** |
| S-594 | MH-510 | MH-511 | 27.68 | **0.142** | **0.241** | **100** |
| S-595 | MH-509 | MH-510 | 12.90 | **0.063** | **0.107** | **100** |
| S-596 | MH-508 | MH-509 | 30.87 | **0.099** | **0.168** | **100** |
| S-597 | MH-508 | MH-505 | 11.04 | **0.099** | **0.168** | **100** |
| S-598 | MH-505 | MH-500 | 15.03 | **0.075** | **0.129** | **100** |
| S-599 | MH-499 | MH-519 | 10.10 | **0.083** | **0.141** | **100** |
| S-600 | MH-519 | MH-520 | 11.23 | **0.083** | **0.141** | **100** |
| S-601 | MH-521 | MH-520 | 21.28 | **0.069** | **0.117** | **100** |
| S-602 | MH-521 | MH-516 | 3.69 | **0.104** | **0.177** | **100** |
| S-603 | MH-506 | MH-516 | 23.14 | **0.104** | **0.177** | **100** |
| S-604 | MH-505 | MH-506 | 23.42 | **0.104** | **0.177** | **100** |
| S-605 | MH-527 | MH-525 | 14.06 | **0.178** | **0.303** | **100** |
| S-606 | MH-524 | MH-525 | **11.37** | **0.227** | **0.386** | **100** |
| S-607 | MH-523 | MH-524 | 39.89 | **0.227** | **0.386** | **100** |
| S-608 | MH-522 | MH-523 | 14.56 | **0.111** | **0.189** | **100** |
| S-609 | MH-521 | MH-522 | 15.91 | **0.111** | **0.189** | **100** |
| S-610 | MH-531 | MH-533 | 10.81 | **0.079** | **0.134** | **100** |
| S-611 | MH-533 | MH-535 | 8.18 | **0.067** | **0.114** | **100** |
| S-612 | MH-535 | MH-536 | 14.42 | **0.067** | **0.114** | **100** |
| S-613 | MH-525 | MH-536 | 19.68 | **0.439** | **0.749** | **100** |
| S-614 | MH-538 | MH-469 | 24.58 | **0.072** | **0.122** | **100** |
| S-615 | MH-534 | MH-538 | 27.44 | **0.072** | **0.122** | **100** |
| S-616 | MH-533 | MH-534 | 22.06 | **0.072** | **0.122** | **100** |
| S-621 | MH-540 | MH-541 | 29.16 | **0.555** | **0.946** | **100** |
| S-622 | MH-539 | MH-540 | 8.23 | **0.555** | **0.946** | **100** |
| S-623 | MH-537 | MH-539 | 15.56 | **0.555** | **0.946** | **100** |
| S-624 | MH-536 | MH-537 | 19.12 | **0.555** | **0.946** | **100** |
| S-625 | MH-614C | MH-510 | 30.17 | **0.059** | **0.101** | **100** |
| S-626 | MH-614B | MH-614C | 24.51 | **0.059** | **0.101** | **100** |
| S-627 | MH-614A | MH-614B | 29.03 | **0.059** | **0.101** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-628 | MH-592 | MH-614A | 28.42 | **0.020** | **0.033** | **100** |
| S-629 | MH-592 | MH-598 | **18.82** | **0.061** | **0.104** | **100** |
| S-630 | MH-598 | MH-597 | 14.74 | **0.061** | **0.104** | **100** |
| S-631 | MH-597 | MH-596 | 7.59 | **0.061** | **0.104** | **100** |
| S-632 | MH-596 | MH-595 | **4.75** | **0.061** | **0.104** | **100** |
| S-633 | MH-595 | MH-594 | 2.20 | **0.061** | **0.104** | **100** |
| S-634 | MH-594 | MH-593 | 26.67 | **0.061** | **0.104** | **100** |
| S-635 | MH-593 | MH-509 | 8.58 | **0.061** | **0.104** | **100** |
| S-636 | MH-583 | MH-523 | 40.55 | **0.077** | **0.130** | **100** |
| S-637 | MH-582 | MH-583 | 1.55 | **0.077** | **0.130** | **100** |
| S-638 | MH-580 | MH-583 | 15.79 | **0.155** | **0.264** | **100** |
| S-639 | MH-581 | MH-580 | 18.49 | **0.180** | **0.307** | **100** |
| S-640 | MH-587 | MH-581 | 39.43 | **0.180** | **0.307** | **100** |
| S-641 | MH-588 | MH-587 | 18.32 | **0.090** | **0.154** | **100** |
| S-642 | MH-589 | MH-588 | 30.34 | **0.090** | **0.154** | **100** |
| S-643 | MH-590 | MH-589 | 9.36 | **0.090** | **0.154** | **100** |
| S-644 | MH-591 | MH-590 | 6.45 | **0.090** | **0.154** | **100** |
| S-645 | MH-592 | MH-591 | 10.69 | **0.056** | **0.095** | **100** |
| S-648 | MH-545 | MH-546 | 16.29 | **0.094** | **0.161** | **100** |
| S-649 | MH-544 | MH-545 | 13.55 | **0.094** | **0.161** | **100** |
| S-650 | MH-547 | MH-544 | **15.50** | **0.094** | **0.161** | **100** |
| S-651 | MH-548 | MH-547 | 11.25 | **0.094** | **0.161** | **100** |
| S-652 | MH-550 | MH-548 | 20.35 | **0.122** | **0.208** | **100** |
| S-653 | MH-586 | MH-550 | 12.55 | **0.122** | **0.208** | **100** |
| S-654 | MH-585 | MH-586 | 12.88 | **0.122** | **0.208** | **100** |
| S-655 | MH-584 | MH-585 | **2.59** | **0.122** | **0.208** | **300** |
| S-656 | MH-582 | MH-584 | 25.55 | **0.122** | **0.208** | **100** |
| S-658 | MH-614 | MH-614A | 35.15 | **0.027** | **0.046** | **100** |
| S-659 | MH-591 | MH-612 | 20.32 | **0.049** | **0.084** | **100** |
| S-660 | MH-613 | MH-612 | 12.45 | **0.043** | **0.074** | **100** |
| S-661 | MH-613 | MH-614 | 32.86 | **0.027** | **0.046** | **100** |
| S-662 | MH-580 | MH-577 | 5.69 | **0.120** | **0.205** | **100** |
| S-663 | MH-576 | MH-577 | **6.63** | **0.131** | **0.223** | **100** |
| S-664 | MH-575 | MH-576 | **35.79** | **0.131** | **0.223** | **100** |
| S-665 | MH-599 | MH-575 | 29.24 | **0.200** | **0.341** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-666 | MH-600 | MH-599 | 3.69 | **0.200** | **0.341** | **100** |
| S-666 | MH-600 | MH-599 | 3.69 | **0.200** | **0.341** | **100** |
| S-667 | MH-602 | MH-600 | 13.84 | **0.028** | **0.048** | **100** |
| S-668 | MH-602 | MH-587 | 23.07 | **0.028** | **0.048** | **100** |
| S-669 | MH-612 | MH-611 | 25.60 | **0.129** | **0.219** | **100** |
| S-670 | MH-611 | MH-603 | 35.51 | **0.129** | **0.219** | **100** |
| S-671 | MH-603 | MH-604 | 9.96 | **0.129** | **0.219** | **100** |
| S-672 | MH-604 | MH-605 | 30.19 | **0.129** | **0.219** | **100** |
| S-673 | MH-605 | MH-606 | 3.38 | **0.129** | **0.219** | **100** |
| S-674 | MH-606 | MH-600 | 9.78 | **0.119** | **0.202** | **100** |
| S-675 | MH-577 | MH-578 | 28.89 | **0.285** | **0.485** | **100** |
| S-676 | MH-578 | MH-579 | 4.06 | **0.285** | **0.485** | **100** |
| S-677 | MH-560 | MH-579 | 10.58 | **0.285** | **0.485** | **100** |
| S-678 | MH-559 | MH-560 | 8.92 | **0.285** | **0.485** | **100** |
| S-679 | MH-559 | MH-558 | 17.12 | **0.285** | **0.485** | **100** |
| S-680 | MH-558 | MH-556 | 19.27 | **0.285** | **0.485** | **100** |
| S-681 | MH-556 | MH-562 | 5.25 | **0.167** | **0.284** | **100** |
| S-682 | MH-562 | MH-563 | 4.58 | **0.167** | **0.284** | **100** |
| S-683 | MH-561 | MH-563 | 20.42 | **0.158** | **0.269** | **100** |
| S-684 | MH-572 | MH-561 | 21.31 | **0.158** | **0.269** | **100** |
| S-685 | MH-572A | MH-572 | 1.12 | **0.158** | **0.269** | **100** |
| S-686 | MH-573 | MH-572A | 10.03 | **0.158** | **0.269** | **100** |
| S-687 | MH-574 | MH-573 | 9.43 | **0.158** | **0.269** | **100** |
| S-688 | MH-575 | MH-574 | 21.65 | **0.158** | **0.269** | **100** |
| S-688A | MH-557 | MH-555A | 36.55 | **0.166** | **0.282** | **100** |
| S-689 | MH-548 | MH-549 | 9.02 | **0.082** | **0.140** | **100** |
| S-690 | MH-549 | MH-551 | 3.54 | **0.082** | **0.140** | **100** |
| S-691 | MH-551 | MH-552 | 14.31 | **0.082** | **0.140** | **100** |
| S-692 | MH-552 | MH-553 | 12.36 | **0.082** | **0.140** | **100** |
| S-693 | MH-553 | MH-554 | 12.39 | **0.082** | **0.140** | **100** |
| S-696 | MH-563 | MH-564 | 15.11 | **0.371** | **0.633** | **100** |
| S-697 | MH-565 | MH-565A | 19.80 | **0.204** | **0.348** | **100** |
| S-698 | MH-565A | MH-565B | 6.51 | **0.204** | **0.348** | **100** |
| S-699 | MH-565B | MH-555 | 9.42 | **0.204** | **0.348** | **100** |
| S-701 | MH-615 | MH-613 | 9.25 | **0.028** | **0.048** | **100** |
| S-702 | MH-615 | MH-616 | 7.84 | **0.028** | **0.048** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-703 | MH-616 | MH-617 | 18.63 | **0.028** | **0.048** | **100** |
| S-704 | MH-617 | MH-618 | 20.45 | **0.028** | **0.048** | **100** |
| S-705 | MH-606 | MH-607 | 20.93 | **0.127** | **0.216** | **100** |
| S-706 | MH-607 | MH-608 | 8.94 | **0.127** | **0.216** | **100** |
| S-707 | MH-608 | MH-601 | 20.64 | **0.127** | **0.216** | **100** |
| S-708 | MH-601 | MH-609 | 9.44 | **0.127** | **0.216** | **100** |
| S-709 | MH-609 | MH-610 | 7.75 | **0.127** | **0.216** | **100** |
| S-710 | MH-621 | MH-610 | 11.53 | **0.082** | **0.139** | **100** |
| S-711 | MH-620 | MH-621 | 30.58 | **0.082** | **0.139** | **100** |
| S-712 | MH-619 | MH-620 | 30.88 | **0.082** | **0.139** | **100** |
| S-713 | MH-618 | MH-619 | 20.36 | **0.082** | **0.139** | **100** |
| S-715 | MH-565 | MH-566 | 10.36 | **0.237** | **0.404** | **100** |
| S-716 | MH-566 | MH-567 | 12.93 | **0.237** | **0.404** | **100** |
| S-717 | MH-567 | MH-568 | 4.20. | **0.237** | **0.404** | **100** |
| S-718 | MH-568 | MH-569 | 22.74 | **0.237** | **0.404** | **100** |
| S-719 | MH-569 | MH-570 | 17.17 | **0.237** | **0.404** | **100** |
| S-720 | MH-570 | MH-571 | 11.42 | **0.237** | **0.404** | **100** |
| S-721 | MH-625 | MH-571 | 31.56 | **0.492** | **0.838** | **100** |
| S-722 | MH-623 | MH-624 | 21.73 | **0.294** | **0.501** | **100** |
| S-723 | MH-624 | MH-625 | 1.89 | **0.294** | **0.501** | **100** |
| S-724 | MH-622 | MH-623 | 31.20 | **0.294** | **0.501** | **100** |
| S-725 | MH-610 | MH-622 | 15.78 | **0.294** | **0.501** | **100** |
| S-726 | MH-571 | MH-555B | 14.77 | **0.811** | **1.382** | **100** |
| S-728 | MH-626 | MH-625 | 17.03 | **0.140** | **0.238** | **100** |
| S-729 | MH-627 | MH-626 | 22.31 | **0.140** | **0.238** | **100** |
| S-730 | MH-628 | MH-627 | 18.97 | **0.140** | **0.238** | **100** |
| S-731 | MH-629 | MH-628 | 15.52 | **0.140** | **0.238** | **100** |
| S-732 | MH-630 | MH-629 | 23.71 | **0.067** | **0.115** | **100** |
| S-733 | MH-631 | MH-630 | 16.12 | **0.067** | **0.115** | **100** |
| S-734 | MH-632 | MH-631 | 20.00 | **0.067** | **0.115** | **100** |
| S-735 | MH-633 | MH-632 | 24.25 | **0.067** | **0.115** | **100** |
| S-736 | MH-634 | MH-633 | 16.65 | **0.067** | **0.115** | **100** |
| S-737 | MH-635 | MH-634 | 34.69 | **0.067** | **0.115** | **100** |
| S-738 | MH-636 | MH-635 | 13.45 | **0.067** | **0.115** | **100** |
| S-739 | MH-641 | MH-571 | 6.48 | **0.082** | **0.140** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-740 | MH-640 | MH-641 | 26.77 | **0.082** | **0.140** | **100** |
| S-741 | mh-639 | MH-640 | 31.45 | **0.082** | **0.140** | **100** |
| S-742 | mh-638 | mh-639 | 26.62 | **0.082** | **0.140** | **100** |
| S-743 | mh-637 | mh-638 | 22.21 | **0.129** | **0.219** | **100** |
| S-744 | mh-629 | mh-637 | 31.32 | **0.129** | **0.219** | **100** |
| S-745 | MH-669 | MH-629 | 15.21 | **0.086** | **0.146** | **100** |
| S-746 | MH-667 | MH-669 | 17.32 | **0.060** | **0.102** | **100** |
| S-747 | MH-667 | MH-668 | 4.80 | **0.060** | **0.102** | **100** |
| S-748 | MH-666 | MH-668 | 9.60 | **0.060** | **0.102** | **100** |
| S-749 | MH-665 | MH-666 | 22.72 | **0.060** | **0.102** | **100** |
| S-750 | MH-647 | MH-665 | 38.15 | **0.060** | **0.102** | **100** |
| S-751 | MH-645 | MH-643 | 7.19 | **0.036** | **0.060** | **100** |
| S-752 | MH-644 | MH-643 | 12.59 | **0.036** | **0.060** | **100** |
| S-753 | MH-643 | MH-645 | 12.79 | **0.036** | **0.060** | **100** |
| S-755 | MH-648 | MH-649 | 20.02 | **0.021** | **0.037** | **100** |
| S-756 | MH-650 | MH-649 | 7.30 | **0.028** | **0.048** | **100** |
| S-757 | MH-652 | MH-650 | 12.41 | **0.028** | **0.048** | **100** |
| S-758 | MH-653 | MH-652 | 32.50 | **0.021** | **0.036** | **100** |
| S-759 | MH-647 | MH-648 | 20.02 | **0.052** | **0.088** | **100** |
| S-759A | MH-669 | MH-675 | 61.83 | **0.084** | **0.144** | **100** |
| S-760 | MH-674 | MH-675 | 11.79 | **0.135** | **0.230** | **100** |
| S-761 | MH-673 | MH-674 | 9.24 | **0.054** | **0.092** | **100** |
| S-762 | MH-672 | MH-673 | 18.28 | **0.054** | **0.092** | **100** |
| S-763 | MH-671 | MH-672 | 6.64 | **0.054** | **0.092** | **100** |
| S-764 | MH-670 | MH-671 | 10.39 | **0.054** | **0.092** | **100** |
| S-765 | MH-648 | MH-670 | 22.15 | **0.054** | **0.092** | **100** |
| S-766 | MH-638 | MH-681 | 24.87 | **0.098** | **0.168** | **100** |
| S-767 | MH-681 | MH-680 | 29.40 | **0.098** | **0.168** | **100** |
| S-768 | MH-680 | MH-679 | 38.41 | **0.098** | **0.168** | **100** |
| S-769 | MH-678 | MH-679 | 15.51 | **0.269** | **0.459** | **100** |
| S-770 | MH-677 | MH-678 | 23.69 | **0.269** | **0.459** | **100** |
| S-771 | MH-676 | MH-677 | 20.92 | **0.269** | **0.459** | **100** |
| S-772 | MH-675 | MH-676 | 7.08 | **0.269** | **0.459** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-773 | MH-685 | MH-674 | 14.09 | **0.046** | **0.078** | **100** |
| S-774 | MH-681 | MH-685 | 40.69 | **0.045** | **0.077** | **100** |
| S-775 | MH-682 | MH-649 | 12.18 | **0.062** | **0.105** | **100** |
| S-776 | MH-681 | MH-682 | 1.83 | **0.062** | **0.105** | **100** |
| S-777 | MH-681 | MH-683 | 22.97 | **0.042** | **0.071** | **100** |
| S-778 | MH-683 | MH-684 | 3.64 | **0.042** | **0.071** | **100** |
| S-779 | MH-654 | MH-684 | 17.81 | **0.061** | **0.104** | **100** |
| S-780 | MH-651 | MH-654 | 19.61 | **0.022** | **0.037** | **100** |
| S-781 | MH-652 | MH-651 | 6.59 | **0.022** | **0.037** | **100** |
| S-781A | MH-656 | MH-654 | 3.53 | **0.030** | **0.051** | **100** |
| S-782 | MH-654 | MH-656 | 6.50 | **0.030** | **0.051** | **100** |
| S-783 | MH-657 | MH-655 | 9.00 | **0.030** | **0.051** | **100** |
| S-784 | MH-658 | MH-657 | 19.94 | **0.019** | **0.033** | **100** |
| S-785 | MH-685 | MH-686 | 9.09 | **0.045** | **0.076** | **100** |
| S-786 | MH-686 | MH-688 | 9.04 | **0.045** | **0.076** | **100** |
| S-787 | MH-687 | MH-688 | 26.03 | **0.122** | **0.208** | **100** |
| S-788 | MH-684 | MH-687 | 18.40 | **0.122** | **0.208** | **100** |
| S-790 | MH-689 | MH-690 | 8.46 | **0.195** | **0.333** | **100** |
| S-791 | MH-690 | MH-691 | 17.64 | **0.121** | **0.207** | **100** |
| S-792 | MH-692 | MH-691 | 6.85 | **0.046** | **0.078** | **100** |
| S-793 | MH-693 | MH-692 | 17.46 | **0.046** | **0.078** | **100** |
| S-794 | MH-693 | MH-693 | 10.00 | **0.047** | **0.080** | **100** |
| S-795 | MH-725 | MH-726 | 4.49 | **0.047** | **0.080** | **100** |
| S-796 | MH-724 | MH-725 | 7.31 | **0.047** | **0.080** | **100** |
| S-797 | MH-723 | MH-724 | 26.24 | **0.047** | **0.080** | **100** |
| S-798 | MH-722 | MH-723 | 2.61 | **0.047** | **0.080** | **100** |
| S-799 | MH-661 | MH-722 | 15.80 | **0.047** | **0.080** | **100** |
| S-800 | MH-659 | MH-661 | 12.80 | **0.034** | **0.058** | **100** |
| S-801 | MH-659 | MH-657 | 7.27 | **0.034** | **0.058** | **100** |
| S-802 | MH-679 | MH301 | 16.40 | **0.368** | **0.627** | **100** |
| S-803A | MH-679 | MH-731 | 18.09 | **0.248** | **0.422** | **100** |
| S-803 | MH-730 | MH-731 | 14.29 | **0.124** | **0.211** | **100** |
| S-804 | MH-729 | MH-730 | 10.68 | **0.124** | **0.211** | **100** |
| S-805 | MH-728 | MH-729 | 26.94 | **0.124** | **0.211** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-806 | MH-727 | MH-728 | 11.81 | **0.124** | **0.211** | **100** |
| S-807 | MH-690 | MH-727 | 10.16 | **0.124** | **0.211** | **100** |
| S-808 | MH-731 | MH-721 | 41.55 | **0.352** | **0.600** | **100** |
| S-809 | MH-733 | MH-721 | 15.31 | **0.187** | **0.319** | **100** |
| S-810 | MH-732 | MH-733 | 4.75 | **0.187** | **0.319** | **100** |
| S-811 | MH-735 | MH-732 | 13.32 | **0.187** | **0.319** | **100** |
| S-812 | MH-734 | MH-735 | 2.53 | **0.187** | **0.319** | **100** |
| S-813 | MH-691 | MH-734 | 16.77 | **0.187** | **0.319** | **100** |
| S-814 | MH-661 | MH-664 | 26.95 | **0.046** | **0.078** | **100** |
| S-815 | MH-664 | MH-663 | 2.98 | **0.046** | **0.078** | **100** |
| S-816 | MH-663 | MH-662 | 11.67 | **0.046** | **0.078** | **100** |
| S-817 | MH-662 | MH-701 | 10.21 | **0.046** | **0.078** | **100** |
| S-818 | MH-701 | MH-700 | 15.93 | **0.046** | **0.078** | **100** |
| S-819 | MH-700 | MH-696 | 7.97 | **0.046** | **0.078** | **100** |
| S-820 | MH-696 | MH-699 | 4.69 | **0.046** | **0.078** | **100** |
| S-821 | MH-698 | MH-699 | 14.60 | **0.046** | **0.078** | **100** |
| S-821A | MH-721 | MH-720 | 20.30 | **0.165** | **0.281** | **100** |
| S-822A | MH-719 | MH-720 | 3.14 | **0.143** | **0.244** | **100** |
| S-823A | MH-705 | MH-706 | 19.88 | **0.036** | **0.061** | **100** |
| S-823B | MH-718 | MH-719 | 19.24 | **0.143** | **0.244** | **100** |
| S-823C | MH-697 | MH-714 | 5.77 | **0.053** | **0.091** | **100** |
| S-824 | MH-704 | MH-705 | 13.26 | **0.036** | **0.061** | **100** |
| S-824A | MH-716 | MH-718 | 18.54 | **0.143** | **0.244** | **100** |
| S-825 | MH-702 | MH-704 | 14.52 | **0.027** | **0.046** | **100** |
| S-825A | MH-717 | MH-716 | 3.54 | **0.143** | **0.244** | **100** |
| S-826 | MH-703 | MH-702 | 21.86 | **0.027** | **0.046** | **100** |
| S-826A | MH-715 | MH-717 | 7.37 | **0.143** | **0.244** | **100** |
| S-827 | MH-739 | MH-703 | 3.79 | **0.027** | **0.046** | **100** |
| S-827A | MH-694 | MH-715 | 19.19 | **0.143** | **0.244** | **100** |
| S-828 | MH-693 | MH-694 | 19.77 | **0.049** | **0.084** | **100** |
| S-828A | MH-720 | MH-642 | 39.85 | **0.022** | **0.038** | **100** |
| S-829 | MH-695 | MH-694 | 6.01 | **0.062** | **0.106** | **100** |
| SL-298 | MH-437 | MH-450 | 72.67 | **0.054** | **0.091** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) | Final Flow ($q_{ft}$) | Designed Diameter of Sewer D |
|---|---|---|---|---|---|---|
| | From | To | (m) | (l/s) | (l/s) | (mm) |
| S-01 | MH-03 | MH-02 | 20.95 | **0.008** | **0.014** | **100** |
| S-829A | MH-642 | MH-646 | 31.07 | **0.022** | **0.038** | **100** |
| S-830 | MH-697 | MH-695 | 20.46 | **0.062** | **0.106** | **100** |
| S-830A | MH-712 | MH-646 | 5.70 | **0.275** | **0.469** | **100** |
| S-831 | MH-712 | MH-711 | 13.10 | **0.275** | **0.469** | **100** |
| S-832 | MH-710 | MH-711 | 15.89 | **0.275** | **0.469** | **100** |
| S-833 | MH-713 | MH-710 | 9.95 | **0.053** | **0.091** | **100** |
| S-834 | MH-714 | MH-713 | 30.04 | **0.053** | **0.091** | **100** |
| S-833 | MH-713 | MH-710 | 9.95 | **0.053** | **0.091** | **100** |
| S-834 | MH-714 | MH-713 | 30.04 | **0.053** | **0.091** | **100** |
| S-835 | MH-710 | MH-709 | 15.18 | **0.184** | **0.314** | **100** |
| S-836 | MH-708 | MH-709 | 13.77 | **0.184** | **0.314** | **100** |
| S-837 | MH-707 | MH-708 | 14.41 | **0.097** | **0.165** | **100** |
| S-838 | MH-706 | MH-707 | 16.20 | **0.097** | **0.165** | **100** |
| S-839 | MH-749 | MH-708 | 24.32 | **0.064** | **0.109** | **100** |
| S-840 | MH-745 | MH-749 | 9.65 | **0.064** | **0.110** | **100** |
| S-841 | MH-750 | MH-745 | 5.17 | **0.064** | **0.110** | **100** |
| S-842 | MH-744 | MH-750 | 4.67 | **0.064** | **0.110** | **100** |
| S-843 | MH-742 | MH-744 | 11.97 | **0.064** | **0.110** | **100** |
| S-844 | MH-741 | MH-742 | 18.72 | **0.064** | **0.110** | **100** |
| S-845 | MH-740 | MH-741 | 3.96 | **0.064** | **0.110** | **100** |
| S-846 | MH-738 | MH-740 | 19.99 | **0.089** | **0.152** | **100** |
| S-847 | MH-743 | MH-738 | 4.97 | **0.089** | **0.152** | **100** |
| S-848 | MH-737 | MH-743 | 6.88 | **0.089** | **0.152** | **100** |
| S-849 | MH-736 | MH-737 | 6.19 | **0.089** | **0.152** | **100** |
| S-850 | MH-704 | MH-736 | 10.79 | **0.089** | **0.152** | **100** |
| S-851 | MH-740 | MH-746 | 28.63 | **0.024** | **0.041** | **100** |
| S-852 | MH-747 | MH-746 | 27.99 | **0.026** | **0.044** | **100** |
| S-852A | MH-739A | MH-747 | 5.38 | **0.026** | **0.044** | **100** |
| S-853 | MH-749 | MH-751 | 11.07 | **0.057** | **0.097** | **100** |
| S-854 | MH-751 | MH-754 | 31.97 | **0.057** | **0.097** | **100** |
| S-855 | MH-754 | MH-755 | 7.83 | **0.168** | **0.286** | **100** |
| S-856 | MH-755 | MH-757 | 15.87 | **0.168** | **0.286** | **100** |
| S-857 | MH-756 | MH-757 | 30.65 | **0.297** | **0.506** | **100** |
| S-858 | MH-746 | MH-756 | 23.44 | **0.297** | **0.506** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-859 | MH-753 | MH-754 | 11.92 | **0.079** | **0.135** | **100** |
| S-860 | MH-752 | MH-753 | 11.58 | **0.108** | **0.184** | **100** |
| S-861 | MH-748 | MH-752 | 23.80 | **0.108** | **0.184** | **100** |
| S-862 | MH-746 | MH-748 | 43.41 | **0.069** | **0.118** | **100** |
| S-863 | MH-762 | MH-748 | 22.45 | **0.024** | **0.041** | **100** |
| S-864 | MH-763 | MH-762 | 22.65 | **0.016** | **0.027** | **100** |
| S-865 | MH-764 | MH-763 | 23.13 | **0.016** | **0.027** | **100** |
| S-866 | MH-764 | MH-765 | 4.74 | **0.016** | **0.027** | **100** |
| S-867 | MH-765 | MH-766 | 2.89 | **0.016** | **0.027** | **100** |
| S-868 | MH-767 | MH-766 | 7.18 | **0.019** | **0.032** | **100** |
| S-869 | MH-768 | MH-767 | 14.36 | **0.019** | **0.032** | **100** |
| S-870 | MH-768A | MH-768 | 13.64 | **0.019** | **0.032** | **100** |
| S-871 | MH-770 | MH-766 | 17.18 | **0.021** | **0.036** | **100** |
| S-872 | MH-771 | MH-770 | 5.19 | **0.045** | **0.076** | **100** |
| S-873 | MH-773 | MH-772 | 20.33 | **0.055** | **0.094** | **150** |
| S-873A | MH-771 | MH-772 | 16.36 | **0.045** | **0.076** | **150** |
| S-874 | MH-773A | MH-773 | 11.29 | **0.055** | **0.094** | **150** |
| S-876 | MH-762 | MH-761 | 25.80 | **0.019** | **0.032** | **150** |
| S-877 | MH-769 | MH-761 | 16.81 | **0.081** | **0.137** | **100** |
| S-878 | MH-770 | MH-769 | 6.63 | **0.081** | **0.137** | **100** |
| S-879 | MH-753 | MH-758 | 12.80 | **0.076** | **0.129** | **100** |
| S-880 | MH-758 | MH-760 | 25.08 | **0.076** | **0.129** | **100** |
| S-880A | MH-760 | MH784 | 16.90 | **0.216** | **0.367** | **100** |
| S-881 | MH-761 | MH-760 | 20.15 | **0.114** | **0.195** | **100** |
| S-882 | MH-757 | MH-783 | 35.11 | **0.465** | **0.792** | **100** |
| S-883 | MH-783 | MH-782 | 23.52 | **0.465** | **0.792** | **100** |
| S-884A | MH-811 | MH-782 | 16.74 | **0.390** | **0.665** | **100** |
| S-884 | MH-787 | MH-811 | 9.03 | **0.313** | **0.533** | **100** |
| S-885 | MH-786 | MH-787 | 12.82 | **0.313** | **0.533** | **100** |
| S-886 | MH-785 | MH-786 | 4.23 | **0.313** | **0.533** | **100** |
| S-887 | MH-759 | MH-785 | 14.18 | **0.313** | **0.533** | **100** |
| S-888 | MH-784 | MH-759 | 12.38 | **0.313** | **0.533** | **100** |
| S-889 | MH-772 | MH-774 | 20.88 | **0.106** | **0.181** | **100** |
| S-890 | MH-774 | MH-775 | 18.47 | **0.106** | **0.181** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-891 | MH-775 | MH-776 | 21.04 | **0.119** | **0.203** | **100** |
| S-892 | MH-776 | MH-777 | 9.17 | **0.119** | **0.203** | **100** |
| S-893 | MH-780 | MH-781 | 3.85 | **0.068** | **0.116** | **100** |
| S-894 | MH-772 | MH-780 | 32.27 | **0.068** | **0.116** | **100** |
| S-895 | MH-788 | MH-789 | 24.89 | **0.062** | **0.105** | **100** |
| S-896A | MH-779 | MH-789 | 16.52 | **0.080** | **0.137** | **100** |
| S-896 | MH-778 | MH-779 | 17.78 | **0.080** | **0.137** | **100** |
| S-897 | MH-795 | MH-796 | 11.78 | **0.080** | **0.137** | **100** |
| S-898 | MH-791 | MH-807 | 19.66 | **0.121** | **0.205** | **100** |
| S-899 | MH-807 | MH-806 | 14.60 | **0.121** | **0.205** | **100** |
| S-900 | MH-808 | MH-806 | 25.11 | **0.040** | **0.068** | **100** |
| S-901 | MH-808 | MH-809 | 10.58 | **0.040** | **0.068** | **100** |
| S-902 | MH-809 | MH-810 | 5.45 | **0.040** | **0.068** | **100** |
| S-903 | MH-810 | MH-811 | 10.00 | **0.040** | **0.068** | **100** |
| S-904 | MH-811 | MH-782 | 16.74 | **0.855** | **1.457** | **100** |
| S-905 | MH-782 | MH-829 | 24.39 | **0.855** | **1.457** | **100** |
| S-906 | MH-829 | MH-828 | 29.84 | **0.855** | **1.457** | **100** |
| S-907 | MH-826 | MH-827 | 22.17 | **0.133** | **0.226** | **100** |
| S-908 | MH-813 | MH-826 | 5.70 | **0.133** | **0.226** | **100** |
| S-909 | MH-812 | MH-813 | 21.78 | **0.133** | **0.226** | **100** |
| S-910 | MH-804 | MH-812 | 8.79 | **0.133** | **0.226** | **100** |
| S-911 | MH-805 | MH-804 | 24.68 | **0.193** | **0.330** | **100** |
| S-912 | MH-806 | MH-805 | 10.88 | **0.193** | **0.330** | **100** |
| S-896B | MH-789 | MH-790 | 21.22 | **0.179** | **0.305** | **100** |
| S-897A | MH-790 | MH-791 | 11.52 | **0.179** | **0.305** | **100** |
| S-896A | MH-796 | MH-797 | 10.37 | **0.064** | **0.109** | **100** |
| S-897A | MH-795 | MH-796 | 12.80 | **0.064** | **0.109** | **100** |
| S-898A | MH-793 | MH-795 | 19.32 | **0.064** | **0.109** | **100** |
| S-893B | MH-777 | MH-825 | 22.18 | **0.185** | **0.315** | **100** |
| S-894B | MH-824 | MH-825 | 22.56 | **0.185** | **0.315** | **100** |
| S-895B | MH-824 | MH-797 | 36.48 | **0.185** | **0.315** | **100** |
| S-896A | MH-779 | MH-789 | 16.52 | **0.080** | **0.137** | **100** |
| S-896 | MH-778 | MH-779 | 17.78 | **0.080** | **0.137** | **100** |
| S-897 | MH-795 | MH-796 | 11.78 | **0.080** | **0.137** | **100** |
| S-899A | MH-792 | MH-793 | 4.74 | **0.071** | **0.120** | **100** |

**Table 5.6D1 Design Results of 100mm Condominials in Basin D**

| **Sewer Code** | **Manhole Code** | | **Length** | **Initial Flow, ($q_{it}$) (l/s)** | **Final Flow ($q_{ft}$) (l/s)** | **Designed Diameter of Sewer D (mm)** |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-900A | MH-791 | MH-792 | 21.79 | **0.071** | **0.120** | **100** |
| S-913 | MH-804 | MH-803 | 12.30 | **0.124** | **0.211** | **100** |
| S-914 | MH-800 | MH-803 | 15.90 | **0.124** | **0.211** | **100** |
| S-915 | MH-799 | MH-800 | 21.11 | **0.058** | **0.098** | **100** |
| S-916 | MH-798 | MH-799 | 16.69 | **0.058** | **0.098** | **100** |
| S-917 | MH-794 | MH-798 | 17.16 | **0.058** | **0.098** | **100** |
| S-918 | MH-793 | MH-794 | 20.71 | **0.058** | **0.098** | **100** |
| S-919 | MH-800 | MH-801 | 13.22 | **0.049** | **0.084** | **100** |
| S-920 | MH-801 | MH-821 | 37.93 | **0.049** | **0.084** | **100** |
| S-921 | MH-823 | MH-821 | 13.64 | **0.260** | **0.442** | **100** |
| S-922 | MH-797 | MH-823 | 32.23 | **0.260** | **0.442** | **100** |
| S-923 | MH-800 | MH-802 | 17.31 | **0.051** | **0.087** | **100** |
| S-924 | MH-802 | MH-814 | 13.86 | **0.199** | **0.340** | **100** |
| S-925 | MH-814 | MH-815 | 4.99 | **0.113** | **0.192** | **100** |
| S-926 | MH-815 | MH-816 | 20.29 | **0.113** | **0.192** | **100** |
| S-927 | MH-816 | MH-822 | 12.38 | **0.113** | **0.192** | **100** |
| S-928 | MH-819 | MH-822 | 20.16 | **0.319** | **0.543** | **100** |
| S-928A | MH-814 | MH-817 | 27.35 | **0.118** | **0.201** | **100** |
| S-929 | MH-820 | MH-819 | 8.40 | **0.319** | **0.543** | **100** |
| S-929A | MH-830 | MH-817 | 24.89 | **0.435** | **0.741** | **100** |
| S-930 | MH-821 | MH-820 | 26.49 | **0.319** | **0.543** | **100** |
| S-930A | MH-822 | MH-830 | 15.10 | **0.435** | **0.741** | **100** |
| S-931 | MH-827 | MH-818 | 23.02 | **0.988** | **1.683** | **100** |
| S-932 | MH-817 | MH-818 | 50.41 | **0.988** | **1.683** | **100** |
| S-932A | MH-817 | 0.00 | 11.20 | **1.541** | **2.625** | **100** |
| S-924 | MH-802 | MH-814 | 13.86 | **0.199** | **0.340** | **100** |
| **TOTAL LEN GTH (m)** | | | **6533.62** | | | |

