Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Funded by -

CONTENTS

ACRONYMS

ABR	Anaerobic Baffled Reactor
ADS	Anaerobic Digester System
AF	Anaerobic Filter
BDT	Bangladeshi Taka
BOD	Biochemical Oxygen Demand
Capex	Capital Expenditure
COD	Chemical Oxygen Demand
CxB	Cox's Bazaar
CW	Constructed Wetland
DEWAT	Decentralised Wastewater Treatment System
DPHE	Department of Public Health Engineering
DOE	Department of Environment
FE	Final Effluent
FS	Faecal Sludge
FSM	Faecal Sludge Management
FSTP	Faecal Sludge Treatment Plant
Iccrdb	International Centre for Diarrhoeal Disease Research, Bangladesh
IFRC	International Federation of Red Cross and Red Crescent Societies (IFRC)
IFSTN	Intermediate Faecal Sludge Transfer Network
IOM	International Organization for Migration
LSP	Lime Stabilisation Ponds
M&E	Monitoring and Evaluation
O&M	Operation and Maintenance
Opex	Operational Expenditure
PFD	Process Flow Diagram
SS	Suspended Solids
SSU	Solid Separation Unit
TS	Total Solids
TSS	Total Suspended Solids
TWiG	Technical Working Group
UFF	Upflow Filters
WASH	Water, Sanitation and Hygiene
WLC	Whole Life Cost
WSP	Waste Stabilisation Ponds
WVI	World Vision International

EXECUTIVE SUMMARY

OBJECTIVES

On behalf of Oxfam GB and the CxB WASH sector, Arup have conducted this Technical Assessment study of different Faecal Sludge Management (FSM) methods in the Rohingya camps in Cox's Bazar (CxB), Bangladesh. This is a phase 2 study, following completion of phase 1 in 2019.

This phase of the study builds on existing FSM technical information and monitoring and evaluation (collected by others since 2019), broadens to include whole FSM chain, wider range of stakeholders and camp areas covered and focuses on current challenges of sustainability and environmental impact, space requirements and costs. The WASH sector will use findings of this study to inform development of a (longer term) FSM Strategy for the camps. To this end, this study aims to provide a technical assessment to answer the following questions, where costs and operational robustness are the key criteria:

1. Does the FSM chain meet the need? i.e., does each stage in the FSM chain have capacity to manage the sludge generated, what are the bottlenecks and inefficiencies, and how can these be addressed?
2. Which type of FSTP is performing best against most assessment parameters? This should include reasoning for improving or decommissioning FSTPs.
3. Which mode of FS transfer/transport is most cost effective and resilient?
4. Does the containment type influence the sludge chain, and which containment is best?
5. Is the centralised or decentralised approach of FSM more cost effective and sustainable?

METHOD

A core team of FSM experts was formed from the CxB WASH sector group, to guide and support the project. Arup, Oxfam, and the core team identified a wider stakeholder group (eight NGOs operating FSM in the camps) to include in the study and to provide the evidence/data for analysis and FSTPs to visit. Review meetings where also held with DPHE and other technical experts when appropriate.

A series of 'camp wide' and 'detailed field' assessments were completed to draw conclusions on the whole FSM chain and inform the discussion on centralised and decentralised FSM systems. Camp wide assessments are based on existing data provided by the sector and stakeholder data collected on operational cost and performance of containment, desludge and transfer. The FSTP assessments are based on the field visits covering 20 FSTPs and eight technology types, conducted during this study by technical partner Oxfam Bangladesh. The FSTPs types[1] were compared against a set of indicators to summarise performance, including: cost; footprint area; speed of construction and commissioning/decommissioning; operation and maintenance issues; pathogen inactivation and environmental impact.

In many cases the existing or collected datasets are limited e.g. do not cover the whole camp area or all parameters required, some assumptions and extrapolation of data has been undertaken. The findings from the report should therefore be treated as provisional and relevant to the particular context in CxB.

FINDINGS

The camp wide review of desludge and transport data gave an approximate 'total volume of sludge generation (at point of desludging)' and the wet season variation, this was extrapolated to give an estimation of 1.1 l/h/d and a total monthly production of 29,718m^3 of FS. Wet season impact resulted in approximately 26% more volume generated (at point of desludging).

The analysis of the containment systems showed a wide range of latrines are used and the current dataset records many more types than the sectors 'Unified Standard Design for Latrines'. Latrines are desludged more often either because of insufficient capacity for the number of users, mixed use (black and grey water), operational defects and/or poor infiltration.

Analysis of the transport and transfer systems showed that IFSTN (permanent pipe networks) have a lower cost to operate and can transport increased volumes of sludge throughout the year. Their construction comes with an initial higher Capex but (based on available data) this investment can pay off within nine years when compared against other transport modes. The FS volume in transit during the wet season was noted as impacted by: poor access conditions to desludge and/or transfer, limited infiltration capacity (hence treatment capacity) at the receiving FSTP, and accessibility or overflowing of latrines in low land/flood prone areas.

(1) Lime, Anaerobic lagoons (centralised), Aerobic treatment (aeration), Biological multi-stage (central), Anaerobic baffled reactor (ABR). Waste Stabilisation Ponds (WSP), Anaerobic Digester System (ADS), Upflow filters (UFF) and Decentralised Wastewater Treatment System (DEWATs)

Review of camp wide treatment performance data and the detailed review of parameters for the 20 FSTPs visited, showed that generally the centralised plants were operating well and had the lowest overall cost for the volume treated. The WASH sector infrastructure data (2021) set shows the total FSTP daily treatment capacity of 879m^3 across the camps. For a population in RCs of 904,639 and a sludge generation rate of 1.1 l/h/day we get a daily sludge production of 995m^3. It is fair to consider that there is some sludge retention in the camps' latrines and tanks, and that some people might still practice open defecation, so this slightly lower treatment capacity might accommodate for the sludge produced in camp. However, during the wet season the volume of sludge in transit increases and this treatment capacity might not be enough.

Eight out of the 20 FSTPs visited were not utilising their full design capacity at the time of the study, leaving a nominal 196m^3 of underutilised capacity in total. Reasons stated as: site was under commissioning or decommissioning, poor final effluent quality, and variable volumes of incoming sludge depending on the season. If FSTPs not investigated in this study (included in the WASH sector infrastructure data) have a similar underutilisation, again this shows that the available treatment capacity is slightly below the demand (sludge generation).

Across the 20 FSTPs visited the Capex of treatment per m^3 ranged from approximately $1,000 to $14,000 USD and Opex from $1 to $44 USD.

Several types of decentralised FSTPs were not achieving the DoE effluent standards but the WSPs, ABR and DEWATs showed potential for good performance, with some passing results from certain FSTPs or in certain months. The Aeration plant performs best against the effluent standards (passing COD, pathogen, pH and nutrient requirements). Centralised FSTPs showed generally a better performance than the smaller decentralised FSTPs.

Lime FSTPs had high pH and generally poor performance for COD/BOD and nutrients removal. Lime sites are not appropriate for this stage of the emergency, given their high Opex and low treatment performance, and a majority are being decommissioned. GeoTubes and Constructed Wetlands (assessed in phase 1` and not phase 2) are poorly performing and not appropriate for use as a standalone technology and should be decommissioned.

FSTPs that are not meeting DoE effluent standards for most parameters, can pose a risk to human health and the environment. Most of the site visited use infiltration via soak pit or infiltration field as the final disposal for liquid, perhaps negating the need to meet the DoE (discharge to surface water) standards, it is likely that larger or additional treatment units, and hence a larger areas, would be required for these FSTPs to achieve better effluent quality. Where infiltration is the final disposal route for FSTP liquid effluent (and DoE pathogen standards are not achieved), risk assessments to ground water are required to properly design the infiltration area and upstream FSTP and define the capacity of the treatment and associated FSM chain.

Final solids products from FSTPs are generally being stored at sites and are not being widely reused or recycled. There is a need to understand the market and acceptability for sludge products (compost, gas etc) to understand if additional solids handling could be made cost efficient i.e., offset Capex and Opex costs by selling fertiliser or compost in local areas. Consolidation/centralisation of final solids handling can help move solids off FSTP sites, allowing for an efficient treatment to be established and a better use of FSTP area. Review would be required of if final solids require further 'rewetting' or 'drying' to facilitate process to produce saleable products, this may prove cost or logistically prohibitive.

In the shorter term e.g., next 5 years, improving the existing FSTP infrastructure is likely to have the lowest Capex and environmental impact (from materials use etc). However most existing sites do not have space for additional process stages required to achieve DoE effluent standards or accommodate population growth, therefore this is unfeasible. In the 'longer term' i.e., 5 to 10 years most FSTPs in this study will have reached their design life, it would be most cost effective, looking at whole chain cost, to provide a centralised FSTP with permeant pipe as transfer system.

General view of CxB camp

1 INTRODUCTION

1.1 BACKGROUND

In response to the influx of Rohingya refugees into Bangladesh from Myanmar, an unprecedented number of agencies have implemented Faecal Sludge Management (FSM) projects in Cox Bazar (CxB) camps. In 2018, Oxfam and Arup, with support from UNHCR and others, started a technical assessment study of Faecal Sludge Treatment Plants (FSTPs), with the aim of drawing conclusions, from evidence gathered through practical experience, on best practice in FSM for disaster response.

The initial technical study was completed in 2019 and included eight FS treatment technologies, with FSTPs treating over $5m^3/d$ (the wider FSM chain was not included). The study included assessment of the following parameters for each FSTP: cost, footprint area, speed of construction and commissioning, operation and maintenance issues, process performance and resilience to natural disasters. The full publication can be found: here.

Since publication of the initial study there has been significant progress in various aspects of FSM in CxB, via a number of actors. Importantly this has included monitoring and evaluation (M&E) of some FSTPs, developing Minimum Standards for Sanitation in Emergencies (by the FSM TWiG) and signposting documents to assist development of a Strategic Plan for FSM.

As the Rohingya emergency moves to the longer term, the WASH sector wants to focus their FSM efforts on FSTP and FSM chain technologies which have good treatment performance, limited operational input, low space requirements, and are cost effective. FSM systems in CxB are being rationalised, with a limited number of new facilities being built and the focus shifting to improving performance and sustainability of existing systems, while modifying or decommissioning unsatisfactory elements. The sustainability (cost, operational and environmental) of FSM systems is critical to ensure they can operate well in the long term, as donor support reduces.

This ‘phase 2’ of the FSM technical study will focus on CxB and aims to build on the initial study, but broaden the scope to the FSM chain, refine the data captured to align with recent M&E work (by others), and include a wider reach for stakeholder engagement to ensure relevant FSM data and experiences are captured.

1.2 OBJECTIVES OF THIS STUDY

The objective of this phase of the project is to provide a ‘Technical Assessment of FSM systems in CxB’, building on the initial study, and studies by others (UNICEF, UPM, ICDDR-B, IOM, UNHCR, DPHE, Oxfam, ITN Buet, MSF et al), see Appendix I for stakeholder identification and Chapter 5 for references.

This study will be used by the CxB WASH sector to understand the performance and cost of the main FSM chains in use across the camps and to inform the long-term FSM Strategy for the camps (a future piece of work to be undertaken by CxB WASH sector). To this end, this study aims to provide a technical assessment to answer the following questions, where costs and operational robustness are the key criteria:

1. Does the FSM chain meet the need? i.e., does each stage in the FSM chain have capacity to manage the sludge generated, what are the bottlenecks and inefficiencies, and how can these be addressed?
2. Which type of FSTP is performing best against most assessment parameters? This should include reasoning for improving or decommissioning FSTPs.
3. Which mode of FS transfer/transport is most cost effective and resilient?
4. Does the containment type influence the sludge chain, and which containment is best?
5. Is the centralised or decentralised approach of FSM more cost effective and sustainable?

This 'phase 2' will:

- **Review latest available information** - Building on the initial study, aligning with established M&E studies and bringing in more relevant stakeholders. This phase will include a review of how the different FSTPs are performing and identify challenges that have emerged. Additional data (collected by others) on FSTP design, operational performance, and effluent quality is available since the initial study, and this has been reviewed to give an assessment of FSTP performance, including consideration of the FSM chain i.e., from contaminant to reuse/disposal.
- **Review long term operation and sustainability** - Validating the initial study conclusions on which technologies are the most efficient and effective. This phase will update the focus to what is most efficient, based on local challenges, and in the long-term.
- **Include full FSM chain** - The study will include assessment of operational costs and issues associated with the full FSM chain i.e., including contaminant and transport. This is in response to data gaps noted in formation of an FSM Strategic Plan (a separate study) and the need to understand the key influencing factors when deciding if a centralised or decentralised FSTP is most appropriate.

1.3 STRUCTURE OF REPORT

This report briefly outlines the methodology and range of information collected in chapter 2, followed by camp wide assessments in chapter 3 and detailed field visit information in Appendix H. The camp wide assessment includes a review of the containment, transportation, treatment and disposal. More detailed analysis is then undertaken for the 20 FSTPs visited during the study and presented in section 3.4 and Appendix H. Conclusions are provided in chapter 4. The background data is attached in Appendices, and the accompanying Power BI Dashboard. Key points are highlighted throughout the report in **blue boxes**.

2 METHODOLOGY

2.1 PROJECT STAGES

The main project stages are shown in Figure 1 below. Details of each are included in progress meeting records in Appendix K.

Figure 1: Project stages

2.2 STAKEHOLDERS

A core team was established to guide this project. This included representatives from the CxB WASH Sector, Oxfam, IOM, UNICEF MSF and UNHCR. Regular core team meetings were held throughout the project to review findings and progress (see Appendix K for records). Review meetings where also held with DPHE and other technical experts when appropriate.

A wider group of stakeholders was identified during the engagement stage. This included the NGOs operating the FSTPs and associated FSM chains. A full list of stakeholders and engagement notes are included in Appendix I.

Oxfam were the technical partner for the study and conducted all the field work in Bangladesh (Arup worked based in UK). A full list of contributors, including interviewees and field visit contributors, is provided in Appendix I.

2.3 TECHNOLOGIES INCLUDED IN THIS STUDY

A list of the FSTPs included in this study is given in Table 1 below. The name and key components of each are provided. The FSTP selection was initially determined by Arup and Oxfam and then discussed and agreed with the core team during the initial stakeholder engagement stage.

The intention of the FSTPs selected was to capture the range of technologies that are being successfully used in the camps and are likely to be used in the mid to long term. Several FSTPs of each type were selected to understand any issues posed by different locations (hence different catchments and FSM chain), and different operators. FSTPs were also selected where they were known to have good available data e.g., were covered in existing effluent monitoring and evaluation studies, or are known to have good records available on the design, cost, and operation. It should be noted that this selection method can lead to a bias of investigating FSM chains that are better implemented, operated and maintained. However, it is believed that a majority of the main types of system in use are covered, and findings could be applicable to other FSM systems of the same type.

An attempt is made to classify the FSTPs by the main treatment process e.g., biological, chemical, or mechanical. However most FSTPs are made up of many elements (multistage) so are not simple to classify. It is also noted in the table, if they are considered centralised or decentralised. This is based on the area served and volume treated i.e., centralised treats sludge from a large area (multiple camps) and volume over 100m^3/d.

No FSTP reference number was assigned in this report, as there are multiple references in existence and there is a need to avoid further confusion (see recommendations in chapter 4).

TECHNOLOGY NAME/ KNOWN AS	KEY COMPONENTS (see Appendix H for a Process Flow Diagram of each)	COMMENT / CLASSIFICATION	NUMBER OF FSTPS INCLUDED UNDER THIS STUDY
Camp 4X FSTP (aka Mega FSTP-1)	- Anaerobic lagoons - UFF - Trickling filter - Polishing pond (final effluent (FE) to surface water outlet) - Planted drying bed (solids handling)	- Largely biological treatment - Multistage / multi process - Large scale + - FSTP considered as a 'centralised' plant.	1
Kutupalong FSTP (FSTP-2)	- Planted drying bed - Anaerobic filter - Vertical CW - Horizonal CW - Polishing pond (FE to surface water outlet)	- Largely biological treatment - Multistage / multi process - Three process streams in parallel, operated by multiple agencies - Large scale FSTP considered as a 'centralised' plant.	1
Lime treatment	- Lime lagoons/ stabilisation ponds - Dewatering / drying beds - Polishing pond (FE is infiltrated) - Solids incineration	- Chemical treatment - Multistage / multi process - Decentralised	3
Anaerobic baffled reactor (ABR)	- Buffer tanks - ABR - Filter - Polishing pond (FE is infiltrated)	- Biological treatment - Multistage / multi process - Decentralised	6
Aeration	- Aeration tank - Settlement tank - Liquid filtration and chlorination (FE is to surface water via plantation) - Solid drying/ incineration	- Biological treatment - Multistage / multi process - Decentralised	2

Table 1: Technologies included in this study

TECHNOLOGY NAME/ KNOWN AS	KEY COMPONENTS (see Appendix H for a Process Flow Diagram of each)	COMMENT / CLASSIFICATION	NUMBER OF FSTPS INCLUDED UNDER THIS STUDY
Waste Stabilisation Ponds (WSP)	- Drying beds - Anaerobic pond - Facultative pond - Maturation pond - Plantation bed	- Biological treatment - Multistage / multi process - Decentralised	**2**
Anaerobic Digester System (ADS)	- Drying bed - Bio-digestion (aka anaerobic digester) - Liquid treatment – planted filters and polishing pond and soakaway (FE is infiltrated) - Connection for biogas transfer to allow use	- Biological treatment[2] - Multistage / multi process - Decentralised	**1**
Upflow filters (UFF) and Decentralised Waste Water Treatment System (DEWATs)	**UFF** - Presettlement - UFF - Filtration - Soakaway (FE is infiltrated) **DEWATs** - Bio-digestion[3] - UFF - Liquid clarification & chlorination - Infiltration of final liquid and storage of solids.	- Note, although 4 UFF were visited only useable data was provided for 3. - Biological and mechanical treatment - Multistage / multi process - Decentralised	**4**
Transport/ transfer technologies: **- Vactug** **- Permanent pipe and pump networks or IFSTN (intermediate faecal sludge transfer network)** **- Temporary pipe and pump networks** **- Pit to pit transfer**	- Vactug – Vactug vehicle and associated hose, see Figure 10 for photograph. - Permeant pipe/ IFSTN is a permanent (below ground) pipe network with some gravity and some pumped sections and storage tanks. - Temporary pipe and pump are generally 100m+hoses with transportable pumps, the hose and pumps are taken around to the area that needs desludging - Pit to pit transfer is shorted lengths of temporary pipe i.e., hose, area used with pumps to transfer sludge between pits to reach storage tanks accessible by road (for tanker collection) or from the final pit to the receiving FSTP.	N/A	N/A

Table 1: Technologies included in this study

Technologies not included

There are two technologies that were included in the initial study that were not included in this ‘phase 2’ i.e. GeoTubes and CW. These were identified as performing poorly as standalone technologies during the initial study, and from the discussion with the core team as to whether such technologies are continuing to be used, it was concluded that a majority are decommissioned or planned to decommission. Therefore, the decision was made not to include these. A comparison of FSTPs included in phase 1, and this phase 2 FSM study, is given in Appendix B.

