



Knowledge Product for Climate Resilient & Sustainable Safely Managed Sanitation Service Delivery Model

Innovating for Equity, Sustainability, and Climate Action in
Sanitation Service Delivery

Transforming Sanitation Solutions

Message by CEO PRMSC

It gives me immense pleasure to present this Knowledge Product on the Climate Resilient and Safely Managed Sanitation Service Delivery Model, a critical contribution to the sanitation sector under our ongoing efforts to contribute in the vision of Government of Punjab to advance WASH Systems and ensure access of clean water and safe sanitation for all.

This Knowledge Product not only reflects our commitment to achieving Sustainable Development Goal 6 but also serves as a practical roadmap for transforming sanitation services in rural Punjab through sustainable, environment friendly and decentralized wastewater treatment solutions.

The development and successful implementation of the Sewage Treatment Unit (STU) model is a result of collaborative planning, technical innovation, and inclusive consultation between Punjab Rural Municipal Services Company (PRMSC), our partners, and key stakeholders. This model embodies our shared vision to create clean, climate-resilient, and dignified sanitation solutions for underserved communities.

I commend the efforts of AGAHE and Welthungerhilfe (WHH) for conceptualizing, piloting and documenting this replicable and scalable model. It is our firm belief that the dissemination of such innovative models will guide policy, influence sustainable infrastructure development, and help institutionalize safely managed sanitation services across the province. Let us continue working together to ensure that every citizen has access to safe, inclusive, climate resilient and sustainable sanitation services.



A handwritten signature in black ink, appearing to be 'Ali Raza'.

Chief Executive Officer
Punjab Rural Municipal Services Company
(PRMSC)

Acknowledgement

Punjab Rural Municipal Services Company (PRMSC) acknowledges with appreciation the valuable contributions of **AGAHE** and **Welthungerhilfe (WHH)** for their continued efforts to facilitate the government departments for improving WASH Systems in Punjab and in particular developing the “**Climate Resilient and Safely Managed Sanitation Service Delivery Model**” and producing this comprehensive Knowledge Product.

This innovative model Sewage Treatment Unit (STU) was developed in close coordination with PRMSC and other relevant stakeholders. It stands as a testament to effective collaboration, technical excellence, and a shared commitment to environmental sustainability and public health. We extend our gratitude to the dedicated teams from AGAHE, Welthungerhilfe (WHH) and PRMSC for their leadership in conceptualizing, piloting, and documenting a model that aligns with national standards and offers a scalable solution to Pakistan’s rural sanitation challenges.

Overall Supervision from PRMSC

Mr. Ali Raza Chief Operating Officer, PRMSC

Mr. Hussain Kamran – Environmental Specialist, PRMSC

Developed by:

Association for Gender Awareness & Human Empowerment (AGAHE)

Mr. Muhammad Waqas Tahir – PM WASH, AGAHE

Mr. Mohsin Ali – WASH Officer Infrastructure, AGAHE

Facilitated by:

Mr. Mohsin Ghaffar – Training & Communication Officer (AGAHE)

Technical Review by:

Mian Hameedullah – Sector Advisor WASH, Welthungerhilfe (WHH), Pakistan

Mr. Shahnawaz Arif – Advocacy Coordinator, Welthungerhilfe (WHH), Pakistan

Mr. Hussain Kamran – Environmental Specialist, PRMSC

Consultation:

Punjab Rural Municipal Services Company (PRMSC)

Housing Urban Development & Public Health Engineering Department (HUD&PHED)

Punjab Municipal Development Fund Company (PMDFC)

Sector Partners working in Pakistan

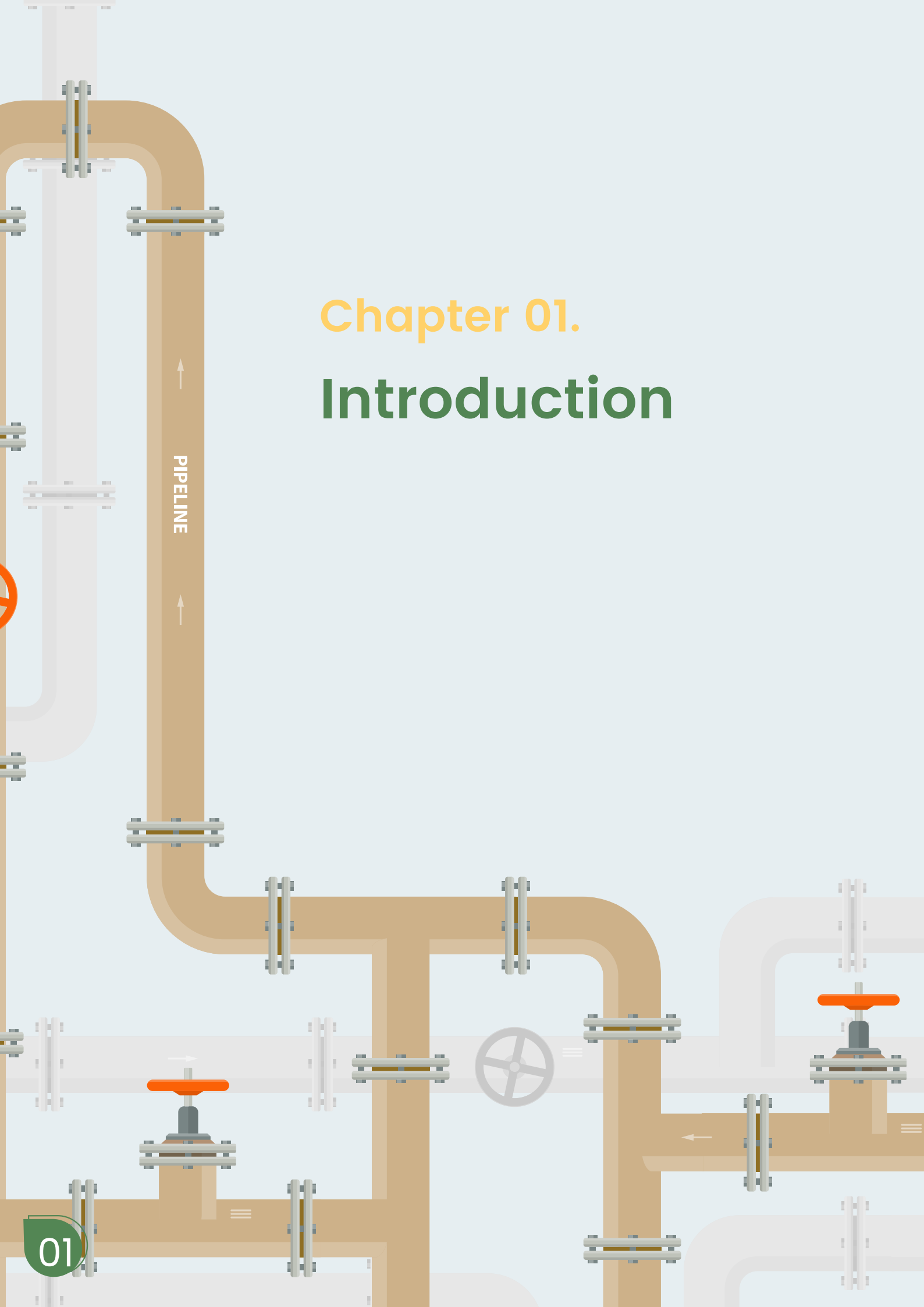
Creative design and layout:

Developed by Team One Design

Ar. Allaina Zohair, Ar. Usama Zafar, Ar. Hussain Mehdi

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Chapter 01.

Introduction

Introduction

In an era of escalating climate risks, rapid urbanization, and widening inequalities, the need for inclusive, sustainable, and climate-resilient sanitation systems has never been more urgent. Globally, over 3.5 billion people still lack access to safely managed sanitation, and in Pakistan, the situation is particularly acute, nearly 69 million people remain exposed to the health and environmental hazards of inadequate sanitation. The country continues to face significant challenges in achieving universal access to water and sanitation, as envisioned under Sustainable Development Goal 6 (SDG 6).

Recognizing this critical gap, AGAHE, and Welthungerhilfe (WHH) under WASH System Strengthening Program are facilitating government efforts to advance sanitation systems for sustainable service delivery to leave no one behind. In response to the pressing challenges, AGAHE and WHH in collaboration with Punjab Rural Municipal Services Company (PRMSC) and in consultation with consultation with Housing, Urban Development & Public Health Engineering Department (HUD&PHED), Punjab Municipal Development Fund Company (PMDFC), and other development partners have developed climate resilient, gender responsive and sustainable safely managed sanitation service delivery model. This model is designed to demonstrate a scalable and policy-aligned approach to delivering safe sanitation services in underserved communities.

This initiative aims to transform how sanitation services are delivered in underserved communities by introducing a replicable, cost-effective, and environmentally sound model: the **Climate Resilient and Sustainable Safely Managed Sanitation Service Delivery Model**. This model integrates a decentralized, solar-powered Sewage Treatment Unit (STU) with an underground sewerage network, designed specifically for rural and peri-urban contexts where conventional infrastructure is either absent or failing. It ensures the safe collection, treatment, and reuse of wastewater, significantly reducing public health risks, environmental degradation, and water insecurity. The treated effluent meets national environmental quality standards and is reused for agriculture, closing the loop on water use and supporting climate adaptation.

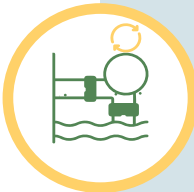
What sets this model apart is its systems approach: it combines engineering innovation with community ownership, institutional collaboration, and financial sustainability. It is aligned with Pakistan's national sanitation policies and contributes directly to multiple Sustainable Development Goals (SDGs), including **SDG 6**: Clean Water and Sanitation, **SDG 3**: Good Health and Well-being, **SDG 5**: Gender Equality, **SDG 11**: Sustainable Cities and Communities, **SDG 13**: Climate Action.

This knowledge product has been developed as a strategic resource for WASH Stakeholders including government departments, policymakers, donors, and development partners. It documents the model’s design, implementation, and operational framework, and offers practical guidance for replication and scale-up. It also serves as a call to action, to reimagine sanitation not as a peripheral service, but as a climate-smart, dignity-driven, and development-enabling priority.

By investing in climate-resilient and safely managed sanitation, we invest in healthier communities, stronger systems, and a more sustainable future for all.



In addition, the knowledge product serves as:



Safely managed sanitation with a Focus on Innovative WASH model Sewage Treatment Unit (STU)

The STU Knowledge product is a comprehensive resource designed to equip all the Government & private institutions with the knowledge and strategies needed to establish sustainable and effective sanitation systems. This knowledge product underscores the importance of safely managed sanitation systems by focusing on the implementation of Sewage Treatment Units (STUs) as a cornerstone of hygiene, sustainability, and environmental health.



Ensuring Sustainable Sanitation Systems

Safely managed sanitation is integral to the well-being of communities. This knowledge product highlights the critical role of STUs in treating wastewater effectively, ensuring that waste is processed and disposed of in an environmentally sound manner. By incorporating STUs into our sanitation systems, institutions can eliminate health hazards, prevent contamination of local water resources, and reduce the risk of waterborne diseases, thereby contributing to a healthier environment for all of us.



Spotlight on Sewage Treatment Units

STUs are advanced systems designed to treat sewage through biological, chemical, or physical processes. This knowledge product provides detailed insights into their design, operation, and maintenance, tailored specifically for Government and private institutions in Pakistan. It includes step-by-step operation and maintenance protocols, ensuring long-term functionality and cost efficiency. The emphasis on solar-powered options and energy-efficient technologies makes these units both environmentally friendly and sustainable.



Aligning with National Goals and SDGs

By adopting STUs, we contribute directly to achieving the Sustainable Development Goals, particularly SDG 6 (Clean Water and Sanitation). This initiative aligns with national and provincial policies promoting safe sanitation and environmental conservation, ensuring compliance with Pakistan’s broader developmental vision.



A Step Towards a Cleaner Future

The knowledge product serves as a roadmap for Public and Private institutions to implement safely managed sanitation systems that not only support immediate health outcomes but also advance the environmental stewardship. By focusing on Sewage Treatment Units, this initiative empowers systems to create cleaner, safer, and more sustainable environments for future generations. Together, let’s champion a culture of hygiene and sustainability, paving the way for a healthier and more equitable future for all.

1.1- PURPOSE OF THE KNOWLEDGE PRODUCT

This guidebook has been developed as a strategic knowledge and advocacy product to promote the adoption, replication, and scale-up of the Climate Resilient and Sustainable Safely Managed Sanitation Service Delivery Model, a transformative solution piloted under the WASH System Strengthening Initiative in District Muzaffargarh.

The purpose of this guidebook is to:

01.

Introducing a Scalable Sanitation Service Delivery Model
Present a practical, climate-resilient, and gender-responsive model for safely managed sanitation that can be adopted, adapted, and scaled by government institutions and development partners in Pakistan.
02.

Provide technical and operational guidance
For planning, designing, constructing, and maintaining the model in diverse rural and peri-urban contexts and to empower stakeholders with evidence-based tools, cost estimates, and design templates to facilitate replication and institutional uptake.
03.

Advocate for inclusive, dignified, climate resilient and sustainable sanitation
As a national development priority and a global climate action imperative.
04.

Resource Provision for Stakeholders
Provide stakeholders—such as government bodies, educators, parents, and community leaders—with an evidence-based, practical resource to understand, advocate for, and implement safely managed sanitation initiatives through STUs.
05.

Demonstrate the model’s impact
On public health, environmental protection, and climate resilience through decentralized wastewater management.

This guidebook is not only a technical manual, but also a call to action for governments, development partners, and communities to invest in scalable sanitation solutions that are climate-smart, socially inclusive, and economically viable.

1.2- TARGET AUDIENCE

This guidebook is designed to serve a diverse range of stakeholders who play a critical role in addressing Pakistan’s sanitation challenges and advancing innovative WASH solutions. The target audience includes:

This guidebook is intended for a wide spectrum of stakeholders involved in sanitation service delivery, policy, and advocacy at local, national, and international levels. These include:

- 1

Government Institutions
Government Ministries, departments, authorities, companies including but not limited to Public Health Engineering Department, Local Government Authorities, Climate Change and Environmental Protection Department and Agencies, Punjab Rural Municipal Services Company, Punjab Municipal Development Fund Company and Planning & Development Department etc. and other actors responsible for sanitation services, infrastructure, health, and climate adaptation.
- 2

Development Partners & Donors
International and national organizations supporting WASH, climate resilience, and sustainable development initiatives.
- 3

Civil Society and NGOs
Organizations working on WASH, gender equality, environmental justice, and community empowerment.
- 4

Academic and Research Institutions
Universities, think tanks, and research centers focused on sustainable development, environmental engineering, and public health.
- 5

Policy Makers and Legislators
Elected representatives and policy advisors shaping sanitation, climate, and health agendas.
- 6

Community-Based Organizations and Local Leaders
Grassroots actors leading sanitation initiatives and ensuring community ownership and sustainability.
- 7

Media and Advocacy Networks
Journalists, influencers, and communication professionals raising awareness and shaping public discourse on sanitation and climate resilience.

Chapter 02.

Safely Managed Sanitation – Global & National Perspectives.

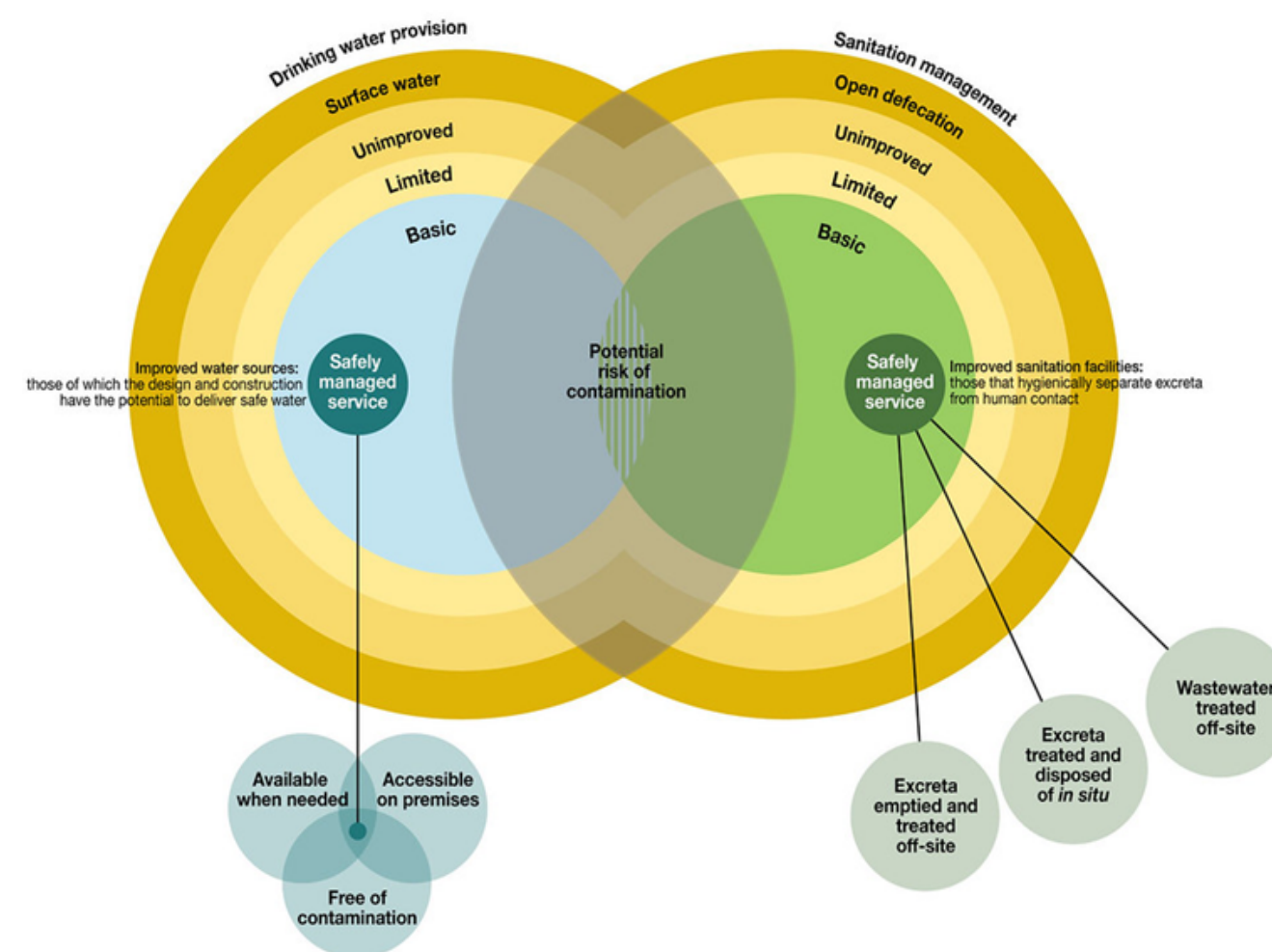
2- UNDERSTANDING SAFELY MANAGED SANITATION

Safely Managed Sanitation (SMS) refers to the highest level of sanitation service as defined by the WHO/UNICEF Joint Monitoring Programme (JMP). It ensures that:

- Excreta are safely contained in private, improved sanitation facilities.
- Waste is either treated and disposed of on-site, or safely transported and treated off-site.
- Facilities are not shared between households and are supported by handwashing with soap and water.