**Table 5.6D2 Design Results of 150mm Street Sewers/Collectors in Basin D**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-617 | MH-466 | MH-467 | 4.92 | **1.949** | **3.320** | **150** |
| S-618 | MH-467 | MH-543 | 34.77 | **1.949** | **3.320** | **150** |
| S-619 | MH-543 | MH-542 | 23.48 | **1.949** | **3.320** | **150** |
| S-620 | MH-542 | MH-541 | 20.22 | **1.949** | **3.320** | **150** |
| S-647 | MH-541 | MH-547 | 23.79 | **2.504** | **4.266** | **150** |
| S-694 | MH-554 | MH-555A | 19.61 | **2.680** | **4.567** | **150** |
| S-695 | MH-546 | MH-554 | 24.69 | **2.598** | **4.426** | **150** |
| S-700 | MH-555A | MH-555 | 31.25 | **2.846** | **4.849** | **150** |
| S-727 | MH-555 | MH-555B | 37.57 | **3.050** | **5.196** | **150** |
| **TOTAL LEN GTH (m)** | | | **220.30** | | | |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-123 | MH-104 | MH-105 | 18.04 | **0.026** | **0.022** | **100** |
| S-124 | MH-105 | MH-106 | 8.39 | **0.026** | **0.043** | **100** |
| S-125 | MH-106 | MH-107 | 23.34 | **0.026** | **0.043** | **100** |
| S-127 | MH-107 | MH-108 | 40.87 | **0.049** | **0.083** | **100** |
| S-128 | MH-108 | MH-113 | 16.98 | **0.042** | **0.071** | **100** |
| S-130 | MH-111 | MH-112 | 22.28 | **0.043** | **0.073** | **100** |
| S-129 | MH-112 | MH-113 | 19.33 | **0.043** | **0.073** | **100** |
| S-131 | MH-110 | MH-111 | 23.86 | **0.043** | **0.073** | **100** |
| S-132 | MH-113 | MH-114 | 3.18 | **0.119** | **0.203** | **100** |
| S-133 | MH-114 | MH-115 | 16.25 | **0.119** | **0.203** | **100** |
| S-134 | MH-115 | MH-116 | 5.86 | **0.119** | **0.203** | **100** |
| S-135 | MH-116 | MH-117 | 17.09 | **0.119** | **0.203** | **100** |
| S-136 | MH-118 | MH-117 | 15.40 | **0.035** | **0.060** | **100** |
| S-137 | MH-118 | MH-119 | 18.80 | **0.035** | **0.060** | **100** |
| S-138 | MH-119 | MH-120 | 25.85 | **0.035** | **0.060** | **100** |
| S-139 | MH-120 | MH-121 | 16.81 | **0.060** | **0.102** | **100** |
| S-140 | MH-121 | MH-122 | 51.66 | **0.051** | **0.088** | **100** |
| S-141 | MH-122 | MH-123 | 21.77 | **0.145** | **0.248** | **100** |
| S-142 | MH-123 | MH-124 | 5.34 | **0.145** | **0.248** | **100** |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) | Final Flow ($q_{ft}$) | Designed Diameter of Sewer D |
|---|---|---|---|---|---|---|
| | From | To | (m) | (l/s) | (l/s) | (mm) |
| S-143 | MH-124 | MH-124A | 12.68 | **0.124** | **0.211** | **100** |
| S-144 | MH-124A | MH-125 | 13.16 | **0.124** | **0.211** | **100** |
| S-145 | MH-125 | MH-126 | 12.68 | **0.124** | **0.211** | **100** |
| S-146 | MH-126 | MH-127 | 2.80 | **0.124** | **0.211** | **100** |
| S-147 | MH-127 | MH-128 | 6.65 | **0.124** | **0.211** | **100** |
| S-147A | MH-128 | MH-129 | 12.26 | **0.124** | **0.211** | **100** |
| S-148 | MH-129 | MH-130 | 14.00 | **0.124** | **0.211** | **100** |
| S-149 | MH-131 | MH-130 | 27.20 | **0.052** | **0.089** | **100** |
| S-150 | MH-132 | MH-131 | 37.68 | **0.052** | **0.089** | **100** |
| S-151 | MH-133 | MH-132 | 13.50 | **0.026** | **0.045** | **100** |
| S-152 | MH-133A | MH-133 | 10.83 | **0.026** | **0.045** | **100** |
| S-153 | MH-132 | MH-134 | 21.80 | **0.036** | **0.061** | **100** |
| S-154 | MH-134 | MH-135 | 12.34 | **0.036** | **0.061** | **100** |
| S-155 | MH-136 | MH-135 | 21.77 | **0.011** | **0.018** | **100** |
| S-156 | MH-135 | MH-137 | 35.50 | **0.069** | **0.118** | **100** |
| S-158 | MH-107 | MH-179 | 39.54 | **0.040** | **0.068** | **100** |
| S-159 | MH-179 | MH-180 | 22.51 | **0.040** | **0.068** | **100** |
| S-160 | MH-189 | MH-180 | 41.71 | **0.017** | **0.029** | **100** |
| S-161 | MH-108 | MH-177 | 34.07 | **0.050** | **0.085** | **100** |
| S-162 | MH-177 | MH-183 | 22.71 | **0.059** | **0.100** | **100** |
| S-163 | MH-182 | MH-183 | 18.31 | **0.090** | **0.153** | **100** |
| S-164 | MH-181 | MH-182 | 24.38 | **0.090** | **0.153** | **100** |
| S-165 | MH-180 | MH-181 | 16.60 | **0.086** | **0.147** | **100** |
| S-166 | MH-117 | MH-170 | 28.72 | **0.164** | **0.279** | **100** |
| S-167 | MH-109 | MH-170 | 29.83 | **0.039** | **0.066** | **100** |
| S-168 | MH-108 | MH-109 | 23.10 | **0.039** | **0.066** | **100** |
| S-169 | MH-120 | MH-170A | 31.18 | **0.035** | **0.060** | **100** |
| S-170 | MH-170 | MH-170A | 39.37 | **0.123** | **0.209** | **100** |
| S-171 | MH-177 | MH-176 | 22.39 | **0.053** | **0.091** | **100** |
| S-172 | MH-176 | MH-168 | 35.57 | **0.053** | **0.091** | **100** |
| S-173 | MH-169 | MH-168 | 15.83 | **0.128** | **0.218** | **100** |
| S-174 | MH-170 | MH-169 | 22.65 | **0.128** | **0.218** | **100** |
| S-175 | MH-170A | MH-178 | 31.18 | **0.187** | **0.319** | **100** |
| S-176 | MH-178 | MH-179 | 42.59 | **0.187** | **0.319** | **100** |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-177 | MH-179 | MH-176 | 43.85 | **0.187** | **0.319** | **100** |
| S-178 | MH-176 | MH-162 | 19.57 | **0.348** | **0.593** | **100** |
| S-180 | MH-165 | MH-163 | 26.16 | **0.571** | **0.958** | **100** |
| S-181 | MH-166 | MH-165 | 15.49 | **0.216** | **0.368** | **100** |
| S-182 | MH-167 | MH-166 | 27.60 | **0.216** | **0.368** | **100** |
| S-183 | MH-167 | MH-168 | 7.11 | **0.216** | **0.368** | **100** |
| S-184 | MH-175 | MH-176 | 5.58 | **0.115** | **0.196** | **100** |
| S-185 | MH-174 | MH-175 | 18.23 | **0.115** | **0.196** | **100** |
| S-186 | MH-173 | MH-174 | 14.25 | **0.115** | **0.196** | **100** |
| S-187 | MH-172 | MH-173 | 18.53 | **0.115** | **0.196** | **100** |
| S-188 | MH-171 | MH-172 | 12.68 | **0.115** | **0.196** | **100** |
| S-189 | MH-124 | MH-171 | 31.36 | **0.115** | **0.196** | **100** |
| S-190 | MH-130 | MH-130A | 22.18 | **0.223** | **0.380** | **100** |
| S-191 | MH-130A | MH-144 | 17.63 | **0.223** | **0.380** | **100** |
| S-204 | MH-152 | MH-151 | 20.33 | **0.081** | **0.139** | **100** |
| S-205 | MH-151 | MH-150 | 6.22 | **0.081** | **0.139** | **100** |
| S-206 | MH-150 | MH-149 | 12.75 | **0.081** | **0.139** | **100** |
| S-207 | MH-149 | MH-148 | 9.66 | **0.081** | **0.139** | **100** |
| S-208 | MH-159 | MH-148 | 9.88 | **0.081** | **0.139** | **100** |
| S-209 | MH-158 | MH-159 | 7.77 | **0.081** | **0.139** | **100** |
| S-210 | MH-157 | MH-158 | 39.33 | **0.081** | **0.139** | **100** |
| S-211 | MH-155 | MH-157 | 19.65 | **0.081** | **0.139** | **100** |
| S-212 | MH-156 | MH-155 | 14.04 | **0.081** | **0.139** | **100** |
| S-213 | MH-155 | MH-154 | 21.35 | **0.081** | **0.139** | **100** |
| S-214 | MH-154 | MH-153 | **26.52** | **0.081** | **0.139** | **150** |
| S-215 | MH-153 | MH-152 | 26.94 | **0.081** | **0.139** | **100** |
| S-217 | MH-181A | MH-181 | 15.24 | **0.042** | **0.071** | **100** |
| S-218 | MH-191 | MH-181A | 17.18 | **0.042** | **0.071** | **100** |
| S-219 | MH-190 | MH-191 | 2.60 | **0.036** | **0.061** | **100** |
| S-220 | MH-189 | MH-190 | 30.06 | **0.036** | **0.061** | **100** |
| S-221 | MH-183 | MH-184 | 7.32 | **0.177** | **0.302** | **100** |
| S-222 | MH-184 | MH-185 | 25.88 | **0.177** | **0.302** | **100** |
| S-223 | MH-193 | MH-185 | 14.77 | **0.047** | **0.064** | **100** |
| S-224 | MH-192 | MH-193 | 35.20 | **0.050** | **0.055** | **100** |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-225 | MH-191 | MH-192 | 28.05 | **0.050** | **0.055** | **100** |
| S-226 | MH-188 | MH-165 | 22.25 | **0.320** | **0.530** | **100** |
| S-227 | MH-187 | MH-188 | 36.75 | **0.320** | **0.530** | **100** |
| S-228 | MH-186 | MH-187 | 30.15 | **0.254** | **0.417** | **100** |
| S-229 | MH-185 | MH-186 | 16.92 | **0.254** | **0.417** | **100** |
| S-230 | MH-193 | MH-194 | 46.83 | **0.059** | **0.085** | **100** |
| S-231 | MH-196 | MH-194 | 44.01 | **0.087** | **0.148** | **100** |
| S-232 | MH-202 | MH-196 | 18.99 | **0.087** | **0.148** | **100** |
| S-233 | MH-203 | MH-202 | 15.64 | **0.087** | **0.148** | **100** |
| S-234 | MH-204 | MH-203 | 16.85 | **0.113** | **0.192** | **100** |
| S-235 | MH-208 | MH-204 | 53.01 | **0.027** | **0.047** | **100** |
| S-236 | MH-207 | MH-208 | 27.45 | **0.027** | **0.047** | **300** |
| S-237 | MH-195 | MH-198 | 27.58 | **0.102** | **0.166** | **100** |
| S-238 | MH-198 | MH-199 | 23.97 | **0.102** | **0.166** | **100** |
| S-239 | MH-199A | MH-199 | 15.94 | **0.030** | **0.050** | **100** |
| S-240 | MH-199A | MH-199B | 20.78 | **0.030** | **0.050** | **100** |
| S-241 | MH-199B | MH-187 | 52.61 | **0.030** | **0.050** | **100** |
| S-242 | MH-199 | MH-200 | 15.16 | **0.158** | **0.262** | **100** |
| S-243 | MH-200 | MH-201 | 26.36 | **0.113** | **0.189** | **100** |
| S-244 | MH-201 | MH-201A | 28.40 | **0.113** | **0.189** | **100** |
| S-245 | MH-205 | MH-204 | 21.02 | **0.116** | **0.198** | **100** |
| S-246 | MH-206 | MH-205 | 31.70 | **0.011** | **0.019** | **100** |
| S-247 | MH-236 | MH-205 | 27.97 | **0.064** | **0.110** | **100** |
| S-248 | MH-235 | MH-236 | 9.57 | **0.046** | **0.078** | **100** |
| S-249 | MH-233 | MH-235 | 13.66 | **0.046** | **0.078** | **100** |
| S-250 | MH-232 | MH-233 | 10.47 | **0.011** | **0.019** | **100** |
| S-251 | MH-194 | MH-195 | 39.54 | **0.166** | **0.267** | **100** |
| S-252 | MH-195 | MH-211 | 23.47 | **0.099** | **0.162** | **100** |
| S-253 | MH-210 | MH-211 | 17.41 | **0.073** | **0.124** | **100** |
| S-254 | MH-209 | MH-210 | 19.06 | **0.073** | **0.124** | **100** |
| S-255 | MH-203 | MH-209 | 20.8 | **0.073** | **0.124** | **100** |
| S-256 | MH-222 | MH-223 | 9.51 | **0.087** | **0.148** | **100** |
| S-257 | MH-223 | MH-244 | 7.78 | **0.087** | **0.148** | **100** |
| S-245A | MH-212 | MH-219 | 19.09 | **0.054** | **0.093** | **100** |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-245B | MH-220 | MH-219 | 15.97 | **0.054** | **0.093** | **100** |
| S-245C | MH-220 | MH-221 | 22.74 | **0.054** | **0.093** | **100** |
| S-245D | MH-221 | MH-222 | 20.10 | **0.054** | **0.093** | **100** |
| S-258 | MH-243 | MH-244 | 51.16 | **0.092** | **0.157** | **100** |
| S-259 | MH-242 | MH-243 | 18.77 | **0.092** | **0.157** | **100** |
| S-260 | MH-241A | MH-242 | 10.90 | **0.092** | **0.157** | **100** |
| S-261 | MH-241 | MH-241A | 16.60 | **0.092** | **0.157** | **100** |
| S-262 | MH-240 | MH-241 | 11.63 | **0.092** | **0.157** | **100** |
| S-263 | MH-239 | MH-240 | 15.27 | **0.092** | **0.157** | **100** |
| S-264 | MH-236 | MH-239 | 15.34 | **0.092** | **0.157** | **100** |
| S-256A | MH-213 | MH-214 | 12.24 | **0.435** | **0.729** | **100** |
| S-257A | MH-214 | MH-215 | 8.18 | **0.435** | **0.729** | **100** |
| S-258A | MH-215 | MH-216 | 15.90 | **0.435** | **0.729** | **100** |
| S-259A | MH-216 | MH-217 | 19.98 | **0.435** | **0.729** | **100** |
| S-260A | MH-217 | MH-218 | 46.03 | **0.435** | **0.729** | **100** |
| S-261A | MH-218 | MH-227 | 56.00 | **0.548** | **0.918** | **100** |
| S-262A | MH-226 | MH-227 | 30.15 | **0.058** | **0.098** | **100** |
| S-262B | MH-233 | MH-234 | 37.25 | **0.039** | **0.066** | **100** |
| S-263A | MH-225 | MH-226 | 24.21 | **0.062** | **0.105** | **100** |
| S-264A | MH-224 | MH-225 | 7.16 | **0.062** | **0.105** | **100** |
| S-265 | MH-222 | MH-224 | 33.68 | **0.062** | **0.105** | **100** |
| S-265A | MH-244 | MH-245 | 36.19 | **0.238** | **0.405** | **100** |
| S-274 | MH-226 | MH-228 | 19.14 | **0.063** | **0.108** | **100** |
| S-275 | MH-228 | MH-229 | 5.10 | **0.063** | **0.108** | **100** |
| S-276 | MH-229 | MH-230 | 26.20 | **0.063** | **0.108** | **100** |
| S-281 | MH-227 | MH-231 | 80.85 | **0.606** | **1.016** | **100** |
| S-283 | MH-255 | MH-272 | 33.04 | **0.059** | **0.101** | **100** |
| S-284 | MH-271 | MH-272 | 20.19 | **0.059** | **0.101** | **100** |
| S-285 | MH-271 | MH-270 | 9.64 | **0.059** | **0.101** | **100** |
| S-286 | MH-275 | MH-270 | 18.89 | **0.066** | **0.112** | **100** |
| S-287 | MH-274 | MH-275 | 10.70 | **0.066** | **0.112** | **100** |
| S-288 | MH-273 | MH-274 | 43.13 | **0.066** | **0.112** | **100** |
| S-289 | MH-272 | MH-273 | 15.59 | **0.066** | **0.112** | **100** |
| S-290 | MH-262A | MH-246 | 93.64 | **0.037** | **0.063** | **100** |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-291 | MH-262A | MH-262 | 38.98 | **0.037** | **0.063** | **100** |
| S-292 | MH-262 | MH-263 | 16.60 | **0.056** | **0.096** | **100** |
| S-293 | MH-263 | MH-266 | 2.20 | **0.070** | **0.119** | **100** |
| S-294 | MH-266 | MH-267 | 28.36 | **0.070** | **0.119** | **100** |
| S-295 | MH-268 | MH-267 | 25.94 | **0.139** | **0.236** | **100** |
| S-296 | MH-270 | MH-269 | 20.34 | **0.197** | **0.335** | **100** |
| S-297 | MH-269 | MH-268 | 35.67 | **0.197** | **0.335** | **100** |
| S-298 | MH-248 | MH-249 | 30.30 | **0.010** | **0.018** | **100** |
| S-299 | MH-257 | MH-249 | 12.54 | **0.042** | **0.072** | **100** |
| S-300 | MH-259 | MH-257 | 19.14 | **0.042** | **0.072** | **100** |
| S-301 | MH-259A | MH-259 | 8.65 | **0.042** | **0.072** | **100** |
| S-302 | MH-261 | MH-259A | 25.11 | **0.028** | **0.048** | **100** |
| S-303 | MH-262 | MH-261 | 18.56 | **0.028** | **0.048** | **100** |
| S-304 | MH-249 | MH-260 | 27.91 | **0.082** | **0.140** | **100** |
| S-306 | MH-259A | MH-265 | 23.91 | **0.099** | **0.169** | **100** |
| S-307 | MH-264A | MH-265 | 16.47 | **0.043** | **0.073** | **100** |
| S-308 | MH-264 | MH-264A | 17.31 | **0.043** | **0.073** | **100** |
| S-309 | MH-263 | MH-264 | 13.83 | **0.043** | **0.073** | **100** |
| S-310 | MH-265 | MH-281 | 49.31 | **0.119** | **0.202** | **100** |
| S-311 | MH-280 | MH-281 | 37.83 | **0.115** | **0.196** | **100** |
| S-312 | MH-267 | MH-280 | 31.73 | **0.226** | **0.385** | **100** |
| S-313 | MH-280 | MH-279 | 21.27 | **0.122** | **0.207** | **100** |
| S-314 | MH-278 | MH-279 | 37.10 | **0.274** | **0.467** | **100** |
| S-315 | MH-276 | MH-278 | 25.23 | **0.274** | **0.467** | **100** |
| S-316 | MH-268 | MH-276 | 25.29 | **0.145** | **0.247** | **100** |
| S-319 | MH-281 | MH-282 | 55.28 | **0.259** | **0.441** | **100** |
| S-320 | MH-276 | MH-277 | 15.95 | **0.119** | **0.203** | **100** |
| S-321 | MH-298 | MH-277 | 38.85 | **0.073** | **0.125** | **100** |
| S-322 | MH-297 | MH-298 | 21.89 | **0.073** | **0.125** | **100** |
| S-323 | MH-296 | MH-297 | 22.67 | **0.073** | **0.125** | **100** |
| S-324 | MH-295 | MH-296 | 30.32 | **0.062** | **0.106** | **100** |
| S-325 | MH-296 | MH-299 | 30.32 | **0.057** | **0.098** | **100** |
| S-326 | MH-299 | MH-300 | 31.11 | **0.057** | **0.098** | **100** |
| S-327 | MH-300 | MH-303 | 30.03 | **0.057** | **0.098** | **100** |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-328 | MH-302A | MH-303 | 15.79 | **0.424** | **0.723** | **100** |
| S-329 | MH-302 | MH-302A | 12.04 | **0.393** | **0.670** | **100** |
| S-330 | MH-301A | MH-302 | 31.09 | **0.393** | **0.670** | **100** |
| S-331 | MH-301 | MH-301A | 12.19 | **0.393** | **0.670** | **100** |
| S-332 | MH-294 | MH-277 | 8.02 | **0.005** | **0.009** | **100** |
| S-333 | MH-294 | MH-293 | 26.46 | **0.005** | **0.009** | **100** |
| S-334 | MH-293 | MH-292 | 18.07 | **0.005** | **0.009** | **100** |
| S-335 | MH-292 | MH-291 | 14.70 | **0.005** | **0.009** | **100** |
| S-336 | MH-291 | MH-290 | 11.70 | **0.005** | **0.009** | **100** |
| S-337 | MH-290 | MH-289 | 35.78 | **0.005** | **0.009** | **100** |
| S-338 | MH-289 | MH-306 | 82.15 | **0.016** | **0.027** | **100** |
| S-339 | MH-305 | MH-306 | 16.33 | **0.505** | **0.861** | **100** |
| S-340 | MH-304A | MH-305 | 30.87 | **0.488** | **0.831** | **100** |
| S-341 | MH-304 | MH-304A | 32.87 | **0.488** | **0.831** | **100** |
| S-342 | MH-303 | MH-304 | 29.49 | **0.488** | **0.831** | **100** |
| S-343 | MH-279 | MH-286 | 12.55 | **0.399** | **0.679** | **100** |
| S-344 | MH-287A | MH-286 | 26.10 | **0.006** | **0.010** | **100** |
| S-345 | MH-286A | MH-286A | 13.89 | **0.005** | **0.008** | **100** |
| S-346 | MH-289 | MH-286A | 23.70 | **0.005** | **0.008** | **100** |
| S-348 | MH-284 | MH-285 | 13.21 | **0.407** | **0.693** | **100** |
| S-349 | MH-286A | MH-285 | 32.16 | **0.407** | **0.693** | **100** |
| S-351 | MH-287A | MH-288 | 40.51 | **0.007** | **0.011** | **100** |
| S-355 | MH-309 | MH-309 | 39.05 | **0.527** | **0.897** | **100** |
| S-356 | MH-314 | MH-302A | 35.29 | **0.005** | **0.009** | **100** |
| S-357 | MH-314 | MH-315 | 31.89 | **0.005** | **0.009** | **100** |
| S-358 | MH-316 | MH-315 | 53.89 | **0.424** | **0.723** | **100** |
| S-359 | MH-316 | MH-317 | 34.81 | **0.393** | **0.670** | **100** |
| S-360 | MH-317 | MH-301 | 24.68 | **0.393** | **0.670** | **100** |
| S-361 | MH-304A | MH-321 | 15.66 | **0.012** | **0.021** | **100** |
| S-362 | MH-321 | MH-320 | 18.83 | **0.012** | **0.021** | **100** |
| S-363 | MH-320 | MH-319 | 14.16 | **0.012** | **0.021** | **100** |
| S-364 | MH-318 | MH-319 | 30.39 | **0.432** | **0.737** | **100** |
| S-365 | MH-315 | MH-318 | 47.00 | **0.432** | **0.737** | **100** |
| S-366 | MH-319 | MH-311 | 22.60 | **0.012** | **0.021** | **100** |

**Table 5.6E1 Design Results of 100mm Condominials in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-367 | MH-311 | MH-312 | 7.50 | **0.012** | **0.021** | **100** |
| S-368 | MH-312 | MH-313 | 15.34 | **0.012** | **0.021** | **100** |
| S-369 | MH-319 | MH-313 | 29.28 | **0.454** | **0.774** | **100** |
| S-370 | MH-310 | MH-305 | 13.67 | **0.012** | **0.021** | **100** |
| S-373 | MH-323 | MH-324 | 28.95 | **0.469** | **0.799** | **100** |
| S-374 | MH-313 | MH-323 | 36.62 | **0.469** | **0.799** | **100** |
| **TOTAL LEN GTH (m)** | | | **5476.69** | | | |

**Table 5.6E2 Design Results of 150mm Street Sewers/Collectors in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-157 | MH-90 | MH-137 | 22.81 | **3.920** | **6.804** | **150** |
| S-192 | MH-144 | MH-145 | 32.73 | **4.213** | **7.302** | **150** |
| S-193 | MH-145 | MH-146 | 4.11 | **4.213** | **7.302** | **150** |
| S-194 | MH-146 | MH-147 | 17.07 | **4.213** | **7.302** | **150** |
| S-195 | MH-147 | MH-160 | 45.36 | **4.213** | **7.302** | **150** |
| S-196 | MH-160 | MH-161 | 29.65 | **4.213** | **7.302** | **150** |
| S-197 | MH-161 | MH-162 | 30.12 | **4.213** | **7.302** | **150** |
| S-198 | MH-137 | MH-138 | 3.30 | **3.990** | **6.922** | **150** |
| S-199 | MH-138 | MH-140 | 16.42 | **3.990** | **6.922** | **150** |
| S-200 | MH-140 | MH-141 | 13.54 | **3.990** | **6.922** | **150** |
| S-201 | MH-141 | MH-142 | 7.38 | **3.990** | **6.922** | **150** |
| S-202 | MH-142 | MH-143 | 26.07 | **3.990** | **6.922** | **150** |
| S-203 | MH-143 | MH-144 | 39.76 | **3.990** | **6.922** | **150** |
| S-266 | MH-245 | MH-250 | 13.35 | **3.861** | **6.578** | **150** |
| S-267 | MH-250 | MH-251 | 70.31 | **3.861** | **6.578** | **150** |
| S-268 | MH-252 | MH-251 | 25.93 | **3.861** | **6.578** | **150** |
| S-269 | MH-252 | MH-253 | 5.15 | **3.861** | **6.578** | **150** |
| S-270 | MH-254 | MH-253 | 14.87 | **3.861** | **6.578** | **150** |
| S-271 | MH-255 | MH-254 | 28.82 | **3.861** | **6.578** | **150** |

**Table 5.6E2 Design Results of 150mm Street Sewers/Collectors in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-272 | MH-256 | MH-255 | 12.57 | **3.861** | **6.578** | **150** |
| S-273 | MH-555B | MH-256 | 29.85 | **3.861** | **6.578** | **150** |
| S-277 | MH-248 | MH-230 | 53.99 | **4.099** | **6.983** | **150** |
| S-278 | MH-247 | MH-248 | 28.47 | **4.099** | **6.983** | **150** |
| S-279 | MH-246 | MH-247 | 81.71 | **4.099** | **6.983** | **150** |
| S-280 | MH-245 | MH-246 | 12.66 | **4.099** | **6.983** | **150** |
| S-282 | MH-230 | MH-231 | 65.87 | **4.162** | **7.091** | **150** |
| **TOTAL LEN GTH (m)** | | | **731.87** | | | |

**Table 5.6E3 Design Results of 225mm Outfall Sewers/Sub-Mains in Basin E**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-179 | MH-162 | MH-163 | 9.60 | **4.561** | **7.896** | **225** |
| S-179A | MH-163 | MH-164 | 12.10 | **5.133** | **8.854** | **225** |
| S-305 | MH-231 | MH-260 | 29.48 | **4.767** | **8.107** | **225** |
| S-317 | MH-260 | MH-283 | 52.64 | **4.850** | **8.247** | **225** |
| S-318 | MH-283 | MH-282 | 51.10 | **4.850** | **8.247** | **225** |
| S-347 | MH-282 | MH-284 | 38.71 | **5.108** | **8.688** | **225** |
| S-350 | MH-284 | MH-288 | 27.97 | **5.515** | **9.382** | **225** |
| S-352 | MH-288 | MH-307 | 50.59 | **5.522** | **9.393** | **225** |
| S-353 | MH-307 | MH-308 | 49.33 | **5.522** | **9.393** | **225** |
| S-354 | MH-308 | MH-309 | 25.14 | **5.522** | **9.393** | **225** |
| S-371 | MH-309 | MH-322 | 28.43 | **6.049** | **10.290** | **225** |
| S-372 | MH-322 | MH-324 | 29.04 | **6.049** | **10.290** | **225** |
| **TOTAL LEN GTH (m)** | | | **404.13** | | | |

**Table 5.6E1-1 Design Results of 100mm Condominials in Basin E1**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-933 | MH-152 | MH-151 | 20.33 | **0.086** | **0.146** | **100** |
| S-934 | MH-151 | MH-150 | 6.22 | **0.086** | **0.146** | **100** |
| S-935 | MH-150 | MH-149 | 12.75 | **0.086** | **0.146** | **100** |
| S-936 | MH-149 | MH-148 | 9.66 | **0.086** | **0.146** | **100** |
| S-937 | MH-159 | MH-148 | 9.88 | **0.163** | **0.277** | **100** |
| S-938 | MH-158 | MH-159 | 7.77 | **0.163** | **0.277** | **100** |
| S-939 | MH-157 | MH-158 | 39.33 | **0.163** | **0.277** | **100** |
| S-940 | MH-155 | MH-157 | 19.65 | **0.136** | **0.232** | **100** |
| S-941 | MH-154 | MH-155 | 21.35 | **0.086** | **0.146** | **100** |
| S-942 | MH-153 | MH-154 | 26.52 | **0.086** | **0.146** | **100** |
| S-943 | MH-152 | MH-153 | 26.94 | **0.086** | **0.146** | **100** |
| S-944 | MH-148 | MH-838E | 32.37 | **0.009** | **0.016** | **100** |
| S-945 | MH-838E | MH-839 | 26.50 | **0.009** | **0.016** | **100** |
| S-946 | MH-839 | MH-838D | 12.25 | **0.024** | **0.041** | **100** |
| S-947 | MH-831 | MH-838D | 22.32 | **0.111** | **0.190** | **100** |
| S-948 | MH-830 | MH-831 | 9.79 | **0.085** | **0.145** | **100** |
| S-949 | MH-829 | MH-830 | 12.79 | **0.085** | **0.145** | **100** |
| S-950 | MH-157 | MH-829 | 12.44 | **0.085** | **0.145** | **100** |
| S-951 | MH-839 | MH-839A | **11.15** | **0.015** | **0.025** | **100** |
| S-952 | MH-839A | MH-839B | **13.31** | **0.015** | **0.025** | **100** |
| S-953 | MH-839B | MH-164 | **20.08** | **0.015** | **0.025** | **100** |
| S-956 | MH-842 | MH-842 | **9.55** | **0.130** | **0.222** | **100** |
| S-957 | MH-843 | MH-842 | **6.72** | **0.130** | **0.222** | **100** |
| S-958 | MH-838A | MH-843 | **19.74** | **0.130** | **0.222** | **100** |
| S-959 | MH-838B | MH-838A | **2.66** | **0.027** | **0.046** | **100** |
| S-960 | MH-838C | MH-838B | 6.51 | **0.027** | **0.046** | **100** |
| S-961 | MH-838D | MH-838C | 20.61 | **0.027** | **0.046** | **100** |
| S-962 | MH-831 | MH-832 | 12.71 | **0.012** | **0.021** | **100** |
| S-963 | MH-832 | MH-833 | 15.78 | **0.012** | **0.021** | **100** |
| S-964 | MH-833 | MH-837 | 14.65 | **0.120** | **0.204** | **100** |
| S-965 | MH-837 | MH-838 | 9.11 | **0.120** | **0.204** | **100** |
| S-966 | MH-838 | MH-838A | 2.33 | **0.079** | **0.134** | **100** |
| S-967 | MH-834 | MH-833 | 7.94 | **0.089** | **0.152** | **100** |
| S-968 | MH-835 | MH-834 | 20.95 | **0.089** | **0.152** | **100** |
| S-969 | MH-156 | MH-835 | 18.87 | **0.008** | **0.013** | **100** |

**Table 5.6E1-1 Design Results of 100mm Condominials in Basin E1**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-970 | MH-155 | MH-156 | 14.04 | **0.008** | **0.013** | **100** |
| S-971 | MH-835 | MH-836 | 30.79 | **0.029** | **0.050** | **100** |
| S-972 | MH-868 | MH-836 | 13.66 | **0.020** | **0.034** | **100** |
| S-973 | MH-868 | MH-867 | 40.04 | **0.020** | **0.034** | **100** |
| S-974 | MH-867 | MH-866 | 30.12 | **0.065** | **0.110** | **100** |
| S-975 | MH-866 | MH-863 | 14.82 | **0.065** | **0.110** | **100** |
| S-976 | MH-862 | MH-863 | 12.14 | **0.058** | **0.098** | **100** |
| S-977 | MH-869 | MH-867 | 4.62 | **0.024** | **0.041** | **100** |
| S-978 | MH-870 | MH-869 | 3.78 | **0.024** | **0.041** | **100** |
| S-979 | MH-871 | MH-870 | 11.61 | **0.024** | **0.041** | **100** |
| S-980 | MH-872 | MH-871 | 39.18 | **0.024** | **0.041** | **100** |
| S-981 | MH-838 | MH-844 | 9.45 | **0.087** | **0.149** | **100** |
| S-982 | MH-844 | MH-845 | 15.30 | **0.087** | **0.149** | **100** |
| S-983 | MH-845 | MH-846 | 29.70 | **0.087** | **0.149** | **100** |
| S-984 | MH-847 | MH-846 | 23.38 | **0.063** | **0.107** | **100** |
| S-986 | MH-836 | MH-848 | 8.48 | **0.070** | **0.120** | **100** |
| S-990 | MH-849 | MH-850 | 18.45 | **0.179** | **0.305** | **100** |
| S-991 | MH-846 | MH-849 | 16.58 | **0.179** | **0.305** | **100** |
| S-992 | MH-848 | MH-847 | 18.83 | **0.070** | **0.120** | **100** |
| S-993 | MH-847 | MH-862 | 16.71 | **0.058** | **0.098** | **100** |
| S-994 | MH-863 | MH-864 | 17.63 | **0.149** | **0.253** | **100** |
| S-995 | MH-864 | MH-865 | 26.90 | **0.149** | **0.253** | **100** |
| S-996 | MH-856 | MH-865 | 22.90 | **0.043** | **0.073** | **100** |
| S-997 | MH-857 | MH-856 | 18.61 | **0.043** | **0.073** | **100** |
| S-998 | MH-858 | MH-857 | 16.38 | **0.018** | **0.030** | **100** |
| S-999 | MH-859 | MH-858 | 16.30 | **0.018** | **0.030** | **100** |
| S-1000 | MH-860 | MH-859 | 12.67 | **0.018** | **0.030** | **100** |
| S-1001 | MH-861 | MH-860 | 3.67 | **0.018** | **0.030** | **100** |
| S-1004 | MH-854 | MH-852 | 21.13 | **0.227** | **0.387** | **100** |
| S-1005 | MH-855 | MH-854 | 3.75 | **0.227** | **0.387** | **100** |
| S-1006 | MH-865 | MH-855 | 30.10 | **0.227** | **0.387** | **100** |
| S-1007 | MH-857 | MH-873 | 20.39 | **0.027** | **0.045** | **100** |
| S-1008 | MH-873 | MH-874 | 8.80 | **0.014** | **0.023** | **100** |
| S-1009 | MH-875 | MH-874 | 41.32 | **0.014** | **0.023** | **100** |

**Table 5.6E1-1 Design Results of 100mm Condominials in Basin E1**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1010 | MH-876 | MH-875 | 52.49 | **0.014** | **0.023** | **100** |
| S-1014 | MH-883 | MH-885 | 13.74 | **0.116** | **0.197** | **100** |
| S-1015 | MH-882 | MH-883 | 19.00 | **0.116** | **0.197** | **100** |
| S-1016 | MH-881 | MH-882 | 5.57 | **0.116** | **0.197** | **100** |
| S-1017 | MH-880 | MH-881 | 18.81 | **0.116** | **0.197** | **100** |
| S-1018 | MH-879 | MH-880 | 12.80 | **0.116** | **0.197** | **100** |
| S-1019 | MH-878 | MH-879 | 15.00 | **0.070** | **0.120** | **100** |
| S-1020 | MH-877 | MH-878 | 17.40 | **0.070** | **0.120** | **100** |
| S-1021 | MH-873 | MH-877 | 19.58 | **0.070** | **0.120** | **100** |
| S-1022 | MH-879 | MH-889 | 50.62 | **0.016** | **0.028** | **100** |
| S-1023 | MH-888 | MH-889 | 61.15 | **0.008** | **0.014** | **100** |
| S-1024 | MH-887 | MH-888 | 13.04 | **0.008** | **0.014** | **100** |
| S-1025 | MH-886 | MH-887 | 24.51 | **0.008** | **0.014** | **100** |
| **TOTAL LEN GTH (m)** | | | **1497.47** | | | |

**Table 5.6E1-2 Design Results of 225mm Outfall Sewers/Sub-Mains in Basin E1**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-954 | MH-164 | MH-840 | 13.74 | **5.148** | **8.879** | **225** |
| S-955 | MH-840 | MH-841 | 26.83 | **5.148** | **8.879** | **225** |
| S-987 | MH-841 | MH-841A | 27.45 | **2.863** | **4.998** | **225** |
| S-988 | MH-841A | MH-841B | 19.81 | **2.863** | **4.998** | **225** |
| S-989 | MH-850 | MH-841B | 19.34 | **2.863** | **4.998** | **225** |
| S-1002 | MH-850 | MH-851 | 18.74 | **2.922** | **5.098** | **225** |
| S-1003 | MH-851 | MH-852 | 13.25 | **2.922** | **5.098** | **225** |
| S-1011 | MH-852 | MH-853 | 16.58 | **2.986** | **5.207** | **225** |
| S-1012 | MH-853 | MH-884 | 21.41 | **2.986** | **5.207** | **225** |
| S-1013 | MH-884 | MH-885 | 25.21 | **2.986** | **5.207** | **225** |
| S-1026 | MH-885 | MH-890 | 22.40 | **3.018** | **5.261** | **225** |
| S-1027 | MH-890 | MH-890A | 11.01 | **3.018** | **5.261** | **225** |
| S-1028 | MH-890A | MH-891 | 16.00 | **3.018** | **5.261** | **225** |
| **TOTAL LEN GTH (m)** | | | **251.77** | | | |