GeoTubes and Constructed Wetlands are poorly performing as standalone FST technologies and should be decommissioned.

2.4 INFORMATION COLLECTION AND PARAMETERS ASSESSED

The following Table 2 outlines the parameters covered in this study, and gives details of how the information was collected and analysed for each. The parameters include cost efficiency and environmental sustainability, which is a particular sector focus as the emergency shifts to medium to long term solutions.

Information was collected via initial telephone interviews between Arup and the NGOs operating FSTPs, plus substitute data (e.g., for overall camp studies) held by WASH sector, DPHE and others (see chapter 5). stakeholders sent follow up information including site drawings and costs. Site visit questionnaires were drafted by Arup based on the initial engagement and reviewed with the core team ahead of field visits. Oxfam Bangladesh conducted field visits to each FSTP, holding interviews with senior site operators/managers and touring the site infrastructure. Several rounds of clarifications were made by Oxfam and Arup with NGO partners to close out any outstanding information[4]. Data requests for desludge and transportation information were drafted by Arup and disseminated to stakeholders via WASH sector leads. Examples of the forms used for the telephone interview and site visits are included in Appendix J.

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(2) Bio digestion in ADS is a sludge holding chamber/tank under anaerobic conditions where sludge is held for a extended period of time (i.e. longer than bio-digestion used in DEWATS systems), this acts as a small-scale anaerobic digester. Biogas is generated and collects at the top of the chamber, connection points for the gas (pipework) are provided however gas is not being used and is just vented to atmosphere.
(3) Bio-digestion in DEWATs systems is a sludge holding/settlement tank where sludge is help (for approximately one day), similar to a septic tank. Some digestion of solids occurs, and some settlement of solids also occurs. The tank is vented at the top but otherwise is a sealed tank.
(4) A 'Red/Amber/Green' table was presented to the core team (see Appendix K) showing the overall status of the data collected for each parameter for each FSTP i.e. green = good data and all received, amber = available data provided by insufficient / assumptions required for analysis and red = poor or no data available.

Table 2: Parameters assessed in this study

	PARAMETER	DATA COLLECTION METHOD	ANALYSIS
FSTP	**Treatment capacity**	- Data collected from operator interviews during site visits and review of available FSTP design information – provided by site operator/manager.	- FSTP treatment capacity normalised to average m^3/d. - Review of treatment capacity for seasonal variation. - Review actual vs. design capacity.
	Area requirements and scalability	- Data collected from operator interviews during site visits – area occupied by treatment units (e.g., tanks) and whole site area. - Review of available design information – provided by site operator/manager.	- Treatment units and total area per m^3 sludge treated. - Scalability – considered easily scalable if system is modular, based on prefabricated standard equipment.
	Capital costs (Capex)	- Data provided operating NGO. - Initial capital cost with a breakdown plus any 'repeat Capex' i.e., capital cost of equipment that needs to be replaced during the design life	- Cost converted from BDT to GBP and USD. - Capex per FSTP type, per m^3 sludge treated and per site area.
	Operational costs (Opex)	- Data provided operating NGO. - Average monthly operational costs and a breakdown of these.	- Cost converted from BDT to GBP and USD. - Review of Opex for seasonal variation or significant change over time. - Monthly average Opex per FSTP type, per m^3 sludge treated and per site area.
	Whole life cost (WLC)	- Design life data provided operating NGO.	- WLC calculated = (Capex)+(Capex repeats during deign life)+(Opex x design life)
	Speed of construction and setup	- Data collected from operator interviews during site visits – i.e., construction and commissioning time in days/months.	- Construction time vs. scale (i.e., treatment capacity in m^3) - Review on ease of set up, key reequipments e.g. topography, power supply, super structure, drainage etc.
	Expertise required for setup and operations	- Data collected from operator interviews during site visits – i.e., number of skilled and unskilled labour, management etc.	- Number of staff and what skills
	Operation and maintenance issues	- Data collected during interviews and site visit.	- O&M activities – how difficult and how often. - How many people required.
	Treatment performance	- Laboratory data provided WASH sector and stakeholders, including studies by DPHE, Iccrdb, IFRC, Oxfam, WVI, IOM and WASH sector.	- Data reviewed for sites visited. - Final effluent vs. 2019 DOE standards and pathogen inactivation. - WHO (2006) standards for who guidelines for the safe use of wastewater, excreta and greywater - If sites are infiltrating narrative given on effluent quality requirements. - Actual performance vs. design (generally for BOD, solids, and pathogens) - Review through treatment process i.e. % removal of COD, BOD, SS, Nitrate (NH4, N), Phosphate (P), E.coli, helminths.
	Treatment process complexity and pinch points	- Data collected from operator interviews during site visit. - Review of laboratory data at stages through the process.	- Identifying underperforming elements/units (by calculation of % removal) and causes (narrative). - Complexity was a judgement based on number of treatment steps/ processes, amount and type of mechanical / electrical equipment and how sensitive (to changes in operation) the equipment and process is.

DATA PRESENTATION	CONSTRAINTS / ASSUMPTIONS
- See section 3.4.2	- No flow measurement data available. - No site measurements taken to verify drawing or dimension information provided. - Limited qualitative data – detailed explanations difficult to get.
- See section 3.4.3	- No site measurements taken to verify drawing or dimension information provided. - In some cases, FSTP designed to suit site area i.e., sized to meet area available rather than on sludge generation/ treatment demand. Plus, treatment unit can be more spread out allowing good access etc around the site. Where this caused outlying data is has been noted.
- See section 3.4.4 and dashboard	- Exchange rates BDT to USD taken in April 2022 . - Capex repeats – NGO partners do not have visibility of this for the FSM chain so limited data provided. See WLC line for assumptions. - No data was collected on desludge or transport Capex.
- See section 3.4.4 and dashboard	- Data overlaps - sometimes you have a crew in charge of multiple FSTPs therefore economies of scales are achieved and difficult to accurately assign total Opex to one particular FSTP. - Crew rotate and do different tasks, including desludging of latrines. Transfer networks cost shared with us do not include the staff.
- See section 3.4.4	- Design life – NGO partners do not have visibility of this so limited/uncertain data provided. - Capex repeats – limited knowledge from partner NGOs therefore the following assumptions have been assumed for Capex repeats within the FSTPs design life: - Capex repeats assumptions (within design life of plant) - Plant with lots of mechanical equipment = 40% of original Capex - Plants with large infrastructure / civil works= 30% of original Capex - Small plants with simple prefabricated units/ in situ concrete tanks = 20% of original Capex - Small plants with simple inset units e.g., simple lined earth bunds for ponds (rather than constructing tanks) = 10% of original Capex
- Section 3.4 and Appendix A.	- Where sites are being decommissioned ease/issues are noted. - Limited qualitative data – detailed explanations difficult to get.
- Section 3.4 and Appendix A.	- Limited qualitative data – detailed explanations difficult to get. - Skilled/Unskilled labour – was not defined in the question – and it is not always specified. De-sludge operators consider skilled labour.
- Section 3.4.6 and Appendix A.	- Limited qualitative data – detailed explanations difficult to get.
- Summary in section 3.4.7, details in Appendix A and Appendix C.	- Data range from 2019 to present. Number of data points and date range noted in this report. - Data on raw sludge and final effluent as well as some intermediate process point was available, see Appendix G. - Where no data available closest possible representative site chosen i.e., same type, size and operator. This is noted in the treatment performance review.
- See section 3.4.11 and Appendix A.	- Only small data set where each stage in the process is monitored over a long period of time. Difficult to identify trends.

Table 2: Parameters assessed in this study

	PARAMETER	DATA COLLECTION METHOD	ANALYSIS
FSTP	**Disposal of final products**	- Data collected during interviews and site visit.	- Final effluent vs. 2019 Department of Environment (DoE) standards and - Pathogen inactivation vs. DoE and WHO agricultural reuse standards. - If sites are infiltrating narrative given on effluent quality requirements. - Comments on final solids volume and disposal route.
	Resilience to disaster	Data collected during interviews and site visit.	- Any special features noted in interview or design documentation (drawings etc).
Sludge chain (containment and transportation)	**Volume of sludge collected and transported**	Data provided operating NGO. (Sludge Transportation Data collection form circulated by WASH sector to key Stakeholders)	- Volume of sludge desludged and transported (m^3) per Transfer system (average, wet and dry seasons) - Cox's Bazar FSM chain – Average volume of sludge in transit per month - Transportation Performance (wet/dry season resilience)
	Desludging cost	Data provided operating NGO. (Sludge Transportation Data collection form circulated with key Stakeholders)	- Cost converted from BDT to GBP and USD. - Assessment of Transportation Mode Cost-effectiveness through the analysis of the cost per m^3 sludge collected and transported. - Assessment on the highest and lowest operation cost for each Transportation modes.
	Transportation cost	Data provided operating NGO. (Sludge Transportation Data collection form circulated with key Stakeholders)	- Assessment of Transportation Mode operational Cost-effectiveness through the analysis of the cost per m^3 sludge collected and transported. - Assessment on the highest and lowest operation cost for each Transportation modes.
	Pinch points / influence on FSM chain	Data provided operating NGO. Data collected during interviews and site visit.	- Seasonal variation in desludging volume. Narrative on causes.
	Whole chain costs	Calculated	- Monthly desludging cost + Monthly Transportation cost
	Sludge transport mode	Data provided operating NGO. (Sludge Transportation Data collection form circulated with key Stakeholders)	- Cox's Bazar FSM chain - Breakdown of volume of sludge in transit and coverage area per Transportation mode
	FSTP catchment areas	Data provided operating NGO. (Sludge Transportation Data collection form circulated with key Stakeholders)	- Mapped based on camps/blocks provided by operating NGO. - Aim to show that coverage meets the need.
	Latrines / containment	Data on latrine types and database of locations provided by WASH sector *WASH_Infra(LT_Bath_TW)_GPS_March_31_2022_Final_ta_rev.xlsx*	- Cox's Bazar FSM chain – Number of latrine units and Type of facilities

DATA PRESENTATION	CONSTRAINTS / ASSUMPTIONS
- See section 3.4.9 and Appendix A.	- No standards for quality required to infiltrate. - No measurement/ good data for volume/ weight of final solids.
- See section 3.4.10 and Appendix A.	
- See Section 3.1 - See Section 3.3.1 Cost-effectiveness - See Section 3.3.2 Transportation Performance	- Based on/ limited to data provided by stakeholders i.e. data coverage not 100% of the camps/ stakeholders.
- See Section 3.3.1 Cost-effectiveness	- Only operational cost, no Capex costs collected.
- See Section 3.3.1 Cost-effectiveness	- Transportation cost not always specified in the transfer system. Such entries were not included in the Transportation Mode Cost-effectiveness assessment. - Only operational cost, no Capex costs collected.
- See Section 3.2.2 Containment Performance - See Section 3.3.2 Transportation Performance	- Challenge to understand the impact of Containment on the FSM chain using the Sludge Transportation Data collection form data since the Type of facility desludged is not specified and each block has more than one type of facility. - Anecdotal evidence of Containment performance collected during interviews and site visit used for this assessment.
- See Section 3.3.1 Cost-effectiveness	
- See Section 3.3 Transportation	
- See Appendix A - See Dashboard	Catchment areas/ collection areas for each FSTP and transport mode provided by stakeholders from transport form and sketched during site visits. Effort made to close out discrepancies via queries to operators.
- See Section 3.1 - See Dashboard	*WASH_Infra(LT_Bath_TW)_GPS_March_31_2022_Final_ta_rev.xlsx* still being updated at the time of writing this report, and no information on the containment for Camps 23, 24 and 25 was available.

3 CAMP WIDE ASSESSMENTS

As part of this study several camp wide assessments have been completed. These focus on understanding the overall FSM chain across the camps i.e., understanding sludge generation, containment, transportation, treatment and disposal. The aim is to inform the WASH sector and stakeholders on generation and treatment capacity (study objective Q1), how the containment, collection and transportation is operating (study objective Q2 and 3), and which systems are cost effective and sustainable (study objective Q2 and 4). This will inform on which types of systems (centralised or decentralised) are performing better overall (based on operation and cost – study objective Q5). This section of the report uses camp wide data provided by stakeholders and the WASH sector for FSM chains, further supported with the more detailed analysis from the 20 FSTPs visited.

Section 3.1 outlines the sludge generation; containment is covered in section 3.2; and transportation in section 3.3. It should be noted that the review of containment was limited in this study due to the availability of existing data and scope of study. There is an accompanying Power BI Dashboard for data presented in these sections. Section 3.4 covers FSTPs and is based on the site visits (20 FSTPs) giving information for parameters outlined in Table 2. Stakeholder camp wide data is supplemented for the review of FSTP treatment performance.

A 'Sludge Transportation Data Collection Form' was circulated with key Stakeholders to collect data and provide visibility of the FSM chains in CxB. A copy of the raw data collected is included in Appendix D.

Stakeholders completed these forms indicating which camp and block sludge is collected from within their coverage area, specifying monthly volume of sludge collected and the Target FSTP (where sludge is treated), amongst other parameters that will be further discussed in the following sections.

Camps 8W, 15, 16, 23, 25 and 27 were not included in this assessment because no data was received before the time of writing this report. Out of the 180 blocks (plus camp 20X), data was received for 135 blocks (plus camp 20X). The area included in the camp wide assessment is shown in Figure 2. This area comprises a total of 668,532 people (estimated from the *Bangladesh: Cox's Bazar Refugee Response (4W at Camp Level) – November 2021*), 34,927 latrine units of 29 types, and 146 different Target FSTPs.

3.1 SLUDGE GENERATION

Different stakeholders are using different sludge generation rates per person across the camps, to estimate sludge generated within their FSTP catchment area. The range for sludge generation being used was between 0.4 l/h/d and 2.6 l/h/d. The total Rohingya population in CxB is 904,639 people. Assuming the range of sludge generated stated above, a total generation of between 362 and 1,140 m^3/day (or 10,860 to 34,200 m^3/month) is expected.

A literature review of global sludge information in the initial study, gave an approximate average generation rate for public toilet latrines of 0.2 to 0.6 l/h/d, and 2 l/h/d for septic tanks[5]. The range used by stakeholder within CxB is above the average from literature, and therefore it is assumed that the lower end of the range (used by NGOs) is more accurate.

It is difficult to plan FSM with such a wide range for sludge generation. If the sludge transport data collected under this study is used, this gives an average of 21,962m^3 of sludge transferred and treated per month for the area included in the camp wide assessment (Figure 2). As noted, this area includes 668,532 people[6]. Based on these figures, the average amount of sludge collected is equivalent to 1.1 l/h/d. If this is extrapolated it gives an average production of sludge of 29,718m^3/month for the 904,639 population. This is perhaps a more robust number than using the range based on stakeholder information, and can be used in planning FSM.

To improve the accuracy of this estimation further, camp wide data collection would be required on total volume of sludge transferred and treated. However, this will not account for 'uncollected' sludge either in unemptied containment or from volume lost to open defecation. Additionally, groundwater infiltration into the pit, in some areas, and seasonal variation, increases sludge volumes which should not be counted as a human generation rate. The frequency of desludging and the overall volume transferred and treated can also be impacted by poor infiltration out of the pit at containment, which can create errors in the estimation of the sludge generation rate.

(1) It should be noted that, measuring sludge generation at the user (while defecating and anal cleansing) is different to measuring at containment level (while desludging and as reported in the transport data collected) due to decomposition and direct infiltration within the latrine. At user level the generation rate is always higher (around 1.5 - 2 l/h/d).
(2) Estimated from the Bangladesh: Cox's Bazar Refugee Response (4W at Camp Level) - November 2021.

Applying the range of sludge generation used by NGOs to the total Rohingya population of 904,639 people, gives a total generation of between 362 and 1,140 m^3/day.

Due to the large range, it is difficult for NGOs/service providers to accurately size transfer and treatment facilities. The WASH sector could recommend a max/min generation rate that facilities should be designed for, and collect further evidence to substantiate these rates. Based on rationalising the existing rates used by NGOs a range of 0.8 to 1.5 l/h/d could be used. This is in line with the average generation rate of 1.1 l/h/d calculated from the sludge transfer and transport data.