Safely Managed Sanitation is not just about infrastructure, it is about safeguarding human health, protecting ecosystems, and upholding dignity, especially for women, children, and marginalized communities. It is a critical enabler of multiple Sustainable Development Goals (SDGs), particularly SDG 6.2, which calls for “access to adequate and equitable sanitation and hygiene for all... by 2030.

SDG GOAL 6. Ensure availability and sustainable management of water and sanitation for all



Sources: JMP Progress on drinking water, sanitation and hygiene – 2017 Update and SDG Baseline.

GRID-Arendal/Studio Arca

Inadequate sanitation is a major cause of disease worldwide, and improving sanitation has significant health benefits. Basic and safely managed sanitation services can reduce diarrheal diseases and lessen the adverse health impacts of other conditions that cause death and disease among millions of children. Diarrhea and worm infections weaken children, making them more susceptible to malnutrition and opportunistic infections like pneumonia, measles, and malaria.

The combined effects of inadequate sanitation, unsafe water supply, and poor personal hygiene result in severe welfare losses, including wasted time, reduced productivity, ill health, impaired learning, environmental degradation, and lost opportunities. Addressing these deficits is essential to improving health and well-being globally.

2.1- Need for and Importance of Safely Managed Sanitation

Safely managed sanitation is crucial for public health, environmental preservation, and community development in Pakistan, especially in rural areas where sanitation infrastructure is very basic and limited. In rural areas, improper waste disposal contributes to waterborne diseases, which are a leading cause of illness and mortality, especially among children. Access to safely managed sanitation facilities reduces the spread of diseases like diarrhea, cholera, and typhoid, which are common in rural Pakistan due to contaminated water sources. By managing wastewater safely, communities prevent pollutants from entering groundwater and rivers, which are essential sources of drinking water for many rural areas. Proper sanitation practices also lessen the environmental impact of untreated waste, preserving natural resources for future generations. Moreover, safely managed sanitation supports economic growth by reducing healthcare costs and increasing productivity, as healthier communities can contribute more effectively to the economy. Sustainable sanitation systems create employment opportunities, promote social equity, and are essential to Pakistan’s long-term development goals, especially in achieving SDG 6: Clean Water and Sanitation for All.

Safely managed sanitation is essential for protecting human health, conserve the environment, and achieving sustainable development. It involves hygienically treating and disposing of human waste, ensuring it does not come into contact with people or contaminate water, soil, or the environment.



Need for Safely Managed Sanitation

Health Protection

Prevents waterborne diseases like cholera, diarrhea, and typhoid, reducing health risks, particularly for vulnerable populations.

Environmental Safety

Prevents contamination of water sources and ecosystems, ensuring a cleaner and healthier environment.

Human Dignity

Provides safe and private sanitation facilities, fostering dignity and security, especially for women and children.

Sustainable Development

Addresses global commitments under SDG-6, ensuring access to adequate sanitation for all.

Importance of Safely Managed Sanitation

Improved Public Health

Reduces healthcare costs and improves productivity by preventing sanitation-related illnesses.

Economic Benefits

Supports livelihoods by promoting a cleaner, healthier workforce and reducing environmental cleanup costs.

Gender Equality

Empowers women and girls by providing safe, private, and accessible sanitation facilities.

Resilient Communities

Strengthens community resilience to environmental challenges by maintaining a clean and safe habitat.

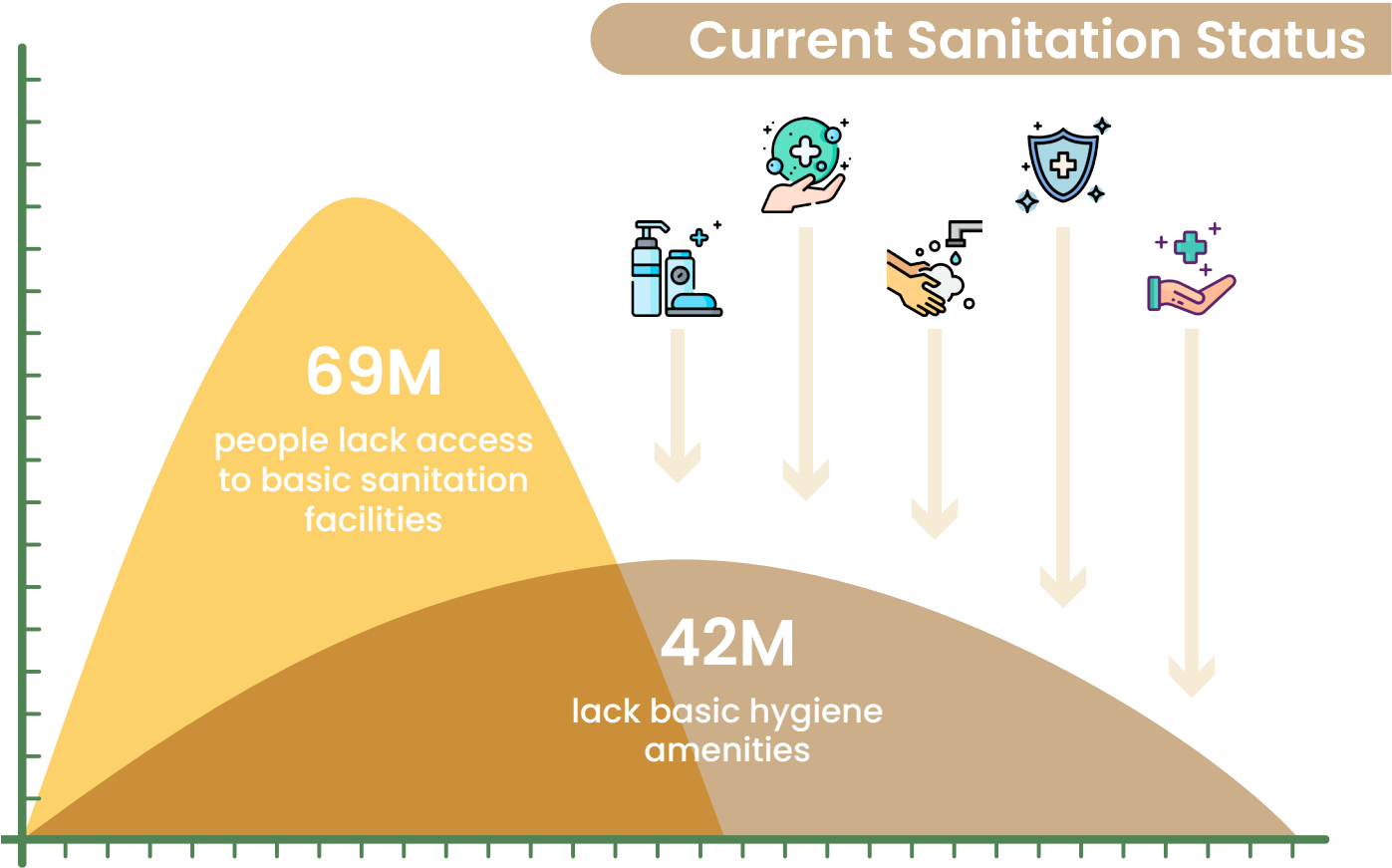
Safely managed sanitation is not just a necessity but a cornerstone of public health, environmental protection, and social well-being, contributing significantly to sustainable and equitable development.

2.2- Contextual Analysis of Current Sanitation Status in Pakistan

Pakistan, one of the world’s most populous countries, faces a critical challenge in ensuring adequate sanitation for its rapidly growing population. Despite significant efforts by the government, NGOs, and international institutions to improve Water, Sanitation, and Hygiene (WASH) conditions, the progress remains insufficient to meet the growing demand. The lack of safely managed sanitation systems contributes to widespread environmental degradation, water wastage, and public health crises.

A particularly neglected area is wastewater management. In Pakistan, Wastewater Treatment is extremely low, If been treated then data is very limited, leading to pollution of rivers, groundwater, and soil. This failure has far-reaching consequences, including the spread of waterborne diseases that claim the lives of an estimated 110 children daily. Industrial effluents, agricultural runoff, and untreated urban waste further exacerbate these issues, threatening water quality and increasing the burden on the healthcare system. With a population exceeding 241 million, approximately 69 million people lack access to basic sanitation facilities, and 42 million lack basic hygiene amenities. This shortfall directly undermines Pakistan’s ability to achieve Sustainable Development Goal

6 (SDG 6), which focuses on ensuring availability and sustainable management of water and sanitation for all.



In Punjab

Punjab, with a population of nearly 127 million, is a focal point of Pakistan’s sanitation challenges. The province struggles with both urban and rural sanitation issues. Urban areas face overloaded sewage systems, while rural regions often lack basic infrastructure altogether. Only 35% of water sources in Punjab are safe for drinking, largely due to contamination from untreated wastewater and agricultural chemicals. The consequences include high rates of diarrheal diseases and stunted growth in children, imposing significant economic and health burdens.

In Muzaffargarh

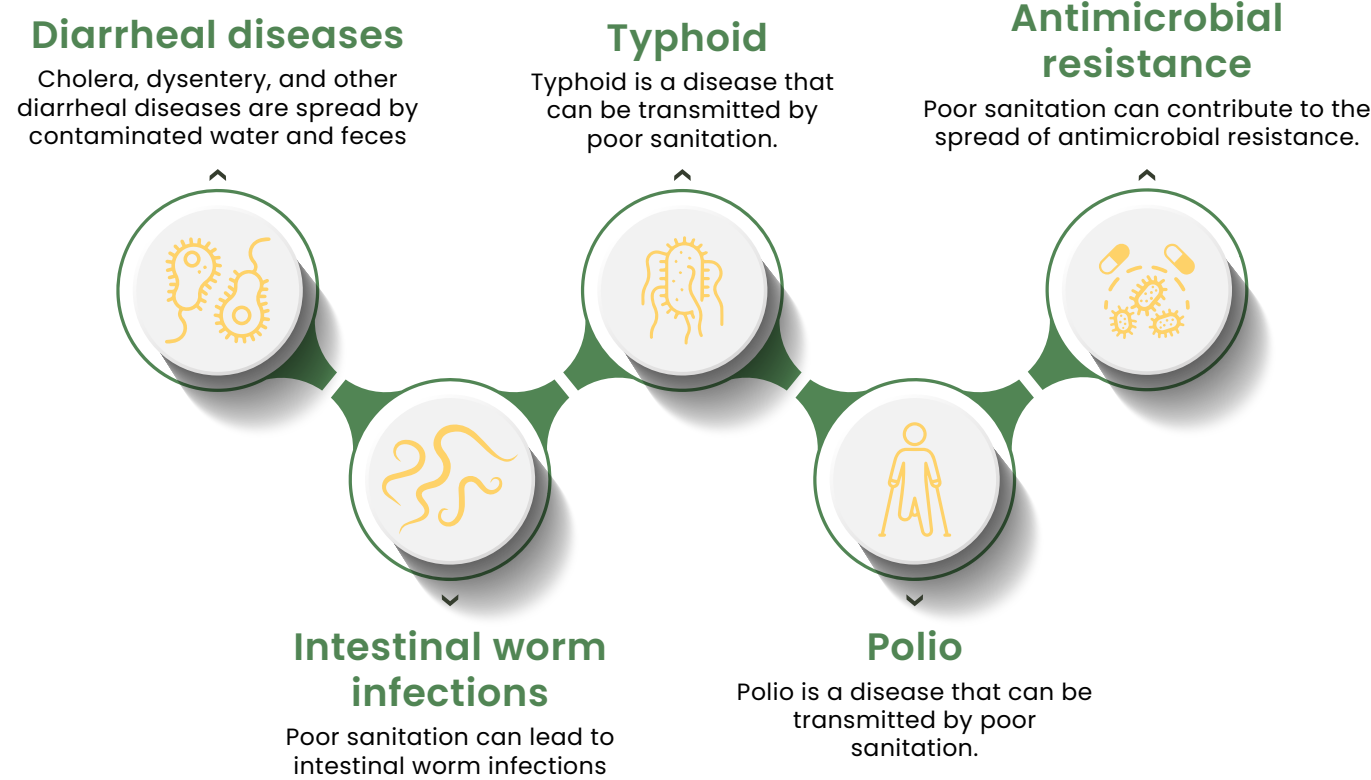
Muzaffargarh is mostly a rural area with serious sanitation challenges. Many communities lack proper sanitation facilities, so they depend on unsafe methods, which harms both health and the environment. Poor sanitation leads to issues like water contamination and the spread of diseases. The current wastewater management infrastructure is insufficient to meet the growing population’s need, that’s why a significant portion of wastewater remains untreated, especially in rural areas having no access to a centralized sewerage system with some areas not even having an open drain system. This untreated wastewater converts into ponds and stagnant water. Untreated wastewater is used for

irrigation purposes leading to the contamination of food products and potential health risks. A large amount of wastewater is disposed openly. Furthermore, the finances linked with the construction and operation of the wastewater and limited expertise in the area also creates hinderance for the local population in constructing a small-scale sewage treatment unit for proper and safe disposal of wastewater. Muzaffargarh faces significant challenges in safely managed sanitation due to a lack of essential infrastructure. Many areas do not have access to proper sanitation systems, waste treatment facilities, or reliable water supply networks, leaving communities to rely on makeshift septic systems, or poorly constructed latrines. These inadequate facilities lead to widespread contamination of water sources, increasing the spread of diseases such as cholera, typhoid, and diarrhea. limited sanitation infrastructure means that existing systems are often insufficient and lack regular maintenance, resulting in frequent breakdowns and overflow. That’s why there is a much need for implementing modern sanitation facilities that meet national and provincial environmental quality standards. Addressing these infrastructure gaps is essential for improving health, environmental protection, and overall quality of life for communities in Muzaffargarh, where safely managed sanitation remains a critical unmet need.

Challenges			
01.	Limited Access to Sanitation Facilities Approximately 69 million people lack access to basic sanitation facilities, and 42 million do not have basic hygiene amenities.	↔	Inadequate Wastewater Management - Only 1% of the country’s wastewater is treated, leading to widespread pollution of rivers, groundwater, and soil. - Untreated sewage contributes to environmental degradation and public health crises.
02.	High Prevalence of Waterborne Diseases - Poor sanitation is linked to waterborne diseases, causing an estimated 110 child deaths daily. - Industrial effluents, agricultural runoff, and urban waste exacerbate water quality issues.	↔	Economic and Health Burden - Sanitation-related illnesses, such as diarrheal diseases, result in significant healthcare costs and stunted growth in children. - Poor sanitation hampers economic productivity and increases the burden on healthcare systems.
03.	Urban and Rural Disparities Urban areas suffer from overloaded sewage systems, while rural regions lack basic sanitation infrastructure.	↔	Sanitation Challenges in Punjab - Only 35% of water sources are safe for drinking, with contamination caused by untreated wastewater and agricultural chemicals. - The province experiences high rates of diarrheal outbreaks and stunted growth in children due to poor sanitation.
04.	Failure to Achieve SDG 6 Targets Pakistan is far from meeting the Sustainable Development Goal target of treating 50% of wastewater.	↔	Lack of Innovative Wastewater Treatment Solutions Existing infrastructure for wastewater management is insufficient, necessitating scalable and innovative solutions like Sewage Treatment Units (STUs).

Risks Associated with Poor Sanitation:

Poor sanitation can lead to a number of health risks, including:



Global & National Perspectives

2.3.1- Global Perspective: Sanitation as a Cornerstone of Sustainable Development and Climate Action

Globally, sanitation is no longer viewed as a standalone service, it is recognized as a cross-cutting enabler of health, dignity, environmental protection, and climate resilience. The Sustainable Development Goals (SDGs), adopted by 193 countries under the United Nations 2030 Agenda, place sanitation at the heart of global development.

Key SDG Linkages:



SDG 3: Good Health and Well-being

- Promotes good health and well-being by reducing waterborne diseases and improving child survival.



SDG 5: Gender Equality

- Advances gender equality by ensuring safe, private, and dignified sanitation for women and girls.



SDG 6.2: Clean water & Sanitation

- Calls for access to adequate and equitable sanitation and hygiene for all, with a focus on ending open defecation and addressing the needs of women and vulnerable groups.

SDG 6.3:

- Aims to improve water quality by reducing pollution, halving untreated wastewater, and increasing safe reuse.



SDG 11: Sustainable cities & communities

- Supports sustainable cities and communities through inclusive and resilient sanitation infrastructure.



