GILGIT DEVELOPMENT AUTHORITY (GDA)

SANITARY SEWERAGE SYSTEM WITH TREATMENT PLANT FOR GILGIT CITY

ENVIRONMENTAL IMPACT ASSESSMENT (EIA) REPORT

DECEMBER, 2016

JERS ENGINEERING CONSULTANTS

124-H, Model Town, Lahore, Pakistan

Voice: +92-42-35881207, 35847124
Fax: +92-42-35868659
E-Mail: info@jers.com.pk , mail@jers.com.pk
Web: http://www.jers.com.pk

EXECUTIVE SUMMARY

Gilgit Development Authority (GDA) Government of the Gilgit Baltistan under the Gilgit Environmental Improvement Project intends for provision of physical infrastructure for sewerage and waste water treatment for the Gilgit City to meet the present & future requirements for efficient and effective service delivery. Gilgit lacks in sewerage and drainage systems except for a few drains in the town. These drains collect sewerage but have no disposal system and essentially function as storage ponds. In most houses, soakage pits are constructed for collection of domestic wastewater. Presently all the wastewater from the Gilgit city is being discharged into River Gilgit. Consequently, there is a risk and danger of undermining the water quality of the river that could adversely affect aquatic life and the health of the downstream water users. In this context Gilgit Development Authority (GDA) engaged JERS Engineering Consultants in association with Urban Unit to provide consultancy services for proper sewage collection and treatment before its ultimate disposal into the Gilgit River.

JERS and Urban Unit has prepared the **Master Plan** for Gilgit city after detailed study of the Project area, evaluation of available data / information collected from related Agencies and field investigations. Specific recommendations for most suitable and cost effective alternatives are being given for consideration and approval of Client. Under this project, an Environmental Impact Assessment report is also required, for the sole purpose of quantifying any and all negative environmental impact arising from the activities proposed under the Master Plan and their remedies and mitigation plans.

This Executive summary briefly presents the outcome and findings of the Environmental Impact Assessment Report.

- **Objectives of the Study**

The main objective of this Study is to highlight anticipated environmental impacts of the proposed project and to suggest mitigation measures to eliminate or reduce the foreseen negative impacts to an acceptable level.

- **Components of the EIA Report**

The Report contains the identified environmental impacts and their mitigation measures. Besides, the Report also includes the preparation of Environmental Management and Monitoring Plan to cover the mitigation measures, monitoring

requirements and institutional responsibilities (during design, construction and operation phases of the proposed project).

- **Policy, Legal and Administrative Frameworks**

To carry out the present EIA Study, the environmental legislation and Guidelines enforced by the Pakistan Environmental Protection Agency (EPA) & Gilgit-Baltistan Environmental Protection Agency (GB-EPA) have been followed.

- **Project Description**

The overall vision of this project is no doubt the strategic planning of sewerage and its treatment, but the vision may decorate to turn the Gilgit city a sanitized town. In order to achieve this vision the following objectives are proposed:

  - Provision & assessment of sewer capacity including disposal station requirement up to the planning horizon year.
  - Options and recommendation for the treatment of the domestic sewage to conform NEQs standards.

- **Analysis of Alternatives**

Different alternatives for the sewerage collection system & wastewater treatment system were evaluated for selection of most feasible option for the Gilgit, by also considering No Project alternative.

- **Baseline Conditions**

Baseline conditions were studied with respect to the physical, ecological and socioeconomic aspects of the project area. Topography, geology and soils, ground water, climate and meteorology, seismicity, air quality, noise, land use, agriculture and cropping pattern, flora, fauna, demographic variables, quality of life, infrastructure, health and educational facilities and historical cultural resources were studied during this EIA.

- **Public Consultation and Disclosure**

Public consultation was carried out with the objectives of involving people in various processes of the Project. Local residents, industrialists, shop keepers, vendors, GDA staff, hospital owners, teachers, pedestrians, businessmen and government officials from various departments were identified as potential stakeholders for the project. Survey and scoping sessions were held with these stakeholders to find out their perceptions and perceived impacts about the existing and proposed sewerage, drainage & solid waste management system for the city. Majority of the respondents contacted, showed their un-satisfaction about the existing system of the city and

considered the proposed project necessary for neat and clean, and hygienic environment of the city. The proposed project will also contribute in reducing the diseases, bad odour, and water contamination and provide mental satisfaction to the local people.

- **Environmental Impacts and Mitigation Measures**

Positive environmental impacts will help to improve the present environmental conditions and reduce health risks to residents of the City. From economy point of view it will not only reduce the medical expenses of the common men but also increase their productive working hours, which in turn will result in poverty alleviation, improve hygienic conditions and enhance socio economic conditions in the area. The value of property will also be uplifted due to improved aesthetic conditions and elimination of ugly scenes due to overflow of sewage in the streets and stagnated sewage in depressions.

Some of the significant anticipated negative environmental impacts of the project are; i) Noise during construction; ii) possible contamination of groundwater iii) soil Erosion, iv) contamination of Water Supply lines, v) health and safety of operation and maintenance staff.

In order the mitigate the likely negative impacts the suggested mitigation measures include; i) Careful construction planning and adequate monitoring of excavation operations so that excavated areas and trenches are not left unattended and cuts and side slopes are stabilized with provision for drainage arrangements, ii) Laying sewers opposite to water supply lines and keeping enough space between these two lines, iii) Training to O&M staff in hygienic procedures designed to avoid infection from wastewater, health and safety procedures against any exposure to hazardous conditions and vaccination against infectious diseases with regular medical checkups. iv) Regular monitoring of the sewerage and wastewater treatment systems.

- **Environmental Management Plan (EMP)**

The EMP provides an approach for managing and monitoring environment related issues and describes the institutional framework and resource allocation. An environmental monitoring plan has also been devised to monitor various parameters during the construction and operational phases of the project.

- **Conclusions and Recommendations**

The study concludes that the project does not involve any long term irreversible negative impacts. Most of the negative impacts identified in the study are temporary

and manageable through adopting mitigation measures. Generally, the proposed project is an environmental improvement project aimed to facilitate sustainable urban development in Gilgit, and therefore its overall impacts on the environment will be very much positive.

Table of contents

LIST OF ABBREVIATIONS

CC	Construction Contractor
CO	Carbon-mono Oxide
DC	Design Consultant
DCR	District Census Report
DOE	District Officer Environment
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EMP	Environmental Management Plan
GB	Gilgit Baltistan
GB-EPA	Gilgit Baltistan Environmental Protection Agency
GDA	Gilgit Development Authority
GoP	Government of Pakistan
IEE	Initial Environmental Examination
MC	Municipal Corporation
MD	Managing Director
MPA	Member of Provincial Assembly
MVE	Motor-Vehicle Examiner
MVR	Motor-Vehicle Rules
NEQs	National Environmental Quality Standards
NGO	Non-Governmental Organization
NSL	Natural Surface level
O&M	Operation and Maintenance
PAP	Project Affected Persons
PEPA	Pakistan Environmental Protection Act
PNCS	Pakistan National Conservation Strategy
R&R	Resettlement and Rehabilitation
RE	Resident Engineer
RoW	Right of Way
SC	Supervision Consultant
SO	Oxides of Sulphur
THQ	Tehsil Headquarter
TOR	Terms of Reference
UC	Union Council

List of Tables

List of Figures

List of Annexures

1 INTRODUCTION

1.1 Project Background

Urbanization presents one of the key challenges and, at the same time, opportunities in the new millennium. Urbanization is taking place at a rapid pace and is beyond the effective control of most government across the world. The scale and complexity of urban problems are increasing everywhere and out of those most challenging is to meet the water and sanitation demands. All cities must plan ahead to enable a sustainable future in the rapidly changing urban environment. Cities must review their strategic plans to develop better economic, social and environmental future. Those cities that fail to plan ahead and execute the plans will not be competitive in the globalized world.

Provision of municipal services like water supply, sewerage, sanitation, solid waste management, urban roads, storm water drains, street lighting, bus terminals etc. have remained the most sensitive environmental issues confronting the local administration in the urban localities since the independence of Pakistan. Lack of awareness and availability of funds has been a major hurdle in this regard. Only sporadic and ill-conceived efforts have been made from time to time to address the ever-deteriorating scenario of provision of basic municipal services. However, it is heartening to note that more recently; problem realization has gained momentum both on part of administration and people at large.

In the same context, Gilgit Development Authority (GDA) Government of the Gilgit Baltistan under the Gilgit Environmental Improvement Project intends for provision of physical infrastructure for sewerage, storm water drainage and waste water treatment for the Gilgit City to meet the present & future requirements for efficient and effective service delivery.

This report deals with the Environmental Impact Assessment (EIA) for Improvement of Sewerage system and provision of wastewater treatment system for Gilgit City. It has been prepared in compliance to Gilgit Baltistan's environmental regulations as conceived in the Gilgit Baltistan Environmental Protection Act 2014.

The Report encompasses screening of potential Environmental impacts of the project and the proposed mitigation measures in order to eliminate or reduce the negative impacts to an acceptable level, describes the institutional requirements and provides

an Environmental Management and Monitoring Plan. The EIA is based on the information collected through review of previous reports available with GB-EPA and the other public sector agencies and Consultants survey in this regard. Overall, the proposed project is an environmental improvement project aimed to facilitate sustainable urban development in Gilgit City, but some negative Environmental and Social impacts may emerge, if proper mitigation measures for the same are not adopted.

1.2 Need for the Environmental Assessment Study

All Projects financed under Government of Gilgit Baltistan are required to comply with the environmental legislation of Government of Gilgit Baltistan. Therefore it's their Policy to promote environmentally sound, socially acceptable and commercially viable urban infrastructure projects. Thus all projects are required to conform to:

The terms of Environmental Protection Agency (EPA) as mandated by the Gilgit Baltistan Environmental Protection Act 2014.

Part VI Section 16 of the Gilgit Baltistan Environmental Protection Act '15 states that:

> *"No proponent of a project shall commence construction or operation unless he has filed with the Agency an initial environmental examination or environmental impact assessment, and has obtained from the Agency approval in respect thereof."*

1.3 Project Screening and Categorization

This was the first step of the EIA procedure. Preliminary assessment of the project was done against the Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations 2000.

The projects for sewerage/drainage/wastewater treatment systems are not exactly described in the SCHEDULE- I and II of the Pakistan Environmental Protection Agency (Review of IEE and EIA) Regulations 2000. The proposed Sewerage, drainage & solid waste management projects worth Rs. 25 million and above are included under Category F of SCHEDULE II i.e. the projects requiring an EIA before commencement of construction. In addition, an EIA is mandatory for other Projects falling under Category J, which are likely to cause any adverse environmental effect.

Hence an Environmental Impact Assessment (EIA) report including Environmental and Social Management Plan has been prepared to fulfill these requirements for the project.

1.4 Objectives of the EIA Study

The main objective of the EIA Study is to highlight anticipated impacts of the proposed project covering environmental and occupational health and safety issues and to suggest mitigation measures to eliminate or reduce the foreseen negative impacts to an acceptable level. These objectives can be further elaborated as below:

- Determine pre-project environment and social conditions to assess post-project conditions if they have changed for better or worse;
- Document all the environmental impacts likely to occur due to the implementation of the proposed project;
- Provide maximum information to the proponent and other stakeholders about the existing environmental conditions and the implications of the proposed project;
- Allow planners to alleviate potential impacts of the proposed project on different environmental conditions such as physical environment, biological environment and socio-economic environment; and
- Aid decision makers to take informed decisions.

1.5 The Proponent and the Environmental Consultant

The Proponent of the proposed project is Gilgit Development Authority (GDA) while M/s JERS Engineering Consultants are the Environmental Consultants, whose contact details are given as under:

a) Proponent Contact Address

Gilgit Development Authority (GDA)
Raja Anwar Villa, Adjacent Chief Minister's House,
Chinar Bagh Gilgit
Ph: 05811-922306-308

b) Environmental Consultants

M/s Jers Engineering Consultants
124-H, Model Town, Lahore
Ph: 042-35881207, 042-35847124
Fax: 042-5868659

1.6 Structure of the Report

This Report includes following sections, which cover all the requirements provided EPA:

1 "**Introduction**" briefly presents the project background, objectives and need for the EIA study.

2 "**Policy, Legal and Administrative Framework**" comprises policy guidelines, statutory obligations and roles of institutions concerning EIA study of the proposed project.

3 "**Project Description**" furnishes information about the location of the proposed project, cost and size of the project, and its major components.

4 "**Analysis of Alternatives**" discusses different alternatives considered for the proposed project to arrive at the preferred alternative for detailed environmental assessment.

5 "**Baseline Data**" establishes baseline conditions for the physical, biological and socio-economic and cultural conditions prevalent in and around the project area.

6 "**Public Consultation and Disclosure**" describes the outcome of the public consultation sessions held with different stakeholder groups that may be impacted by the project.

7 "**Environmental Impacts and Mitigation Measures**" identifies, predicts and evaluates environmental impacts of the proposed project activities at the design, construction and operation stages. It also details the measures (including the mitigations costs) to reduce/eliminate potential adverse impacts of the project on different environmental conditions at respective stages.

8 "**Environmental Management Plan**" lays out the mitigation measures for the impacts identified, defines responsibilities of the project proponent, contractor(s) and other role players; identifies training requirements at different levels; specifies supervision and monitoring mechanisms and parameters; and provides budgetary requirements to ensure that all the mitigation measures are effectively implemented during construction and operation stages of the project.

9 "**Conclusions and Recommendations**" describes the outcome of the study with recommendations to get full benefits of the project in an environmentally sound and acceptable way.

1.7 Scope of Work/ Terms of Reference

Terms of Reference (TOR) of the present study were provided to the Consultants comprehensively covering all aspects in detail to meet the EPA requirements. The consultants have critically reviewed the TOR and the Report has been prepared accordingly.

2 POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 General

This section deals with the relevant policy, legal and administrative framework instituted by the Government of Gilgit Baltistan for the protection of environment. All the relevant provisions of these policy and legal frameworks have been duly considered in this EIA study. In addition to this, the roles and responsibilities of the proponent as well as the Gilgit-Baltistan Environmental Protection Agency (GB-EPA) have been mentioned in this section.

2.2 Policy Framework

The Federal Ministry of Environment has been devolved under 18th amendment in the constitution of Islamic Republic of Pakistan and similarly provinces were enabled to legislate on the subject of environment, therefore Gilgit Baltistan assembly under schedule 4 of "Gilgit-Baltistan (Empowerment and Self-Governance) Order 2009" can make laws on the list of subjects provided in it. In that context, Gilgit Baltistan has its own Environmental Protection Act and hence the Gilgit Baltistan Environmental Protection Agency (GB-EPA) is the responsible authority for policy making on environmental protection in Gilgit Baltistan. The proposed project will be financed by Govt. of GB which require compliance to the Environmental Policy and Guidelines, so it is obligatory on the part of the Proponent to follow these for environmental assessment.

2.3 National Environment Policy, 2005

The National Environmental Policy (2005) provides an overarching framework for addressing the environmental issues (particularly pollution of fresh water bodies and coastal waters, air pollution, lack of proper waste management, deforestation, loss of biodiversity, desertification etc.) confronting Pakistan. It recognizes the goals and objectives of the Pakistan National Conservation Strategy (PNCS, 1992), National Environmental Action Plans, and other existing environment related national policies, strategies, and action plans. It also provides broad guidelines to the federal government, provincial governments, federally administered territories and local governments to address their environmental concerns and to ensure effective management of their environmental resources.

2.4 Legal Framework

The Government of Gilgit Baltistan has promulgated laws/acts, regulations and standards for the protection, conservation, rehabilitation and improvement of the environment. In addition to this, they have also developed environmental assessment procedures governing developmental projects. Following are the excerpts of these laws and procedures relevant to the proposed project.

2.4.1 *Gilgit Baltistan Environmental Protection Act, 2014 (GBEPA-14)*

The Act was enacted in 2014 by repealing the Pakistan Environmental Protection Act (1997). It provides the framework for establishment of the Gilgit Baltistan Environmental Protection Council, establishment of Gilgit-Baltistan Environmental Protection Agency, Establishment of the Gilgit-Baltistan Sustainable Development Fund, protection and conservation of species, conservation of renewable resources, establishment of Environmental Courts and Green Courts, Initial Environmental Examination (IEE), and Environmental Impact Assessment (EIA).

Section 16 of the Act stresses the need to carry out environmental assessment study prior to construction or operation of a project.

2.4.2 *EPA (Review of IEE and EIA) Regulations, 2000*

These regulations provide lists of the projects requiring IEE and EIA. They also briefly describe the preparation and review of environmental reports.

2.4.3 *Pakistan Environmental Assessment Procedures, 1997*

Pakistan Environmental Assessment Procedures (1997) is, in fact, a package which contains the following sets of information relevant to the proposed Project:

a) Policy and Procedures for Filing, Review and Approval of Environmental Assessment Reports

It describes environmental policy and administrative procedures to be followed for filing of environmental assessment reports by the proponents and its review and approval by the concerned environmental protection agency/department.

b) Guidelines for the Preparation and Review of Environmental Reports

These guidelines are developed to facilitate both the proponents and decision makers to prepare reports (inclusive of all the information contained therein) and carry out their review so as to take informed decisions.

c) National Environmental Quality Standards, 2000

The Pakistan Environmental Protection Council first approved these standards in 1993. They were later revised in 1995 and 2000. They furnish information on the permissible limits for discharges of municipal and industrial effluent parameters and industrial gaseous emissions in order to control environmental pollution.

d) Other Relevant Laws

i) ***Land Acquisition Act (1894):*** Projects may require government procurement of privately owned land and the displacement of land users. Land may be acquired through:

i. Expropriation (Compulsory Acquisition)
ii. Voluntary negotiation with the owners for sale of land
iii. Donation from the land owners

The Land Acquisition Act (1894) deals with the government acquisition of private properties for public purposes including large development projects. There are 55 sections in this Act mainly dealing with area notifications, surveys, acquisition, compensation, apportionment awards, disputes resolution, penalties and exemptions.

ii) ***Project Implementation and Resettlement of Affected Persons Ordinance 2000:*** This ordinance will be used to safeguard the interests of persons and groups involuntarily displaced from the existing places to new resettlement areas.

iii) ***Canal and Drainage Act, 1873:*** This Act entails provisions for the prevention of pollution of natural or man-made water bodies.

iv) ***Cutting of Trees (Prohibition) Act, 1975:*** This Act prohibits cutting or chopping of trees without permission of the Forest Department.

v) ***Pakistan Penal Code, 1860:*** This Act defines the penalties for violations concerning pollution of air, water bodies and land.

vi) ***The North-West Frontier Province Wild-Life (Protection, Preservation, Conservation and Management). Act, 1975:*** This Act defines rules and

regulations for the protection, preservation, conservation and management of wildlife.

vii) ***The Antiquities Act, 1975:*** Archaeological sites and monuments are specifically protected by this Act.

viii) ***Motor Vehicle Rules, 1969:*** Motor Vehicle Rules 1969 (MVR 1969) define powers and responsibilities of Motor Vehicle Examiners (MVEs). The establishment of MVE inspection system is one of the regulatory measures that can be taken to tackle the ambient air quality problems associated with the vehicular emissions.

2.5 Institutional and Administrative Framework

Government of GB has financed the proposed project. The proposed project falls under the following Institutional and Administrative Framework.

Environmental Protection Agency, Gilgit Baltistan (GB-EPA)

The Pakistan Environmental Protection Agency (Pak-EPA) is meant for the enforcement of environmental laws in Pakistan. They have delegated powers to provincial environmental protection departments/agencies for review, approval and monitoring of environmental assessment projects. The proposed project is in Gilgit-Baltistan therefore the GB-EPA will be responsible for reviewing the report, issuing Environmental Approval and overall/broad based monitoring of the proposed project activities to ensure compliance with the Environmental Management Plan.

3 PROJECT DESCRIPTION

3.1 General

This Section describes in detail the proposed project of sewerage & wastewater treatment system of Gilgit City. It also presents the details of existing situation prevailing in the city.

3.2 Existing Sewerage System

The City lacks in sewerage system except for a few drains in the main town. The Northern Areas Public Works Department has constructed a network of roadside sanitary drains for Gilgit. The Frontier works Organization has also constructed similar drains along the Karakoram Highway. These drains are constructed for the collection of storm water and are not meant for municipal grey water. Existing drains along the roadsides do not have the capacity to adequately capture the large volume of storm water that occur during the rainy season. The kuchha and pukka household drains in the Mohallas and residential colonies are constructed on a self-help basis.

During visits, instances of drain blockages and clogging due to garbage dumping and improper maintenance were a regular sight. Figure 3.1, 3.2 & 3.3 provides an illustration of some of the drains in residential and commercial areas of Gilgit.

Figure 3.1: A view of Open drains in City Area

Figure 3.2: Unplanned Open drains in the City Area

Figure 3.3 Existing situation of open drains

Drainage water is mostly used for irrigation. The excess is released in an untreated state into the Gilgit and Hunza Rivers. There is no Nullah in Konodas and the said area is feed through pumping from Gilgit River.

Poor drainage in Gilgit results in high water tables in area situated at the tail end of the city, such as Kashrot, Majini Mohallah, and Airport. The water table is creating problems for building and construction projects in these areas.

The individual house owners have constructed soakage pits. While in some areas sewerage system is collected in septic tank. Some houses have constructed septic tanks before its disposal in soakage pits. At different locations damages in the soakage pits were observed. Due to these damages the waste water flows into open spaces and causes health problems and deterioration of

roads. Due to lack of any proper system, raw sewage is collected in the depression which creates environmental and health problems for the nearby community. Four Main Nullahs are passing through the entire city.

- Kargah Nullah
- Jutial Nullah
- Sultan Abad Nullah
- Napurah Nullah

These four main Nullahs carry the sewage flow for city area. While in some area people construct septic tanks and soakage pits to dispose of the sewage.

3.3 Existing situation of drains

The Keeping in view the existing system of city, the drainage system is being disposed of in the following 5 different zones:-

3.3.1 *Zone-1*

There are two existing channels coming from Kargah nullah which are basically water channels. Lower channel pass through Kargah bhudda area, locals of this area, Naupura, Narot, Naikoi, upper barmas, lower barmas, Mohallah Alamdar, Nagral Mohallah areas disposed their domestic sewage into lower channel coming from Kargah Nullah.

Finally this channel pass through the back side of airport and disposed of into Gilgit River without treatment.

Two main drains coming from public school for boys in lower Jutial and one from Gilgit Sareena hotel. Sewage of Jutial area fall into this drain and this drain is connect to main channel from Kargah nullah near Shaheed millat chock.

3.3.2 *Zone-2*

Sewage from other side of Jutial public school flow towards NATCO bus stand and drop into one existing septic tank. The waste water from Shahr-e-Quaid-e-Azam also drop into Gilgit River without any Treatment.

3.3.3 *Zone-3*

JAGEER BASEEN area is located another side of Kargah nullah on chitral road. There are some existing drains connected at Khushbakht chowk and sewage flow of jageer Baseen area disposed of into Gilgit River through a drain from Khushbakht chowk.

3.3.4 *Zone-4*

There are existing water channels& drainage network running in Danyour area. Drains exist along both sides of the Hunza road and locals of some areas drop their sewage flow into these drains.

Finally these drains disposed of into the Gilgit River near China Bridge without any treatment. Two water channels coming from Sultanabad nullah, one is passing through the upper side of the Danyour and used for irrigation and agriculture purpose. The second channel pass through the Danyour. In some areas of the Danyour soakage pits are constructed for sewage collection.

3.3.5 *Zone-5*

Nagar colony is located on the other side of river and there is no any existing water channels and drainage system in Nagar colony area.

Some existing drains were found in Mujahid colony, main drains constructed along the road and sewage from the upper side of the road drops into the main drain which is then finally disposed of into the Gilgit River.

3.3.6 *Zone-6*

Sakarkoi also lacks in a proper sewerage system and consists of only irrigation water channels. Existing Drainage System Shown in Figure 3.4.