**Table 5.6F1 Design Results of 100mm Condominials in Basin F**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-375 | MH-325 | MH-326 | 7.82 | **0.007** | **0.012** | **100** |
| S-376 | MH-327 | MH-326 | 20.02 | **0.045** | **0.071** | **100** |
| S-377 | MH-328 | MH-327 | 14.53 | **0.060** | **0.093** | **100** |
| S-378 | MH-329 | MH-328 | 19.97 | **0.013** | **0.012** | **100** |
| S-379 | MH-330 | MH-329 | 10.81 | **0.013** | **0.012** | **100** |
| S-380 | MH-327 | MH-333 | 31.58 | **0.051** | **0.083** | **100** |
| S-381 | MH-333 | MH-334 | 25.43 | **0.051** | **0.083** | **100** |
| S-382 | MH-335 | MH-334 | 28.27 | **0.042** | **0.068** | **100** |
| S-383 | MH-334 | MH-335 | 22.18 | **0.111** | **0.181** | **100** |
| S-384 | MH-335 | MH-336 | 22.62 | **0.184** | **0.307** | **100** |
| S-385 | MH-336 | MH-337 | 17.00 | **0.103** | **0.172** | **100** |
| S-386 | MH-335 | MH-337 | 28.38 | **0.034** | **0.055** | **100** |
| S-387 | MH-326 | MH-335 | 55.40 | **0.060** | **0.096** | **100** |
| S-388 | MH-337 | MH-379 | 33.74 | **0.144** | **0.238** | **100** |
| S-389 | MH-379 | MH-378 | 37.74 | **0.144** | **0.238** | **100** |
| S-390 | MH-378 | MH-377 | 23.31 | **0.144** | **0.238** | **100** |
| S-391 | MH-375 | MH-377 | 10.77 | **0.088** | **0.146** | **100** |
| S-392 | MH-374 | MH-375 | 20.33 | **0.088** | **0.146** | **100** |
| S-393 | MH-336 | MH-374 | 56.04 | **0.088** | **0.146** | **100** |
| S-395 | MH-345 | MH-328 | 22.31 | **0.027** | **0.046** | **100** |
| S-396 | MH-331 | MH-345 | 26.22 | **0.016** | **0.026** | **100** |
| S-397 | MH-333 | MH-331 | 45.15 | **0.016** | **0.026** | **100** |
| S-398 | MH-335 | MH-338 | 7.16 | **0.061** | **0.103** | **100** |
| S-400 | MH-340 | MH-339 | 17.46 | **0.076** | **0.130** | **100** |
| S-401 | MH-341 | MH-340 | 20.01 | **0.092** | **0.156** | **100** |
| S-402 | MH-342 | MH-341 | 20.13 | **0.092** | **0.156** | **100** |
| S-403 | MH-343 | MH-342 | 27.78 | **0.092** | **0.156** | **100** |
| S-404 | MH-346 | MH-343 | 26.06 | **0.092** | **0.156** | **100** |
| S-405 | MH-344 | MH-346 | 6.05 | **0.031** | **0.053** | **100** |
| S-406 | MH-345 | MH-344 | 12.00 | **0.031** | **0.053** | **100** |
| S-407 | MH-376 | MH-380 | 38.24 | **0.051** | **0.088** | **100** |
| S-408 | MH-377 | MH-376 | 38.27 | **0.051** | **0.088** | **100** |
| S-409 | MH-372 | MH-377 | 15.65 | **0.064** | **0.109** | **100** |
| S-410 | MH-371 | MH-372 | 6.04 | **0.064** | **0.109** | **100** |
| S-411 | MH-370 | MH-371 | 9.66 | **0.064** | **0.109** | **100** |

**Table 5.6F1 Design Results of 100mm Condominials in Basin F**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-412 | MH-369 | MH-370 | 10.58 | **0.064** | **0.109** | **100** |
| S-413 | MH-368 | MH-369 | 7.77 | **0.064** | **0.109** | **100** |
| S-414 | MH-338 | MH-368 | 39.14 | **0.064** | **0.109** | **100** |
| S-415 | MH-347 | MH-346 | 12.17 | **0.038** | **0.065** | **100** |
| S-416 | MH-348 | MH-347 | 18.77 | **0.038** | **0.065** | **100** |
| S-417 | MH-349 | MH-348 | 10.44 | **0.025** | **0.042** | **100** |
| S-418 | MH-350 | MH-349 | 19.16 | **0.025** | **0.042** | **100** |
| S-419 | MH-351 | MH-350 | 10.55 | **0.025** | **0.042** | **100** |
| S-420 | MH-352 | MH-351 | 5.59 | **0.025** | **0.042** | **100** |
| S-421 | MH-340 | MH-355 | 34.23 | **0.079** | **0.134** | **100** |
| S-422 | MH-355 | MH-356 | 26.31 | **0.079** | **0.134** | **100** |
| S-423 | MH-356 | MH-357 | 19.66 | **0.079** | **0.134** | **100** |
| S-424 | MH-354 | MH-357 | 23.55 | **0.043** | **0.073** | **100** |
| S-425 | MH-353 | MH-354 | 30.59 | **0.044** | **0.076** | **100** |
| S-426 | MH-348 | MH-353 | 9.06 | **0.044** | **0.074** | **100** |
| S-427 | MH-377 | MH-368 | 23.59 | **0.059** | **0.101** | **100** |
| S-428 | MH-367 | MH-368 | 12.35 | **0.078** | **0.133** | **100** |
| S-429 | MH-362 | MH-367 | 32.00 | **0.078** | **0.133** | **100** |
| S-430 | MH-361 | MH-362 | 21.71 | **0.078** | **0.133** | **100** |
| S-431 | MH-360 | MH-361 | 17.60 | **0.099** | **0.169** | **100** |
| S-432 | MH-358 | MH-360 | 33.21 | **0.099** | **0.169** | **100** |
| S-433 | MH-357 | MH-358 | 17.50 | **0.143** | **0.244** | **100** |
| S-434 | MH-368 | MH-384 | 28.14 | **0.159** | **0.270** | **100** |
| S-435 | MH-384 | MH-383 | 15.47 | **0.159** | **0.270** | **100** |
| S-436 | MH-383 | MH-385 | 14.64 | **0.361** | **0.612** | **100** |
| S-437 | MH-367 | MH-385 | 22.12 | **0.201** | **0.343** | **100** |
| S-438 | MH-366 | MH-367 | 32.95 | **0.201** | **0.343** | **100** |
| S-439 | MH-364 | MH-366 | 23.02 | **0.072** | **0.123** | **100** |
| S-440 | MH-361 | MH-364 | 13.65 | **0.072** | **0.123** | **100** |
| S-441 | MH-381 | MH-382 | 26.46 | **0.170** | **0.286** | **100** |
| S-442 | MH-382 | MH-383 | 20.78 | **0.170** | **0.286** | **100** |
| S-443 | MH-385 | MH-386 | 42.13 | **0.600** | **1.019** | **100** |
| S-444 | MH-386 | MH-387 | 39.27 | **0.600** | **1.019** | **100** |
| S-445 | MH-387 | MH-389 | 25.26 | **0.600** | **1.019** | **150** |

**Table 5.6F1 Design Results of 100mm Condominials in Basin F**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-446 | MH-389 | MH-391 | 28.12 | **0.738** | **1.254** | **100** |
| S-449 | MH-353 | MH-457 | 16.53 | **0.043** | **0.074** | **100** |
| S-450 | MH-457 | MH-456 | 14.70 | **0.043** | **0.074** | **100** |
| S-451 | MH-456 | MH-449 | 18.24 | **0.021** | **0.035** | **100** |
| S-452 | MH-452 | MH-449 | 17.72 | **0.028** | **0.048** | **100** |
| S-453 | MH-453 | MH-452 | 21.48 | **0.028** | **0.048** | **100** |
| S-454 | MH-461 | MH-453 | 29.22 | **0.015** | **0.026** | **100** |
| S-455 | MH-460 | MH-461 | 13.20 | **0.015** | **0.026** | **100** |
| S-456 | MH-458 | MH-460 | 14.58 | **0.015** | **0.026** | **100** |
| S-457 | MH-420 | MH-458 | 13.49 | **0.015** | **0.026** | **100** |
| S-458 | MH-354 | MH-441 | 27.99 | **0.033** | **0.056** | **100** |
| S-459 | MH-441 | MH-449 | 9.98 | **0.029** | **0.049** | **100** |
| S-460 | MH-456 | MH-449 | 44.13 | **0.034** | **0.057** | **100** |
| S-461 | MH-358 | MH-359 | 27.18 | **0.087** | **0.148** | **100** |
| S-462 | MH-436 | MH-359 | 18.45 | **0.038** | **0.064** | **100** |
| S-463 | MH-441 | MH-436 | 28.26 | **0.027** | **0.046** | **100** |
| S-464 | MH-365 | MH-366 | 39.38 | **0.102** | **0.174** | **100** |
| S-465 | MH-363 | MH-365 | 32.07 | **0.149** | **0.255** | **100** |
| S-466 | MH-359 | MH-363 | 26.62 | **0.149** | **0.255** | **100** |
| S-467 | MH-365 | MH-388 | 49.60 | **0.105** | **0.178** | **100** |
| S-468 | MH-388 | MH-440 | 42.00 | **0.038** | **0.064** | **100** |
| S-469 | MH-440 | MH-439 | 17.16 | **0.073** | **0.125** | **100** |
| S-470 | MH-438 | MH-439 | 33.00 | **0.073** | **0.125** | **100** |
| S-471 | MH-437 | MH-438 | 25.19 | **0.026** | **0.044** | **100** |
| S-472 | MH-435 | MH-437 | 23.88 | **0.026** | **0.044** | **100** |
| S-473 | MH-435 | MH-436 | 8.76 | **0.025** | **0.043** | **100** |
| S-474 | MH-388 | MH-389 | 54.81 | **0.092** | **0.157** | **100** |
| S-477 | MH-395 | MH-396 | 26.67 | **0.094** | **0.161** | **350** |
| S-478 | MH-394 | MH-395 | 20.83 | **0.102** | **0.173** | **350** |
| S-479 | MH-393 | MH-394 | 6.80 | **0.102** | **0.173** | **100** |
| S-480 | MH-392 | MH-393 | 35.43 | **0.102** | **0.173** | **100** |
| S-481 | MH-440 | MH-392 | 6.51 | **0.142** | **0.243** | **100** |
| S-482 | MH-449 | MH-450 | 7.57 | **0.060** | **0.102** | **100** |
| S-483 | MH-450 | MH-451 | 13.97 | **0.060** | **0.102** | **100** |

**Table 5.6F1 Design Results of 100mm Condominials in Basin F**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-484 | MH-451 | MH-446 | 13.71 | **0.060** | **0.102** | **100** |
| S-485 | MH-446 | MH-447 | 26.40 | **0.040** | **0.068** | **100** |
| S-486 | MH-447 | MH-448 | 5.97 | **0.040** | **0.068** | **100** |
| S-487 | MH-455 | MH-448 | 22.25 | **0.005** | **0.009** | **100** |
| S-488 | MH-454 | MH-455 | 13.66 | **0.005** | **0.009** | **100** |
| S-489 | MH-453 | MH-454 | 25.88 | **0.005** | **0.009** | **100** |
| S-490 | MH-449 | MH-442 | 28.45 | **0.074** | **0.126** | **100** |
| S-491 | MH-446 | MH-442 | 26.32 | **0.040** | **0.069** | **100** |
| S-492 | MH-424 | MH-438 | 16.57 | **0.023** | **0.039** | **100** |
| S-493 | MH-425 | MH-424 | 16.96 | **0.018** | **0.031** | **100** |
| S-494 | MH-426 | MH-425 | 6.94 | **0.018** | **0.031** | **100** |
| S-495 | MH-427 | MH-426 | 18.79 | **0.018** | **0.031** | **100** |
| S-496 | MH-427 | MH-428 | 5.00 | **0.018** | **0.031** | **100** |
| S-497 | MH-429 | MH-428 | 10.43 | **0.096** | **0.164** | **100** |
| S-498 | MH-392 | MH-400 | 16.04 | **0.086** | **0.146** | **100** |
| S-499 | MH-416 | MH-400 | 44.68 | **0.027** | **0.046** | **100** |
| S-500 | MH-420 | MH-416 | 26.08 | **0.032** | **0.055** | **100** |
| S-501 | MH-424 | MH-420 | 12.72 | **0.029** | **0.050** | **100** |
| S-502 | MH-395 | MH-398 | 16.33 | **0.077** | **0.011** | **100** |
| S-503 | MH-398 | MH-399 | 33.88 | **0.077** | **0.131** | **100** |
| S-504 | MH-400 | MH-399 | 45.41 | **0.122** | **0.208** | **100** |
| S-505 | MH-428 | MH-430 | 13.12 | **0.134** | **0.229** | **100** |
| S-506 | MH-430 | MH-431 | 15.87 | **0.134** | **0.229** | **100** |
| S-507 | MH-431 | MH-432 | 24.24 | **0.134** | **0.229** | **100** |
| S-508 | MH-445 | MH-432 | 26.07 | **0.008** | **0.013** | **100** |
| S-509 | MH-444 | MH-445 | 19.13 | **0.008** | **0.013** | **100** |
| S-510 | MH-420 | MH-421 | 21.66 | **0.037** | **0.063** | **100** |
| S-511 | MH-421 | MH-422 | 18.01 | **0.037** | **0.063** | **100** |
| S-512 | MH-422 | MH-423 | 13.07 | **0.037** | **0.063** | **100** |
| S-513 | MH-433 | MH-423 | 18.07 | **0.012** | **0.021** | **100** |
| S-514 | MH-432 | MH-433 | 29.53 | **0.012** | **0.021** | **100** |
| S-515 | MH-416 | MH-417 | 17.70 | **0.029** | **0.050** | **100** |
| S-516 | MH-417 | MH-418 | 15.06 | **0.029** | **0.050** | **100** |
| S-517 | MH-418 | MH-419 | 27.43 | **0.029** | **0.050** | **100** |

**Table 5.6F1 Design Results of 100mm Condominials in Basin F**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-518 | MH-423 | MH-419 | 28.57 | **0.010** | **0.017** | **100** |
| S-519 | MH-399 | MH-401 | 29.82 | **0.222** | **0.378** | **100** |
| S-520 | MH-401 | MH-402 | 22.72 | **0.008** | **0.013** | **100** |
| S-521 | MH-402 | MH-403 | 27.04 | **0.008** | **0.013** | **100** |
| S-522 | MH-419 | MH-403 | 32.39 | **0.003** | **0.005** | **100** |
| S-525 | MH-409 | MH-410 | 10.67 | **0.109** | **0.186** | **100** |
| S-526 | MH-408 | MH-409 | 13.55 | **0.109** | **0.186** | **100** |
| S-527 | MH-406 | MH-408 | 17.04 | **0.109** | **0.186** | **100** |
| S-528 | MH-404 | MH-406 | 30.15 | **0.109** | **0.186** | **100** |
| S-529 | MH-401 | MH-404 | 13.49 | **0.136** | **0.231** | **100** |
| S-530 | MH-404 | MH-405 | 24.32 | **0.094** | **0.160** | **100** |
| S-531 | MH-403 | MH-405 | 26.62 | **0.005** | **0.008** | **100** |
| S-534 | MH-405 | MH-407 | 26.72 | **0.021** | **0.037** | **100** |
| S-535 | MH-407 | MH-408 | 25.00 | **0.021** | **0.037** | **100** |
| S-536 | MH-412 | MH-413 | 19.66 | **0.021** | **0.037** | **100** |
| S-537 | MH-413 | MH-414 | 15.88 | **0.021** | **0.037** | **100** |
| S-538 | MH-414 | MH-415 | 15.32 | **0.021** | **0.037** | **100** |
| **TOTAL LENGTH (m)** | | | **3447.46** | | | |

**Table 5.6F2 Design Results of 225mm Outfall Sewers/Sub-Mains in Basin F**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-394 | MH-324 | MH-390A | 59.95 | **6.518** | **11.089** | **225** |
| S-447 | MH-390 | MH-391 | 54.00 | **6.598** | **11.224** | **225** |
| S-448 | MH-390A | MH-390 | 53.91 | **6.598** | **11.224** | **225** |
| S-475 | MH-391 | MH-397 | 50.52 | **7.335** | **12.478** | **225** |
| S-476 | MH-397 | MH-396 | 50.67 | **7.335** | **12.478** | **225** |
| S-523 | MH-396 | MH-411 | 50.96 | **7.430** | **12.639** | **225** |
| S-524 | MH-411 | MH-412 | 27.30 | **7.430** | **12.639** | **225** |
| S-532 | MH-410 | MH-415A | 35.24 | **7.539** | **12.824** | **225** |
| S-533 | MH-415A | MH-415 | 30.39 | **7.539** | **12.824** | **225** |
| **TOTAL LEN GTH (m)** | | | **412.94** | | | |

**Table 5.6G1 Design Results of 100mm Condominials in Basin G**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1029 | MH-912 | MH-911 | 38.40 | **0.007** | **0.011** | **100** |
| S-1030 | MH-911 | MH-910 | 24.97 | **0.007** | **0.011** | **100** |
| S-1031 | MH-910 | MH-909 | 2.50 | **0.007** | **0.011** | **100** |
| S-1032 | MH-909 | MH-908 | 30.56 | **0.007** | **0.011** | **100** |
| S-1033 | MH-908 | MH-907 | 29.58 | **0.007** | **0.011** | **100** |
| S-1034 | MH-907 | MH-905 | 27.28 | **0.007** | **0.011** | **100** |
| S-1035 | MH-905 | MH-904 | 29.15 | **0.007** | **0.011** | **100** |
| S-1036 | MH-904 | MH-897 | 37.20 | **0.007** | **0.011** | **100** |
| S-1037 | MH-898 | MH-897 | 3.23 | **0.013** | **0.021** | **100** |
| S-1038 | MH-906 | MH-898 | 35.46 | **0.013** | **0.021** | **100** |
| S-1039 | MH-913 | MH-906 | 4.40 | **0.013** | **0.021** | **100** |
| S-1040 | MH-914 | MH-906 | 14.34 | **0.013** | **0.021** | **100** |
| S-1041 | MH-915 | MH-914 | 19.70 | **0.008** | **0.014** | **100** |
| S-1042 | MH-917 | MH-915 | 31.53 | **0.008** | **0.014** | **100** |
| S-1043 | MH-918 | MH-917 | 27.52 | **0.008** | **0.014** | **100** |
| S-1044 | MH-897 | MH-896 | 25.77 | **0.026** | **0.043** | **100** |
| S-1045 | MH-896 | MH-895 | 31.04 | **0.017** | **0.029** | **100** |
| S-1046 | MH-895 | MH-894 | 18.65 | **0.017** | **0.029** | **100** |
| S-1052 | MH-901 | MH-902 | 31.27 | **0.015** | **0.026** | **100** |
| S-1053 | MH-900 | MH-901 | 33.04 | **0.019** | **0.032** | **100** |
| S-1054 | MH-899 | MH-900 | 28.52 | **0.019** | **0.032** | **100** |
| S-1055 | MH-896 | MH-899 | 6.80 | **0.019** | **0.032** | **100** |
| S-1056 | MH-914 | MH-916 | 25.90 | **0.012** | **0.021** | **100** |
| S-1057 | MH-916 | MH-919 | 35.55 | **0.012** | **0.021** | **100** |
| S-1058 | MH-920 | MH-919 | 27.56 | **0.011** | **0.019** | **100** |
| S-1059 | MH-921 | MH-920 | 2.92 | **0.011** | **0.019** | **100** |
| S-1060 | MH-922 | MH-921 | 12.21 | **0.011** | **0.019** | **100** |
| S-1061 | MH-923 | MH-922 | 22.97 | **0.011** | **0.019** | **100** |
| S-1062 | MH-924 | MH-923 | 32.21 | **0.007** | **0.012** | **100** |
| S-1063 | MH-925 | MH-923 | 35.62 | **0.016** | **0.028** | **100** |
| S-1064 | MH-937 | MH-925 | 24.81 | **0.016** | **0.028** | **100** |
| S-1065 | MH-940 | MH-937 | 65.72 | **0.020** | **0.034** | **100** |
| S-1066 | MH-941 | MH-940 | **50.18** | **0.020** | **0.034** | **100** |
| S-1067 | MH-942 | MH-941 | 27.64 | **0.007** | **0.011** | **100** |
| S-1068 | MH-919 | MH-934 | 36.35 | **0.030** | **0.052** | **100** |
| S-1069 | MH-934 | MH-932 | 13.61 | **0.030** | **0.052** | **100** |

**Table 5.6G1 Design Results of 100mm Condominials in Basin G**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1070 | MH-933 | MH-932 | 9.21 | **0.041** | **0.070** | **100** |
| S-1071 | MH-935 | MH-933 | 30.23 | **0.041** | **0.070** | **100** |
| S-1072 | MH-937 | MH-935 | 24.97 | **0.017** | **0.029** | **100** |
| S-1073 | MH-932 | MH-931 | 25.75 | **0.079** | **0.134** | **100** |
| S-1074 | MH-930 | MH-931 | 13.35 | **0.048** | **0.081** | **100** |
| S-1075 | MH-930 | MH-929 | 27.80 | **0.048** | **0.081** | **100** |
| S-1076 | MH-929 | MH-928 | 23.38 | **0.048** | **0.081** | **100** |
| S-1077 | MH-928 | MH-927 | 16.26 | **0.048** | **0.081** | **100** |
| S-1078 | MH-926 | MH-927 | 27.17 | **0.017** | **0.029** | **100** |
| S-1079 | MH-901 | MH-926 | 44.93 | **0.017** | **0.029** | **100** |
| S-1080 | MH-927 | MH-956 | 24.98 | **0.072** | **0.123** | **100** |
| S-1081 | MH-956 | MH-957 | 31.38 | **0.072** | **0.123** | **100** |
| S-1082 | MH-957 | MH-958 | 9.68 | **0.072** | **0.123** | **100** |
| S-1083 | MH-958 | MH-960 | 34.40 | **0.123** | **0.209** | **100** |
| S-1088 | MH-944 | MH-941 | 23.16 | **0.007** | **0.012** | **100** |
| S-1089 | MH-945 | MH-944 | 10.35 | **0.007** | **0.012** | **100** |
| S-1090 | MH-945 | MH-943 | 32.03 | **0.007** | **0.012** | **100** |
| S-1091 | MH-946 | MH-943 | 19.92 | **0.007** | **0.013** | **100** |
| S-1092 | MH-947 | MH-946 | 25.73 | **0.007** | **0.013** | **100** |
| S-1093 | MH-936 | MH-935 | 39.32 | **0.018** | **0.030** | **100** |
| S-1094 | MH-938 | MH-936 | 23.16 | **0.018** | **0.030** | **100** |
| S-1095 | MH-939 | MH-938 | 28.92 | **0.022** | **0.037** | **100** |
| S-1096 | MH-943 | MH-939 | 26.57 | **0.022** | **0.037** | **100** |
| S-1097 | MH-938 | MH-948 | 26.64 | **0.018** | **0.031** | **100** |
| S-1098 | MH-948 | MH-954 | **12.84** | **0.016** | **0.028** | **150** |
| S-1099 | MH-954 | MH-953 | 34.66 | **0.016** | **0.028** | **100** |
| S-1100 | MH-953 | MH-949 | 26.91 | **0.016** | **0.028** | **100** |
| S-1101 | MH-931 | MH-949 | 28.57 | **0.047** | **0.080** | **100** |
| S-1101A | MH-948 | MH-948A | 29.36 | **0.017** | **0.028** | **100** |
| S-1102 | MH-947 | MH-948A | 81.39 | **0.004** | **0.006** | **100** |
| S-1103 | MH-949 | MH-950 | 6.82 | **0.071** | **0.121** | **100** |
| S-1104 | MH-950 | MH-951 | 12.63 | **0.071** | **0.121** | **100** |
| S-1105 | MH-951 | MH-952 | 35.17 | **0.122** | **0.207** | **100** |
| S-1106 | MH-948A | MH-952 | 64.68 | **0.024** | **0.042** | **100** |

**Table 5.6G1 Design Results of 100mm Condominials in Basin G**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1107 | MH-955 | MH-951 | 14.48 | **0.043** | **0.074** | **100** |
| S-1108 | MH-955 | MH-959 | 30.40 | **0.043** | **0.074** | **100** |
| S-1112 | MH-952 | MH-964 | 57.09 | **0.149** | **0.255** | **100** |
| **TOTAL LEN GTH (m)** | | | **1978.45** | | | |

**Table 5.6G2 Design Results of 225mm & 300mm Outfall Sewers/Sub-Mains in Basin G**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1047 | MH-893 | MH-894 | 15.29 | **3.018** | **5.261** | **225** |
| S-1048 | MH-892 | MH-893 | 13.24 | **3.018** | **5.261** | **225** |
| S-1049 | MH-891 | MH-892 | 11.89 | **3.018** | **5.261** | **225** |
| S-1050 | MH-894 | MH-903 | **17.07** | **3.035** | **5.291** | **225** |
| S-1051 | MH-903 | MH-902 | **20.71** | **3.035** | **5.291** | **225** |
| S-1084 | MH-963 | MH-960 | 31.74 | **3.050** | **5.317** | **225** |
| S-1085 | MH-962 | MH-963 | 18.60 | **3.050** | **5.317** | **225** |
| S-1086 | MH-961 | MH-962 | 8.53 | **3.050** | **5.317** | **225** |
| S-1087 | MH-902 | MH-961 | 69.98 | **3.050** | **5.317** | **225** |
| S-1110 | MH-960 | MH-965 | 54.81 | **3.173** | **5.526** | **225** |
| S-1111 | MH-965 | MH-964 | 21.46 | **3.173** | **5.526** | **225** |
| **TOTAL LEN GTH (m)** | | | **283.32** | | | |
| S-1113 | MH-964 | MH-965 | **17.39** | **3.323** | **5.781** | **300** |

**Table 5.6H1 Design Results of 100mm Condominials in Basin H**

| **Sewer Code** | **Manhole Code** | | **Length** | **Initial Flow, ($q_{it}$) (l/s)** | **Final Flow ($q_{ft}$) (l/s)** | **Designed Diameter of Sewer D (mm)** |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1114 | MH-1001 | MH-1002 | 26.78 | **0.007** | **0.013** | **100** |
| S-1115 | MH-997 | MH-998 | 13.33 | **0.011** | **0.019** | **100** |
| S-1116 | MH-996 | MH-997 | 23.04 | **0.011** | **0.019** | **100** |
| S-1117 | MH-996 | MH-999 | 41.12 | **0.034** | **0.045** | **100** |
| S-1118 | MH-1000 | MH-1002 | 31.86 | **0.035** | **0.060** | **100** |
| S-1118A | MH-998 | MH-992 | 40.84 | **0.022** | **0.037** | **100** |
| S-1119 | MH-995 | MH-992 | 12.36 | **0.016** | **0.023** | **100** |
| S-1120 | MH-994 | MH-995 | 43.44 | **0.016** | **0.023** | **100** |
| S-1121 | MH-993 | MH-994 | 42.19 | **0.016** | **0.023** | **100** |
| S-1122 | MH-996 | MH-993 | 53.21 | **0.012** | **0.008** | **100** |
| S-1123 | MH-992 | MH-987 | 52.71 | **0.045** | **0.073** | **100** |
| S-1124 | MH-986 | MH-987 | 9.99 | **0.032** | **0.052** | **100** |
| S-1125 | MH-985 | MH-986 | 18.54 | **0.032** | **0.052** | **100** |
| S-1126 | MH-991 | MH-985 | 24.74 | **0.027** | **0.038** | **100** |
| S-1127 | MH-993 | MH-991 | 17.39 | **0.021** | **0.019** | **100** |
| S-1128 | MH-987 | MH-987A | 30.01 | **0.088** | **0.144** | **100** |
| S-1129 | MH-987A | MH-978 | 45.68 | **0.088** | **0.144** | **100** |
| S-1130 | MH-977 | MH-978 | 10.32 | **0.051** | **0.086** | **100** |
| S-1131 | MH-976 | MH-977 | 19.65 | **0.051** | **0.086** | **100** |
| S-1132 | MH-983 | MH-976 | 30.60 | **0.041** | **0.068** | **100** |
| S-1133 | MH-984 | MH-983 | 11.60 | **0.034** | **0.055** | **100** |
| S-1134 | MH-985 | MH-984 | **19.05** | **0.034** | **0.055** | **100** |
| S-1135 | MH-978 | MH-979 | **32.45** | **0.158** | **0.262** | **100** |
| S-1136 | MH-979 | MH-980 | 45.28 | **0.158** | **0.262** | **100** |
| S-1137 | MH-980 | MH-965 | 38.41 | **0.158** | **0.262** | **100** |
| S-1139 | MH-976 | MH-975 | 38.47 | **0.051** | **0.086** | **100** |
| S-1140 | MH-975 | MH-975A | 45.26 | **0.051** | **0.086** | **100** |
| S-1141 | MH-975A | MH-968 | 20.17 | **0.053** | **0.090** | **100** |
| S-1142 | MH-968 | MH-966 | 45.82 | **0.053** | **0.090** | **100** |
| S-1143 | MH-999 | MH-1002 | 39.88 | **0.105** | **0.154** | **100** |
| S-1144 | MH-1002 | MH-1003 | 41.17 | **0.105** | **0.154** | **100** |
| S-1145 | MH-1003 | MH-1004 | 58.79 | **0.105** | **0.154** | **100** |
| S-1146 | MH-1004 | MH-990 | 42.69 | **0.251** | **0.391** | **100** |
| S-1147 | MH-990 | MH-989 | 7.46 | **0.328** | **0.502** | **100** |
| S-1148 | MH-989 | MH-988 | 15.79 | **0.328** | **0.502** | **100** |
| S-1149 | MH-988 | MH-982 | **24.95** | **0.328** | **0.502** | **100** |

**Table 5.6H1 Design Results of 100mm Condominials in Basin H**

| **Sewer Code** | **Manhole Code** | | **Length** | **Initial Flow, ($q_{it}$)** | **Final Flow ($q_{ft}$)** | **Designed Diameter of Sewer D** |
|---|---|---|---|---|---|---|
| | From | To | (m) | **(l/s)** | **(l/s)** | **(mm)** |
| S-1150 | MH-983 | MH-982 | 31.49 | **0.032** | **0.046** | **100** |
| S-1151 | MH-1006 | MH-1004 | 94.72 | **0.098** | **0.166** | **100** |
| S-1152 | MH-1005 | MH-1006 | 44.65 | **0.098** | **0.166** | **100** |
| S-1153 | MH-1007 | MH-1005 | 13.40 | **0.098** | **0.166** | **100** |
| S-1154 | MH-1008 | MH-1007 | 26.00 | **0.060** | **0.103** | **100** |
| S-1155 | MH-1009 | MH-1008 | 43.72 | **0.060** | **0.103** | **100** |
| S-1156 | MH-991 | MH-1147 | 36.21 | **0.028** | **0.028** | **100** |
| S-1157 | MH-975A | MH-973 | 25.95 | **0.047** | **0.079** | **100** |
| S-1158 | MH-974 | MH-973 | 29.93 | **0.393** | **0.604** | **100** |
| S-1158A | MH-973 | MH-971 | 13.24 | **0.469** | **0.732** | **100** |
| S-1159 | MH-981 | MH-974 | 14.77 | **0.393** | **0.604** | **100** |
| S-1160 | MH-982 | MH-981 | 16.81 | **0.393** | **0.604** | **100** |
| S-1161 | MH-971 | MH-970 | 7.35 | **0.261** | **0.412** | **100** |
| S-1162 | MH-970 | MH-969 | 7.79 | **0.261** | **0.412** | **100** |
| S-1163 | MH-969 | MH-967 | 21.75 | **0.261** | **0.412** | **100** |
| S-1164 | MH-967 | MH-966A | 30.14 | **0.261** | **0.412** | **100** |
| S-1166 | MH-1022 | MH-982 | 42.82 | **0.060** | **0.103** | **100** |
| S-1167 | MH-1022 | MH-1021 | 38.48 | **0.060** | **0.103** | **100** |
| S-1168 | MH-1021 | MH-1020 | 26.60 | **0.060** | **0.103** | **100** |
| S-1169 | MH-1020 | MH-1019 | 26.50 | **0.060** | **0.103** | **100** |
| S-1170 | MH-1019 | MH-1016 | 25.82 | **0.060** | **0.103** | **100** |
| S-1171 | MH-1016 | MH-1015 | 58.68 | **0.089** | **0.152** | **100** |
| S-1171A | MH-1015 | MH-1014 | 43.07 | **0.089** | **0.152** | **100** |
| S-1172 | MH-1013 | MH-1014 | 78.51 | **0.486** | **0.828** | **100** |
| S-1173 | MH-1012 | MH-1013 | 72.62 | **0.103** | **0.175** | **100** |
| S-1174 | MH-1011 | MH-1012 | 67.19 | **0.103** | **0.175** | **100** |
| S-1175 | MH-1010 | MH-1011 | 64.49 | **0.103** | **0.175** | **100** |
| S-1175A | MH-1007 | MH-1010 | 26.85 | **0.103** | **0.175** | **100** |
| S-1176 | MH-1016 | MH-1017 | 41.87 | **0.070** | **0.119** | **100** |
| S-1177 | MH-971 | MH-1020 | 27.46 | **0.273** | **0.432** | **100** |
| S-1178 | MH-1020 | MH-1019 | **28.32** | **0.273** | **0.432** | **100** |
| S-1179 | MH-1019 | MH-1018 | 32.21 | **0.273** | **0.432** | **100** |
| S-1180 | MH-1018 | MH-1017 | 31.71 | **0.273** | **0.432** | **100** |
| S-1183 | MH-1017 | MH-966C | 45.98 | **0.380** | **0.615** | **100** |

**Table 5.6H1 Design Results of 100mm Condominials in Basin H**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1184 | MH-1023 | MH-1013 | 6.06 | **0.310** | **0.529** | **100** |
| S-1185 | MH-1024 | MH-1023 | 20.32 | **0.310** | **0.529** | **100** |
| S-1186 | MH-1025 | MH-1024 | 63.11 | **0.310** | **0.529** | **100** |
| S-1187 | MH-1059 | MH-1025 | 15.09 | **0.173** | **0.295** | **100** |
| S-1188 | MH-1026 | MH-1059 | 37.53 | **0.173** | **0.295** | **100** |
| S-1189 | MH-1027 | MH-1026 | 25.01 | **0.173** | **0.295** | **100** |
| S-1190 | MH-1028 | MH-1027 | 33.41 | **0.049** | **0.083** | **100** |
| S-1191 | MH-1029 | MH-1028 | 32.49 | **0.049** | **0.083** | **100** |
| S-1192 | MH-1034A | MH-1029 | 51.02 | **0.049** | **0.083** | **100** |
| S-1192A | MH-1014 | MH-1067 | 51.37 | **0.628** | **1.070** | **100** |
| S-1193 | MH-1067 | MH-1067A | 60.88 | **0.628** | **1.070** | **100** |
| S-1195A | MH-1030 | MH-1027 | 37.80 | **0.054** | **0.092** | **100** |
| S-1196A | MH-1031 | MH-1030 | 56.31 | **0.054** | **0.092** | **100** |
| S-1197A | MH-1032 | MH-1031 | 55.25 | **0.054** | **0.092** | **100** |
| S-1198A | MH-1033 | MH-1032 | 59.32 | **0.054** | **0.092** | **100** |
| S-1199A | MH-1034 | MH-1033 | 65.72 | **0.054** | **0.092** | **100** |
| S-1202 | MH-1060 | MH-1068 | 118.84 | **0.049** | **0.083** | **100** |
| S-1203 | MH-1068 | MH-1069 | 52.50 | **0.549** | **0.935** | **100** |
| S-1204 | MH-1069 | MH-1070 | 31.88 | **0.549** | **0.935** | **100** |
| S-1205 | MH-1070 | MH-1078 | 22.54 | **1.111** | **1.894** | **100** |
| S-1206 | MH-1078 | MH-1066A | 9.18 | **1.111** | **1.894** | **100** |
| S-1207 | MH-1057 | MH-1068 | 61.32 | **0.314** | **0.536** | **100** |
| S-1208 | MH-1044 | MH-1057 | 34.59 | **0.203** | **0.346** | **100** |
| S-1209 | MH-1043 | MH-1044 | 16.82 | **0.306** | **0.521** | **100** |
| S-1210 | MH-1037 | MH-1043 | 30.68 | **0.306** | **0.521** | **100** |
| S-1211 | MH-1036 | MH-1037 | 28.57 | **0.306** | **0.521** | **100** |
| S-1213 | MH-1036 | MH-1038 | 30.15 | **0.197** | **0.335** | **100** |
| S-1214 | MH-1039 | MH-1038 | 25.47 | **0.197** | **0.335** | **100** |
| S-1215 | MH-1040 | MH-1039 | 29.69 | **0.197** | **0.335** | **100** |
| S-1216 | MH-1041 | MH-1040 | 35.65 | **0.327** | **0.556** | **100** |
| S-1217 | MH-1042 | MH-1041 | 28.09 | **0.327** | **0.556** | **100** |
| S-1218 | MH-1036 | MH-1037 | 50.52 | **0.134** | **0.228** | **100** |
| S-1219 | MH-1061 | MH-1045 | 16.11 | **0.789** | **1.344** | **100** |
| S-1220 | MH-1046 | MH-1061 | 22.12` | **0.274** | **0.466** | **100** |