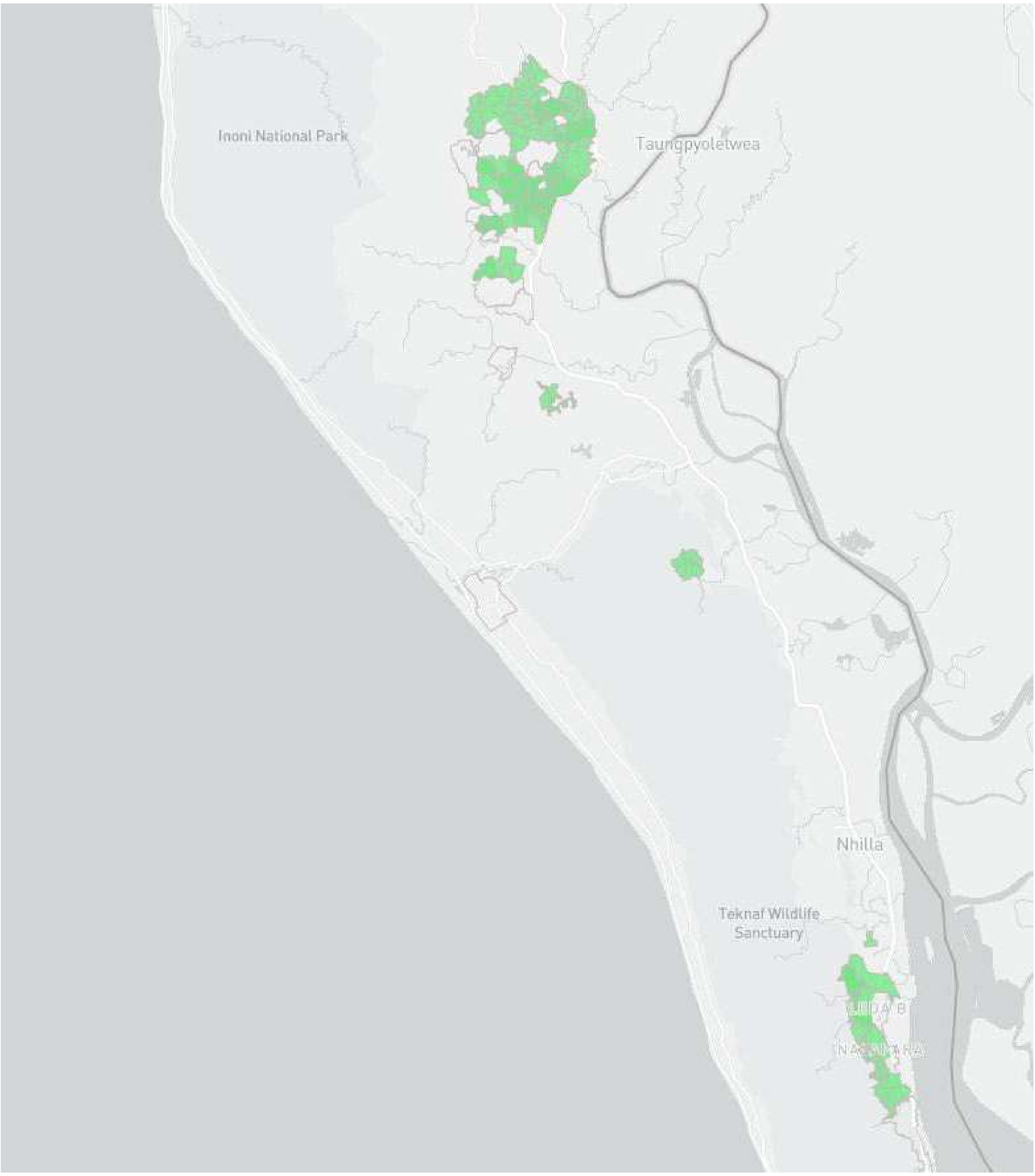

Figure 2: Camp Wide Assessment coverage area

3.2 CONTAINMENT

The following section provides a summary of existing containment types (e.g. latrine), and number, based on the latest WASH sector infrastructure review in March 2022 (data provided by sector for this study).

3.2.1 Cox's Bazar WASH Infrastructure Development Programme

A meeting was held in February 2018 to finalise the Unified/Standard Design for latrines in Rohingya settlements, and to ensure that the implementation of WASH infrastructure development programmes was in line with globally accepted humanitarian standards.

The advantages and disadvantages of several latrine design options were discussed, and the following types of latrines were agreed as being suitable for the different landscape and topography contexts in CxB[7]:

1. Direct pit single cubicle (Figure 3)
2. Direct pit with offset soak well single cubicle (Figure 4)
3. Twin pit offset single cubicle (Figure 5)
4. Twin pit direct single cubicle (two types)
5. Twin pit offset four cubicles
6. Septic tank with drain field, four cubicles (Figure 6 and Figure 7)
7. Latrine cubicles with biogas plants (three types of biogas plants) (Example of latrine cubicles with biogas plants in Figure 8 and Figure 9 below.
8. Single cubicle bath house

Appendix E provides detail of the design of each type of latrine.

(7) In addition, it was concluded that biogas is a proven option for faecal waste management and has an additional benefit of producing energy that can be used as cooking fuel and may also reduce desludging requirements. As a result, it was agreed that latrine designs that suits the addition of a biogas link could be adopted (equally could not be adopted). Additionally waste treatment/disposal mechanisms should be designed to ensure future latrines would match space limitation and require low or no desludging.

Figure 3: Direct pit single cubicle latrine example

Figure 4: Direct pit with offset soak well single cubicle latrine example

Figure 5: Twin pit offset single cubicle latrine example

Figure 6: Septic tank with drain field, four cubicles example

Figure 7: Septic tank with soak pit example

Figure 8: Biogas latrine example 1

Figure 9: Biogas latrine example 2

The March 2022 WASH Infrastructures dataset (shared with Arup in April 2022), was used to assess the containment facilities in CxB. This georeferenced dataset lists the number of latrines, segregated by latrine type, and provides an accurate representation of containment in CxB. It should be noted that the reviewed dataset was still being updated at the time of writing this report, and no information on the containment for camps 23, 24 and 25 was available.

It was not possible to assess which type of latrine is most commonly used, as 'poo per loo,' or containment volume is not recorded in this dataset. Additionally, no data was collected on the cost (Capex) of different containment types as this was considered outside the scope of this study.

The type and number of latrines shown in Table 3 are based on the March 2022 dataset. The highlighted types (in red) appear to correlate with the types of facilities discussed in the Unified/Standard Design for Latrines in Rohingya settlements meeting. The remaining types of latrines recorded appear to generally agree with types classified in February 2018.

Type of latrine	Number of latrine units	Number of camps where this latrine is used
Durable Latrine	12,084	8
Septic tank (6)	7,774	22
Twin Pit offset (3 or 5)	5,238	14
Direct pit with soak pit (1 or 2)	4,577	17
Twin Pit Latrine (3,4 or 5)	4,188	14
Direct Pit (1 or 2)	3,772	23
Direct pit offset pit (2)	2,301	12
Semi durable latrine	1,938	8
Single Pit offset	1,629	15
Bio-Fill Latrine	1,290	20
Bio-gas Plant (7)	1,172	10
Household Latrine	772	6
Single Pit	711	10
Communal Latrine	595	8
Emergency latrine	531	10
Durable	264	8

Table 3: Number of latrines per Latrine Type and Camp coverage

Type of latrine	Number of latrine units	Number of camps where this latrine is used
Holding Tank	177	5
Four pit	81	2
Septic tank latrine and bathing facility	70	3
Tank	64	1
Triple pit	62	3
Two latrine & one Bathing Shed	60	2
Disabled friendly latrine	55	3
Mobile Latrine	52	7
5th Pit	28	1
Latrine (Sub type Unknown)	20	3
Semi durable	20	6
Institutional Latrine	4	2
Emergency	1	1
Total	**49,530**	

Table 3: Number of latrines per Latrine Type and Camp coverage

There are a total of 49,530 latrine units in CxB. The latrine types used across most camps are highlighted in blue in Table 3. The most widespread type is the Direct pit (present in 23 different camps), followed by the Septic tank and Bio-Fill Latrine. The type of latrine with the greatest number of latrine units is the Durable Latrine, present in camps 6, 7, 8W, 8E, 14, 15 and 16.

There is some uncertainty on the type of latrine assessment, e.g., what is the difference between a Durable Latrine, Semi durable latrine and Semi durable? The Direct pit offset pit latrine type appears to refer to two different types of latrines. Further review of the WASH infrastructure dataset is outside of the scope of this study. However, it is recommended that a review of the types of latrine is carried out to adopt a standardised naming convention. Some suggestions for rationalising/grouping of latrine types, based on size of latrine/pit, are given in Table 4 below, along with how these align with the Unified/Standard Design for latrines.

The type of latrine most adopted in CxB is the Durable Latrine (24% of the latrine units are recorded as Durable Latrines). If the grouping for latrine types is considered, the group with the largest number of latrines is the ‘Unknown’ group (29%) followed by Group B – single pit (28%).

Possible latrine grouping – for consideration by WASH sector	Type of latrine as noted in current available data	Unified/Standard Design for latrines in Rohingya settlements
Group A - emergency/temporary latrines	- Emergency latrine - Emergency - Mobile Latrine	Not included
Group B - single pit	- Direct pit with soak pit (1 or 2) - Direct Pit (1 or 2) - Direct pit offset pit (2) - Single Pit offset - Household Latrine - Single Pit - Disabled friendly latrine	Type 1 and 2
Group C - larger pits	- Twin Pit offset (3 or 5) - Twin Pit Latrine (3,4 or 5) - Bio-Fill Latrine - Bio-gas Plant (7) - Communal Latrine - Four pit - Triple pit - Two latrine and one Bathing Shed - Institutional Latrine	Type 3, 4 and 5 (bio gas type 7)
Group D – tanks or very large pits	- Septic tank (6) - Holding Tank - Septic tank latrine and bathing facility - Tank - 5th Pit	Type 6 and 8
Unknown and would need more details to be allocated to group	- Durable Latrine - Durable - Semi durable - Latrine (Sub type Unknown)	Unknown

Table 4: Possible grouping for latrine types

3.2.2 Containment Performance

The focus of the containment performance review was to draw a conclusion on which type of latrine is the most efficient with regard to frequency of desludging and wet/dry season resilience (study objective Q3 and 4). Information on the fields listed below was collected during this exercise:

- How many days (average) required per month to desludge the block
- Number of latrine chambers desludged per month (Nos)
- Volume of sludge m^3 per month (annual average)
- Volume of sludge average m^3 per month (wet season)
- Volume of sludge average m^3 per month (dry season)

When cross referencing the data collected for the different blocks against the 2022 WASH Infrastructures dataset it was concluded that each block has more than one type of latrine, making it difficult to draw conclusions on each field, or trends by latrine type. Additionally, detail of the latrine types desludged in each block was not collected in this study. Therefore, an assessment of the suitability/performance of the different types of latrines was not possible.

Even though this assessment was not possible based on the camp wide data, information was collected during the field surveys of the 20 FSTPs. Appendix F provides detail on the anecdotal evidence collected via the site surveys for each latrine type – frequency of desludging, seasonal and location variations, and main issues. Conclusions are noted below:

- Single pit latrines are the type of latrine with the highest frequency of desludging (ranging from once a month to 4/5 times a month if located in a low-lying areas).
- The main reason for Single pit latrines being desludged more often is their lower storage volume/ capacity.
- For two of the FSTPs visited the type of latrine with the highest frequency of desludging was the Septic tank (1 to 2 times a month). Reasons noted were:
    - Over population and poor infiltration out of the pit due to damage to soak pit,
    - Design not adequate for the number of users, and
    - Connection of black and grey water.
- For one of the sites the type of latrine with the highest frequency of desludging was the Biofill latrine (twice a month) because of not operating as designed, and the sludge solidifying in the bottom of the latrine, thus reducing its capacity.
- In regard to the impact of the rainy season on the frequency of desludging, all operators agreed that the sludge volume increases during this period because of limited infiltration capacity out of pit at containment, and additional flow of rain, mud and sand into pits, from overland flows, drainage etc.
- A higher volume of sludge, and therefore a bigger strain on desludging, was also associated with low lying areas, where it was noted that infiltration is limited because of a higher groundwater table and natural drainage paths.
- A low frequency of desludging causes increased settlement of sludge at containment, leading to less available storage volume, accumulation, and solidification of sludge.

From anecdotal data collected during the FSTP site visits, latrines are desludged more often either because of insufficient capacity for the number of users, mixed use (black and grey water), operational defects and/or poor infiltration.

If further research confirms these limitations and targets areas with insufficient latrine units, actions can be taken to adopt suitable latrine designs and management plans for the contexts where these are implemented.

A tracking system of containment capacity and emptying will allow a desludging schedule to be better managed and lead to prompt desludging and efficient maintenance of the units' volume. A tracking system could be regular visual inspection and feedback to the desludging schedule, or an automated level sensor that sends information to the service provider/desludging schedule.

It is recommended that the latrine naming/grouping is rationalised and in line with the Unified/Standard Design for latrines, and more data is collected to develop a proactive emptying schedule.

3.3 TRANSPORTATION

The main purpose of the Sludge Transportation Data Collection Form circulated to stakeholders during this study was to understand how sludge is transferred to treatment across the camp, and which transportation mode is the most cost effective and resilient to the different contexts in CxB (study objective Q4).

The transportation mode options were divided between 'Single' and 'Mixed', as more than one mode of transport can be applied in one FSM chain i.e., 'Mixed'. It was reported that the following transportation modes are used in CxB:

- **Vactug** – a small petrol or diesel vehicle designed to be able to access smaller roads/tracks, equipped with hose and vacuum pump, which pumps sludge out of containment to a 20m^3 tank housed on the back of the vehicle.
- **Intermediate Faecal Sludge Transfer Network (IFSTN)** (see Figure 11) – a permanent below ground pipe network with some gravity and some pumped sections and transfer tanks within the network. Some sections of the pipe network are also flexible (non-permanent) and added as needed i.e., for last 100m between latrine and transfer tank. IFSTN can be done at small scale or big scale (multi-camp, multi-stakeholder).
- **Pit transfer/ temporary pipe and pump** – Temporary pipe and pump is generally hoses of 100m or more, with transportable pumps. The hoses and pumps are taken around to the area that needs desludging. Pit to pit transfer uses short lengths of hose with portable pumps to transfer sludge between pits to reach pit/storage tanks accessible by road for tanker collection, or from the final pit to the receiving FSTP.
- **Manual Desludging and Transport** (Figure 12) – sludge is pumped or manually bailed from containment into barrels and carried between two people to the FSTP.
- **Combination** of the above when more than one transportation mode is used.

Figure 10: Example of VacTug

Figure 11: Example of IFSTN transfer tank

Figure 12: Example of manual transport

Data was received for 188 transfer systems. As noted above, the data collected covered 135 blocks (plus camp 20X) out of the 180 blocks (plus camp 20X). No data was received for camps 8W, 15, 16, 23, 25 and 27 before the time of writing this report, hence they were not included in this assessment. The data coverage is approximately 68% of the total camps' area. A summary of data received is shown in Table 5 below.

The transportation mode most used in CxB is the *Pit transfer/temporary pipe and pump*, transferring an average of 64% of the volume of sludge in transit in CxB every month.

Transportation Mode	Sample	Volume of Sludge m^3 per month (annual average)	Coverage Area (ha)
Single: Pit transfer/ temporary pipe and pump	112	14,155	2,026
Mixed (Specify in Remarks with ratio of usage)	36	3,620	324
Single: IFSTN/ permanent pipe network and pump	22	2,332	196
Single: Manual Desludging and Transport	17	1,667	238
Single: VacTug	1	188	8
Total	**188**	**21,962**	**2,792**

Table 5: Break down of volume desludged and coverage area in CxB by transportation mode

3.3.1 Cost-effectiveness

The annual average monthly desludging and transportation operational costs were collected to understand which desludging/transportation mode is the most cost effective. There were some entries (29/188) where there was not a Transportation cost associated with the transfer system. For those entries, the ratio of cost per m^3 of sludge transported was not derived and not included in the overall assessment. The reasons that no costs were provided were stated as:

- Centralised sludge management systems constructed and operated by different Stakeholders than the ones desludging the latrines (2/188)
- Latrines located near the treatment plant, and therefore desludged directly to the FSTP (7/188)
- Incomplete entry and query not addressed at the time of writing this report (20/188)

A total expenditure of $53,563 and $33,331 USD was reported for desludging and transport respectively for an average month in the areas included in the camp wide assessment (refer to Figure 2). Comparing this to the total volume in transit per month, gives an average $2.43 and $1.51 USD per m^3 of sludge desludged and transported respectively, or $3.94 USD per m^3 for total conveyance to the FSTP.

Figure 13, below, shows the average monthly desludging and transportation cost per m^3 of sludge transported for each type of transportation mode. It can be concluded from this assessment that the *Manual Desludging and Transport* has the highest average desludging and transportation costs, and that the *IFSTN / permanent pipe network* the lowest.