SDG 13: Climate Action

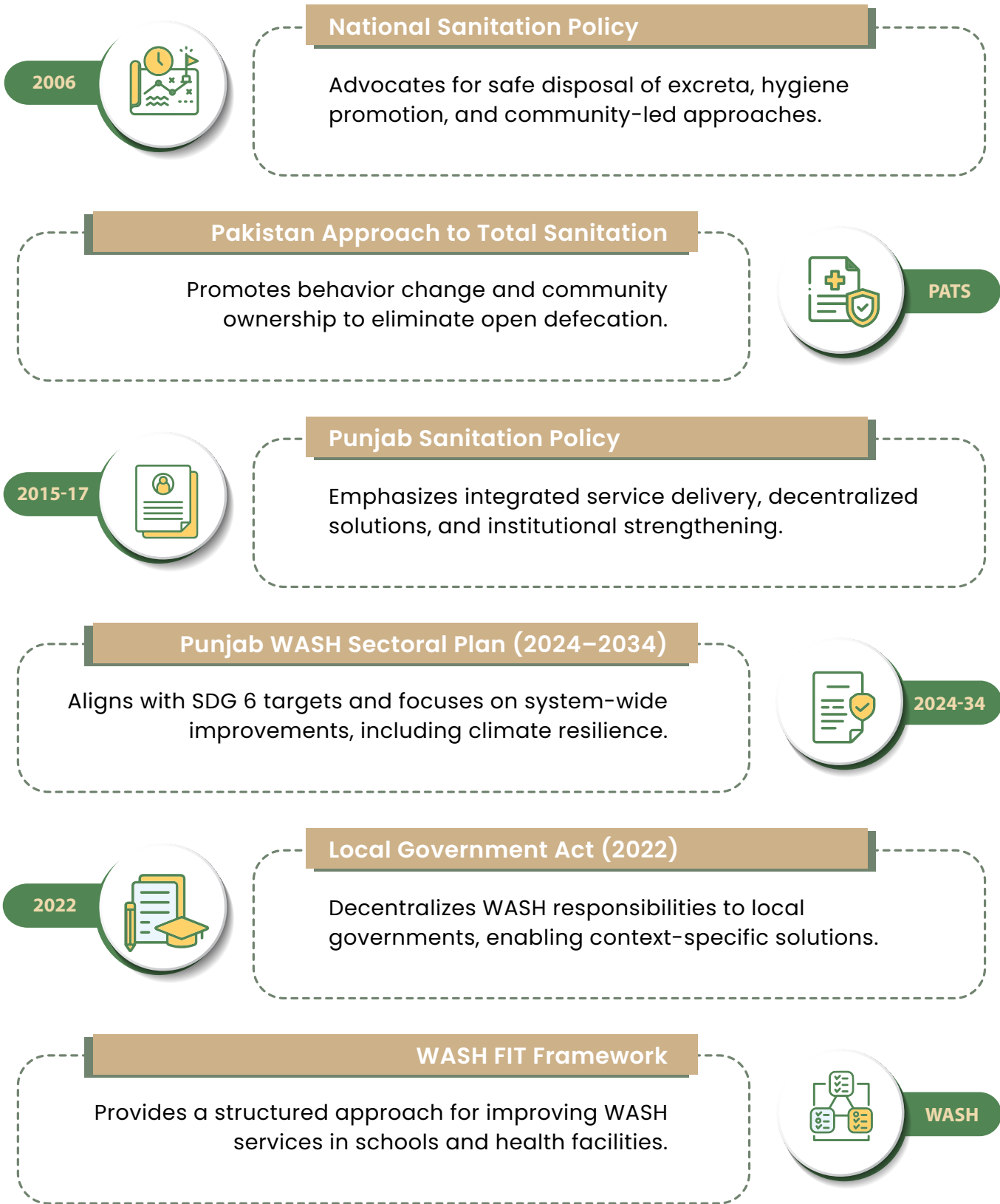
- Encourages climate action by promoting low-carbon, adaptive sanitation systems that reduce environmental pollution.

The UN-Water Global Analysis and Assessment of Sanitation and Drinking-Water (GLAAS) and the WHO/UNICEF Joint Monitoring Programme (JMP) emphasize that countries with decentralized, inclusive, and climate-smart sanitation models are more likely to achieve universal access.

2.3.2 - National Perspective: Pakistan's Policy Commitments and Institutional Landscape

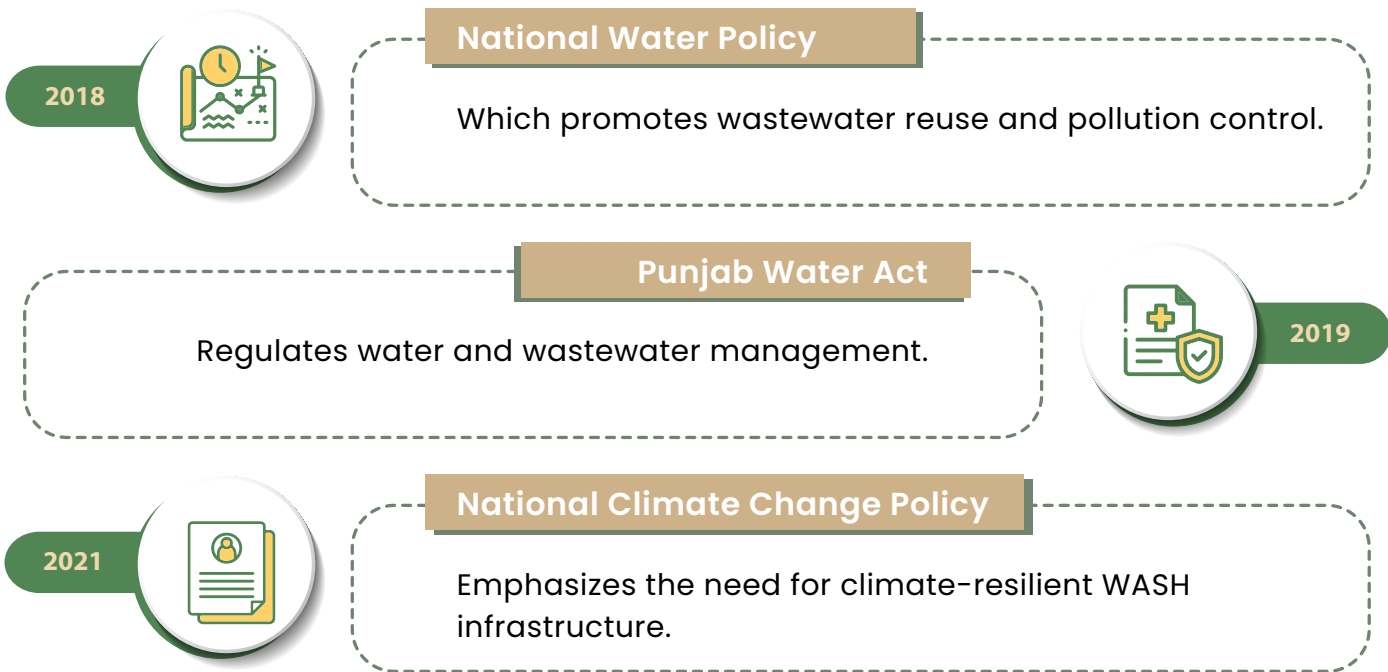
Pakistan has made significant policy commitments to improve sanitation access and quality, recognizing its role in achieving national development goals and international obligations. However, implementation remains uneven due to systemic challenges.

Key National Policy Frameworks:



In addition to sanitation-specific frameworks, the Climate Resilient and Sustainable Safely Managed Sanitation Service Delivery Model aligns with broader national policies on water and climate change.

These include:



Punjab Climate Change Action Plan emphasizes Adaptation in water and sanitation systems to reduce health risks and environmental degradation, Decentralized wastewater treatment to prevent pollution and support water reuse, Integration of solar energy and low-carbon technologies in public service delivery, Gender-responsive climate action to protect women and marginalized groups from climate-induced vulnerabilities.

The model also supports Pakistan's commitments under the Paris Agreement and its Nationally **Determined Contributions (NDCs)** by integrating solar energy, reducing environmental pollution, and enhancing community-level climate adaptation.



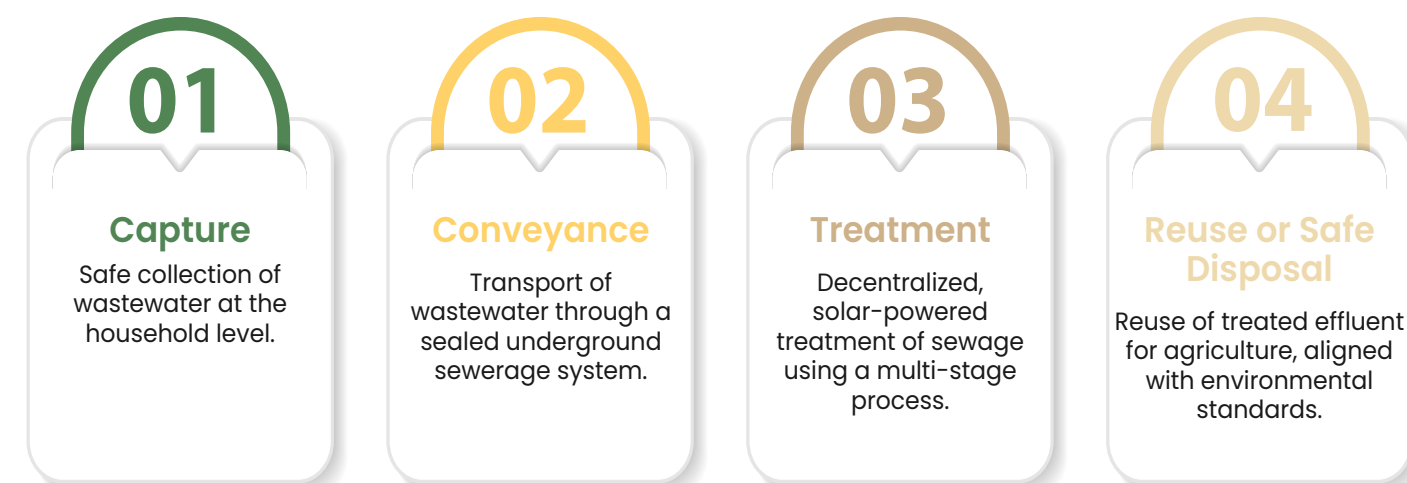
Chapter 03.

Climate Resilient and Sustainable Safely Managed Sanitation Service Delivery Model

3- Climate Resilient & Sustainable Safely Managed Sanitation Service Delivery Model

The Climate Resilient and Sustainable Safely Managed Sanitation Service Delivery Model is a decentralized, community-managed sanitation solution designed to ensure the safe and sustainable management of human waste, from the point of generation to final treatment and reuse. It is specifically tailored for rural and peri-urban areas where conventional sewerage systems are either non-existent or ineffective. This model integrates technical innovation with social inclusion, climate adaptation, and financial sustainability. It ensures the safe collection, treatment, and reuse of wastewater, thereby reducing public health risks, environmental degradation, and water insecurity.

This model is built around the sanitation service chain, which includes:



The model is composed of two interlinked components:

- 1. Sewerage System
- 2. Sewage Treatment Unit

3.1 Sewerage system

A sewerage system that collects and transports wastewater from household to a treatment unit. It includes underground RCC sewer pipelines that carry wastewater safely. Manholes are built at regular distances to allow maintenance, for HH connection and inspection. The system prevents pollution by keeping wastewater away from water sources and human interaction. For smooth flow and to avoid any blockage proper designing of sewerage system is necessary.

Here is the designed criteria and method adopted for designing of sewerage system in Basti Nai Abadi Mondka.

3.1.1 Social & Technical Survey

The social & technical survey conducted in Basti Nai Abadi Mondka for designing the sewerage system. In social survey AGAHE team collect the data of households and population, which is necessary to design the diameter of sewer line. While in technical survey engineer develop the map of the village, measure the length & width of streets, pavement type (Kacha, Brick Pavement, tuff tile pavement or metal road), and taking ground levels for calculate the depth of sewer pipe in each street.



3.1.2 Designing of Sewerage system

Designing of the sewerage system is the crucial component for operation and sustainability of the system. To design this sewerage system the following steps were taken.

Calculation of Population: This sewerage system has been designed for 20 years with a growth rate of 1.98 .

Here is the formula to calculate the designed population:

$$Pd = Pi \times (1+n/100)^N$$

Where;	
Pd	= Designed population at the end of Design
Pi	= Present Population (560 persons)
n	= Annual Growth rate (1.98)
N	=Number of years (design period). (20 years)
Total Population after 20 years= 828 Persons.	

3.1.3 Flow Calculations

This sewerage system is designed to flow under gravity. The Diameter of sewer pipe was designed against the usage of water in liter per person per day (LPCD). It normally varies in a range of 75 – 380 liters per person per day (LPCD). In rural areas average flow is 135 LPCD.

The calculation of sewer pipe is designed as per the total discharge of the street or carrying total sewer.

Total Population= 828

Total Avg. flow = 828 x135= 111,780 liters per day.



3.1.4 Design of the Sewerage system

After calculation of flow the next step is to design the sewer pipe for Lateral Sewer, sub main and main sewer. The design of the sewer pipe diameter and velocity was carried out to ensure efficient flow. A self-cleaning velocity of 2.5 ft/sec. was considered to prevent blockages in the system. The appropriate pipe diameter was selected based on the required flow rate to maintain this velocity. This design ensures that wastewater moves smoothly through the pipes to the sewerage treatment unit without clogging.

To determine the flow, we counted the population of each street and flow in cubic meter, and then develop a hydraulic statement include the flow in cusec, diameter of pipe, invert levels, excavation and number of manholes. The Flow calculation is given below.

Flow Calculation & Required Diameter of Sewer Pipe								
Length of Sewer Line & Number of				Excavation of sewer line & manhole no.1				Required diameter of sewer pipe in inches
Street Name	Length (ft)	Sewer Line Dia (Inches)	No of Manholes	Population in 20 years	Flow L/D	Flow m³/s	Flow in sewer pipe	
F1-F	50	9	1	31.08	4196.171366	0.0000486	0.0000486	9
F2-F	288	9	5	72.53	9791.06652	0.0001133	0.0001133	9
F3-F	200	9	3	72.53	9791.06652	0.0001133	0.0001133	9
E1-E	116.5	9	3	186.50	25177.02819	0.0002914	0.0005666	9
D1-D	195	9	4	62.17	8392.342731	0.0000971	0.0000971	9
C1-C	80	9	1	300.47	40562.98987	0.0004695	0.0011332	9
B1-B	518	9	5	72.53	9791.06652	0.0001133	0.0001133	9
A1-A	488	9	6	414.44	55948.95154	0.0006476	0.0018941	9
A2-A	38	9	1	41.44	55948.95154	0.0000648	0.0000648	9
F-E	75	9	2	476.60	64341.29427	0.0007447	0.0027036	9
E-D	151	9	2	72.53	9791.06652	0.0001133	0.0001133	9
D-C	140	9	2	580.21	78328.53216	0.0009066	0.0037235	9
C-B	55	9	1	165.77	22379.58062	0.0002590	0.0002590	9
B-A	233	9	3	828.87	111897.9031	0.0012951	0.0012951	9
A-A3	257	12	3	828.87	111897.9031	0.0012951	0.0012951	12

The required diameter of sewer pipe against Flow in cubic meter and required self-cleaning **velocity 2.5 ft/sec.** is given below in the table for guidance.ⁱⁱⁱ

Dia. of Sewer Pipe		Discharge (Q)		Slope
Inch	mm	M³/sec	Cusec	ft/ft,m/m
8	225	0.0302	1.08	0.0045
12	300	0.057	2.05	0.0030
15	375	0.086	3.08	0.0023
18	450	0.126	4.51	0.0017
21	525	0.168	5.99	0.0014
24	600	0.222	7.93	0.0012
27	675	0.284	10.15	0.0010
30	750	0.345	12.31	0.0009

ⁱThe Book Name “Sewerage” by Dr Sajjad. MSc. Environmental Design, Lahore. .

As shown in the table the sewer flow is less than **0.0302 m3/sec** but sometimes, bigger objects also enter sewers. Clogging is less likely if sewers are not smaller than **9 inches (225 mm)**. This smallest size must be larger than the house sewer connections in general use. Thus, the articles that pass through the house connections may readily pass through the sewer. Sometimes people, even outside their houses, use sewers to dispose of solid waste, construction waste (e.g. broken bricks, debris etc.) and animal remains, especially at Eid ul Azha. Thus, a minimum size of 9 inches (225mm) is recommended for gravity-flow sanitary sewers. That, why we designed the 9-inch diameter sewer size for this sewer system.

Manholes: Manholes are masonry or concrete chambers, provided at some distance, on the sewer line. **The purpose is to:**

- (1) to connect house sewer with sewer system
- (2) cleaning of sewer lines in case of blockage
- (3) inspection of sewers.

These are provided:

- (1) at every change in direction in sewer line;
- (2) where two different diameter pipes are to be connected.

In this sewer system we designed and constructed Brick Masonry manholes at every **50 feet** in **9 inch sewer line** and at **80 feet** in **12 inch dia sewer line** . The internal Diameter of manholes is 3feet & 4 feet at bottom and 2.5feet at opening. The Reinforced Plastic Composite (RPC) Manhole Covers are used for covering the manholes.

After designing of sewer line and manholes we develop a hydraulic statement for calculate the excavation, invert level depth of every manhole and clear cover at the sewer line that was 3 feet at start point.