**Table 5.6H1 Design Results of 100mm Condominials in Basin H**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1221 | MH-1047 | MH-1046 | 17.64 | **0.274** | **0.466** | **100** |
| S-1222 | MH-1040 | MH-1047 | 44.96 | **0.496** | **0.844** | **100** |
| S-1223 | MH-1037 | MH-1084 | 51.70 | **0.949** | **1.617** | **100** |
| S-1224 | MH-1084 | MH-1083 | 47.15 | **0.949** | **1.617** | **100** |
| S-1225 | MH-1083 | MH-1075 | 13.04 | **0.949** | **1.617** | **100** |
| S-1226 | MH-1076 | MH-1075 | 11.04 | **0.289** | **0.493** | **100** |
| S-1227 | MH-1077 | MH-1076 | 13.29 | **0.289** | **0.493** | **100** |
| S-1228 | MH-1057 | MH-1077 | 33.82 | **0.289** | **0.493** | **100** |
| S-1229 | MH-1075 | MH-1074 | 65.21 | **1.471** | **2.507** | **100** |
| S-1230 | MH-1073 | MH-1074 | 63.32 | **0.364** | **0.619** | **100** |
| S-1231 | MH-1073 | MH-1072 | 52.03 | **0.364** | **0.619** | **300** |
| S-1232 | MH-1072 | MH-1071 | 53.38 | **0.364** | **0.619** | **100** |
| S-1233 | MH-1071 | MH-1070 | 21.07 | **0.364** | **0.619** | **100** |
| S-1237 | MH-1047 | MH-1048A | 15.66 | **0.567** | **0.966** | **100** |
| S-1238 | MH-1048 | MH-1048A | 22.03 | **0.332** | **0.565** | **100** |
| S-1238A | MH-1048A | MH-1063A | 20.58 | **0.924** | **1.575** | **100** |
| S-1239 | MH-1048 | MH-1049 | 61.90 | **0.332** | **0.565** | **100** |
| S-1239A | MH-1063A | MH-1063 | 50.51 | **0.482** | **0.822** | **100** |
| S-1240 | MH-1050 | MH-1049 | 47.19 | **0.724** | **1.142** | **100** |
| S-1240A | MH-1063 | MH-1062 | 52.54 | **0.482** | **0.822** | **100** |
| S-1241 | MH-1051 | MH-1050 | 33.43 | **0.323** | **0.550** | **100** |
| S-1241A | MH-1062 | MH-1061 | 23.40 | **0.482** | **0.822** | **100** |
| S-1242 | MH-1063A | MH-1090 | 15.60 | **0.495** | **0.843** | **100** |
| S-1242A | MH-1052 | MH-1050 | 37.31 | **0.063** | **0.017** | **100** |
| S-1243 | MH-1053 | MH-1052 | 12.02 | **0.063** | **0.017** | **100** |
| S-1244 | MH-1054 | MH-1053 | 40.07 | **0.063** | **0.017** | **100** |
| S-1245 | MH-1054 | MH-1056 | 27.04 | **0.100** | **0.171** | **100** |
| S-1246 | MH-1056 | MH-1056A | 23.97 | **0.100** | **0.171** | **100** |
| S-1247 | MH-1056A | MH-1056B | 5.50 | **0.100** | **0.171** | **100** |
| S-1248 | MH-1056B | MH-1056C | 29.69 | **0.100** | **0.171** | **100** |
| S-1249 | MH-1056C | MH-1056D | 14.03 | **0.100** | **0.171** | **100** |
| S-1250 | MH-1056D | MH-1056E | 28.98 | **0.100** | **0.171** | **100** |
| S-1252 | MH-1049 | MH-1056F | 38.42 | **1.008** | **1.718** | **100** |
| S-1253 | MH-1056F | MH-1092 | 16.35 | **1.158** | **1.973** | **100** |

**Table 5.6H1 Design Results of 100mm Condominials in Basin H**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1254 | MH-1091 | MH-1092 | 75.95 | **0.050** | **0.085** | **100** |
| S-1255 | MH-1091 | MH-1089 | 67.99 | **0.050** | **0.085** | **100** |
| S-1256 | MH-1089 | MH-1088 | 64.04 | **0.050** | **0.085** | **100** |
| S-1257 | MH-1088 | MH-1090 | 64.79 | **0.050** | **0.085** | **100** |
| S-1258 | MH-1090 | MH-1064 | 64.86 | **0.589** | **1.004** | **100** |
| S-1259 | MH-1064 | MH-1087 | 26.59 | **0.589** | **1.004** | **100** |
| S-1260 | MH-1087 | MH-1086 | 38.57 | **0.589** | **1.004** | **100** |
| S-1261 | MH-1085 | MH-1086 | 29.30 | **1.310** | **2.232** | **100** |
| S-1262 | MH-1075 | MH-1085 | 31.87 | **1.310** | **2.232** | **100** |
| S-1265 | MH-1095 | MH-1094 | 32.58 | **1.266** | **2.157** | **100** |
| S-1266 | MH-1092 | MH-1095 | 44.69 | **1.266** | **2.157** | **100** |
| S-1265A | MH-1094 | MH-1099 | 36.50 | **1.697** | **2.891** | **100** |
| S-1266A | MH-1099 | MH-1101 | 17.53 | **1.697** | **2.891** | **100** |
| S-1267 | MH-1101 | MH-1100 | 61.02 | **0.919** | **1.566** | **100** |
| S-1268 | MH-1100 | MH-1102 | 13.94 | **0.919** | **1.566** | **100** |
| S-1269 | MH-1102 | MH-1103 | 28.66 | **0.919** | **1.566** | **100** |
| S-1270 | MH-1103 | MH-1104 | 29.72 | **0.919** | **1.566** | **100** |
| S-1273 | MH-1055 | MH-1054 | 28.67 | **0.057** | **0.098** | **100** |
| S-1274 | MH-1056E | MH-1056F | 28.64 | **0.103** | **0.175** | **100** |
| S-1275 | MH-1056E | MH-1096 | 34.11 | **0.125** | **0.213** | **100** |
| S-1276 | MH-1096 | MH-1097 | 31.11 | **0.125** | **0.213** | **100** |
| S-1277 | MH-1097A | MH-1098 | 22.01 | **0.047** | **0.080** | **100** |
| S-1278 | MH-1097B | MH-1097C | 47.67 | **0.047** | **0.080** | **100** |
| S-1279 | MH-1097C | MH-1097 | 154.23 | **0.047** | **0.080** | **100** |
| S-1280 | MH-1094 | MH-1098 | 44.44 | **1.667** | **2.840** | **100** |
| S-1281 | MH-1097 | MH-1098 | 61.53 | **0.200** | **0.341** | **100** |
| S-1282 | MH-1101 | MH-1100 | 28.49 | **0.873** | **1.487** | **100** |
| S-1283 | MH-1098 | MH-1100 | 46.38 | **1.879** | **3.201** | **100** |
| **TOTAL LEN GTH (m)** | | | **6005.18** | | | |

**Table 5.6H2 Design Results of 150mm Street Sewers/Collectors in Basin H**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) | Final Flow ($q_{ft}$) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | (l/s) | (l/s) | |
| S-1234 | MH-1074 | MH-1080 | 84.08 | **2.082** | **3.546** | **150** |
| S-1235 | MH-1080 | MH-1081 | 18.03 | **2.082** | **3.546** | **150** |
| S-1263 | MH-1086 | MH-1093 | 75.97 | **1.988** | **3.387** | **150** |
| S-1264 | MH-1093 | MH-1094 | 23.48 | **1.988** | **3.387** | **150** |
| S-1286 | MH-1100 | MH-1108 | 31.38 | **2.764** | **4.710** | **150** |
| **TOTAL LEN GTH (m)** | | | **232.94** | | | |

**Table 5.6H3 Design Results of 225mm & 300mm Outfall Sewers/Sub-Mains in Basin H**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) | Final Flow ($q_{ft}$) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | (l/s) | (l/s) | |
| S-1138 | MH-965 | MH-966 | 13.48 | **7.361** | **12.643** | **225** |
| S-1165 | MH-966 | MH-966A | 12.20 | **7.414** | **12.733** | **225** |
| S-1181 | MH-966A | MH-966B | 28.55 | **7.676** | **13.146** | **225** |
| S-1182 | MH-966B | MH-966C | 49.36 | **7.676** | **13.146** | **225** |
| S-1194 | MH-966C | MH-1067A | 55.68 | **8.056** | **13.761** | **225** |
| S-1201 | MH-1067A | MH-1018 | **57.86** | **8.684** | **14.831** | **225** |
| S-1236 | MH-1018 | MH-1081 | 59.16 | **8.928** | **15.246** | **225** |
| **TOTAL LEN GTH (m)** | | | **276.29** | | | |
| S-1271 | MH-1082 | MH-1104 | 60.76 | **11.010** | **18.792** | **300** |
| S-1272 | MH-1081 | MH-1082 | 28.67 | **11.010** | **18.792** | **300** |
| S-1284 | MH-1104 | MH-1105 | 31.46 | **11.929** | **20.358** | **300** |
| S-1285 | MH-1105 | MH-1106 | 64.29 | **11.929** | **20.358** | **300** |
| S-1285A | MH-1106 | MH1288 | 25.79 | **14.693** | **25.068** | **300** |
| **TOTAL LEN GTH (m)** | | | **210.97** | | | |

**Table 5.6J1 Design Results of 100mm Condominials in Basin J**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1287 | MH-1115 | MH-1114 | 19.82 | **0.036** | **0.061** | **100** |
| S-1288 | MH-1114 | MH-1113 | 14.31 | **0.036** | **0.061** | **100** |
| S-1289 | MH-1113 | MH-1112 | 19.53 | **0.036** | **0.061** | **100** |
| S-1290 | MH-1112 | MH-1111 | 17.95 | **0.109** | **0.186** | **100** |
| S-1291 | MH-1111 | MH-1110 | 22.87 | **0.109** | **0.186** | **100** |
| S-1292 | MH-1109 | MH-1110 | 12.87 | **0.020** | **0.034** | **100** |
| S-1293 | MH-1108 | MH-1109 | 21.26 | **0.020** | **0.034** | **100** |
| S-1294 | MH-1107 | MH-1108 | 36.49 | **0.020** | **0.034** | **100** |
| S-1295 | MH-1110 | MH-1118 | 33.22 | **0.134** | **0.229** | **100** |
| S-1296 | MH-1117 | MH-1118 | 5.05 | **0.113** | **0.193** | **100** |
| S-1297 | MH-1116 | MH-1117 | 21.40 | **0.113** | **0.193** | **100** |
| S-1298 | MH-1112 | MH-1116 | 21.58 | **0.113** | **0.193** | **100** |
| S-1299 | MH-1118 | MH-1119 | 22.89 | **0.271** | **0.462** | **100** |
| S-1300 | MH-1119 | MH-1120 | 13.85 | **0.271** | **0.462** | **100** |
| S-1301 | MH-1120 | MH-1121 | 11.41 | **0.271** | **0.462** | **100** |
| S-1302 | MH-1153 | MH-1121 | 28.28 | **0.170** | **0.289** | **100** |
| S-1303 | MH-1152 | MH-1153 | 15.11 | **0.170** | **0.289** | **100** |
| S-1304 | MH-1137 | MH-1152 | 9.60 | **0.170** | **0.289** | **100** |
| S-1305 | MH-1136 | MH-1137 | 25.56 | **0.050** | **0.085** | **100** |
| S-1306 | MH-1134 | MH-1136 | 30.16 | **0.050** | **0.085** | **100** |
| S-1307 | MH-1134 | MH-1135 | 15.88 | **0.057** | **0.097** | **100** |
| S-1309 | MH-1135 | MH-1112 | 45.58 | **0.132** | **0.225** | **100** |
| S-1310A | MH-1138 | MH-1137 | 14.99 | **0.069** | **0.117** | **100** |
| S-1311A | MH-1139 | MH-1138 | 11.99 | **0.069** | **0.117** | **100** |
| S-1312 | MH-1139 | MH-1140 | 28.59 | **0.083** | **0.142** | **100** |
| S-1313 | MH-1140 | MH-1141 | 13.43 | **0.083** | **0.142** | **100** |
| S-1314 | MH-1141 | MH-1142 | 30.41 | **0.083** | **0.142** | **100** |
| S-1315 | MH-1142 | MH-1143 | 24.71 | **0.083** | **0.142** | **100** |
| S-1316 | MH-1143 | MH-1150 | 7.68 | **0.191** | **0.325** | **100** |
| S-1317 | MH-1150 | MH-1154 | 16.88 | **0.038** | **0.064** | **100** |
| S-1318 | MH-1154 | MH-1158 | 7.14 | **0.038** | **0.064** | **100** |
| S-1319 | MH-1158 | MH-1157 | 16.03 | **0.038** | **0.064** | **100** |
| S-1320 | MH-1157 | MH-1156 | 16.79 | **0.038** | **0.064** | **100** |
| S-1321 | MH-1155 | MH-1156 | 24.39 | **0.468** | **0.797** | **100** |
| S-1322 | MH-1121 | MH-1155 | 15.79 | **0.468** | **0.797** | **100** |
| S-1323 | MH-1150 | MH-1151 | 40.48 | **0.266** | **0.454** | **100** |

**Table 5.6J1 Design Results of 100mm Condominials in Basin J**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1324 | MH-1151 | MH-1162 | 26.87 | **0.266** | **0.454** | **100** |
| S-1325 | MH-1162 | MH-1161 | 20.02 | **0.152** | **0.259** | **100** |
| S-1326 | MH-1161 | MH-1160 | 14.68 | **0.152** | **0.259** | **100** |
| S-1327 | MH-1160 | MH-1159 | 10.17 | **0.152** | **0.259** | **100** |
| S-1328 | MH-1156 | MH-1159 | 21.56 | **0.516** | **0.879** | **100** |
| S-1329 | MH-1159 | MH-1180 | 10.55 | **0.676** | **1.152** | **100** |
| S-1330 | MH-1180 | MH-1181 | 18.39 | **0.676** | **1.152** | **100** |
| S-1331 | MH-1181 | MH-1182 | 10.64 | **0.676** | **1.152** | **100** |
| S-1332 | MH-1182 | MH-1183 | 16.14 | **0.676** | **1.152** | **100** |
| S-1333 | MH-1183 | MH-1179 | 14.62 | **0.676** | **1.152** | **100** |
| S-1335 | MH-1177 | MH-1178 | 7.09 | **0.065** | **0.110** | **100** |
| S-1336 | MH-1176 | MH-1177 | 17.56 | **0.065** | **0.110** | **100** |
| S-1337 | MH-1175 | MH-1176 | 6.03 | **0.101** | **0.173** | **100** |
| S-1338 | MH-1172 | MH-1175 | 23.07 | **0.101** | **0.173** | **100** |
| S-1339 | MH-1162 | MH-1172 | 21.6 | **0.169** | **0.287** | **100** |
| S-1340 | MH-1176 | MH-1189 | 29.70 | **0.065** | **0.111** | **100** |
| S-1341 | MH-1189 | MH-1188 | 8.75 | **0.065** | **0.111** | **100** |
| S-1342 | MH-1174 | MH-1188 | 39.83 | **0.193** | **0.328** | **100** |
| S-1343 | MH-1174A | MH-1174 | 12.18 | **0.330** | **0.563** | **100** |
| S-1344 | MH-1173 | MH-1174A | 6.90 | **0.121** | **0.205** | **100** |
| S-1345 | MH-1173 | MH-1172 | 17.20 | **0.121** | **0.205** | **100** |
| S-1351 | MH-1133 | MH-1134 | 24.95 | **0.030** | **0.051** | **100** |
| S-1352 | MH-1133 | MH-1129 | 14.89 | **0.030** | **0.051** | **100** |
| S-1353 | MH-1129 | MH-1127 | 36.34 | **0.055** | **0.094** | **100** |
| S-1354 | MH-1127A | MH-1127 | 30.81 | **0.019** | **0.032** | **100** |
| S-1355 | MH-1126 | MH-1127A | 29.82 | **0.019** | **0.032** | **100** |
| S-1356 | MH-1124 | MH-1126 | 41.36 | **0.019** | **0.032** | **100** |
| S-1357 | MH-1131 | MH-1139 | 7.08 | **0.061** | **0.104** | **100** |
| S-1359 | MH-1130 | MH-1129 | 23.92 | **0.048** | **0.082** | **100** |
| S-1360 | MH-1131 | MH-1132 | 25.07 | **0.072** | **0.122** | **100** |
| S-1361 | MH-1132 | MH-1146 | 29.3 | **0.072** | **0.122** | **100** |
| S-1362 | MH-1146 | MH-1147 | 25.79 | **0.072** | **0.122** | **100** |
| S-1363 | MH-1147 | MH-1148 | 76.71 | **0.096** | **0.163** | **100** |
| S-1364 | MH-1128 | MH-1148 | 11.37 | **0.096** | **0.163** | **100** |
| S-1365 | MH-1127 | MH-1128 | 16.00 | **0.096** | **0.163** | **100** |
| S-1366 | MH-1144 | MH-1143 | 20.94 | **0.053** | **0.090** | **100** |

**Table 5.6J1 Design Results of 100mm Condominials in Basin J**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1367 | MH-1145 | MH-1144 | 21.38 | **0.053** | **0.090** | **100** |
| S-1368 | MH-1149 | MH-1145 | 19.43 | **0.053** | **0.090** | **100** |
| S-1369 | MH-1149 | MH-1149A | 24.74 | **0.053** | **0.090** | **100** |
| S-1370 | MH-1164 | MH-1149A | 6.24 | **0.193** | **0.329** | **100** |
| S-1371 | MH-1163 | MH-1164 | 18.43 | **0.193** | **0.329** | **100** |
| S-1372 | MH-1147 | MH-1163 | 34.84 | **0.193** | **0.329** | **100** |
| S-1373 | MH-1174 | MH-1205 | 18.85 | **0.202** | **0.345** | **100** |
| S-1374 | MH-1205 | MH-1206 | 17.25 | **0.202** | **0.345** | **100** |
| S-1375 | MH-1206 | MH-1212 | 12.61 | **0.202** | **0.345** | **100** |
| S-1376 | MH-1212 | MH-1207 | 13.76 | **0.202** | **0.345** | **100** |
| S-1377 | MH-1208 | MH-1207 | 27.16 | **0.128** | **0.218** | **100** |
| S-1378 | MH-1209 | MH-1208 | 14.60 | **0.128** | **0.218** | **100** |
| S-1379 | MH-1210 | MH-1209 | 24.63 | **0.128** | **0.218** | **100** |
| S-1380 | MH-1210A | MH-1210 | 29.79 | **0.155** | **0.264** | **100** |
| S-1381 | MH-1165 | MH-1210A | 20.61 | **0.155** | **0.264** | **100** |
| S-1382 | MH-1165 | MH-1166 | 21.64 | **0.183** | **0.311** | **100** |
| S-1383 | MH-1166 | MH-1167 | 14.97 | **0.183** | **0.311** | **100** |
| S-1384 | MH-1167 | MH-1168 | 23.12 | **0.183** | **0.311** | **100** |
| S-1385 | MH-1168 | MH-1169 | 8.10 | **0.183** | **0.311** | **100** |
| S-1386 | MH-1169 | MH-1170 | 2.37 | **0.183** | **0.311** | **100** |
| S-1387 | MH-1170 | MH-1174A | 15.96 | **0.183** | **0.311** | **100** |
| S-1388A | MH-1207 | MH-1213 | 23.77 | **0.382** | **0.650** | **100** |
| S-1389 | MH-1213A | MH-1213 | 25.00 | **0.041** | **0.069** | **100** |
| S-1394 | MH-1213 | MH-1214 | 23.66 | **0.476** | **0.811** | **100** |
| S-1395 | MH-1214 | MH-1197 | 69.45 | **0.476** | **0.811** | **100** |
| S-1407 | MH-1203 | MH-1204 | 24.51 | **0.058** | **0.077** | **100** |
| S-1408 | MH-1202 | MH-1203 | 3.07 | **0.058** | **0.077** | **100** |
| S-1409 | MH-1202 | MH-1201 | 11.23 | **0.058** | **0.077** | **100** |
| S-1410 | MH-1200 | MH-1201 | 12.75 | **0.058** | **0.077** | **100** |
| **TOTAL LEN GTH (m)** | | | **2085.79** | | | |

**Table 5.6J2 Design Results of 150mm Street Sewers/Collectors in Basin J**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) | Final Flow ($q_{ft}$) | Designed Diameter of Sewer D |
|---|---|---|---|---|---|---|
| | From | To | (m) | (l/s) | (l/s) | (mm) |
| S-1334 | MH-1179 | MH-1178 | 11.18 | **2.217** | **3.777** | **150** |
| S-1346 | MH-1178 | MH-1184 | 17.21 | **2.293** | **3.906** | **150** |
| S-1347 | MH-1184 | MH-1184A | 17.17 | **2.293** | **3.906** | **150** |
| S-1348 | MH-1184A | MH-1185 | 9.80 | **2.293** | **3.906** | **150** |
| S-1349 | MH-1185 | MH-1187 | 11.26 | **2.293** | **3.906** | **150** |
| S-1390 | MH-1186 | MH-1187 | 6.5 | **2.594** | **4.419** | **150** |
| S-1391 | MH-1186 | MH-1190 | 12.24 | **2.594** | **4.419** | **150** |
| S-1392 | MH-1190 | MH-1191 | 21.14 | **2.594** | **4.419** | **150** |
| S-1393 | MH-1191 | MH-1193 | 33.46 | **2.643** | **4.481** | **150** |
| S-1396 | MH-1197 | MH-1198 | 32.96 | **3.258** | **5.509** | **150** |
| S-1398 | MH-1193 | MH-1194 | 31.11 | **2.643** | **4.481** | **150** |
| S-1399 | MH-1194 | MH-1204 | 21.47 | **2.643** | **4.481** | **150** |
| S-1400 | MH-1195 | MH-1204 | 12.8 | **2.722** | **4.596** | **150** |
| S-1401 | MH-1195 | MH-1196 | 19.54 | **2.722** | **4.596** | **150** |
| S-1402 | MH-1196 | MH-1197 | 38.94 | **2.722** | **4.596** | **150** |
| S-1403 | MH-1198 | MH-1199 | 16.54 | **3.368** | **5.696** | **150** |
| **TOTAL LEN GTH (m)** | | | **313.32** | | | |

**Table 5.6J3 Design Results of 225mm & 300mm Outfall Sewers/Sub-Mains in Basin J**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) | Final Flow ($q_{ft}$) | Designed Diameter of Sewer D |
|---|---|---|---|---|---|---|
| | From | To | (m) | (l/s) | (l/s) | (mm) |
| S-1404 | MH-1200B | MH-1199 | 54.04 | **7.560** | **12.861** | **225** |
| S-1405 | MH-1200A | MH-1200B | 31.10 | **7.560** | **12.861** | **225** |
| S-1406 | MH-415 | MH-1200A | 27.29 | **7.560** | **12.861** | **225** |
| **TOTAL LEN GTH (m)** | | | **112.43** | | | |
| S-1403A | MH-1199 | MH-1199A | 26.11 | **10.928** | **18.557** | **300** |
| **TOTAL LEN GTH (m)** | | | **26.11** | | | |

**Table 5.6K1 Design Results of 100mm Condominials in Basin K**

| **Sewer Code** | **Manhole Code** | | **Length** | **Initial Flow, ($q_{it}$) (l/s)** | **Final Flow ($q_{ft}$) (l/s)** | **Designed Diameter of Sewer D (mm)** |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1413 | MH-1215 | MH-1216 | 20.32 | **0.048** | **0.082** | **100** |
| S-1414 | MH-1216 | MH-1217 | 13.41 | **0.048** | **0.082** | **100** |
| S-1415 | MH-1217 | MH-1217A | 16.02 | **0.048** | **0.082** | **100** |
| S-1416 | MH-1217A | MH-1219 | 14.32 | **0.048** | **0.082** | **100** |
| S-1417 | MH-1218 | MH-1219 | 11.10 | **0.009** | **0.015** | **100** |
| S-1418 | MH-1219 | MH-1220 | 11.00 | **0.096** | **0.164** | **100** |
| S-1419 | MH-1220 | MH-1221 | 22.14 | **0.096** | **0.164** | **100** |
| S-1419A | MH-1221 | MH-1222 | 24.78 | **0.096** | **0.164** | **100** |
| S-1420 | MH-1222 | MH-1223 | 33.21 | **0.096** | **0.164** | **100** |
| S-1421 | MH-1223 | MH-1224 | 22.66 | **0.096** | **0.164** | **100** |
| S-1421A | MH-1224 | MH-1225 | 20.93 | **0.096** | **0.164** | **100** |
| S-1422 | MH-1226 | MH-1225 | 18.18 | **0.144** | **0.245** | **100** |
| S-1423 | MH-1227 | MH-1226 | 35.83 | **0.144** | **0.245** | **100** |
| S-1424 | MH-1228 | MH-1227 | 30.72 | **0.144** | **0.245** | **100** |
| S-1425 | MH-1229 | MH-1228 | 9.51 | **0.144** | **0.245** | **100** |
| S-1426 | MH-1230C | MH-1229 | 8.92 | **0.144** | **0.245** | **100** |
| S-1427 | MH-1230B | MH-1230C | 8.87 | **0.144** | **0.245** | **100** |
| S-1428 | MH-1230A | MH-1230B | 21.11 | **0.144** | **0.245** | **100** |
| S-1429 | MH-1230 | MH-1230A | 11.78 | **0.144** | **0.245** | **100** |
| S-1430 | MH-1231 | MH-1230 | 30.67 | **0.039** | **0.067** | **100** |
| S-1431 | MH-1218A | MH-1231 | 12.73 | **0.039** | **0.067** | **100** |
| S-1432 | MH-1215 | MH-1218A | **28.66** | **0.039** | **0.067** | **100** |
| S-1433 | MH-1225 | MH-1232 | **18.18** | **0.333** | **0.567** | **100** |
| S-1434 | MH-1232 | MH-1233 | 15.77 | **0.333** | **0.567** | **100** |
| S-1435 | MH-1233 | MH-1234 | 21.32 | **0.333** | **0.567** | **100** |
| S-1436 | MH-1234 | MH-1235 | 10.04 | **0.552** | **0.941** | **100** |
| S-1437 | MH-1235 | MH-1236 | 9.97 | **0.552** | **0.941** | **100** |
| S-1438 | MH-1236 | MH-1237 | 3.47 | **0.552** | **0.941** | **100** |
| S-1439 | MH-1237 | MH-1238 | 25.88 | **0.552** | **0.941** | **100** |
| S-1440 | MH-1244 | MH-1234 | 16.29 | **0.183** | **0.312** | **100** |
| S-1441 | MH-1245 | MH-1244 | 17.82 | **0.183** | **0.312** | **100** |
| S-1442 | MH-1259 | MH-1245 | 13.66 | **0.125** | **0.213** | **100** |
| S-1443 | MH-1260 | MH-1259 | 13.43 | **0.125** | **0.213** | **100** |
| S-1444 | MH-1261 | MH-1260 | 12.00 | **0.125** | **0.213** | **100** |
| S-1445 | MH-1262 | MH-1261 | 18.79 | **0.125** | **0.213** | **100** |
| S-1446 | MH-1262 | MH-1263 | **31.13** | **0.125** | **0.213** | **100** |

**Table 5.6J1 Design Results of 100mm Condominials in Basin J**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-01 | MH-03 | MH-02 | 20.95 | **0.008** | **0.014** | **100** |
| S-1447 | MH-1264 | MH-1263 | 8.80 | **0.204** | **0.347** | **100** |
| S-1448 | MH-1266 | MH-1264 | 22.06 | **0.204** | **0.347** | **100** |
| S-1449 | MH-1267 | MH-1266 | 22.04 | **0.204** | **0.347** | **100** |
| S-1450 | MH-1268 | MH-1267 | 18.53 | **0.204** | **0.347** | **100** |
| S-1451 | MH-1269 | MH-1268 | 21.78 | **0.204** | **0.347** | **100** |
| S-1452 | MH-1270 | MH-1269 | 71.48 | **0.104** | **0.177** | **100** |
| S-1453 | MH-1230 | MH-1270 | 47.59 | **0.104** | **0.177** | **100** |
| S-1454 | MH-1238 | MH-1239 | 20.93 | **0.552** | **0.941** | **100** |
| S-1455 | MH-1239 | MH-1240 | 19.12 | **0.552** | **0.941** | **100** |
| S-1456 | MH-1240 | MH-1251 | 13.88 | **0.552** | **0.941** | **100** |
| S-1457 | MH-1250 | MH-1251 | 22.21 | **0.120** | **0.205** | **100** |
| S-1458 | MH-1249 | MH-1250 | 24.52 | **0.120** | **0.205** | **100** |
| S-1459 | MH-1248 | MH-1249 | 9.99 | **0.120** | **0.205** | **100** |
| S-1460 | MH-1247 | MH-1248 | 23.6 | **0.120** | **0.205** | **100** |
| S-1461 | MH-1246 | MH-1247 | 24.69 | **0.120** | **0.205** | **100** |
| S-1462 | MH-1245 | MH-1246 | 41.45 | **0.130** | **0.221** | **100** |
| S-1463 | MH-1246 | MH-1252 | 4.38 | **0.134** | **0.228** | **100** |
| S-1464 | MH-1252 | MH-1253 | 23.42 | **0.134** | **0.228** | **100** |
| S-1465 | MH-1253 | MH-1254 | 27.05 | **0.134** | **0.228** | **100** |
| S-1468 | MH-1276 | MH-1277 | 20.91 | **0.608** | **1.035** | **100** |
| S-1469 | MH-1275 | MH-1276 | 33.13 | **0.491** | **0.837** | **100** |
| S-1470 | MH-1274 | MH-1275 | 27.87 | **0.491** | **0.837** | **100** |
| S-1471 | MH-1274 | MH-1265 | 10.94 | **0.385** | **0.655** | **100** |
| S-1472 | MH-1263 | MH-1265 | 20.06 | **0.385** | **0.655** | **100** |
| S-1473 | MH-1272 | MH-1271 | 28.57 | **0.041** | **0.069** | **100** |
| S-1474 | MH-1271 | MH-1273 | 23.53 | **0.041** | **0.069** | **100** |
| S-1475 | MH-1273 | MH-1274 | 11.94 | **0.041** | **0.069** | **100** |
| s-1476 | mh-1279 | mh-1280 | 12.58 | **0.051** | **0.086** | **100** |
| s-1477 | mh-1280 | mh-1280A | 42.05 | **0.051** | **0.086** | **100** |
| s-1478 | mh-1280A | mh-1276 | 46.35 | **0.051** | **0.086** | **100** |
| **TOTAL LEN GTH (m)** | | | **1400.07** | | | |

**Table 5.6K2 Design Results of 300mm & 350mm Outfall Sewers/Sub-Mains in Basin K**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-1285A | MH-1106 | MH-1288 | 25.79 | **14.693** | **25.068** | **300** |
| S-1485 | MH-1288 | MH-1289 | 7.02 | **14.693** | **25.068** | **300** |
| S-1486 | MH-1289 | MH-1290 | 33.03 | **14.693** | **25.068** | **300** |
| S-1486A | MH-1290 | MH-1291 | 30.29 | **14.693** | **25.068** | **300** |
| S-1487 | MH-1291 | MH-1199A | 29.31 | **14.693** | **25.068** | **300** |
| **TOTAL LEN GTH (m)** | | | **125.44** | | | |
| S-1466 | MH-1254 | MH-1278 | 8.76 | **26.229** | **44.661** | **350** |
| S-1490 | MH-1277 | MH-1278 | 51.55 | **26.229** | **44.661** | **350** |
| S-1480 | MH-1258 | MH-1241 | 14.81 | **26.363** | **44.889** | **350** |
| S-1481 | MH-1257 | MH-1258 | 17.62 | **26.363** | **44.889** | **350** |
| S-1482 | MH-1256 | MH-1257 | 10.92 | **26.363** | **44.889** | **350** |
| S-1483 | MH-1255 | MH-1256 | 30.21 | **26.363** | **44.889** | **350** |
| S-1484 | MH-1254 | MH-1255 | 33.85 | **26.363** | **44.889** | **350** |
| S-1488 | MH-1199A | MH-1285 | 23.54 | **25.621** | **43.625** | **350** |
| S-1489 | MH-1285 | MH-1277 | 12.45 | **25.621** | **43.625** | **350** |
| **TOTAL LEN GTH (m)** | | | **203.71** | | | |

**Table 5.6K3 Design Results of 400mm Trunk-Mains in Basin K & Along Route to WWTP**

| Sewer Code | Manhole Code | | Length | Initial Flow, ($q_{it}$) (l/s) | Final Flow ($q_{ft}$) (l/s) | Designed Diameter of Sewer D (mm) |
|---|---|---|---|---|---|---|
| | From | To | (m) | | | |
| S-01 | MH-03 | MH-02 | 20.95 | **0.008** | **0.014** | **100** |
| S-1491 | MH-1241 | MH-1242 | 22.32 | **27.064** | **46.083** | **400** |
| S-1491 | MH-1241 | MH-1242 | 22.32 | **27.064** | **46.083** | **400** |
| S-1492 | MH-1242 | MH-1242 | 9.68 | **27.064** | **46.083** | **400** |
| S-1493 | MH-1243 | MH-1292 | 10.05 | **27.064** | **46.083** | **400** |
| S-1494 | MH-1292 | MH-1293 | 9.66 | **27.064** | **46.083** | **400** |
| S-1495 | MH-1293 | MH-1294 | 16.02 | **27.064** | **46.083** | **400** |
| S-1496 | MH-1294 | MH-1295 | 20.51 | **27.064** | **46.083** | **400** |
| S-1497 | MH-1295 | MH-1296 | 48.65 | **27.064** | **46.083** | **400** |
| S-1498 | MH-1296 | MH-1297 | 33.34 | **27.064** | **46.083** | **400** |
| S-1499 | MH-1297 | MH-1298 | 89.34 | **27.064** | **46.083** | **400** |
| **TOTAL LEN GTH (m)** | | | **281.89** | | | |

### 5.4.2 Summarized Results

Table 5.9 presents summarized results of hydraulic analysis of the LIUC sewerage network.

Table 5.9 Sewer diameters and lengths for Teshie Old Towm sewerage network

| Basin Code | Length (m) | | | | | |
|---|---|---|---|---|---|---|
| | (100mm) Condominials & Public Sewers | (150mm) Collector Sewer | (225mm) Outfall Sewer/ Sub-Main | (300mm) Outfall Sewer/ Sub-Main | (300mm) Outfall Sewer/ Sub-Main | (400mm) Trunk Main |
| A | 1.503 | 91 | 0 | 0 | 0 | 0 |
| B | 1,984 | 351 | 0 | 0 | 0 | 0 |
| C | 2,171 | 0 | 0 | 0 | 0 | 0 |
| D | 6,534 | 220 | 0 | 0 | 0 | 0 |
| E | 5,477 | 732 | 404 | 0 | 0 | 0 |
| E1 | 1,497 | 0 | 252 | 0 | 0 | 0 |
| F | 3,447 | 0 | 413 | 0 | 0 | 0 |
| G | 1,978 | 0 | 283 | 18 | 0 | 0 |
| H | 6,005 | 232 | 276 | 211 | 0 | 0 |
| J | 2,086 | 313 | 112 | 26 | 0 | 0 |
| K | 1,400 | 0 | 0 | 126 | 204 | 282 |
| **Total** | **32,581** | **1939** | **1740** | **381** | **204** | **282** |

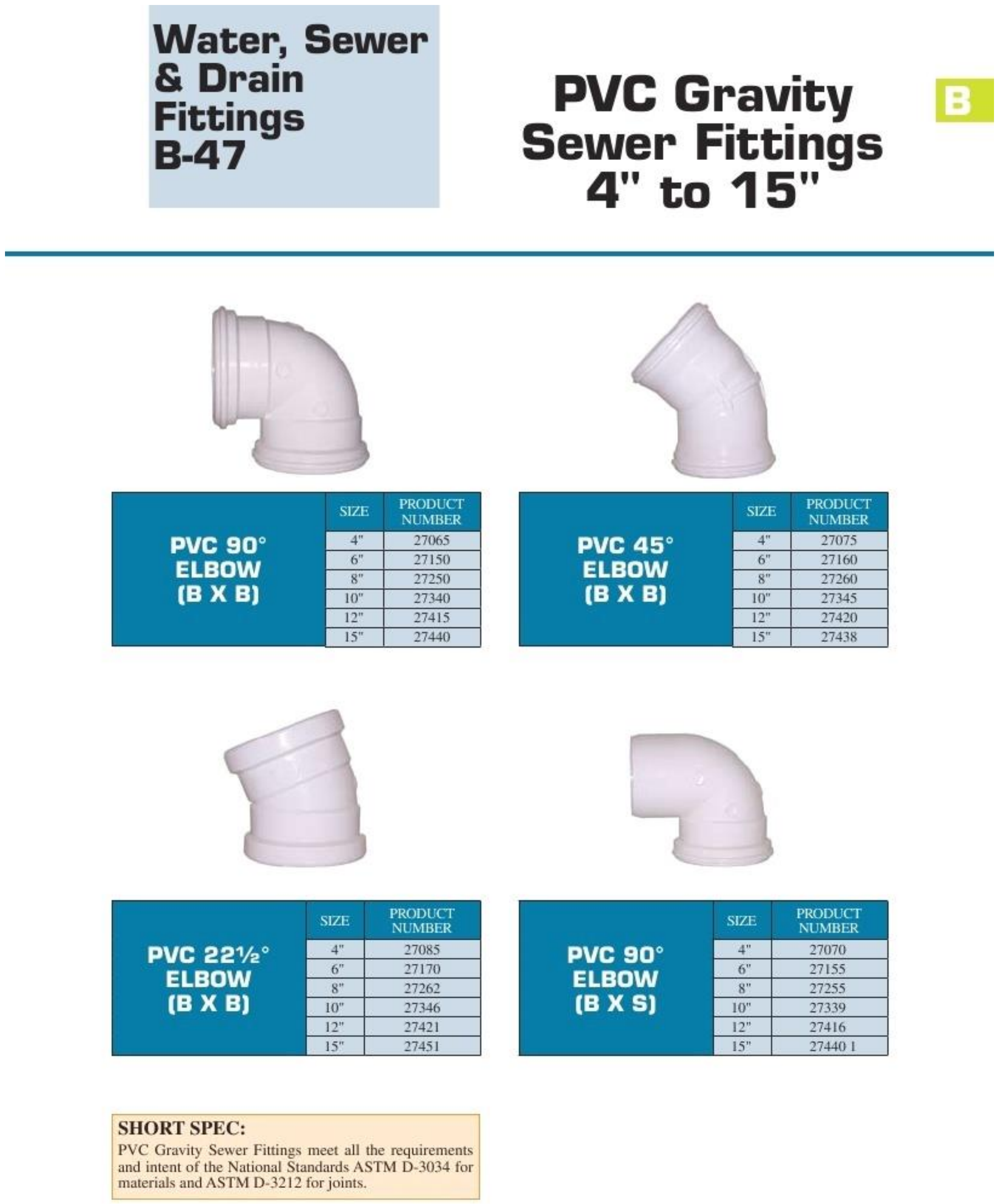
Table 5.9 above presents the following conclusions:

- Total length of 100 mm and 150mm condominials and street sewers is **34.52kMs**,
- Total length of 225 mm, 300 mm & 350 mm outfall sewers/sub-mains is **2.33kMs**, and that of the trunk mains is **0.30kMs** approximately.
- The entire LIUC gravity sewerage network has total sewer length of **37.2kMs**.
- The design also takes care of a total of **2.46kMs** of 100mm condominials within the WWTP adjoining area and 102- manholes and ancillary fittings.
- The total number of manholes of different types designed for the LIUC sewerage network is **1700**.