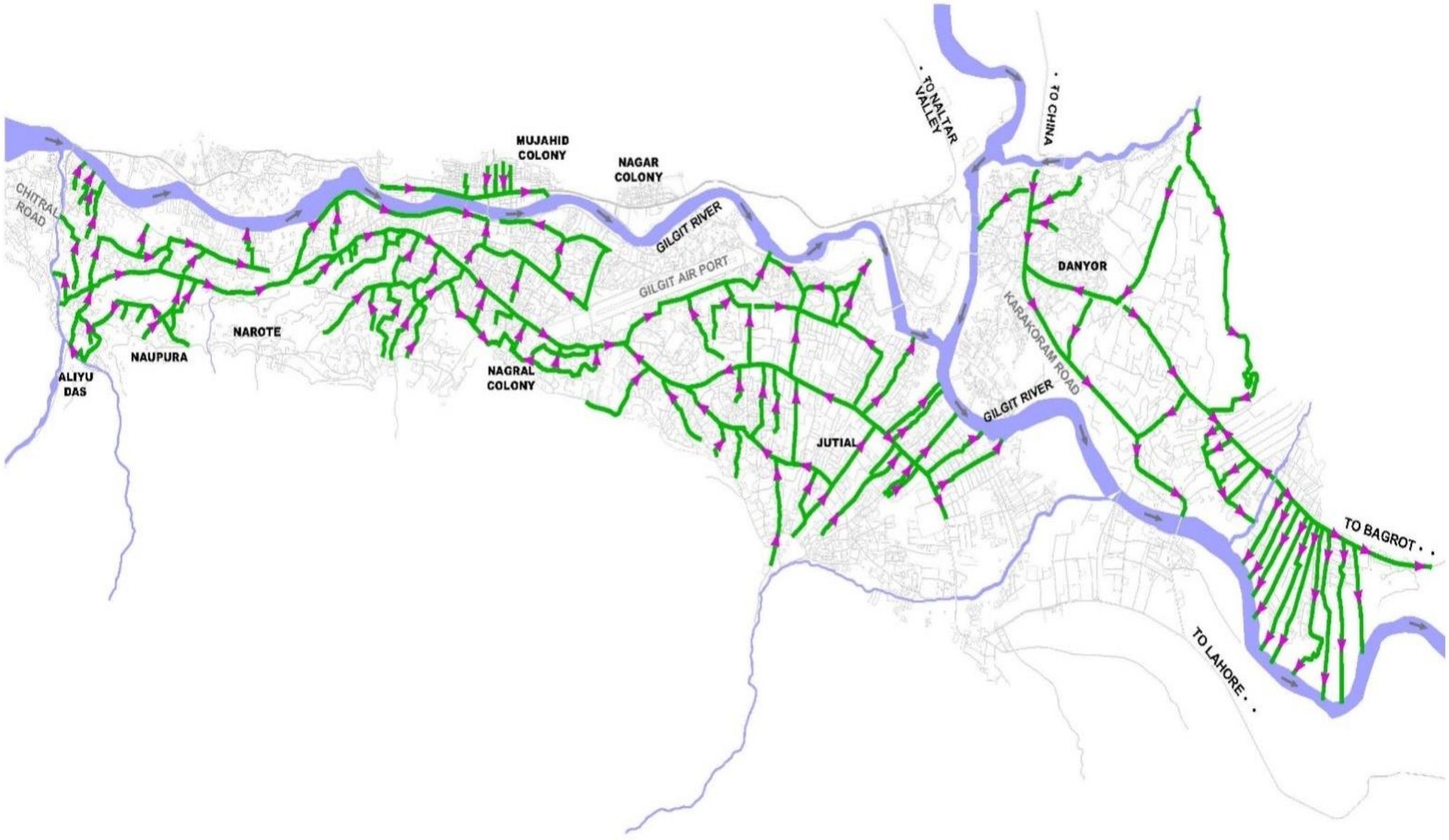


Figure 3.4: Existing Drainage Network

3.4 Design Criteria for Sewerage System & wastewater treatment

3.4.1 *Population Growth*

The knowledge about the past populations and assumptions about future populations are fundamental to the planning decisions. The projections are the estimates for the future planning horizon. They illustrate the plausible courses of future populations and are developed using normative procedures comprising of mathematical models and analytical growth rated. The projected numbers are “best assessed” populations estimates based on voter lists along with multiplying factor provided by the client.

Additionally, the socio-economic models of pollution are more commonly used by the planners for outline development plans/master plans, industrial development or IT and IT service driven development. The fact is that, none of the methods guarantees the exact precision of population projections as the cities are dynamic entities and their development changes from time to time and depending upon the master planning, city administration, policies, infrastructural creation and socio-economic conditions.

The main objectives of the population projections are:

- To forecast the projected population for the project horizon year 2035 with interim target years i.e. 2020, 2025, and 2030.
- Analysis of the present and future populations using data and published reports.
- Analysis of the future trends of the population’s growth.
- Distribution of the population over the proposed sewerage network and WWTP.
- Estimated of wastewater generation using per capita water consumption patterns.

The estimated population of the Gilgit city for the year 2015 is estimate as 332,251 persons. The growth rate on the basis of Gilgit (rural and urban areas) has been analyzed based on population density. The projected populations of the Gilgit city will be 906,056 persons as shown in Table 3-1.

Table 3.1: Projected Population of Gilgit City

Projected Population (GILGIT CITY)					
Year	Annual Growth Rate %	Projected Population	Population Increase Due to Summer Population		Total Population
			Percentage	Persons	
2015		332,251	9%	29903	362,153
2020	5.5%	434,238	15%	65136	499,374
2025	4.5%	541,140	17%	91994	633,133
2030	4.0%	658,379	18%	118508	776,887
2035	3.0%	761,391	19%	144664	906,056

The graphical presentation of the population projections is given in the **Figure 3.5.**

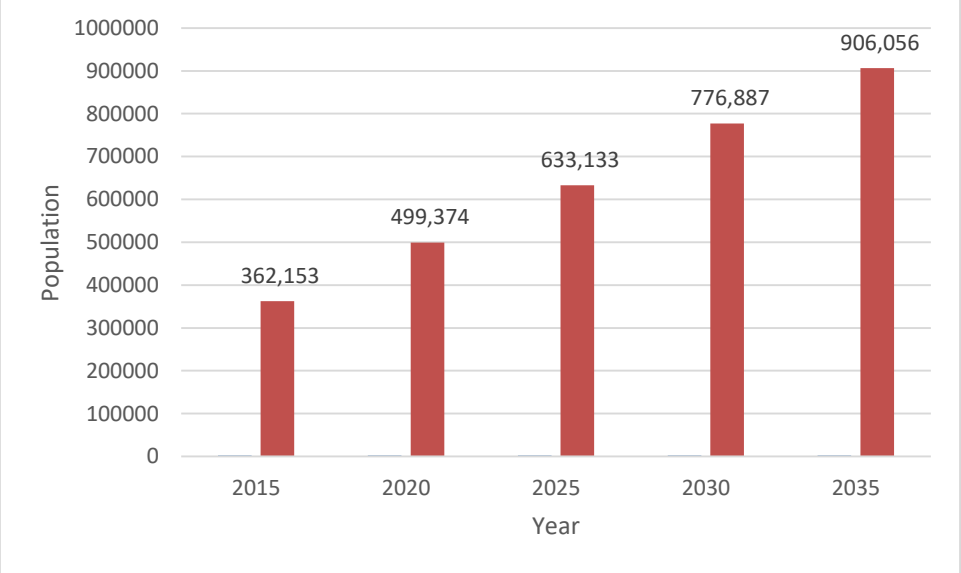


Figure 3.5: Graphical Presentation of Population projection of Gilgit City

3.4.2 *Design Horizon*

In a conventional design, it is common to design trunk sewers and interceptors for the projected peak flows expected during 25-50 years period or for the saturation population of the area. Such long design periods make it possible to capture economies of scale in sewerage system. However, these have to be balanced against the opportunity cost of capital, uncertainties in predicting future land use patterns or direction of the growth of the city and high cost of maintain large sewers with low flows. The use of shorter design periods avoids such problems and reduces the large capital requirements in sewerage systems, facilities financing, and enhances prospects of achieving greater coverage with a given investment. With a shorter design periods and construction by phase, starting from upstream ends, the effects of errors in

forecasting the population growth and their water consumption can be minimized and corrected. For these reasons, simplified sewerage employs design period of 20 years or less. In this regard, it is noteworthy that the USEPA limits the design period to 10-15 years[1]. Our neighbor country, India has developed guidelines for sewerage design. The following design criteria developed by the Central Public Health and Environmental Engineering Organization (CPHEEO) is normally used for sewerage projects[2].

Table 3.2: Design Period of Sewerage Components

No	Design Component	Design Period	Remarks
1	Land Acquisition for STP, Pumping Stations, sewers etc	30 Years	Land acquisition in future difficult
2	Sewer network (laterals, Trunk mains, Outfall etc)	30 Years	Replacement difficult and costly
3	Pumping mains	30 Years	Cost may be economical
4	Pumping Stations-Civil Work	30 Years	Duplication machinery within the pumping station or sufficient standby would be easier
5	Pumping Machinery	15 Years	Life of pumping machinery is 15 years
6	Sewage Treatment Plants	30 Years	The construction shall be modular in phased manner as actual population less than design population and in Indian cities initially flows are much less due to connectivity problems.
7	Effluent disposal and utilization	30 Years	Provision of design capacities in the initial stages itself is economical

3.4.3 *Design Flows*

Wastewater flow quantities are necessarily lower than the quantity supplies/used because water is lost through leakage/evaporation, garden watering, house cleaning etc. To determine the expected amount of wastewater, it is important to keep records of pumping for each day and fluctuations during the day. Reliance on estimates of water usage can lead to erroneous design flows. Information should be obtained from the area under

[1] Bakaling, A., Simplified Sewerage :Design Guidelines, UNDP-World Bank Water & Sanitation Program, 1994,

[2] A Toolkit for Master Plan Preparation for Sewerage, National Capital Region Planning Board, India,

consideration. The design flow is based on this returned quantity multiplied by a peaking factor which is inversely proportional to the population size.

3.4.3.1 Unit Flow Factor

Unit flow factors are design parameter that are used to estimate design flows of sewerage systems and sewerage treatment facilities. The unit flow factor is the average sewage flow (average dry weather flow ADWF) contributed by the one unit of sewerage (person or employee) per day. The design flow is determined by summing the products of the number of the contributing units of each source with appropriate unit flow factors. The unit flow factors for various sources like residential, commercial, governmental, educational and religious can be adopted as followed as per guidelines developed by the CPHEEO.

Table 3.3: Unit flow factors for various sources

Waste water Source	Water Requirements (lpcd)	Sewerage flow(inclusive of 5% infiltration) lpcd
Residential	160(42 gpcd)	135
Commercial	47	40
Government institutions	47	40
Educational	47	40

For the current scenario, sewage flow is to be adopted as 80% of the water consumption. Water consumption has been taken as 35 gpcd/132 lpcd, so the sewage flow become 28 gpcd (i.e. 80 % of water consumption).

3.4.3.2 Peak Flow Factor

Peaking flows are the cumulative results of combinations of factors such as diurnal and seasonal flow variations of flow components and characteristics responses of inflow and base flows to the storm events. Peak flows can be determined by multiplying the average dry weather flow (DWF) by the peaking factor (PF).

The maximum design flow is determined using Average Daily Flow (ADF) and the Harmon Peaking Factor (HPF):

$$M = 1 + 14/ 4 + P^{0.05} \quad \ldots\ldots\ldots\ldots \quad (3.1)$$

Where:

M = the Harmon Peaking Factor
p = population (in thousands)

The maximum design flow shall be the average daily flow times the peaking factor M.

The peak domestic sewage flow is calculated as:

$$Q(d) = Pq\ M/\ 86.4 + lA \qquad \ldots\ldots\ldots\ldots \qquad (3.2)$$

Where:

Q (d) = Peak domestic sewage flow (including extraneous flow) in litres per second.

P = Design Population in thousands

q = Average daily per capita domestic flow in litres/capita/day

M = Peaking Factor (as derived from the Harmon Formula) [from equation 6.1]

ℓ = Unit of peak extraneous flow in litres/hectare/second

A = Area in hectares

Population based peaking factors are to be used for hydraulic modelling purposes in the current project. Population based peaking factors decrease with increasing populations. For cumulative sewerage flow, the following criteria presented in **Table-3-4** based on the population, have been used for the current project.

Table 3.4: Peaking Factors

Population in Thousands	Peaking Factor
Up to 5	4.5
5 to 10	4
10 to 25	4
25 to 50	3.5
50 to 80	2.5
80 to 100	2
100 to 200	2
Above 200	2

3.4.3.3 Shape of the Sewers

The shape of the sewers varies from circular, elliptical, egg shaped, semi elliptical to mouth shaped as shown in the **Figure 6.2.** The application of the respective kind will depend on site conditions and project requirements. Circular sewers are adopted when the flow of the sewers is nearly uniform, as these are stronger, cheaper and structurally more stable than others. Oval or egg shaped sewers are adopted best for situations where there is an intermittent flow of sewerage- that is, when the flow varies considerably at different times. The reason for this is, at time when there is , but a small quantity

of sewage passing, the flow occupies the narrow bottom of the egg-shaped sewer at a greater depth than it would be in a circular sewer of the same area of section. This increase depth of the sewage causes it to flow with greater velocity, and thus renders the sewer high hydraulic efficiency. However, they have become obsolete due to problems in laying, instability at bottom and high precision required during laying.

Horizontal elliptical pipe is used with equivalent circular sizes with tongue and groove cement mortar or mastic compound joint. The horizontal elliptical pipe is installed with the major axis horizontal and is used for minimum cover situations or other conditions where vertical clearance problems are encountered. It offers the hydraulic advantage of greater capacity for the same depth of flow than other shapes of equivalent sectional area. Load under similar cover conditions are similar to that of circular pipe with the same pan. Thus they are mostly used under conditions of insufficient covers for laying of pipes.

(a) Circular sewer **(b) Egg shaped/ elliptical sewer** **(c) Horizontal elliptical**

Figure 3.6: Various shapes of the sewers

In ordre to ensure smooth flow for carrying peak discharge by a hydraulically efficient system and leass prone to blockage, it is proposed to have a circular pipes for sewerage collection netrwork.

3.4.3.4 Manning factor "n"

Manning's '**n**' roughness coefficient is the friction factor utilized in the Manning's Equation for gravity flow to describe the roughness of a particular pipe material or condition. There has been much debate over the idea that the '**n**' value of a pipe can change over time as the pipe ages and a slime layer grows on the pipe wall. One side of the debate claims that the roughness or '**n**' value of this slime layer is the same whether the slime layer grows on a concrete wall, a vitrified clay wall, or a plastic wall. The other side of this debate proposes that

a different '**n**' value should be used for different pipe materials, generally ranging from **0.008** for plastic pipe to **0.016** for unlined concrete pipe with vitrified clay pipe between the two values. A Manning's '**n'** design value of 0.013, the most widely accepted value in the industry, provides some degree of conservatism if, in fact, there is a significant benefit to the smoother plastic pipe and PVC-lined (T-lock) pipe walls. For Gilgit City Sewerage Plan, it is recommended that an '**n**' value of **0.008** be used for all pipe materials.

3.4.3.5 Pipe Material and Specifications

PVC shall be used for dia. 8" to 24". For larger dia corrugated PE/RCC with T-Grip Lining/GRP pipes shall be used.

3.4.3.6 Minimum Sewer pipe Diamter

Although there are some agencies that allow new 6-inch sewers , a minimum sanitary sewer pipe size of 8-inches is generally accepted as the industry standard and is the current proposed Gilgit City design criteria.Therefore, except for service lines (laterals), the minimum acceptable gravity pipe diameter for all newly constructed pipelines in this Master Plan shall be 8-inches.

3.4.3.7 Minimum Velocoties and Gradients in Sewer

It is proposed that minimum gradient to be adopted are such that to maximum velocity of 15 ft/sec at design peak flow in new sanitary sewer under the ultimate scenario (2035), subject to minimum velocity of 2.5 ft/sec for peak flows at the current scenario(2015).

In case of construction of manholes for laterals, braches and sometimes even on the intermediate sections, minimum velocity for the design flow is likely to be less that the self-cleaning velocity. But manholes and sewers will be flushed out during peak flow period carrying forward silt, which may get deposited during minimum flow period, especially during night hours. Adopting lower values of velocities through lesser gradients will be helpful in avoiding deep excavations. However, at certain sections, where undercrossing of deeper sub drains and main drains as physical constraints, smaller sections of the sewer may be sloped at a steeper gradient to minimize the number and height of the drops required invert levels. While developing sewers, this point shall be given due consideration prior to the design of the sewers. In case, where the above

velocity criteria are not met, prescribes slope for different flows shall be adopted.

3.4.3.8 Bedding of Sewers

Above sub soil water level

For sewer 8'' to 12''	Sand
For sewer 15'' dia and above	Crush stone ¼ "- 1" size

The disposal station shall be located at places where sludge water can be disposed of safely, economically and hygienically.

3.4.3.9 Hydraulic Formula/ Design Formula

Manning formula shall be adopted for the design of the gravity sewers:

$$V = 1/n \times R^{2/3} \times S^{1/2} \quad \ldots\ldots\ldots\ldots\ldots \quad (6.3)$$

And,

$$Q = A \times V \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6.4)$$

Where,

V= Velocity when pipe flow in m/sec

n = Manning Roughness Coeffcient(0.013)

S = Slope of hydraulic gradient

R = Hydraulic radius in m

Q = Flow rate when pipe flows full in m^3 / sec

A = Cross Sectional area of Sq. meters

3.4.3.10 Manhole (Sewer Appurtenance)

Based on shape; manholes are of two types:

(a) Rectangular Manhole

According to sewer master planning tool kit developed by the CPHEEO, the minimum size of the rectangular manhole should be as follows:

- Size 900mm × 800 mm for depth up to 0.9m
- Size 1200mm × 900mm for depth between 0.9 to 2.5 m

(b) Circular Manhole

- Circular manholes are stronger than rectangular manholes and arch type manholes and thus these are preferred over rectangular as well as arch type manholes.

- The Circular manholes are provided for all depths starting from 0.9m
- Circular manholes are straight down in lower portion and slanting in top portion so as to narrows down the top opening equal to the internal dia of the manhole cover.

Sewer transitions occur wherever conduits of different characteristics are connected. The difference may be flow, area, shape, alignment and conduit material with a combination of one or all characteristics. Manholes should be located at all such locations.

For the **Gilgit Sewerage Master Plan**, it is proposed to use circular Manholes with narrow top portion having size equal to that of manhole cover.

The dimensions of manhole adopted with respect to size and depth of sewer are summarized in the following **Table 3-5.**

Circular manholes can be provided for all depths starting for 4 ft and for the depth below 4ft rectangular/square chamber might be adopted depending upon the accessibility.

Table 3.5: Dimensions of manhole adopted

Size of Sewer (Inches)	*Depth(Feet)*	*Manhole(Feet) Dia. (circular)*
9 - 21	4 -7	4
24 - 30	8- 20	5
33- 42	8- 20	6.5
45 -54	8- 20	7.5
60	8- 20	8
66	8- 20	8
72	8- 20	9

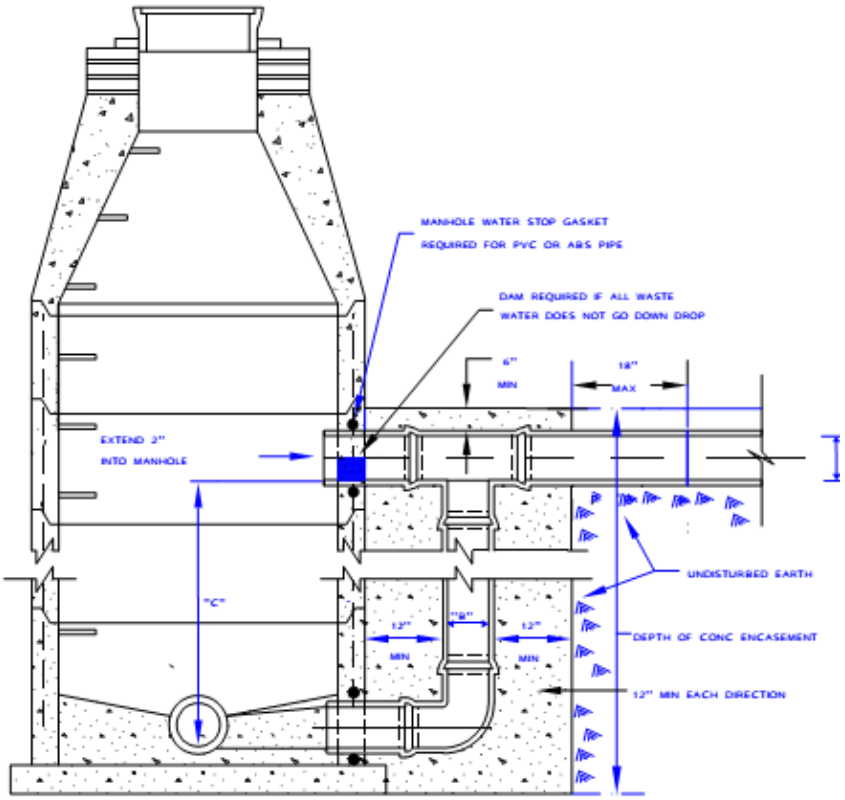


Figure 3.7: A typical circular manhole

3.4.3.11 Spacing of the Manhole

On sewers, which are to be cleaned manually, but cannot be entered for cleaning or inspection, the optimum distance between the manholes may be 100-150 feet (for smaller dia. Sewers). In Case of current scenario, a manhole spacing of 100 feet might be adopted for arterial sewers which will be finalized in the final engineering design. Foe the sewers, which are to be cleaned with mechanical devices, the spacing of the manholes will depend upon the type of the equipment to be used for cleaning sewers. For diameter, less than 35 inches, spacing of manholes adopted is 100- 300 ft. (30 -90 m) subjected to site accessibility and availability. Generic, co-relation between the straight sewer line and manhole spacing is given in the **Table 3.6.**

Table 3.6: Manhole spacing

Size of sewer (In)	Spacing (ft)
9-12	*100-150*
15-24	*200-250*
27-42	*300*
45-60	*400*
>60	*500*

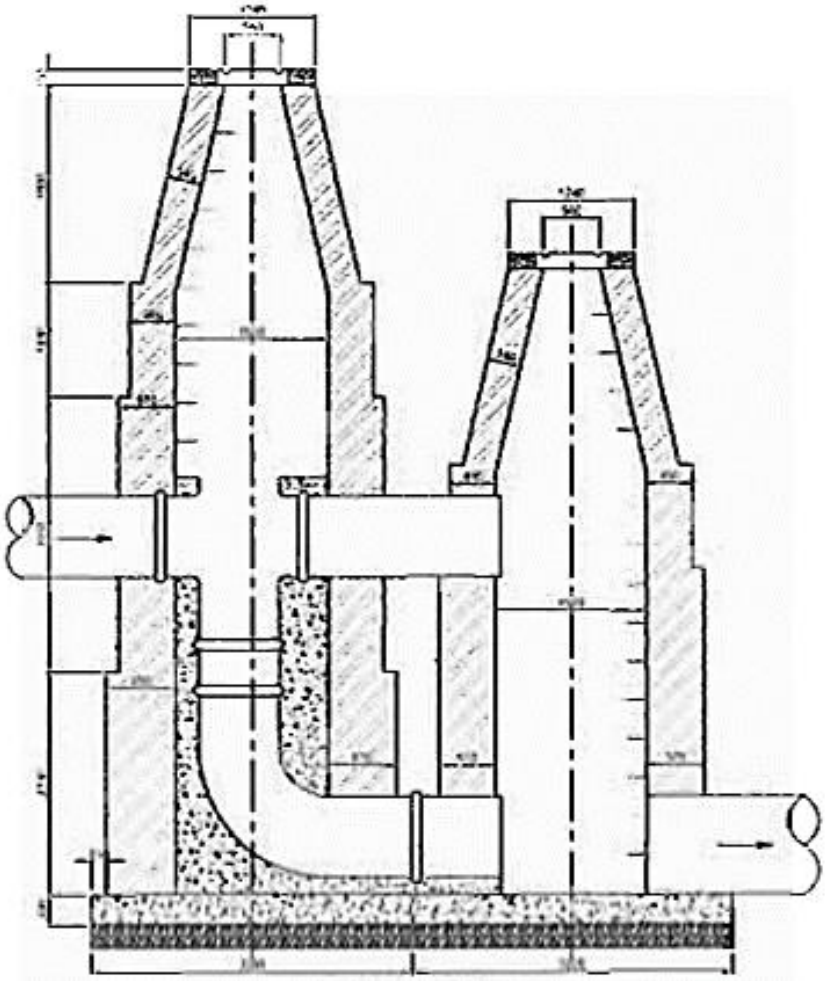


Figure 3.8: A typical drop manhole

The spacing of the manholes above 300 ft to 500 ft may be allowed for sewers of diameters 45inces or above and which may further be increased upto 1000 ft for sewer of 72 inches diameter subject to site accessibility.

3.4.3.12 Drop Manhole

A main line or house service line lateral entering a manhole at a higher elevation than the main flow line or channel. If the higher elevation flow is routed to the main manhole channel outside of the manhole, it is called an outside drop. If the flow is routed down through the manhole barrel, the pipe down to the manhole channel is called an inside drop.

When a sewer connects with another sewer, where the difference in level between water lines (peak flow levels) of main line and the invert level of arterial/branch line/feeding line is more than 20” or a drop of more than 20” is required to be given in the same sewer line and it uneconomical /impractical to arrange connection with 20”, a drop connection shall be provided for which a

manhole may be built incorporating a vertical drop pipe from the higher sewer to the lower sewer.

3.4.3.13 Junction Manhole

Junction manholes are provided where more than two pipes intersect. These are provided to combine the inflow from two or more pipes with one designated outlet. The diameter of the junction manhole must be large enough so that the distances between adjacent openings have enough strength to resist lateral and vertical loads, as well as stress caused by handling.

Figure 3.9: A typical junction manhole

3.4.3.14 Manhole Cover

As per IS- 4111 (Code of practice for ancillary structures in sewerage System – manholes), the size of the manhole covers should be such that there should be clear opening of not less than 22” for manholes exceeding 35” depth. Manhole cover and frame shall made of SFRC (steel fibre Reinforced Concrete) conforming to the relevant IS. Atypical manhole covers is shown in the **Figure 3.10.**

Figure 3.10: A typical cam lock manhole cover

3.4.4 *Pumping/Disposal Station*

Disposal station is normally provided under special circumstances in wastewater collection networks. These may be (1) when a natural barrier like river, canal etc. comes in the sewer route or (2) the depth of excavation increases to an extent that it becomes uneconomical/impractical to provide the sewer at such a depth and thus the hydraulic grade line is lifted by providing a Disposal Station.