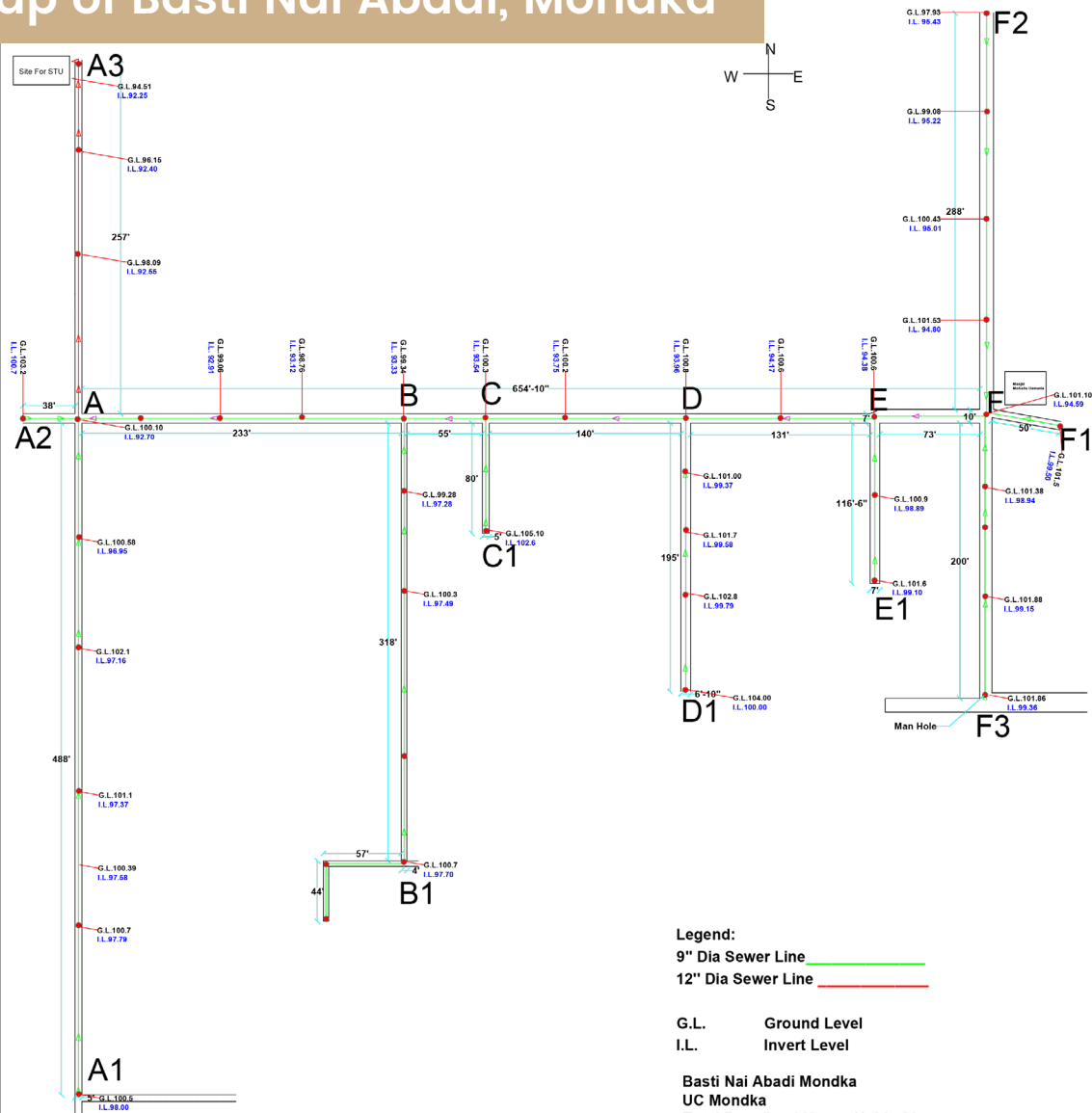
Hydraulic Statement of Basti Nai Abadi Mondka

Length of Sewer Line & Number of				Excavation of sewer line & manhole no.1				Excavation of sewer line & manhole no.2				Excavation of sewer line & manhole no.3				Excavation of sewer line & manhole no.4				Excavation of sewer line & manhole no.5				Excavation of sewer line & manhole no.6			
Street Name	Length (ft)	Sewer Line Dia (Inches)	No of Manholes	Ground Level/	Excavation at previous M.H	Excavation in ft.	Invert level	Ground Level/	Excavation at previous M.H	Excavation in ft.	Invert level	Ground Level/	Excavation at previous M.H	Excavation in ft.	Invert level	Ground Level/	Excavation at previous M.H	Excavation in ft.	Invert level	Ground Level/	Excavation at previous M.H	Excavation in ft.	Invert level	Ground Level/	Excavation at previous M.H	Excavation in ft.	Invert level
F1-F	50	9	1	101.5	-	2	99.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
F2-F	288	9	5	97.93	-	2.5	95.43	99.08	2.50	3.86	95.22	100.43	3.86	5.42	95.22	101.53	5.42	6.73	94.80	101.10	6.73	6.51	94.59	-	-	-	-
F3-F	200	9	3	101.85	-	2.5	99.36	101.88	2.50	2.73	99.15	101.38	2.73	2.44	99.15	101.10	2.44	2.37	98.75	-	-	-	-	-	-	-	-
E1-E	116.5	9	3	101.6	-	2.50	99.10	100.90	2.50	2.01	98.89	100.60	2.01	1.92	98.89	-	-	-	-	-	-	-	-	-	-	-	-
D1-D	195	9	4	104	-	4	100.00	102.80	4.00	3.01	99.79	101.70	3.01	2.12	99.79	101.00	2.12	1.63	99.79	-	-	-	-	-	-	-	-
C1-C	80	9	1	105.1	-	2.50	102.60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B1-B	518	9	5	100.7	-	3.00	97.70	100.30	3.00	2.81	97.49	99.28	2.81	2.00	97.49	-	-	-	-	102.10	-	-	-	-	-	-	-
A1-A	488	9	6	100.5	-	2.50	98.00	100.70	2.50	2.91	97.79	100.39	2.91	2.81	97.79	101.10	2.81	3.73	97.37	-	3.73	4.94	97.16	100.58	4.94	3.63	96.95
A2-A	38	9	1	103.2	-	2.5	100.70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
F-E	75	9	2	101.1	-	6.51	94.59	100.60	6.51	6.22	94.33	-	-	-	94.33	-	-	-	-	-	-	-	-	-	-	-	-
E-D	151	9	2	100.6	6.22	6.43	94.17	100.80	6.43	6.84	95.96	-	-	-	95.96	-	-	-	-	-	-	-	-	-	-	-	-
D-C	140	9	2	100.2	6.84	6.45	93.75	100.30	6.45	6.76	95.54	-	-	-	95.54	-	-	-	-	-	-	-	-	-	-	-	-
C-B	55	9	1	99.34	6.76	6.01	93.33	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
B-A	233	9	3	98.76	6.01	5.64	93.12	99.06	5.64	6.15	92.91	100.10	6.15	7.40	92.91	-	-	-	-	-	-	-	-	-	-	-	-
A-A3	257	12	3	98.09	7.40	5.64	92.55	96.15	5.54	3.75	92.40	94.51	3.75	2.26	92.40	-	-	-	-	-	-	-	-	-	-	-	-

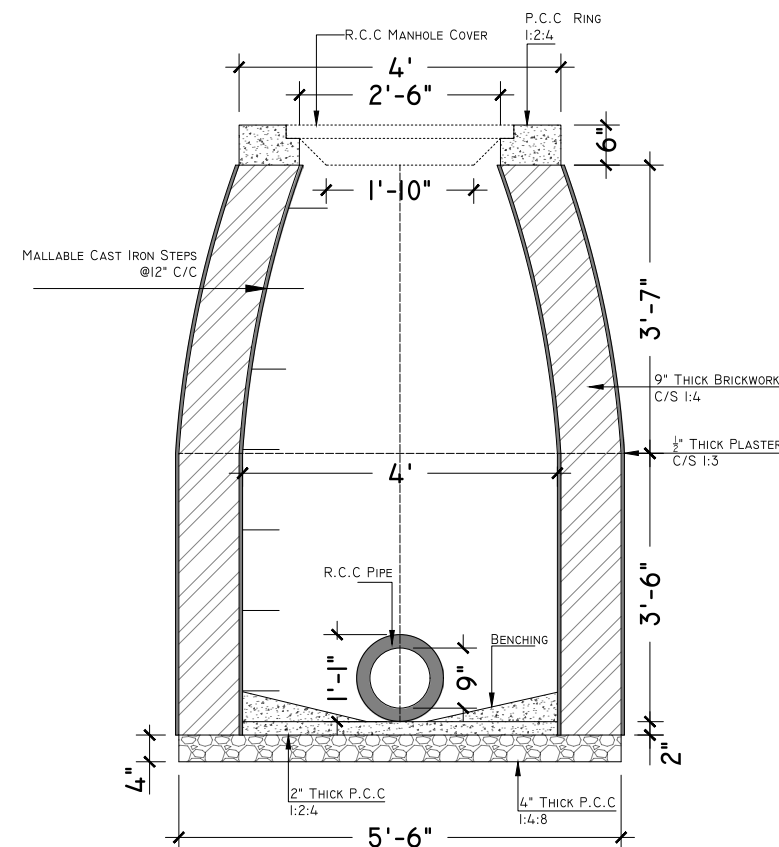


3.1.5 Drawings of Sewerage

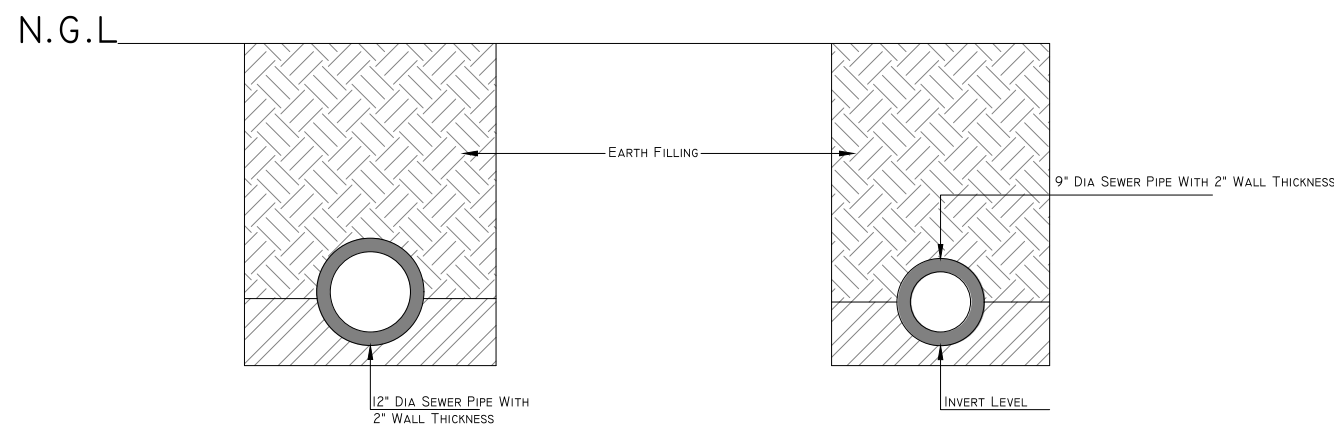
Map of Basti Nai Abadi, Mondka



Cross section of Manhole



Cross section of Sewer Pipe Laying



Reinforcement and wall thickness for concrete pipes

Sr. No.	Internal Dia of RCC Sewer Pipe	Wall Thickness	Size of ring Bars	No. of circular rings	No. of rings for bells	Straight Bars
	Inch	Inch	Inch			
1.	9	2	5/32	28	2	6
2.	12	2	3/16	25	3	4

3.1.6 Developing BOQs

For the development of the Bill of Quantities (BOQ) for the construction of the sewer line and manholes, all calculations were carried out as per the approved design and specifications. The quantities for each item were accurately calculated, including the excavation required for laying the sewer line and constructing the manholes.

The total sewer line length measured 2,700 running feet (rft), while 51 manholes were constructed at designated intervals. The required quantities of Reinforced Cement Concrete (RCC) sewer pipes were calculated separately for 9-inch and 12-inch diameters based on the design. The brickwork required for manhole construction was estimated in cubic feet, ensuring compliance with standard thickness and dimensions.

Similarly, the internal and external plastering of manholes was quantified. For the stability of the manhole covers, the quantity of Plain Cement Concrete (PCC) was assessed. Additionally, dismantling and restoration of brick soling were considered in areas where existing pavement structures were disturbed due to excavation.

The cost estimation for all items was obtained from the Market Rate System (MRS) of Muzaffargarh for the period of January to June 2024 to ensure accurate and updated pricing. The final BOQ reflected the detailed breakdown of materials, labor, and associated costs, ensuring transparency and precision in financial planning. Here is the Summary of Cost estimation:

Sr.No	Description of Work	Cost in PKR	Remarks
1	Laying & Construction of 2700 Rft Sewer Line (9" & 12")	4,521,210	
2	Construction of 51 no. of Manhole's		
3	Back Filling & Restoration and remaining Finishing Work.		

3.2- What is Sewage Treatment Unit (STU)?

A Standard Sewage Treatment Unit is developed to properly contain and remove the Total suspended solids (TSS), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD) from the sewage with primary, secondary and final treatment to ensure the safe discharge of used water or reusing it for irrigation purpose.

Components of STU:

This sewage treatment unit is comprising of 09 interconnecting chambers including

- 01 Screening Chamber
- 01 Inlet Chamber
- 02 Settler Chambers
- 03 Anaerobic Baffled Reactor (ABR) Chambers
- 02 Anaerobic Filters (AF) Chambers

Brief Details of Components:

Screening Chamber: A Screen Chamber is the 1st chamber of sewage treatment unit where incoming used water is filtered by removing large solid waste materials like large particles and plastic bags etc.

Inlet Chamber: The Inlet Chamber serves as a primary collection and pumping unit for incoming sewage. It is equipped with two automatic submersible sewage pumps to transfer the sewage to the treatment unit.

Settler chambers: The treatment process begins with two settler chambers that retain used water for up to two hours. This process allows solids to settle and removes 70–80% of suspended particles including Biochemical Oxygen Demand and Chemical Oxygen Demand.

Anaerobic Baffled Reactors: The sewage treatment unit features 3 Anaerobic Baffled Reactor Chambers for Intermediate Level treatment by retaining the used water for 8 to 24 hours for biological treatment at a controlled temperature to break down organic matter.

Anaerobic Filter Chambers:

Next, 2 Anaerobic Filter (AF) chambers treat the water through layered gravel media of different size with a retention time of 7 to 24 hours. Here water is gradually filtered before being discharged for safe reuse.



01.

Environmental Protection

Sewage Treatment Units are crucial in protecting the environment by preventing untreated sewage from being released into water bodies, which can lead to water pollution, harm aquatic life, and disrupt ecosystems. Proper treatment of wastewater helps maintain the health of rivers, lakes, and groundwater resources, preserving natural habitats and biodiversity.

02.

Public Health Safeguard

Untreated sewage is a major source of waterborne diseases such as cholera, dysentery, and typhoid. STUs play a critical role in reducing the risks associated with untreated wastewater by ensuring that pathogens, harmful chemicals, and toxins are effectively removed, thereby protecting the community's health.

03.

Sustainable Water Use & Resource Recovery

STUs can help recycle treated wastewater for non-potable uses such as irrigation in rural areas. This contributes to water conservation, especially in areas facing water scarcity, by reducing reliance on freshwater resources and encouraging a circular water economy.

04.

Enhancing Urban & Rural Infrastructure

In areas where traditional sewage systems are lacking or overburdened, STUs offer a decentralized solution to wastewater management. By providing an effective and sustainable means of treating wastewater, STUs help improve urban and rural sanitation infrastructure, ensuring better sanitation services for all.

05.

Supporting Sustainable Development Goals (SDGs)

The implementation of STUs directly contributes to achieving SDG 6 (Clean Water and Sanitation) by ensuring the sustainable management of water and sanitation systems. It also supports other SDGs, such as SDG 3 (Good Health and Well-being), by preventing waterborne diseases, and SDG 11 (Sustainable Cities and Communities), by enhancing rural sanitation infrastructure.

06.

Economic Benefits

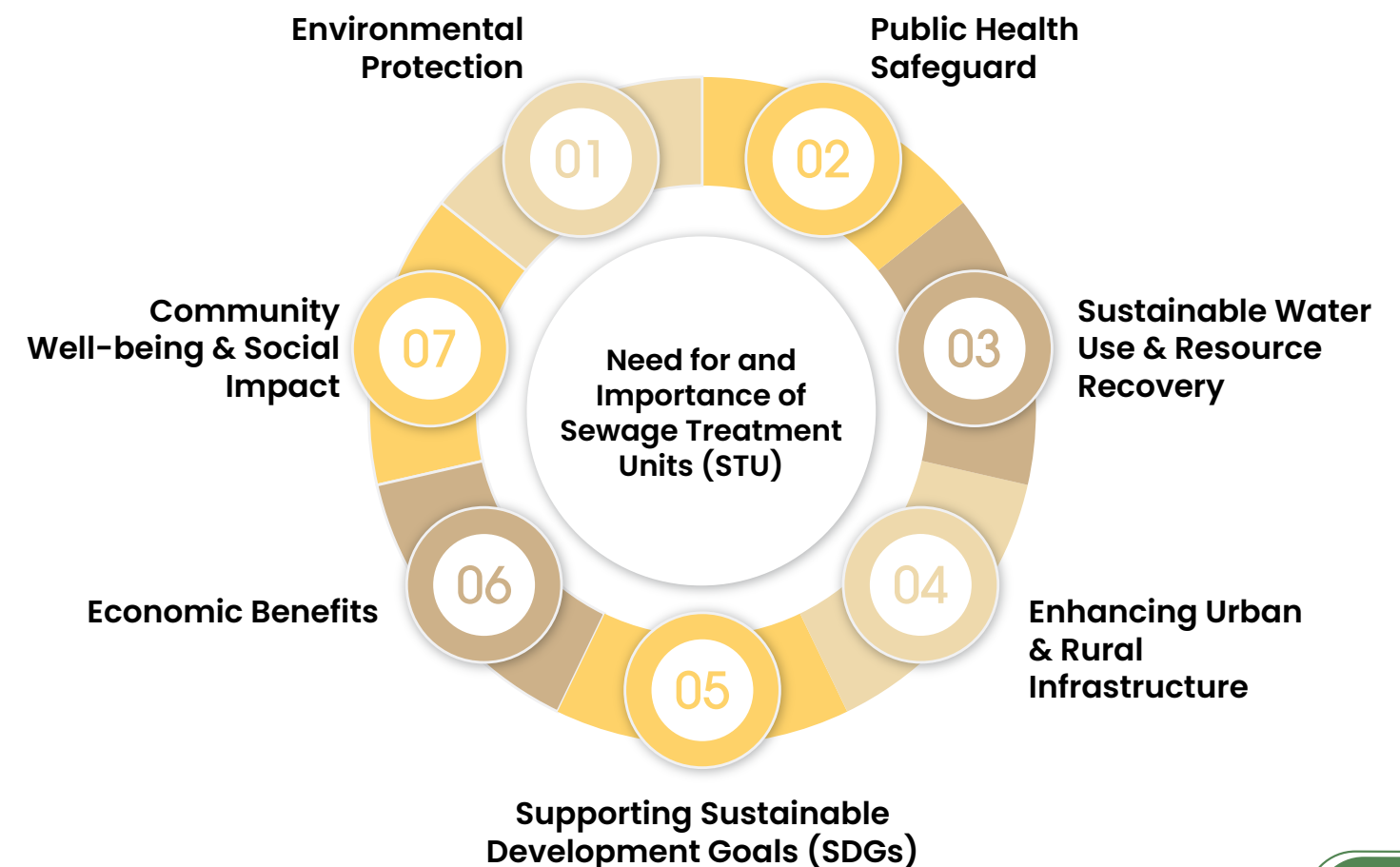
Proper sewage treatment through STUs can lead to significant economic savings by reducing the long-term costs of water pollution management, healthcare associated with waterborne diseases, and the degradation of environmental resources. Furthermore, the treated water from STUs can be repurposed for various productive uses, creating new opportunities for economic growth and resource management.