All pipes of the proposed LIUC sewerage network presented in Table 5.9 above have been designed to **BS EN1401** specifications, meaning that pipes of the network are non pressurized underground uPVC sewage pipes. This recommendation does not include pipe works and ancillaries for wastewater treatment facilities presented in Chapter 6.0.

Refer to Annex B for the full hydraulic analysis.

Figure 5.3 a, b, c and d depicts the standard types of PVC gravity sewer fittings that will be used for joining of uPVC sewage pipes. The fittings have been proposed in accordance with ASTM D-3034/ASTM 3112 specifications for joints.



Water, Sewer & Drain Fittings B-47

PVC Gravity Sewer Fittings 4" to 15"

B

| PVC 90° ELBOW (B X B) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27065 |
| | 6" | 27150 |
| | 8" | 27250 |
| | 10" | 27340 |
| | 12" | 27415 |
| | 15" | 27440 |

| PVC 45° ELBOW (B X B) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27075 |
| | 6" | 27160 |
| | 8" | 27260 |
| | 10" | 27345 |
| | 12" | 27420 |
| | 15" | 27438 |

| PVC 22½° ELBOW (B X B) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27085 |
| | 6" | 27170 |
| | 8" | 27262 |
| | 10" | 27346 |
| | 12" | 27421 |
| | 15" | 27451 |

| PVC 90° ELBOW (B X S) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27070 |
| | 6" | 27155 |
| | 8" | 27255 |
| | 10" | 27339 |
| | 12" | 27416 |
| | 15" | 27440 1 |

**SHORT SPEC:**
PVC Gravity Sewer Fittings meet all the requirements and intent of the National Standards ASTM D-3034 for materials and ASTM D-3212 for joints.

Figure 5.3a PVC gravity sewer elbows

# Water, Sewer & Drain Fittings B-48

# PVC Gravity Sewer Fittings 4" to 15"

| PVC 45° ELBOW (B X S) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27080 |
| | 6" | 27165 |
| | 8" | 27261 |
| | 10" | 27344 |
| | 12" | 27419 |
| | 15" | 27438 1 |

| PVC TEE WYE (B X B X B) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" x 4" | 27062 |
| | 6" x 4" | 27127 |
| | 6" x 6" | 27122 |
| | 8" x 4" | 27216 |
| | 8" x 6" | 27206 |
| | 8" x 8" | 27202 |
| | 10" x 6" | 27297 |
| | 10" x 8" | 27294 |
| | 12" x 6" | 27371 |
| | 12" x 8" | 27369 |
| | 15" x 6" | 27446 2 |
| | 15" x 8" | 27445 1 |

| PVC 22½° ELBOW (B X S) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27090 |
| | 6" | 27175 |
| | 8" | 27263 |
| | 10" | 27347 |
| | 12" | 27422 |
| | 15" | 27451 1 |

**PVC DOUBLE BELL COUPLING**

| SIZE | PRODUCT NUMBER | |
|---|---|---|
| | STOP COUPLING | REPAIR COUPLING |
| 4" | 27115 | 27115 3 |
| 6" | 27195 | 27196 |
| 8" | 27285 | 27285 1 |
| 10" | 27360 | 27361 |
| 12" | 27435 | 27436 |
| 15" | 27441 | 27441 1 |

**SHORT SPEC:**
PVC Gravity Sewer Fittings meet all the requirements and intent of the National Standards ASTM D-3034 for materials and ASTM D-3212 for joints.

Figure 5.3b PVC gravity sewer elbows, tees and double bell coupling

**Water, Sewer & Drain Fittings B-49**

# PVC Gravity Sewer Fittings 4" to 15"

B

| PVC TEE (B X B X B) SIZE | PRODUCT NUMBER |
|---|---|
| 4" x 4" | 27055 |
| 6" x 4" | 27125 |
| 6" x 6" | 27120 |
| 8" x 4" | 27215 |
| 8" x 6" | 27205 |
| 8" x 8" | 27200 |
| 10" x 4" | 27305 |
| 10" x 6" | 27295 |
| 10" x 8" | 27293 |
| 10" x 10 | 27290 |
| 12" x 4" | 27380 |
| 12" x 6" | 27370 |
| 12" x 8" | 27367 |
| 12" x 10" | 27366 |
| 12" x 12" | 27365 |
| 15" x 4" | 27447 |
| 15" x 6" | 27444 |
| 15" x 8" | 27445 |
| 15" x 10" | 27461 |
| 15" x 12" | 27462 |
| 15" x 15" | 27439 |

| PVC WYE (B X B X B) SIZE | PRODUCT NUMBER |
|---|---|
| 4" x 4" | 27060 |
| 6" x 4" | 27140 |
| 6" x 6" | 27135 |
| 8" x 4" | 27240 |
| 8" x 6" | 27230 |
| 8" x 8" | 27225 |
| 10" x 4" | 27330 |
| 10" x 6" | 27320 |
| 10" x 8" | 27316 |
| 10" x 10 | 27315 |
| 12" x 4" | 27405 |
| 12" x 6" | 27395 |
| 12" x 8" | 27393 |
| 12" x 10" | 27392 |
| 12" x 12" | 27390 |
| 15" x 4" | 27442 |
| 15" x 6" | 27443 |
| 15" x 8" | 27446 |
| 15" x 10" | 27460 |
| 15" x 12" | 27463 |
| 15" x 15" | 27448 |

| PVC DOUBLE WYE (All Bell) SIZE | PRODUCT NUMBER |
|---|---|
| 6" x 4" | 27133 |
| 6" x 6" | 27134 |
| 8" x 6" | 27231 |

**SHORT SPEC:**
PVC Gravity Sewer Fittings meet all the requirements and intent of the National Standards ASTM D-3034 for materials and ASTM D-3212 for joints.

Figure 5.3c PVC gravity sewer tees, single and double wyes

**Water, Sewer & Drain Fittings B-50**

# PVC Gravity Sewer Fittings 4" to 15"

| PVC REDUCER (S X B) | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 6" x 4" | 27100 |
| | 8" x 4" | 27276 |
| | 8" x 6" | 27275 |
| | 10" x 4" | 27354 1 |
| | 10" x 6" | 27353 1 |
| | 10" x 8" | 27350 1 |
| | 12" x 4" | 27422 5 |
| | 12" x 6" | 27423 |
| | 12" x 8" | 27424 |
| | 12" x 10" | 27425 |
| | 15" x 4" | NS |
| | 15" x 6" | 27456 |
| | 15" x 8" | 27456 1 |
| | 15" x 10" | NS |
| | 15" x 12" | 27450 |

**NOTES:**

- NS items are special order and are non-returnable.
- Eccentric reducers are also available. Call your local Team EJP sales office.

## Clean-Out Adaptor & Plug

| DESCRIPTION | PRODUCT NUMBER |
|---|---|
| 4" Clean-Out w/Plug | 27113 |
| 4" Clean-Out L/Plug | 27113 1 |
| 4" Clean-Out Plug Only | 27113 2 |
| 6" Clean-Out w/Plug | 27192 |
| 6" Clean-Out L/Plug | 27192 3 |
| 6" Clean-Out Threaded Plug Only | 27192 1 |

| PVC END CAP | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27110 |
| | 6" | 27190 |
| | 8" | 27281 |
| | 10" | 27358 |
| | 12" | 27428 |
| | 15" | 27453 |

| PVC END PLUG | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27105 |
| | 6" | 27185 |
| | 8" | 27280 |
| | 10" | 27355 |
| | 12" | 27430 |
| | 15" | 27449 |

| SDR 35 to SCH. 40 ADAPTOR | SIZE | PRODUCT NUMBER |
|---|---|---|
| | 4" | 27114 |
| | 6" | 27193 |

Figure 5.3d PVC gravity sewer reducers, end caps, clean out adaptors & plugs

# 6. DESIGN OF SEWERAGE TREATMENT PLANT

## 6.1 UNIT PROCESS CONFIGURATION

The proposed sewage treatment plant will comprise of preliminary, primary, secondary and tertiary treatment units. Additionally, it will include sludge treatment and biogas utilization facilities. Figure 6.1 below presents a schematic diagram of the unit processes proposed for the LEKMA WWTP.

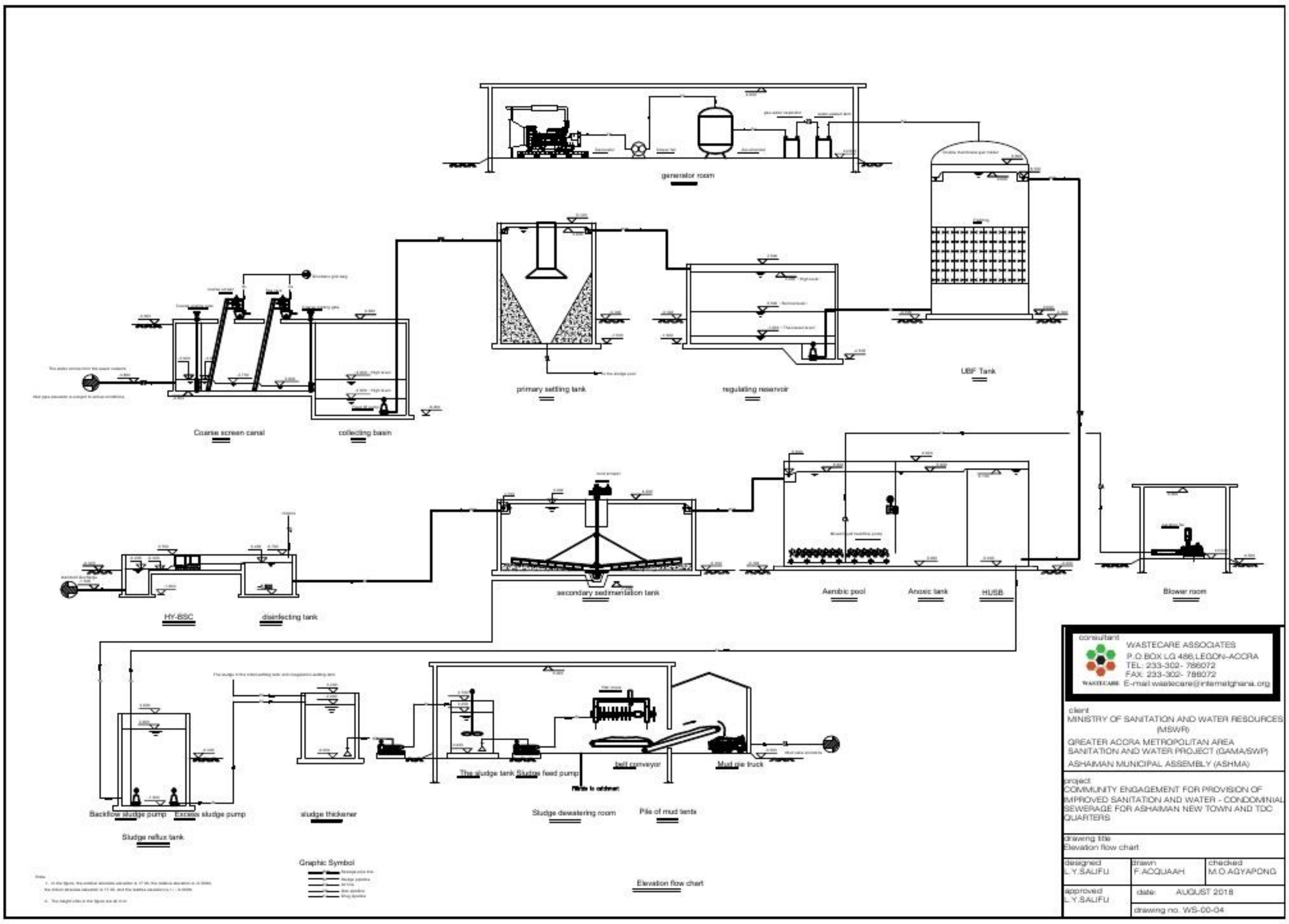



**Figure 6-1: Schematic diagram of unit processes for WWTP - Teshie Old Town**

Table 6.1 presents a summarized description of the main processes/unit operations of the WWTP for the Teshie Old Town and WWTP enclave sewage flows.

**Table 6.1 Treatment stages and associated unit processes**

| Treatment Stage | Unit Process/Facility | Description of Unit Process |
|---|---|---|
| Preliminary Treatment | Screening | Wastewater influent flows through coarse and then fine screens under gravity to remove debris and floating materials. |
| | Attenuation tank | Flow equalization provides a more constant hydraulic or organic loading of downstream treatment processes. The diurnal variation of wastewater inflows can have adverse effects on the efficiency, reliability, and control of unit process operations. |
| Primary Treatment | Primary sedimentation tank | This involves the separation and removal of suspended solids and floatables (scum) from wastewater by physico-chemical methods. This process also leads to reductions in TSS, COD and BOD loading of the influent. |
| Secondary Treatment | Upflow bed filter | The organic fraction of the wastewater (i.e. COD and BOD) is converted to biogas under anaerobic conditions in the reactor. Biogas will be harvested for generation of electricity. |
| | Aerobic/anoxic tank | Aerobic-anoxic treatment, which is mimics activated sludge process, is applied to reduce the nutrient content of the wastewater effluent from the UBF as well as any leftover BOD and COD. |
| | Secondary sedimentation tank | This involves the removal of microorganisms (biological floc) and other solids after biological treatment. The sludge is recycled to the primary sedimentation tank. |
| Tertiary Treatment | Disinfection tank | This is an effluent polishing process that is intended to destroy pathogens. |
| Sludge Treatment | Sludge dewatering/drying | Sludge dewatering is basically the separation of liquid and solids. Dewatering can be done naturally by drying beds and solar energy or by mechanical and thermal units. |
| Biogas Utilization | Biogas recovery and cleaning | A biogas storage bag is used for safe and secure storage of biogas. The biogas produced by the anaerobic digestion process will partially be used for thermal drying of the solid fraction. |

## 6.2 WWTP PLAN VIEW

Figure 6.2 essentially presents the plan view of the LEKMA wastewater treatment plant (WWTP) and shows how plant facilities will be arranged at the site to achieve the desired treatment quality following the operation and unit processes described in Table 6.1.

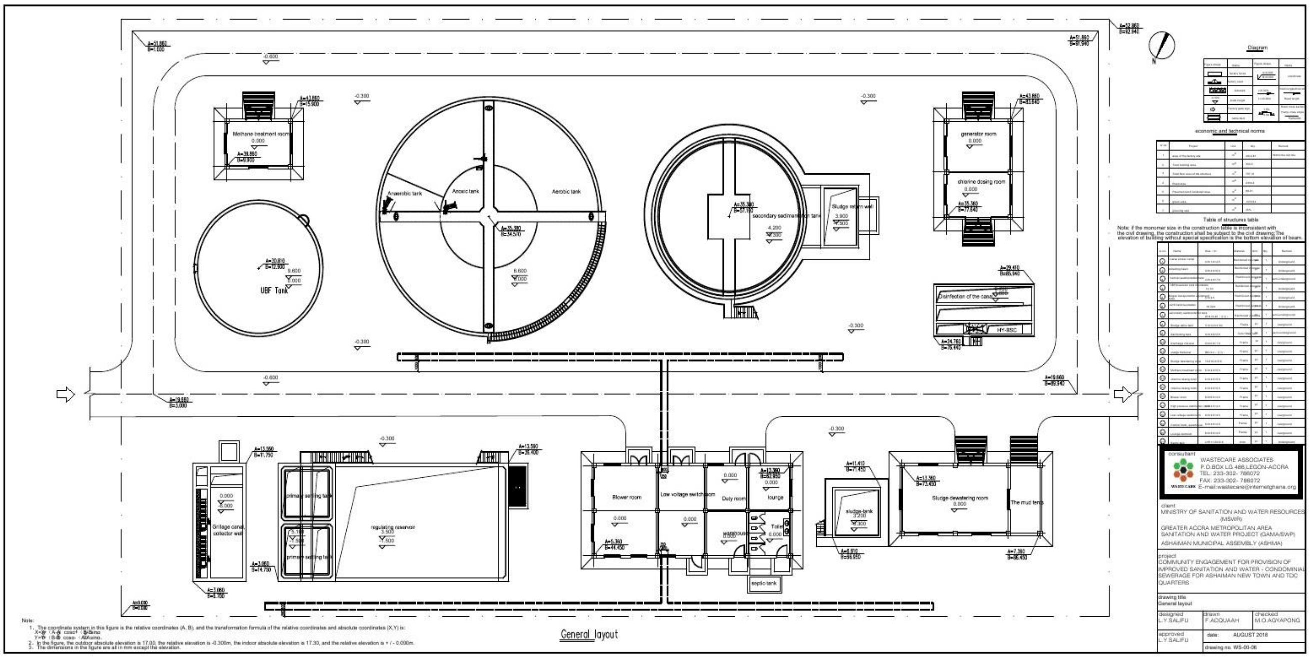



**Figure 6.2: Schematic diagram of unit operations and processes for Teshie Old Town WWTP**

## 6.3 CIVIL WORKS

Table 6.2 below presents the summarized scope of civil works for the proposed wastewater treatment plant. The works follow the main operation and process units described in the previous sections. Table 6.3 summarises the bulk civil engineering materials for the works at the treatment plant site.

**Table 6.2: Summarized Description of Civil works for WWTP**

| Item | Unit Process/Operation | Functional Size | Type of Facility | Unit | Qty | Remarks |
|---|---|---|---|---|---|---|
| 1 | Coarse/fine screen canal | 60 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Underground Tank |
| 2 | Collection basin | 235 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Underground Tank |
| 3 | Primary settling tank | 175 $m^3$ | Reinforced Concrete | No. | 2 | Rectangular Semi-Underground |
| 4 | Regulating tank/elevator pump room | 800 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Semi-Underground |
| 5 | UBF anaerobic tank with R.C foundation | 990 $m^3$ | Reinforced Concrete | No. | 1 | Cylindrical Underground |
| 6 | Biogas transportation equipment with R.C base | 19 $m^3$ | Reinforced Concrete | No. | 1 | Cylindrical Underground |
| 7 | A2/0 tank with R.C. foundation | 1865 $m^3$ | Reinforced Concrete | No. | 1 | Cylindrical Underground |
| 8 | Secondary sedimentation tank | 925 $m^3$ | Reinforced Concrete | No. | 1 | Underground |
| 9 | Sludge recirculation tank | 55 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Over-ground |
| 10 | Disinfection tank | 95 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Semi-underground |
| 11 | Outlet/PAP metering channel | 8 $m^3$ | Reinforced Concrete | No. | 1 | Rectangular Over-ground |
| 12 | Sludge dewatering room | 390 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 14 | Methane treatment room | 120 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 15 | Chemical dosing room | 120 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 16 | Blower room | 260 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 17 | High pressure distribution room | 135 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 18 | Low voltage switch room | 130 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 19 | Control room, warehouse | 185 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 20 | Lounge, waiting room | 185 $m^2$ | Sandcrete Block | No. | 1 | Rectangular Over-ground |
| 21 | Bio-digester | 10 $m^3$ | Precast Concrete | No. | 1 | Rectangular, partially Underground |

| Item | Unit Process/Operation | Functional Size | Type of Facility | Unit | Qty | Remarks |
|---|---|---|---|---|---|---|
| 22 | WWTP site road works & side kerbs | 600 m | Bituminous | SET | 1 | Over-ground |
| 23 | WWTP site, paving of open areas | 2340 $m^2$ | Precast Blocks | SET | 1 | Over-ground |
| 24 | WWTP site, U-drainage works | 600 m | Precast Concrete | SET | 1 | Underground |
| 25 | WWTP site, earthworks & site grounds stabilization works | 8800 $m^2$ | Earthworks & Drainage | SET | 1 | Underground |

**Table 6.3: Estimated Quantities for Major Works**

| Item | Project Area | Unit | Quantity | Remarks |
|---|---|---|---|---|
| 1 | Area of the Plant site | $m^2$ | 4,912.81 | As indicated in General Layout |
| 2 | Total area for buildings | $m^2$ | 333.00 | |
| 3 | Total floor for the operation and process units structure | $m^2$ | 757.31 | |
| 4 | Road area | $m^2$ | 2,334.40 | |
| 5 | Paved area | $m^2$ | 89.21 | |
| 6 | Green area | $m^2$ | 1,370.84 | |
| 7 | Greening Proportion | | 35% | |

The estimated works in Table 6.3 include the reconstruction of the existing old stabilisation ponds which is integrated in the WWTP for final polishing to alternate the use of chemical dosing when the need arises.

## 6.4 ELECTRO-MECHANICAL WORKS

Table 6.4 lists the electro-mechanical equipment to be installed to the various operation and process units of the proposed WWTP. The equipment type, specifications, materials used in fabrication and the quantity of each item is provided. The equipment listing will have to be read together with the relevant technical drawings provided in Annex C for completeness.

Important considerations of operation and maintenance (O&M) regarding critical electro-mechanical equipment include allowing for spares, the use of appropriate pumps and hoists for easy lift of submersible pumps. This is discussed further under relevant sections of Chapter 7, Operation and Maintenance Management.

**Table 6-4: Electro-mechanical works for WWTP**

| Item | Electromechanical Equipment Type & Code | Specifications | Material | Unit | Qty | Availability |
|---|---|---|---|---|---|---|
| **1.0 SCREENING CHAMBER & COLLECTION BASIN/WELL** | | | | | | |
| 1.1 | Automatic mechanical coarse and fine bar rack with matched control box, equipment for coarse and fine screens respectively | Rotary drum cleaning rack, width=600mm, gap = 20mm, Inclination = $75^0$, N = 1.1kW 0.5m water depth in front of screen 9.8x1.0x6.0m | Equipment body: carbon steel, non-corrosive | No. | 2 | Assembled locally, imported control box can be repaired locally |
| 1.2 | Screen chamber inlet gate, wall mounted manual cast iron inlay gate with auxiliary hoist | Gate dimension (Length x Height) = 300 x 300 mm, gate centre distance/pool top distance = 4500 mm | Equipment body: cast iron | No. | 1 | Assembled locally |
| 1.3 | Inlet lift pumps (submersible pumps), | Pump discharge = 90m$^3$/h, operating head = 10m, N = 5.5kW, well depth = 6.0m | Equipment body: cast iron and ductile iron impeller | No. | 5 | Imported, can be assembled locally repair/refurbishment with parts available locally |
| 1.4 | Grid slack trolley for screening activities | Trolley capacity/volume = 0.5m$^3$ | Trolley body: carbon steel, non-corrosive | No. | 2 | Purchased locally |
| **2.0 PRIMARY SETTLING TANK** | | | | | | |
| 2.1 | Centre diversion tube | Dimension = ϕ800mm, δ=6mm | Equip. body: carbon steel, non corrosive | SET | 2 | Imported, can repaired/refurbished locally |
| 2.2 | Rectangular weir plate (water weir plate) | L= 20m, B = 300mm, δ=6mm | Equip. body: SS304 | SET | 1 | Assembled locally |
| **3.0 ATTENUATION /REGULATING TANK** | | | | | | |
| 3.1 | Adjustable pit lift pumps (submersible pumps, | Pump discharge = 90m$^3$/h, operating head = 18m, N = 7.5kW, Tank depth = 5.0m | Equipment body: cast iron and ductile iron impeller | No. | 3 | Imported, can be assembled locally repair/refurbishment with parts available locally |
| 3.2 | Adjustable tank mixers (submersible mixers), belt hoist type, | Impeller Diameter = 320 mm, n = 740rpm， N=2.2kW， Pool depth 5.0m | | No. | 2 | Imported, can be assembled locally repair/refurbishment with parts available locally |

| Item | Electromechanical Equipment Type & Code | Specifications | Material | Unit | Qty | Availability |
|---|---|---|---|---|---|---|
| **4.0 UPFLOW BLANKET FILTER (UBF) TANK** | | | | | | |
| 4.1 | UBF Padding, (Elastic Padding) | Specific Area3200—6100㎡/m³; voidage 90—99%, Padding height is 3.6m, including bracket | | $m^3$ | 370 | Imported |
| 4.2 | Methane Collection System | Air - water separator, water - sealed tank, single - film gas tank | | SET | 1 | Imported |
| 4.3 | Gas-water Separator | V=0.5m3 | Equipment body: carbon steel, non corrosive | SET | 1 | Imported |
| 4.4 | Water-Sealed Tank | V=0.5m3,With the relief valve | Equipment body: carbon steel, non corrosive | SET | 1 | Imported |
| 4.5 | Methane Bag | Q = 400$m^3$ | PVC | SET | 1 | Imported |
| 4.6 | Influent Distribution System | | | SET | 1 | Imported |
| 4.7 | Air Compressor, Booster Fan, | Q=0.5m/min, P=0.5MPa, N=7.5kW, Explosion-proof electric machine | | No. | 3 | Imported, can be assembled locally repair/refurbishment with parts available locally |
| 4.8 | piping pumps, equipment | Q=75m³/h, H=12m, N=7.5kW, Explosion-proof electric machine, | stainless steel impeller | No. | 3 | Imported, can be assembled locally repair/refurbishment with parts available locally |
| 4.9 | Biogas Generator System, complete set with all fittings and accessories, equipment code PU03 | | | No. | 1 | Imported |
| **5.0 A2O (HYPOXIA, ANOXIC & AEROBIC) TANK** | | | | | | |
| 5.1 | Anaerobic tank mixer with submerged propeller and self coupling lifting device, | R=43rpm,Impeller Diameter = 1000mm, N=1.5kW | Impeller material: fiber-glass | No. | 1 | Imported, assembly and repair/refurbishment can be done locally |
| 5.2 | Oxygen tank mixer with submerged propeller and self coupling lifting device, | R=43rpm,Impeller Diameter = 1400mm, N=1.5kW | Impeller material: fiber-glass | No. | 1 | Imported, assembly and repair/refurbishment can be done locally |

| Item | Electromechanical Equipment Type & Code | Specifications | Material | Unit | Qty | Availability |
|---|---|---|---|---|---|---|
| 5.3 | Aerator tray, disc type micro orifice aerator with auxiliary installation accessories | Φ215，service area0.5~0.8$m^2$/PC，VC1.87$m^3$/h，<br>Oxygen utilization > 25% | Diaphragm material EPDM | No. | 318 | Imported |
| 5.4 | Mixed liquid backflow pump, submersible backflow pump (through-wall pump), with self - coupling, with lifting, mating door, | Q=90$m^3$/h，<br>H=0.7m，N=1.5kW | Pump case, shaft and impeller: cast iron, | No. | 1 | Imported, repair /refurbishment of pumps can be done locally |
| 5.5 | Padding, interception network | Φ25mm | PVC | $m^3$ | 160 | Imported |
| **6.0 SECONDARY SEDIMENTATION TANK** | | | | | | |
| 6.1 | Mud scraper, full bridge type centre drive type, complete matched mirror stainless steel weir board, scum baffle, steady flow tube, road plate, rail, local control box, etc, | Pool Size D=14m，Pool height 4.8m，N=0.75kW | underwater segment SS304，Water part of carbon steel corrosion | SET | 1 | Imported, repair /refurbishment can be done locally |
| **7.0 SLUDGE RECIRCULATION TANK** | | | | | | |
| 7.1 | Submersible sewage pump complete with self - coupling, lifting device, | Q=45$m^3$/h<br>H=12m，N=4kW | Shell cast iron, impeller ductile cast iron | No. | 3 | Imported, assembly and repair/refurbishment of pumps can be done locally |
| 7.2 | Excess sludge submersible sewage pump complete with self - coupling, lifting device, | Q=15$m^3$/h<br>H=10m，N=1.5kW | Shell cast iron, impeller ductile cast iron | No. | 3 | Imported, assembly and repair/refurbishment of pumps can be done locally |
| **8.0 BLOWER ROOM** | | | | | | |
| 8.1 | Aeration fan, roots blower type complete with sets of 2 mufflers for inlet and outlet, soft joint for outlet, check valve for outlet and 1 muffler for vent, | Q=18N$m^3$/min (under the standard conditions，△P=65kPa，N=37kW | | No. | 3 | Imported, assembly and repair/refurbishment of pumps can be done locally |
| **9.0 DISINFECTION BASIN** | | | | | | |
| 9.1 | Flow measuring meter complete set, | Measurement Range：2.5~25L/s，Shouted the width b=150mm | SS304 | No. | 1 | Imported |
| **10.0 CHEMICAL DOZING ROOM** | | | | | | |

| Item | Electromechanical Equipment Type & Code | Specifications | Material | Unit | Qty | Availability |
|---|---|---|---|---|---|---|
| 10.1 | Sodium hypochlorite tank, vertical storage tank complete with matched FRP mixer | $V=2m^3$， N=0.75KW | PE | No. | 1 | Imported/locally available |
| 10.2 | Sodium hypochlorite charge pump, ANDOSE type complete with all fittings and accessories | Q=70L/h，<br>H=5bar，N=0.37kW | Pump Head：PVC，<br>Membrane PTFE | No. | 3 | Imported, assembly and repair/refurbishment of pumps can be done locally |
| **11.0 SLUDGE DEWATERING FACILITY** | | | | | | |
| 11.1 | Sludge transfer pump, screw type of pump | $Q=20m^3/h$，<br>H=0.6MPa，N=18.5kW | Rotor：SS304，<br>Stator: Chemigum | No | 3 | Imported, assembly and repair/refurbuishment of pumps can be done locally |
| 11.2 | Pipeline mixer complete with all fittings and accessories | DN80，PN10 | Carbon steel corrosion | No. | 1 | Imported, assembly and repair/refurbishment can be done locally |
| 11.3 | Box type plate frame dehydrator | Dry Mud Rate：1.0t/d，N=7.5kW，<br>Water content in mud 98%，<br>Mud moisture content75% | Main material: Q345B, filter plate and cloth material: polypropylene | SET | 1 | Imported |
| 11.4 | Belt conveyor, screw type conveyor | Bandwidth：1.0m，<br>L=5m，N=1.5kW | | No. | 1 | Imported |
| 11.5 | PAM dosing device with vertical medicine cabinet and dissolution kit | $V=2m^3$，N=0.55kW | Dissolution kit: PE;<br>Agitator: impeller and shaft ：304 | No. | 1 | Imported |
| **12.0 SLUDGE DEWATERING FACILITY** | | | | | | |
| 12.1 | PAM dosing pump, helical rotor pump | $Q=1m^3/h$，<br>H=30m，N=0.75kW | chemical gun | No. | 1 | Imported, repair/refurbishment can be done locally |
| 12.2 | Mobile slope sewage pump | $Q=10m^3/h$，<br>H=15m， N=0.75kW | Pump case and impeller: cast iron | No. | 1 | Imported, repair/refurbishment can be done locally |

## 6.5 INSTRUMENTATION AND AUTOMATIC CONTROLS

Table 6.5 below presents the list of electro-mechanical instrumentation, automatic controls and ventilation and air-conditioning (VAC) equipment. This category of equipment allows for automatic operation, flow and pressure measurements, and performance monitoring of elements of the above listed electro-mechanical installations.

**Table 6.5: Proposed List of Instrumentation and Automatic Controls Equipment**

| Item No. | Installation Point | Instrument Name | Specification | Unit | Qty. |
|---|---|---|---|---|---|
| **1.0 SCREENING CHAMBER** | | | | | |
| 1.1 | Water lift pump outlet pipe | Local pressure gauge | Pressure gauge with glycerine shockproof case measuring range：0-0.19MPa，Φ100mm | No. | 2 |
| 1.2 | Water-collecting well | TQ-UHS | High and low level control，0-5.0m | SET | 1 |
| **2.0 ATTENUATION TANK** | | | | | |
| 2.1 | Regulating well | TQ-UHS | High and low level control，0-5.0m | SET | 1 |
| 2.2 | Adjust pit lift pump outlet | Local pressure gauge | Diaphragm pressure gauge, measuring element SS304，0~0.15MPa，Φ100mm | No. | 2 |
| **3.0 SLUDGE REFLUX TANK** | | | | | |
| 3.1 | Sludge Recirculation Pump Outlet | Local pressure gauge | Diaphragm pressure gauge, measuring range 0~0.10MPa，Φ100mm | No. | 4 |
| 3.2 | Residual Sludge Pump Outlet | Local Pressure Gauge | Diaphragm pressure gauge, measuring range 0~0.10MPa，Φ100mm | No. | 2 |
| **4.0 FLOW MEASURING CHANNEL** | | | | | |
| 4.1 | Flow measurement channel | Ultrasonic Open Channel Flow meter | Measurement range: 0~100m cubed /h, displayed in place | No. | 1 |
| **5.0 CHEMICAL DOZING ROOM** | | | | | |
| 5.1 | Chemical Dosing Tank | SZBI | Measurement range：0~1.5m | No. | 1 |
| 5.2 | Chemical Charge Pump Outlet | Local Pressure Gauge | Diaphragm pressure gauge, Plastic housing working pressure：0.7MPa，Φ63mm | No. | 2 |
| **6.0 SLUDGE TANK** | | | | | |
| 6.1 | Sludge Storage Tank Wall | | High and low level control，0-5.0m | SET | 1 |
| **7.0 SLUDGE DEWATERING ROOM** | | | | | |
| 7.1 | Sludge Feed Pump Outlet | Local Pressure Gauge | Diaphragm pressure gauge, measuring pressure ：0~1.6MPa，Φ100mm | No. | 2 |
| 7.2 | PAM Dosing Pump Outlet | Local Pressure Gauge | Diaphragm pressure gauge, measuring pressure ：0~1.6MPa，Φ100mm | No. | 2 |

## 6.6 ELECTRICAL WORKS

The electrical power supply and installations to be used in the WWTP is described in this section. Electricity will be supplied the Electricity Company of Ghana (ECG) 415V/50Hz suitable for 3-phase machinery and equipment. A standby generator to run on biogas will provide alternative and emergency power.

The following Table 6.6 summarises the main electrical installations and the accessories including earthing for lightning protection, control distribution board for the site. All installations shall be to the appropriate standards approved by the Ghana Standards Authority (GSA) and Ghana Building Regulations.

Further details of the power supply plan for individual process units of the WWTP, wiring and lighting system for auxiliary buildings including site outdoor lighting are provided in the accompanying electrical drawings in Appendix III.

**Table 6.6: Proposed List of Electrical Works**

| Item No. | Electrical Facilities | Specification | Unit | Qty. |
|---|---|---|---|---|
| 6.6.1 | Power cabling for WWTP facilities wiring | Low pressure power cables 0.6/1.0KV voltage rating (Three Phase-380VAC) | COILS | 16 |
| 6.6.2 | Switchgears & power distribution boxes complete set with buttons, internal switches, indicator lights, automatic thermo-relays, contactors, stancheons and circuit breakers | Model 380VAC (Three Phase Voltage) | SET | 1 |
| 6.6.3 | Power cable seal joints | (DN25mm-DN50mm). | m | 33 |
| 6.6.4 | PVC electrical conduits | (DN25mm-DN40mm). | m | 33 |
| 6.6.5 | Cable Ducts | One (1) side, two (2) levels in cable trench, dimension = 600mm x 600mm depth | m | 60 |
| 6.6.6 | Hot dip galvanized steel tube | (SC25mm – SC50mm) | m | 763 |
| 6.6.7 | Hot dip galvanized steel box | box iron No.10 | m | 15 |
| 6.6.8 | Electrical installation mat | Installation thickness $\delta$ = 3mm, surface area (1m x 2m width), capable of withstanding 65kV | $m^2$ | 48.0 |
| 6.6.9 | Anti-fire plugs | Anti-fire plugs complete with inorganic fire proof sealing compounds | Kg | 5.0 |
| 6.6.10 | Electrical sockets | AC 250V, current rating 10A | No. | 50 |
| 6.6.11 | LED wall light | AC 220V, (13W-60W), (1700lm-8000lm) at 4000k, 700mA classifications | No. | 14 |
| 6.6.12 | DP electrical switches | AC 220V, 20A | No. | 20 |
| 6.6.13 | Street lights | Conical tapering G.I street light complete with lights, seating plate, junction box, stiffening anchorage plate etc. Foundation concrete works, base plate holding down and other fixing bolts and nuts inclusive. Installed height (3.5-4.0m). | No. | 20 |

# 7. OPERATION AND MAINTENANCE MANAGEMENT

There is very limited sewer connection across the whole of Ghana with the national sewerage coverage persistently below 4.5% for so many decades. Tema and Akosombo are the only townships with comprehensive sewerage systems. Accra and Kumasi have limited sewerage. The treatment facilities for both the Accra and Tema systems as is typical of many sewage and septage/faecal sludge treatment facilities are non-functional. In all about 50 wastewater treatment plants of varying designs and complexity are in a state of disrepair.