It must be noted that Capex was not included in the Sludge Transportation Data Collection, and even though the cost of the sludge transfer system was queried during the site visits, the costs collected were sometimes referring to multiple

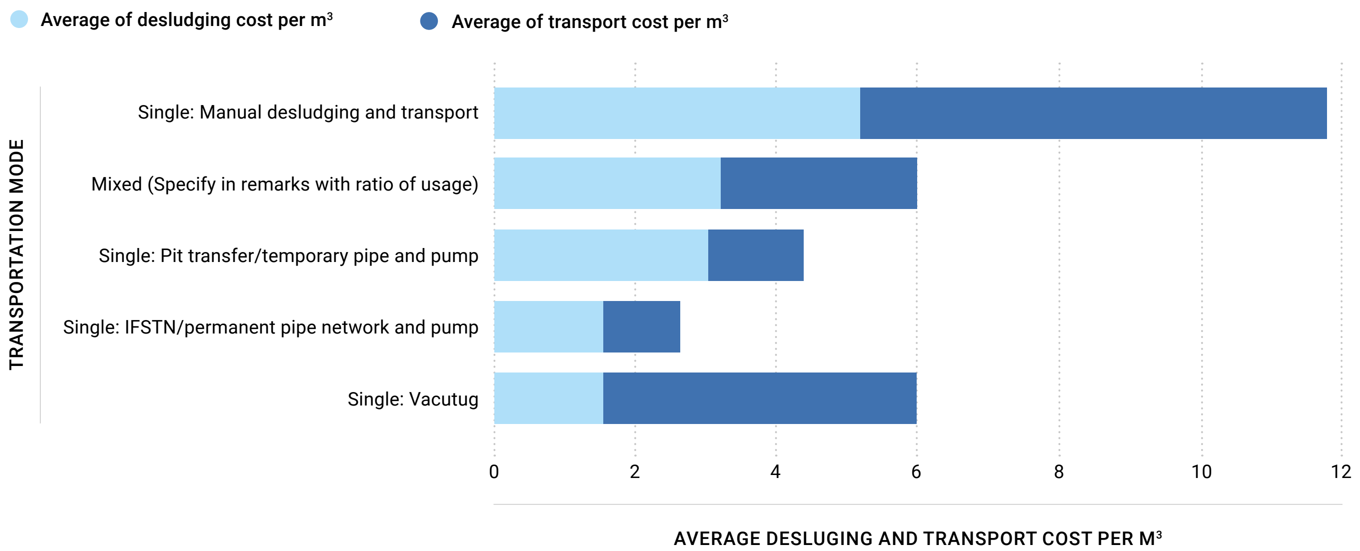

Figure 13: Monthly desludging and transportation costs per m^3 of sludge and Transportation Mode (USD/m^3/month)

transportation modes, hence it was challenging to find a correlation between initial investment and volume transferred, and to provide a robust assessment including Capex. Despite this data limitation, an attempt was made to understand the impact of the initial capital investment on the cost-effectiveness, and analysis was carried out using the pilot study by UNHCR and Oxfam in 2018.

UNHCR and Oxfam piloted an IFSTN in camp 3 and 4 to understand if such transportation mode is more efficient than a VacTug system. In this study two different metrics for Capex of an IFSTN were presented:

- Average 10M BDT of capital expenditure required for tanks, pipes, pumps and necessary fittings procurement and installation for a camp of 30,000 population
- Pilot IFSTN Capex of 48M BDT for a total population of 119,770

This resulted in a Capex ranging from 333 to 400 BDT per person.

The higher Capex per person was used in this assessment (400 BDT/person). For all the IFSTN/permanent pipe network entries collected through the Sludge Transportation Data collection, a population was estimated and an average cost per Volume of Sludge per month (annual average) calculated (refer to Appendix E for detailed data). The data from the Inter Sector Coordination Group 4W at camp level, from November 2021, was used to estimate the population per block.

Table 6 below shows in how many years the initial investment of building an IFSTN transportation mode would be paid back, based on the monthly savings in Opex compared against the other transportation modes used in CxB.

Due to data limitations this assessment did not consider the Capex of building each of the transportation modes compared against the IFSTN systems. If this cost is to be considered the range of years required to pay back the cost of building a IFSTN system should decrease from the 1.7 to 8.7 years range obtained.

Transportation Mode	Monthly ave Desludging and Transportation cost per m^3 (USD/m^3/month)	Potential ave OPEX saving if using IFSTN per m^3 transported (USD/m^3/month)	CAPEX payback based on potential saving (years)
Single: Pit transfer/ temporary pipe and pump	4.4	1.7	8.7
Mixed (Specify in Remarks with ratio of usage)	6	3.4	4.5
Single: IFSTN/ permanent pipe network and pump	2.6	n/a	n/a
Single: Manual Desludging and Transport	11.8	9.1	1.7
Single: Vacutug	6	3.3	4.6

Table 6: CAPEX payback based on potential Opex saving if using IFSTN

Building an IFSTN/permanent pipe network comes at a greater construction capital cost than Manual Desludging and Transport. However, the lower Opex per m^3 pays off the initial investment after an average maximum of 1.7 years. Even though manual sludge carrying provides paid work and contributes to CxB's economy it is low performing in terms of health and safety, and volume transported, and therefore should be considered at the bottom of the hierarchy of transfer options.

The low monthly average desludging and transport cost per m^3 for the Pit transfer/ temporary pipe and pump option, compared to the Capex of building a IFSTN / permanent pipe network, means it takes comparatively the longest, with average of 8.7 years.

This analysis is revisited in Section 3.3.2 below where the Opex costs of the transfer and treatment systems per volume of sludge transported and treated are merged for the FSTPs visited in Phase 2. The Whole Chain Cost (WCC) analysis has the purpose of understanding if the investment in apparently more expensive technologies results in an overall higher WCC.

3.3.2 Operational cost of whole FSM chain

As introduced above, key Stakeholders completed sludge transportation data collection forms to provide information on the FSM chains in CxB. Details on the coverage area and Opex of each transfer chain were provided as well as for the FSTP where sludge is transferred and treated.

Out of the 20 FSTP sites visited, 15 provided information in the Transport Data forms collected and so were included in the analysis of the Whole Chain Cost (WCC). The WSP and UFF sites visited in Camp 7 are included in the 15 sites/ chains abovementioned, however transportation Opex were not provided, and these plants were excluded from this analysis.

The WCC should include both construction and running costs (i.e., CAPEX and OPEX), however, the 'Sludge Transportation Data Collection Form' circulated did not query on the transfer systems' construction costs (Capex) and the level of assumptions required to get these retrospectively was not deemed suitable i.e., the number of assumptions would mean the assessment was not robust/ realistic. In addition stakeholders interviewed did not have good certainty/easy access to data on the initial capex costs for desludge or transport equipment.

The WCC analysis only includes OPEX costs for each of the chain elements (Desludging, Transportation and Treatment). The units used are USD/m^3 so a comparison between different chains can be made. Figure 14, below, shows the operational WCC cost for the 13 sites where this assessment was possible, the same data is shown in Table 7.

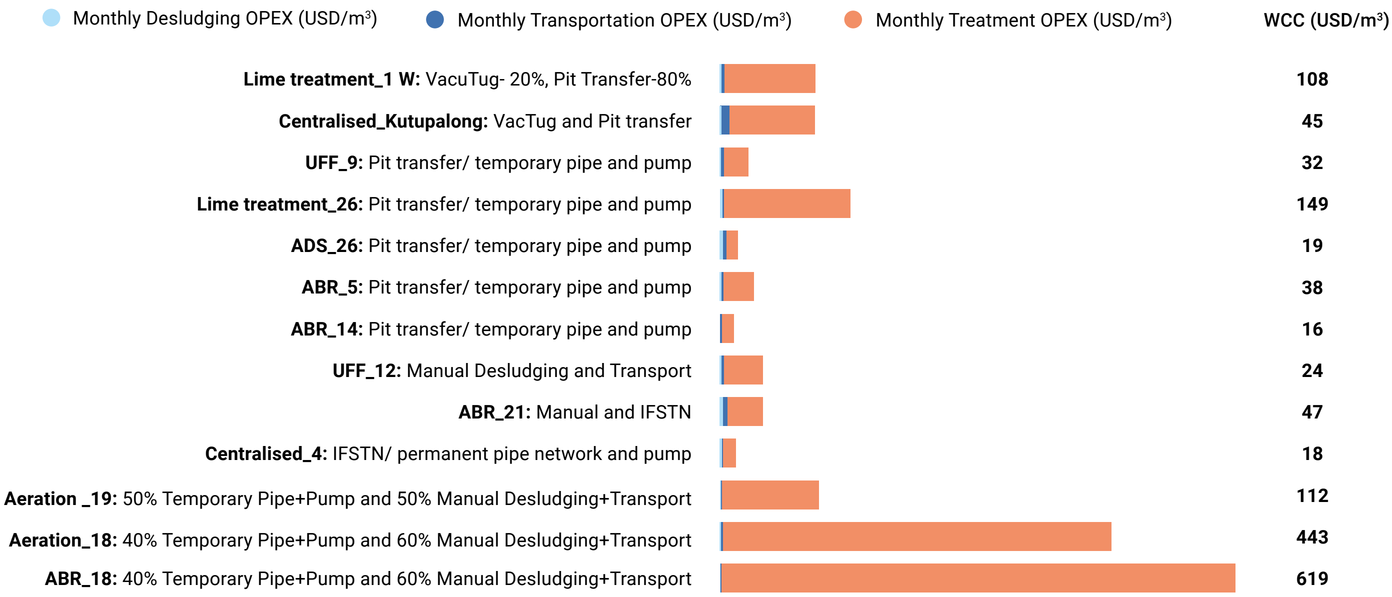

Figure 14: Whole Chain Cost Opex

FSTP visited	Transportation mode	Monthly Desludging OPEX (USD/m³)	Monthly Transportation OPEX (USD/m³)	Monthly Treatment OPEX (USD/m³)	Whole Chain Monthly OPEX Cost (USD/m³)
Lime treatment_ 1W	VacuTug- 20%, Pit Transfer-80%	1.54	2.66	103	108
Centralised_ Kutupalong	VacTug and Pit transfer	1.82	8.74	35	45
UFF_9	Pit transfer/ temporary pipe and pump	1.43	3.18	27	32
Lime treatment_26	Pit transfer/ temporary pipe and pump	2.83	1.89	144	149
ADS_26	Pit transfer/ temporary pipe and pump	4.49	3.00	12	19
ABR_5	Pit transfer/ temporary pipe and pump	1.72	1.12	35	38
ABR_14	Pit transfer/ temporary pipe and pump	1.62	0.46	14	16
UFF_12	Manual Desludging and Transport	1.91	1.84	20	24
ABR_21	Manual and IFSTN	2.33	3.74	41	47
Centralised_4	IFSTN/ permanent pipe network and pump	2.94	1.01	14	18
Aeration _19	50% Temporary Pipe+Pump and 50% Manual Desludging+Transport	0.91	0.88	110	112
Aeration_18	40% Temporary Pipe+Pump and 60% Manual Desludging+Transport	1.33	1.60	440	443
ABR_18	40% Temporary Pipe+Pump and 60% Manual Desludging+Transport	0.43	0.52	618	619

Table 7: Whole Chain Cost Opex

The Temporary Pump and Manual desludging arrangement highlighted in blue in Table 7 have the lowest desludging and transportation costs, however the highest treatment Opex in Camp 18 results in the highest Whole Chain Cost / m^3.

For the FSTPs visited the highest proportion of Opex is in the operation of the plant (Monthly Treatment Opex).Figure 15, below, shows the percentage of Opex for each chain element in the WCC.

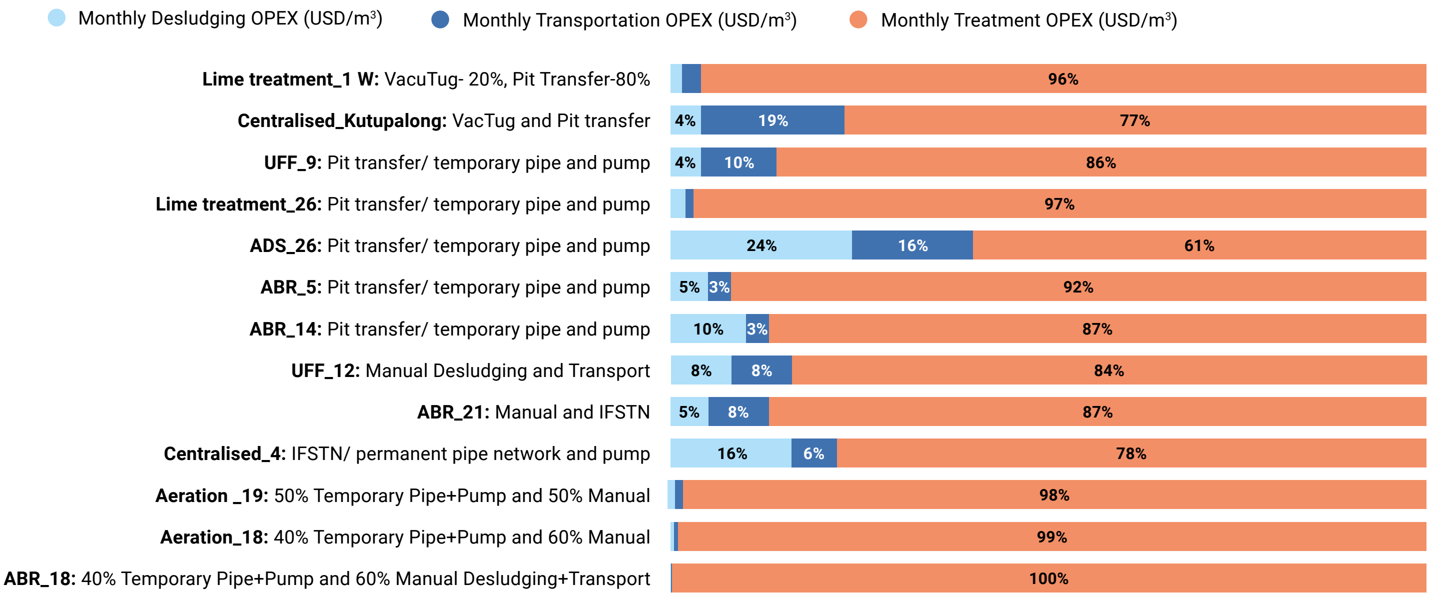

Figure 15: Whole Chain Cost percentage breakdown

The ADS system in Camp 26 also shows a high percentage of the WCC associated with the Desludging and Transportation costs. Similar to the Centralised plants the reason behind this proportion lies on the low Opex of this FSTP

It is not believed that including construction costs (Capex) in this assessment will impact the conclusions significantly, i.e. costs of treatment will still be the governing WCC and therefore the WCC will be dictated by the treatment WLC. Nevertheless, it is advised that in future assessments include construction costs (Capex) for completeness.


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Faecal Sludge Management Unit (FSM)

3.3.3 Transportation Performance

Like the review carried out in Section 3.2.2, the performance of the different transport modes was assessed. Wet and dry season deviation factors were derived from the data collected to draw a conclusion on which transportation mode is the most efficient in regard to transporting increased volumes of sludge during the wet season (study objective Q3), as follows:

- Volume of sludge m^3 per month (annual average)
- Volume of sludge average m^3 per month (wet season)
- Volume of sludge average m^3 per month (dry season)
- **Wet season deviation = Volume of sludge average m^3 per month (wet season) / Volume of sludge m^3 per month (annual average)**
    - If greater than 1, more sludge is transferred and treated during the wet season; if less than 1 less sludge is transferred and treated during the wet season
- **Dry Season deviation = Volume of sludge average m^3 per month (dry season) / Volume of sludge m^3 per month (annual average)**
    - If greater than 1, more sludge is transferred and treated during the dry season; if less than 1 less sludge is transferred and treated during the dry season

Based on the containment review it was expected that the wet season would be associated with higher desludging and transport volumes. However, some data showed lower desludging and transport volumes in the wet season (wet season deviation < 1), and higher volumes in dry season (dry season deviation > 1). Table 8 below shows the performance of the different transportation modes in CxB.

The IFSTN/permanent pipe network and pump reports the greatest increase in volume desludged and transported during the wet season (highlighted in blue in Table 8), while Manual Desludging and Transport reports the smallest increase (highlighted in red in Table 8). This trend was discussed with key stakeholders, and the reason behind the Manual Desludging and Transport showing the smallest increase is reported to be because of the poorer conditions of the

Transportation Mode	Sample size (number of systems)	Average of Wet Season deviation	# of Systems with a Wet Season deviation < 1	Average of Dry Season deviation	# of Systems with a Dry Season deviation > 1
Single: Pit transfer/ temporary pipe and pump	112	1.22	4	0.94	17
Mixed (Specify in Remarks with ratio of usage)	36	1.19	1	0.90	0
Single: IFSTN/permanent pipe network and pump	22	1.26	1	0.90	1
Single: Manual Desludging and Transport	17	1.06	3	1.02	5
Single: Vacutug	1	1.19	0	0.94	0

Table 8: Transportation Mode performance

roads and access to move sludge. During the wet season it is preferable to desludge and transport smaller volumes to keep the latrines in use, than to desludge the latrines fully and manually transport a large volume of sludge on muddy roads/paths.

Another reason for a wet season deviation < 1, not related with the transportation mode applied, is a reduced infiltration capacity at the receiving FSTP, impacting the volume disposed/ throughput (hence a bottleneck to upstream transportation and treatment). So, while a reduced infiltration capacity at containment can increase the volume of sludge collected and treated during the wet season, a reduced infiltration capacity at the FSTP, or a challenge to transport can reduce the volume of sludge transferred and treated. Anecdotally, 10% of the latrines in Camp are built in flooding areas due to lack of space and poor areas allocated to sanitation, causing these to overflow during the wet season.

An assessment of which type of treatment technology could better cope with increasing volumes of sludge during the wet season was carried out (see Table 9). However, it should be kept in mind that a lower wet season deviation does not necessarily relate to the target FSTP not being able to treat incoming flows. A lower wet season deviation can be because of a bottleneck in the transport of sludge and/or a reduced infiltration capacity of treated effluent (e.g., FSTP located on a low land, flood prone areas, or area with high water table).

The transfer systems where the target FSTP is a UFF show the greatest capacity to transport and treat increasing volumes during the wet season (as listed in Table 9). As mentioned above, possible explanations include higher resilience of the transportation mode or FSTP effluent infiltration capacity.

The Constructed Wetland, Solid Separation Unit and Geotube technologies were not included in this study from a treatment performance perspective, but these were included in the camp wide containment and transportation assessments because existing data was available.