07.

Community Well-being & Social Impact

Safe wastewater management improves the quality of life for communities by ensuring cleaner environments, reducing the incidence of diseases, and promoting overall public health. By implementing STUs, communities can experience better sanitation, improved hygiene, and enhanced dignity, particularly for vulnerable groups such as women and children.

A Sewage Treatment Unit (STU) is a facility designed to treat wastewater generated from households to remove contaminants, making it safe for discharge or reuse. The treatment process typically involves physical and biological methods to remove solid waste, organic matter, and harmful microorganisms from sewage.





3.3- Construction of Sewage Treatment Unit (STU)

Guidelines for construction of Sewage Treatment Unit

3.3.1- Site Selection

- **Land Requirement**

The selected site should be at least specific 10 Marla plot (90' x 30') to accommodate the construction of Sewage Treatment Unit (STU).

- **Accessibility & Safety**

The Sewage Treatment Unit (STU) must be strategically placed, maintaining a minimum distance of 2 meters from neighboring boundaries, 10 meters from watercourses, 15 meters from buildings, and 50 meters from wells, reservoirs, or other water sources. It should also be situated away from access roads, driveways, and paved areas to ensure safety and environmental compliance.²

- **Climate Resilience**

During site selection, elevated sites should be preferred for construction to avoid the cost of landfilling and facilitate easy disposal of wastewater without additional structural measures. This elevated site will also serve as protection against excessive rainfall and floods.

- **Available System Integration**

The site should be selected in such a manner so that the Unit can be integrated with the existing wastewater disposal mechanism i.e drainage or sewerage scheme.

² <https://proseptic.co.uk/useful-information/sewage-treatment-plant-regulations/>



3.3.2- Design of STU

Here is the methodology, adopted for designing of Sewage treatment unit, in Basti Nai Abadi Mondka.

Calculation of Wastewater Flow	
Design Selection Criteria	Detail
Design Period	20 years
Estimated No of Households	80
Persons per Household	07
Estimated Population	560
Growth rate	1.98%
Population after 20 years	828
Currently Estimated Flow	75.6 m3/day
Estimated Flow After 20 years.	111.78 m3/day
Wastewater Generation Rate	80% of the estimated flow
Wastewater Generated	89.5 m3/day
Contingency of 10% in Generated Wastewater	8.95 m3/day
Total quantity of generated wastewater	98.45 m3/ day.

Pre-Water Quality Testing of Wasterwater

The AGAHE & SES team conducted water quality sampling in Basti Nai Abadi Mondka to assess the condition of wastewater before designing the treatment technology. The team collected samples from various locations at different times of the day to capture variations in wastewater composition. Using sterile containers, they carefully took samples from designated points, ensuring proper labeling and documentation. The collected samples were then preserved and transported under controlled conditions & temperature to the laboratory for detailed analysis of COD, BOD, & TSS. This systematic approach helped in critically evaluating wastewater quality for further treatment planning. The sample results are given below:

Wastewater Quailty of Basti Nai Abadi Mondka							
Sr. No.	Parameters	NEQS	Sample ID				
			1	2	3	4	5
			7:00 AM	10:00 AM	1:00 PM	3:00 PM	5:30 PM
1.	TSS (mg/L)	150	64	320	92	1164	196
2.	COD (mg/L)	150	307.2	268.8	230.4	576	243.2
3.	BOD (mg/L)	80	232	200.3	174	429.3	182.9

In this table highlighted results are higher than permissible limits.



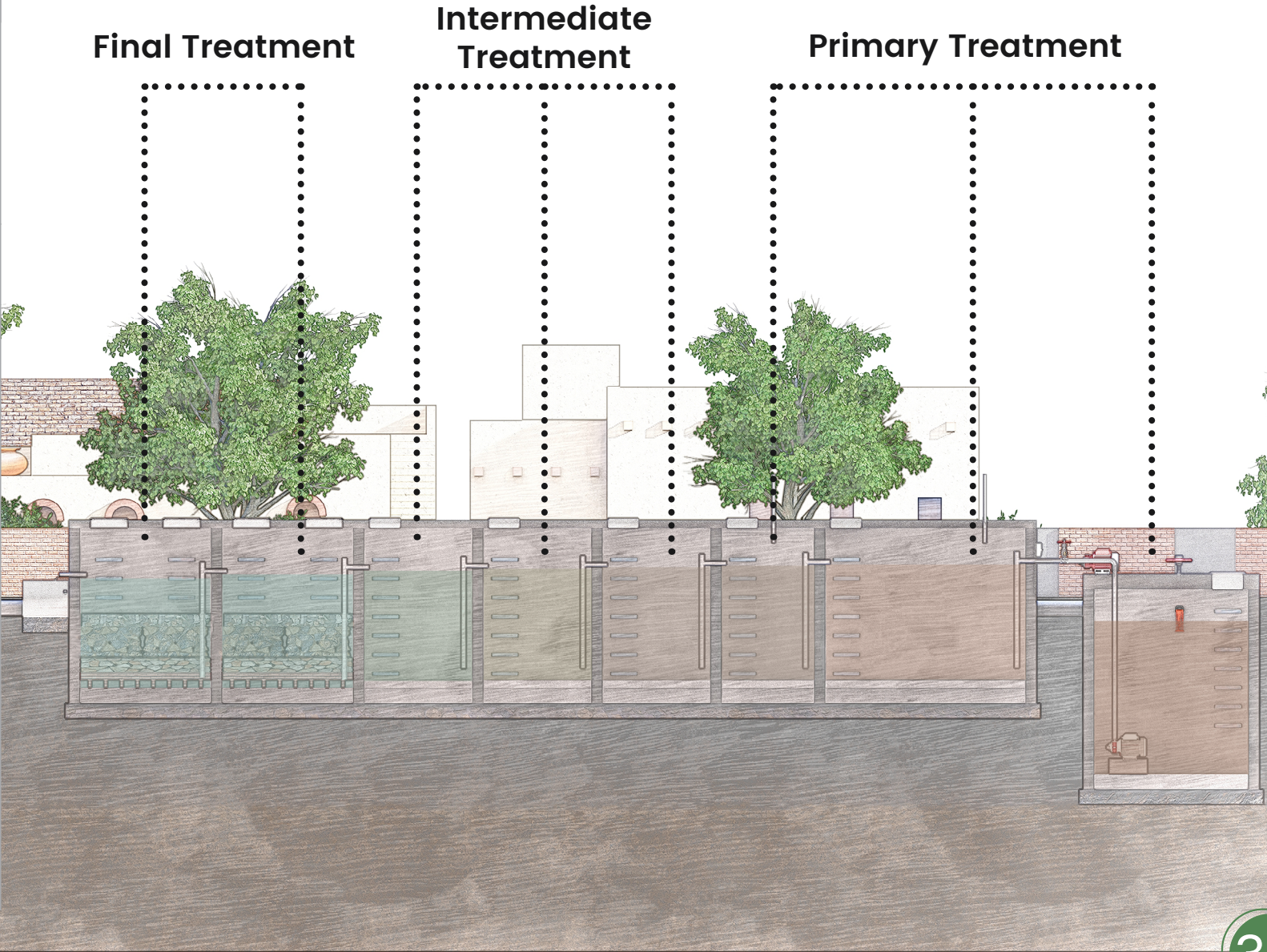
3.4-Components for Sewage Treatment Unit (STU)

A- Safely managed Sanitation

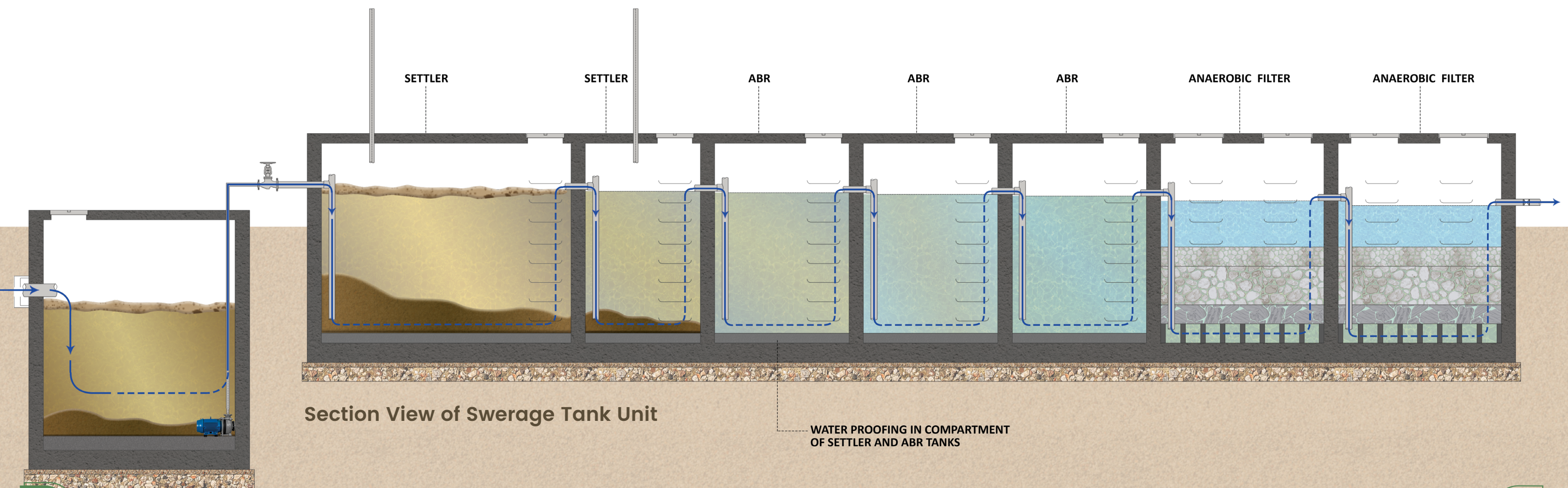
This STU is a complete package fulfilled the needs for safely managed sanitation system, primarily influenced by the ABR, AF, clarifiers, filtration, and disinfection components.

Process of Treatment	
Primary Treatment 2 Settlers Chambers	Function The primary treatment focuses on the removal of large solids and sediment from wastewater. This is achieved using a settling tank (settler), which removes inorganic suspended solids and a fraction of biodegradable organic matter. Process The settler is designed with two compartments, where the first compartment is larger to accommodate most of the sludge accumulation. It has a design depth ranging from 1.5 to 2.5 meters, with a scum layer of approximately 0.2 meters. Performance The primary treatment removes about 60–70% of total suspended solids (TSS) and 20–30% of associated BOD (biological oxygen demand). Sludge Handling Sludge is removed periodically (every 1–2 years), and some immature sludge is left for continued decomposition.
Intermediate Treatment 3 Anerobic Baffled Reactor Chambers	Technology The secondary treatment is carried out through an Anaerobic Baffled Reactor (ABR), which uses multiple compartments separated by baffles. This system performs primary sedimentation, anaerobic biodegradation, and significant solids removal, with a very low sludge generation rate compared to conventional aerobic treatments. Design Criteria • Hydraulic Retention Time (HRT): 8–24 hours. • Organic Loading Rate (OLR): < 3 kg COD/m³/day. • Upflow velocity: ≤ 1.2 m/h. • Number of chambers: 4 to 8. Performance The ABR system significantly reduces the organic load through anaerobic biodegradation, with minimal sludge production. It is well-suited for decentralized wastewater treatment, especially in semi-arid and tropical regions. Wastewater Flow The ABR system is designed to handle peak flows up to 4.2 m³/hr, with an organic loading rate of 0.66 kg COD/m³/day, well below the upper limit of 3 kg COD/m³/day.

Final Treatment (Tertiary Treatment) 2 Anerobic Filter Chambers	Technology The Anaerobic Filter (AF) is used as the tertiary treatment. This is a fixed-bed biological reactor with filtration chambers, where the effluent from the ABR flows through a medium (e.g., gravel, plastic pieces) providing surface area for bacterial growth and further organic matter removal. Design Criteria • Hydraulic Retention Time (HRT): 7–24 hours. • Organic Loading Rate (OLR): < 4 kg BOD/m³/day. • Up flow velocity: ≤ 2 m/h. • Filter Material: PVC pipe pieces, cinder, gravel, or activated carbon. Performance The AF provides further reduction in COD and BOD, achieving a COD removal rate of 30% and a BOD removal rate of 56%. The treated effluent from the AF meets the required standards for safe disposal or potential reuse.
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Top View of Swerage Tank Unit



Section View of Swerage Tank Unit

1- Operational & Maintenance Considerations

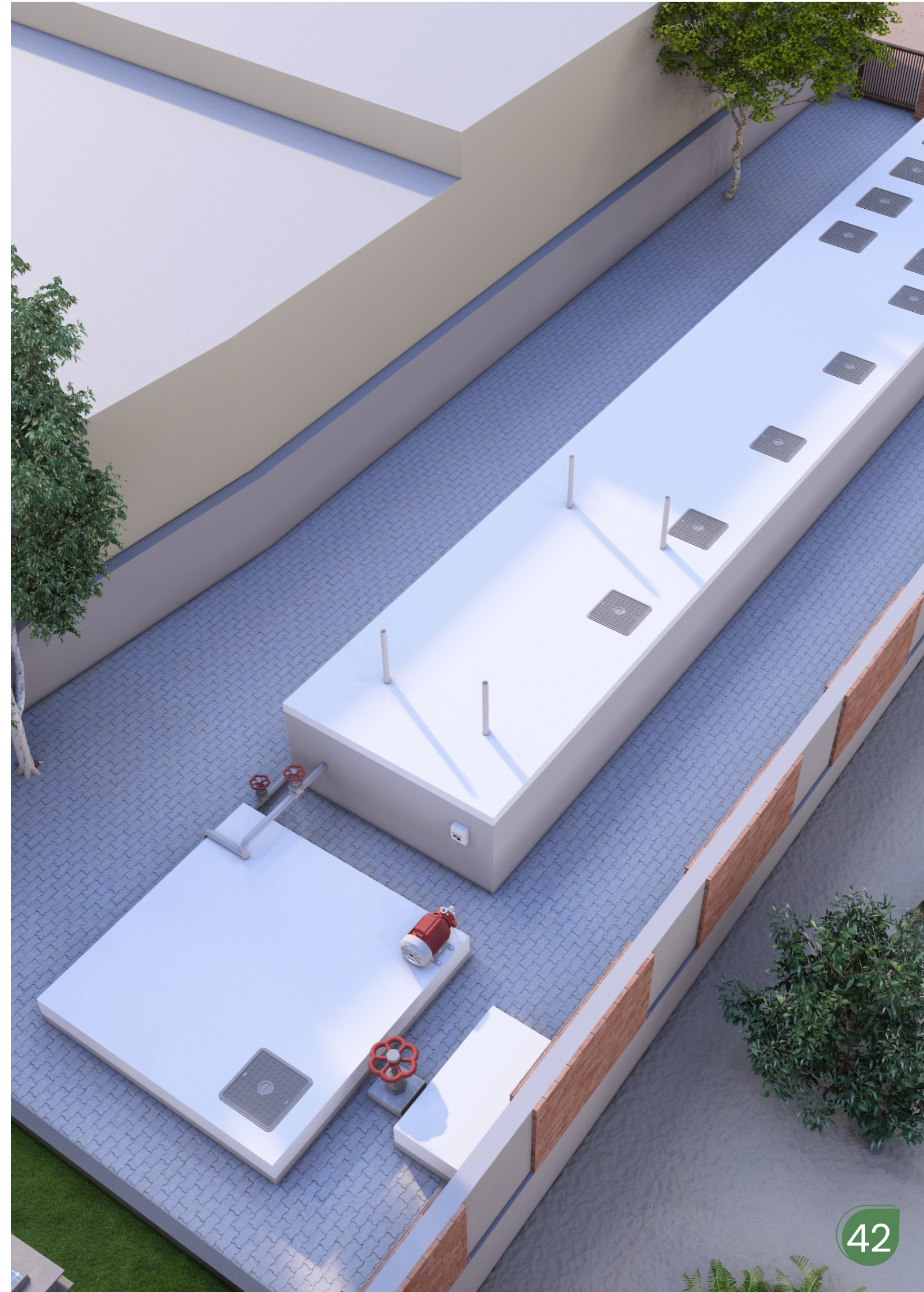
- The sludge produced in the primary and secondary treatments is managed through periodic de-sludging (every 1-2 years).
- Maintenance of the filter material in the AF and periodic monitoring of system performance are crucial for long-term operation. A dedicated O&M committee has been formed to monitor and maintain for this sewage treatment Unit.