The volume of the sump is computed based on the pumping capacity and the number of starts/stops per hour. The maximum starts/stops occur when the inflow is half the outflow. The volume is calculated using the following formula.

$$V = Q \times T \qquad \ldots\ldots\ldots\ldots \qquad (3.5)$$

Where;

V = volume of the sewerage to be lifted

Q = Pumping in cubic meter per hour

T = time between starts/stop in hours

The criteria to be adopted for the design of the disposal station is as follows:

- A minimum of two submersible-type pumps or centrifugal pumps per station should be furnished – one duty, one back-up. Peak design capacity should be available with the largest pump out of service
- The pump should be capable of developing the required total head at the rated capacity.
- Pump should be suitable for single as well as parallel efficient operation at any point in between the minimum and maximum system resistance.

- The total head capacity curve of the pump should be continuously rising towards the shut- off. The pump should deliver at least 125% of its rated capacity at 75% of the specified total head.
- Pump station inventory should consider the need to convey low flows effectively as well as phasing considerations.
- Either constant speed or variable frequency drive may be used for pump station drivers.
- Electrical service infrastructure should be sized for ultimate requirements.
- Emergency power should be provided on site.
- Upstream sewer mains may not be considered part of available wet well storage volume.
- The pumping mains should be designed to give the most economical solution taking into consideration the power consumption, the cost of rising main and the velocity at sewage flows during the design period.

3.4.5 *Design Criteria for Waste Water Treatment Plant*

The criteria to be considered for the selection and the design of the wastewater treatment plant is as follows:

3.4.5.1 Wastewater Characteristics

The characteristics of domestic wastewater (influent) and the corresponding desirable effluent characteristics have been shown in Table 3.7. The effluent characteristics have been considered keeping in view the National Environmental Quality Standards (NEQS);

Table 3.7: Influent and Effluent Concentration

Characteristics	Influent Concentration	Effluent Concentration (NEQS)	Effluent Concentration (Horticulture Purpose)
Biochemical Oxygen Demand (BOD5)	Up to 250 mg/l	80 mg/l	< 30 mg/l
Chemical Oxygen Demand (COD)	Up to 350 mg/l	150 mg/l	< 80 mg/l
Total Suspended Solids (TSS)	Up to 300 mg/l	200 mg/l	< 80 mg/l
Design Temperature	Ambient	Ambient	Ambient
Fats, Oil and Grease	Up to 20 mg/l	< 10 mg/l	< 5 mg/l

3.4.5.2 Primary Screens

Upon reaching the sewage treatment plant, sewage flows through the primary screening facility which is the first stage of treatment. The screens shall be provided upstream of all inlet pump stations and shall be designed to protect downstream processes and equipment. The purposes of primary screens are:

- To protect equipment from rags, wood and other debris
- To reduce interference with in-plant flow and performance.

Design parameters for primary screen are summarized in **Table 3.8 below.**

Table 3.8: Design Parameters for Primary Screens

Description	Unit	Design Criteria	
		Manually Raked	Mechanically Raked
Maximum clear spacing	mm	25	25
Slope to the vertical		30^0-45^0	15^0-45^0
Maximum approach velocity at the feed channel	m/s	1.0	1.0
maximum flow through velocity at the screen face	m/s	1.0	1.0
Minimum freeboard	mm	150	150
Screening skip storage capacity	day	7	7
Minimum channel width	mm	500	500
Minimum channel depth	mm	500	500
RC Staircase with riser detail	1 unit	Anti-skid and non-corrosive	Anti-skid and non-corrosive

3.4.5.3 Inlet Chamber

Provision for inlet chamber before the primary screen channel is necessary for proper operation and maintenance of the plant. A penstock shall be installed upstream to isolate the pump station in the event of flooding in relation to the bypass and emergency overflow.

Table 3.9: Recommended Design Parameters for Inlet Pump Station/Well

Description	Unit	Design Parameters	
		PE ≤50,000	PE > 50,000
Number of pumps (all identical and work sequentially)		4 (2 sets),1 duty,1 assist, per set (100% standby)	6 (3 sets), 1 duty, 1 assist, per set (50% standby)
Pumps design flow		Each at 0.5 Q peak	Each at .025 Q peak
Maximum retention time at Q ave	min	30	30
Min pass through openings	mm	75	75
Minimum suction and discharge openings	mm	100	100
Pumping cycle (average flow conditions)	Start/ hour	6 min 15 max	6 - 15

Description	Unit	Design Parameters	
		PE ≤50,000	PE > 50,000
Lifting device*		Mechanical and block	Mechanical

Note: Motorized hoists shall be provided when the lifting weight exceeds 100 kg.

3.4.5.4 Secondary /Fine Screens

The design criteria to be adopted for the secondary/ fine screens of wastewater treatment plant is as follows:

Table 3.10: Design parameters for secondary screens

Description	Unit	Design Criteria	
		Manually Raked	Mechanically Raked#
Maximum clear spacing	mm	12	12
Slope to the vertical	m/s	30 -45	15 - 45
Maximum approach velocity at the feed channel	m/s	1.0	1.0
Maximum flow through velocity at the screen face	m/s	1.0	1.0
Minimum freeboard	mm	150	150
Screenings skip storage capacity	day	7	7
Minimum channel width	mm	500	500
Minimum channel depth	mm	500	500
RC Staircase with riser detail	1 unit	Anti-skid and non-corrosive	Anti-skid and non-corrosive

3.4.5.5 Grit and Grease Chambers

This unit is important to minimize problems associated with grit and grease. Grit creates problems to pumps and also sludge digestion and dewatering facilities. Grease creates problems at the clarifier and is carried over in the final effluent.

In grit removal system, grit or discrete particles that have subsiding velocities or specific gravities substantially greater than those of organic putrescible solids, e.g. eggshells, sands, gravel are removed by gravitate settlement or centrifugal separation. Same principle apply to oil and grease removal system, where free oil and grease globules lighter than water rise through the liquid and skimmed from the top surface. The design parameters are summarized in **Tables 3.11 & 3.12** below.

Table 3.11: Design Parameters for Grease Chambers

Description	Unit	Design Criteria →50000 PE
Grease removal	-	Mechanical
Chamber type		Aerated type
Minimum detention time *(Q peak)*	min	3
Grit and grease storage period before off-site disposal	day	7

Table 3.12: Design parameters for grit removal chambers

Description	Unit	Design Criteria >50000 PE
Grease removal	-	Mechanical
Chamber type	-	Aerated
Minimum detention time (Q peak)	minute	3
Maximum gravity flow through velocity	m/s	0.20
Maximum centrifugal flow through velocity	m/s	<1.0
Head loss (at partial flume)	-	-
Aeration requirement	l/s/meter length of tank	10.0
Chamber dimension: Depth Width Length Width	-	Manufacturer's Specification
Estimated grit quantity	103 m3 of sewage	0.03
Washing and dewatering of grit	-	Yes

3.4.5.6 Balancing Tanks

Balancing tanks are mandatory for all treatment processes that are not designed at peak flow. The tanks are effective means of equalizing sewage flow. For extended aeration plants that are designed with a retention time of more than 18 hours and clarifiers designed at peak flow, the use of balancing tanks is not required. The purposes of balancing tanks are to:

- Prevent flow variations entering secondary treatment processes.
- Reduce hydraulic loading into secondary treatment processes.
- Reduce potential overflows that may cause health hazard and pollution.
- The design requirements for balancing tanks are:

All balancing tanks must be completely aerated and mixed. Flow control shall by a non-mechanical constant flow device, such as an orifice, in order to avoid double pumping. Allowance must be made for an emergency overflow. Bypass

and drain down facilities as well as suitable access for cleaning shall be provided.

Table 3.13: Design Parameters for Balancing Tanks

Description	Unit	Design Criteria
Volume of tanks	m^3	1.5 hr detention at Q_{peak}
Mixing power requirements	W/m3 of sewage	5 at TWL
Aeration	m3 air/hour/ m3 sewage	1 m3 of air supply for every m3 of sewage stored per hour at TWL
Overflow bypass to down-stream unit requirement		Yes

3.4.5.7 Design Criteria of Biological Treatment Stage

Biological treatment is the heart of the sewage treatment process. It is the processes where the dissolved and non- settle-able organic material remaining in the sewage are removed by living organisms. For reasons of long term whole life economics, ease of operation and maintenance, consistent effluent standards and standardization, the following types of biological treatment processes are recommended.

Suspended Growth System consists of the following biological treatment systems:

- Conventional Activated Sludge (CAS) System
- Extended Aeration (EA)/Oxidation Ditch (OD) System
- Sequencing Batch Reactor (SBR)/Intermittent Decant Extended Aeration (IDEA).

(A) Conventional Activated Sludge (CAS) System

The design parameters to be considered while designing sewage wastewater treatment plant based on conventional activated sludge system are as follows:

Table 3.14: Design parameters for CAS system

Description	Unit	Design Criteria
Organic loading (depending on filter type) Low rate Intermediate rate High rate	Kg BOD_5/day/m^3	 0.08 – 0.15 0.15 – 0.5 0.5 – 2.0
Recirculation of flow to head of plant Q recycle Qin flow (to maintain wetting rate and improve flow)		> 1.0
Acceptable media		HDPE, PVC, stone, slag, coke, etc. (random or standard arrangement)
Hydraulic loading	m3/day/m2	

Description	Unit	Design Criteria
Low rate Intermediate rate High rate		1 - 4 4 - 10 10 - 40
Sludge Yields Low-rate filters Intermediate filters High-rate filters	kg sludge 1 kg BOD5 influent	 0.5 0.6 - 0.8 1 .O
Minimum depth of media	m	1.5

(B) Sequencing Batch Reactor (SBR)

Sequencing Batch Reactors system is suspended activated sludge system. In this system, sewage flows into one or more reactors where biological oxidation and clarification of sewage take place within the same reactors sequentially on cyclical mode

Table 3.15: Design criteria for SBR wastewater treatment plant

Description	Unit	Design Criteria
Primary Sedimentation System		Must be provided
Minimum number of aeration tanks		2
F/M ratio		0.25 – 0.50
Hydraulic retention time (HRT)	hrs	J6 (for system where only ammonia removal is require)
Oxygen requirement (for BOD and ammonia nitrogen removal)	KgO/kg substrate	2.0
Mixed liquor suspended solids (MLSS)	mg/J.	1500-3000 Typical: 2500
Dissolved oxygen (DO) level in tank	mg/.e	1.0
Aeration device rating		Continuous, 24 hrs
Sludge yield	Kg sludge produced/ kg BOD consumed	0.8 – 1.0
Sludge age	day	5 – 10
Waste activated sludge, QWAS	m3/d	Refer to equation below †
Return activated sludge flow, QRAS	m3/d	$\frac{MLSS}{C \cup \ MLSS} x\ Qavg$ Cu is underflow concentration
QRAS/ QINFLOW		0.75 – 1.0
Mixed liquor suspended solids recirculation for de-nitrification purpose		4 – 6 of Q avg
RAS pump rating	hrs/day	24
Organic loading	Kg BOD kg MLSS	0.25 – 0.5
Volumetric loading	kg BOD /m3.d	0.3 – 0.6
Minimum mixing requirement	W/ m3	20

Sludge Age = Total solids in aeration tank

Excess sludge wasting/day + solid in effluent

$$WAS = \frac{VT \; x \; MLSS}{\emptyset \; sludge} - [Qavg \; x \; SS \; \mathbf{eff}] \quad \ldots\ldots\ldots\ldots \quad (3.6)$$

Where:

VT = Volume of reactor (m^3)

MLSS = Mixed liquor suspended solids (kg/m^3)

θsludge = sludge age (days)

Q_{avg} = average flow (m^3/day)

SS_{eff} = effluent suspended solids (kg/m^3)

CU = underflow concentration (kg/m^3)

Table 3.16: SBR treatment tank dimensions

Description	Unit	Design Criteria
Water depth	m	3 – 5
Length: Width	m	3:1
Max width of joined tank	m	< 30

3.4.5.8 Design Requirements for SBR System

Sequencing Batch Reactors system is suspended activated sludge system. In this system, sewage flows into one or more reactors where biological oxidation and clarification of sewage take place within the same reactors sequentially on cyclical mode.

Table 3.17: Design criteria for SBR system

Parameter	Unit	Continuous Fill and Intermittently Decent	Intermittently Fill and Intermittently Decent
No. of Reactors	Unit	Minimum 2	Minimum 2
Hydraulic Retention time at Qavg (at average water level)	hr	18 – 24	18 – 24
F/M Ratio	D	0.05 – 0.08	0.05 – 0.30
Sludge Yield	Kg sludge/ kg BOD5 loud	0.75 – 0.85	0.75 – 1.10
MLSS (End of decant)	mg/l	3000 - 4500	3000 – 4500
Cycle Time	Hr	4 - 8	4 – 8
DO (Reactor) DO (Effluent)	mg/l mg/l	0 – 6.5 2.0	0 – 6.5 2.0
Oxygen Requirement	$\frac{kg\ O2}{kg\ Substrate}$	$\frac{Cycle\ time}{aeration\ time}\ x\ \frac{20kg}{kg\ subs}$	$\frac{Cycle\ time}{aeration\ time}\ x\ \frac{20kg}{kg\ subs}$
Decant time	hrs	≥1.0	≥1.0
Decant volume	m	Max 0.5	Max 1.0

Parameter	Unit	Continuous Fill and Intermittently Decent	Intermittently Fill and Intermittently Decent
Decanting device loading rate	m3/m/hr	≤20 for decant draw-down from TWL	≤20 for decant draw-down from TWL
Minimum number of decanter		2 nos. independent decanter per tank	2 nos. independent decanter per tank
Max. decanter length	m	4.0	4.0
WAS	kg sludge/d	$WAS = \frac{Total\ Solids\ in\ System}{Sludge\ age}$	$WAS = \frac{Total\ Solids\ in\ System}{Sludge\ age}$
Fill volume	m3	$V_{fill} = (Q_p\ m^3/hr \times 1.5hr) + (T_{fill} - 1.5) \times Q_{AVG}$ (if no balancing tank) $V_{fill} = Q_{AVG} \times T_{fill}$ (if preceded by balancing tank)	$V_{fill} = (Q_p\ m^3/hr \times 1.5hr) + (T_{fill} - 1.5) \times Q_{AVG}$ (if no EQ) $V_{fill} = Q_{AVG} \times T_{fill}$ (if preceded by balancing tank)

- For continuous fill, length to width ratio shall be based on 3 : I
- Decanting device loading rate shall be based on Vm/decant time during decanting.
- RAS maybe necessary where length to width ratio poses dilution affect into the inlet.

3.4.5.9 Design Parameters for Extended Aeration (EA) System

The Extended Aeration process is similar to the Conventional Activated sludge process except that it operates in the endogenous respiration phase of the growth curve, which requires a low organic loading and long aeration time. The system produces high MLSS concentration, high RAS pumping rate and low sludge wastage.

The advantage of having long hydraulic retention times is that it allows the plant to operate effectively over widely varying flow and waste loadings. Secondary clarifiers must be designed to the variations in hydraulic loadings and high MLSS concentrations associated with this process.

EA plants shall be designed as either plug flow or completely mixed. Anoxic zone at the head of the reactor must be provided for de-nitrification. The .anoxic zone must be mixed without inducing dissolved oxygen

For Oxidation Ditches, the minimum velocity within the channel shall be sufficient to keep the activated sludge in suspension. The minimum velocity within the channel shall not be less than 0.3 mis.

Table 3.18: Design criteria for EA wastewater treatment plant

Description	Unit	Design Criteria
Minimum number of aeration tanks		2
F/M ratio		0.05 – 0.1
Hydraulic retention time (HRT)	hrs	18 - 24
Oxygen requirement (for BOD and ammonia nitrogen removal)	Kg O/kg substrate	2.0
Mixed liquor suspended solids (MLSS)	mg/ ℓ.	2500-5000 Typical: 3000
Dissolved oxygen (DO) level in tank	mg/ ℓ	2.0
Sludge yield	Kg sludge produced/ kg BOD5 consumed	0.4 (at 24 hrs HRT) 0.6 (at 18 hrs HRT)
Sludge age	day	>20
Waste activated sludge, QWAS	m3/d	Refer to equation †
Return activated sludge flow, QRAS	m3/d	$\frac{MLSS}{C\cup\ MLSS}$ x Qavg Cu is underflow concentration
RAS pump rating	hrs/day	24
Recirculation ratio, QRAS/ QINFLOW		0.5 – 1.0
MLSS recycle ratio		4 – 6 times of Qavg
Volumetric loading	kg BOD5 /m3 /d	0.1– 0.4
Minimum mixing requirement	W/ m3	20

Table 3.19: EA wastewater treatment tank dimensions

Description	Unit	Design Criteria
Water depth	m	3 – 5
Length: Width	ratio	3:1
Max width of joined tank	m	<60

Table 3.20: Organic loading parameters for EA wastewater treatment system

Description	Unit	Design Criteria
Organic loading (depending on filter type) Low rate Intermediate rate High rate	kg BOD5 /day/m3	 0.08 – 0.15 0.15 – 0.50 0.50 – 2.00
Recirculation of flow to head of plant Qrecycle QInflow (to maintain wetting rate and improve flow)		>1.0
Acceptable media		HDPE, PVC, Stone, Slag, Coke, etc. (random or standard arrangement)
Hydraulic Loading Low rate Intermediate rate	m3/day/ m2	 1 – 4 4 – 10

High rate		10 – 40
Sludge Yield Low rate filters Intermediate filters High rate filters	Kg sludge/ kg BOD5 influent	 0.5 0.6 – 0.8 1.0
Minimum depth of media	m	1.5

Note:

Sludge Age = total solids in aeration tank

Excess sludge wasting/day + solid in effluent

$$WAS = (VT \times MLSS)/(\emptyset \text{ sludge}) - [Q_{avg} \times SS \text{ eff}] \quad \ldots\ldots\ldots\ldots\ldots \quad (6.7)$$

Where:

VT = Volume of reactor (m^3)
MLSS = Mixed liquor suspended solids (kg/m^3)
θsludge = sludge age (days)
Q_{avg} = average flow (m^3/day)
SS_{eff} = effluent suspended solids (kg/m^3)
CU = underflow concentration (kg/m^3)

Designer shall ensure that with 50% of blockage at the face of screen, sufficient freeboard is provided to prevent the approach channel from overflowing washing and dewatering of screenings shall be provided.

3.4.5.10 Design Parameters for Trickling Filters

The Trickling Filter is an established biological treatment process removing 65 to 85% BOD_5 and suspended solids. The process consists of a bed of highly permeable medium. An overhead rotating distributor applies sewage to the media. The now trickles over and flows downward 10 the under drain system
The media provides a large surface area to develop biological slime growth which is also known as zoogleal film. The film contains living organisms that break down organic material in the sewage.
Many variations of the Trickling Filters have been constructed.
Secondary screens (< 6 mm) and flow balancing tanks to equalize the flow must be provided before trickling filters. Provisions shall be available for even distribution to achieve complete wetting of the filter media.

3.4.5.11 Design Parameters for the Secondary Clarifiers

Following design shall be adopted for the design of the secondary clarifiers:

Table 3.21: Design parameters for secondary clarifiers

Description	Unit	Design Criteria	
		PE ≤ 5,000	PE > 5,000
Minimum number of tanks		2*	2
Tank configuration		Square Circular Rectangular	Square Circular Rectangular
Minimum side water depth	m	3**	3
Minimum hydraulic retention time (HRT) at Qpeak	hrs	2	2
Surface overflow rate at Qpeak	m3/d/m2	≤ 30	≤ 30
Solids loading rate at Qpeak	kg/d/ m2	<150	<150
Solids loading rate at Qavg	kg/d/m2	<50	<50
Weir loading rate at Qpeak	m3/d/m	<180	<180
Return activated sludge (RAS) pumping rate		Continuous	Continuous
Waste activated sludge (WAS) pumping rate		Continuous or batch	Continuous or batch
Sizing of Rectangular Tanks			
Length: Width		3:1 or greater	
Maximum side water depth	m	3.0	
Width: Depth		1:1 to 2.5:1	
Sizing of Circular Tanks			
Water depth, minimum	m	3.0**	
Floor slope wall		1:12	

3.4.5.12 Intermittent Disinfection

Following guidelines shall be used for the disinfection of the sewage water after the treatment.

Table 3.22: Design guide for intermittent disinfection

Type	Design Criteria
Contact Tank	
Contract Period	15 minutes at Qpeak
Maximum depth	3 m
Depth: width	2 : 1
Min no. of passes	4
Length: Width at each pass	6 : 1
Wetted Depth: Width	< 2:1

3.5 Proposed Sewerage System

Based on the topography of the project area the whole city has been divided into 11 zones to ultimately dispose of the sewage flow through gravity. The details of these zones are as below:-

3.5.1 *Sewerage Zones*

3.5.2 *Zone-1*

In this zone only JAGEER BASEEN area is included. Zone boundary started from Verza Basin to RCC Bridge Basin. Main septic tank is proposed at the lower side of Khushbakht chowk along the bank of river. Sewage flow from upper area of JAGEER BASEEN from bridge and lower area along chitral road from RCC Bridge is collected at Khushbakht chowk and then discharged into the septic tank.

3.5.3 *Zone-2*

This zone boundary started from upper bridge on Kargah nullah to Jutial public school for boys. Main trunk sewer started from lower RCC Bridge on Ghizer road to eye hospital. This Main trunk sewer will carry the flow of areas including Kargah Bhudda, Narot, Naupura, Naikoi, Baseen Khari, Barmas, Mohallah Alamdar, NLI market, Nagral, Nagral Kalchmote, Airport area, Konodas bridge area, Majini Mohallah. While sewage flow from Jutial public school and upper area of Jutial from Gilgit Sareena hotel towards Shaheed millat road drops into main trunk sewer through lateral sewers and collected near the eye hospital where a pump station is provided to pump this sewage towards the proposed STP.

3.5.4 *Zone-3*

This zone boundary starts from Jutial public school lower area and upper area to Sakwar. Sewage flow between the areas of SHERULLAH BAIG ROAD & NATCO BUS STAND, upper Jutial area from other side of Sareena hotel and Jutial public school to NATCO bus stand is collected at proposed STP from where the effluent shall be disposed of in Gilgit river after treatment.

3.5.5 *Zone-4*

For the area of Sakwar separate Septic tank is proposed.

3.5.6 *Zone-5*

For the area of MANAWAR separate Septic tank is proposed.

3.5.7 *Zone-6 & 7*

These zones consists of only Danyour area. Boundary of these zones starts from bridge on Sultanabad Nullah to China Bridge along the Karakorum road and the area under the BAGROT road to Gilgit River. Main sewer trunk is proposed along the main road from check post to China Bridge. Lateral sewer lines are proposed to drop into the main sewer trunk. Separate Septic tank is proposed for this area.

3.5.8 *Zone 8*

For the area of Sultan-abad, separate Septic tank is proposed

3.5.9 *Zone-9*

This zone shall comprise of area starts from Gulsher Colony including Eid Gah area, police line, Chamogar colony, Nagar Colony and Shah Karim Hostel. Separate septic tank has been proposed for this zone. This zone also consists of Mujahid colony, from education office to the office of Advocate General. Separate septic tank shall be proposed for this zone & main trunk Sewer lines shall be proposed along the Konodas raod.

3.5.10 *Zone-10*

This zone shall comprise of, Sakarkoi, area. Separate septic tank has been proposed for this area.

3.5.11 *Zone-11*

This Zone comprises of KIU and Allied colonies. Separate septic tank has been proposed for this area. The proposed zone boundary of Gilgit City is shown in Figure 3.11.