Technology Type	Average of Wet Season deviation
UFF	1.70
Constructed Wetland	1.48
WSP	1.43
ABR	1.30
Centralized	1.28
ABR and Lime	1.21
ABR and Centralized	1.20
ABR and Geotex Tube	1.20
ABR, Geotex Tube and Lime	1.20
ADS, ABR and Geotex Tube	1.19
ADS	1.18
Solid Separation Unit (SSU)	1.13
UFF and ABR	1.12
Aeration	1.10
Waste stabilization pond (WSP)	1.07
Lime	1.06
DEWATS	0.98
Geotube	0.94

Table 9: Average Wet Season deviation per Type of Technology

The Constructed Wetland, Solid Separation Unit and Geotube technologies were not included in this study from a treatment performance perspective, but these were included in the camp wide containment and transportation assessments because existing data was available.

IFSTN are cheaper to run and can transport increased volumes of sludge. **Their construction comes with an initial higher cost but this investment can pay off within 1.7 to 8.7 years.**

Even though priority should be given to changing transport modes that are proven to be less cost efficient and resilient, an IFSTN can still require the support of other desludging and transportation techniques because of access limitations. Challenging topography requiring lots of pumping (and cost of fuel) could also make the IFSTN Opex increase to an unsustainable level. In those instances, the conditions to apply other transportation modes should be improved, e.g., better paths to allow VacTug access or to lay down temporary pipe (for last 100m) for transfer.

Treatment capacity at a FSTP level will dictate how much volume is transferred and if an IFSTN can be cost effective. Therefore, the full FSM chain should be investigated when assessing cost of which the transportation mode.

3.4 TREATMENT

The following section analyses the different types of FSTP visited against the parameters previously described in Table 2 and highlights which technology types are performing better against each. Information is based on the 20 FSTPs visited, unless otherwise stated.

3.4.1 Number of FSTPs and total treatment capacity

The sludge transportation data collected covers 146 different FSTPs. A comparison was made against the FSTPs reported in the WASH Infrastructures dataset from October 2021.

Table 10 shows the 164 Sanitation FSM sites listed in the WASH Infrastructures dataset from October 2021 (WASH IF dataset_Oct 21). Out of the 164 sites, 101 have been covered in the transportation data collection forms, with 45 facilities that could not be matched. This suggests that there are either more facilities than the 2021 WASH Infrastructures dataset, or that different names or locations were used when referring to the same plant (leading to double counting).

The WASH sector Infrastructure data (2021) set shows the total FSTP daily treatment capacity of 879m^3 across the camps, the accuracy and coverage of this was not investigated in detail during this study. Some existing monitoring regimes collect information on treatment capacity of each FSTP that could be used to update the 2021 data set e.g., DPHE effluent monitoring data, and the WASH infrastructure 2022 dataset; Although neither are a full data set (DPHE monitoring rounds are ongoing picking up different FSTPs each round) it is the best available data to understand total treatment capacity available across the camps. As the DPHE dataset builds it should be cross refenced against the WASH infrastructure database to understand total capacity.

The WASH sector Infrastructure data (2021) set shows the total FSTP daily treatment capacity of 879m^3 across the camps. For a population in RCs of 904,639 and a sludge generation rate of 1.1 l/h/day we get a daily sludge production of 995m^3. It is fair to consider that there is some sludge retention in the camps' latrines and tanks, and that some people might still practice open defecation, so this slightly lower treatment capacity might accommodate for the sludge produced in camp. However, during the wet season the volume of sludge in transit increases and this treatment capacity might not be enough.

As the DPHE dataset of actual FSTP capacity builds it should be cross refenced against the WASH infrastructure database to understand total capacity.

	WASH IF dataset_Oct 21		Transportation Data (collected in this study)		
Type of Technology	Total	Covered in Transportation data	Total	With a 'WASH IF dataset_Oct 21' match	Possible facilities not included in the 'WASH IF dataset_ Oct 21'
Lime Stabilization Ponds (LSP)	36	25	29	25	4
Solid Separation Unit (SSU)	39	31	34	31	3
Centralized	1	1	2	1	1
Anaerobic Baffled Reactor (ABR)	29	22	38	22	16
Up Flow Filter (UFF)	27	5	11	5	6
Waste Stabilisation Pond (WSP)	16	6	11	6	5
Anaerobic Digester System (ADS)	1	1	1	1	0
Aeration	1	1	2	1	1
Constructed Wetland (CW)	1	1	2	1	1
Decentralised Wastewater Treatment System (DEWATS)	9	7	12	7	5
Geotube	0	0	3	0	3
Other	4	1	1	1	0
Total	**164**	**101**	**146**	**101**	**45**

Table 10: Correlation between FSTP sites of the WASH IF dataset_Oct 21 and Target FSTPs of the Transportation Data collected

From a high-level analysis of the WASH IF dataset_Oct 21, there are 6 sites with the same Facility ID but located in different blocks or locations (see Table 11).

Facilities_ID or barcode_1	Block Name	Type of Technology	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
D- 001	C10_A	Other	21.193	92.153
D- 001	C10_B	Other	21.194	92.154
FSM-Camp 24	C24_D	Lime Stabilization Ponds (LSP)	20.970	92.243
FSM-Camp 24	C24_D	Lime Stabilization Ponds (LSP)	20.969	92.243
IOM-DLT-2018-10-C20-005(KSR-015)	C20_B	Solid Separation Unit (SSU)	21.190	92.141
IOM-DLT-2018-10-C20-005(KSR-015)	Camp 20X	Solid Separation Unit (SSU)	21.194	92.137

Table 11: Different FSTPs with the same Facility ID, WASH IF dataset_Oct 21

3.4.2 Design Capacity versus actual capacity

From the FSTPs visited, the highest design capacity was the Mega FSTP 1, with up to 180m^3 per day. The technologies with the lowest design capacity were the WSPs and UFFs, maximum 5m^3 and 6m^3 per day respectively.

Eight out of the 20 FSTPs visited were not utilising their full design capacity at the time of the study, leaving a nominal 196m^3 of underutilised capacity in total, see Figure 16 to see the percentage capacity utilisation. The main reasons were the following:

- Plants were being commissioned/brought into operation and the process was being fed progressively with an increased sludge load to achieve optimal performance (**under commissioning**). This was the case for the multistage biological process in the FSTP in Kutupalong, and the ABR in camp 18.
- Plants that are going to be **decommissioned** such as the aeration plant in camp 18.
- **Not enough faecal sludge** could be collected and transported to the site with the current methods, such as in the aeration plant in camp 19 where 70% of sludge collected is by manual transfer with no holding tank available.
- **Problems with the FSTP final product quality**, such as in the ABR for camp 12 which cited issues with the TSS in the final liquid effluent.
- **Variable production of sludge depending on the season.** FSTP in camp 4 was treating 120 m^3/d at the time of the visit (dry season), the amount linked to the sludge produced by the served population. However, the plant was designed to treat 150 m^3/d during the wet the wet season and is being upgraded to reach 180m^3/d.

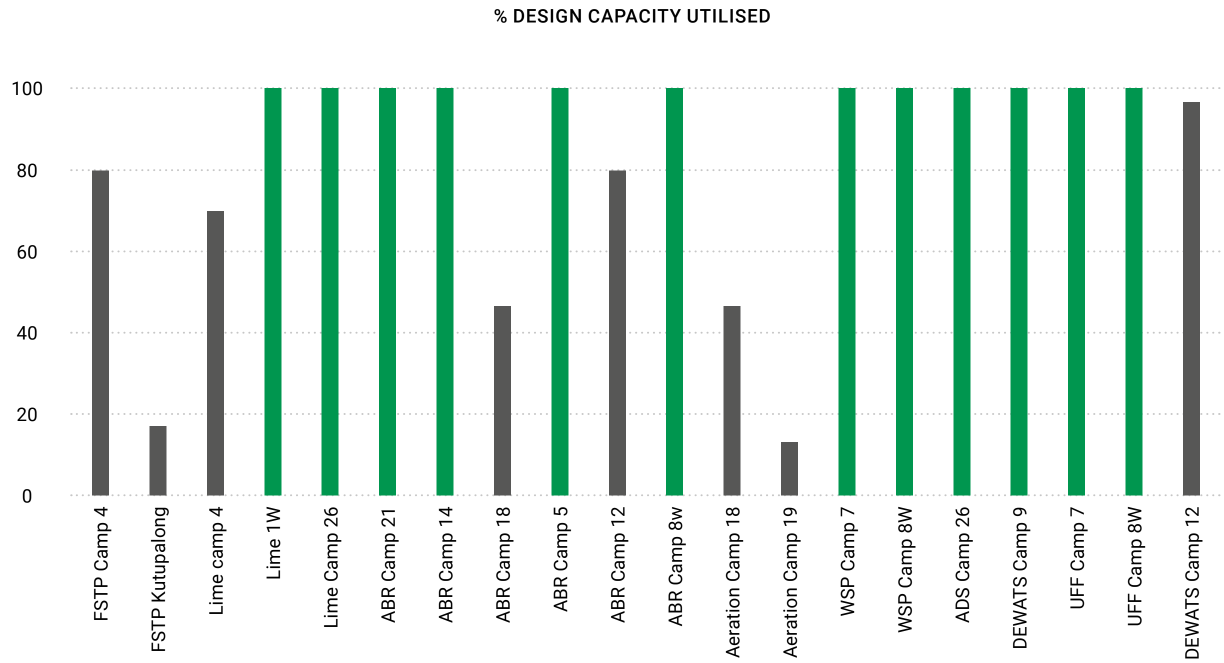


Figure 16: % of design capacity utilised for FSTPs visited

3.4.3 Area required

The area required by each technology is expressed in m^2 of land used by the treatment units (i.e. tank areas plus an additional 5% added to account for essential access roads and paths) per m^3 of sludge treated (using the design capacity).

The total site area is often dictated by what land is available / allocated for the FSTP and, where space is available, sites have ancillary facilities (e.g. laboratories, washrooms etc). Therefore, referring to the area used by the treatment units plus the space for access roads and paths provides a more realistic indicator of the actual area needed than using the total site area.

The data collected shows that sites with WSP and ABR technologies require the lowest area per m^3 sludge treated.

The range of area required per m^3 sludge treated is shown in Figure 17.

Four of the six ABR sites visited required less than $27m^2/m^3$ of sludge treated. For the WSP, the area required ranges from 8.4 to $16.8m^2/m^3$ of sludge treated. However, consideration needs to be given to the scalability of these solutions. The WSP technology can only be scaled up by adding more ponds (i.e., three in parallel), with the required length: width: depth ratios (for retention times), which require significant additional space. ABR plants are not easy to scale up as the existing units (concrete or brick tanks) were designed for the specific treatment capacity. New (parallel) construction would be possible, or bypass/ flow management is required to increase an existing ABR's treatment capacity. It should be noted that the ABR in camp 18 has a higher area requirement than the other ABRs. This site has a relatively high number of sludge drying beds and solids handling area, driving up the site footprint. Discussion with stakeholders indicated this site has been well designed to allow for the actual solids handling, and the area is not thought to be an over allowance.

UFF, DEWATS and Aeration are similarly efficient in terms of area required. The components required for the treatment in these technologies allow for an efficient use of the space, and because these are modular, they are scalable. Building modules together to provide a higher capacity can be a more efficient use of space. For example, one aeration site visited could treat double the volume of sludge, needing only to increase the treatment area by 30%. Common components are shared between modules, and the volume of the tanks can be increased without expanding the footprint area.

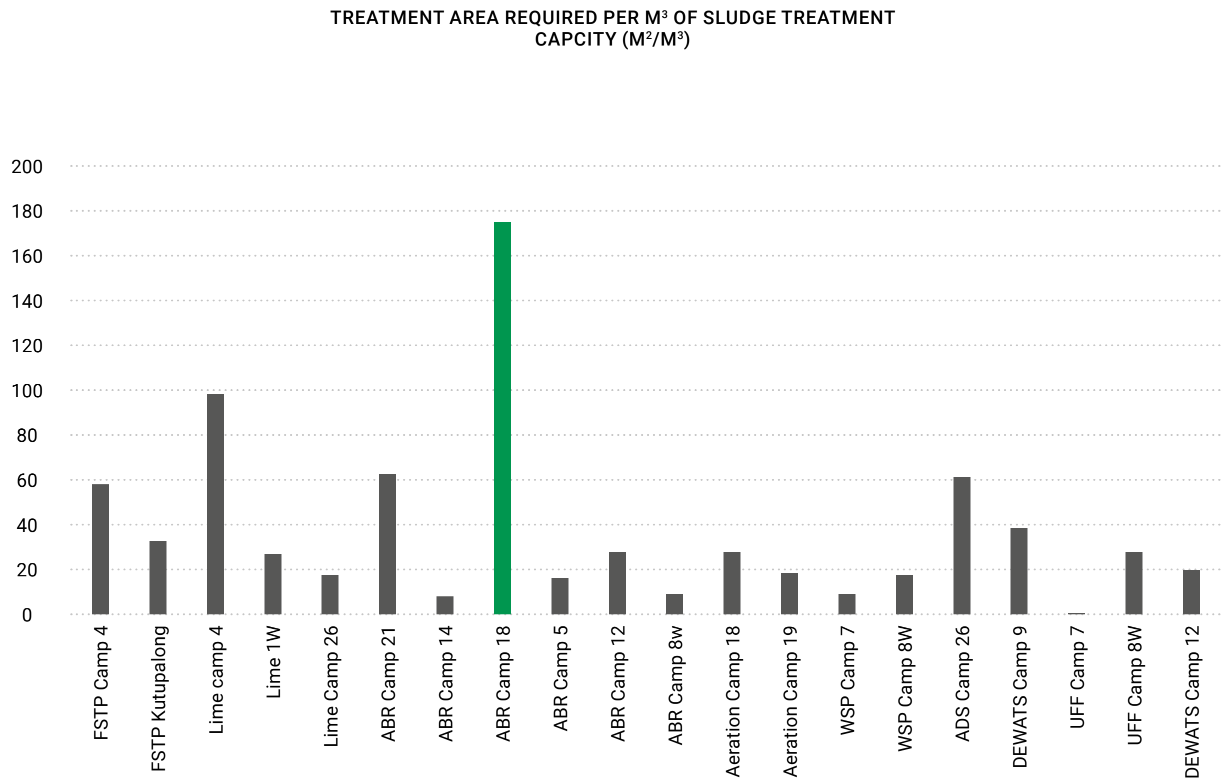


Figure 17: Area required per m³ capacity for FSTPs visited

3.4.4 Capex, Opex and Whole Life Cost

Figure 18 and Figure 19 below show the capital cost (Capex in USD) per m3 of sludge (design capacity); and operational cost (Opex in USD) per m3 of sludge per day (volume currently treated).

The data shows that the technologies with the lowest Capex per m3 capacity are: lime treatment, anaerobic digester, and ABR. These technologies are relatively simple, and their construction does not require major civil engineering works. The lime however, has relatively significant Opex due to the cost of the chemicals. The anaerobic digester has the lowest Capex and Opex. However, only one site for an anaerobic digester system was visited, and more data should be collected to conclude whether this is the lowest cost technology.

The UFF is the technology with highest Capex per m3(note limited capex data), along with the centralised multi-technology plants. The data shows that DEWATS, however, have a much lower capex than the UFF, despite of being based in similar processes. The UFF sites visited used multiple tanks and incorporated different components such as downstream constructed wetlands which require additional civil works. UFF sites were using 'assemble on site' tanks, which increased the initial cost and labour. By contrast, the DEWATS visited were using infiltration trenches to dispose the effluent. The Opex recorded for both, DEWATS And UFFs, is relatively low, as with the multi-technology centralised sites. Reasons for outliers are highlighted and investigated in Appendix A.