2- Solar Powered

- Primarily impacted by the solar power system and energy-efficient components (solar-powered pumps).

3- Capacity and Flow Estimates

- **Design Period:** The STU is designed for a period of 20 years.
- **Population and Wastewater Flow:**
 - **Estimated population after 20 years:** 828 people.
 - **Estimated wastewater generation:** 89.5 m³/day, with an added contingency of 10%, bringing the total to 98.45 m³/day.
- **Flow Considerations:** The STU is designed to handle peak wastewater flow efficiently, with a maximum flow rate of 4.2 m³/hr during peak hours.



3.5- Flow estimation

Before designing the Sewage Treatment Unit (STU) for Basti Nai Abadi, Mondka, AGAHE conducted a detailed assessment to estimate the wastewater flow rate. This estimation was crucial for determining the STU’s capacity to manage the community’s sewage needs effectively. The process included analyzing the volume of wastewater generated daily, understanding the characteristics of the influent, evaluating the available land for the unit’s construction, and identifying potential applications for the treated water. This thorough groundwork ensured that the STU would be both efficient and tailored to the specific needs of the community, aligning with the principles of the Innovative WASH model.

The Estimated flow of wastewater is given below

Design Selection Criteria	Detail
Design Period	20 years
Estimated No of Households	80
Persons per Household	07
Estimated Population	560
Growth rate	1.98%
Population after 20 years	828
Currently Estimated Flow	75.6 m³/day
Estimated Flow After 20 yrs.	111.78 m³/day
Wastewater Generation Rate	80% of the estimated flow
Wastewater Generated	8.95 m³/day
Contingency of 10% in Generated Wastewater	8.95 m³/day
Total quantity of generated wastewater	98.45 m³/ day.

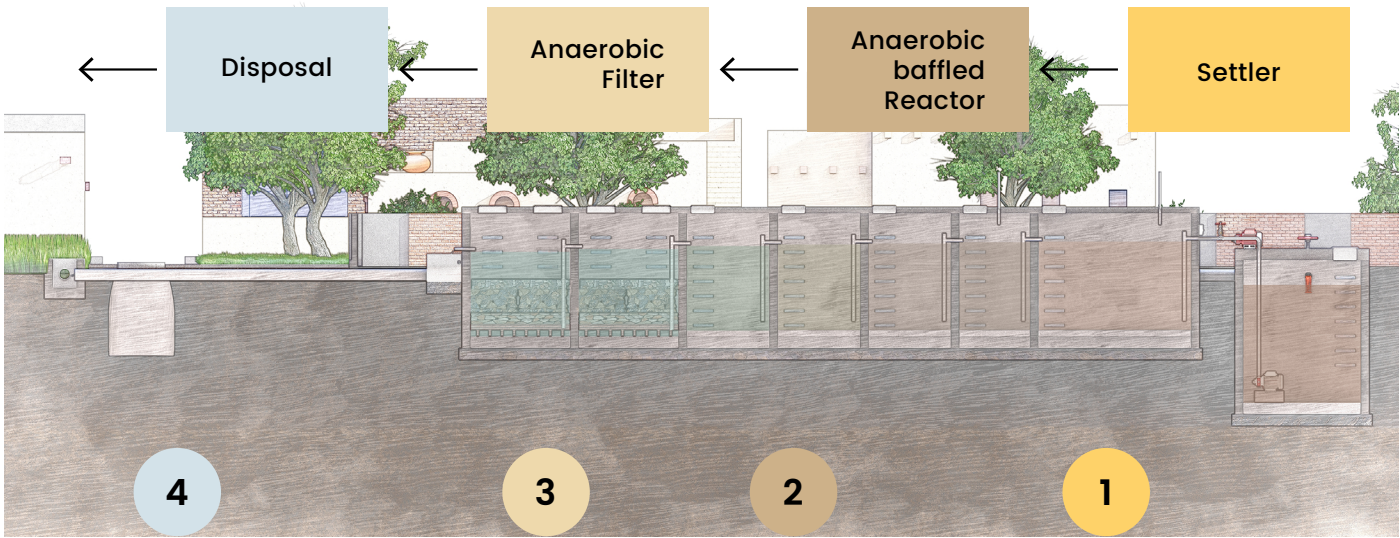
3.6- Phases of Sewerage treatment Unit and Designing Criteria

This STU treats wastewater via

- 1. Primary treatment (Settler)
- 2. Intermediate treatment (Anaerobic baffled Reactor)

3. Final Treatment (Anaerobic Filter)

The following Diagram will show the treatment mechanism



3.6.1- Primary treatment (Settler)

This settling tank has been included in the proposed STU for removing a substantial portion of suspended material which is primarily inorganic in nature. However, a small fraction of biodegradable settleable organic matter also gets removed with inorganic fraction. The conventional primary sedimentation tank normally removes about 60-70% of suspended solids and 20-30% of associated BOD.

Below are design considerations during the design of settler. The design criteria have been set considering both the consultant’s experience and data gathered from the book of DEWATS Decentralised Wastewater Treatment in Developing Countries by Sasse, L ,1998.

- A settler consists of a minimum of 2, sometimes 3 compartments. The compartment walls extend 15 cm above liquid level.
- The first compartment occupies about half the total volume because most of the sludge and scum accumulate here.
- The depth from outlet level to the bottom of settler may be between 1.50 and 2.50 m.
- The ventilation pipe for digestion gases should end outside buildings, at a minimum of 2 m above ground.
- For domestic sewage, the accumulating sludge volume should be calculated at 0.1 L/ cap/d.
- There should be manholes in the cover slab; one each above inlet and outlet and one at each partition wall, preferably at the inlet of each compartment. The manholes should be placed in such a manner to make the drawing of wastewater samples from each compartment possible.

- When removing the sludge, some immature (still active) sludge should be left inside to enable continuous decomposition of newly settled solids. This means, if the sludge is removed by pumping, the pump head should be brought down to the very bottom. It is not necessary to remove all the liquid. The sludge should be immediately treated further in drying beds or compost pits for pathogen control.

3.6.1.1 Design Criteria	
HRT	= 1.5 – 2 hrs.
De-sludging	= 1-year interval or 1-2 years
Sludge Production	= 0.1 l/c/d if de-sludging within 2 years
Sludge Production	= 0.08 l/c/d if de-sludging above 2 years
Sludge Production	= 0.005 l/g of BOD removed*3
Depth	= 1.5 – 2.5 m
Scum Layer	= 0.2 m
Length to Width	= 3:1 to 2:1
Length of 1 st Chamber	= 2/3 of total settler length (If 2 chambers) (SCBP, 2019)

3.6.1.2 Formula used during designing

max flow at peak hours (m3/hr)=(volume of wastewater (m3))/(time of most WW flow (hr))

COD/BODratio=(CODin (mg/l))/(BODin (mg/l))

COD removal rate (%)= (SS/CODratio)/(Surface Load (m3/m2)) x factor HRT

CODout (mg/l)=(1- COD removal rate (%)) x CODin (mg/l)

BOD out (mg/l)=(1-BOD5 removal rate (%)) x BOD5 in (mg/l)

"Sludge volume per BOD₅ removal" (l/gBOD₅) = factor sludge reduction (%) × sludge volume (TTR) (l/gBOD₅ removal)

"Sludge " reduction (g/m3) = BOD₅ in (g/m3) - BOD₅ out (g/m3)

"Sludge volume (m³) = Sludge volume " from BOD reduction (m3/m3) x wastewater flow (m3/d) x desludging intervals (months) x 30 (days)

water volume (m³) = HRT (h) x max flow at peak hours (m3/h)

min settler surface area (m2) = max flowpeak hours (m3/h) / surface loading (m3/m2)

volume of ST (m3) = sludge volume (m³) + water volume (m³)

required 1st chamber inner length (m)= (2/3 x volume of ST)/choser inner width x chosen water depth

area (m2) = width (m) x inner length (m)

actual volume of settler (m³) = area (m²) x water depth (m)

COD reduction (g/m3)=CODin(g/m3)-CODout(g/m3)

Primary Treatment



3.6.1.3 Designed Values

Wastewater Flow	=100 m3/day
Number of trains	=1
Inlet BOD	=260 mg/l
Inlet COD	=500 mg/l
TSS	=400 mg/l
SRT	=24 months
Free board	=0.75 m (2.5 ft)
Wetted Depth	=2.32 m (7.6 ft)
Max Flow Rate (Peak Hrs.)	=4.2 m3/hr.
COD/BOD ratio	=1.92
HRT in Settler	=2 hrs.
COD removal rate	= 0.47
Outlet COD	=266.7 mg/l
BOD5 removal rate	=0.49 %
Outlet BOD	=131.4 mg/l
Sludge volume	=29.2 m3
Water Volume	=8.4 m3
Minimum Settler Surface (m²)	=7 m2
Volume of ST	=38 m3
Inner Width	=2.75 m (9 ft)
1st Chamber Inner Length	=3.93 m (13 ft)
2nd Chamber Length	=1.96 m (6 ft)
Actual Area	=16.2 m2 (53 ft)
Actual Volume of Settler	=37.6 m3

3.6.2 – Intermediate Treatment (Anaerobic Baffled Reactor, ABR)

Anaerobic Baffled Reactor (ABR) offers mechanism for primary as well as secondary sedimentation through provision of compartments separated by baffles. Majority of solids are removed in the first chamber of ABR, sludge generation is low and SRT is high in comparison with Settler. Technology is very robust to the majority of shock loads. The system is ideal for decentralized wastewater treatment as it is easy to build and construct. Reduction in sludge biomass production due to anaerobic process, reduction in solids in the effluent due to major sedimentation in the settler as well as baffled chambers, effective anaerobic biodegradation in ABR, and most importantly low capital and operational cost as compared to aerobic processes are some reasons for the selection of ABR. Another major advantage is that such a system is best suited for semi-arid and tropical countries.

Below are design considerations for the design of ABR.

- The up-flow velocity of the baffled anaerobic tank should never be more than 1.2 m/h.
- The baffled anaerobic tank consists of a number of chambers (with four to eight chambers) in series.
- The organic load should be less than 3 kg COD/m³. d.
- The HRT of the ABR should not be less than 8 hours.
- Inoculation with old sludge from settler can achieve adequate treatment performance. In principle, it is advantageous to start with a quarter of the daily flow and if possible, with slightly stronger wastewater.
- The loading rate increases slowly over three months. This would give the bacteria enough time to multiply before suspended solids are washed out.

3.6.2.1 Design Criteria	
HRT	= 8-24 hrs.
OLR	<3 kg COD/m ³ /d
Chambers	= Min 4, Max 8
Up flow Velocity	<=1.2 m/hrs.
Desludging	= 2-3 years
Wetted Depth at outlet	=1.8 to 2.74 m
Sludge Volume	= 5-10% of Volume of ABR (SCBP, 2019)

3.6.2.2 Formula used during designing

The following are some of the formulae which were used during the designing of ABR: -

- Determine BOD_{in} and COD_{in} (outlet Anaerobic Settler)
- max flow at peak hours (m³/hr)=volume of wastewater (m³)/time of most WW flow (hr)
- Required max. lenght of chamber (m)=water depth at outlet (m) x 0.4 (lenght to height ratio)
- required min. width of chamber (m)=("max. peak flo" w(m³/hr))/ ("upflow velocit" y (m/hr)x lenght of chamber (m))
- "Actual up flow velocity" (m/hr)=("max. peak flo" w(m³/hr))/(actual lenght(m)x actual width (m))
Up-flow velocity should be less than 2 m/h.
- Just pick a number of chambers. Check!!! Minimum no. of chambers is 4 and maximum is 8!!!
- Actual volume of ABR (m3) = length (m) × width (m) × depth (m) × number of chambers
- Sludge volume (m³) = 5% × actual volume of ABR (m³)
- Water volume (m³) = actual volume of ABR (m³) – sludge volume (m³)
- "HRT (" hr) =("water volume of ABR" (m³))/ ("daily wastewater flow" (m³/d)) x 24 hr/1 d
- Check!!! HRT should be below 20 hrs. for an economically viable treatment!!!
- Prioritize actual up-flow velocity!!!
- If the HRT is less than 12 hours or more than 20 hours,
- then you need to refine and assume a new number of chambers.
- "BOD₅ removal rate (%) = (factor efficiency of BOD₅ removal to COD removal × COD removal rate (%))"
- BOD₅ out (mg/l)=(1-BOD₅ removal rate (%)) x BOD₅ in (mg/l)
- "Organic load BOD" (kg/m3 x day)=BODin (g/m³)x ("max peak flow per hour" (m³/hr))/ ("actual volume of ABR" (m)) x 24 hr/1 day x 1 kg/1000 g
- BODin<300 = factor = (BOD_{in}-150) *0.1/150 + 0.77
- Temp<20oC: factor = (temp-10) *0.39/20 + 0.47
- No. >3: factor = (no. -3) *0.06 + 0.9
- HRT <20 hrs.: factor = (HRT-10) *0.13/10 + 0.82
- "Total BOD_{removal rate} " (%)=1-(BOD_{out} (mg/l))/(BOD_{in} (mg/l))
- BOD₅ out (mg/l)=(1-BOD₅ removal rate by factor x BOD₅ in (mg/l)
- "BOD_{removal rate} by factor (%) = factor strengh × factor temperature × factor HRT × factor no. chambers" x factor organic load
- BOD_{rem} <0.5: factor = 1.06
- "Total COD_{removal Rate} (%) = " "Total BOD_{removal rate} " / ("Factor efficiency BOD removal to COD remova" l) " "
- COD_{outlet} =(1-total COD₅ removal rate) x COD_{in} (mg/l)

Intermediate Treatment (ABR)



3.6.2.3 Designed Values

Inlet BOD	= 131.4 mg/l
Inlet COD	= 266.7 mg/l
Length to Height Ratio	= 0.5 (Range 0.4 - 0.6)
Free Board	= Varies as per option 1 and 2
Wetted Depth	= 2.32 m (7.6 ft)
Up flow Velocity	= 1 m/hr. (Max. 2 but close to 1 is recommended)
Maximum flow at peak hours	4.2 m ³ /hr
Max Length of a Chamber	= 2.12 m (7 ft.)
Req. Mini Width of Chamber	= 0.66 m (2 ft.)
Actual up flow velocity	= 0.71 m/hr
Width of Settler	= 2.75 m (9 ft)
Area	= 5.83 m ²
Total Number of Chambers	= 03
Actual Volume of ABR	= 40.58 (m ³)
Sludge Volume	= 5% of Volume of Wastewater; 2.03 m ³
Water Volume	=Actual Volume – Sludge Volume = 38.55 m ³
HRT	= 9.2 hrs ~ 10 hr
Organic Loading Rate	= 0.66 kg of COD/m ³ /d < 2 kg of COD/ m ³ /d
Factor Strength (BOD _{rem} against strength)	= 0.72 BOD _{in} <150 = factor = (BOD _{in} *0.37/150 + 0.4
Factor Temperature (BOD _{rem} against temp)	= 0.97 (Temp < 25°C: factor = (temp - 20) * 0.14/5 + 0.86)
Factor of up flow chambers (BOD _{rem} against chambers)	= 0.9 (No. >3: factor = (no. -3) * 0.06 + 0.9)
Factor HRT (BOD _{rem} relative to HRT)	= 0.78 (HRT<10 hrs. factor = (HRT-5) * 0.325/5 + 0.5
Factor Organic Load (BOD Removal vs O. Load)	= 1 as per graph
BOD Removal Rate (%)	= 0.492
BOD _{out}	= 66.78 mg/l
Factor efficiency (BOD _{rem} rate by COD _{rem})	= 1.06 (BOD _{rem} <0.50: factor = 1.06)
COD Removal Rate (%)	= 0.464
COD _{out}	= 143 mg/l

3.6.3 – Final Treatment (Anaerobic Filter)

Anaerobic filter (AF) is a fixed-bed biological reactor with one or more filtration chambers in series. As wastewater flows through the filter, organic matter comes in contact with active biomass growing on the surface of the filter media. Anaerobic filters are widely used as secondary treatment in treating household black or grey water and improve the solids removal compared to septic tanks or anaerobic baffled reactors (ABRs) alone. Since AF work on the principle of anaerobic digestion, it has the capability to treat high strength wastewaters as well. High strength wastewater has been identified as a cause of early failure of on-site sewage disposal systems. High daily mass loading rate is a direct cause of drain field failure (Matejcek et al., 2000). Therefore, addition of AFs following ABRs is a promising alternative to the conventional septic tank for the treatment of domestic wastewater (black and grey water combined), particularly in the semi-urban and rural areas of the developing countries (Sharma et al., 2014).

Below are design considerations for the design of Anaerobic Filter.

- Filter material, such as gravel, rocks, cinder, or specially formed plastic pieces provide additional surface area for bacteria to settle.
- The fresh wastewater is forced to come in contact with active bacteria intensively. The larger the surface provided for bacterial growth, the quicker the digestion.
- Anaerobic filters may be operated as down flow or up flow systems. The up-flow system is normally preferred and used as the risk of washing out active bacteria is less in this case.
- An important design criterion of AF is that of equal distribution of wastewater upon the filter area. The baffles walls or pipes (bottom-up approach) ensure the direction of wastewater flow within the tank and force the wastewater to flow through the filter media in each of the chambers.