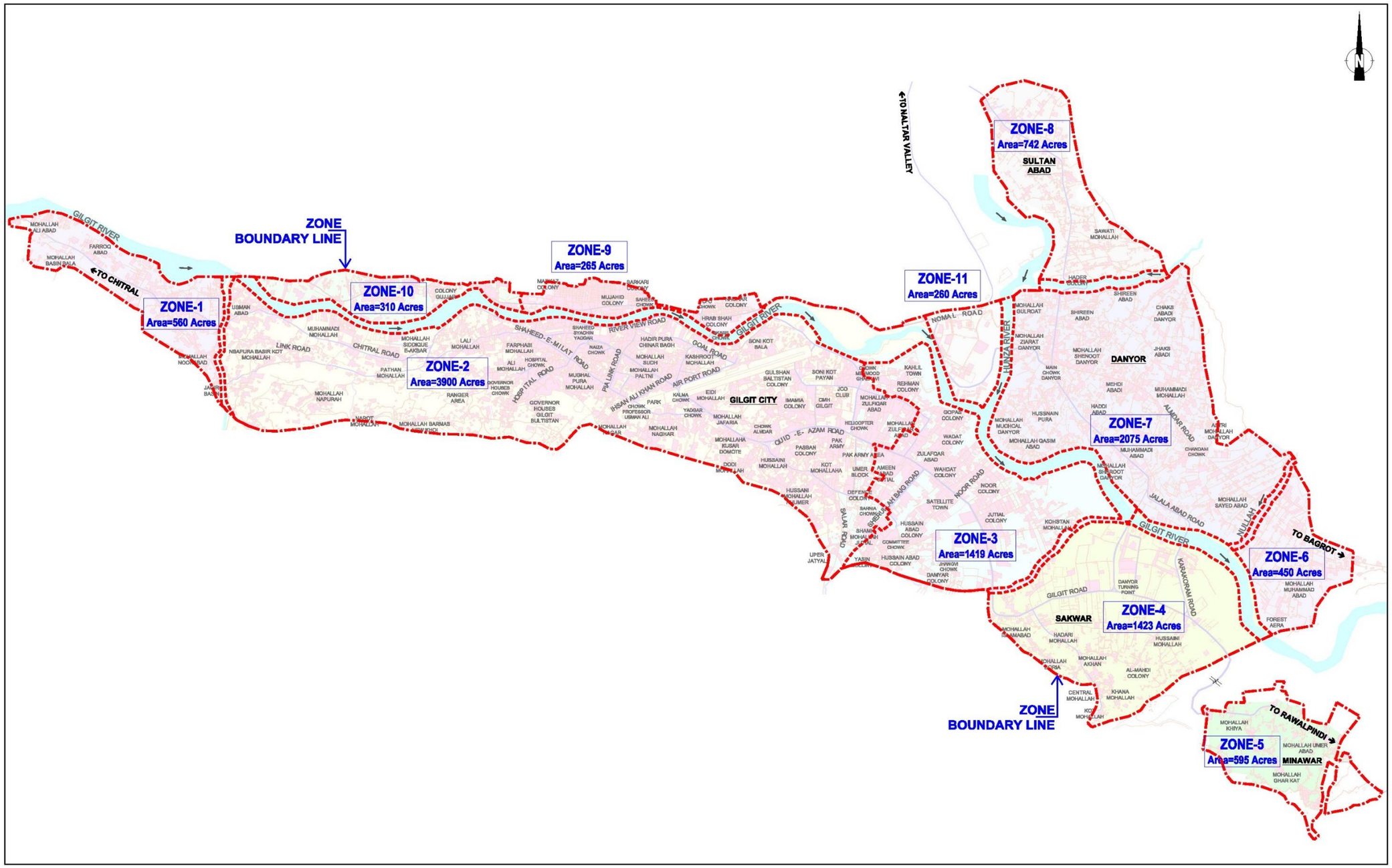


Figure 3.11: Proposed Zoning for Sewerage System

The proposed sewerage system consists of separate collection networks i.e. independent pipes/conduits for both wastewater and storm water generated in the project area. Wastewater/sewage generated in the area is conveyed through lateral and trunk sewers/conduits up to sewage treatment plants (STP) and treated for subsequent disposal into the water body. Storm water collected on the roads, open areas and roofs is separately collected in the storm water conduits/drains and disposed of into water bodies or stored for re-use. Separate system is easy to operate but capital and O&M cost is larger.

Advantages of Separate System:

- Load on treatment units become less as only sewage is connected with the STP.
- The natural storm water is not unnecessary polluted.
- The sewers are small in size.
- The storm water shall be discharged into natural streams without any treatment.
- The system proves to be economical when pumping is required for the lifting of sewage.

3.6 Objectives of the Proposed Project

- Reduction of waterborne and communicable diseases by provision of sanitation facilities to the residents of Gilgit
- Improvement in the quality of living of urban residents and reduction of poverty in the low income and slum areas.
- Enhanced public health awareness for improvement of public health
- Saving of man-days of public presently affected with diseases.
- Improvement of urban environmental conditions
- Provision of expanded and upgraded urban environmental infrastructure with respect to sewerage and sanitation.
- Development of appropriate cost-recovery mechanisms to ensure sustainability of urban sewerage, drainage and sanitation services.
- Improvement of the working efficiency of individuals and ultimately the organizations.
- Rehabilitate all choked drains
- Provide sewerage/drainage facility to un-served areas

3.7 Salient Features of the Proposed Project

Mechanical Treatment Plant is proposed for Zone-2&3. The flows of area for Zone-2 is collected at Gilgit Eye Hospital where Sewage Pumping station is proposed which will pump the sewage of Zone-2 into Energy Dissipation Chamber at a distance of about 3300 ft. From Energy dissipation Chamber, sewage flows under gravity up to Proposed Mechanical Treatment Plant**.** For Mechanical Treatment Plant, 4-5 acre land will be required. In this option 3300 ft pumping of sewage flow is required, after this sewage will flow through gravity for a distance of about 11600 ft to Treatment plant.

While for other zones, individual septic tanks are proposed. All sewage flows under gravity and no pumping will be required. After treatment, the effluent will be disposed of into Gilgit River.

3.7.1 *Zone-1*

In this zone only JAGEER BASEEN area is included. Zone boundary started from Verza Basin to RCC Bridge Basin. Main septic tank is proposed at lower side to Khushbakht chowk along the bank of river. Sewage flow from upper area of JAGEER BASEEN from bridge and lower area along chitral road from RCC Bridge collected at Khushbakht chowk and then collected into the septic tank.

For sewage collection system, uPVC pipes are used with trunk sewer having maximum diameter of 500mm while all proposed lateral sewer are of min. 200mm in diameter.

3.7.2 *Zone 2 &3*

Zone-2 boundary started from upper bridge on Kargah nullah to Jutial public school for boys. Main trunk sewer started from lower RCC Bridge on Ghizer road to eye hospital. This Main trunk sewer will carry the flow of areas including Kargah Bhudda, Naroti, Naupura, Naikoi, Barmas, Mohallah Alamdar, NLI market, Nagral colony, Airport area, Konodas bridge area, Majini. While sewage flow from Jutial public school and upper area of Jutial from Gilgit Sareena hotel towards Shaheed millat chowk) drop into main trunk sewer through distribution system and collected near the eye hospital where a pump station/gravity which one is suitable will be provided to pump this sewage towards the proposed STP.

Zone-3 boundary starts from Jutial public school lower area and upper area to Sakwar. Sewage flow between the areas of SHERULLAH BAIG ROAD & NATCO BUS STAND, upper Jutial area from other side of Sareena hotel and Jutial public school to NATCO bus stand shall be collected at proposed STP from where the effluent shall be disposed of in Gilgit river after treatment.

For sewage collection system, uPVC pipes are used. In Zone-2, maximum diameter used for trunk sewer is of 950mm while all proposed lateral sewer are of min. 200mm in diameter. In Zone-3, maximum diameter used for trunk sewer is of 600mm while all proposed lateral sewer are of min. 200mm in diameter.

3.7.3 *Zone-4*

For the area of Sakwar separate Septic tank is proposed. In Zone-4, maximum diameter used for trunk sewer is of 550mm while all proposed lateral sewer are of min. 200mm in diameter.

3.7.4 *Zone-5*

For the area of MANAWAR Septic tank is proposed. In Zone-5, maximum diameter used for trunk sewer is of 400mm due to low dense area while all proposed lateral sewer are of min. 200mm in diameter.

3.7.5 *Zone 6 &7*

These zones consists of only Danyour area. Boundary of these zones starts from bridge on Sultanabad Nullah to China Bridge along the Karakorum road and the area under the BAGROT road to Gilgit River. Main trunk sewer is proposed along main road from check post to China Bridge. Lateral sewer lines shall drop into main trunk sewer. Separate Septic tanks are proposed. In Zone-6&7, maximum diameter used for trunk sewer is of 650mm while all proposed lateral sewer are of min. 200mm in diameter.

3.7.6 *Zone 8*

For the area of Sultan-abad separate Septic tank is proposed. In Zone-8, maximum diameter used for trunk sewer is of 450mm while all proposed lateral sewer are of min. 200mm in diameter.

3.7.7 *Zone 9*

This zone shall comprise of area starts from Gulsher Colony including Eid Gah area, police line, Chamogar colony, Nagar Colony and Shah Karim Hostel. Separate septic tank has been proposed for this zone. This zone also consists of Mujahid colony, from education office to the office of Advocate General. Separate septic tank shall be proposed for this zone & main trunk Sewer lines shall be proposed along Konodas raod. In Zone-9, maximum diameter used for trunk sewer is of 550mm while all proposed lateral sewer are of min. 200mm in diameter.

3.7.8 *Zone 10*

This zone shall comprise of, Sakarkoi, area. Separate septic tank proposed for this zone. In Zone-10, maximum diameter used for trunk sewer is of 250mm while all proposed lateral sewer are of min. 200mm in diameter.

3.7.9 *Zone 11*

This Zone Comprise of KIU and Allied colonies. Separate septic tank shall be proposed for this zone. In Zone-11, maximum diameter used for trunk sewer is of 250mm while all proposed lateral sewer are of min. 200mm in diameter.

3.8 Sewage Treatment Technologies

The technical parameters/Design criteria together with project scope and description are given in the following paragraphs.

In the developing/underdeveloped countries of the world, more than 90% of the sewage is discharged untreated into rivers, lakes or the oceans due to lack of proper wastewater collection and treatment facilities.[3]The flow rate and the pollution load of the wastewater is governed by the size and socioeconomic status of the population of the community. The **Table 3.23** presents the municipal waste water composition of cities of Lahore and Karachi and compares it with the NEQS and World Bank discharge limits. The composition of sewage varies greatly from city to city and town to town with season and its characterization is important for determining the wastewater treatment technology and size of the wastewater treatment plan.

Table 3.23: Composition of sewage in Pakistan[4]

Water Quality Parameter	Units	Permissible Limit		Lahore	Karachi
		NEQS,	IFC/WBG		
COD	mg/L	150	125	580-803	220-475
BOD	mg/L	80	30	200-215	200-1400
TSS	mg/L	200	50	106-176	300-1200
TDS	mg/L	3,500	-	486-598	50-200
Chlorides	mg/L	1,000	-	32-72	1000- 1800
Sulphates	mg/L	600	-	-	250-900

Currently the Gilgit City is deprived of proper sewage collection, conveyance and treatment system. Sewage waste water is used for the irrigation purposes and

[3] Emily Corcoran, Sick Water? The central role of the wastewater management in the sustainable development, A rapid response assessment, UN Habitat, 2008

[4] Planning and Development Division of Pakistan (1987).

excessive water is discharges into the Gilgit and Hunza Rivers without any prior treatment meet the National Environmental Quality Standards (NEQS). The individual house owners have constructed soakage pits. While in some areas sewerage system is collected in septic tank. Some houses have constructed septic tanks before its disposal in soakage pits. Due to lack of any proper system this raw sewage is collected in areas in depression and creates environmental and health problems for the nearby communities.

Untreated wastewater contains numerous pathogenic microorganisms and may have toxic compounds that may endanger public health and environment in either way. Therefore, it is required to treat the sewage water to meet the prescribed NEQS (given in **Table 3.23**) before its final disposal or reuse/recycle.

Sewage Treatment is the process of removing contaminants from wastewater. It includes physical, chemical and biological processes to remove suspended solids, biodegradable organics, pathogens, nutrients, heavy metals and dissolved inorganic solids.

Its objective is to produce treated effluent and sludge:

- To protect human health
- To prevent environment
- Water Conservation
- Compliance with regulations and standards

Sewage Treatment Methods

1. Pre Treatment (Physical)
2. Primary Treatment (Physical)
3. Secondary Treatment (Biological)
4. Tertiary Treatment (Chemical)

1. Pre Treatment

Preliminary treatment is the removal of coarse solids and other large materials often found in raw wastewater. Removal of these materials is necessary

- To Screen out, grind up or separate debris
- To protect the pumping and other equipment in the treatment plant
- To avoid any maintenance and operational problem in treatment process

Depending on the characteristics of the sewage, pretreatment processes at the STP may include grease removal using a grease trap, and screening using a bar screen to

remove larger solids such as plastics, rags. If there is a lot of sand or grit in the sewage, a grit chamber may also be installed.

Treatment Technologies

a) Bar screens

b) Grit Chamber

Bar Screens

Water is introduced to the Bar Screen; here coarse solids are removed, such as sticks, rags, and other debris in untreated wastewater by interception. By use of fine screening even floatable matter and algae are removed.

Grit Chamber

Grit is removed consisting of sand, gravel, cinders, or other heavy solid materials that have subsiding velocities or specific gravities substantially greater than those of the organic solids in wastewater.

2. Primary treatment

Primary treatment is the removal of suspended solids (settle-able), organic matter and inorganic matter. It reduces the Total Suspended Solids (TSS) in the water by about 40 to 60% and reduces the Biochemical Oxygen Demand (BOD) by about 25 to 35%.

Equalization Tank

Some organic nitrogen, organic phosphorous and heavy metal associated with solids are also removed during primary sedimentation but colloidal and dissolved constituents are not affected.

3. Secondary treatment

Secondary Treatment is the Biological process, to remove dissolved and colloidal organic matter from wastewater. Micro-organisms are added to the wastewater. The microorganisms absorb organic matter from sewage as their food supply.

Following approaches are used to accomplish secondary treatment:

3.8.1 *Aerobic Process*

Suspended Growth

i. Conventional Activated Sludge

ii. Extended Aeration

iii. Sequential Batch Reactor

iv. Oxidation Ditch

v. Oxidation Pond

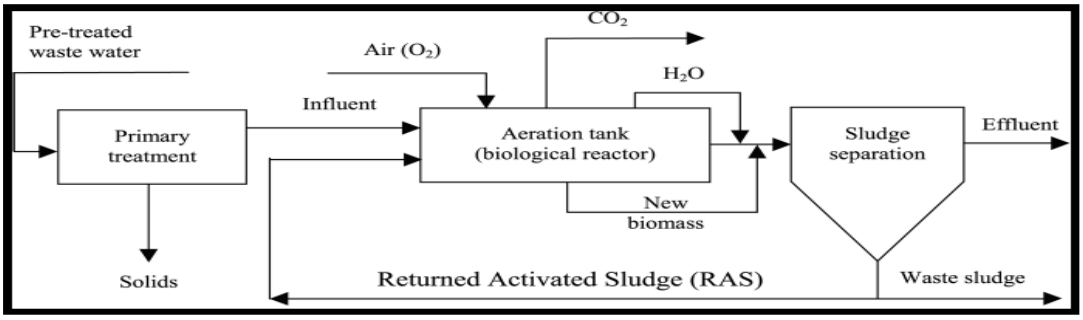
1. Conventional Activated Sludge System

Activated sludge is a process biological wastewater treatment technique in which a mixture of waste water and biological sludge is aerated. Because the microorganisms are suspended in the wastewater, this process is known as Suspended Growth Process

Activated sludge wastewater treatment system is the most widely used biological wastewater treatment for removal of biochemical oxygen demand from wastewater.

The Activated Sludge process in which air is continuously injected into the wastewater. Microorganisms are mixed thoroughly with the organic compounds under conditions that stimulate their growth through use of the organic compounds as food. As the microorganisms grow and are mixed by the agitation of the air, the individual organisms clump together (flocculate) to form an active mass of microbes called Activated Sludge. Wastewater flows continuously into an aeration tank where air is injected to mix the activated sludge with the wastewater and to supply the oxygen needed for the organisms to break down the organic compounds. The mixture of activated sludge and wastewater in the aeration tank is called mixed liquor. The mixed liquor flows from the aeration tank to a secondary clarifier where the activated sludge is settled out. Most of the settled sludge is returned to the aeration tank (and is called return sludge) to maintain the high population of microbes that permits the rapid break down of the organic compounds. Because more activated sludge is produced than is desirable or wasted to the sludge handling system for treatment and disposal.

In Conventional activated sludge system, the wastewater is typically aerated for 6-8 hrs in aeration basin. Sufficient air is provided to keep the sludge in suspension. The air is injected near the bottom of the aeration tank through a system of diffusers. The volume of sludge returned to the aeration basin is typically 20-30 % of the wastewater flow.



A portion of the activated sludge is purposely removed by wasting it from the process. The wasting of sludge is necessary to maintain the desired quantity. A basic idea behind successful operation of an activated sludge system is to keep a balance of microorganisms to the amount of food in the wastewater. Proper operation makes food the only part of microorganism's diet that limits their growth.

If nutrients or oxygen limit the growth of the microorganisms, they will not settle satisfactorily in the clarifier. The activated sludge process depends on settling the mixed liquor so that it can be returned to the aeration tank to keep in balance with the organic material in the incoming wastewater. This balance is generally related to process loading as expressed by the F/M ratio.

Inability to settle the mixed liquor can result in a high concentration of suspended solids in the clarifier effluent.

The process traps particulate material and can, under ideal conditions, convert ammonia to nitrite and nitrate ultimately to nitrogen gas.

2. Extended Aeration

This is the modified form of Conventional Activated Sludge.

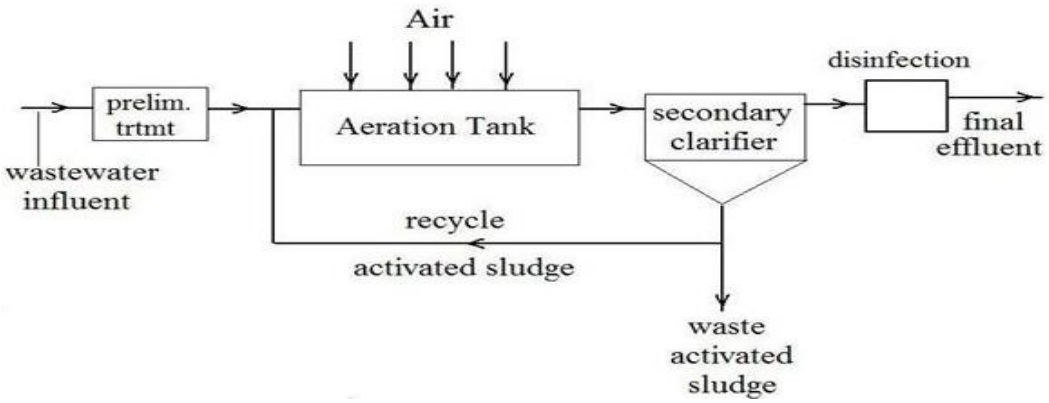
a) Variations involve changes in loading rates or a physical rearrangement of the process.

b) The various levels of process loading are described by the F/M ratio and MCRT.

c) "Physical arrangement"
- structural arrangement of the aeration tank
- various arrangements of the process streams that are used to provide flexibility

d) Extended aeration rate
- The lowest range of process loading where successful operation may be accomplished

e) Plants operating in this range
  - Generally small in size
  - Do not receive 24 hour supervision
  - Aeration period 18-24 hrs
  - Such plants are very conservative in design
  - MCRT of 20-40 days
  - F/M ratio of 0.05 to 0.15 lbs BOD applied/lb MLVSS/day.



- Effluent of the extended aeration process often contains small pinpoint floc, which may be observed passing over the weirs of the secondary clarifier
- In the higher end of the loading range, a number of operating problems may occur
- Because the entire aeration range is in the nitrification zone, DE nitrification and rising sludge problems may result

- Brown, greasy foam
- Filaments
- Poor satiability

Advantages

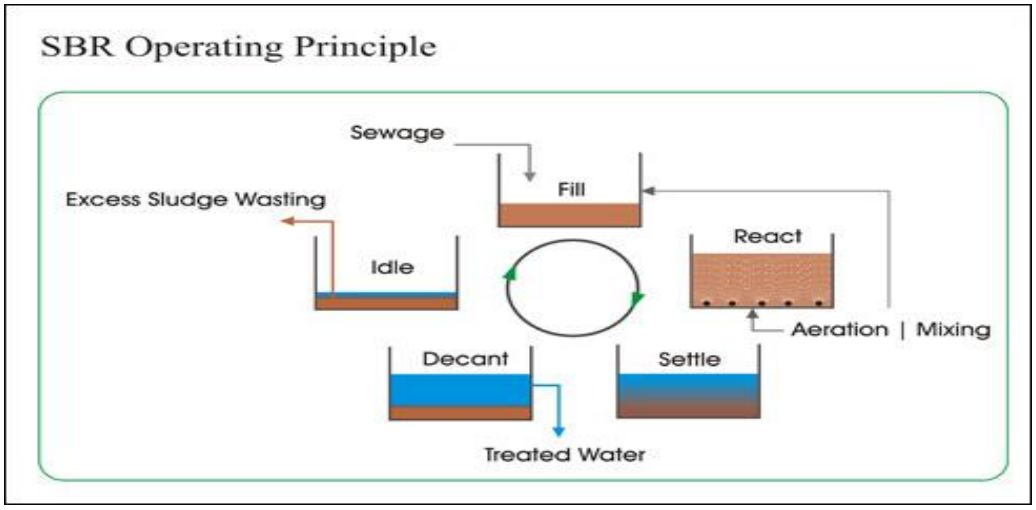
- Reliable quality effluent is possible
- Relatively uncomplicated design and operation
- Capable of treating shock/toxic loads

Disadvantages

- Aeration energy use is high
- Relatively large aeration tanks
- Adaptable mostly to small plants

3. Sequencing Batch Reactor SBR

The SBR is fundamentally the same as any other variation of activated sludge. The same concepts, design procedures, and biological kinetics used for continuous flow systems are applicable to the design and operation of SBRs. However, the impacts of a batch operation compared to continuous flow systems must be understood and applied for a successful SBR system.



Correctly sized SBRs, using only the aerated portion of the cycle as the basis of system SRT, do not have less total volume than comparable continuous flow systems.

High levels of nitrogen removal are easily achievable, and with great process flexibility. With proper instrumentation the occurrence of anoxic zones and the time of the zones can be operator varied to suit specific conditions.

High levels of nitrogen and phosphorous removal are best accomplished using biological removal of nitrogen and chemical precipitation of phosphorus.

Installed diffuser and blower requirements in an SBR are greater than those for comparable continuous flow system. Installed blower HP increases with a decreasing number of reactors in a given SBR system. Power draw for the aeration system is approximately the same for similar conditions and operation.

Advantages

- Single tank for reaction and settling (requires two or more tanks for continuous operation
- Good settling and no sludge
- Flexible operation, automation possible
- Typically for smaller plants
- Often no primary clarifier- easy sludge handling

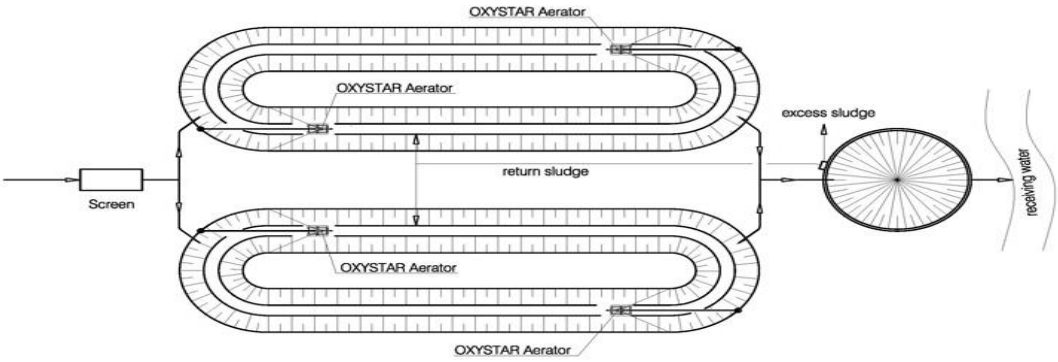
Disadvantages

- Special decanting and aeration equipment
- Need to recycle early decant if solids in weir trough

4. Oxidation Ditch Process

An oxidation ditch is a modified activated sludge biological treatment process that utilizes long solids retention times (12-24 hrs) to remove biodegradable organics.

Oxidation ditches are typically complete mix systems, but they can be modified to approach plug flow conditions. Typical oxidation ditch treatment systems consist of a single or multi-channel configuration within a ring, oval, or horseshoe-shaped basin.



Horizontally or vertically mounted aerators provide circulation, oxygen transfer, and aeration in the ditch. Surface aerators, such as brush rotors, disc aerators, draft tube aerators, or fine bubble diffusers are used to circulate the mixed liquor. The mixing process entrains oxygen into the mixed liquor to promote microbial growth and the motive velocity ensures contact of microorganisms with the incoming wastewater. The aeration sharply increases the dissolved oxygen (DO) concentration but decreases as biomass uptake oxygen as the mixed liquor travels through the ditch. Solids are maintained in suspension as the mixed liquor circulates around the ditch. If design SRTs is selected for nitrification, a high degree of nitrification will occur. Oxidation ditch effluent is usually settled in a separate secondary clarifier. An anaerobic tank may be added prior to the ditch to enhance biological phosphorus removal. An oxidation ditch may also be operated to achieve partial DE nitrification.

Advantages

The main advantage of the oxidation ditch is the ability to achieve removal performance objectives with low operational requirements and operation and maintenance costs. Some specific advantages of oxidation ditches include:

- Long hydraulic retention time and complete mixing minimize the impact of a shock load or hydraulic surge.

Disadvantages

- Effluent suspended solids concentrations are relatively high compared to other modifications of the activated sludge process.
- Requires a larger land area than other activated sludge treatment options. This can prove costly, limiting the feasibility of oxidation ditches in urban, suburban, or other areas where land acquisition costs are relatively high.
- Accordingly the civil cost for structures is also high.

- De-slugging and control of suspended solids may also cause problems in long run.