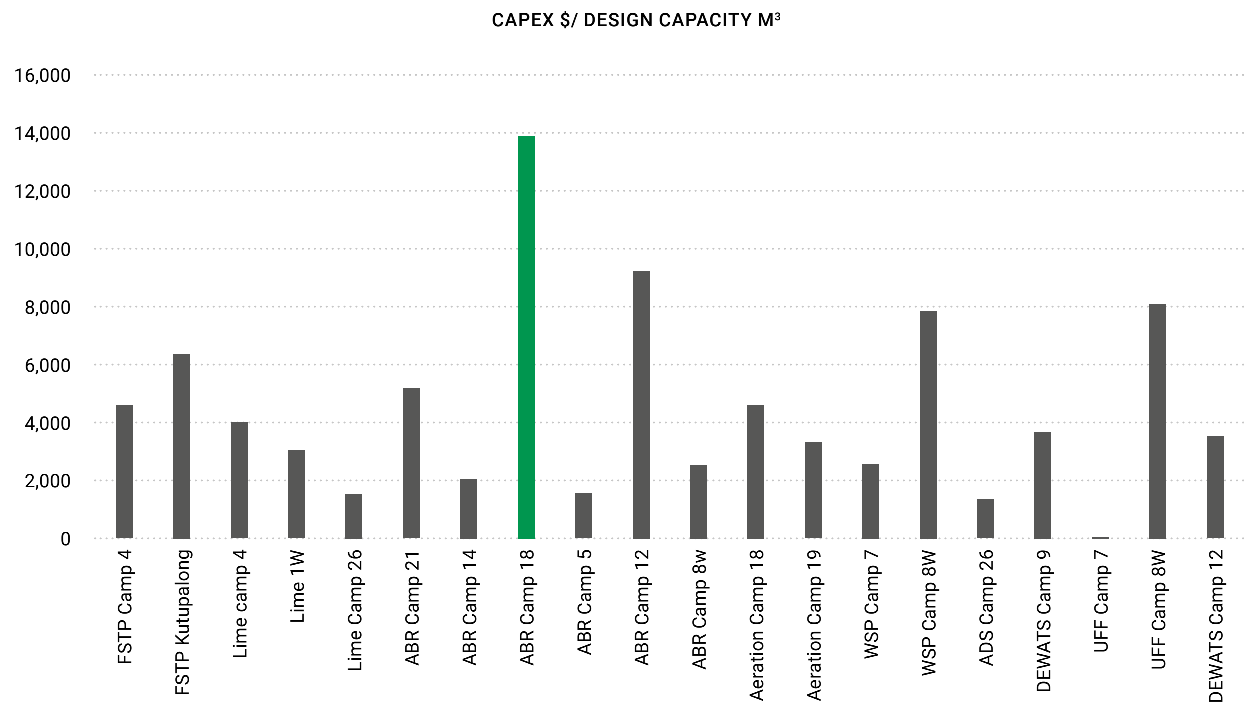


Figure 18: Capex per m³ capacity for FSTPs visited

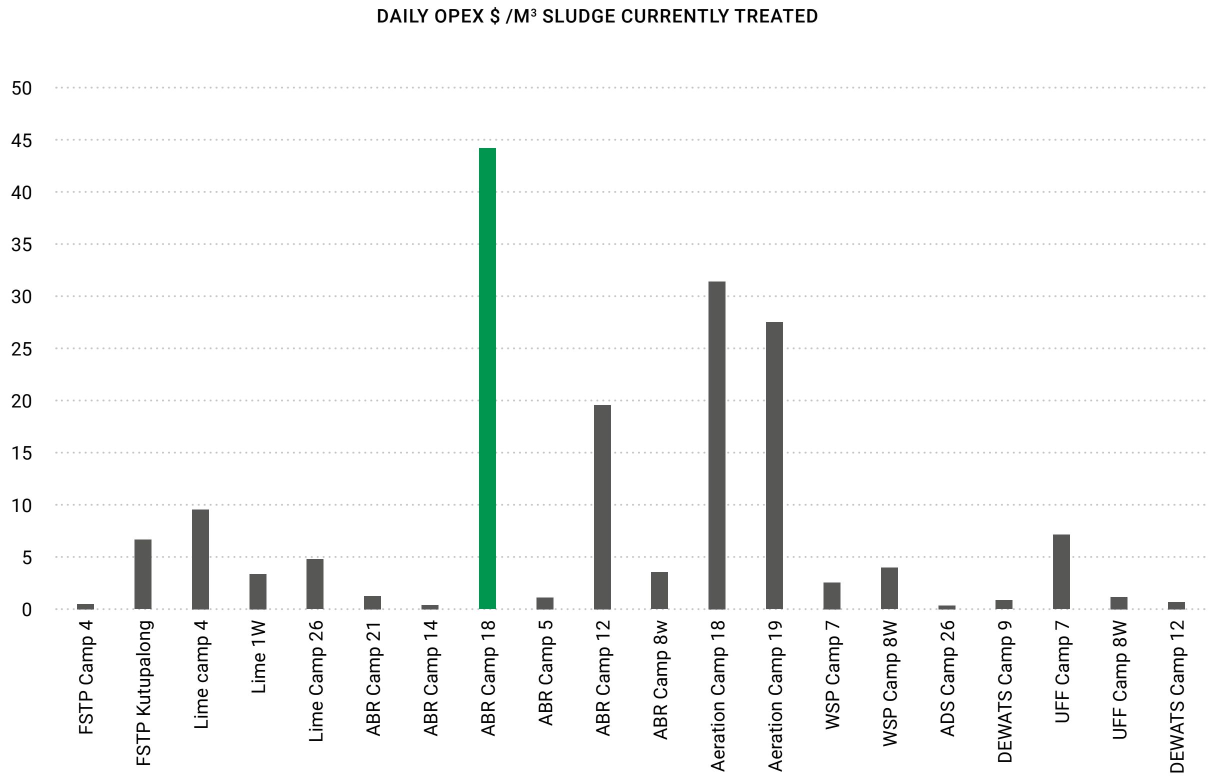


Figure 19: Daily Opex per m^3 treated for FSTPs visited

WLC was calculated to give a view of the overall cost of an FSTP for its full life cycle. Transportation costs have not been included; they have been analysed separately in section 3.3. A comparison of WLC per year per m^3 capacity showed that most types of FSTP are within the range of USD $500 to $1,500. The centralised plants were at the lower end of this range, showing that, across their lifecycle, they are comparable or more cost effective than (most) decentralised FSTPs (noting limited data set and assumptions). There are three outliers, of which two are ABRs and one aeration. These can be explained by the relatively high initial Capex, or limited detail on Capex, leading to over estimation of Capex and Capex repeats.

An attempt was made to include the transfer chain in the WLC but information of initial Capex of transfer was not available for this assessment, hence only FSTPs are covered. The WLC assessment includes assumptions on Capex repeats (as stated in Table 2). A majority of operators were not clear on this as FSTPs had not been operating long enough to incur any need for replacement/ refurbishment of large elements. There was also limited clarity on design life. Therefore, these WLC figures should be treated with caution.

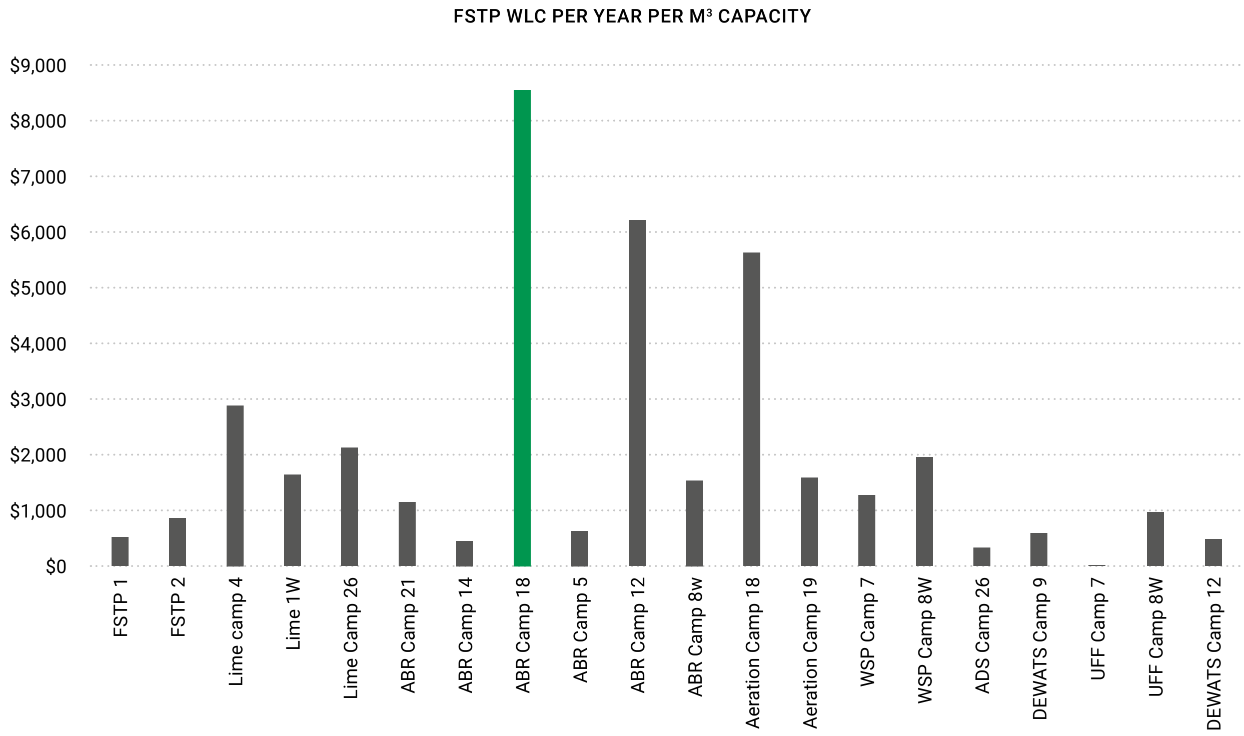


Figure 20: WLC per year per m³ capacity

3.4.5 Site specific influencing factors

The data collected only showed two trends cited for how the site conditions were influencing the FSTPs:

1. The topography influenced the mechanism used to move the sludge through the plant. Flat sites required pumping, which increases the complexity of the treatment, the risk of failure and the Opex costs. By contrast, sites with a slope benefit from gravity flow.
2. Sites with limited road access present more challenges in transferring sludge to the FSTP and tend to rely on manual transfer of sludge. These sites are more susceptible to changes in incoming sludge volumes which can impact the treatment performance for biological treatment processes.

3.4.6 Operation and Maintenance

The specific operation and maintenance activities for each treatment type have been described in Appendix H. However, there are some common issues worth highlighting:

- Replacement of filter media also includes cleaning or disposal of the old filter media and flow management during this activity which can be onerous. This item will be applicable to all FSTPs using filters i.e., UFF, DEWATs, mega FSTP 1 and all ABRs with downstream filters. The Mega FSTP 1 has some resilience as it has two parallel process streams for the upstream (phase 1) elements including UFFs i.e., one could be used when the other is offline for maintenance. Other smaller/decentralised sites have a single process stream which means taking elements offline for maintenance is more difficult. Bypass pipes to facilitate maintenance should be considered in the design.
- Unless spare parts are stored, there is a supply chain risk when replacing gate valves to control flow. A majority of sites had used locally available valves so that spares are available. Larger centralised plants, where bigger valves are required, may have more supply chain difficulties as the larger sizes may not be in common use on Bangladesh.
- Blockages in pipework and flow controls are frequent. Some sites had designed in rodding points/ access chambers for blockage clearance or enough valves to isolate certain sections of pipework (e.g. DEWATS). This helps to manage blockages if they occur.

3.4.7 Treatment Performance

A review of the treatment performance of the FSTPs was undertaken based on the available (camp wide) monitoring data provided by the WASH sector, Stakeholders and FSTP operators. Monitoring data was available for raw (incoming) sludge and final (liquid) effluent for approximately 165 FSTPs[8], and in some cases (for 13 FSTPs) long term data was available for additional monitoring points through the treatment process. The focus of the review was on the 20 FSTPs visited during this study. This was supplemented with a general review of available camp wide data by FSTP type, especially where additional monitoring was available. The key sources, data range and coverage of laboratory monitoring data are shown in Appendix C. It should be noted that limited information was available for two (of 20) sites visited (FSTP 2 and one of the aeration sites). This was because they were being commissioned at the time of visit, so no historic monitoring had been undertaken, and only a few samples were taken to aid commissioning.

The FE standard achieved for each FSTP was compared against the Bangladesh Department for Environment Guidelines (2019) Schedule 7 standards for sewage discharge (to surface water), with the key pollutants and pathogens reviewed. It is important to note that these standards do not include helminths. Therefore, this data was also compared against the WHO wastewater reuse for agriculture standard i.e., 1 egg/l. In addition, the FSTP performance was reviewed against performance of similar type FSTPs within the camps, and between FSTP types. This aimed to give an indication of which technologies are operating well. A summary of findings is given in below, and a detailed review is included in Appendix C, with key items for each plant visited in Appendix A.

The key quality parameters reviewed were:

- pH and temperature
- BOD and COD
- Nutrients: Nitrate, Phosphate and Total Nitrogen
- Suspended Solids and Total solids
- Pathogens: E. coli, helminth eggs, V. cholerae and Enterococcus

(8) This is the total (approx.). number of FSTPs sampled across all agencies. Note data was provided for some sites that are of technology types not included in this study hence data points were not used. There is also some overlap in data where slightly different X, Y coordinates given so not clear which is the receiving FSTP potentially leading to double counting.

Key findings from the treatment performance review were:

- A majority of FSTPs fail to meet the DoE effluent standards for most parameters, hence the effluent can pose a risk to human health and the environment.
- Performance for all FSTPs is better against pH and nutrients (Nitrate and Phosphorus), although a majority fail in Total Nitrogen . The raw incoming sludge is generally already below the nitrate and phosphorus standards, likely due to the domestic nature of the wastewater i.e., limited pollution from agricultural runoff or industrial sources, hence FSTPs meet the effluent standards. It should be noted that the raw sludge would be classified as a 'Category A' under the Bangladesh Standards and Guidelines for Sludge Management[10] i.e., sludge is produced in a sewage treatment plant treating only domestic or urban wastewater.
- The aeration plant (activated sludge) performs best against the standards, passing the COD and pathogen requirements, as well as pH and nutrients. This plant also showed consistent performance, achieving the standards most of the time. This FSTP also had regular monitoring and good access to a laboratory, providing evidence of its consistent performance. The plant (camp 18) is being decommissioned but the data can be used as evidence of potential performance should this technology be used again in the future.
- The 'mega FSTP' anaerobic lagoons also showed good performance with relatively consistent COD and BOD removal over the year i.e., no evidence of seasonal variation in treatment performance. Although the BOD and COD standards were not achieved the FE was not significantly over the standard. This FSTP also performed well for pathogen removal with most samples (even over long term) passing for E. coli and helminth eggs. This FSTP also had regular monitoring over 2020 and 2021, providing evidence of its consistent performance.
- The two 'centralised' FSTPs showed generally better and more consistent performance than the smaller 'decentralised' FSTPs. The consistency is likely to be related to size i.e., larger plants have more built-in retention time and larger flows so can cope better with changes in raw sludge (e.g., a small strong load would have limited impact when mixed at the inlet works and diluted) and are able to smooth out any shock loading. The good performance may also be due to adequate design sizing i.e., designed and sized with some redundancy/ growth capacity.
- Some smaller (or decentralised) FSTP samples meet the standards for solids, COD and pathogens. However, this performance was not consistent by FSTP types (e.g., one UFF might be passing whilst another fails) and there was no clear trend in design, raw sludge or operation, that could determine reasons for better performance.
- Of the smaller (decentralised) FSTPs, the ABRs and ADS perform the best for BOD/COD, although most results were still breaching the DoE standards. Plants that are not operating at their design capacity are underloaded which can affect the removal rates e.g. biological treatment cannot build up to its optimum performance.
- Lime sites had high pH and generally poor performance for COD/BOD and nutrients removal. Some lime FSTPs show passing results for pathogens but this is not consistent across lime sites, and there was no clear trend in design, raw sludge, or operation, that could determine reasons for better performance.

- The review of DEWATS and UFF showed they were performing relatively poorly compared to other decentralised FSTPs. There was some limited evidence that the smaller systems ($12m^3$/d capacity) had lower solids removal than the larger systems ($21m^3$/d capacity), and hence lower BOD and COD removal. BOD and COD removal was generally poor across all UFF. Both DEWATs and UFFs had added a stage of retention/settlement ahead of filtration (since phase 1 review) which is helping the process and avoids the issue of frequent filters blocking.
- It was noted during the core team meetings that many FSTPs dispose of treated liquid final effluent via a soakaway or infiltration system, and hence do not discharge to surface water, perhaps negating the need to meet the DoE standards and allowing smaller FSTPs with lower treatment performance to be used. There are no specific Bangladesh standards relating to disposal of final effluent via infiltration, though there is a standard for pit latrines, where the bottom of the pits should be 1.5m above the ground water table. The contamination risk to ground water and nearby surface water (and potentially to drinking water supplies), is well understood (by WASH sector, stakeholders and operators of FSTPs etc). It was acknowledged that a site-specific risk assessment was required to assess the risk of groundwater contamination and the potential (consequential) pollution of drinking water supplies.

3.4.8 FSM chain influence on treatment performance

The data for the raw (incoming) sludge was reviewed against the transport method, with the aim of seeing if the different upstream sludge chains influence the quality of the raw sludge arriving at the FSTP, and impacting the downstream performance. One key parameter reviewed was solids (total solids and suspended solids) to understand if conveyance and transport systems that include storage tanks, influence the solids content of raw sludge arriving at the FSTP, e.g., to see if solids are removed / settled out in storage tanks in the network and sludge with a higher liquid content arrives at the FSTPs. A summary is given in Table 12 below. While limited data restricted this assessment, an attempt was also made to compare a chain within network storage, and one without, camp 15 was used as the example for an area with lots of storage tanks within the network.

The data showed no significant difference in the raw sludge solids content from the differing transport modes, or from a network with lots of storage tanks. The VacTug showed slightly lower average solids, which was not expected (no network settlement would occur for the Vactug mode). However, the range of data (2-15 mg/l TS) was similar to other modes of transport, but less consistent e.g. can transport a load with more solids or less but limited ability to mix within the VacTug capacity or at inlet to FSTPs (where there are generally no buffer tanks). The deviation in consistency (of values from average solids) was also slightly higher for the example with several storage tanks, indicating that a 'slug' of solids might hit the network when tanks are fully emptied. The piped systems generally deliver more consistent raw sludge.

(10) https://doe.portal.gov.bd/sites/default/files/files/doe.portal.gov.bd/publications/2398e6c5_c300_472d_9a0c_0385522748f3/Bangladesh%20Standards%20and%20Guideline%20for%20sludge%20management-%20September%202016.pdf
(11) Extract from Standards and Guidelines for Sludge Management 2015 - To protect groundwater and surface water from pollution, the following buffer zones are recommended between the area of application and the water receptor: - Depth to aquifer => 5 m - Distance from surface water/borehole => 200 m shall be prohibited.

Transport mode	Ave raw sludge solids	Comment
Single: IFSTN/ permanent pipe network and pump	8.0g/l Total Solids and 5.1g/l TSS	*13 data points. Data reasonably consistent.*
Mixed: VacTug	6.4g/l Total Solids, and 3.3g/l TSS	*12 data points. Average lower than other modes. Relatively inconsistent e.g. limited ability to mix within the vactug capacity.*
Single: Manual Desludging and Transport	Limited raw sludge quality data for camps where we have transport data (i.e., camp 12)	*2 data points i.e. not enough to draw conclusions*
Single: Pit transfer/ temporary pipe and pump	7.9g/l Total Solids and 5.0g/l TSS	*19 data points for TS and TSS*
FSM chain / FSTP catchment with lots of network storage tanks (Camp 15 used as an example transport data not provided)	4.9g/l TSS	*Similar TSS to others, deviation from Ave TSS is greater indicating some 'slugs' of solids maybe occur when tanks are fully emptied*

Table 12: Raw sludge solids by transport mode

3.4.9 Disposal of final products

Liquids were infiltrated, evaporated or discharged to the environment. No site reported the reuse of the effluent. More detail can be found in the treatment performance review, section 3.4.7.