## 7.1 IMPROVING OPERATION AND MAINTENANCE REGIME

The foregoing paragraph gives an overview of the trend of operation and maintenance (O&M) management of publicly-owned sanitation facilities, especially wastewater treatment plants, which has been very abysmal. Lack of routine maintenance of machinery and timely replacement of electro-mechanical equipment, for example, pumps has been identified as the main reasons for the plants going out of operation and ultimately becoming non-functional and abandoned. This situation has affected many plants of varying technical complexity and size. Box 7.1 summarises a number of the inter-related reasons identified for the frequent failure, breakdown and disrepair of many wastewater treatment plants.

**Box 7.1: Reasons for Poor O&M to Breakdown of Facilities**

- General low priority of excreta and wastewater management
- Poor accountability which beset the collection of fees
- Low level of technical support
- Poorly designed systems
- Inappropriate levels of service
- Lack of training
- Irresponsive institutional arrangements/lack of community involvement
- Lack of spare parts
- Lack of finance (low levels of revenue collection + non-economic tariffing)
- Non-payment of utility bills; water and electricity

Operating a trouble-free sanitary sewer network requires an effective maintenance programme involving (i) instituting bye-laws that define sewer network area, (ii) regulated sewer inspections, (iii) preventive maintenance and (iv) repairs.

Table 7.1 lists important activities required for the continuous operation of condominial or shallow sewers.

The Asafo simplified sewerage system in Asafo, Kumasi which became operational in 1994 is the only municipality-owned wastewater treatment plant which has remained operational for over a decade-and –a-half. In the recent past the Accra sewerage system’s treatment plant which is an Upflow Anaerobic Sludge Blanket (UASB), located at Mudor near the Odaw estuary is reported to have functioned for two (2) years from 2002 when it became operational up until the latter parts of 2004 when the plant became beset with the chronic challenge of poor O&M. Recently, in 2016, the UASB cells and sedimentation tanks of the Mudor have been rehabilitated and expanded with the installation of additional unit processes to cater for flows from the Accra central and Korle Bu Teaching Hospital sewer networks in addition to hauled septage from cesspit emptier trucks which hitherto has been discharged into the ocean at Lavender Hill, Korle Gonno.

**Table 7.1: General requirements for Operation and Maintenance for Simplified Sewers**

| **Activity** | **Frequency** | **Human resources** | **Materials & spare parts** | **Tools & equipment** |
|---|---|---|---|---|
| Clean grease trap | Daily/weekly | Household | Water | |
| Repairs and removal of blockages | When needed | Local labour or mechanic | Water, specialized materials and spare parts | Rodding tool, mechanic's tool set |
| Check inspection chambers, appurtenances such as pumps and controls, vacuum and surge chambers, check valves | At least annually | Household or mechanic | Water | Basic mechanic tool set |
| Inspect street sewers | Regularly | Staff sewerage department | Specialized spare parts and materials | Specialized tools and equipment |

There are a number of common factors that explain the continued operation of the Asafo simplified sewerage system. Tables 7.2 and 7.3 list a number of "successful" and "not-so-successful" management aspects of the Asafo simplified sewerage system, that can provide guidance for sustaining O&M of wastewater treatment plants in Ghana.

The lessons and experiences of the Asafo simplified sewerage system regarding the reasons and factors of success and/or failure is critical for the proposed simplified sewerage for Teshie Old Town. It is essential that a small-scale service provider (local operator) is embedded within Teshie Old Town to promote *community-private operator-partnership*. This is very critical not only to enhance household connections but also ensure rapid response to routine sewer complaints including blockage of grease traps and house connections.


Sewerage Maintenance Fee collection and House-Connection Kiosk, Asafo, Kumasi

## 7.2 SEWERAGE TARRIFFS

An important aspect that affects sustainability of O&M and hence the continued functionality of the whole sewerage system is the need to reach community-led agreement on fees (tariffs) to be charged per category of dwelling or premises.

The KMA-WMD designed a fees schedule based on the category of premises connected to the Asafo system as shown in Text-Box 7.1. Similarly, for the Teshie Old Town LIUC, tariffs can be set depending on the size of house (number of households per house/dwelling) and commercial outlets such as "chop"/beer bars as well as public toilets connected to the sewer.

| **Housing and Population Characteristics - Asafo Tenement Pilot Area (1990)** | | | **Applied Fee Schedule for Sewerage Services (2010)** | |
|---|---|---|---|---|
| House Type | No. of Houses | Percentage (%) | Applied Fee (GH¢) | Total Revenue (GH¢) |
| Single Storey | 139 | 43.7 | 3.00 | 417 |
| Two Storey | 152 | 47.8 | 5.00 | 760 |
| Three Storey | 23 | 7.2 | 7.00 | 161 |
| Four Storey | 4 | 1.3 | 7.00 | 28 |
| Total | 318 | 100 | | 1,366.00 |

**Box 7.1: Example of Fees Schedule for categories of dwellings**

These aspects can be properly defined during construction and/or before commencement of full operation of the sewerage system. The community engagement component of this assignment will be very critical during that stage.

The Asafo sewer network relies on a waste stabilisation pond for treatment with no running machinery or equipment in the entire system unlike the many other plants that became dysfunctional due to machinery and electro-mechanical equipment failure leading to shut-down and eventual deterioration of all unit processes.

On the other hand, lessons from the 2-year period when the Accra Sewerage Treatment Plant (UASB) at Mudor was operational also provide opportunity for learning. During the test-run period the designers of the UASB plant (from Lettinga Associates of Netherlands) managed the plant and provided training to counterpart staff of the Accra Metropolitan Assembly (AMA) Sewerage Department, specially recruited for operating the plant. The departure of the external team and subsequent non-payment of electricity bills and inability to replace broken down pumps led to the collapse of the plant.

The lessons from the Asafo simplified sewerage and the Mudor UASB plant, among others, has informed the design of the Teshie Old Town Simplified Sewerage system and will influence proposals for improving O&M management.

**Table 7.2: Summary of Analysis of Successful Aspects of Asafo Simplified Sewerage System**

| ITEM | KEY ISSUE UNDER CONSIDERATION | REASONS FOR SUCCESS |
|---|---|---|
| 1.0 | Innovative Project Design | • Simplified Sewerage adopted is simple and cost-effective<br>• Superior consultancy support services from Consultant (Asafo Boakye & Partners, ABP) |
| 2.0 | Design and construction of the system to a very high standard | • Good Design in accordance with established principles<br>• Effective Supervision of construction<br>• Strict bidding procedure ensured that highly qualified and professional contractor was chosen for works execution. |
| 3.0 | Capacity building of Private sector | • Project planning and implementation was encouraged a policy of active Participation of Private Sector in all aspects.<br>• KMA's commitment to private sector involvement and good facilitative role ensured a conducive environment for the private sector to operate. |
| 4.0 | Emphasis on capacity building of the KMA | • Project design envisaged the KMA as the key implementation agency<br>• All key extension activities were directly provided by seconded multidisciplinary staff of KMA<br>• Most of the Contract staff who worked with the KSP Project continued to work with the KMA even after the end of the Project . |
| 5.0 | Decentralization of management of operation and maintenance services. | • Privatization of operation and maintenance activities<br>• Strict adherence to the conditions of the contract by the KMA. |

**Table 7.3: Summary of Analysis of Not-So-Successful Aspects of Asafo Simplified Sewerage System**

| ITEM | DESCRIPTION OF ACTIVITY | REASONS FOR FAILURE OR ONLY LIMITED SUCCESS. |
|---|---|---|
| 1.0 | Low level of connection to the sewerage system. Less than 35% of potential beneficiaries had connected after 2 years and only 50% after 5 years. 50% are still unconnected. Major institutions like the hospital and army barracks still unconnected. | • High internal plumbing and connection costs<br>• Inability of Kumasi Metropolitan Assembly (KMA) to mobilize demand<br>• Inability of KMA to provide and maintain the required regulatory environment<br>• Lack of financing/credit facilities to support or assist poor households<br>• Discussions on the issue and KMA facilitation still |

| ITEM | DESCRIPTION OF ACTIVITY | REASONS FOR FAILURE OR ONLY LIMITED SUCCESS. |
|---|---|---|
| | | not completed |
| 2.0 | No Arrangement/System in place for Recovery of O&M Costs | • Inability of KMA to conclude discussions with GWCL with regard to billing of users.<br>• Inadequate User Education |
| 3.0 | Compared to condominial systems planning the level of community mobilisation was inadequate. | • Level of extension support and information dissemination was not adequate<br>• Scope of key messages disseminated was not comprehensive<br>• No brochures or supportive literature were provided. |
| 4.0 | Inadequate monitoring and Evaluation of the project, and also poor documentation of system performance and related experiences | • Inadequate efforts by KMA coupled with non-implementation of M & E arrangements<br>• Key partners in M&E- TNC and RWSG were no longer available (TNC folded up in 1994, RWSG closed its Ghana Office in 1995)<br>• Resource constraints within KMA. |
| 5.0 | Inadequate in-house capacity of KMA to update and refine the Strategic Sanitation Plan | • Weak internal/Institutional structures<br>• Poor and inadequate M&E<br>• Resource constraints within KMA |
| 6.0 | Inadequate Sewerage System Maintenance Since 1999 | • Contract of maintenance Contractor not renewed since December 1999<br>• Inability of KMA to generate any revenues from operation of the system to cover O & M costs |
| 7.0 | Weak financial and Cost recovery arrangements. | • There was no contribution<br>• No system in place for filling and collection of user fees<br>• Low connection rate |

Source: The RWSG-WA (now WSP), World Bank, Abidjan- Cote D'Ivoire Final Report, Review of the Asafo Simplified Sewerage Scheme, by Trend Group, 2001 in "A rapid evaluation of the pilot Asafo simplified sewerage scheme in Kumasi, Ghana", pS-Eau/afd. Salifu, L.Y., 2013.

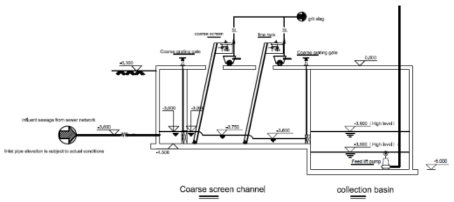
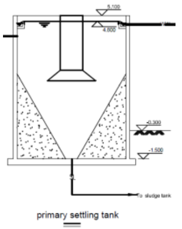
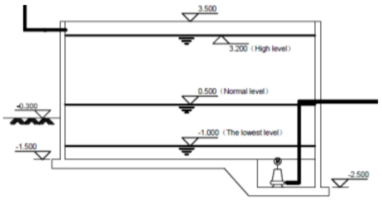
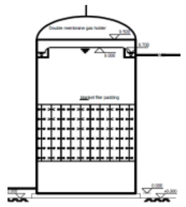
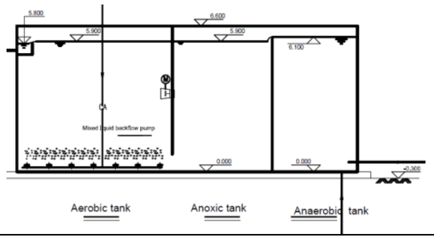
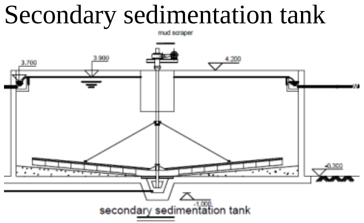
Learning from ingredients of success from international experience, especially from Brazil, prior to commencement of construction of the sewer network representatives of the basins (sewer sheds) will be facilitated to form a neighbourhood organisation to encourage social participation and reaching agreements on where to locate sewer lines and inspection of works. Representatives of basin organisations will complete terms of agreement for the construction of the sewers, operation and maintenance costs as well as the administration of fees to be charged for sewerage services.

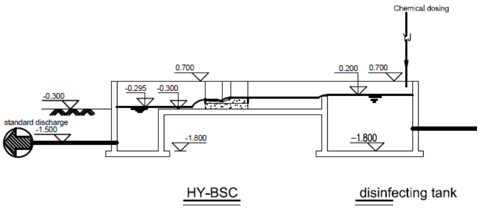
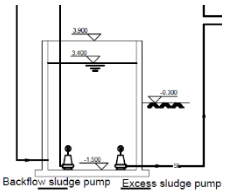
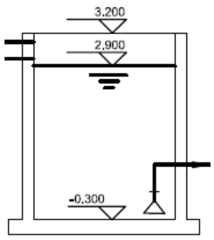
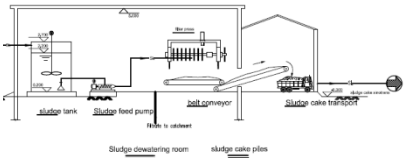
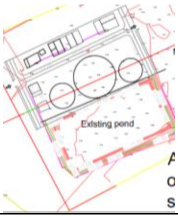
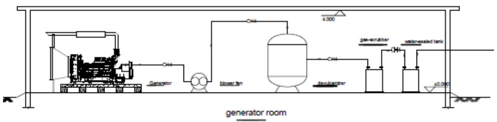
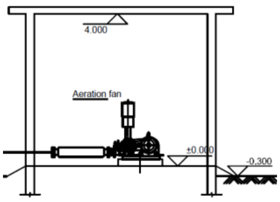
### 7.3 DESCRIPTION OF O&M ACTIVITIES FOR SPECIFIC UNIT PROCESSES

The O&M challenge has to be given special attention and tackled to break the chain of running WTP plants to deterioration and abandonment. Table 7.4 describes the type of O&M activities related to the specific operation and unit processes applied in the Teshie Old Town (i.e. LEKMA) WWTP. It is critical that appropriate sewerage tariff and financing mechanisms from LEKMA that caters for both sewer maintenance and the WWTP process units are defined.

The following Chapter 8, Cost and Financial estimation caters for operation and maintenance over a test-run period of 24 months to be offered by the Consultant's team including training of staff of LEKMA.

**Table 7.4: O&M Activities for Unit Operations and Processes of the proposed LEKMA WWTP**

| No. | UNIT OPERATION AND PROCESS | OPERATION AND MAINTENANCE PROCEDURES |
|---|---|---|
| 1 | Fine screen, coarse screen channel and collection basin<br><br> | Scheduled removal and disposal of debris |
| | | Checking grit accumulation in grit chamber and flush/hose chamber |
| | | Bar screen to be taken out of service for maintenance including removal of obstructions, sanding, painting etc. |
| 2 | Primary Sedimentation tank<br><br> | Frequent removal of by use of hand-operated scum trough for removal of floating oil, grease abd scum from the surfaces. Removal of accumulations e.g. scum and grime from influent/effluent baffles, wiers and blockages e.g. sludge withdrawal pipes |
| | | Close inspection and log of condition of mechanical equipment once on each operation shift |
| | | Draining of primary basin annually for detail inspection of structural integrity and patching of concrete bas e as necessary |
| | | Clean and paint all exposed metal surfaces as necessary |
| 3 | Attenuation tank<br><br> | Regular inspection of inspection chamber for removal of water and sediments; |
| | | Periodic removal of sediments from trough and |
| | | Regular inspection of pump to detect leakages and even vibrations |
| 4 | UBF Tank<br> | Close inspection of air-tight cover and pressure gauge for biogas using manometers |
| | | Regular inspection of filter material to see effectiveness |
| | | Regular inspection of and maintenance pumps, hoists |
| 5 | Tanks (Anaerobic, Anoxic and Aerobic Tanks)<br><br> | Regular inspections of sumps to see accumulation of sediments on bottom of tanks, sump, pumps, hoists |
| | | Regular inspection of repair, maintenance pumps, hoists |
| 6 | Secondary sedimentation tank<br><br> | Remove accumulation from influent baffles, effluent weirs, scum baffles and scum box |
| | | Close inspection and log of condition of mechanical equipment once on each operation shift |
| | | Draining of primary basin annually for detail inspection of structural integrity and patching of concrete bas e as necessary |

| No. | UNIT OPERATION AND PROCESS | OPERATION AND MAINTENANCE PROCEDURES |
|---|---|---|
| 7 | Outlet flow measuring device and Disinfecting tank   | Inspect flow measuring gauge daily and compare calibration to set standard; adjust as required<br>Chemical dosing tank and service pump to be checked daily for proper feed.<br>Perform coliform count periodically and compare to set disinfection standards<br>Drain chemical dosing chamber annually, remove sediments and inspect structural integrity; patch defective concrete area as required. |
| 8 | Sludge recirculation tank   | Check sludge level and feed pipes daily and inspect submersible dive pump by hoisting<br>Clean all vertical walls and channels daily using squilgee<br>Record daily temperature and flow of recirculated sludge<br>Collect bi-weekly samples of recirculated sludge and determine pH, alkalinity, TS, TVS etc. |
| 9 | Sludge thickener   | Check sludge level and feed pipes daily and inspect submersible dive pump by hoisting<br>Clean all vertical walls and channels daily using squilgee<br>Drain thickener annually and inspect sub-surface concrete structure and patch defective concrete<br>Metal surfaces inspected for corrosion, sand/blasting and painting. |
| 10 | Sludge dewatering room and sludge cake piles  | Supply of Sodium Hypochloride<br>Hose down all sludge spillage daily<br>Conveyor cloth should be washed as specified by equipment supplier<br>Routinely check drive and gear reducers; drive chains and sprockets, suction lines and pumps and conveyor bearing for wear, corrosion and proper torque |
| 11 | Waste Stabilisation (Polishing) pond  | Inspect ponds embankment and slopes for integrity of stone pitching<br>Check rate of accumulation of sediments periodically<br>Check inlet and outlet flow rates<br>Take samples of inflow and outflow for quality tests |
| 12 | Generator room  | Check all biogas balloons for integrity of material for tear and leakage of gas<br>Check daily pressure and volume of gas in storage bags<br>Check daily pumps and gas conveyance pipes<br>Routinely service electricity generator as specified by manufacturer |
| 13 | Blower room   | Check daily the rotors of pumps and ventilation fans |

# 8. COST AND FINANCIAL ESTIMATES

## 8.1 PROJECT COST

The summary of cost estimates for the construction of the sewerage system comprising the described sewer network, appurtenances and wastewater treatment plant works for Teshie Old Town/WWTP enclave is presented in Table 8-1 below.

**Table 8-1: Estimate of the GAMA-SWP Teshie Old Town/WWTP Enclave Sewerage Project**

| Bill | Description | Amount (Gh¢) |
|---|---|---|
| 01. | General Items | **1,253,750.00** |
| 02. | Gravity Sewerage Works Construction | **5,963,431.13** |
| 03. | Sewerage Manholes & Grease Traps | **2,836,234.63** |
| 04. | Sewage Treatment Plant Civil Works | **7,974,861.94** |
| 05. | Sewage Treatment Plant Electromechanical Works | **5,927,140.00** |
| 06. | Sewage Treatment Plant Pipework & Pipework Ancillaries | **864,003.80** |
| 07. | Sewage Treatment Plant Electrical Works | **1,135,157.81** |
| 08. | Sewage Treatment Plant Instrumentation | **64,837.00** |
| 09. | Operation And Maintenance Provisions | **553,755.00** |
| 10. | Environmental & Social Safeguards Implementation | **270,297.25** |
| 11. | GS & WWTP Systems Management Team Office | **468,989.00** |
| 12. | Wwtp Laboratory Building | **260,258.50** |
| **A** | **Sub-Total** | **27,572,716.05** |
| **B** | **Add 7.5% Of Sub-Total As Contingency** | **2,067,953.70** |
| **C** | **Total Tender Price (A+B)** | **29,640,669.75** |
| **D** | **Discount (……..)% If Any** | |
| **E** | **Total Tender Price Carried To Form Of Tender** | **29,640,669.75** |

The estimated cost of constructing the Teshie Old Town and WWTP enclave simplified sewers and construction of a new WWTP is Twenty-nine million, six hundred and forty thousand, six hundred and seventy Ghana cedis (**GHS 29,640,670.00**)[2]; equivalent to US Dollars Five million, three hundred and eighty nine thousand, two hundred and twelve dollars and sixty eight cents (**US$5,389,212.68**).

[2] US1=GHS5.50

## 8.2 COMMENTARY ON INCIDENTAL PROJECT REGULATORY COSTS

The project estimates presented in Section 8.1 captures costs of compliance of important regulatory provisions of the World Bank and the Environmental Protection Agency (EPA) of Ghana. Key among these is the implementation of environmental and social safeguards resulting from impact analyses and the compensation valuation of persons to be affected by the implementation of the proposed project.

The above aspects are presented in detail in two (2) separate reports (i) the Environmental Impact Statement to this project, and (ii) the related Compensation Valuation analysis prepared as part of Resettlement Action Plan (RAP).

### 8.2.1 Environmental and Social Safeguards

The impact mitigation analysis is presented in detail in the Environmental Impact Statement (EIS) to this project which is submitted as a separate report. Cost elements of impact mitigation management and the Environmental and Social Management Plan (ESMP) including environmental and social monitoring reporting are presented in the EIS.

The Operation and Maintenance (O&M) management provisions are captured in Table 8.1 as part of O&M provisions (Item No.9) and the cost of implementation for Environmental and Social Safeguards (Item No. 10). Further details of these items are presented in the comprehensive Bill of Quantities (BoQs) of this presented as a separate volume.

### 8.2.2 Compensation Valuation of Project Affected Persons

In compliance with relevant legal and regulatory framework guiding compensation for project affected persons (PAPs) a Resettlement Action Plan (RAP) was prepared and submitted as a separate report.

The RAP provides details of PAPs compensations and implementation issues. It is expected that the Government of Ghana (GoG) through the Ministry of Finance will provide funds for direct compensation to project affected persons and the budget of RAP Implementation including grievance redress mechanism as well as monitoring and evaluation.

The costs of re-instatement of partial demolishing of properties (pavements, floors and walls of rooms/fences) are captured in the Bill of Quantities (BoQs), presented in Table 8.1, Item No.4 WWTP Civil Works.

# 9. CONCLUSION

## 9.1 IMPLEMENTATION AGENCY

The proposed construction of the simplified sewer network and treatment plant for Teshie Old Town and the WWTP enclave is part of International Development Agency (IDA) financed Greater Accra Metropolitan Area (GAMA) Sanitation and Water Project, implemented by LEKMA under direct facilitation support of the Ministry of Sanitation and Water Resources (MSWR).

## 9.2 AGENCY RESPONSIBLE FOR OPERATION AND MAINTENANCE

After successful testing and commissioning of all components, the assets will be transferred to the LEKMA for taking care of operation and maintenance responsibilities.

Considering the financial, technical & human resource constraints of LEKMA and based on experience from similar projects it is proposed that capacity building of municipal staff in oversight of operation and maintenance of the sewerage network and treatment plant is provided by the Consultants PD/WasteCare Associates JV during the first (2) years. The physical facilities management shall include provision of adequate training for the MA's O&M team prior to final transfer of the project to the MA. It is expected that after the two (2) years all treatment bottlenecks that comes with each of the unit operations and/or processes would have been encountered and the trained O&M team of the MA would have gained adequate skill/expertise to continue with oversight of the facility.

It is expected that LEKMA with back-stopping support from the Consultant will evaluate management options for the sewerage system including the engagement of private operator.

## 9.3 IMPLEMENTATION PLAN

The following major activities have been proposed for implementation of remaining aspects of the project:

### 9.3.1 Preparation of Bid Document

The draft bid document for this project has been prepared and is submitted for review and comments by the MSWR-GAMA-PCU/LEKMA. The final version will be produced incorporating review comments, and then for commencement of procurement process.

### 9.3.2 Bidding Process & Award of Contract

The Consultant will assist LEKMA to invite and receive competitive bids at the national level. The bids will be evaluated for technical and financial competence and work will be awarded to the lowest responsive bidder.

### 9.3.3 Project Execution

The project will be executed by the responsive contractor who will be awarded the works by the MSWR-GAMA-PCU and LEKMA. The supervision of construction work will be carried out by PD/WasteCare Associates JV.

### 9.3.4 Implementation Period and Work Plan

Three (3) months have been proposed for the following pre-construction activities that is left to be done

1) Review of draft bid documents and draft detailed design report,
2) Carry out the bidding process and award of Contract.

After the award of contract three (3) months of project construction period will be used to carry out the following:

1) Pre-construction start-up meeting,
2) Engage with utility agencies, Ghana standards board and the EPA for relevant statutory duties,
3) Engage in community sensitization for smooth project implementation,
4) Mobilize personnel, equipment and materials to site

A total of twelve (12) months will be required to execute physical construction of the project scope of works (See Figure 9.1). A further 3 months is proposed to cater for unforeseen delays.

| | **Proposed Implementation Plan** | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Activity** | **Months** | | | | | | | | | | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
| Review of draft bid documents and draft detailed design report | | | | | | | | | | | | | | | | | | |
| Carry out the bidding process and award of Contract | | | | | | | | | | | | | | | | | | |
| Pre-contract start-up meeting | | | | | | | | | | | | | | | | | | |
| Engagement with utility agencies, Ghana standards board and the EPA. | | | | | | | | | | | | | | | | | | |
| Community sensitization for smooth project implementation | | | | | | | | | | | | | | | | | | |
| Mobilize personnel, equipment and materials to site | | | | | | | | | | | | | | | | | | |
| Construction works | | | | | | | | | | | | | | | | | | |

**Figure 9.1: Proposed Implementation Schedule**

### 9.3.5 Contract Packaging

The whole project is proposed to be executed in a single package (i.e. one,1, -lot) comprising the scope of simplified sewerage network, sewage treatment plant works, operation and maintenance facilities provisions for the maintenance period and monitoring/supervision for implementation of environmental and social impacts mitigation measures during construction and post construction periods.

### 9.3.6 Project Funding

The project will be funded as part of the IDA/World Bank financed GAMA-SWP [LOAN/CREDIT No.: IDAH4850] with counterpart funding from Government of the Republic Ghana/MSWR.

# ANNEXES

**A Tentative Annual Cost Estimates For Operation And Maintenance (O&M) Management**

**B Project Drawings & Technical Reports**

B1. LIUC Sewerage Network Layout

B2. Plan View of WWTP

B3. Standard Drawings of LIUC Sewerage Network

B4. Standard Drawings of Sewage Treatment Plant Facilities

B5. ESIA and RAP Reports

**C Sewerage Network Hydraulic Analysis**

C1. Analysis of Basin Flows

C2 Hydraulic Analysis of Sewer Flows

**ANNEX A: Tentative Annual Cost Estimates for Operation and Maintenance (O&M) Management**

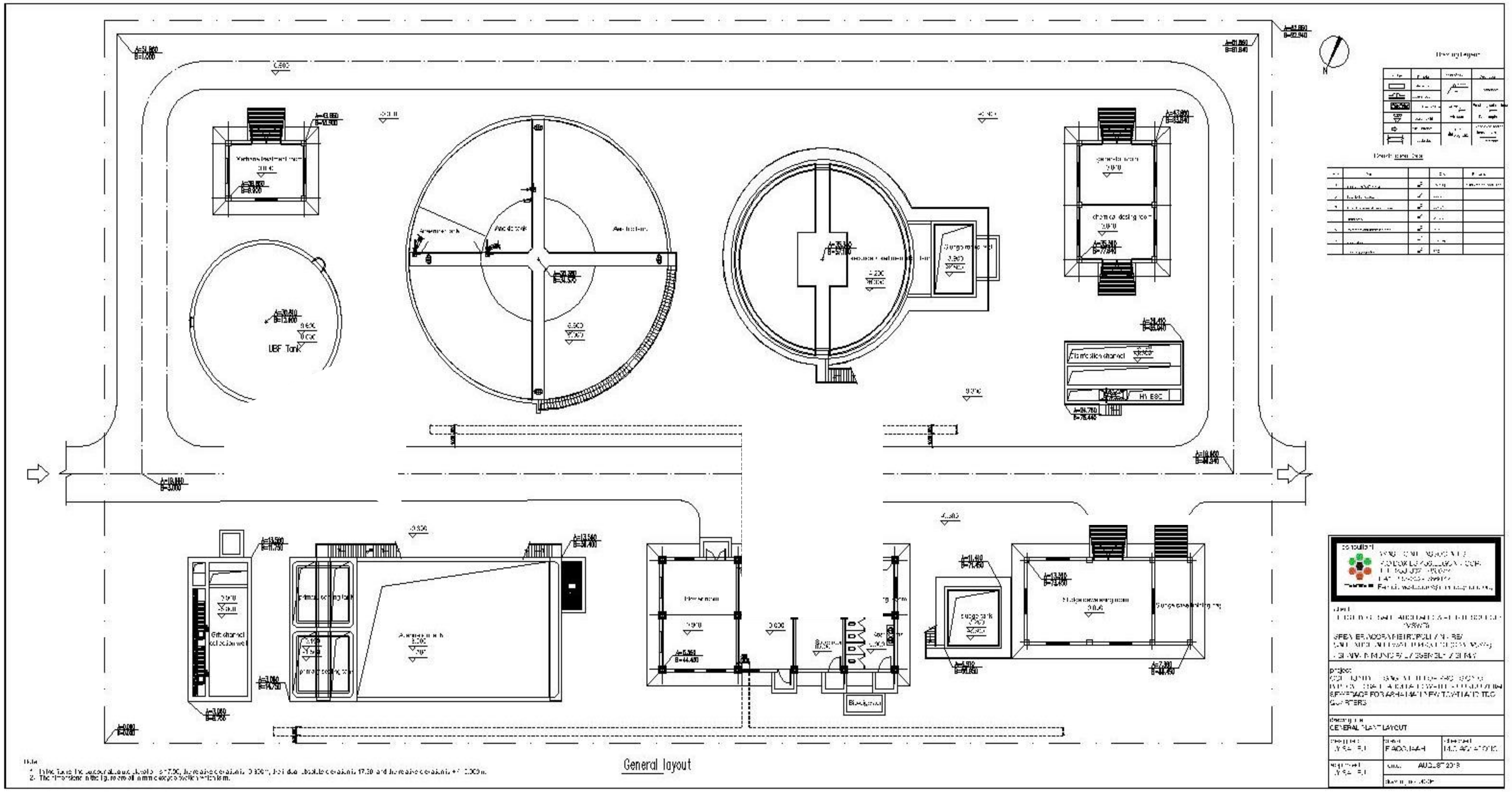
| No. | Unit of Operation and Process | Activity | Annual Cost Estimate (USD) |
|---|---|---|---|
| ***A. O&M Activities for Sewers*** | | | |
| 1 | Sewer network | Cleaning of grease traps | 9,700 |
| 2 | | Repairs and removal of blockages | |
| 3 | | Checking inspection chambers, appurtenances such as pumps and controls, vacuum and surge chambers, check valves | |
| 4 | | Inspection of street sewers | |
| | ***Sub-Total*** | | ***9,700.00*** |
| ***B. O&M Activities for the proposed LEKMA WWTP*** | | | |
| 1 | Fine screen, coarse screen channel and collection basin | Scheduled removal and disposal of debris | 1,200.00 |
| 2 | | Checking grit accumulation in grit chamber and flush/hose chamber | |
| 3 | | Bar screen to be taken out of service for maintenance including removal of obstructions, sanding, painting etc. | |
| 4 | Primary Sedimentation tank | Frequent removal of by use of hand-operated scum trough for removal of floating oil, grease abd scum from the surfaces. Removal of accumulations e.g. scum and grime from influent/effluent baffles, wiers and blockages e.g. sludge withdrawal pipes | 1,800.00 |
| 5 | | Close inspection and log of condition of mechanical equipment once on each operation shift | |
| 6 | | Draining of primary basin annually for detail inspection of structural integrity and patching of concrete bas e as necessary | |
| 7 | | Cleaning and painting of all exposed metal surfaces as necessary | |
| 8 | Attenuation tank | Regular inspection of inspection chamber for removal of water and sediments | 600.00 |
| 9 | | Periodic removal of sediments from trough and | |
| 10 | | Regular inspection of pump to detect leakages and even vibrations | |
| 11 | UBF Tank | Close inspection of air-tight cover and pressure gauge for biogas using manometers | 1,440.00 |
| 12 | | Regular inspection of filter material to see effectiveness | |
| 13 | | Regular inspection of and maintenance pumps, hoists | |
| 14 | Tanks (Anaerobic, Anoxic and Aerobic Tanks) | Regular inspections of sumps to see accumulation of sediments on bottom of tanks, sump, pumps, hoists | 1,800.00 |
| 15 | | Regular inspection of repair, maintenance pumps, hoists | |
| 16 | Secondary sedimentation tank | Remove accumulation from influent baffles, effluent weirs, scum baffles and scum box | 3,000.00 |
| 17 | | Close inspection and log of condition of mechanical equipment once on each operation shift | |
| 18 | | Draining of primary basin annually for detail inspection of structural integrity and patching of concrete bas e as necessary | |

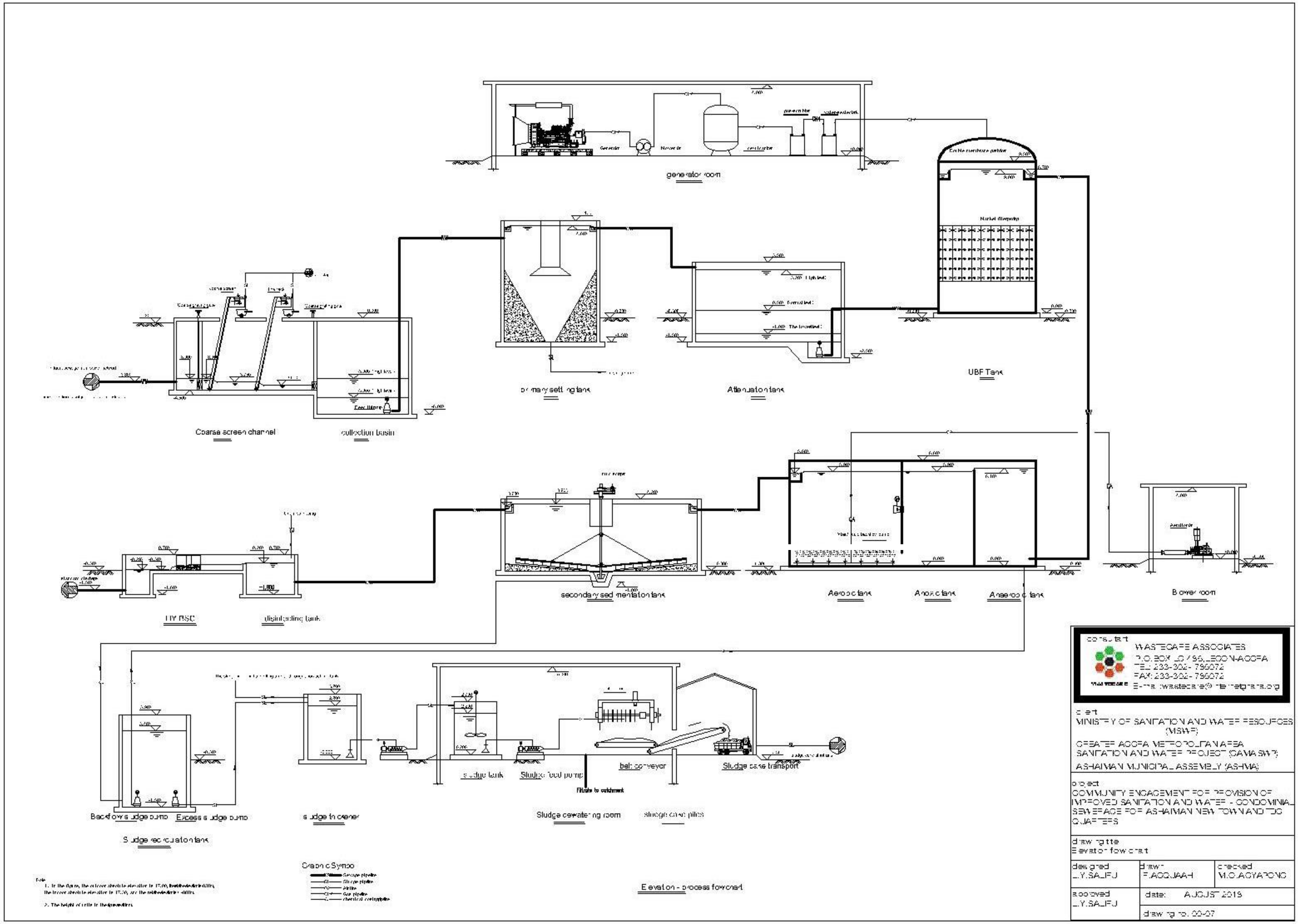
| No. | Unit of Operation and Process | Activity | Annual Cost Estimate (USD) |
|---|---|---|---|
| 19 | Outlet flow measuring device and Disinfecting tank | Daily Inspection of flow measuring gaug and comparing of calibration to set standard; adjust as required | 600.00 |
| 20 | | Chemical dosing tank and service pump to be checked daily for proper feed. | |
| 21 | | Perform coliform count periodically and compare to set disinfection standards | |
| 22 | | Drain chemical dosing chamber annually, remove sediments and inspect structural integrity; patch defective concrete area as required. | |
| 23 | Sludge recirculation tank | Check sludge level and feed pipes daily and inspect submersible dive pump by hoisting | 900.00 |
| 24 | | Clean all vertical walls and channels daily using squilgee | |
| 25 | | Record daily temperature and flow of recirculated sludge | |
| 26 | | Collect bi-weekly samples of recirculated sludge and determine pH, alkalinity, TS, TVS etc. | |
| 27 | Sludge thickener | Check sludge level and feed pipes daily and inspect submersible dive pump by hoisting | 1,200.00 |
| 28 | | Clean all vertical walls and channels daily using squilgee | |
| 29 | | Drain thickner annually and inspect sub-surface concrete structure and patch defective concrete | |
| 30 | | Metal surfaces inspected for corrosion, sand/blasting and painting. | |
| 31 | Sludge dewatering room and sludge cake piles | Supply of Sodium Hypochloride | 300.00 |
| 32 | | Routinely check drive and gear reducers; drive chains and sprockets, suction lines and pumps and conveyor bearing for wear, corrosion and proper torque | 1,800.00 |
| 33 | | Hose down all sludge spillage daily | |
| 34 | | Conveyor cloth should be washed as specified by equipment supplier | |
| 35 | Waste Stabilisation (Polishing) pond | Inspect ponds embankment and slopes for integrity of stone pitching | 600.00 |
| 36 | | Checking of rate of accumulation of sediments periodically | |
| 37 | | Checking of inlet and outlet flow rates | |
| 39 | Generator room | Checking of all biogas balloons for integrity of material for tear and leakage of gas | 1,800.00 |
| 40 | | Checking daily pressure and volume of gas in storage bags | |
| 41 | | Check daily pumps and gas conveyance pipes | |
| 42 | | Routinely service electricity generator as specified by manufacturer | |
| 43 | Blower room | Daily checking of the rotors of pumps and ventilation fans | 900.00 |
| | ***Sub-Total*** | | ***17,940.00*** |