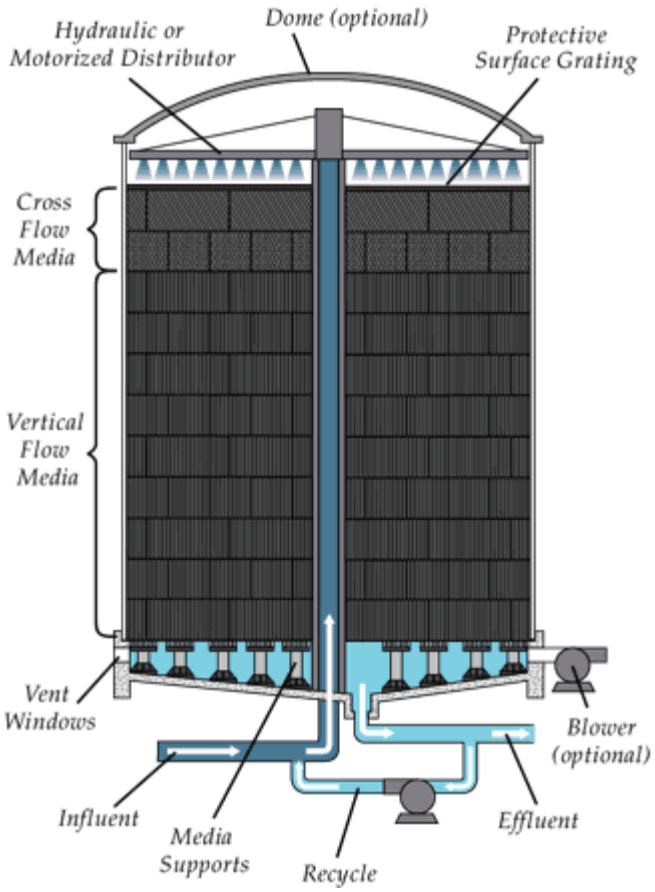
Attached Growth Processes

1. Trickling Filter Process

Trickling filter is an Attached growth process i.e. process in which microorganisms responsible for treatment are attached to an inert packing material. Packing material used in attached growth processes include rock, gravel, slag, sand, redwood, and a wide range of plastic and other synthetic materials.

The wastewater in trickling filter is distributed over the top area of a vessel containing non-submerged packing material. Air circulation in the void space, by either natural draft or blowers, provides oxygen for the microorganisms growing as an attached biofilm.

Packing are the means of providing large amounts of surface area where the microorganisms cling and grow in slime on the rocks as they feed on the organic matter.



Excess growths of microorganisms wash from the packing media and would cause undesirably high levels of suspended solids in the plant effluent if not removed. The microorganisms absorb the organic matter in the sewage and stabilize it by aerobic

metabolism, thereby removing oxygen-demanding substances from the sewage. Thus, the flow from the filter through a sedimentation basin to allow these solids to settle out. As in case of activated sludge process this sedimentation basin is referred to as Secondary Clarifier. Trickling filters remove up to 85 percent of organic pollutant from sewage.

Low rate Trickling Filters

A Low rate filter is a relatively simple, highly dependable device that produces an effluent of consistent quality with an influent of varying strength. The filters may be circular or rectangular in shape. Generally, feed flow from a dosing tank is maintained by suction level controlled pumps. Dosing tanks are small usually with only a 2 min detention time based on twice the average design flow, so that intermittent dosing is minimized. If the interval between dosing time is longer than 1 or 2 h, the efficiency of the process deteriorates because the character of biological slime is altered by a lack of moisture.

In most low rate filters, only the top 0.6 to 1.2m of the filter packing will have appreciable biological slime. As a result, the lower portion of the filter may be populated by autotrophic nitrifying bacteria, which oxidize ammonia nitrogen to nitrite and nitrate forms. If the nitrifying population is sufficiently well established and if climatic conditions and wastewater characteristics are favourable, a well operated low rate filter can provide good BOD removal and highly nitrified effluent.

With a favourable hydraulic gradient, the ability to use gravity flow is a distinct advantage. If the site is too flat to permit gravity flow, pumping will be required. Odours are common problem, especially if the wastewater is stale or septic, or if the weather is warm. Filters should not be located where the odours would create a nuisance. Filter flies may breed in the filters unless effective control measured are used.

High rate Trickling Filter

High rate filters use either a rock or plastic packing. The filters are usually circular and flow is usually continuous. Recirculation of the filter effluent or final effluent permits higher organic loadings, provides higher dosing rates on the filter to improve the liquid distribution and better control of slime layer thickness, provides more oxygen in the

influent wastewater flow, and return viable organisms. Recirculation also helps to prevent ponding in the filter and to reduce the nuisance from odours and flies.

Advantages

- Simple, reliable, biological process.
- Suitable in areas where large tracts of land are not available for land intensive treatment systems.
- May qualify for equivalent secondary discharge standards.
- Effective in treating high concentrations of organics depending on the type of medium used.
- Energy Efficient, requires less electricity as compared to any other process.
- Appropriate for small- to medium-sized communities.
- Rapidly reduce soluble BOD in applied wastewater.
- Efficient nitrification units.
- Durable process elements.
- Low O&M requirements.
- Moderate level of skill and technical expertise needed to manage and operate the system

Disadvantages

- Possible accumulation of excess biomass that cannot retain an aerobic condition and can impair TF performance (maximum biomass thickness is controlled by hydraulic dosage rate, type of media).
- Requires low loadings depending on the medium.

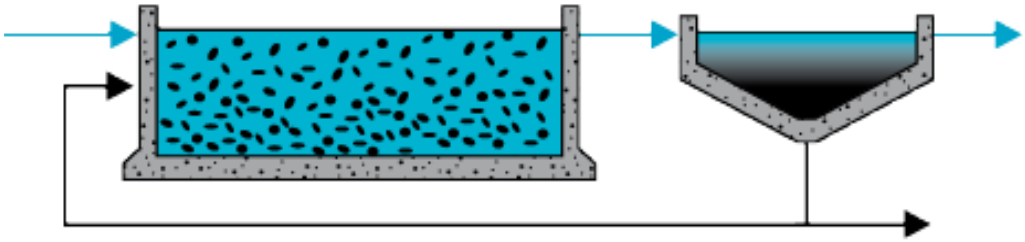
2. MBBR – Moving Bed Bio Reactor

MBBR is an alternative offers an alternative of activated sludge system. MBBR systems are based on reactors that are filled with plastic carriers to provide a surface that is colonized by bacteria that grow into a biofilm. The reactors can be operated under aerobic conditions for BOD removal and nitrification or under anoxic conditions for DE nitrification.

During operation, the carriers are kept in constant circulation. In an aerobic reactor, circulation is induced through the action of air bubbles injected into the tank by a coarse

bubble diffuser system. In an anoxic reactor, a submerged mixer is typically supplied. The carriers can occupy up to 70% of the reactor volume on a bulk volume basis. Experience has shown that mixing efficiency decreases at higher percentage fills.

Because MBBR is primarily an attached growth process, treatment capacity is a function of the specific surface area (SSA) of the reactor. The SSA for a reactor is calculated as the quotient of the total surface area on the carrier that is available for biofilm establishment and the reactor volume.



Advantages

- Requirement of less area as compared to other activated sludge processes.
- Mostly used to upgrade the existing AS systems.

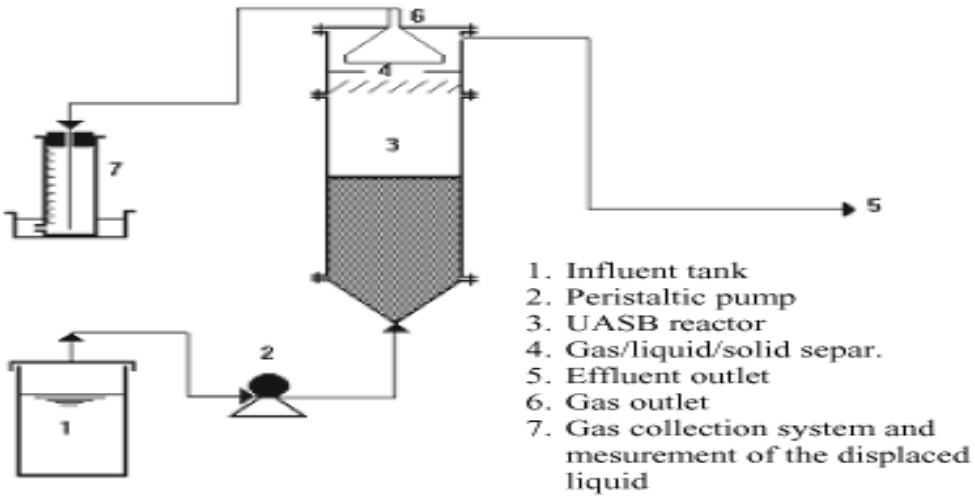
Disadvantages

- Upstream fine screening
- The verification of whether the media is moving about the entire volume of the tank or merely clumping at the top layers and if so the method of mixing it up through the tank volume without shearing of the biomass on it are issues of infirmity and which may need gentle movers of the media through the volume of the tank.
- The area per unit volume of the media offered by various vendors are different and also each vendor advocates his own criteria for the relative ratio of volume of media to volume of aeration tank, which makes it difficult to bring about a common and validated standard design criteria.
- The quality of plastic of media varies.
- Media retention screen assemblies
- Limited degree of process control
- Less common process

3.8.2 *Anaerobic Process*

1. **UASB / EGSB (Upflow Anaerobic Sludge Blanket Digester / Expanded Granular Sludge Bed Digester)**

The anaerobic process for sewage treatment is not suitable. The sewage has low strength organic loading i.e ranges between 100 to 250 mg/l of BOD. At this range the typically removal efficiency is not more than 35 % of the BOD5 and SS originally present and some of the heavy metals. Coupled with a disinfection step, these processes can provide substantial but not complete removal of bacteria and virus. However, they remove very little phosphorus, nitrogen, non-biodegradable organics, or dissolved minerals.



Advanced/Tertiary Wastewater Treatment

Advanced treatment is used to remove the nutrients, toxic compounds, organic matter and suspended solids. Unit operations or processes include chemical coagulation, flocculation, and sedimentation followed by filtration and activated carbon. Ion Exchange and Reverse Osmosis for specific ion removal or for reduction of dissolved solids.

3.8.3 *Technical Comparison of Different Technologies*

The availability of treatment technologies to be applied on urban sewage is very large. The decision regarding adoption of certain type of treatment system should be derived from balance of technical and economic criteria, taking in account quantities and qualitative aspects of each alternative. There is no such generalized formula to evaluate criteria and therefore common sense and experience is used to weight the different aspects of each process according to prevailing conditions.

The key factors, which govern the choice of the treatment system include:

1. Ability to Meet Standards

This is a primary screening criteria. Any system that is not able to meet the NEQS requirement does not need to be considered any further.

2. Land Requirement

This will be a crucial factor in the technology evaluation as limited/fixed land areas is available at project site.

Also, use of additional land hall be quite environmentally expensive considering cutting of trees.

3. Cost Effectiveness & Life Cycle Cost

This includes installation costs and operation costs, which are usually capitalized over life of the project to provide a common basis for comparing different options. Care should be taken to ensure that unit cost comparison are appropriate. For example, economies of scale often reduce the unit cost of treating sewage but are not necessarily cost effective if sewage flow are not high enough to allow the technology to perform optimally.

4. Reliability

This is a measure of how well a system perform in relation to expectations without breakdowns or failure to treat sewage to meet water quality objectives. For STPs designed, reliability also needs to be associated with simplicity of operation and ease of maintenance.

5. Operation and Maintenance

This includes the operational / running cost of plant. It is very important factor during evaluation of STPs. Many STPs fails because of high running expenditures.

Comparison Summary

Below are the comparisons of different technologies based on standard urban size sewage treatment plant have capacity of 4 MGD (million gallons per day)

Land Area Requirment				
HRTF	Sequential Batch Reactors	CAS/ Extended Aeration	Oxidation Ditches	Oxidation Pond

Table 3.24: Land Area Requirement Comparison

Discharge Quality (Horticulture Purpose)				
HRTF	Sequential Batch Reactors	CAS/Extended Aeration	Oxidation Ditches	Oxidation Pond

Table 3.25: Discharge Quality Comparison

** HRTF: High Rate Trickling Filter*

** SBR: sequential batch Reactor*

** AS: Activated Sludge System*

Opetational Cost				
HRTF	Sequential Batch Reactors	CAS/Extended Aeration	Oxidation Ditches	Oxidation Pond

Table 3.26: Operational cost Comparison

Capital Cost				
HRTF	Sequential Batch Reactors	CAS/Extended Aeration	Oxidation Ditches	Oxidation Pond

Table 3.27: Capital Cost Comparison

Technology	Operational Problems & Control	Odor Problem	Versatility	Performance Reliability	Maintenance Frequency
Conventional Activated Sludge	Moderate	Low	Moderate	Moderate	Moderate
Extented Aeration	Easy	Moderate	High	High	Low
Oxidation Ditch	High	High	Low	Moderate	High
Oxidation Ponds	High	High	Low	Low	High
HRTF	**Easy**	**Low**	**High**	**High**	**Low**
SBR	Easy	Low	Moderate	High	Low

Table 3.28: Comparison among different technologies

Other than comparisons between land area, capital cost and operational cost, the following factors have to be considered between the systems:

- **Operational Problems & Control:** The ease to operate the system to maintain its optimum operational conditions.
- **Odor:** Possibility of odor problems during operation.
- **Versatility:** The capability to accommodate different flow rates or pollutant loading.
- **Performance Reliability:** The scale of reliability for the process to generate quality discharge and sludge, with only little variations and fluctuations.
- **Maintenance Frequency:** The frequency of maintenance of equipment.

3.9 Proposed Treatment Process Specification

For the selection of the most suitable technology from the option discussed above, Multiple Criteria Decision Analysis (MCDA) has been used[5]. MCDA is a structured approach used to determine overall preferences between different options, on the basis of various objectives which the decision making body has already identified. Measurable criteria were developed in order to assess the extent to which the objectives will have to achieve. The basic components of the MCDA analysis are:

- The various available technologies

[5] Agunwamba J C, Comparative Analysis of Hospital Waste management in Calabar Metropolis and developed Countries

- The criteria on which each area alternative is measured
- The measured value for each criterion for each option.

In selecting a treatment technology), the following criteria has been developed:

- Ability to meet NEQS
- Capital cost
- Operational cost
- Land requirements
- Energy Requirements
- Sludge Generation
- Resistance Capacity to influence variations and shock loads
- Reliability
- Simplicity in O&M
- Dependence on Temperature
- Odor
- Noise
- Training and operational requirements
- Occupational safety aspects
- Degree of automation

The overall score of each alternative will be computed using multiplying total weightage with the actual score of each technology. i.e.

Score of each alternative = Weightage × Actual score of the technology obtained.

Table 3.29: Marking scheme for the ranking of candidate technologies

Criterion	Maximum Score	Remarks
Ability to meet NEQS	10	For the factor having total marks 10 10= Most suitable technology 5 and above= Suitable technology Below 5= Not suitable
Capital Cost	10	
Operational Cost	10	
Land Requirements	10	
Energy Requirements	10	
Sludge Production	10	
Resistance Capacity to influence variations and shock loads	10	
Reliability	05	For the factor having total marks 5 5= most suitable Technology
Simplicity in O&M	05	
Dependence on Temperature	05	
Odour	05	

Noise	05	3 and above= Suitable Technology Below 3= Not suitable technology
Training and Operational Requirements	05	
Occupational Safety Aspects	05	
Degree of automation	05	
Total Marks	110	

The final choice of treatment system should be made carefully, on the basis of various factors viz. technical, economic and environmental, many of which depend on local conditions. An evaluation of the above mentioned technologies on the basis of these factors is given in **Table 3.29.** Based on the MCDA findings, the candidate technologies can be priorities in the following sequence.

HRTF < UASB < MBR < SBR < Extended Aeration < Stabilization ponds < Aerated Lagoons < Oxidation ditches < Septic Tanks

The most appropriate treatment process keeping in view the Gilgit Environment shall be High Rate Trickling Filter Process as its performance is good even at low temperatures. Also the operation & maintenance cost is lesser, land area requirement is lesser and the quality of treated water is better as compared with other processes.

Table 3.30: Comparison matrix of candidate wastewater treatment technologies

Factors	Technologies								
	Septic tanks	MBR	HRTF	Extended Aeration	Oxidation ditches	Aerated Lagoons	Ponds	SBR	UASB
Ability to meet NEQS	5	9	9	6	5	5	5	8	9
Capital Cost	8	6	8	7	6	6	6	6	7
Operational Cost	6	6	7	7	6	6	6	6	6
Land Requirements	6	6	8	6	6	6	5	8	6
Energy Requirements	8	6	10	7	6	6	7	6	6
Sludge Production	5	7	7	6	7	7	6	5	7
Resistance Capacity to influence variations and shock loads	3	4	7	6	4	4	4	5	7
Reliability	2	3	4	3	4	4	4	3	4
Simplicity in O&M	2	2	4	3	2	2	2	4	4
Dependence on Temperature	3	3	4	3	3	3	3	3	3
Odour	1	4	4	2	3	3	3	3	3
Noise	3	4	3	3	3	3	3	3	3
Training and Operational Requirements	4	2	3	3	3	3	3	3	3
Occupational Safety Aspects	2	4	4	4	3	3	3	2	3
Degree of automation	0	4	2	2	1	1	0	2	3
Total	**58**	**70**	**84**	**68**	**61**	**61**	**60**	**67**	**74**

Raw Sewage Pump Sump & Dry Sump

The raw sewage will flow by gravity to the Raw Sewage Pump Sump (RSPS). The RSPS will be equipped with penstock (1 unit), stainless steel mechanical (1 unit) and manual coarse (1 unit) screens. Submersible pumps with dry installation (4 units) are installed in Dry Sump.

The penstock will be opened all the time, except during maintenance period. By closing the penstock, it will prevent any raw sewage from entering the Raw Sewage Pump Sump.

The mechanical coarse screen will remove any particles larger than 25mm. Its operation is controlled by level switch. The manual coarse screen is a standby unit. During the failure of the mechanical screen, raw sewage will overflow via the manual screen to the pump pit.

The submersible pump will pump the screened sewage to the secondary screen. Its operation is controlled by float switches.

Secondary Screen

The raw sewage will be pumped from the RSPS to the secondary screen, which is a rotary screen. The bar opening of the rotary screen is 3mm. The operation of the rotary screen is synchronized with the raw sewage pump.

Grit & Grease Chamber

After passing through the rotary screen, the sewage will enter the grit & grease chamber (GGC). All the oil and grease will be trapped and float at the top of the GGC. The grit will settle at the bottom of the GGC.

The grit will be removed by submersible pumps (2 units), to a stainless steel grit separator. The grit separator is actually a bent screen with bar opening of 1.0mm. The operation of the grit removal pumps is controlled by timer.

The oil and grease will be removed by a mechanical skimmer. The oily water will be pumped by the skimmer to a FRP oil/water separator, where the oil is separated and transferred to an oil storage tank. The water will return to the GGC.

Operation of the oil skimmer is controlled by timer.

Equalization Tank

The partially treated sewage will flow by gravity to the equalization tank (EQ-T). The EQ-T is to store the excess sewage during the peak flow.

In order to prevent the sewage from turning septic and also to keep the sewage evenly mixed, the sewage has to be agitated. Air is being blown into the sewage by air blowers (2 units) via a series of perforated UPVC pipes.

Operation of air blower is controlled by timer and float switches.

Submersible pumps (2 units) will deliver the sewage to the Trickling Filter pump sump. The operation of the submersible dosing pumps is controlled by timer and float switches.

Trickling Filter Pump Sump 1

The dosing pump in the EQ-T will pump continuously to the Trickling Filter pump sump (BPS -1) 24 hours non-stop, to ensure the Trickling Filter media has a continuous and uniform feeding of raw sewage.

Submersible Trickling Filter pump (2 units) will transfer the raw sewage mixed with recycled water to the top of the first Trickling Filter tower via a rotary sprinkler system. The water will be uniformly distributed on the top surface of the media. The recycled water from the clarifier is automatically returned to the BPS-1 via an opening fixed with a stainless steel non-return flap valve.

The submersible Trickling Filter pump will be running 24 hours non-stop. Their operation is controlled by timer. The BPS-1 is always full of water.

Stage 1 Trickling Filter Tower

The stage 1 Trickling Filter tower (BT-1) is a brick walled building with a roof to prevent direct sunlight on the Trickling Filter media. The building is composed of two towers. The brick walls are water proofed to prevent water from seeping to the external walls. There are openings at both the top and bottom of the tower to allow natural ventilation. Cross flow configuration Trickling Filter media are being installed in the BT-1. The media are made of rigid PVC corrugated sheets. The corrugated sheets are glued together by PVC glue. The installed media are strong enough to allow operator to stand on them.

A rotary sprinkler system consists of a sprinkler head and 4 arms of GI pipe will be installed on the top of the media one each tower. The GI pipes are drilled with holes that allow particles size of more than 12mm to pass through. The GI pipes are prevented from sagging by stainless steel tie ropes.

Clarifier 1

The partially treated sewage from BT-1 will flow by gravity to clarifier 1 (CL-1). The sludge generated from BT-1 will settle in the CL-1, which will be removed by mechanical scrapper (1 unit). Submersible sludge pump (2 units) installed in the scrapper will siphoned the settled sludge and transfer them to a sludge holding tank. No sludge is allowed to accumulate in the clarifier.

The operation of the scrapper and the submersible pump is controlled by timer and limit switches.

Trickling Filter Pump Sump 2

All the partially treated sewage from CL-1 will flow by gravity to the Trickling Filter pump sump 2 (BPS-2) via an opening installed with a non-return flap valve.

The submersible Trickling Filter pump (2 units) in the BPS-2 is exactly the same as those in BPS-1. They will pump the partially treated sewage to the Trickling Filter tower 2.

Stage 2 Trickling Filter Tower

The Stage 2 Trickling Filter tower (BT-2) is identical to BT-1.

The function of BT-1 and 2 is to allow the bacteria to grow on the filter media. When the sewage flow on these media, the bacteria will consume the BOD as their food. The thickness of the biofilm will depend on the concentration of the BOD.

It is important to note that the Trickling Filter dosing pumps have to operate 24 hours non-stop and ensure continuous supply of food and DO to the bacteria. Whenever the operation of these dosing pumps stops, the bacteria will die.

The dead bacteria will be flushed out of the Trickling Filter media by the running water automatically. The dead bacteria are the secondary sludge that settled at the bottom of the clarifiers.

Clarifier 2

The treated sewage from the BT-2 will flow by gravity to the clarifier 2 (CL-2). The CL-2 is same as CL-1 in design, except that the treated sewage is partly recycled to BPS-1 and partly discharged to the disinfection tank.

Disinfection Tank

The treated sewage from the CL-2 will be disinfected by chlorination. Liquid chlorine will be dosed by chemical pump (1 unit) to the chlorination tank. Mixing of the treated sewage and chlorine will be done by compressed air supplied by the same air blower for EQ-T.

Chlorination will be carried out as and when required.

Flow Measurement Chamber

After the disinfection tank, the treated sewage will flow by gravity to the flow measurement chamber (FMC). Ultra-sonic flow meter will be installed on the FMC to measure the flow rate automatically. A V-notch will also be provided in the FMC.

The flow meter will indicate both the hourly and daily flow rates.

Sludge Holding Tank

All the sludge from the 2 clarifiers will be automatically pumped to the sludge holding tank (SHT). The sludge will be aerated to prevent them from turning septic. The same air blower for the EQ-T will be used to supply air to the SHT.

The sludge in the SHT will be pumped to the mechanical sludge dewatering unit as and when necessary. Submersible desludging pump (4 units) will be provided in the SHT. The operation of the desludging pump is manual.

Sludge Dewatering Facility

The purpose of sludge dewatering is to further reduce the moisture content in the sludge, therefore reducing its volume and weight, to become sludge cake and suitable for handling and disposal. Belt Press is a mechanical dewatering machine, complete with polymer dosing system for sludge condition, which is able to achieve sludge cake of more than 20% solids content. Sludge from the machine is well dewatered an ready to be disposed.

Sludge Processing Shed

Sludge storage and transfer station is a place where the dewatered sludge can be temporarily stored while arranging for disposal (transportation) in bulk. The dewatered sludge will be manually removed and can be used as soil conditioner.

3.10 Construction Material Requirements

The major construction materials required for the project include; cement, sand, crushed stone, bricks and steel. These materials are easily available locally and no shortage is foreseen.