3.6.3.1 Design Criteria	
HRT	= 7-24 hrs.
OLR	= <4 kg BOD/m ³ /d
Filter Material	PVC Pipe Pieces, Cinder, Gravels, Granular Activated Carbon, Crushed Glass, cut pieces of corrugated pipes
Up flow Velocity	= Max. 2 m/hr.
Voids in Filter Mass	= 30 - 45%
Outlet Water Depth	= 1.8 – 2.2 m (SCBP, 2019)

3.6.3.2 Formula used during designing

The following are some of the formulae which were used during the designing of ABR: -

- Determine BOD_{in} and COD_{in} (outlet ABR)
- max flow at peak hours (m³/hr)=(volume of wastewater (m³))/(time of most WW flow (hr))
- Filter height (m) = depth of filter tank (m) - 0.6(m) - 0.4(m) - 0.05(m)
- Minimum number of chambers 1 or 2. Additional chambers can be added according to the requirement of outlet wastewater quality.
- HRT inside AF reactor = {depth of filter tank - [filter height x (1 - voids in filter mass)] x length x width x (number of filter tank / daily wastewater flow)}
- Check!!! As a standalone treatment, normal HRT in AF is 24 – 48 hrs!!!
- Max velocity in filter voids = max peak flow per hours / (width of the filter tank x voids in filter mass x length of each tank)
- Net volume of filter tank = Length of each tank x width of the filter tank x number of filter tank x {depth of filter tank - [filter height x (1 - voids in filter mass)]}
- "organic load of AF COD" (kg/m³ x day)=volume of wastewater (m³) x COD_{in} (g/l)/("net volume of filter tank " (m³)) x 1/1000
- temp<20: factor = (temp-10) * 0.39/20 + 0.47
- If COD_{in} range 121-466 and HRT 8-74 hrs then COD removal is 40%-90% (Hudson et. al., 1978)
- surface>=200 m²/m³: factor = 1.06
- HRT<12h: factor: HRT*0.16/12 + 0.44
- BOD_{rem} in relation to organic load graph
- Influence of number of up-flow chamber on COD removal graph
- "CODremoval rate (%) = factor strength x factor temperature x factor surface x factor HRT " "x factor chamber x factor organic loads "
- COD_{outlet}(mg/l)=(1-CODremoval rate x COD_{in} (mg/l)
- BOD_{rem} <0.5: factor = 1.06
- "BOD_{rem} Rate = " CODremoval rate x "factor efficiency BOD removal to COD remova" l" "
- BOD_{outlet} =(1-BODremoval rate) x BOD_{in} (mg/l)



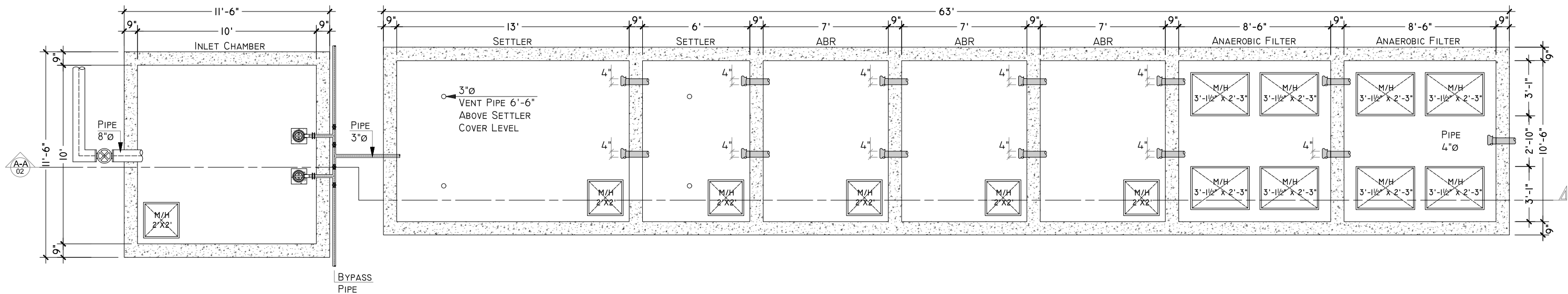
Sr. No.	Items	Specifications
1.	Settling Tank	
	HRT	2 hours
	Quantity	1 Nos. per Train (Total two settlers)
	Settler MOC	Concrete
	Chambers	2 Chambers
	Dimensions (L*W*D)	19*9*10.5 ft.
	Length of 1st Chamber	13 ft.
	Length of 2nd Chamber	6 ft.
	Total Volume	1796 ft ³
	Total No. of Manholes	02
2.	Anaerobic Baffled Reactor (ABR)	
	HRT	2 hours
	Quantity	1 Nos. per Train (Total two settlers)
	ABR MOC	Concrete
	Number of Chambers	2 Chambers
	Dimensions (L*W*D)	19*9*10.5 ft.
	Total Volume	13 ft.
	Drop from settler	6 ft.
	Drop within chambers	1796 ft ³
	Total No. of Manholes	02
	Organic Loading Rate	1.71 kg of COD/m ³ /d < 3 kg of COD/ m ³ /d
3.	Anaerobic Filter (AF)	
	HRT	2 hours
	Quantity	1 Nos. per Train (Total two settlers)
	AF MOC	Concrete
	Number of Chambers	2 Chambers
	Dimensions (L*W*D)	19*9*10.5 ft.

Final Treatment

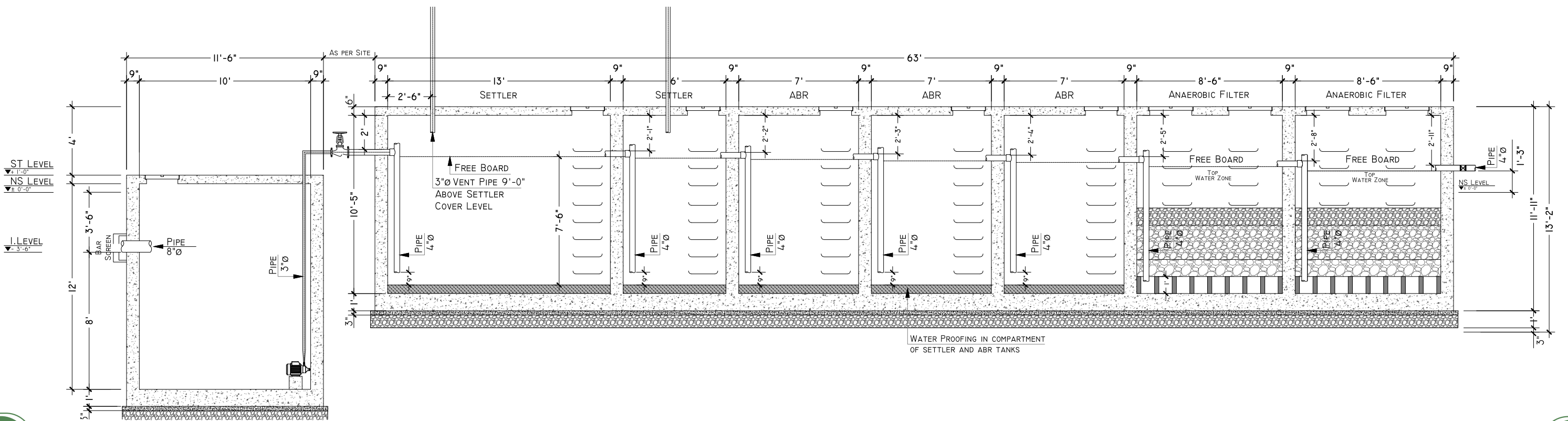


3.6.4 – Drawings of Sewage Treatment Unit:

Plan View of STU



Section View of STU



3.7- Development of BOQ, s & Construction

For the development of the Bill of Quantities (BOQ) for the construction of the Sewerage Treatment Unit (STU), along with its boundary wall and the associated electrical, mechanical, and plumbing works, all calculations were carried out in accordance with the approved design specifications.

The estimation process began with the calculation of the required quantities for the structural components of the STU. This included the measurement of AASHTO sub-base material, reinforced cement concrete (RCC) walls, the foundation, and the slab, ensuring that each element met the necessary design and strength requirements.

Following the structural calculations, the mechanical components were assessed. These included submersible sludge pumps, heavy-duty valves, and UPVC pressure pipes of 3-inch and 4-inch diameters, all of which were determined based on the system’s operational needs and design specifications.

Additionally, for security and protection, a boundary wall was constructed around the STU. This wall serves to safeguard the unit from unauthorized access and external environmental factors, ensuring the efficient and uninterrupted operation of the sewerage treatment facility. Here is the Work Done Summary of cost.

Sr.No	Description of Work	Cost in PKR	Remarks
1	Construction of Inlet Chamber, Settler Tank, ABR Chambers, AF Chambers	9,048,902	
2	Electrical, Mechanical & Plumbing Work		
3	Construction of Boundary Wall.		

3.8- Post Test of Treated Water

The test report for the wastewater effluent from the Sewage Treatment Unit (STU) confirms that the treated water meets the National Environmental Quality Standards (NEQS) for key parameters, including Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), and Total Suspended Solids (TSS). PCRWR report analysis of effluent samples indicates that COD and BOD levels have been effectively reduced to within permissible limits, ensuring minimal organic pollution and improved water quality. Additionally, the TSS concentration is well within the NEQS threshold, signifying efficient solid removal and proper treatment performance. These results demonstrate the effectiveness of the STU in treating wastewater to environmentally safe standards before discharge.



PAKISTAN COUNCIL OF RESEARCH IN WATER RESOURCES

Ministry of Water Resources, Government of Pakistan

Regional Office: 6.4 Km, Main Raiwind Road, Lahore Tel & Fax 042-35320484

www.pcrwr.gov.pk

WATER QUALITY TEST REPORT

Client Name	Mr. Muhammad Iftekhar		
Address	-----		
Sample Provided/Collected By:	Client	Sample Collection Date	07-10-2024
Sample Source	Sewarge Treatment Unit	Sample Receiving Date	08-10-2024
Client Code	Basti Mondka Muzaffargarh	Reporting Date	16-10-2024
Temperature of Lab °C	23-26°	Sample Code	Ref-1346-24

WASTE WATER ANALYSIS

Sr. #	Water Quality Parameter	Units	Det. Limit	Reference Method	PEQS Permissible Limits (2016)	Results
1.	Total Suspended Solids (TSS)	mg/l	1.0	APHA, 22 nd Edition	200	12
2.	Chemical Oxygen Demand (COD)	mg/l	2.0	APHA, 22 nd Edition	150	72
3.	Biological Oxygen Demand (BOD)	mg/l	3.0	APHA, 22 nd Edition	80	48

NGVS: No Guideline Value Set WHO: World Health Organization APHA: American Public Health Association, BDL: Below Detection Limit, QC: Quality Control CSS: Customer Service Section,

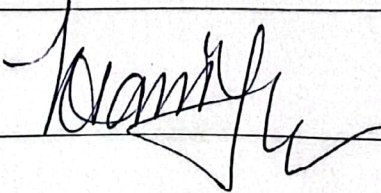
Interpretation

Quality of Water	Safe ☒	Unsafe ☐
Remarks (if any)	Sample is found Safe for the tested parameters.	

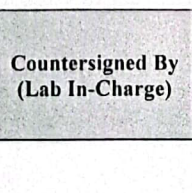
Terms & Conditions:

- Test results in this report relate only to the test sample submitted and tested.
- In case the sample is collected by client, the responsibility of sample’s integrity lies with the client/customer.
- The test report shall not be reproduced except in full, without written approval of RWQL-24PCRWR
- Waste water quality parameters exceeding the PEQS Guideline values are highlighted.
- The contents of this report cannot be, in any manner, used for the publicity of the product or any advertisement.

Prepared by



Countersigned By (Lab In-Charge)





Chapter 04.

Operation & Maintenance Arrangements & Sustainability Plan

4.1 – Operation & Maintenance Arrangements

4.1.1- Formation of O & M Committee & Selection of Caretaker

For Smooth operation & maintenance an Operations and Maintenance (O&M) committee formed, and this committee selected a caretaker for the sewerage system in Basti Nai Abadi Mondka. This caretaker is responsible for the daily upkeep and smooth operation of the system. The goal is to ensure the sewerage system remains functional and benefits the community. Regular maintenance by the caretaker will help prevent blockages and other issues.

4.1.2- Tariff Collection

A structured tariff collection system has been set up to support the ongoing maintenance and operational costs of the sewerage system, ensuring its financial sustainability. The main purpose of this tariff collection is to ensure availability of funds for emergency repair, desludging, and any other emergency need regarding operating of the system.

4.1.3- Development of Sustainability Plan

A detailed sustainability plan was developed to support long-term viability. This plan includes contingency measures, financial planning, and technical support to ensure the STU can serve the community for years to come.

4.1.4- O&M Training

An onsite operation & Maintenance training session was held for the community board organization and the caretaker to teach them how to operate and maintain the sewerage treatment unit (STU) and sewer lines. This session covered essential skills needed for daily management, basic repairs, and troubleshooting of the system. Participants learned how to keep the STU and sewer lines in good working condition, which will help prevent breakdowns and ensure smooth operation. This training empowers the community to take responsibility for the STU, making it less dependent on government institutes. By gaining these skills, the community can keep the system sustainable, functional, and beneficial.



4.2- Operations & Maintenance

A maintenance program ensures the continued efficient operation of the treatment plant and prolongs the life of the plant’s equipment. STU is simple technology that offers biological treatment of wastewater without any complex process and mechanical equipment. The treatment performance of a STU can be enhanced by regular maintenance of STU trains.

General maintenance schedules include overall maintenance of the whole system, as illustrated below:

- 01

Maintenance requirements and maintenance frequency for STU are based on the recommendations of the operational personnel. However, a few components have a specific maintenance period which is defined in the later sections and maintenance personnel is also responsible for the planning and scheduling of maintenance.
- 02

Indoor and outdoor maintenance should be scheduled to take advantage of favorable weather, low load, and low flow periods.
- 03

Maintenance of STU is done after a period of one year sequentially for the two trains, i.e. operation of one train continues while the maintenance of the other. This shall avoid the complete shutdown of the plant.
- 04

Maintenance of each train is carried out by closing the valve of that respective train and diverting the excess flow into the bypass channel.
- 05

As mentioned in earlier sections the inlet and outlet pipes of all modules should be inspected monthly to prevent overflow/backflow into the treatment units.
- 06

Lubrication of gate valves is a major component during maintenance.
- 07

Maintenance personnel should be properly trained before performing inspections, repairs, or preventive maintenance tasks.
- 08

Tools and repair equipment should be inspected and inventoried routinely to ensure their working status, availability, accessibility, and safety.
- 09

A list of outside maintenance firms should be established to conduct minor and major construction jobs from outside.

Maintenance of Settling Tank & ABR

Maintenance schedules of settler and ABR units are summarized below:

- For the settling tank, de-sludging should be carried out after one year.
- For ABR unit de-sludging should be done after two years.
- While desludging from settling tank and ABR units, some sludge should be left inside the system for the continuation of biological removal mechanisms.
- Maintenance and lubrication of piping is required in annual maintenance or in case of any problem during operation.

Maintenance of Anaerobic Filter

Maintenance schedules of settler and ABR units are summarized below:

- Filter media (UPVC corrugated pipes) shall be cleaned after operation of one year. However, their replacement is suggested after five years.
- During the cleaning of filter media, the unbolting of wire mesh shall be done.
- The gravel filter media can be changed depending upon its situation. Operational personnel are responsible for deciding the changing of gravel.
- The pre-cast slabs are removed during the cleaning of filter media with the help of an anchoring Crain which needs to be hired during the maintenance.
- Maintenance and lubrication of piping is required in annual maintenance or in case of any problem during operation.



Maintenance of Sludge Drying Bed & Sludge Management

Sludge management of settling tank and ABR units are summarized below:

- Dry prime (Negative suction) Portable Pump is used to decant the sludge.
- Pumps operate on negative suction principle and is used for desludging purpose.
- The decanted sludge is discharged into the sludge drying bed through 6-inch HDPE pipe.
- The same pipe is used to discharge the produced leachate back to the settling tank.
- The sludge shall remain in the sludge drying bed for a period of six months until completely dried.
- The dried sludge is then collected in bags with the help of spade and can be used as fertilizer for horticulture purposes.
- Inspection of pipes associated with sludge drying bed is the responsibility of operation personnel during its operations.

Maintenance Checklist

Sr. No.	ITEMS	REMARKS		
1.	Settling Tank			
	Sludge removal after one year	☐ Yes	☐ No	☐ N.A.
	Pipe Maintenance	☐ Yes	☐ No	☐ N.A.
2.	Anaerobic Baffled Reactor			
	Sludge removal after one year	☐ Yes	☐ No	☐ N.A.
	Pipe Maintenance	☐ Yes	☐ No	☐ N.A.
3.	Anaerobic Filter			
	Cleaning of filter media	☐ Yes	☐ No	☐ N.A.
	Replacement of filter media	☐ Yes	☐ No	☐ N.A.
	Cleaning / replacement of wire mesh	☐ Yes	☐ No	☐ N.A.
	Pipe Maintenance	☐ Yes	☐ No	☐ N.A.
4.	Effluent Tank			
	Pipe Maintenance	☐ Checked	☐ Not Checked	☐ N.A.