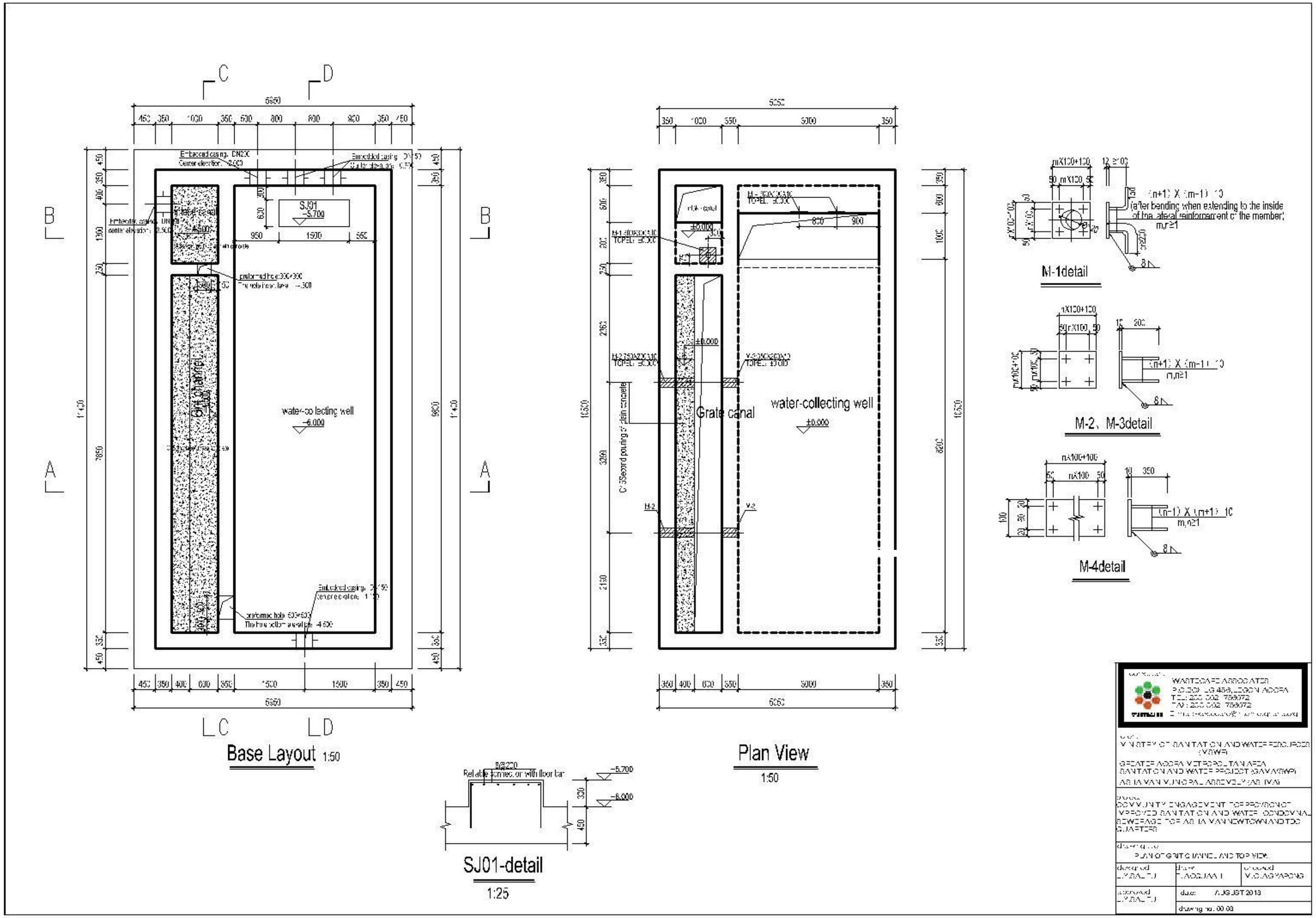
| No. | Unit of Operation and Process | Activity | Annual Cost Estimate (USD) |
|---|---|---|---|
| ***C. O&M Activities for Implementation of Environmental and Social Moniitoring Plan (ESMP)*** | | | |
| | **Environmental and Social Component** | **Monitoring Parameters** | **Annual Cost Estimate (USD)** |
| 1 | Ambient air quality | Number of complaints about odours | 2,349.62 |
| 2 | Noise Levels | Leq, Lmax, Lmin (dBA) | 2,349.62 |
| 3 | STP Effluent Quality | pH, Temperature, color,<br>Dissolved Oxygen, Suspended Solids | 17,906.95 |
| 4 | | COD, BOD, Ammonia, Phosphate, Alkalinity | 7,228.20 |
| 5 | | Nitrates, Sulphates | 490.60 |
| 6 | | Total coliforms, faecal coliforms | 3,139.85 |
| 7 | | Metals (Al, Bo, Cd, Cr, Cu, Fe, Pb, K, Si, Mn, Mo, Ni, Se, Va, Zn, Hg) | 1,907.89 |
| 8 | | Availability of Record of laboratory analysis data | 1,973.68 |
| 9 | | Available monitoring and repair works records; ypes of repair challenges faced | 187.97 |
| 10 | STP Sludge Quality | Dry and organic matter | 556.02 |
| 11 | | Heavy metals (As, Cd, Cr, Cu, Pb, Hg, Zn) | 3,815.79 |
| 12 | | Primary nutrients (N, NH4N, P, K) and secondary nutrients (Ca, Mg, S, Na and oligoelements) | 2,725.56 |
| 13 | | Pathogen microorganisms (Faecal coliforms, E. Coli…) | 784.96 |
| 14 | | Organic compounds (AOX, PAH, PCB, PCDD/F) | 817.67 |
| 15 | Public Complaints and Grievances | ▪ Type and nature of complaints and concerns;<br>▪ Complaint records<br>(Record of grievance and number resolved/unresolved)<br>▪ Management and Stakeholder Meetings | 5,169.17 |
| 16 | Public health and sanitation | ▪ Observable measures for restriction of public access to treatment facilities<br>▪ Record on sewer maintenance activities<br>▪ Record of sewer leakages reported by the public<br>▪ Observable conditions of sewer manholes and sewer lines<br>▪ Record of accidents involving people falling in manholes | 2,819.55 |
| 17 | Waste management | Availability of O&M Plan<br>Availability of dust bins<br>Record of disposal of wastes to approved waste dumps | 939.85 |
| | ***Sub-Total*** | | ***55,162.97*** |
| ***D.*** | ***Other General O&M Activities*** | | |
| 1 | Electricity service charges for operation WWTP | | 2,558.74 |
| 2 | Training and coaching of MMA staff to manage simplified sewerage system | | 12,000.00 |
| 3 | Provision of stationary | | 600.00 |
| | ***Sub-Total*** | | ***15,158.74*** |
| | | | |
| | **Total Annual Estimate O&M Cost** | | **97,961.71** |

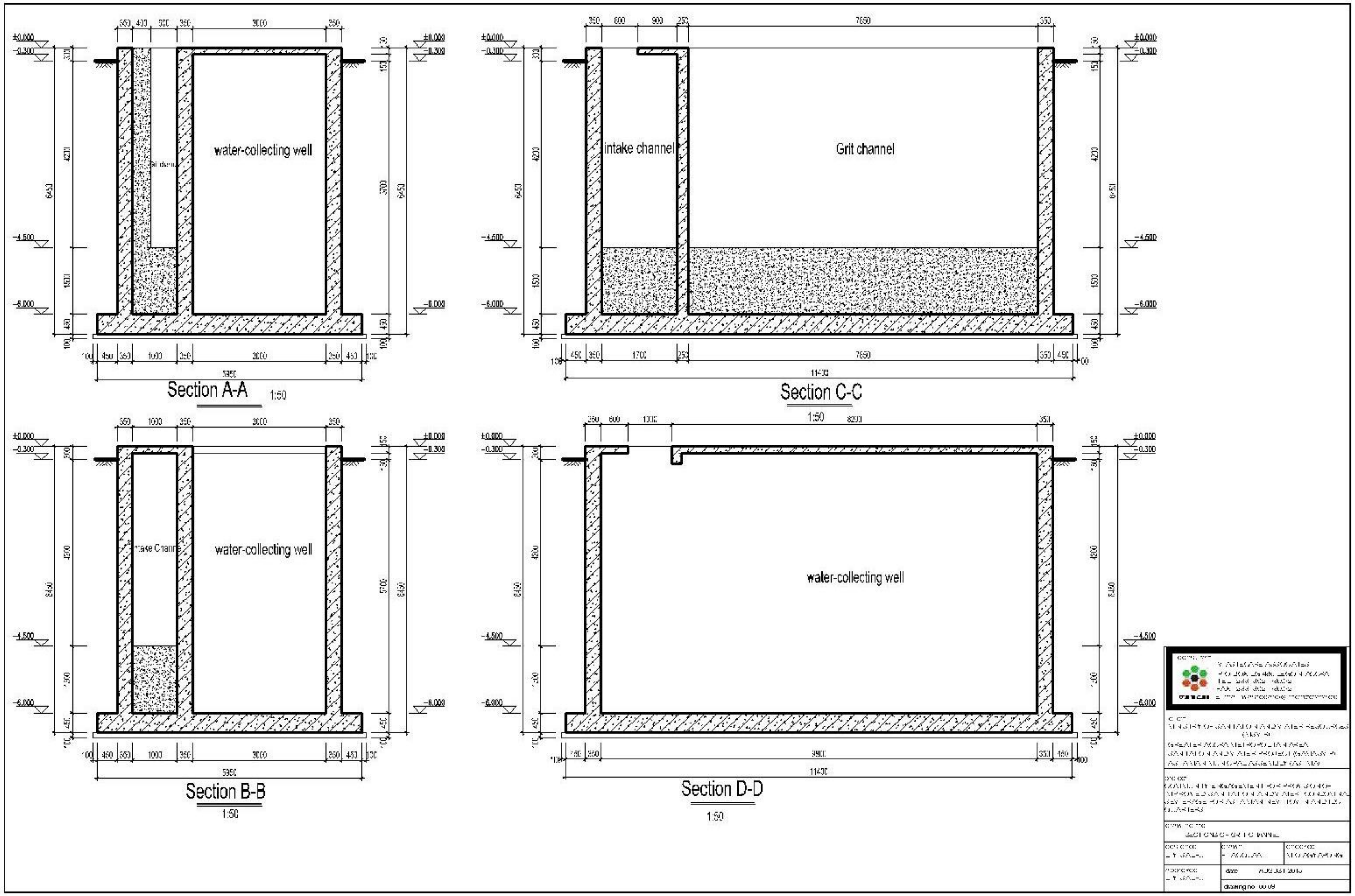
**ANNEX B**: **Project Drawings & Technical Reports**

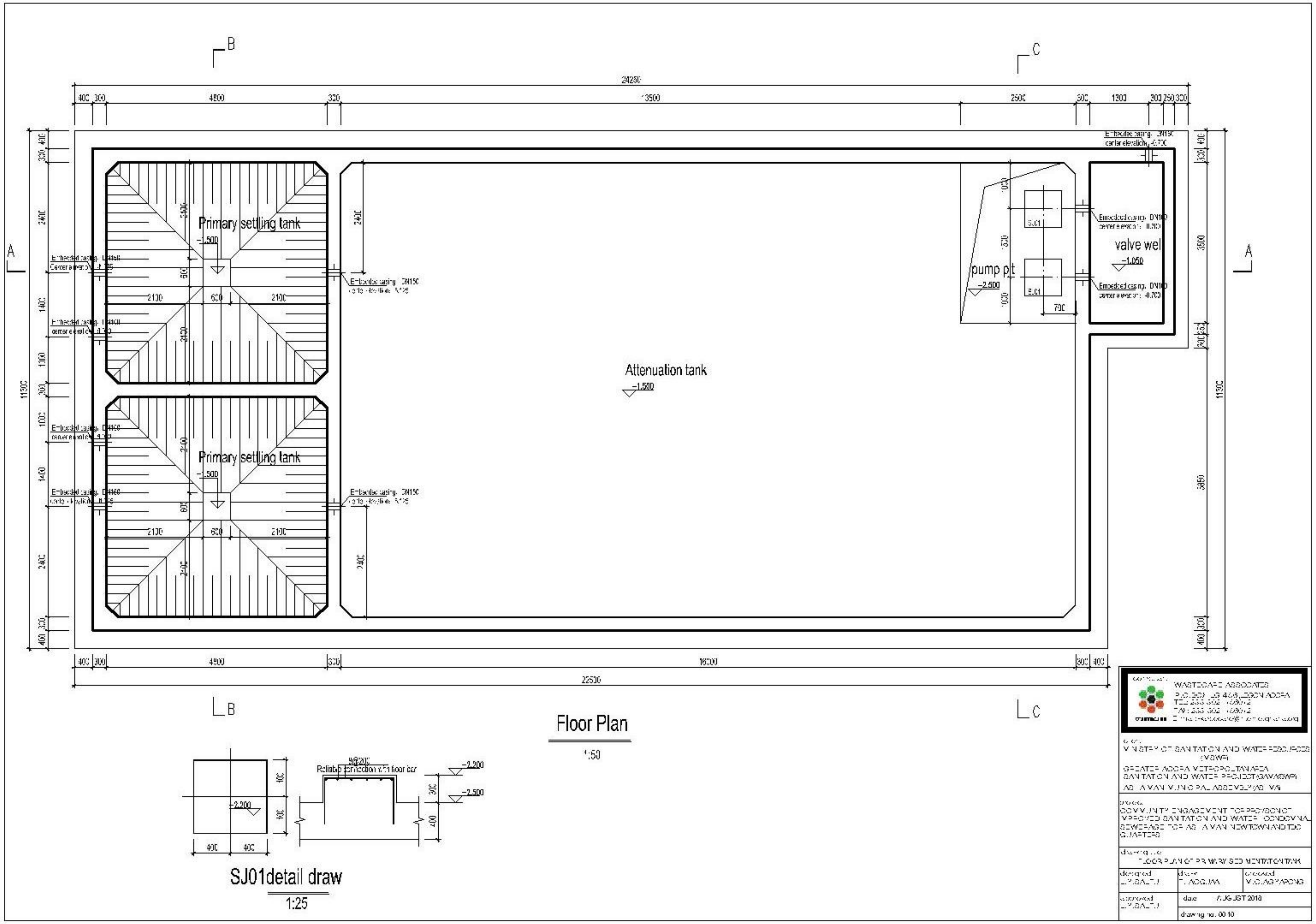

GULF OF GUINEA


UBF Tank
General layout

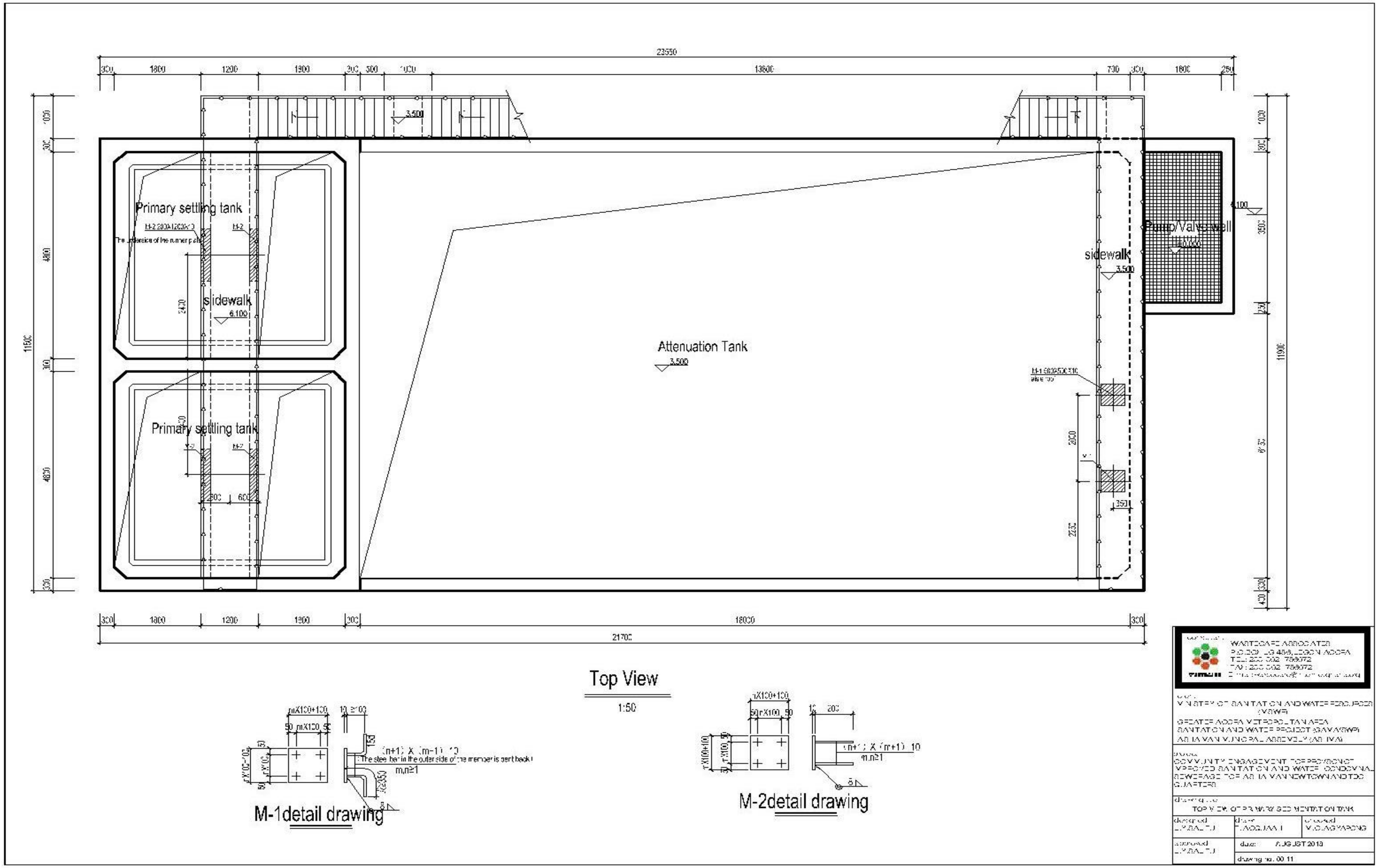

generator room
primary settling tank
Attenuation tank
UBF Tank
Coarse screen channel
collection basin
secondary sedimentation tank
Aerobic tank
Anoxic tank
Anaerobic tank
Blower room
disinfecting tank
sludge tank
Sludge feed pump
belt conveyer
Sludge cake transport
Backflow sludge pump
Excess sludge pump
sludge thickener
Sludge dewatering room
sludge cake piles
Sludge recirculation tank
Graphic Symbol
Elevation - process flowchart
consultant
WASTECARE ASSOCIATES
P.O. BOX LG 796, LEGON-ACCRA
TEL 233-302-796072
FAX: 233-302-796072
client
MINISTRY OF SANITATION AND WATER RESOURCES (MSWR)
GREATER ACCRA METROPOLITAN AREA SANITATION AND WATER PROJECT (GAMA SWP)
ASHAIMAN MUNICIPAL ASSEMBLY (ASHMA)
project
COMMUNITY ENGAGEMENT FOR PROVISION OF IMPROVED SANITATION AND WATER - CONDOMINIAL SEWERAGE FOR ASHAIMAN NEW TOWN AND TDC QUARTERS
drawing title
Elevation flow chart
designed
L.Y.SALIFU
drawn
F.ACQUAAH
checked
M.O.AGYAPONG
approved
L.Y.SALIFU
date: AUGUST 2019
drawing no. 00-07

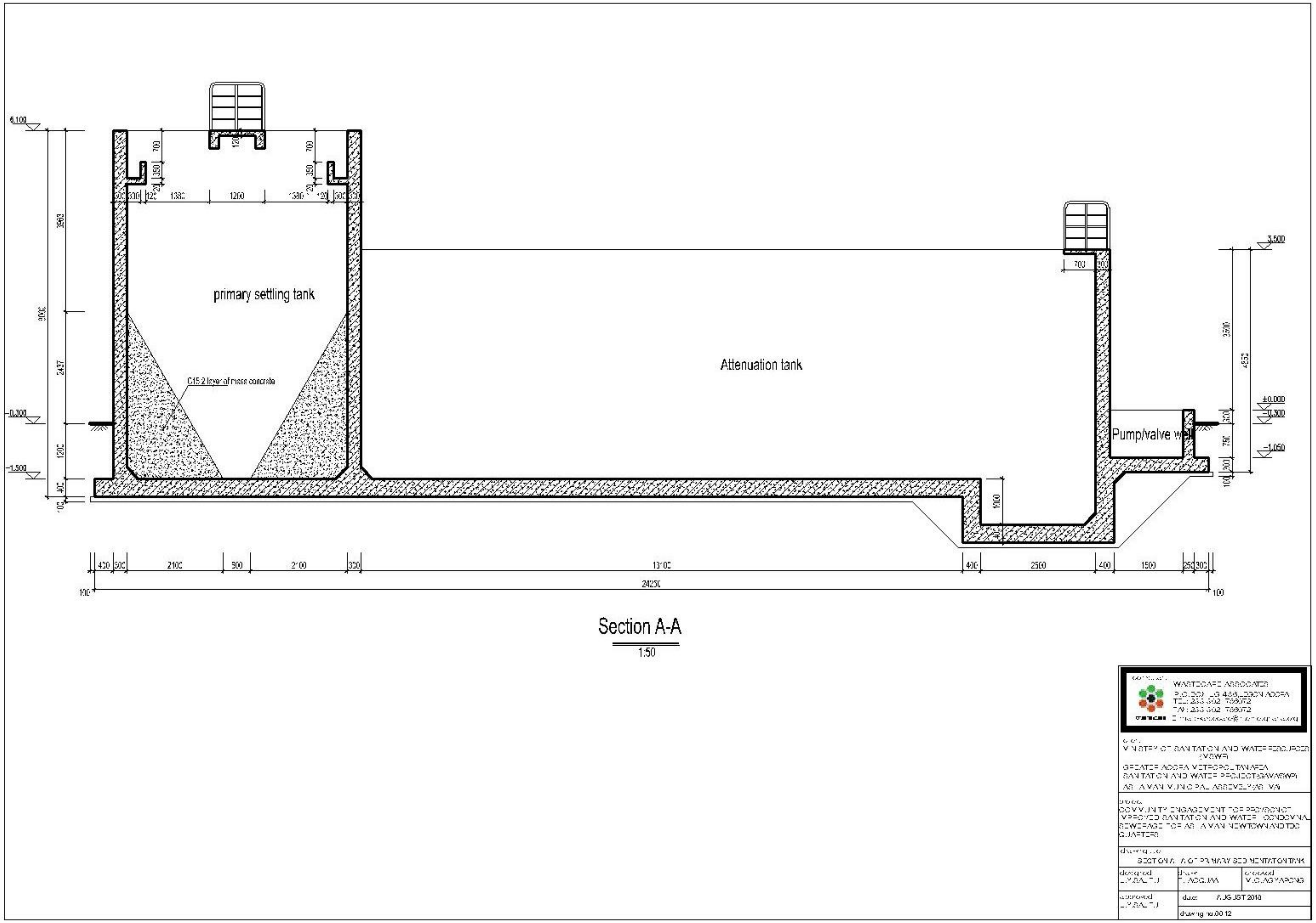

Base Layout 1:50
water-collecting well
Grit channel
SJ01
Plan View
1:50
Grate canal
water-collecting well
SJ01-detail
1:25
M-1detail
M-2、M-3detail
M-4detail
WASTECARE ASSOCIATES
MINISTRY OF SANITATION AND WATER RESOURCES (MSWR)
GREATER ACCRA METROPOLITAN AREA SANITATION AND WATER PROJECT (GAMA-SWP)
AUGUST 2018

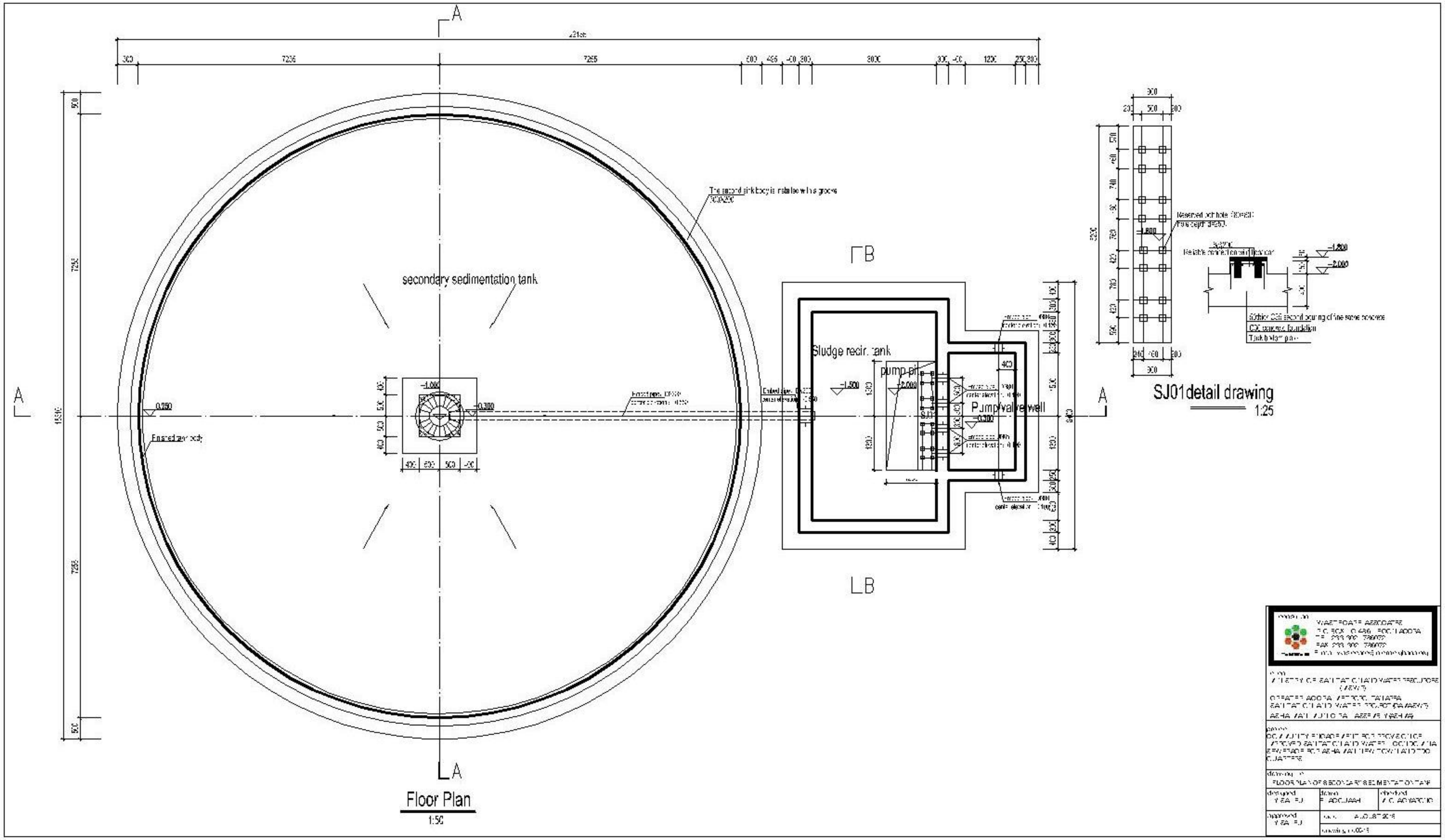

water-collecting well
Section A-A
1:50
intake channel
Grit channel
Section C-C
1:50
water-collecting well
Section B-B
1:50
water-collecting well
Section D-D
1:50

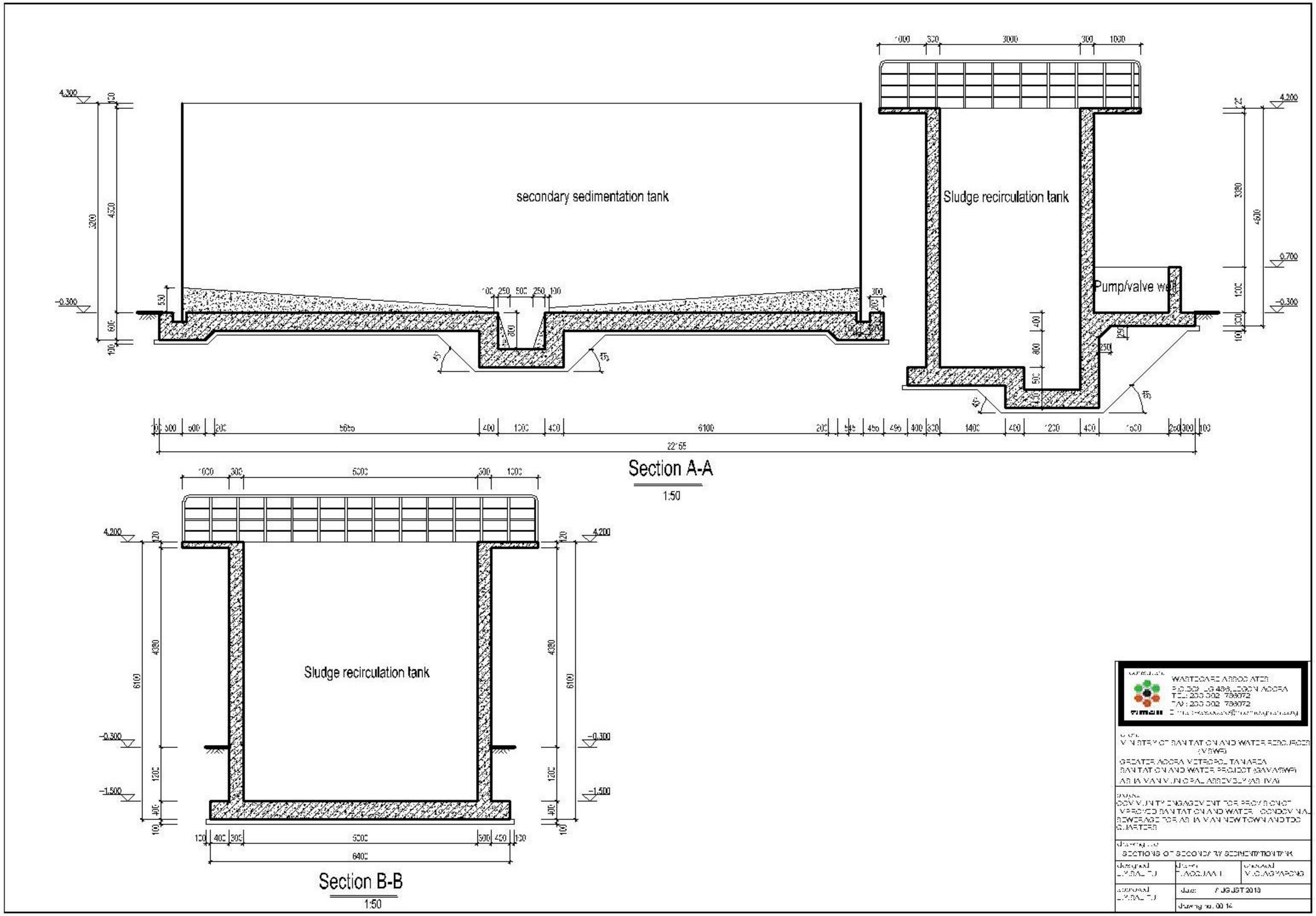


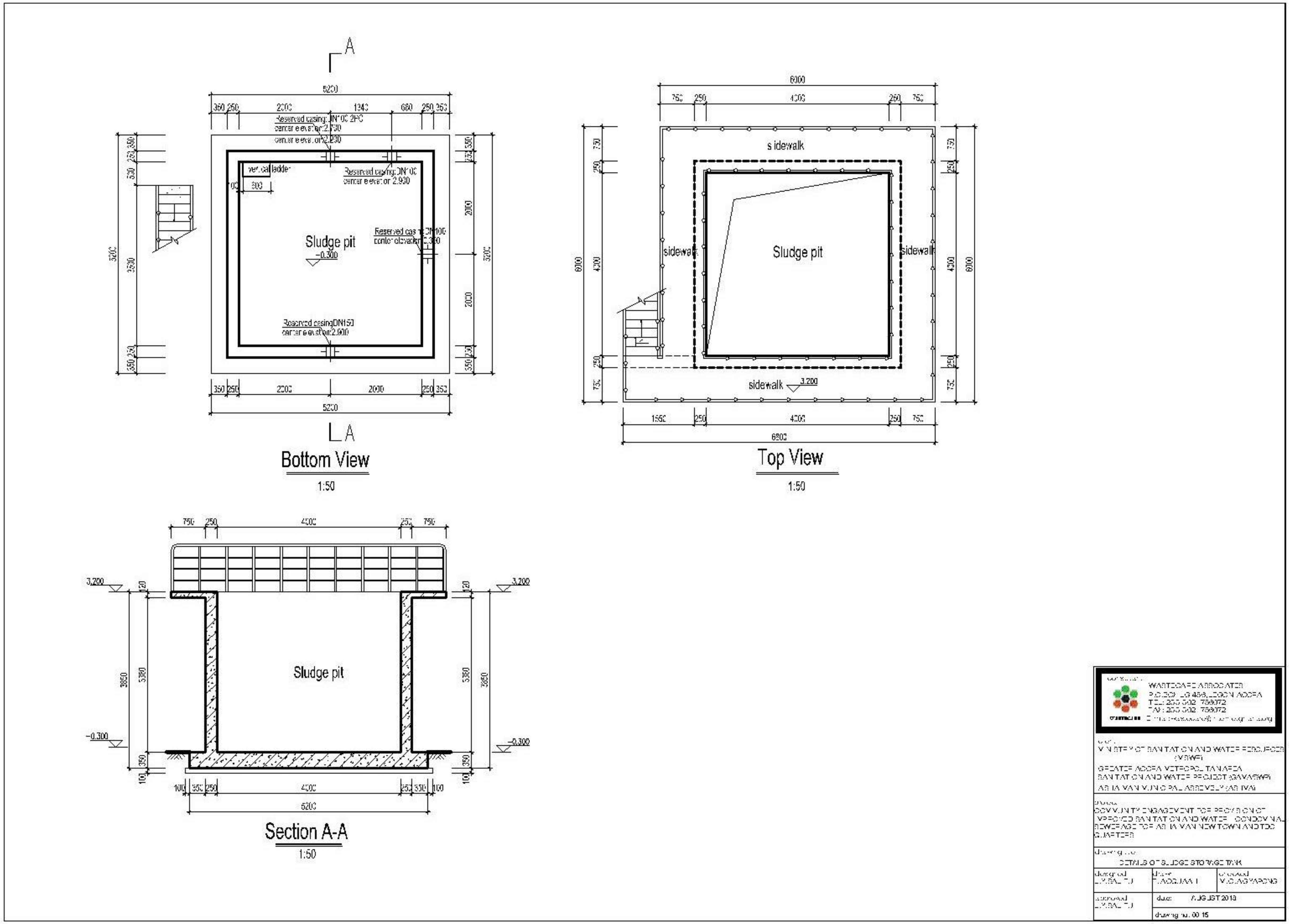
Primary settling tank
Primary settling tank
Attenuation tank
pump pit
valve wel
Floor Plan
1:50
SJ01detail draw
1:25