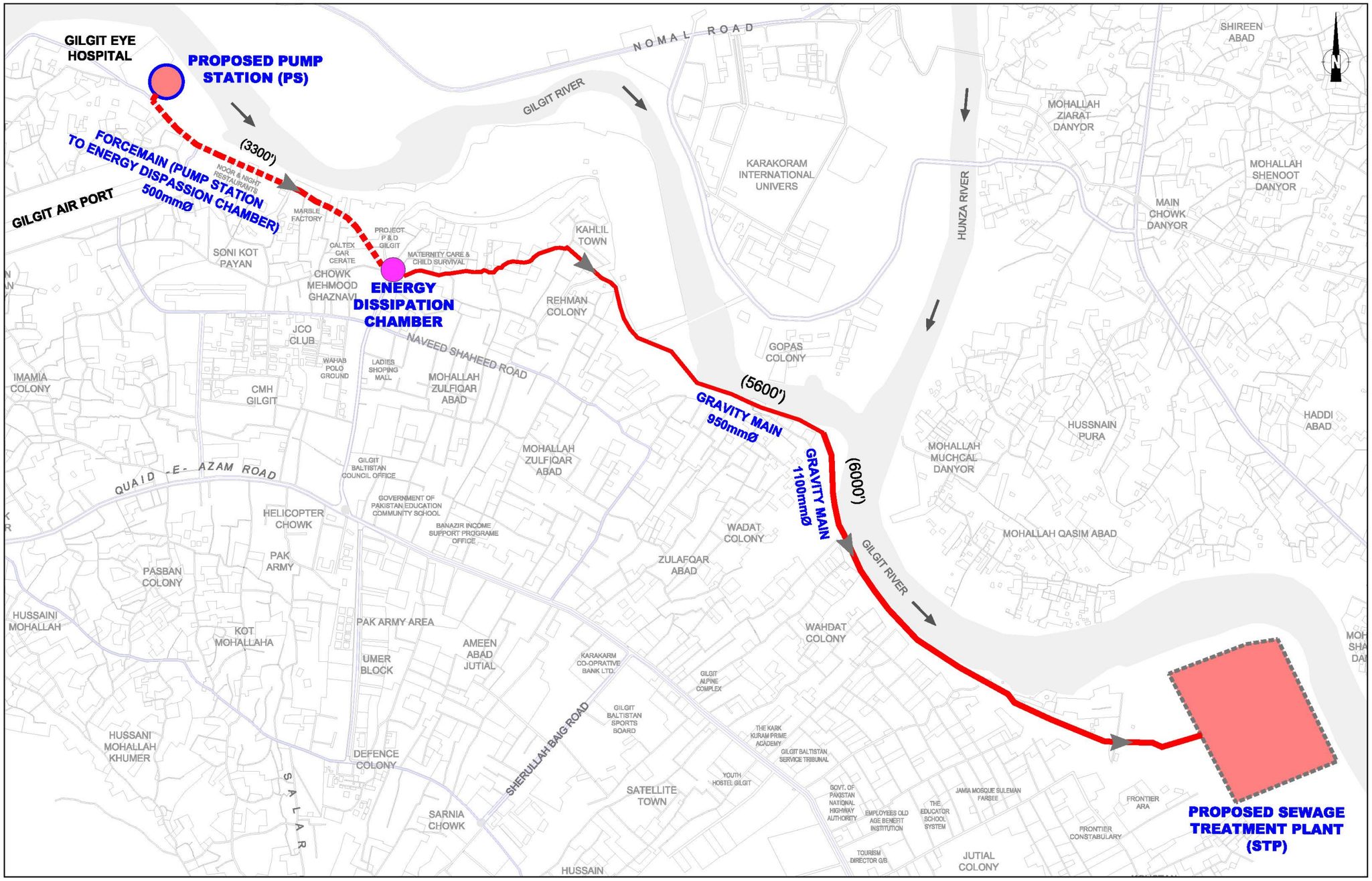


Figure 3.12: Layout Plan of Force main & STP (Option-1)

4 ANALYSIS OF ALTERNATIVES

4.1 General

Analysis and evaluation of different alternative proposals for a project is fundamental to arrive at the optimal one.

At the time of visit of consultant to GDA office, a proposal of one combined WWTP for the entire city was marked on the Google map. This proposal was based on Mechanical Treatment of waste water. The concept was that the wastewater of the whole city would be collected at one place. However, this idea has now been dropped as the Topography of the area does not allow to collect the waste water of the entire city at one place. Therefore the following two Proposals/Options were considered and has been discussed in the following Paragraphs:

4.2 Option -1

In this option, Mechanical Treatment Plant is proposed for Zone-2&3. The flows of area for Zone-2 is collected at Gilgit Eye Hospital where Sewage Pumping station is proposed which will pump the sewage of Zone-2 into Energy Dissipation Chamber at a distance of about 3300 ft. From Energy dissipation Chamber, sewage flows under gravity up to Proposed Mechanical Treatment Plant. For Mechanical Treatment Plant, 4-5 acre land will be required. In this option 3300 ft pumping of sewage flow is required, after this sewage will flow through gravity for a distance of about 11600 ft to Treatment plant.

While for other zones, individual septic tanks are proposed. All sewage flows under gravity and no pumping will be required. After treatment, the effluent will be disposed of into Gilgit River.

4.2.1 *Zone-1*

In this zone only JAGEER BASEEN area is included. Zone boundary started from Verza Basin to RCC Bridge Basin. Main septic tank is proposed at lower side to Khushbakht chowk along the bank of river. Sewage flow from upper area of JAGEER BASEEN from bridge and lower area along chitral road from RCC Bridge collected at Khushbakht chowk and then collected into the septic tank.

For sewage collection system, uPVC pipes are used with trunk sewer having maximum diameter of 500mm while all proposed lateral sewer are of min. 200mm in diameter.

4.2.2 *Zone 2 &3*

Zone-2 boundary started from upper bridge on Kargah nullah to Jutial public school for boys. Main trunk sewer started from lower RCC Bridge on Ghizer road to eye hospital. This Main trunk sewer will carry the flow of areas including Kargah Bhudda, Naroti, Naupura, Naikoi, Barmas, Mohallah Alamdar, NLI market, Nagral colony, Airport area, Konodas bridge area, Majini. While sewage flow from Jutial public school and upper area of Jutial from Gilgit Sareena hotel towards Shaheed millat chowk) drop into main trunk sewer through distribution system and collected near the eye hospital where a pump station/gravity which one is suitable will be provided to pump this sewage towards the proposed STP.

Zone-3 boundary starts from Jutial public school lower area and upper area to Sakwar. Sewage flow between the areas of SHERULLAH BAIG ROAD & NATCO BUS STAND, upper Jutial area from other side of Sareena hotel and Jutial public school to NATCO bus stand shall be collected at proposed STP from where the effluent shall be disposed of in Gilgit river after treatment.

For sewage collection system, uPVC pipes are used. In Zone-2, maximum diameter used for trunk sewer is of 950mm while all proposed lateral sewer are of min. 200mm in diameter. In Zone-3, maximum diameter used for trunk sewer is of 600mm while all proposed lateral sewer are of min. 200mm in diameter.

4.2.3 *Zone-4*

For the area of Sakwar separate Septic tank is proposed. In Zone-4, maximum diameter used for trunk sewer is of 550mm while all proposed lateral sewer are of min. 200mm in diameter.

4.2.4 *Zone-5*

For the area of MANAWAR Septic tank is proposed. In Zone-5, maximum diameter used for trunk sewer is of 400mm due to low dense area while all proposed lateral sewer are of min. 200mm in diameter.

4.2.5 *Zone 6 &7*

These zones consists of only Danyour area. Boundary of these zones starts from bridge on Sultanabad Nullah to China Bridge along the karaka ram road and the area under the BAGROT road to Gilgit River. Main trunk sewer is proposed along main road from check post to China Bridge. Lateral sewer lines shall drop into main trunk sewer. Separate Septic tanks are proposed. In Zone-6&7, maximum diameter used

for trunk sewer is of 650mm while all proposed lateral sewer are of min. 200mm in diameter.

4.2.6 *Zone 8*

For the area of Sultan-abad separate Septic tank is proposed. In Zone-8, maximum diameter used for trunk sewer is of 450mm while all proposed lateral sewer are of min. 200mm in diameter.

4.2.7 *Zone 9*

This zone shall comprise of area starts from Gulsher Colony including Eid Gah area, police line, Chamogar colony, Nagar Colony and Shah Karim Hostel. Separate septic tank has been proposed for this zone. This zone also consists of Mujahid colony, from education office to the office of Advocate General. Separate septic tank shall be proposed for this zone & main trunk Sewer lines shall be proposed along Konodas raod. In Zone-9, maximum diameter used for trunk sewer is of 550mm while all proposed lateral sewer are of min. 200mm in diameter.

4.2.8 *Zone 10*

This zone shall comprise of, Sakarkoi, area. Separate septic tank proposed for this zone. In Zone-10, maximum diameter used for trunk sewer is of 250mm while all proposed lateral sewer are of min. 200mm in diameter.

4.2.9 *Zone 11*

This Zone Comprise of KIU and Allied colonies. Separate septic tank shall be proposed for this zone. In Zone-11, maximum diameter used for trunk sewer is of 250mm while all proposed lateral sewer are of min. 200mm in diameter.

4.3 Option -2

In this option to avoid operational cost for sewage pumping, Two Mechanical Treatment plants will be proposed for Zone-2&3 separately. The gravity flows for Zone-2 will be collected at near Gilgit Eye Hospital where disposal Station and Sewage Treatment Plant will be proposed. Land required for mechanical treatment Plant is about 3-3.5 acres for Zone-2.

Second Treatment Plant will be proposed for Zone-3 Sewage flow. Land required for mechanical treatment Plant is about 1.5-2 acres for Zone-3.

Individual Septic tanks are proposed for the remaining zones same as discussed in Option-1.

4.3.1 *Consultant's Recommendation*

The consultants are of the opinion that if the land 3-3.5 Acre can be made available in zone-2 near Gilgit eye hospital for treatment plant then this option is recommended as the pumping shall be avoided. Since the required land is not available in zone-2 therefore this option does not appear to be feasible.

Hence option 1 will be preferred for collection and treatment of influent in a combine treatment plant in zone-3. In this option on 3300 ft length of force main will be required and the remaining 11600 ft will flow through gravity up to Proposed Treatment Plant. Implementation of this project involves large amount of road dismantling so road rebuilding/restoration is key factor after the implementation of this project. So Consultants recommended side by side maintenance/restoration of roads and other structures as the sewerage work started.

4.4 "No Project" Option

The current sewerage system in Gilgit city is a combined system, which acts as both Storm Water Drainage and Sewerage System. The combined system is functional, however undersized, and overflows in the rainy season (monsoon). The system also contains leakages at certain points and also suffers with silting which causes the drainage levels to further decrease.

The existing system results in surcharge and overflow conditions in streets causing highly objectionable unhygienic conditions in the city. Also the discharge of untreated sewage in open drains is polluting the environmental conditions of the City.

There is no other option of providing sewerage, drainage & solid waste management system but to continue with the current proposed option.

Therefore the "No Project" conditions will result in further worsening of the present environmental conditions and increase health risks to residents of the city.

From economy point of view, since the residents of the city will be more vulnerable to diseases, they will have to spend a major portion of their earnings on getting medical treatment. Their earnings will also be reduced due to loss of working hours because of frequent illnesses. The value of property will also decrease in the city due to poor aesthetic conditions and overflowing sewage on the streets everywhere.

5 BASELINE DATA

5.1 General

The existing environment and socio-economic conditions of the people of the proposed project area have been studied with respect to physical, ecological, and socio-economic aspects.

5.2 Methodology for Data Collection

In order to study the physical and ecological environment of the area, data was collected from Government surveys, Local government statistics, site visits and District Census Report. Data was also collected through physical observations.

To study the socio-economic conditions of the project area mainly secondary sources of data were used. District Census Report of Gilgit provides authentic and reliable information on the subject and gives a clear picture of the socio-economic conditions of the area.

5.3 Physical Environment

5.3.1 *Topography*

Gilgit-Baltistan (GB) is home to three mountain ranges: the Himalayas, the Karakoram, and the Hindu Kush. Most mountain elevations in the province are at least 1,500 m above sea level, with more than half the area above 4,500 m. Three of the world's highest peaks, K2; Nanga Parbat; and Rakaposhi, are located in the region of Gilgit, present at the foothills of the Karakoram Mountains, roughly at the junction between the three mountain ranges. Gilgit is surrounded by steep mountains with little or no vegetative cover. It lies at the intersection of the Gilgit and Hunza Rivers at a place locally known as Duo Pani. The topography effectively cuts off the entire province from Pakistan's mainland and, therefore, creates geographical barriers that affect economic and administrative processes in GB.

5.3.2 *Climate*

The dominant weather of the city is winter, which lasts eight to nine months a year. Gilgit District is bordered by glaciers that are receding due to the rising temperatures, consistent with global warming. River flow due to varying climates can be highly variable and pose threats to the stability of landscape especially in the vicinity of streams. Future temperature projections by Global Climate Models (GCMs) suggest that the temperature in Gilgit may become 7°C higher than the present level by the end of the 21st century[6].

5.3.3 *Seismicity*

According to the seismic zone map of Pakistan, the Project Area lies in Zone 3 of Modified Mercalli (M.M.) intensity scale, i.e. negligible damage zone as given in Figure. 5-1.

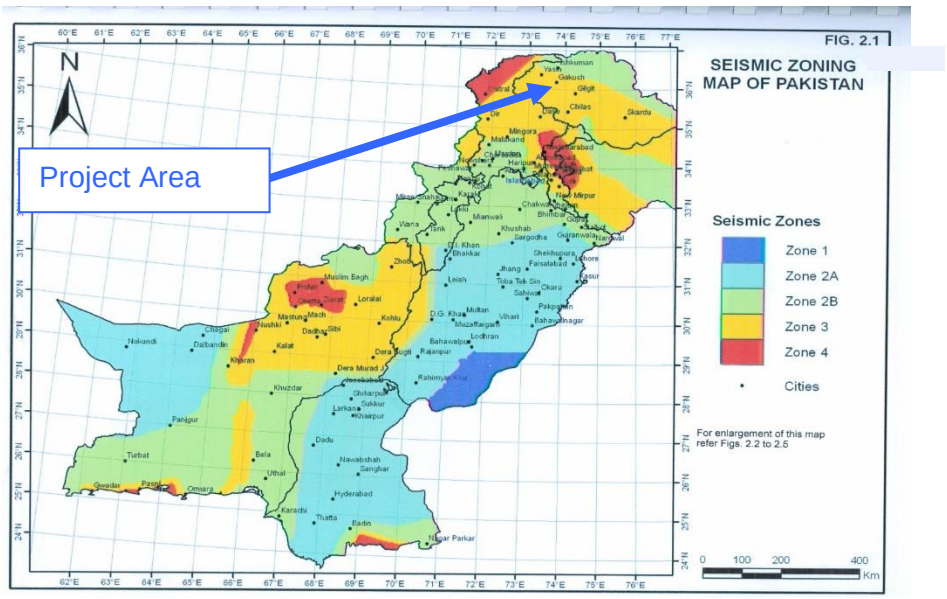


Figure 5-1: Seismic Zoning Map of Pakistan

5.3.4 *Air and Noise*

The IUCN, along with the Space and Upper Atmosphere Research Commission (SUPARCO)[7] conducted an air-quality survey, in Gilgit, in 1998[8]. According to the

[6] Pakistan Meteorological Department. (2013). Technical Report on Climate Change in Pakistan. Islamabad: GoP

[7] SUPARCO is Pakistan's national space agency mandated to conduct research and development in space science and space technology. It works towards developing indigenous capabilities in space technology and promoting space applications for the socioeconomic uplift of the country. www.suparco.gov.pk

[8] Raza, H. (2003). Northern Areas Strategy for Sustainable Development Background Paper: IUCN Pakistan, Northern Areas Programme, Gilgit.

survey, the air quality in Gilgit is relatively better than that of the main cities of Pakistan, especially Islamabad, Lahore and Karachi. However, the survey also reported that burning waste in open air, excessive deforestation, and traffic pollution is leading to higher levels of carbon dioxide, carbon monoxide and sulfur oxides in the atmosphere.

Noise does not pose a serious problem in Gilgit, due to the lack of industrial areas in the city. Major noise sources include general traffic, construction machinery and tractors. In the future, however, noise pollution may be aggravated as trade routes expand around residential areas.

5.3.5 *Land Use*

The city spreads longitudinally along the north and south banks of River Gilgit. The historic city center is located in the south bank of the river with commercial areas administrative buildings, an airport, bus stands, historic settlements, open recreation areas and a polo ground. The Konodas Nullah is fed by the river from the north bank and has an administrative core called Konodas. There is a settlement in this region called Mujahid Colony and the newly constructed Karakoram International University (KIU) is also located on this side of the city.

Most of the land in Gilgit is privately owned with two types of Land settlements[9]: formal and informal. Informal settlements are also known as Kachi Abadis[10]. Such settlements have no land or water rights. Although there are few such settlements in Gilgit, their lack of available water resources is a major concern[11]. Table 1 provides the proportion of areas covered by different uses.

Table 5.1: Land Use Area in Gilgit City

Land Use	**Km^2**	**Area (%)**
Agricultural Area	**21.2**	**22**
Commercial Area	**1.0**	**1**
Residential Area	**9.4**	**10**

x+38 pp.

9 Pakistan Urban Observatory. (2011). City Profile - Gilgit. Retrieved November 20, 2013, from Urban UN-Habitat: http://urban.unhabitat.org.pk/Region/GilgitBaltistan/Gilgit.aspx

10 Pakistan Urban Observatory. (2011). City Profile - Gilgit. Retrieved November 20, 2013, from Urban UN-Habitat: http://urban.unhabitat.org.pk/Region/GilgitBaltistan/Gilgit.aspx

11 Stakeholder consultations and site visits conducted by HBP from 16 September to 18 September 2013. This was to take the key stakeholders in Gilgit City on board with the SEA of the Gilgit City Master Plan and to obtain information from them about the city. The stakeholders involved government officials, secretaries, ministers and representatives of NGOs active in Gilgit City.

Forest Cover	**3.8**	**4**
Vacant Land	**23.8**	**24**
Total:	**97.9**	**100**

5.3.6 *Water Supply and Drainage*

The water supply sources providing for Gilgit includes lakes, springs, reservoirs and ground water. Glacial melt is the primary source of water supply, in the form of nullahs, which eventually discharge into the Gilgit River. The key nullahs in and around the city are Jutial, Konodas, Kargah and Danyour. Jutial Nullah provides the city with most of its irrigation and drinking water.

Five drinking-water supply complexes exist in the south of Gilgit and are recharged by two water channels. This system of water-supply complexes was built in the late 1970s to meet the demands of the time and they are still currently in use by the city residents. The names and locations are as follows:

- Burmus Water Supply Complex
- Jutial Water Lift System, Sonikot
- Jutial Lift Water Supply Complex, Zulfiqar Colony
- Water Supply Complex Danyour Chikas, Choke Area
- Gilgit Filtration Plants – Army Public School and College (APSC) Filtration Plant and District Headquarter Hospital (DHQH) Filtration Plant

There are 57 water purification plants in districts Gilgit out of which 41 are in Gilgit City. The existing water supply system is comprised of the above five water complexes and supplies 67 liters of water per capita per day[12]. The water-storage and distribution capacity of the water-supply complexes at present is inadequate in meeting the city's existing water demand. The expansion of the existing system is problematic due to the lack of available space and the paucity of financial resources. A survey conducted by the IUCN indicates that the present storage capacity of all of the water supply complexes is around 15 times less than the actual demand.

According to data from the District Headquarter Hospital, in Gilgit, in 1999, more than 60% of reported illnesses were related to poor water and sanitation conditions. In a survey conducted by the Water and Sanitation Extension Programme (WASEP), in

[12] Raza, H. (2003). Northern Areas Strategy for Sustainable Development Background Paper: IUCN Pakistan, Northern Areas Programme, Gilgit. x+38 pp.

1999, all five water complexes in Gilgit were found to be highly contaminated with fecal matter. Water in the channels was also found to be contaminated by activities such as the washing of clothes and utensils. Water-treatment plants do not exist in the city. Water channels are de-silted and repaired by villagers on a self-help basis.

The Northern Areas Public Works Department (NAPWD) has constructed a network of roadside sanitary drains for Gilgit. The Frontier Works Organization (FWO) has also constructed similar drains along the Karakoram Highway (KKH)[13]. These drains are constructed for the collection of storm water and are not meant for municipal grey water. Existing drains along roadsides do not have the capacity to adequately capture the larger volumes of storm water that occur during the rainy seasons. The *kuchha* and *pukka* household drains in the *Mohallas* and residential colonies are constructed on a self-help basis.

Drainage water is mostly used for irrigation. The excess is released in an untreated state into the Gilgit and Hunza Rivers. The two main nullahs are also the primary sources of water supply in the city, the Jutial Nullah and the Konodas Nullah, but the unchecked dumping of waste into these nullahs by city residents has led to contamination.

5.3.7 *Natural Disasters*

Gilgit and its surrounding valleys are highly susceptible to natural disasters such as landslides, flash floods and avalanches, which affect civic life in the city and areas within its vicinity. According to the Pakistan Meteorological Department (PMD), Gilgit is located in a seismically active zone with a shake potential equivalent to an earthquake of magnitude 6 to 7 on the Richter scale. A recent example of the types of natural hazards facing Gilgit is the Ata Abad Lake, which formed due to a massive landslide in 2010 and dammed the Hunza River. The unstable lake poses a threat to the downstream populations of Gilgit and Oshkan Das[14].

More than 90% of inhabitants engaged in agriculture and 70% in livestock are likely to be highly affected by natural disasters there. With agriculture making up 23% of the source of livelihood for Gilgit's inhabitants, the economy of the city is at a significant risk of being adversely affected by natural disasters.

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[13] Pakistan Urban Observatory. (2011). City Profile - Gilgit. Retrieved November 20, 2013, from Urban UN-Habitat: http://urban.unhabitat.org.pk/Region/GilgitBaltistan/Gilgit.aspx

[14] Calligaris, C. M. (2010). Executive summary on Attabad landslide survey in Hunza. Ev-K2-CNR, pp 1-20.

5.4 Ecological Baseline

Gilgit is located in a river valley in the southwest of the Karakoram Range. The climate is arid, as monsoon systems break against the southern slopes of Himalayas, about 150 km south of Gilgit, and the average annual rainfall ranges from 120 to 240 millimeters (4.7 to 9.4 inches). Agriculture depends on water that is diverted from mountain streams and rivers fed by snow melt at higher altitudes. The biodiversity of Gilgit and its surroundings is adapted to these extreme variations in climatic and geographical conditions.

The city is urban and largely a degraded habitat. However, the hills in the vicinity of the city and the adjacent valleys, particularly the forests in the Kargah and Jutial Valleys, provide habitat for faunal species, including mammals, birds and herpetofauna. The Gilgit and Hunza Rivers and the smaller nullahs contain both endemic and exotic fish species.

5.4.1 *Flora*

The vegetation in the city falls in the Dry Sub-Tropical Shrub Zone and Dry Temperate Coniferous Forest Zone. The former is located at lower elevations and southern slopes of mountains especially along the Gilgit and Hunza Rivers. The latter consists of forests found in the inner or northern slopes of the Himalayas and are less susceptible to monsoons. The dry temperate coniferous forests occur between elevations of 1,500 to 3,400 meters. These forests are characterized by fewer deciduous tree species, although coniferous species predominate.

Forests occur in the valleys, including the Naltar and Bagrot Valleys and also in the vicinity of the Jutial Nullah. Typical tree species in these forests include Picea smithiana, Cedrus deodara and Pinus willichiana. Smaller shrubs include Quercus ilex and Junglus regia and scattered shrubs of Artimesia maritima, Indigofera gerardiana, Sambucus ebulus, Sorbaria tomentosa, and Plectranthus rugosus. These forests not only provide habitat for faunal species but also provide timber the locals use for domestic and commercial purposes[15].

[15] Sheikh, M. I. & M. Hafeez. 1977. Forests and Forestry in Pakistan. Pakistan Forest Institute, Peshawar.

5.4.2 *Fauna*

Mammals reported in and around the city outskirts include members from the family of Vespertilionidae, Canidae, Felidae, Sciuridae, Muridae and Mustelidae. Large mammals, like the Snow Leopard Panthera uncia, Common Leopard Panthera pardus, Wolf Canis lupus, and Red Fox Vulpes, have been reported in the city hills. In addition, small mammals, such as bats and rodents, have been reported from inside the city limits[16].

Mammals included in the IUCN Red List[17] are the Woolly Flying Squirrel Eupetaurus cinereus and Snow leopard Panthera uncia, both of which are listed as Endangered. The Common Leopard Panthera pardus, Eurasian Otter Lutra and Royle's Mountain Vole Alticola roylei are listed as Near Threatened. The Snow Leopard Panthera uncia is closely associated with the alpine and sub-alpine ecological zones. They favor steep terrain well broken by cliffs, ridges, gullies, and rocky outcrops[18].

More than a hundred bird species have been reported around the city[19]. These include passage migrants, vagrant, resident, breeding and irregular visitors. The altitudinal migratory birds descend from higher altitudes during the winter months. Typical bird species found here include Snow Partridge Lerwa, Chukar Alectoris chukar, Common Quail Coturnix, Common Hoopoe Upupa epops, Common Swift Apus, Rock Pigeon Columba livia and Common Kestrel Falco tinnunculus[20]. No Endangered or Critically Endangered bird has been reported from the area. The only bird included in the IUCN Red List is the European Roller Coracias garrulus, which is listed as Near Threatened.

The main water bodies in Gilgit include the Gilgit and Hunza Rivers and smaller streams or nullahs such as the Kargah, Jutial, Sakwar and Bagrot Nullahs. The Hunza River is comparatively smaller and more turbid compared to the Gilgit River, and the latter has a much higher diversity of aquatic fauna due to less turbidity. Most

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[16] Roberts, T. J. 1997. The mammal of Pakistan. 2nd edition. Oxford University Press, Karachi: 525 pp.

[17] IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 5 October 2013.