Solar System

Primary Treatment
(Settler)

Secondary Treatment
(Anaerobic Baffled
Reactor, ABR)

Final Treatment
(Anaerobic Filter)

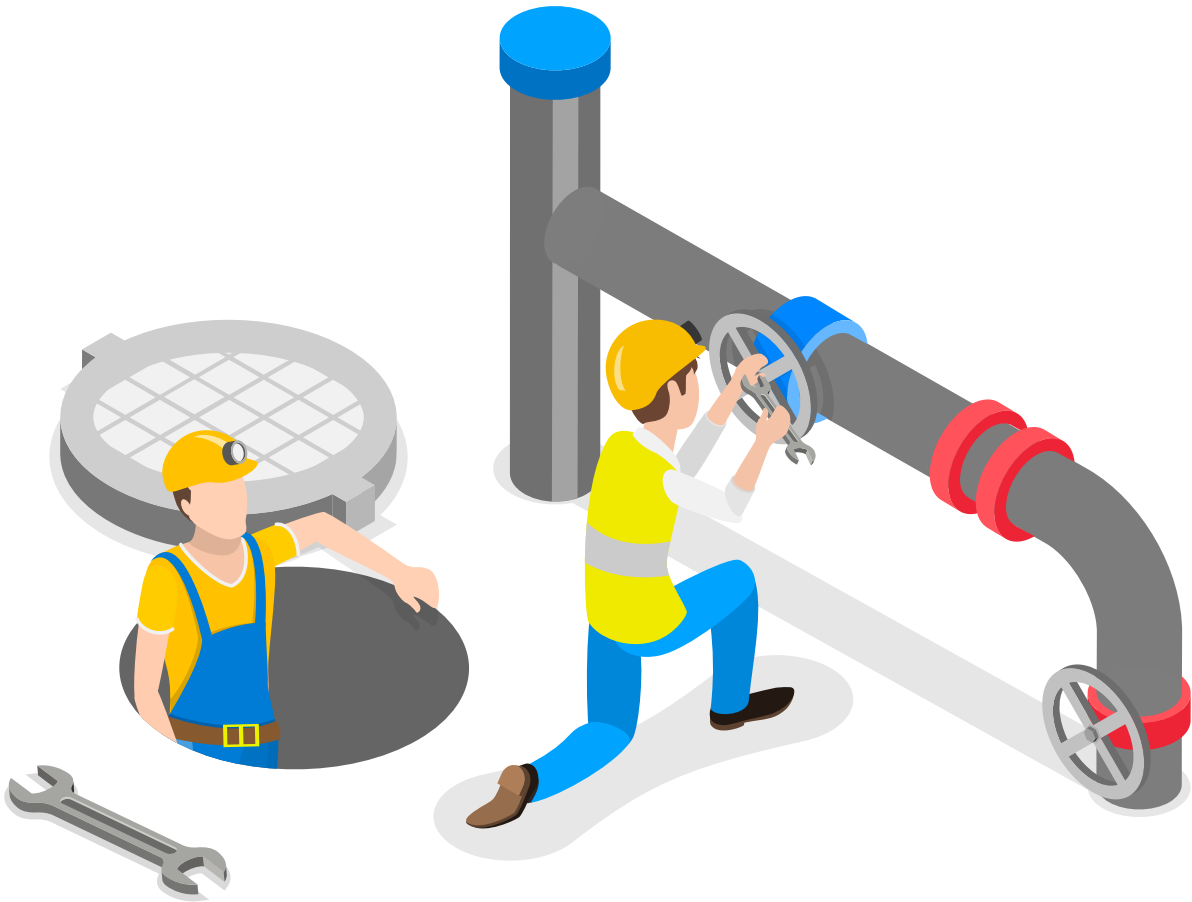
Sewer Pipe
Network and Man

Troubleshooting

Wastewater treatment plants can function improperly for a variety of reasons; plant some time receive material that are not designed to handle, and some facilities are poorly specified, designed, constructed, operated and / or maintained. Similarly, STU due to aforementioned can face various issues that result in improper working, therefore, there is a need to develop a troubleshooting mechanism to avoid such malfunctions.

4.2.1- Troubleshooting Performa

Observations	Possible Explanation	Possible Explanation
Clogging of pipes	As the setup shall run on real domestic wastewater and in natural conditions, it will face clogging	Continuous inspection as mentioned in record list
Elevated suspended solids levels in effluent	• Too short settling time • Filamentous bacteria	Check correct phase operation Check SVI with design basis
low VFA / Alkalinity Ratio	• Due to anaerobic digestion	Increase the pH by adding either a caustic solution or a buffer solution to increase the alkalinity



Operational Records & Checklist

Purpose

An important factor in any efficient wastewater treatment system is the maintenance of accurate operational records. Without a record of past operational performance, it is impossible to identify trends in the process. Operating cost records are essential if meaningful budgets are to be prepared. Accurate records permit plant operating personnel and management to maintain proper control of the WWTP. Similarly, checklist play an important role during the consistent operation of STU.

4.2.2- Operational Checklist

Sr. No.	ITEMS	REMARKS
1. Settling Tank		
	Pipes are working properly	☐ Checked ☐ Not Checked ☐ N.A.
	Volume in depth is normal	☐ Checked ☐ Not Checked ☐ N.A.
	Sludge volume in depth is normal	☐ Checked ☐ Not Checked ☐ N.A.
2. Anaerobic Baffled Reactor		
	Pipes are working properly	☐ Checked ☐ Not Checked ☐ N.A.
	Volume in depth is normal	☐ Checked ☐ Not Checked ☐ N.A.
	Sludge volume in depth is normal	☐ Checked ☐ Not Checked ☐ N.A.
3. Anaerobic Filter		
	Pipes are working properly	☐ Checked ☐ Not Checked ☐ N.A.
	Volume in depth is normal	☐ Checked ☐ Not Checked ☐ N.A.
	Sludge volume in depth is normal	☐ Checked ☐ Not Checked ☐ N.A.
	Any ambiguity related to filter media	☐ Checked ☐ Not Checked ☐ N.A.
4. Effluent Tank		
	Pipes are working properly (including overflow pipe)	☐ Checked ☐ Not Checked ☐ N.A.
	Volume in depth is normal	☐ Checked ☐ Not Checked ☐ N.A.



Operational & Maintenance Checklists and Record Performa

Sr. No.	ITEMS	REMARKS		
1.	Settling Tank			
	Sludge removal after one year	☐ Yes	☐ No	☐ N.A.
	Pipe Maintenance	☐ Yes	☐ No	☐ N.A.
2.	Anaerobic Baffled Reactor			
	Sludge removal after one year	☐ Yes	☐ No	☐ N.A.
	Pipe Maintenance	☐ Yes	☐ No	☐ N.A.
3.	Anaerobic Filter			
	Cleaning of filter media	☐ Yes	☐ No	☐ N.A.
	Replacement of filter media	☐ Yes	☐ No	☐ N.A.
	Cleaning / replacement of wire mesh	☐ Yes	☐ No	☐ N.A.
	Pipe Maintenance	☐ Yes	☐ No	☐ N.A.
4.	Effluent Tank			
	Pipe Maintenance	☐ Checked	☐ Not Checked	☐ N.A.



LIST OF STU Chambers (Tanks) & EQUIPMENTS

The following is the detailed list of civil tanks and equipment envisaged for the project.

STU Chambers or Tank Details

Sr. No.	Items	Specifications
1.	Settling Tank	
	HRT	2 hours
	Quantity	1 Nos. per Train (Total two settlers)
	Settler MOC	Concrete
	Chambers	2 Chambers
	Dimensions (L*W*D)	19*9*10.5 ft.
	Length of 1st Chamber	13 ft.
	Length of 2nd Chamber	6 ft.
	Total Volume	1796 ft ³
	Total No. of Manholes	02
2.	Anaerobic Baffled Reactor (ABR)	
	HRT	2 hours
	Quantity	1 Nos. per Train (Total two settlers)
	ABR MOC	Concrete
	Number of Chambers	2 Chambers
	Dimensions (L*W*D)	19*9*10.5 ft.
	Total Volume	13 ft.
	Drop from settler	6 ft.
	Drop within chambers	1796 ft ³
	Total No. of Manholes	02
	Organic Loading Rate	1.71 kg of COD/m ³ /d < 3 kg of COD/ m ³ /d
3.	Anaerobic Filter (AF)	
	HRT	7 Hours
	Quantity	02 Nos. per Train (Total two AF)
	AF MOC	Concrete. SS mesh 304 grade.
	Number of Chambers	2 Chambers
	Dimensions (L*W*D)	17*9*10.5 ft.
	Total Volume	1606.5 ft ³
	Drop from ABR	6-inch drop in depth from settler
	Drop within chambers	4 inches (for gravity flow)
	Organic Loading Rate	1.125 kg of COD/m ³ /d < 3 kg of COD/ m ³ /d
	Up flow velocity	1m/hrs. < 2 m/hrs.

Mechanical Equipment Details

Sr. No.	Items	Specifications
1.	Settling Tank	
	Inlet Pipe	UPVC 3 inch
	Outlet Pipe	UPVC 4 inch
	Internal Pipes	UPVC 4 inch
	Ventilation Pipes	UPVC 4 inch – 7 ft. height
2.	Anaerobic Baffled Reactor (ABR)	
	Inlet Pipe	UPVC 4 inch
	Outlet Pipe	UPVC 4 inch
	Internal Pipes	UPVC 4 inch
3.	Anaerobic Filter (AF)	
	Inlet Pipe	UPVC 4 inch
	Outlet Pipe	UPVC 4 inch
	Internal Pipes	UPVC 4 inch
	Filter Media Type 1	Gravels 4 inch thickness with 1 ft depth..
	Filter Media Type 2	Gravel 2 inch thickness with 2 ft depth.
	Filter Media Type 3	Gravel 1 inch to .5 inch thick with depth 1 ft.



List of Parameters & Sampling Schedule					
Test	Sample Type	Sampling Point	Frequency	Test Location	Recommended Test Method
Chemical Oxygen Demand (COD)	24-Hour Grab Sample	•Plant Influent •Plant Effluent •Settler Tank •ABR Tank •AF Tank	2 Days / Month	Wastewater Laboratory	Close Reflux Method as per (APHA 2017)
Biological Oxygen Demand (BOD ₅)	24-Hour Grab Sample	•Plant Influent •Plant Effluent •Settler Tank •ABR Tank •AF Tank	2 Days / Month	Wastewater Laboratory	5-day BOD Test (APHA 2017)
Total Suspended Solids (TSS) Volatile Suspended Solids (VSS)	24-Hour Grab Sample	•Plant Influent •Plant Effluent •Settler Tank •ABR Tank	2 Days / Month	Wastewater Laboratory	Filtration Evaporation Method (APHA 2017)
Chemical Oxygen Demand (COD)	24-Hour Grab Sample	•Plant Influent •Plant Effluent	2 Days / Month	Wastewater Laboratory	pH Meter

- Note:**
- Samples must be collected through a manual sampler
 - Samples must be transported to the laboratory within 12 hours of collection
 - Samples must be stored in a refrigerator at 4°C before testing



Chapter 05.

Sustainability Plan

5.1 – Sustainability Plan

A sustainability plan for a safely managed sanitation model ensures that the system runs smoothly for a long time without financial problems. It includes strategies to generate and manage funds for regular maintenance, repairs, and system upgrades. The main sources of revenue are user fees and community contributions, which help keep the service running. To reduce unexpected costs, the plan focuses on cost-effective solutions like preventive maintenance and efficient use of resources.

The AGAHE team and committee calculate expenses on a monthly, bi-annual, annual, and two-year basis. They then determine the average monthly cost to set a fixed household fee, ensuring that operation and maintenance expenses are covered.

Sr. No.	Description	Frequency	Expense	Monthly Expenses (PKR)
1.	Regular Inspection of Sewer line	Monthly	3000	3000
2.	Desludging of Inlet Chamber	After 06 months	6000	1000
3.	Desludging of Settler	After 12 months	15000	1250
4.	Desludging of ABR & AF Chambers	After 24 Months	36000	1500
5.	Washing of Filter Media	After 12 Months	12000	1000
6.	Replacement of Batteries	After 24 months	100,000	4166
7.	Repairing of Pumps	After 12 Months	10,000	833
8.	Replacement of Filter Media	After 24 months	20,000	833
9.	Total			13582/-

Total Benefitted Household= 84 Numbers.

Monthly Fee per household= 165 Rupees.

5.1.1. Formation of O & M Committee

In Basti Nai Abadi Mondka, an Operation & Maintenance (O&M) Committee has been formed to ensure the efficient management of the sewerage system and Sewage Treatment Unit (STU). The committee comprises local community members, representatives from the Community-Based Organization (CBO), and technical operators.

Responsibilities of Operation & Maintenance Committee:

1. The Maintenance and Repair Committee will hold a monthly meeting to discuss the performance and improvement of the Sewage Treatment Unit to ensure its efficiency and sustainability.
2. The committee will conduct regular visits to the Sewage Treatment Unit twice a week.
3. The committee will conduct sessions in the community to raise awareness about sustainability, maintenance, and repair.
4. If there is any issue regarding the sustainability or functionality of the Sewage Treatment Unit, the committee will inform the members of the village’s local organization.
5. The committee will be responsible for appointing a supervisor to maintain the Sewage Treatment Unit.
6. The committee will ensure proper planning for maintaining cleanliness in and around the Sewage Treatment Unit.
7. The committee will participate in programs related to the Sewage Treatment Unit.
8. The committee will ensure that the Sewage Treatment Unit operates efficiently on a daily basis.
9. The committee will be accountable to the members of the village’s local organization.
10. The committee will be fully responsible for repairing any broken pipes or damages related to the Sewage Treatment Unit.
11. The committee will be responsible for replacing the filter media every three years to maintain the efficiency of the Sewage Treatment Unit.
12. The committee will keep records of service charges, expenses, and savings and will secure the saved amount to be used for major or emergency repairs to keep the unit operational.
13. The Sewage Treatment Unit will be indirectly owned by the local community members. However, the village’s local organization and the awareness institution will retain direct rights concerning its operation and maintenance.

Tariff Collection Mechanism

Details of Users	
Total Households	83
Details of Expenses	
Desludging cost after two years	Rs. 50,000
Filter media replacement cost after three years	Rs. 20,000
Bacteria replacement cost after two years	Rs. 130,000
Total Expenses	Rs. 200,000

6- Appendix

Definition of Terms

Anaerobic

Conditions in which no oxygen (free or combined) is available. Also used to describe organisms, biological activity or treatment processes which function in the absence of oxygen.

Biochemical Oxygen Demand

BOD is used to determine the oxygen required to biologically stabilize the organic matter present in wastewater. It is the principal measurement to determine the strength, in terms of oxygen required, of municipal wastewater.

Biological Nutrient Removal

The removal of nitrogen and/or phosphorous from wastewater using biological methods of treatment.

Chemical Oxygen Demand (COD)

COD provides a measure of the oxygen equivalent of that portion of the organic matter that is susceptible to oxidation by a strong chemical oxidant. The COD value is greater than the BOD5 value because more organic substances can be chemically oxidized than biologically oxidized. For many types of waste, the BOD5 and COD results can be correlated.

Denitrification

A biological process by which nitrate is converted to nitrogen gas.

Detention Time

The theoretical time required to displace the contents of a tank or unit at a given rate of discharge.

Dewatering Sludge

The process of removing a part of the water in sludge by any method.

Digested Sludge

Sludge digested under anaerobic conditions until the volatile content has been substantially reduced.

Digestion

Digestion is the decomposition or degradation of biodegradable organic material, in the absence of oxygen (anaerobic digestion). This degradation is carried out by the bacteria and other microscopic organisms present. The complex organic compounds making up organic waste materials are converted to simpler, more stable forms of matter.

Effluent

The flow leaving a tank, channel, or treatment process.

Influent

The wastewater entering a tank, channel, or treatment process.

Microorganisms

Minute organisms, either plant or animal, invisible or barely visible to the naked eye. Among the microorganisms at an active sludge plant are bacteria, protozoa, and rotifers.

Mixed Liquor

A mixture of sludge and sewage in the settler and Anaerobic Baffled Reactor Tank and undergoing

activated sludge treatment.

Sampler

A device used with or without flow measurement to obtain an aliquot portion of water or waste for analytical purposes. May be designed for taking single sample (grab), composite sample, continuous sample, or periodic sample.

Sanitary Sewer

A sewer that carries liquid and water-carried waste from domestic & commercial sources towards the treatment plant.

Screening

The removal of relatively coarse floating and suspended solids by straining through racks or screens.

Sewage

The water spent by a community. This term is now being replaced in technical usage by the preferable term wastewater.

Sludge

The settle-able solids separated from liquids during the treatment process.

Sludge Volume Index

Properly called sludge volume index (SVI). It is the volume in millimeters occupied by 1 g of activated sludge after setting off the aerated liquid for 30 minutes.

Standard Method

Methods for the examination of water and wastewater published jointly by the American Public Health Association. The American Water Works Association and the Water Pollution Control Federation.

Supernatant

Liquid removed from settled sludge.

Storm Sewer

A sewer that carries storm water and surface water, street wash and other wash waters, or drainage, but excludes domestic wastewater and industrial wastes.

Suspended Solids

Suspended solids are those solids, which can be filtered from a water sample. The suspended solids concentration also includes the settleable solids.

Total Solids

Total solids include suspended solids, settleable solids, and dissolved solids.

Turbidity

The turbidity of water indicates the number of suspended solids in the water that interfere with the passage of light through the water. Measuring the turbidity of the effluent indicates the efficiency of the settling process.

Volatile Solids

Volatile solids describe the inorganic compounds in the total solids. Only inorganic compounds remain after the solids are fired at 600o C. The term “volatile” can be applied to suspended as well as total solids. Volatile solids are usually expressed in mg/l of volatile solids.

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Clean water and sanitation are essential to human development.

— *Ban Ki-moon, Former Secretary-General of the United Nations*

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The importance of sanitation as a human right and a key driver of public health and economic development cannot be overstated.

— *UNICEF*

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Access to clean water and sanitation is a fundamental human right and essential for sustainable development.

— *World Health Organization (WHO)*

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Water and sanitation are at the core of sustainable development and are critical for poverty reduction, health, and environmental protection.

— *United Nations Development Programme (UNDP)*

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Ensuring universal access to safe drinking water and sanitation by 2030 requires concerted efforts from governments, civil society, and the private sector.

— *World Health Organization (WHO)*

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Access to safe drinking water is a fundamental human need and, therefore, a basic human right.

— *UN Committee on Economic, Social and Cultural Rights*

Thank You

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