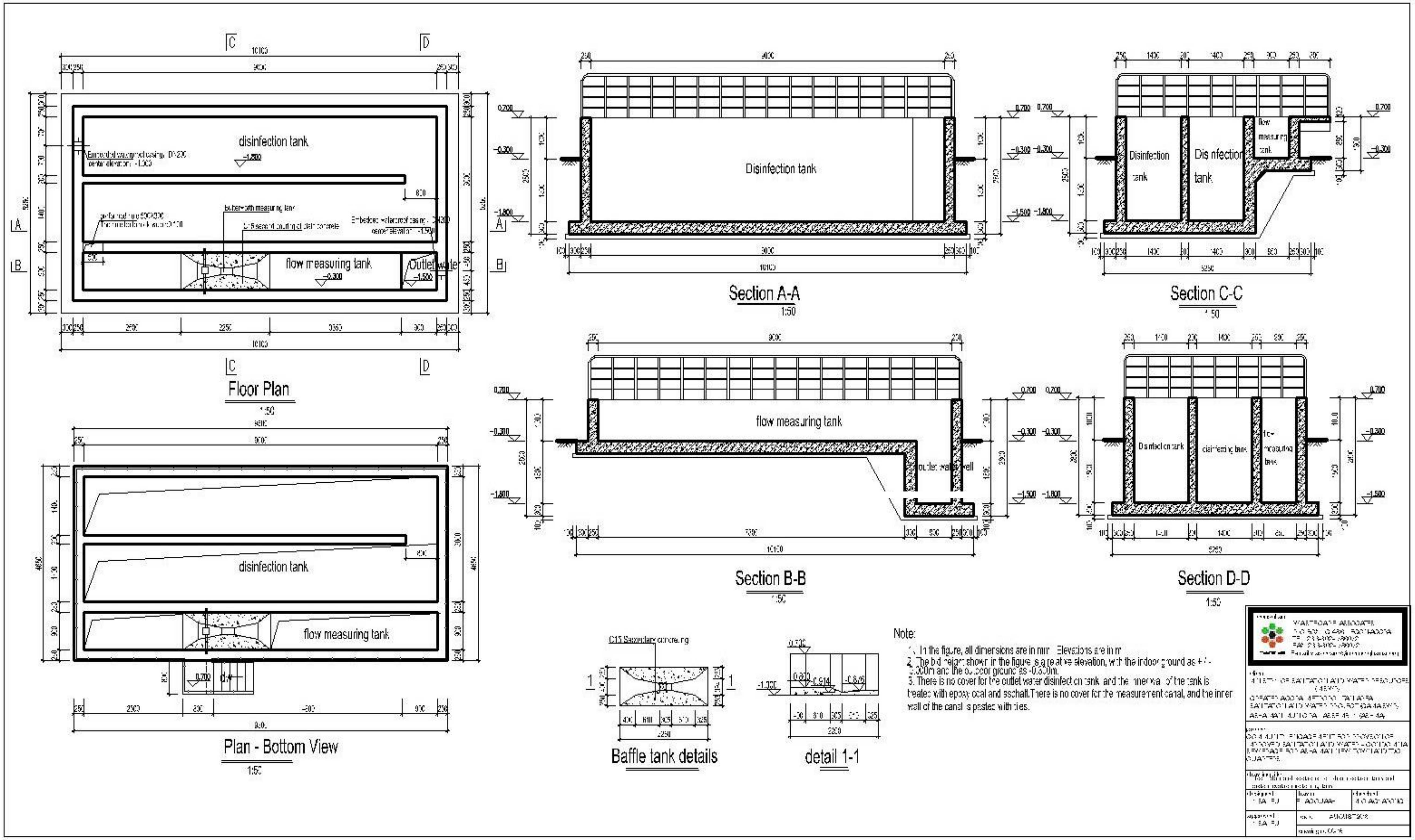

Primary settling tank
sidewalk
Primary settling tank
Attenuation Tank
Pump/Valve well
sidewalk
Top View
1:50
M-1detail drawing
M-2detail drawing
WASTECARE ASSOCIATES
MINISTRY OF SANITATION AND WATER RESOURCES (MSWR)
TOP VIEW OF PRIMARY SEDIMENTATION TANK
AUGUST 2018


primary settling tank
C15 2 layer of mass concrete
Attenuation tank
Pump/valve well
Section A-A
1:50


A
B
secondary sedimentation tank
Sludge recir. tank
pump pit
Pump/valve well
SJ01detail drawing
1:25
Floor Plan
1:50


secondary sedimentation tank
Sludge recirculation tank
Pump/valve well
Section A-A
1:50
Sludge recirculation tank
Section B-B
1:50
WASTECARE ASSOCIATES
SECTIONS OF SECONDARY SEDIMENTATION TANK
AUGUST 2013


Sludge pit
Reserved casing:DN150
center elevation:2.900
vertical ladder
Bottom View
1:50
sidewalk
Sludge pit
3.200
Top View
1:50
Sludge pit
3.200
-0.300
Section A-A
1:50
DETAILS OF SLUDGE STORAGE TANK
AUGUST 2013


disinfection tank
flow measuring tank
Outlet water
Floor Plan
1:50
Disinfection tank
Section A-A
1:50
Disinfection tank
Section C-C
flow measuring tank
outlet water well
Section B-B
1:50
Section D-D
1:50
disinfection tank
flow measuring tank
Plan - Bottom View
1:50
C15 Secondary concreting
Baffle tank details
detail 1-1
Note:
3. There is no cover for the outlet water disinfection tank
treated with epoxy coal and asphalt. There is no cover for the measurement canal, and the inner
wall of the canal is pasted with tiles.
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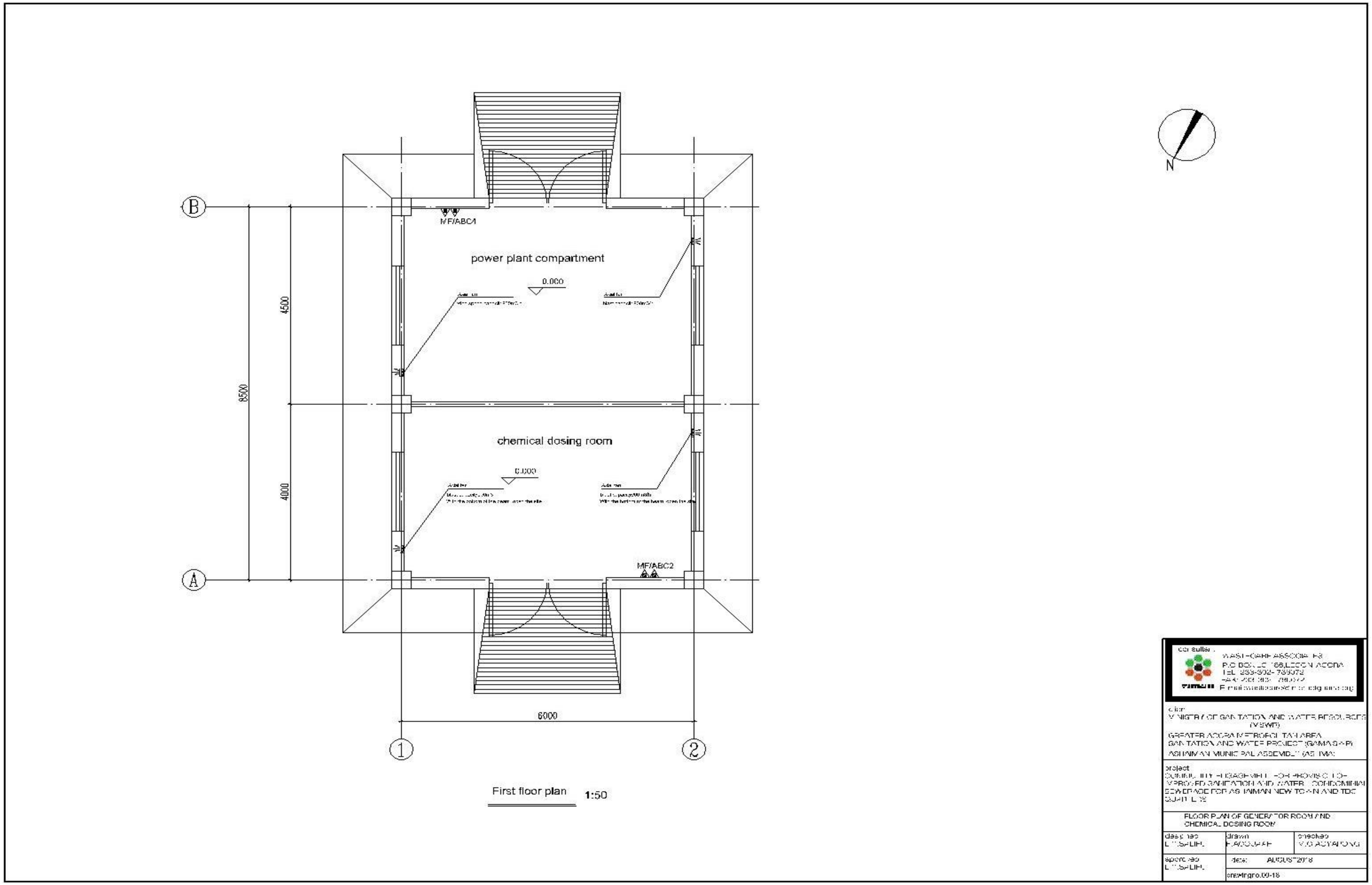
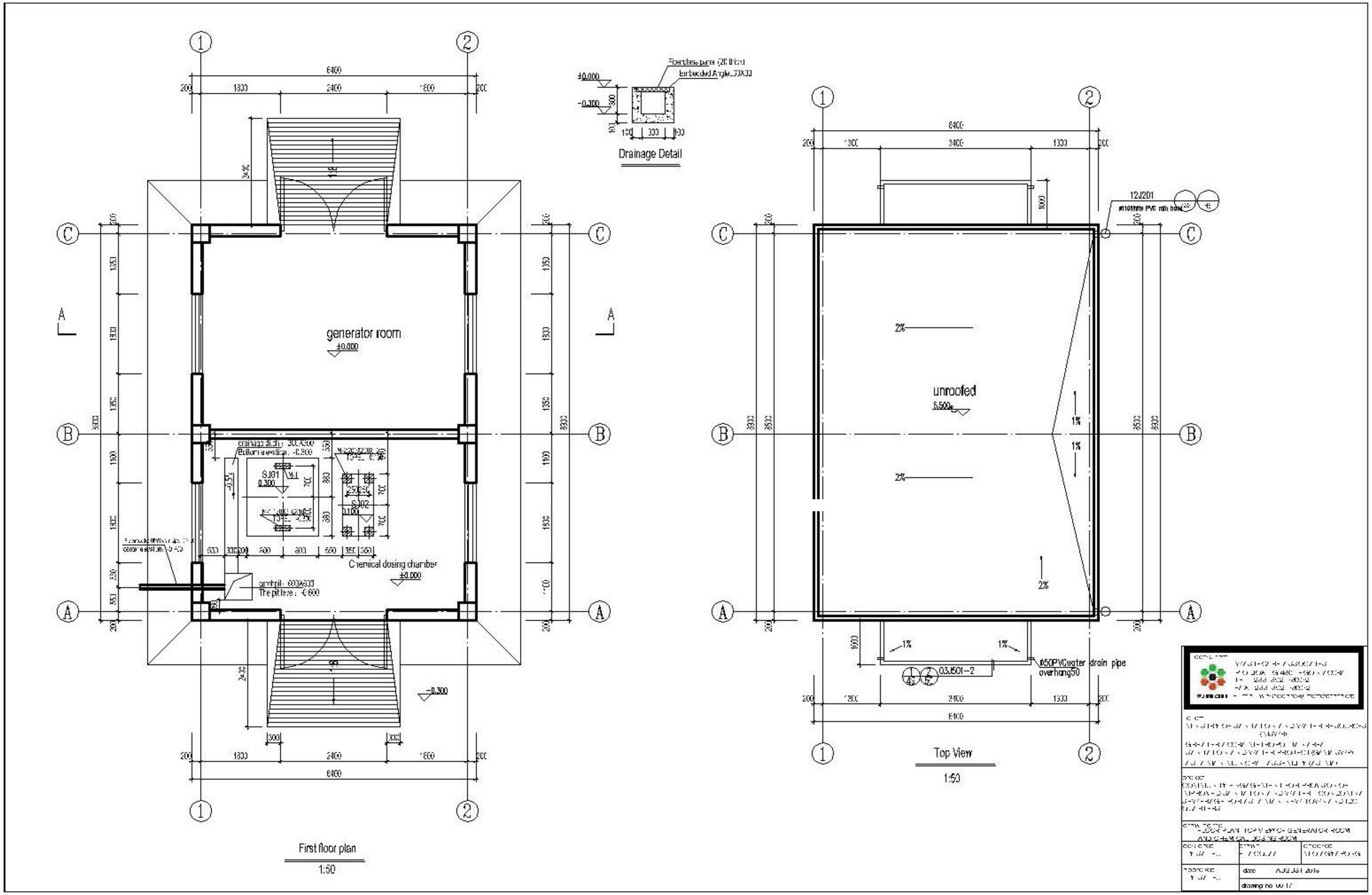
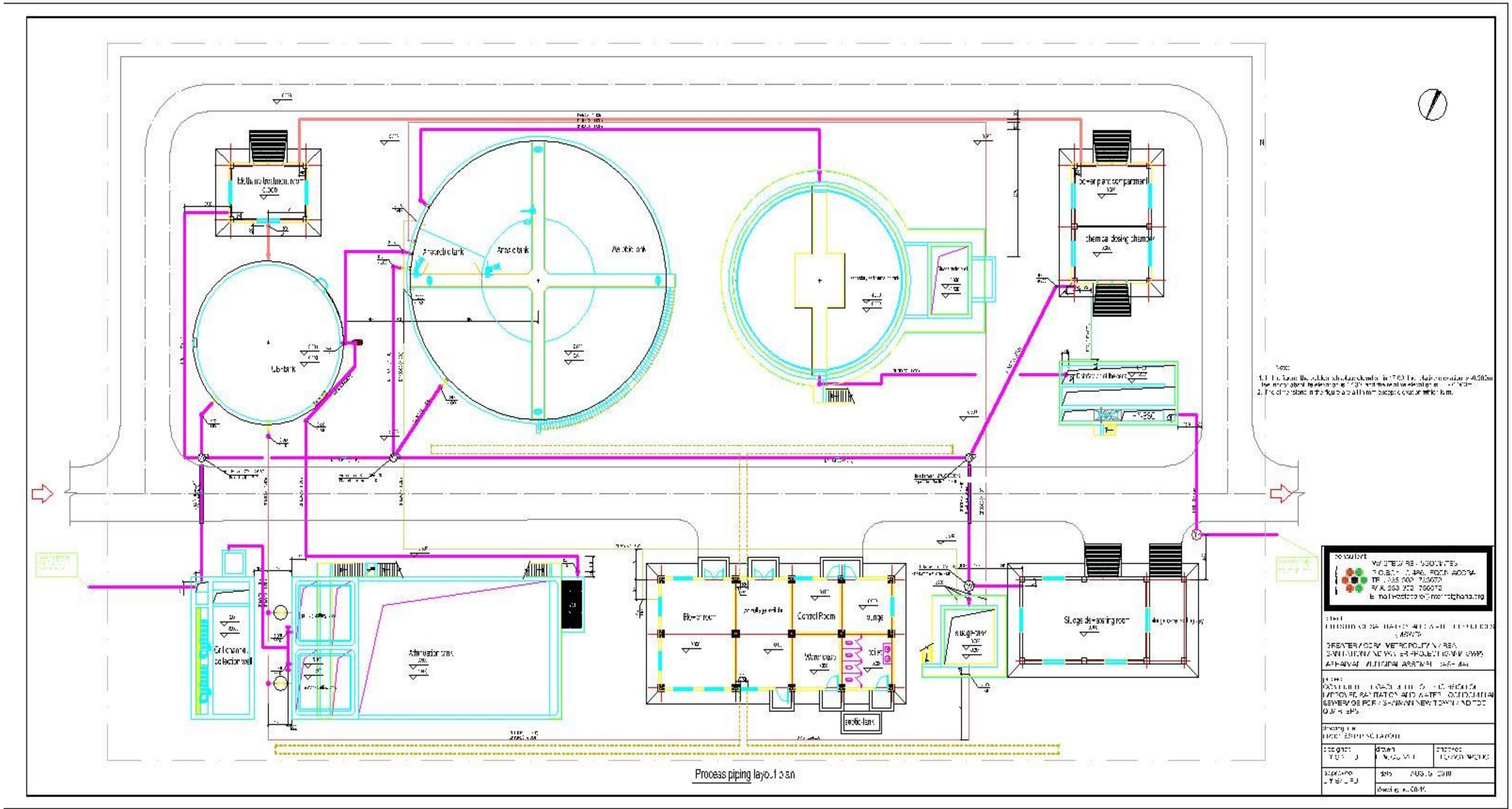
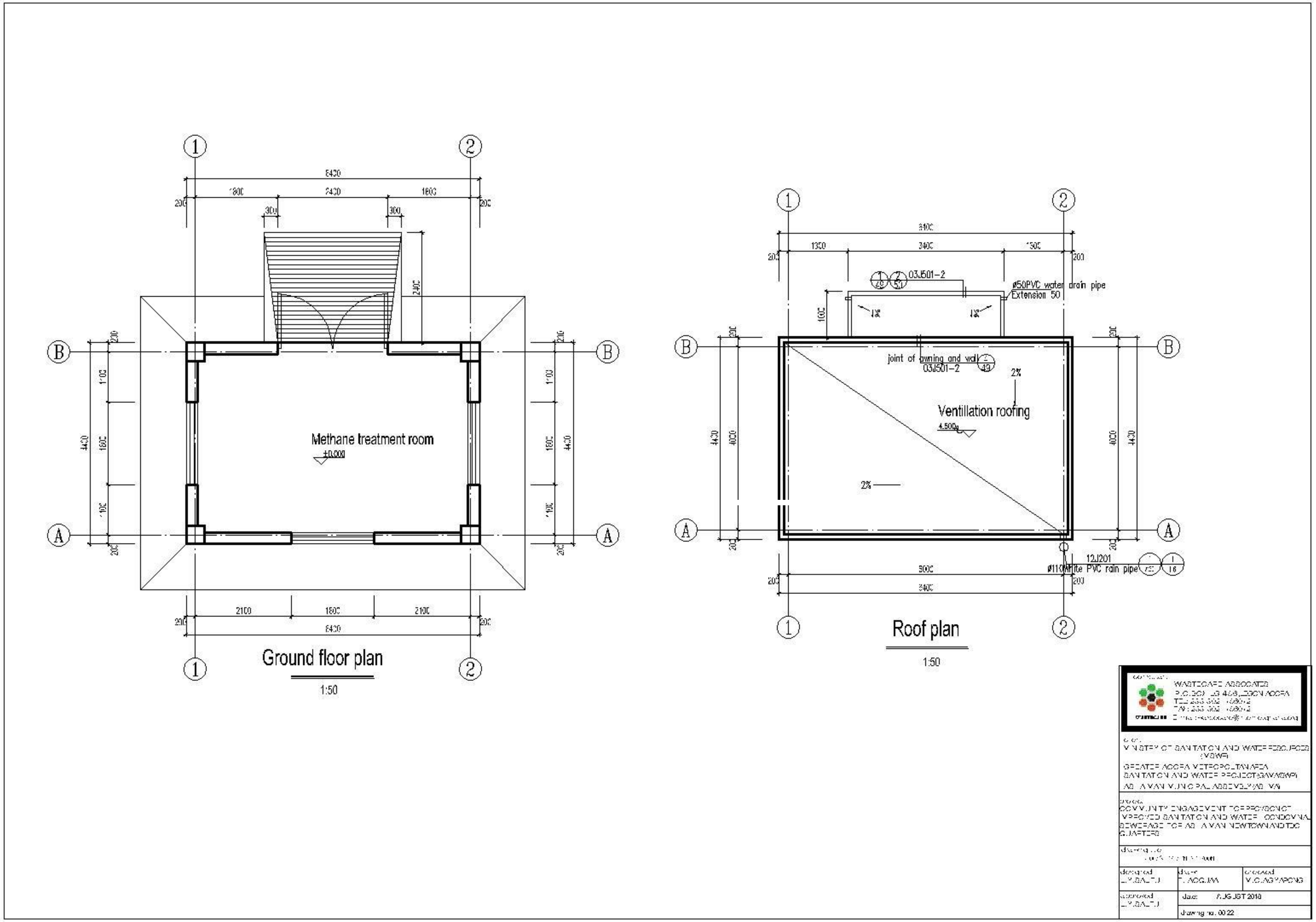


MF/ABC1
power plant compartment
0.000
chemical dosing room
MF/ABC2
4500
8500
4000
6000
B
A
1
2
N
First floor plan
1:50
FLOOR PLAN OF GENERATOR ROOM AND
CHEMICAL DOSING ROOM
AUGUST2018


Drainage Detail
generator room
±0.000
Chemical dosing chamber
±0.000
First floor plan
1:50
unroofed
5.500
2%
1%
Top View
1:50


Aerobic tank
Blower room
Control Room
Attenuation tank
Sludge dewatering room
Process piping layout plan


Methane treatment room
±0.000
Ground floor plan
1:50
Ventillation roofing
4.500
joint of awning and wall
03J501-2
ø50PVC water drain pipe
Extension 50
ø110White PVC rain pipe
12J201
2%
1%
Roof plan
1:50
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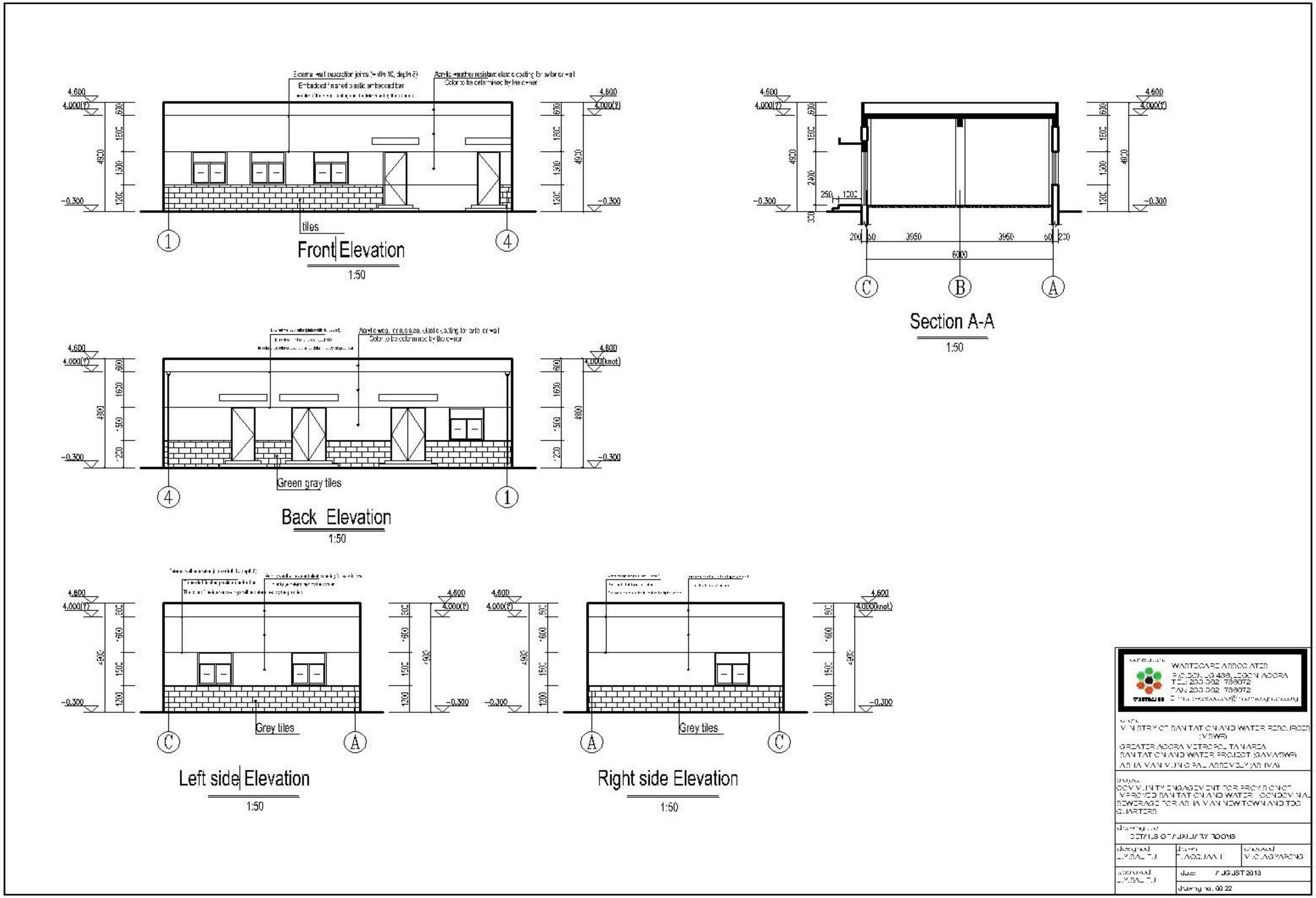
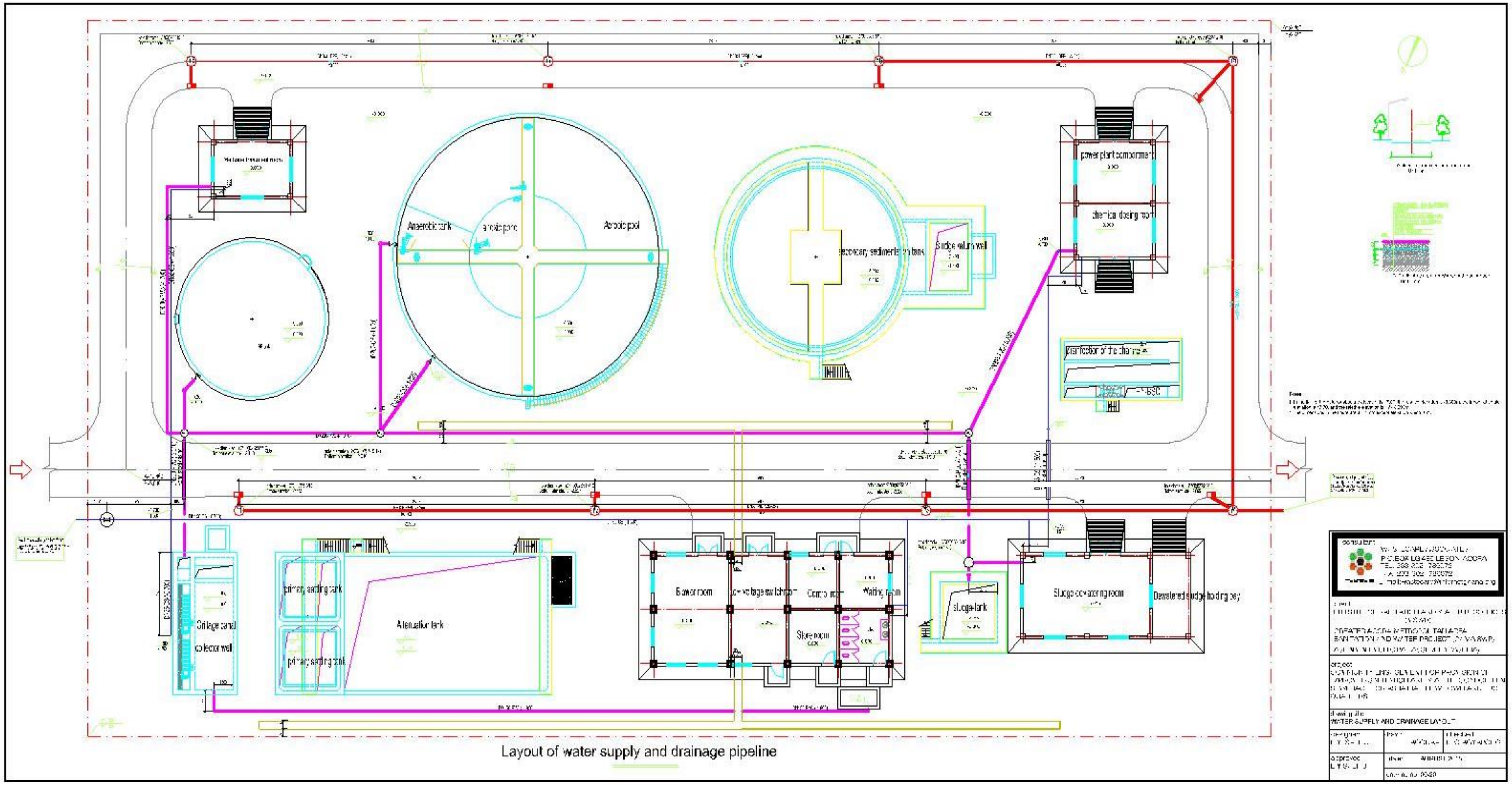
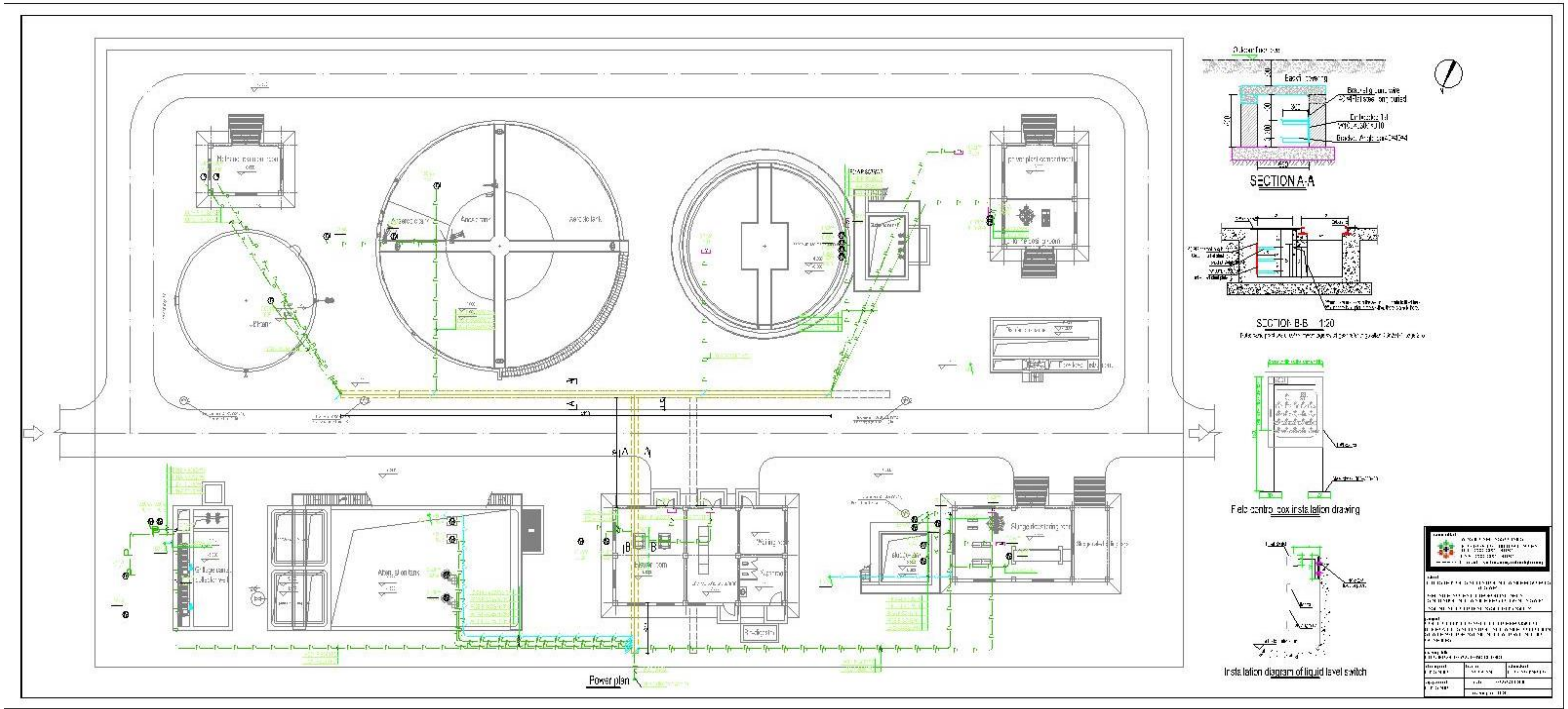
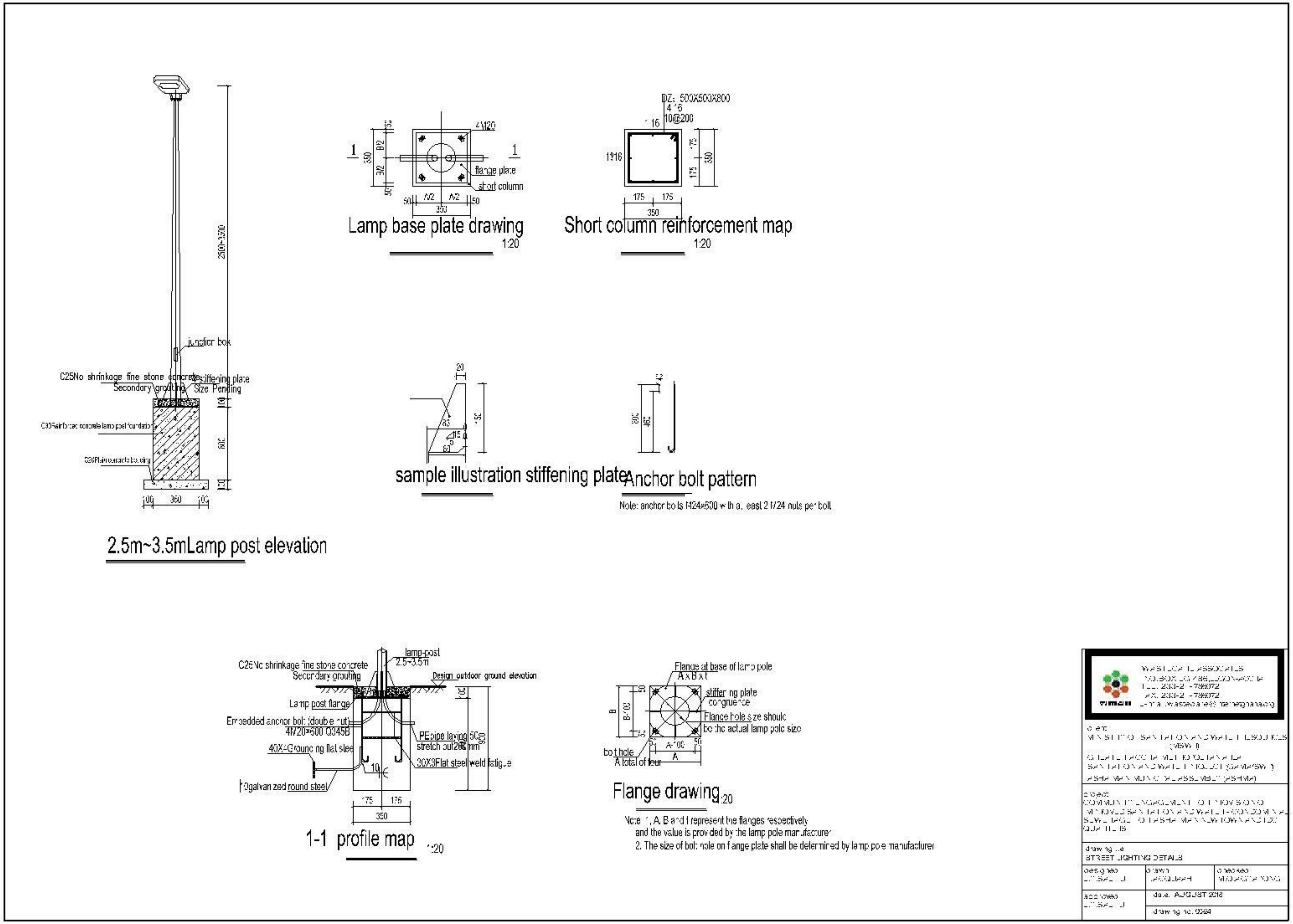
MINISTRY OF SANITATION AND WATER RESOURCES (MSWR)
GREATER ACCRA METROPOLITAN AREA SANITATION AND WATER PROJECT(GAMASWP)
AUGUST 2018


tiles
Front Elevation
1:50
Section A-A
1:50
Green gray tiles
Back Elevation
1:50
Grey tiles
Left side Elevation
1:50
Grey tiles
Right side Elevation
1:50




Layout of water supply and drainage pipeline


SECTION A-A
SECTION B-B 1:20
Power plan
Installation diagram of liquid level switch


Lamp base plate drawing
1:20
flange plate
short column
Short column reinforcement map
1:20
2.5m~3.5mLamp post elevation
junction box
C25No shrinkage fine stone concrete
Secondary grouting
stiffening plate
Size Pending
sample illustration stiffening plate
Anchor bolt pattern
Note: anchor bolts M24x600 with at least 2 M24 nuts per bolt
1-1 profile map
1:20
lamp-post
2.5~3.5m
Design outdoor ground elevation
Lamp post flange
Embedded anchor bolt (double nut)
4M20×600 Q345B
40X4Grounding flat steel
PEpipe laying50
30X3Flat steel weld fatigue
Flange drawing
1:20
Flange at base of lamp pole
AxBxt
stiffening plate
congruence
Flange hole size should be the actual lamp pole size
bolt hole
A total of four
Note: 1. A, B and t represent the flanges respectively and the value is provided by the lamp pole manufacturer
2. The size of bolt hole on flange plate shall be determined by lamp pole manufacturer
drawing title
STREET LIGHTING DETAILS
date: AUGUST 2018