Where infiltration is used and effluent is not meeting the DoE pathogen requirement one standard that could be considered is the Bangladesh is from the Standards and Guidelines for Sludge Management[12], which sets out groundwater protection 'buffer zones' for sites where treated sludge solids are spread i.e., sewage sludge reused for agriculture. Although this relates to the solids portion of the treated sludge (i.e., not the treated final liquid) it could be used, along with previous WASH sector guidance, as a starting point for setting groundwater protection zones around FSTP final effluent infiltration.

Final disposal of solids was not investigated in detail during the study. Disposal routes were noted for the 20 sites visited. Three sites were using incinerators to dispose of the final solid and using the ashes in agriculture. Another three were sending the solids to compost off site (not visited). Two sites reported using the solids for landfill. The rest of the sites were currently storing the sludge on site. Not all of them had a further plan in place, although some operators were assessing different options for circular sanitation, such as the idea of composting the sludge .

As noted in phase 1, there was often limited space at the FSTPs for storage, disposal or reuse of the final solids, which led to poor management. There may be opportunities to consolidate final solids handling and safe disposal or reuse, e.g., with a more centralised composting or other solids treatment process (e.g. Omi processor). Although this would add another handling step to the FSM chain i.e., moving the final solids to a further treatment site after the FSTP, it would ensure the safe disposal/reuse of the final solids, and allow efficiencies to be made in treatment i.e., a minimum scale for composting or other processes to operate efficiently could be achieved. It would also allow sludge products (compost or energy) to be safely reused. It should be noted that solids treatment technologies such as digestion need a certain solids content, and dewatering or rewetting of the final solids from FSTPs might be needed to facilitate further treatment and energy recovery. The future solution adopted would need to be adequate to the context (considering site conditions; capacity to set, operate and maintain it).

The potential value of the final solids as a useful product has not been explored in the FSM chain, as operating NGOs are focused on safe disposal and reducing the volume of final solids (several mentioned composting). There is a need to understand the market and acceptability for sludge products (compost, gas etc) to understand if additional solids handling could be made cost efficient i.e., offset Capex and Opex costs by selling fertiliser or compost in local areas.

3.4.10 Resilience to natural disaster

Resilience to heavy rain and flooding was accounted for in the design of most of the FSTPs visited. The main measures taken are:

- Providing adequate drainage around the site for surface water management
- The treatment units are placed on elevated platforms
- Slope protection is installed to avoid landslide around the site, such as retention walls

One of the sites visited that was being commissioned was particularly looking at how to become more energy efficient and exploring using easy-to-repair items in the units to become more resilient.

3.4.11 Pinch points

Information on the pinch points for each site was limited. Any data recorded has been shared in in Appendix A for each FSTP type. The main pinch points that can be highlighted are:

- Not enough capacity to collect the volume of sludge to meet treatment capacity
- Infiltration of final liquid is limited by high ground water levels in the rainy season, as described in Table 8.

3.4.12 Summary of findings for treatment technologies

The Table 10 below provides a holistic summary of the performance of each technology against each parameter assessed. At the initial phase of the emergency, parameters like construction time and skills required to set up and operate the system were key, due to the time limitations. However, at the current stage, the focus is on technologies that are cost-effective and resilience, to ensure long-term sustainability.

(12) Extract from Standards and Guidelines for Sludge Management 2015 - To protect groundwater and surface water from pollution, the following buffer zones are recommended between the area of application and the water receptor: - Depth to aquifer => 5 m - Distance from surface water/borehole => 200 m shall be prohibited.

PARAMETERS	Centralised	Lime	ABR	Aeration	WSP	Anaerobic digesters	UFF	DEWATS
Design Capacity m^3/day	165 ave (150 to 180)	7 ave (5 to 10)	10 ave (6 to 15)	23 ave (15 to 30)	3.25 ave (2.5 to 4)	5	3 ave (3)	4.5 ave (3 to 6)
Treatment area m^2/m^3	45 ave (33 to 58)	47 ave (17 to 98)	49 ave (9 to 175)	23 ave (18 to 28)	13.5 ave (9 to 18)	61	28 ave (28)	29.5 ave (20 to 39)
Scalability	Medium	Medium	Low	High	Low	Medium	High	High
Capex UDS $/ m^3	5,517 ave (4,646 to 6,388)	2,891 ave (1,554 to 4,060)	5,758 ave (1,564 to 13,907)	3,983 ave (3,333 to 4,633)	5,244 ave (2,600 to 7,888)	1,392	8,133 ave (8,133)	3,555 ave (3,555)
Opex UDS $/ m^3*	3.65 ave (0.60 to 6.7)	5.94 ave (3.44 to 9.57)	11.7 ave (0.4 to 44.2)	29.46 ave (26.75 to 31.4)	3.3 ave (2.6 to 4)	0.39	4 ave (1.4 to 7.22)	0.8 ave (0.69 to 0.91)
Whole life cost	653 ave (474 to 831)	2,188 ave (1,607 to 2,858)	3,063 ave (419 to 8,530)	3,579 ave (1,553 to 5,604)	1,584 ave (1,248 to 1,921)	306	939 ave (939)	500 ave (453 to 548)
Construction time (months)	12	1.3 ave (1 to 2)	4.5 ave (2 to 8)	9 ave (8 to 10)	2.5 ave (2 to 3)	2	1.5 ave (1.5)	1 ave (1)
Complexity of process	Medium	Medium	Low	High	Low	Low	Low	Low
Treatment performance	Good	Poor	Poor (for pathogens)	Good	Medium	Medium	Medium	Medium

Table 13: Review of parameters for each FSTP

Multi-technology centralised FSTPs ('Centralised' in table 12), have the highest capacity to treat sludge. Despite having a high Capex, they are cost efficient, with a low Opex and WLC. The data shows that they can provide better and more consistent performance than the smaller 'decentralised' FSTPs. They are also able to cope with variability of the sludge, which can happen during rainy seasons or when different methods to transport the sludge are used. It is important to note that centralised data is based on two sites, one of which is under commissioning. More data would be needed to confirm these initial findings.

Lime treatment sites have a low Capex and the technology can be set up fast. This made lime a viable choice for rapid emergency response. However, for this phase, they should not be a preferred solution. Their Opex is significant due to constant use of chemicals, and the need to manage lime poses a health and safety risk to the operators. In addition, the data shows that they are performing poorly.

DEWATS and UFF are not meeting DoE FE standards. UFFs show a high Capex, while for DEWATS both capex and opex is low. Both technologies are quick to deploy and to commission and decommission.

Aeration plants require a low land area and are modular and scalable. The data (from camp 18) shows that aeration plants can perform consistently, achieving necessary standards. The Opex for this plant is high, but it could be reduced by transitioning to solar energy to operate the mechanical equipment. This technology is complex to operate, and the stakeholders do not consider it very appropriate for the context. The good effluent quality and low land take need to be considered alongside the complexity when choosing a technology in the future i.e benefits of final effluent quality might outweigh concerns over complexity.

ABR and WSP are the technologies that do not require a lot of area, and they do not have extremely high Capex or Opex. However, data shows treatment performance is below DoE standards. Consideration needs to be given to the scalability of these technologies too. ABR and WSP are not modular, and therefore, they are difficult to scale up and adapt to treat higher volumes without adding a parallel process stream.

Only one site with an anaerobic digester system was visited. The data showed low Capex and Opex, and limited performance. More data would be needed in this technology to raise any conclusion.

Variations in the quantity and quality of sludge to be treated during rainy season (due to more challenging transportation of sludge, and limited infiltration of the final effluent) can impact the treatment performance and needs to be considered in design.

The FSTP design needs to consider the sludge collection area (catchment) and the transport mode and ensure they will not be a bottleneck to the FSTP reaching its design capacity. Multiple transport systems for FSTPs can lead to variations in the raw sludge (solids). Technologies that can absorb this variation without affecting their performance should be preferred. The addition of buffer or balancing tanks at the FSTP can help smooth flows and loads but care must be taken to avoid solids accumulation in these tanks.

The main factors that influence the Capex of an FSTP are the civils work needed, the labour required, construction time, materials, and components. Purchasing materials and components locally, such as local tanks and bricks, reduces the initial investment and help facilitate ongoing maintenance (spare parts).

The Opex of FSTPs is heavily influenced by energy use (usually for pumping), and chemicals required (such as lime or chlorine); as well as the number of operators needed, and the rent of the land. Topography that allows gravity flow should be preferred to minimise costs related to pumping. When pumping is required, solar energy could be used to reduce the Opex cost. A thoughtful layout design, which minimises the space used could also help to reduce the cost, by reducing the rent and the area in need of general site maintenance.

Treatment is the highest proportion of the Whole Chain operational Cost and therefore WLC of the FSTP if an important governing factor in total cost.

14 sites visited were storing the final solids on site without a further plan to reuse it or safely dispose of it. A long-term plan for solid disposal is needed. Consideration should be given to a centralised solution, and investigation into the potential (local) markets for sludge products, i.e., adding value to sludge could help offset costs of a centralised solids treatment site.

The final liquid effluent from the sites is currently infiltrated, evaporated or discharged to the (surface water) environment. A majority of FSTPs fail to meet the DoE standards which can pose a risk to the environment and human health. For sites that infiltrate the FE, a ground water risk assessment and infiltration capacity testing should be a standard step in the design. For existing sites, groundwater risk could be retrospectively assessed, and improvements put in place e.g., for sites with soak pits. Sites that discharge to surface water should ensure pathogen inactivation via improvements to treatment or additional disinfection processes at the back end of FSTPs.

Aeration plants perform well against DoE standards. They are easy to scale and more space-efficient when treating higher volumes. They have high Opex, due to the constant energy required. However, this technology is not considered appropriate for the context due to its complexity.

DEWATS plants have a low WLC, they are scalable, and can be set up quickly. The data shows that they are not meeting DoE standards however FE is infiltrated limiting exposure.

Lime treatment sites have a low Capex, and the technology can be set up fast. However, they are not performing well. Their Opex is significant, and they can pose a health and safety risk to the operators (from lime powder). Decommissioning and replacement of this technology should be considered.

3.5 CENTRALISED AND DECENTRALISED FSTPS

A comparison between Centralised and Decentralised FSTPs was done to assess if adopting centralised treatment plants in the future in CxB is a good strategy.

Centralised plants are those designed to treat the highest volumes of sludge in CxB (120 to 180m³/day). The increased treatment capacity comes with the largest catchment area and FSTP site area and has the highest Capex reported. Two sites were classed as centralised within this study (FSTP 1 aka Mega FSTP 1 with treatment process based on anaerobic lagoons; and the new FSTP 2 in Kutupalong, with a multistage biological treatment).

Figure 21 and Figure 22 show the performance of the centralised plants for treatment area required (per m³ of sludge treated) and Capex (per m³ design treatment capacity) against the minimum, maximum and average performances of the Decentralised plants.

Even while having the largest treatment areas and Capex, the centralised plants show an average treatment area required (per m³ of sludge treated) and Capex (per design treatment capacity) ratios similar to, or lower than, decentralised plants.

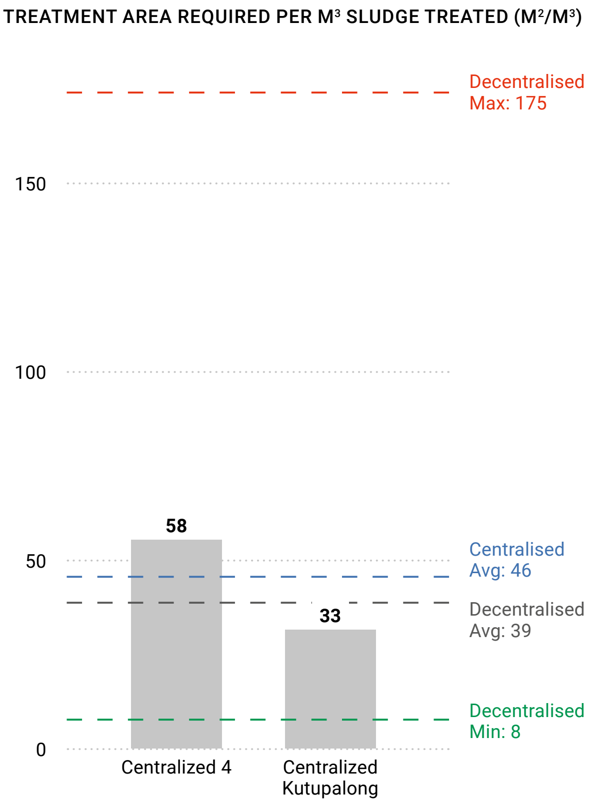


Figure 21: Relative performance of Centralised plants for treatment area required (per m³ of sludge treated)

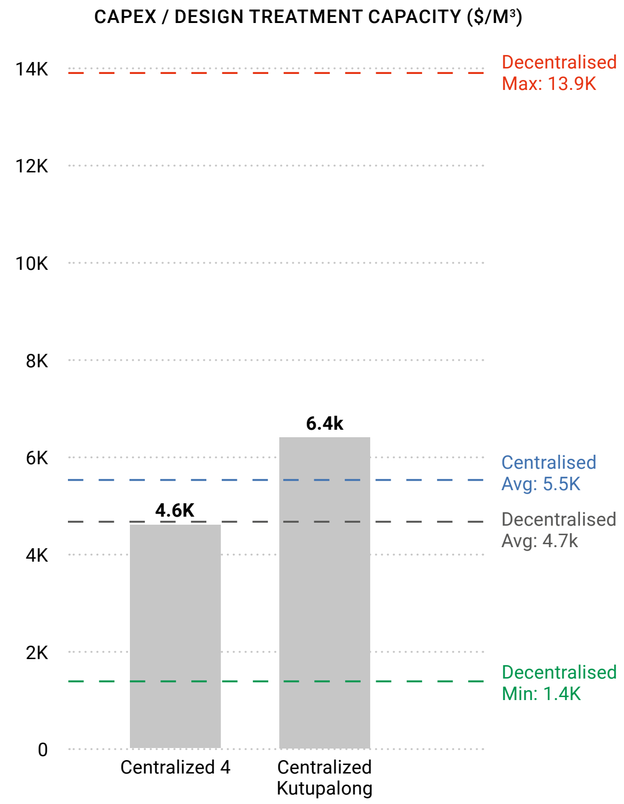


Figure 22: Relative performance of Centralised plants for Capex (per m³ design treatment capacity)

The data collected from the FSTPs visited shows that the centralised plants are amongst the cheapest to operate (a number of ABR and Aeration plants report higher Opex per m^3 than the centralised plants). It should be noted that costs displayed are for the FSTP only and that the Mega FSTP 1 is served by the IFSTN. If sludge was transported via road vehicle or other non-permanent pipe system, the Opex cost of conveying such a large volume of sludge would be larger than any other system, see section 3.3.1 and 3.3.2.

The centralised plant in Kutupalong is in commissioning stage. Given the biological nature of its treatment, time must be allowed for the biological treatment to establish and be optimised. Once the treatment process is stable, optimisation could reduce overall operational cost. However, this is not likely to change the total FSPT Opex significantly. Despite this, the operational cost per m^3 of sludge treated of the centralised plant in Kutupalong is still scoring below the above mentioned ABR and Aeration plants, and one of the Lime plants visited. Overall, the centralised plants show one of the best scores in regard to the daily Opex and WLC/year per volume treated (Figure 23 and Figure 24).

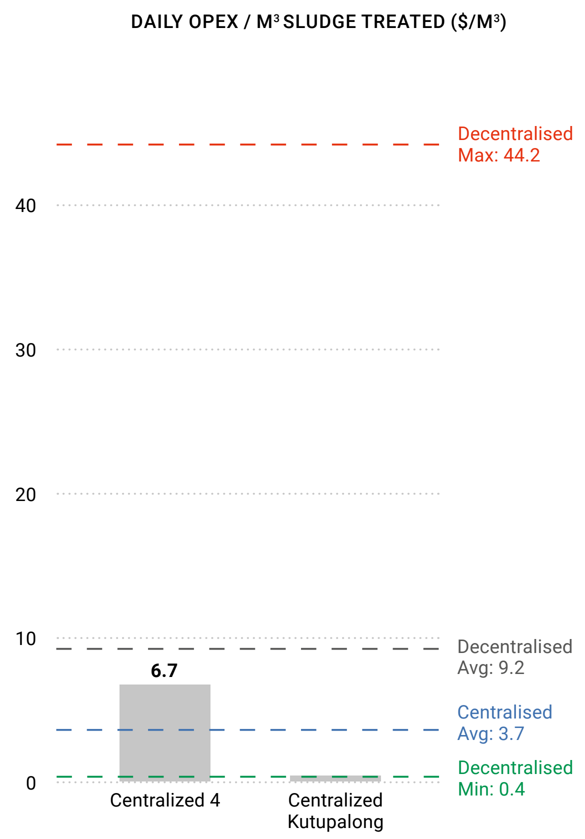


Figure 23: Relative performance of Centralised plants in regard to Daily OPEX per volume treated

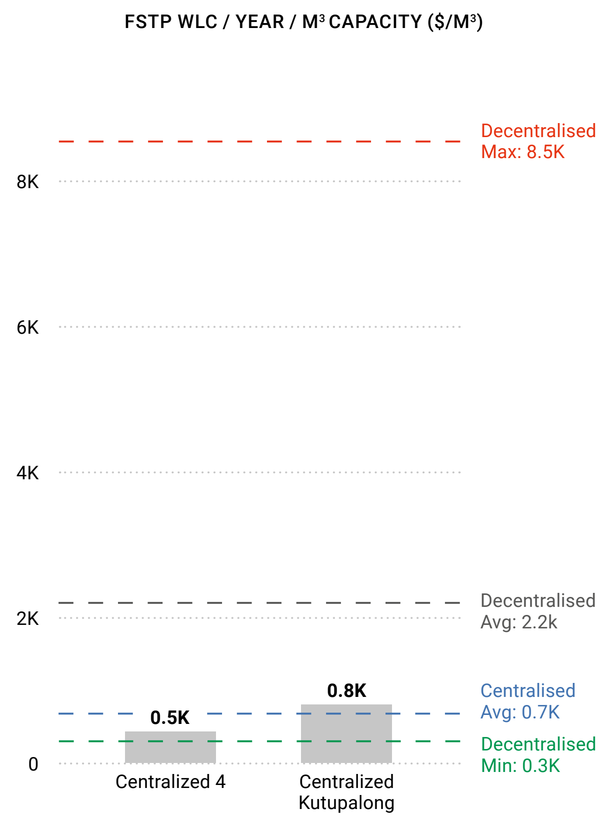


Figure 24: Relative performance of Centralised plants in regard to WLC per volume treated

Because of the greater transportation and treatment capacity of the Centralised FSTPs and associated chains, it is expected that the initial investment (Capex) is higher than for small-scale or decentralised FSTPs. However, the review of WLC in section 3.4.4 showed the centralised plants were at the lower end of the WLC per volume of sludge treated range, showing that, across their lifecycle, they are comparable or more cost effective than most decentralised FSTPs, (noting the limited data set and assumptions).