[18] Jackson, R., Mallon, D., McCarthy, T., Chundaway, R.A. & Habib, B. 2008. Panthera uncia. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.1. <www.iucnredlist.org>. Downloaded on 09 October 2013.

[19] Roberts, T. J. 1992. The birds of Pakistan. Vols. 2, Oxford University Press, Karachi, Pakistan.

[20] Sheikh, K. 2000. Some Findings on the IUCN-Red Data Book Avian Species from Naltar Valley, Northern Pakistan. 4 (1) 1-4 pp. Pakistan

Journal of Ornithology.

of the fish caught by local people is consumed within households, but it is also sometimes offered for sale[21].

5.4.3 *Protected Areas*

Gilgit Baltistan holds several protected areas, many of which lacks effective management systems. Wildlife sanctuaries provide greater protection than do national parks under the existing laws. Game reserves only regulate hunting and affords no protection to the habitat[22]. However, the government publications do not clearly delineate the boundaries of these protected areas hence the protected areas have vague boundaries. The responsibility of protected areas and their management lies with the Forest, Wildlife and Environment Department of GB. NGOs working on conserving the ecological resources and community-uplift schemes include the World Wide Fund for Nature (WWF-P), the International Union for Conservation of Nature (IUCN-P), the Snow Leopard Foundation and the Wildlife Conservation Society (WCS).

5.5 Socio-economic profile

5.5.1 *Demography*

According to the 1998 census[23] conducted across Pakistan, Gilgit's population at the time was 57,750 people[24], which did not include the moza of Danyour (which included Muhammadabad) and the moza of Sakwar (which included Minawar), both of which are within the Gilgit city-limits prescribed by the GDA for the Plan. In 1998, the population growth rate of the city excluding Danyour and Sakwar was, approximately,

21 Dr. Amjad Tahir Virk, Dr. Kashif M. Sheikh and Abdul Hamid Marwat, 2 0 0 3. NASSD Background Paper: Biodiversity. IUCN Pakistan, Northern Areas Progamme, Gilgit. x+74 pp.

22 Ibid

23 GoP conducted a population census in 1998, which is the fifth and latest nation-wide population survey in the country.

24 Professional Development Center North (PDCN), 2013, Population of GB, Aga Khan University, Institute of Educational Development (AKU-IED)

2.66%[25]. A 2011 UN Habitat report provides a projected figure for the same area as 92,365 people in 2018[26].

5.5.2 *Religion and Ethnicity*

GB, Muslim-majority province, holds a 2% non-Muslim minority while around 54% of the total population of Gilgit District is Shia; Ismailis constitute 27% of the population, whereas, the remaining 19% are Sunni[27]. Incidents of religious and ethnic violence, in the city, have risen over the past 10 years, registering 117 incidents of secretarian murders during 1988 to 2010.

5.5.3 *Economy*

The average annual income of the people of Gilgit is around Rs. 30,000 per month. The economy is largely driven by NGO donations and GoP funding[28]. The commercial and social-services sectors provide 45% of all livelihood opportunities in Gilgit and another 23% comes from agriculture[29]. After the opening of the Karakoram Highway (KKH), the increase in trade between China and Pakistan resulted in many of the city's inhabitants becoming directly or indirectly involved in border trade, hoteling and transport.

Fishery, tourism, education, business, government and non-government services are main sources of revenue generation in the city. The total area of cultivated land in Gilgit is 22 km^2. The total production of major crops, such as wheat, maize, barley, potato, vegetables and fruits, for Gilgit District is about 63,000 metric Tons[30].

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25 Pakistan Census Organization—Government of Pakistan (PCO-GoP). (1998). District Census Report of Gilgit. Islamabad: PCO, Statistics
Division.

26 Karrar and Iqbal, 2011, Gilgit Report, .UN—Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

27 Karrar and Iqbal, 2011, Gilgit Report, .UN-Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

28 The World Bank, Asian Development Bank, Government of Pakistan. (2010). Gilgit Baltistan Economic Report-Broadening the Transformation. WB, ADB, GoP.

29 Karrar and Iqbal, 2011, Gilgit Report, UN-Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

30 Pakistan Census Organization-Government of Pakistan (PCO-GoP). (1998). District Census Report of Gilgit. Islamabad: PCO, Statistics Division.

However, due to inadequate marketing and packaging, considerable agricultural produce is wasted[31].

5.5.4 *Power and Gas supply*

Gilgit's energy demand is estimated to be 24 MW or 1.25 KW per household[32]. GB is presently not connected to the national power grid of Pakistan and supplies electricity through hydropower. During summer, electricity generated from hydropower is 7 MW, which drops to 2.7 MW in winters.

Urban power consumption doubles in winter, as the majority of the population in Gilgit relies on electricity for heating, cooking and other domestic facilities. During summer, energy consumption increases due to the use of refrigerators and air conditioners in domestic and commercial settings. One out of every five houses in Gilgit now owns a refrigerator. Due to the shortage of power, many households rely on fuel supplies especially for heating homes and workplaces during the city's harsh winter. Wood and timber from local forests is the main source of fuel, which has led to deforestation.

5.5.5 *Waste Management*

Gilgit city generates about 42.5 tonne of waste per day and Municipal Committee Gilgit (MCG) is the authority responsible to manage this waste. The present annual budget of Municipal committee is around Rs. 18,900,000 (USD 189,000). Equipments and machineries available for waste collection and transportation include 4 tractor trolleys, 200 Dustbins (installed), Dumpsters 15, Beats 7, Mazda 1 and 25 wheel barrows. Waste is picked up manually using handcarts, baskets and polythene bags. Irregular and uncontrolled sweeping, confined to commercial zones, together with refuse generated from the household and commercial areas i.e. indiscriminately thrown on the roadsides. Tractor trolleys are used to collect and transport waste out of the city. There is no proper disposal method for the generated waste and is dumped on land within the city along Gilgit River (Indus River) bank. Major sources of waste in Gilgit city include, Household waste 40%, commercial establishment (e.g. shops and hotels, offices) 60%. This generated waste is comprised of organic waste (e.g. food waste) 70-80% Inorganic waste (e.g. Plastic, glass and metals) 20-30%.

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[31] Karrar and Iqbal, 2011, Gilgit Report, UN-Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

[32] Pakistan Urban Observatory. (2011). City Profile - Gilgit. Retrieved November 20, 2013, from Urban UN-Habitat: http://urban.unhabitat.org.pk/Region/GilgitBaltistan/Gilgit.aspx

About 50% of the total waste generated in the city is either dumped or burned in the open air, while 14% is collected by the MC[33]. According to a study conducted in 2015[34], the average per capita waste generation in Gilgit is around 0.16 kg per day. It was found that from households in the city, 11 tonnes of solid waste was being generated per day. Each household produces about 1.38 Kg wastes which mean 0.16 Kg per capita per day of waste is generated; out of total waste, 6.8 tonnes is degradable waste while 4.2 tonnes of non-degradable waste is generated. Thus non-degradable waste per capital figured as 0.033 Kg per capital and 0.0974 Kg as degradable waste per capita per day.

5.5.6 *Education*

The literacy rate for the urban areas of Gilgit District was reported at 50% in 1998[35]. The enrollment ratio for Gilgit, in 1998, was 62%[36]. There are more than 2000 schools, 14 colleges and one university in the district[37]. KIU currently enrolls 415 students every year. A comparison of Gilgit's early childhood education (ECE) enrollment figures for children aged 3 to 5 years with other provinces of Pakistan, for the year 2011clearly shows that Gilgit's enrollment ratio is even higher than that of Punjab.

5.5.7 *Health*

There is one District Headquarter Hospital (DHQ), five hospitals and 22 dispensaries in Gilgit City. Basic level surgery facilities are present at the Civil Military Hospital (CMH) Gilgit and the DHQ. The numerical strength of doctors and health specialists in the city is likely to be around 70 at present[38]. Female doctors account for less than 30% of the total number of doctors.

Although access to medical facilities has been made easier by the intervention of Government and Non- Government Organizations (NGOs), health expenses still

[33] Karrar and Iqbal, 2011, Gilgit Report, UN-Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

[34] Farasat Ali, Yawar Abbas, 2015, Municipal Solid Waste Quantity, Composition and Current Management Practices in Gilgit City, Gilgit-Baltistan, Pakistan, International Journal of Environmental Monitoring and Analysis; 395): 282-287

[35] PCO-GoP. (1998). District Census Report of Gilgit. Islamabad: Population Census Organization, Statistics Division.

[36] Ibid

[37] Karrar and Iqbal, 2011, Gilgit Report, UN-Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

[38] Karrar and Iqbal, 2011, Gilgit Report, UN-Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

pose a major financial burden on families in Gilgit. Residents of Oshkan Das, Nomal and other suburban settlements in the city also depend on Gilgit's health facilities.

5.5.8 *Tourism and Recreational Facilities*

In Gilgit, there are two recreational parks. The Chinar Bagh covers an area of 8.5 acres and the City Park is located near the airport. Polo grounds in the city are used to hold polo matches and other traditional festivals of the area, which are a major source of tourist attraction. The Shandur Polo Festival in Gilgit attracts ordinary tourists and dignitaries from the world over[39]. The Armed Forces and local administration have their own recreational complexes, which are only for officials. The city also has three cinema halls with a combined seating capacity of 800.

Major tourist attractions around Gilgit include Naltar Peak; Hunza Valley; the Fairy Meadows in Raikot; Shigar Town; Skardu City; Haramosh Peak in the Karakoram Range; Bagrot-Haramosh Valley; Deosai National Park; Astore Valley; Rama Lake; Juglot Town; Phunder Village; Yasin Valley and Kargah Valley.

The number of tourists that visited Gilgit City in 2011 was around 37,000[40]. The lack of properly developed recreation and tourist spots along with meager physical and social infrastructure has negatively affected this industry. Ethnic and sectarian violence has also reduced the number of local and foreign tourists that visit the region[41].

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39 Pakistan Urban Observatory. (2011). City Profile - Gilgit. Retrieved November 20, 2013, from Urban UN-Habitat: http://urban.unhabitat.org.pk/Region/GilgitBaltistan/Gilgit.aspx

40 Karrar and Iqbal, 2011, Gilgit Report, UN-Habitat & Department of Architecture and Planning, NED University of Engineering and Technology.

41 Pakistan Urban Observatory. (2011). City Profile - Gilgit. Retrieved November 20, 2013, from Urban UN-Habitat: http://urban.unhabitat.org.pk/Region/GilgitBaltistan/Gilgit.aspx

6 PUBLIC CONSULTATION AND DISCLOSURE

6.1 General

This section describes the outcome of the impact assessment survey and public consultation sessions held with different stakeholder groups that may be impacted by the project. The consultation process was carried out in accordance with the guidelines laid by EPA. The objectives of this process were to:

- Share information with stakeholders on proposed project and expected impacts on the physical, biological, and socio-economic environment of the project area;
- Understand stakeholder concerns regarding various aspects of the project, including the current sewerage/drainage system and the likely impact of construction and operation related activities;
- Identify the weaknesses and problems in the current sewerage/drainage system;
- Find out valuable suggestions by the stakeholders to improve the current sewerage/drainage system of the city;
- Understand the perceptions, assessment of social impacts and concerns of the affected people/ communities of the project area; and
- Find out the awareness level and situation of acceptability to identify any issues for the implementation of the proposed project.
- To invite people to express their views about the positive / negative impacts on their life styles / environment of the town by the project
- To disclose information about contact offices/officers for any complains/queries

This report includes all the comments, which were taken into account in preparing the definitive development concept for the Sewerage System of Gilgit city. Public consultation performa is attached as Annexure-I and details of public consultations with photos is attached as Annexure-II.

6.2 Identification of Main Stakeholders

There are two types of stakeholders related to the project i.e. primary and secondary stakeholders. Primary stakeholders are those which are directly affected by the Project activities and secondary stakeholders are those which are affected indirectly.

The proposed project does not have direct impacts on any individual; therefore, no primary stakeholders are identified. Secondary stakeholders are institutional stakeholders, which includes local Government representatives, Government Officials of the relevant departments, NGO, general public, local residents, shop keepers, vendors, hospital owners/staff, teachers, pedestrians, and businessmen/traders of the city. All those stakeholders have different types of stakes according to their involvements in various aspects of the project. The consultant tried to contact all the stakeholders and shared their views and concerns and also interacted with the community based organizations that can support the community.

6.3 Categories of Stakeholders Consulted

The stakeholders contacted during the survey and consultations belong to different categories of people as shown in Table 6-1.

Table 6.1: Categories of Stakeholders Consulted

Sr. No	Categories of Stakeholders Consulted
1	Local residents including females
2	Schools (Staff and students)
3	Businessmen/ shop owners
4	Vendors
5	GDA Staff

6.4 Issues briefed during Public Consultation

During the consultation, the stakeholders (groups / individuals) were briefed about the purpose of the sub-project, its cost, funding arrangements and implementation schedule. They were informed about the details of the operation of the project including working of Sewage Treatment Plant. They were briefed about the benefits of the project and the following likely environmental and social impacts and measures proposed to mitigate the negative impacts of the project:

- Health and safety of workers and community
- Bad odour/smell to the neighboring localities
- Nuisance due to noise and dust during the construction stage
- Contamination of soil and groundwater
- Soil erosion during construction
- Traffic problems and related pollution problems

- Damage / loss of public infrastructure / utilities, property, structure, livelihood etc.

6.5 Summary of Comments and Discussions

Following are the viewpoints of the stakeholders based on these sessions and consultations about the proposed sub-project.

People expressed their concern about the blocking of the roads and streets during construction stage, they were briefed that the Contractor will be contractually bound to give a schedule of its activities, and will not be allowed to start sewer/drain laying activities at once in the entire project area, thereby keeping alternate routes open. They were informed that they may have to bear some inconvenience in this regard.

People pointed out that the public property may be damaged during the process of sewers/drain laying. They were informed that the depth of sewer in smaller streets is about 3 to 4 feet and the pipe will be laid in the middle of the streets to avoid possible damage to the people's assets. The trunk sewer of greater diameter and at greater depths is proposed on the main roads. At locations where space is limited Contractor will also use left-in-place shuttering to support excavations. In addition, the contractor will also be bound contractually to arrange insurance against accidental damage to public property and also against accidental injury or death.

People also feared that the steel manhole covers are usually stolen and cause hazards for the residents and particularly for the children and call for some preventive measures. Their fear was removed by informing them that heavier manhole covers made of RCC would be proposed in the design to minimize the possibility of removal/stealing.

People were also concerned that the workers and labourers will be brought by the Contractor from outside the project area and an opportunity of employment generated locally shall be availed by the people from other areas. They were informed that a condition in the Contract Document will be imposed that the maximum skilled and un-skilled employment is offered to the locals.

People were also concerned about the dust which would result due to excavation of trenches for sewer/drain laying. They were informed that Contractor will be bound to undertake frequent sprinkling of water to minimize the hazards of dust etc.

People also pointed out that during the sewer/drain laying, the roads/streets would be damaged and they raised the question that who will be responsible to repair the damages. They were briefed that the cost for the repair of all damages to roads/streets has been included in the project cost and restoration will be done by the same Contractor.

Community also expressed their apprehension about the presence of significant number of male labourers in the general locality, which may restrict the chances of female employment and also cause moral and social problems for the free movement of women-folk in the area. It was clarified that strict discipline would be exercised on the labour force by providing stringent clauses in the contract document.

People were also concerned that during the sewer/drain laying, the water supply/gas pipes and other utilities might be damaged. They were briefed that the Contractor will maintain close liaison with concerned departments to minimize the chances of damage to these utilities. Contractor will also be provided maps of exiting utilities so that he can plan his activities. GDA will also depute its staff to supervise the Contractor's activities. However emergency response programmes will also be laid out by GDA in association with concerned authorities, to cater for any accidental damage.

People also pointed out that the odour coming out of the STP would be hazardous to health and also the outlook of the area in the proximity would be affected. They were explained that for this purpose, design will include a buffer zone consisting of thick plantation around the STP to minimize the odour and also to improve the aesthetic of the area.

Some members of the community sought clarification about the utilization of the water discharged from the sewage treatment plant and the sludge produced, for agricultural purposes. They were explained that treated waste water quality will be better than the waste water flowing in the seepage drain. The sludge produced in STP may require further treatment before safe utilization in agriculture.

People expressed their concern that their private property may be occupied by the Contractor for labour camps & offices, material depot, machinery yard, access road and work site. Their fears were alleviated by informing them that the construction will be done in phases and Contractor will be bound contractually to utilize either the sub-project site or the rented property for material storage, offices etc.

A question was also raised about the capacity of GDA staff to operate and maintain the new system; it was commented that GDA do not have sufficient workers to handle current system, how would they manage the new setup. They were explained that additional machinery and staff training is included in the project cost. These measures would increase the efficiency of GDA in operating and maintaining the new system.

They were briefed about the process of selection of the projects. The sequence of the improvement of other services, would be finalized by the participation of the people.

6.6 Consultant's Assessment

Presently, the city has insufficient sewerage system, which often remains blocked and overflows. The streets of the town mostly remain full of standing waste water, causing disturbance in routine activities of the local residents. These open sewerage drains are potential health hazard. When these drains are cleaned, sludge is set aside along the banks of those drains. This practice is unhygienic. Instead the sludge should be put in to trolley without putting it first on land and then in trolley.

The people were dissatisfied with the existing arrangements of sewerage/drainage system by GDA and emphasized the need for proper sewerage/drainage system instead of open drains.

During public consultations, people were made aware of the benefits of the project and were invited to express their viewpoints on the subject. Several issues were raised by the community during the consultation, which were immediately addressed by the Consultant and GDA officials. Residents of the city were very much supportive to the implementation of the proposed project and perceived the proposed project to be helpful in controlling the stagnation of waste water in the streets, which is prominent everywhere in the city and results in deteriorating the existing environment and quality of life.

Keeping in view the current situation of the city, it can be anticipated that after the implementation of the proposed project, municipal waste water will be managed effectively and disposed of in environmentally safe manner. It will improve the present environment of the city, chances of diseases will be reduced, and clean environment will be visible and improve general hygienic conditions.

7 ENVIRONMENTAL AND SOCIAL IMPACTS AND MITIGATION MEASURES

7.1 General

This section presents likely positive and negative environmental and social impacts of the proposed project. It also prescribes the proposed mitigation measures to prevent and/or alleviate them to the extent possible during design, construction and the operation phases.

7.2 Environmental Impacts and Mitigation Measures

7.2.1 *Design/ Pre-construction Stage*

i) Topography and Drainage

The proposed project does not alter the overall topography of the area. In fact, sewerage and drainage network will help in improving present situation and to improve aesthetic in the city.

ii) Land Acquisition

The proposed sewerage/drainage system will be laid within the existing right of way of the roads without any land acquisition.

iii) Contamination of Groundwater

Groundwater table at the project area is deep hence ground water contamination is highly unlikely.

Loss of Livelihood/Trade/Occupation

The proposed sewerage and drainage system does not affect individuals for their livelihood, trade or occupation, whereas it would enhance the possibility of employment after the implementation of this project. Therefore, the proposed project will not cause any negative impacts in this regard.

7.2.2 *Construction Stage*

i) Noise nuisance to nearby localities

During construction phase of proposed project it is envisaged that noise may be generated during construction activities and use of vehicles/machinery etc., causing nuisance to nearby localities. The mitigation measures should include:

- Monitoring and supervision for strict enforcement/fulfillment of contractual obligations by the Contractor
- Providing residents with advance warning of construction activities
- Use of silencers and ban on excessive use of horns by the construction vehicles/ machinery
- Regular tuning and checkup of construction vehicles and machinery to comply vehicular noise emission levels as per NEQS
- Avoiding construction activities during the night time
- Providing ear muffs to construction workers who will be exposed to direct noise

ii) Air pollution

Dust pollution and fumes of vehicular emissions due to construction activities and movement of vehicles may pose negative impacts to the health of construction workers, local residents and nearby vegetation (crops) if proper mitigation measures are not taken. The mitigation measures should include:

- Monitoring and supervision for strict enforcement/fulfillment of contractual obligations by the Contractor
- Providing residents with advance warning of construction activities
- Limiting the speed of the vehicles in the working area
- Frequent sprinkling of water on katcha tracks and construction material
- Regular tuning and checkup of construction vehicles and machinery to comply vehicular exhaust emission levels as per NEQS
- Use of covered trucks for transportation of excavated materials and disposal to designated sites only
- Construction activities causing dust will not be carried out on excessively windy days.
- Providing masks to the construction workers

iii) Soil Erosion

During construction operations involving open excavations and removal of existing vegetation, the possibility of soil erosion exists due to silt run-off. Slushy conditions may be created on roadsides during rain, which can affect movement of public and transport.

Careful construction planning and adequate monitoring of excavation operations should be carried out so that the excavated areas and trenches are not left unattended, vegetation clearance should be phased, and cuts and side slopes are stabilized with provision for drainage arrangements.

iv) Obstruction to Traffic Flow

Excavation operations for sewer and drain laying may result in temporary blockage of some roads/streets, which may result in hindrance to normal traffic flow.
Following mitigation measures will be adopted to minimize this impact:

- Contractor should submit the construction schedule to RE in advance
- Sequencing of activities in a way to avoid excavation in adjacent streets so that alternate passages are available to the people
- Providing residents with advance warning of construction activities
- Avoiding excavation of trenches at junctions during peak-hours
- Backfilling of the trenches at the junctions in minimum possible time

v) Interference with Other Utilities

The sewerage and drainage system will be laid mostly in built-up area where a number of utility lines like water supply, gas pipes and telephone lines exist. The proposed sewer/drains may interfere with the existing utility lines causing disruption of these services and posing negative impacts.

Mitigation measures should include close liaison with concerned departments, provision of maps of existing utilities to the Contractor, supervision of excavation activities by GDA staff and placing sewer/drain lines away from existing utilities. In case of any relocation of other utilities, these should be relocated well in advance, and in case of any damaged lines the restoration/replacement of damaged utilities will be done immediately to avoid any disturbance to the people.

vi) Overflow/ Bypassing Hazards

Since the sewerage and drainage network is to be laid in the built-up area, where open drains and sullage carriers are already over-flowing, bypassing arrangements will be needed to construct the new system.

Careful construction planning including diversion arrangements should be done by the contractor to minimize chances of ponding of waste-water in the streets.

vii) Contamination of Water Supply lines

Placing of sewer/drain lines near water supply lines is highly undesirable due to chances of mixing of sewage in the water causing serious health problem for the residents.

In order to mitigate this impact, sewerage and drainage lines should be laid on the opposite side of the water supply lines. In unavoidable situations, when sewers are to be laid on the same side of the road, enough space will be kept between these two lines and depth of sewer line should be greater than the water supply line to avoid contamination of water supply lines in the event of sewerage line leakage.

viii) Health and Safety of Workers

Increased air and noise pollution levels may also cause health-related impacts on the workers. The construction workers may also be vulnerable to increased incidences of diseases due to indiscriminate disposal of solid waste and wastewater in the area. During the construction, workers can be exposed to accidents due to operation of construction vehicles and machinery.

Following measures will be taken to mitigate this impact:

- Use of machines and mechanical instruments should be done as per the manufacturers' instruction provided in standard operating procedures (SOPs);
- The Contractor should ensure that the construction workers/labour are trained in safety procedures for all relevant aspects of construction;
- Construction workers should be provided with proper safety equipment such as helmets, goggles, masks, etc.;
- Formal emergency procedures should be developed for construction site in case of an accident. First aid kits and other necessary equipment should be kept available at site along with the list of emergency phone numbers to be contacted in case of any emergency/accident.

ix) Impacts related to Contractor's Camps

During the construction stage, the solid waste and sanitary wastewater will be generated from the contractor's camps due to the construction activities and presence of the temporary toilet. Staggering of solid waste on the ground and

stagnation of waste water will give rise to unhygienic conditions and spread of diseases.

Following mitigation measures will be adopted to minimize this impact:

- Contractor should be responsible for proper disposal of the solid waste and sanitary wastewater at the nearby-designated place
- Contractor should provide septic tank for the toilets to treat the sanitary wastewater before its discharge.
- Before taking-over by GDA, Contractor should be responsible for site-clearance as per satisfaction of RE

x) Flora and Fauna

No negative impacts are foreseen on the flora and fauna of the project area.

xi) Endangered Species

No endangered species are foreseen in the project area.

xii) Protected Areas

There is no protected area in the vicinity of the project area.

xiii) Storage of Construction Material

During the construction phase, the construction materials will need to be stored onsite. The Contractor may occupy the neighboring private property for labour camps & offices, material depot, machinery yard, access road and work site.

Following mitigation measures are proposed:

- Contractor should submit the construction schedule to RE in advance
- Sequencing of activities so that only controlled amount of construction material is stocked near work area
- Providing residents with advance warning of construction activities
- Contractor should be responsible to utilize either the project site or the rented property for material storage, offices etc.

xiv) Accidental Risks

The project involves extensive excavation operations and working at significant depths below surface. This increases probability of accidental injuries to workers and general public. Following mitigation measures are suggested:

- Contractor should designate one of the staff members to act as lead person for emergency response and safety issues
- Contractor should be responsible to provide first aid facilities at construction site as well as camp
- Contractor should provide safety equipment's such as helmets, goggles, ear plugs, gloves, safety harnesses, safety shoes etc. to the workers
- Safety signage should be erected at potentially dangerous working areas
- Proper lighting arrangements should be ensured for night shift working
- Contractor should be responsible to provide insurance against accidental death and injuries to workers and public
- Public and animal access to construction site should be restricted by providing fences.

xv) Landscape Destruction along River Bank

Due to laying of sewer lines along the River Bank, the existing landscaping along the bank will be destroyed to excavation activities hence the impact will be highly negative but can be reverted by employing mitigation measures such as restoring the River Bank Landscaping to its original state once the sewer laying activity has been completed. Riverbanks from Baseen to STP have many different landscapes providing recreational activities to the people especially in summers. The variety of landscapes also has ecological significance that needs preservation. There is strong need to conserve this landscape enhancing its beauty and ecological value addition through tree planting, stone patching, terracing, benches and others. As the sewer laying is basically underground hence the on ground impact can be mitigated easily. The cost for this will be added in the Project itself (In the PC-1 Document)

7.2.3 *Operation & Maintenance Stage*

i) Hazards due to Blockage of Sewer/drainage Lines

The project has been designed to serve the needs upto year 2035. It can be presumed that blockage would not occur under normal operation conditions. However, it was observed that people generally throw solid waste into sewer lines and drains resulting into chocking of the network. Any blockage in the sewerage/drainage network can result in overflows causing nuisance to people, and serious health and sanitation problems during the operation phase. The wastewater may also contaminate soil and groundwater. Mitigation measures should include:

- Public awareness programme should be launched by GDA
- Provision of sufficient O&M staff
- Provision of sewer cleaning equipment for cleaning the sewers should be included in the project cost
- Development of a system to register public complaints and urgent clearance of blockages in the system

ii) Health and safety of Operation and Maintenance Staff

The operation of the proposed sewerage and drainage system may cause some negative impacts on health and safety of workmen. The sewer and drain cleaning staff may be exposed to waterborne communicable diseases if precautionary measures are not adopted. Since the proposed sewerage and drainage system will be operated by GDA, the concerned officials of the GDA will ensure that O&M personnel are fully aware of the hazards involved in running the system.

- All O&M staff should be trained in operation procedures designed to avoid infection from wastewater, and health and safety procedures to protect against any exposure to hazardous conditions.
- Ventilation of sewers/manholes should be done before entry to avoid accumulation of noxious gases.
- Workers should also be inoculated against infectious diseases and kept under regular medical checkup.
- Formal emergency procedures should be developed by concerned officials of GDA for dealing with the accidents.
- The sewer-cleaning workers should be provided protective clothing
- Safety equipment should be provided and maintained by the GDA

iii) Change in Land Value

Upon completion of the proposed sewerage and drainage system, the overall environmental conditions of the town will greatly improve due to elimination of stagnate waste water and overflowing conditions in the streets. This will be a major positive impact of the proposed project enhancing socio-economic conditions of the city residents.

8 ENVIRONMENTAL MANAGEMENT PLAN

8.1 General

This section provides an approach for managing and monitoring environmental issues and describes the institutional framework and resource allocations required for managing environmental issues related to the proposed project. GDA as the Proponent of the project will be responsible for ensuring that the project complies with the laws and regulations controlling the environmental and social concerns of the proposed project and other components during construction and operation. GDA shall also ensure that all pre-construction requisites such as permits and clearances are met.

8.2 Objectives of Environmental Management Plan (EMP)

This EMP has been prepared with the objective to help the GDA address the foreseen adverse impacts of the project including environmental, social and health and safety issues, enhance its overall benefits and introduce standards of good environmental practice. The primary objectives of the EMP are to:

- Provide compensations to the Project Affected Persons
- Define the responsibilities of project role players in accordance with the three project phases (design, construction and operation) and an institutional mechanism to implement the EMP;
- Facilitate the implementation of the mitigation measures by providing the technical details of each impact and proposing an implementation schedule;
- Define a monitoring mechanism and identify monitoring parameters to ensure that all proposed mitigation measures are completely and effectively implemented;
- Identify training requirements at various levels and provide a plan for implementation;
- Identify the resources required to implement the EMP and relevant financial arrangements; and
- Providing a cost estimate for all proposed EMP actions.

8.3 Institutional Mechanism for Implementation of EMP and Environmental Monitoring Plan

This sub-section describes institutional framework and defines roles and responsibilities of different role players for implementation of the proposed mitigation measures and monitoring at different phases of the project.

a) Environmental Protection Agency (EPA), Gilgit-Baltistan (GB)

GB-EPA will perform its role as a regulatory authority. EPA may check at its own, compliance of various project related activities with the requirements of applicable National Environmental Legislation and follow-up of the recommendations for environmental mitigation measures as prescribed in the Environmental Assessment Report.

b) Gilgit Development Authority (GDA)

The Executing Agency of the project will be Gilgit Development Authority (GDA), where its Chief Engineer will be the overall in-charge of the project. The Executing Agency shall comprise of its professional staff, supported by the design and supervision consultants. It shall be responsible for overall co-ordination, planning, implementation and management of the project activities.

c) Construction Contractors

Construction Contractor will be responsible for effective implementation of EMP. The Contractor shall carry out the mitigation measures according to EMP.

8.4 Implementation of Environmental Mitigation Measures

The specific roles and responsibilities of different institutions/agencies for implementation and monitoring of environmental mitigation measures for the proposed project are described hereunder:

(i) Design / Pre-construction Stage

GDA with the assistance of the Design Consultants (DC) will be responsible for adopting the mitigation measures prescribed for the site selection and design stage of the proposed project.

(ii) Construction Stage

The project will be executed through private Construction Contractor (CC) who will be responsible for the implementation of environmental mitigation measures during

the construction stage, while GDA with the assistance of Supervision Consultants (SC) will supervise and monitor compliance of all those mitigation measures. The Supervision Consultant will also depute one Resident Engineer (RE) for implementation of the prescribed mitigation measures.

(iii) Operation & Maintenance Stage

After development of the project, GDA will operate and run the system and will also be responsible for the implementation and monitoring of the environmental mitigation measures during the operational stage. District Officer Environment (DOE) shall assist GDA in this regard.

8.5 Environmental Management Plan (EMP)

The EMP has been developed to eliminate and / or mitigate the negative environmental impacts envisaged during the design, construction and the operation stages. It also provides specific guidelines for long-term monitoring by identifying the roles and responsibilities of the Proponent, Design and Supervision Consultants, and Construction Contractor(s). The cost of each proposed mitigation measure is also provided in the EMP to ensure that they are made part of the total project cost. Tables 8-1 present the environmental and health and safety aspects, issues, mitigation measures, implementation responsibility and the costs incurred at all the stages.

Table 8.1: ENVIRONMENTAL MANAGEMENT PLAN

ENVIRONMENTAL MANAGEMENT PLAN (DESIGN/PRE-CONSTRUCTION STAGE					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Contamination of Groundwater	Groundwater table at the project area is deep which will not contaminate the ground water	Recommended measures for groundwater monitoring include the following: •EPA has established his setup at district level and DO (Environment) has been appointed in each district. DO (Environment) is responsible for environmental monitoring in the whole district and the department has already been furnished with necessary equipment's for monitoring and recording noise pollution, gas emissions, water pollutions etc.	DC	GDA	-

ENVIRONMENTAL MANAGEMENT PLAN (CONSTRUCTION STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Noise nuisance to nearby localities	• Noise may be generated during construction activities and use of vehicles/machinery etc., causing nuisance to nearby localities.	• Monitoring and supervision for strict enforcement/fulfilment of contractual obligations by the Contractor • Providing residents with advance warning of construction activities • Use of silencers and ban on excessive use of horns by the construction vehicles/ machinery • Regular tuning and check-up of construction vehicles and machinery to comply vehicular noise emission levels as per NEQS • Avoiding construction activities during the night time • Providing ear muffs to construction workers who will be exposed to direct noise	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.

ENVIRONMENTAL MANAGEMENT PLAN (CONSTRUCTION STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Air pollution	• Dust pollution and fumes of vehicular emissions due to construction activities and movement of vehicles may pose negative impacts to the health of construction workers, local residents and nearby vegetation (crops).	• Monitoring and supervision for strict enforcement/fulfilment of contractual obligations by the Contractor • Providing residents with advance warning of construction activities • Limiting the speed of the vehicles in the working area • Frequent sprinkling of water on katcha tracks and construction material • Regular tuning and check-up of construction vehicles and machinery to comply vehicular exhaust emission levels as per NEQS • Use of covered trucks for transportation of excavated materials and disposal to designated sites only • Construction activities causing dust will not be carried out on excessively windy days. • Providing masks to the construction workers.	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.

ENVIRONMENTAL MANAGEMENT PLAN (CONSTRUCTION STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Soil Erosion	• During construction operations involving open excavations and removal of existing vegetation, the possibility of soil erosion exists due to silt run-off. • Slushy conditions may be created on roadsides during rain, which can affect movement of public and transport.	• Careful construction planning and adequate monitoring of excavation operations so that the excavated areas and trenches are not left unattended • Cuts and side slopes are stabilized with provision for drainage arrangements to avoid soil erosion.	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.
Obstruction to Traffic Flow	• Excavation operations for sewer and drain laying may result in temporary blockage of some roads/streets, which may result in hindrance to normal traffic flow.	• Contractor should submit the construction schedule to RE in advance • Sequencing of activities in a way to avoid excavation in adjacent streets so that alternate passages are available to the people • Providing residents with advance warning of construction activities • Avoiding excavation of trenches at junctions during peak-hours • Backfilling of the trenches at the junctions in minimum possible time	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.

ENVIRONMENTAL MANAGEMENT PLAN (CONSTRUCTION STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Interference with Other Utilities	The sewerage and drainage system will be laid mostly in built-up area where a number of utility lines like water supply, gas pipes and telephone lines exist. The proposed sewer and drain lines may interfere with the existing utility lines causing disruption of these services and posing negative impacts.	• Close liaison with concerned departments • Provision of maps of existing utilities to the Contractor • Supervision of excavation activities by GDA staff and placing sewer lines away from existing utilities • In case of any relocation of other utilities, these should be relocated well in advance • In case of any damaged lines the restoration/replacement of damaged utilities will be done immediately to avoid any disturbance to the people.	CC GDA	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made. Cost of relocation of existing utilities should be included in the total project cost.
Overflow/ Bypassing Hazards	• Since the sewerage and drainage network is to be laid in the built-up area, where open drains and sullage carriers are already over-flowing, bypassing arrangements may be needed to construct the new system.	• Careful construction planning including diversion arrangements should be done to minimize chances of ponding of waste-water in the streets.	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.

ENVIRONMENTAL MANAGEMENT PLAN (CONSTRUCTION STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Contamination of Water Supply lines	• Placing of sewer/drain lines near water supply lines is highly undesirable due to chances of mixing of sewage in the water causing serious health problem for the residents.	• Sewerage lines should be laid on the opposite side of the water supply lines. • In unavoidable situations, when sewers are to be laid on the same side of the road, enough space will be kept between these two lines and depth of sewer line should be greater than the water supply line to avoid contamination of water supply lines in the event of sewerage line leakage.	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.
Health and Safety of Workers	• Increased air and noise pollution levels may cause health-related impacts on workers. • The construction workers may be vulnerable to increased incidences of diseases due to indiscriminate disposal of solid waste and wastewater in the area. • During the construction, workers can be exposed to accidents due to operating of construction vehicles and machinery.	• Use of machines and mechanical instruments as per the manufacturers' instruction provided in standard operating procedures (SOPs); • Train the construction workers/labour in safety procedures for all relevant aspects of construction; • ·Construction workers will be provided with proper safety equipment such as helmets, goggles, masks, etc.; • ·Formal emergency procedures will be developed for construction site in case of an accident. • First aid kits and other necessary equipment will be kept available at site along with the list of emergency phone numbers to be contacted in case of any emergency/accident.	CC	RE/ GDA	The cost of these measures will be included in other items of work. No additional payment for these will be made

ENVIRONMENTAL MANAGEMENT PLAN (CONSTRUCTION STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Impacts related to Contractor's Camps	• During the construction stage, the solid waste and sanitary wastewater will be generated from the contractor's camps due to the construction activities and presence of the temporary toilet. • Staggering of solid waste on the ground and stagnation of waste water will give rise to unhygienic conditions and spread of diseases.	• Contractor should be responsible for proper disposal of the solid waste and sanitary wastewater at the nearby-designated place • Contractor should provide septic tank for the toilets to treat the sanitary wastewater before its discharge. • Before taking-over by GDA, Contractor should be responsible for site-clearance as per satisfaction of RE	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.
Storage of Construction Materials	• During the construction phase, the construction materials will need to be stored onsite. • The Contractor may occupy the neighbouring private property for labour camps & offices, material depot, machinery yard, access road and work site.	• Contractor should submit the construction schedule to RE in advance • Sequencing of activities so that only controlled amount of construction material is stocked near work area • Providing residents with advance warning of construction activities • Contractor should be bound contractually to utilize either the project sites or the rented property for material storage, offices etc.	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.

ENVIRONMENTAL MANAGEMENT PLAN (CONSTRUCTION STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Accidental Risks	• The project involves extensive excavation operations and working at significant depths below surface. This increases probability of accidental injuries to workers and general public.	• Contractor should designate one of the staff members to act as lead person for emergency response and safety issues • Contractor should be responsible to provide first aid facilities at construction site as well as camp • Contractor should provide safety equipment's such as helmets, goggles, ear plugs, gloves, safety harnesses, safety shoes etc. to the workers • Safety signage should be erected at potentially dangerous working areas • Proper lighting arrangements should be ensured for night shift working • Contractor should be contractually bound to provide insurance against accidental death and injuries to workers and public • Public and animal access to construction site should be restricted by providing fences.	CC	RE/ GDA	The cost of these measures should be included in other items of work. No additional payment should be made.

ENVIRONMENTAL MANAGEMENT PLAN (OPERATION & MAINTENANCE STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Hazards Due to Blockage of Sewer Lines	• People generally throw solid waste into sewer/drain lines resulting into chocking of the network. • Any blockage in the sewerage network can result in overflows causing nuisance to people, and serious health and sanitation problems during the operation phase. • The wastewater may also contaminate soil and groundwater.	• Public awareness programme should be launched by GDA • Provision of sufficient O&M staff • Provision of sewer cleaning equipment for cleaning the sewers should be included in the project cost • Development of a system to register public complaints and urgent clearance of blockages in the system	GDA	GDA	Included in the overall operation & maintenance cost to be borne by GDA.

ENVIRONMENTAL MANAGEMENT PLAN (OPERATION & MAINTENANCE STAGE)					
Aspect	**Impacts**	**Mitigation Measures**	**Responsibility**		**Cost**
			Implementation	**Supervision**	
Health and safety of Operation and Maintenance Staff	• The operation of the proposed sewerage and drainage system may cause some negative impacts on health and safety of workmen. • The sewer and drain cleaning staff may be exposed to waterborne communicable diseases	• All O&M staff should be trained in operation procedures designed to avoid infection from wastewater, and health and safety procedures to protect against any exposure to hazardous conditions. • Ventilation of sewers/manholes should be done before entry to avoid accumulation of noxious gases. • Workers should also be inoculated against infectious diseases and kept under regular medical check-up. • Formal emergency procedures should be developed by concerned officials of GDA for dealing with the accidents. • The sewer-cleaning workers should be provided protective clothing • Safety equipment should be provided and maintained by the GDA	GDA	EPA	Included in the overall operation & maintenance cost to be borne by GDA .

Key

GDA *Gilgit Development Authority*
EPA *Gilgit-Baltistan, Environment Protection Agency, through District Officer Environment (DOE)*
RE *Resident Engineer of Supervision Consultants*
DC: *Design Consultants*
CC *Construction Contractor*

8.6 Environmental Monitoring Plan

The environmental monitoring plan to be enforced during construction will be implemented by GDA with the assistance of Supervision Consultants who will depute a Resident Engineer (RE) for this purpose. The GDA's staff will be trained by the Consultants to perform the environmental monitoring functions. Under the powers conferred to EPA by the Regulations (2000), the Agency may externally monitor various project related activities in order to ensure that the project operations are in compliance with the requirements of applicable National Environmental Legislation. A monitoring plan has been prepared for the proposed project and is presented in Table 8-2. This program provides details regarding monitoring parameters, monitoring location, number of tests/samples, methods/equipment for testing, frequency and responsibility for monitoring.

The environmental monitoring reports for the project will be prepared on monthly basis and complete record will be maintained at the site office.

Table 8.2: ENVIRONMENTAL MONITORING PLAN

Sr. No.	Monitoring Parameter	Monitoring Location	No. of Samples	Method/ Equipment	Standards/ Guidelines	Frequency	Responsibility
A. Project Construction Stage							
	CO NOx So_x PM_{10}	Construction Sites	3	Ambient air quality analyser and PM_{10} Meter	US EPA	Monthly	RE/GDA
2.	Noise	**At Source** Excavation Vehicle/ Machinery/ generators	3	Noise Meter	NEQS	Quarterly	RE/GDA
3.	Gaseous Emissions • Smoke • CO	Excavation Vehicle/ Machinery/ generators	3 3	Gas Analyzer/ Detector as per NEQS	NEQS	Quarterly	RE/GDA
B. Operation Stage							
	CO NOx So_x PM_{10}	Project area	3	Ambient air quality analyser and PM10 Meter	US EPA	Six Monthly	GDA/EPA

Key

GDA *Public Health Engineering Department*
EPA *Environment Protection Agency, Gilgit-Baltistan (GB) through District Officer Environment (DOE)*
RE *Resident Engineer of Supervision Consultants*

8.7 Institutional Development and Environmental Training

The GDA's staff does not have enough experience and capability in dealing with implementation of the environmental mitigation measures and to monitor various environmental quality parameters. Hence, they will require training and expertise assistance to perform environmental management and monitoring according to the prescription of Environmental Management Plan and to implement the environmental monitoring plan.

They will need the assistance of environmental consultants in getting training of record keeping procedures, sampling, testing, analysis and use of environmental monitoring equipment's. They will also be educated about prevailing environmental legislation and standards.

The proposed training program for different staff with their field of training is given in Table 8-3.

Table 8.3: Environmental Training Program

S. No.	Persons to be Trained	No. of Persons	Duration	Subject
1	Construction Staff of GDA and Contractor	3	2 days	Occupational Health and Safety Procedures, Implementation of Environmental Mitigation Measures
2	Operation and Maintenance Staff of GDA	3	2 days/ year	Occupational Health and Safety Procedures for operation of project
3	Environmental Monitoring Staff of GDA	1	2 days	Sampling, Testing and Use of Environmental Monitoring Equipment, Record Keeping

8.8 Environmental Mitigation, Monitoring and Training Costs

For an effective implementation of the environmental mitigation measures, it is very important to provide sufficient funds for implementation of the environmental mitigation measures, monitoring and training. The total cost for these items has been worked out and summary provided below:

Description	Cost
Mitigation Cost	Built in the Project Cost
Monitoring Cost	Rs. 1.00 million
Training Cost	Rs. 0.50 million
Total Cost	**Rs. 1.50 million**

Details of these costs are provided in the following subsections.

a) Mitigation Cost

The environmental mitigation measures can broadly be divided into two categories. The first category includes the mitigation measures, which are mostly of managerial/administrative nature and involve no additional costs or those can be managed within the proposed setup. While the second category involves physical components/items to be executed at the Site for which additional cost will be required. The cost of the following mitigation measures will be included in the Contractor's rates for other items of work and no separate payment shall be made for these items. It will be made a part of the contract documents.

- Control of dust, gaseous emissions, and noise during all construction operations;
- Control of soil erosion
- Proper handling of excavated/surplus earth.

In addition, GDA as a part of its construction supervision function will be responsible to perform the following actions:

- Provision of adequately qualified and experienced staff for supervision and monitoring;
- Health and safety of workers.

GDA as part of its regular operation and maintenance function will be responsible to perform the following actions:

- O&M of the proposed sewerage and drainage system;
- Proper maintenance of the project to make sure that there are no serious issues related to the health of workers.

b) Monitoring Cost

The assessed cost of environmental monitoring for the parameters given in the above Table will be Rs. 1,000,000.

c) Training Cost

The assessed cost for environmental training as per program given in the above Table will be Rs. 500,000.

9 CONCLUSIONS AND RECOMMENDATIONS

9.1 General

Gilgit City is facing serious environmental degradation due to lack of proper sewerage/drainage system and the local population is vulnerable to spread of diseases as a result of contamination of surface and groundwater. Lack of proper sewerage/drainage collection and treatment system is causing unhygienic conditions for the residents of the city.

This section describes the outcome of the Environmental Impact Assessment study with recommendations to get full benefits of the project in an environmentally sound and socially acceptable way.

9.2 Conclusions and Recommendations

Overall, the proposed project is an environmental improvement project aimed to improve the sewerage/drainage system in Gilgit city, but some negative environmental impacts may be emerged, if proper mitigation measures for the same are not adopted.

Some of the significant anticipated negative environmental impacts of the project are; i) Nuisance hazards to foul odour ii) Contamination of groundwater iii) Soil Erosion, iv) Contamination of Water Supply lines, v) Health and safety of Operation and Maintenance Staff.

In order the mitigate the likely negative impacts the suggested mitigation measures include; i) Careful construction planning and adequate monitoring of excavation operations so that excavated areas and trenches are not left unattended and cuts and side slopes are stabilized with provision for drainage arrangements, ii) Laying sewers opposite to water supply lines and keeping enough space between these two lines, iii) Training to O&M staff in hygienic procedures designed to avoid infection from wastewater, health and safety procedures against any exposure to hazardous conditions and vaccination against infectious diseases with regular medical checkups. iv) Regular monitoring of the sewerage and drainage system.

The study concludes that the project does not involve any long term irreversible negative impacts. The negative impacts identified in the study are manageable through adopting

the Environmental Management Plan, by providing monitoring arrangements and resources during design, construction and operation stages of the project.

In the long run, the proposed project will improve the present environmental conditions and reduce health risks to residents of the city. From economy point of view it will not only reduce the medical expenses of the common men but also increase their productive working hours, which in turn will result in poverty alleviation, improve hygienic conditions and enhance socio economic conditions in the area. The value of property will also be uplifted due to improved aesthetic conditions and elimination of ugly scenes due to overflow of sewage in the streets and stagnated sewage in depressions.

Annex-I

Public Consultation Performa

JERS Engineering Consultants

Public Consultation Performa

Name of Interviewer: _____ Date: _____

Location: _____

1. Name of Respondent _____
2. Gender 1. Male 2. Female
3. Age _____
4. Education _____
5. Address _____
6. Marital Status
   i. Married
   ii. Unmarried
   iii. Divorced/ Separated/Widowed
7. Occupancy Status
   i. Govt. Servant _____
   ii. Private Service _____
   iii. Business _____
   iv. Farming _____
   v. Labour _____
   vi. Retired _____
   vii. Any Other (Specify) _____
8. Average Monthly Income _____
9. Do you know GDA is planning to improve the Sewerage/ Drainage system?
   i. Yes _____
   ii. No _____

10. In your opinion what may be the possible positive and negative impacts of the project during construction and operation phases of the project?

i. Construction Phase

Positive impacts

_____

_____

_____

Negative impacts

_____

_____

_____

ii. Operation Phase

Positive impacts

_____

_____

_____

Negative impacts

_____

_____

_____

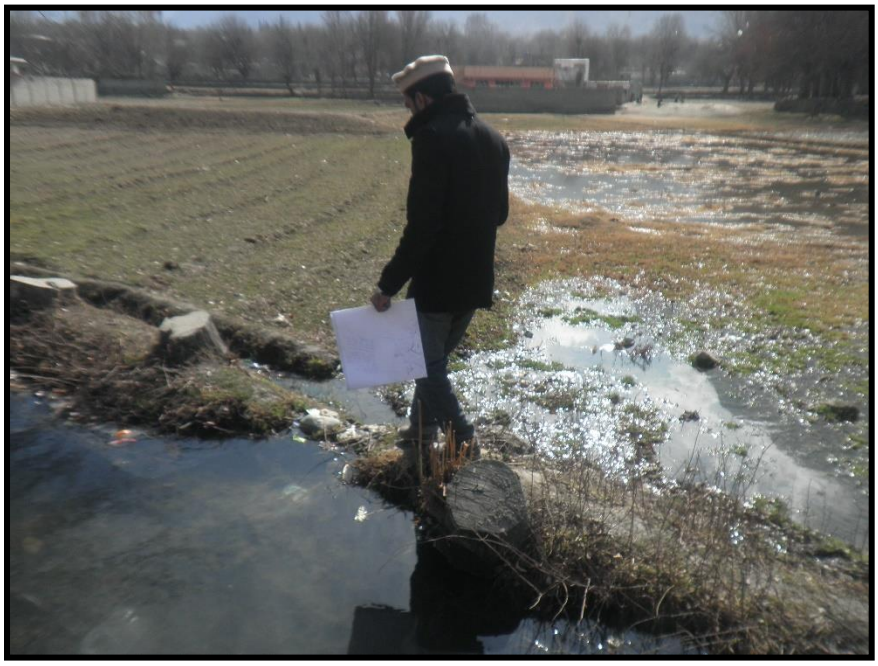
Annex-II

Pictorial evidence of consultations

Meeting with GDA Officials

Meeting with GDA Officials

Present Sewerage/Drainage System



View of an existing drain

View of Drain

View of roadside drain

View of roadside drain