Additionally, Section 3.3.2 showed that for the whole chain operation costs treatment Opex was the most influential factor, and this is dictated by the treatment WLC. It was also highlighted in Section 3.3.3 that the initial investment in IFSTN systems (that are expected to be transferring sludge to centralised plants) is paid off through the respective lowest running cost per volume of sludge transferred.

As highlighted in Section 3.4.7, the two centralised FSTPs showed generally better and more consistent treatment performance than the smaller 'decentralised' FSTPs, perhaps linked to available retention capacity to cope with changes in raw sludge or process conditions. This is beneficial for areas where different transportation modes are used, potentially impact consistency of the raw sludge.

From the data collected and analysed in this study the centralised plants proved to be performing above average in the capacity utilisation, footprint area and cost performance ratios while treating to a relatively good standard.

Centralised treatment technology can cope with a wider range of variation of incoming sludge, which can cater for the diverse transportation modes currently used in CxB.

The overall cost of the centralised system (Mega FSTP 1) would be significantly higher with a different form of sludge transfer i.e. not a piped network.

In the shorter term e.g., next 5 years, improving the existing FSTP infrastructure is likely to have the lowest Capex and environmental impact (from materials use etc). However most existing sites do not have space for additional process stages required to achieve DoE effluent standards or accommodate population growth, therefore this is unfeasible. In the 'longer term' i.e., 5 to 10 years most FSTPs in this study will have reached their design life, it would be most cost effective, looking at whole chain cost, to provide a centralised FSTP with permeant pipe as transfer system.

3.6 SUMMARY OF CAMP WIDE FINDINGS

Sludge generation

- Sludge transferred is (approximately) equivalent to 1.1 l/h/d. If this is extrapolated it gives an average monthly production of sludge of 29,718m^3 (for the 904,639 population). A range of 0.8 to 1.5 l/h/d is thought to be representative.
- It was difficult to assign a sludge collection catchment area to each FSTP as there is some overlap of catchment, and variation in sludge chains/ collection areas over time.

Containment

- There are eight types of containment agreed to be used in CxB. However, many more types are noted as being in use across the camps, and recorded in the WASH database/data collection. The number and naming of types should be rationalised by the sector where possible.
- There is always a mix of containment types within each FSTP catchment area/ across the camps. This means that no particular type of containment is influencing the downstream FSM chain i.e., no influence on quality or quantity of raw sludge.
- The desludging frequency (of all types of containment) can reduce in the rainy season due to challenges with transportation and FSTP infiltration capacity

Transport / transfer

- Sludge transport is mainly via five modes. Most FSTP catchments use a mix of more than one mode to transport sludge to their sites.
- The cost ranges between $0.35 to $25 USD per m^3 sludge transported. The most cost effective per m^3 sludge transferred is the IFSTN.
- The mode selected is largely governed by the surrounding infrastructure (roads, access etc) and size of the FSTP catchment.

Treatment

- There are over 165 FSTP sites across the camps, where the main technologies are those covered in this study. Different (sector) datasets do not align on exact number of FSTPs, with discrepancies between the available data on the overall number. The WASH sector Infrastructure data (2021) set shows the total FSTP daily treatment capacity of 879m^3 across the camps. The total 'actual' treatment capacity is not consistently reported.
- The Capex per m^3 ranged from approximately $1,500 to $14,000 USD/m^3 and Opex from $0.6 to $44 USD/m^3.
- A majority of FSTP types use low/no energy or chemicals, and therefore are good for long term sustainability i.e., all except lime treatment and aeration. Sites with a lower use of construction materials will have a lower environmental impact in terms of construction (not effluent impact), e.g., simple lined earth structures such as the Mega FSTP 1 lagoons, Kutupalong FSTP 2, some of the lime sites or the WSPs. FSTPs such as the ABR and biogas use lined brick or concrete for watertight structures. These have a higher embodied energy and associated environmental impact, although it should be noted that bricks are locally available.

- Sites that are easily scalable (up or down) provide further resilience to change in population or camp layout e.g., Aeration and DEWATs can easily have additional (prefabricated) units added or removed to provide required treatment capacity. However, Aeration is complex and relatively difficult to operate in camp context.
- Looking at the whole FSM chain, the most cost effective FSTPs are shown to be the centralised system with the IFSTN. The centralised plants have also shown lower Opex and better treatment performance.
- Treatment is the largest proportion of the whole chain Opex.

Disposal

- If sites are infiltrating final liquid, an adequately sized infiltration trench/ area is needed based on site survey and taking into account season variation in ground water level. Risk assessments should determine the minimum treatment requirement, but it is likely these should meet the DoE discharge standards for pathogens (albeit they relate to surface water). If not achieved, chlorination or other disinfection should be used to reduce risk of spreading disease via pathogens contaminating the local environment. Sites discharging directly to water courses/ surface water drainage systems are often not meeting the FE standards and therefore chlorination or other disinfection should be used to reduce risk of spreading disease.
- As noted in phase 1, storage, disposal or reuse of the final solids often had limited space at the FSTPs which led to poor management. There may be opportunities to consolidate final solids handling and safe disposal or reuse, e.g., with a more centralised composting or other solids treatment process (e.g. Omi processor). The solution adopted would need to be adequate to the context (considering site conditions; capacity to set, operate and maintain it). Simple and low cost on site solutions could be more suitable than complex, very technical process.


OXFAM

4 CONCLUSIONS

The following section outlines the key conclusions and recommendations of this study and provides responses to the study objective questions set out in section 1.2.

1. USER

Total Rohingya population in CxB is **904,639 people**

Average generation rate estimated at **1.1 l/h/d**

Unknown volume lost to **open defecation**

2. CONTAINMENT

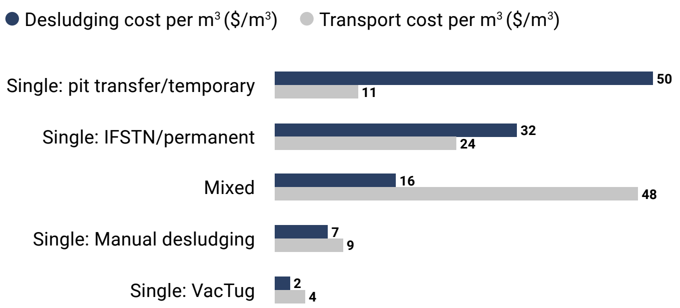
- Wide range of latrines used
- Latrines are desludged more often either because of insufficient capacity for the number of users, mixed use (black and grey water), operational defects and/or poor infiltration
- Public health risk during wet season because of latrine overflowing and poorer latrine maintenance

Unknown volume of **uncollected sludge or latrine overflowing** of latrines during the rainy season

3. TRANSFER

- 29,718 m^3 of FS in transit per month (26% average increase in wet season)
- Volume in transit during the wet season can be impacted by:
- Volume limited due to poor conditions to desludge and/or transfer
- Limited infiltration capacity at treatment
- Overflowing of latrines in low lands
- Latrines not accessible

Figure: Desludging and Transport cost per m³ ($/m³)



IFSTN are cheaper to run and can transport increased volumes of sludge. Their construction comes with an initial higher cost but this investment can pay off within 1.7 to 8.7 years.

4. TREATMENT

- It was not possible from the current data to determine the total available treatment capacity, hence not possible to estimate if total capacity meets the sludge generated.
- 164 Sanitation FSM sites listed in the WASH Infrastructures dataset from October 2021 (WASH IF dataset_Oct 21), but data collected during this study suggests there are either more facilities than the 2021 WASH IF dataset or different naming conventions are used for the same site.

5. DISPOSAL

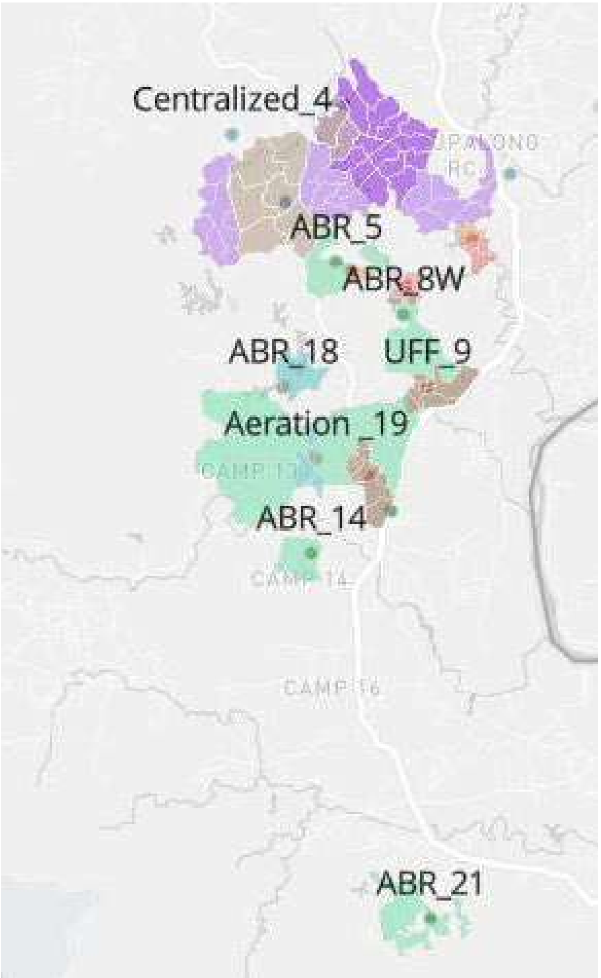
LIQUIDS DISPOSAL

- A majority of FSTPs fail to meet the DoE effluent standards for most parameters, hence the effluent can pose a risk to human health and the environment.
- Risk assessment of contamination of ground water is required to properly design the FSTP and define the capacity of the treatment and associated FSM chain

SOLIDS DISPOSAL

- There is a need to understand the market and acceptability for sludge products (compost, gas etc) to understand if additional solids handling could be made cost efficient i.e., offset Capex and Opex costs by selling fertiliser or compost in local areas.
- Consolidation/centralisation of solids can help move solids off FSTP sites, allow for an efficient solids treatment establishment and a better use of FSTP area (maybe refine treatment and achieve better treatment quality).

CATCHMENT AREAS OF 20 FSTPS VISITED UNDER THIS STUDY



Technology / catchment area

- Lime stabilization ponds (LSP)
- Centralized
- Waste stabilization pond (WSP)
- Anaerobic Baffled Reactor (ABR)
- Up flow filter
- Aeration
- Anaerobic Digester System (ADS)

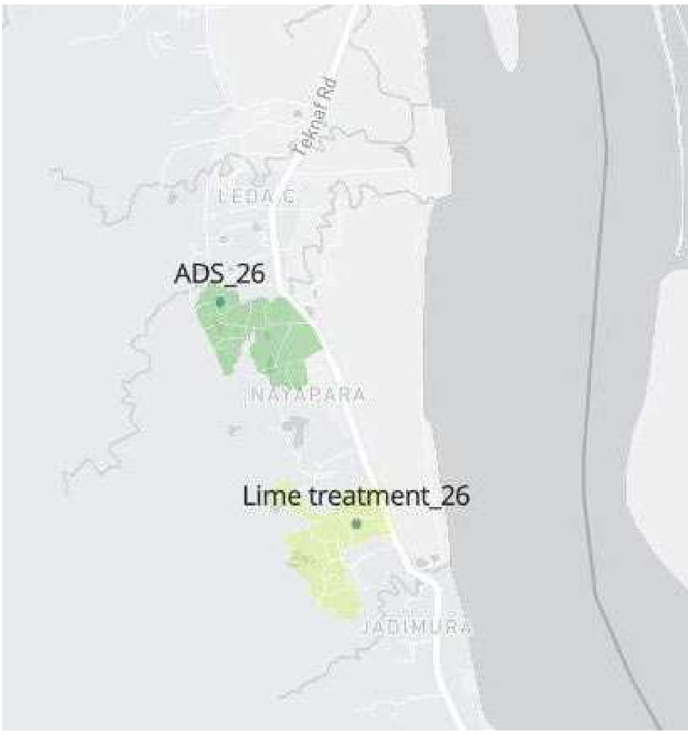
Overview

8 out of the 20 FSTPs visited were not utilising their full design capacity at the time of the study, leaving a nominal 196m^3 of underutilised capacity in total. Reasons being:

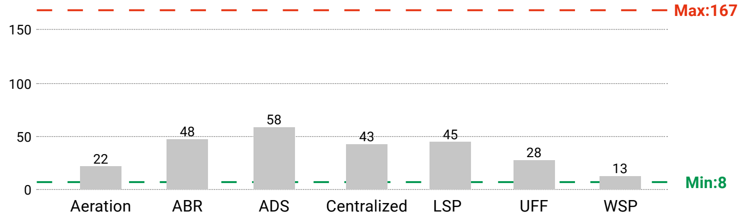
- Under commissioning
- Under decommissioning
- Poor final effluent quality
- Variable production of sludge depending on the season

Treatment performance

- The Aeration plant performs best against the standards (passing COD, pathogen, pH and nutrient requirements)
- Centralised FSTPs showed generally a better performance than the smaller 'decentralised' FSTPs



Average treatment area req per m³ of sludge treated (m²/m³)



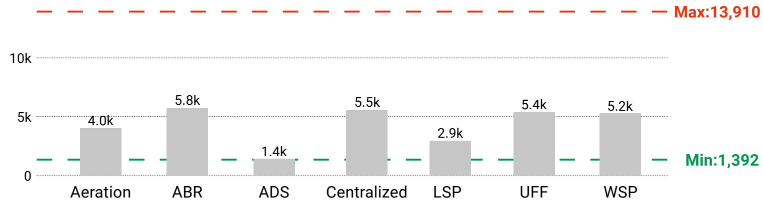
Max

The modular components of Aeration and UFF technologies allow for an efficient use of space, these technologies are also the most scalable.

Min

The higher number of sludge drying beds and solids handling area of the ABR in camp 18 drives up the site footprint and the technology average.

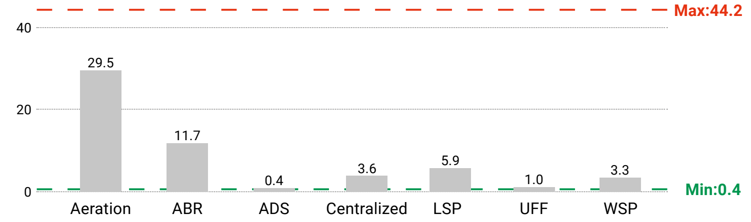
Average CAPEX / design treatment capacity ($/m³)



The main factors that influence the CAPEX of an FSTP are the civils work needed, the labour required, construction time, materials, and components

Purchasing materials and components locally, such as local tanks and bricks, could significantly reduce the initial investment and help facilitate ongoing maintenance (spare parts).

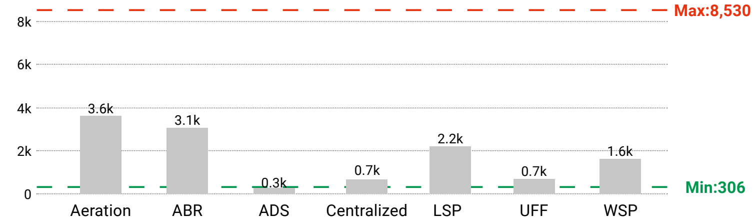
Average daily OPEX / m³ sludge treated ($/m³)



OPEX is heavily influenced by energy use, chemicals required, number of operators needed, rent of the land.

Solar energy can be used to reduce the OPEX. A thoughtful layout design, which minimises the space used can reduce the rent and the area in need of general site maintenance and OPEX.

Average FSTP WLC / year / m³ capacity ($/m³)



Centralised plants are at the lower end of the WLC range, showing that, across their lifecycle, they are comparable or more cost effective than most decentralised FSTPs, (noting the limited data set and assumptions).

The centralised plants proved to be performing above average while treating to a relatively good standard. This treatment technology can also cope with a wider range of variation of incoming sludge, which caters for the diverse transportation modes currently used in CxB.

Before any decision to build new centralised plants, an assessment of camp wide needs must be undertaken, as the current available data does not allow a sludge generation vs. existing FSTP capacity to be assessed.

Improving the existing FSTP infrastructure is likely to have the lowest Capex and environmental impact in the shorter term e.g., next 5 years. However, in the 'longer term' i.e. after 5 to 10 years when most plants in this study have reached their design life, it would be most cost effective, looking at whole chain cost, to have centralised with permeant pipe as transfer system.

4.1 RESPONSE TO RESEARCH QUESTIONS

1 Does the FSM chain meet the need? i.e., does each stage in the FSM chain have capacity to meet sludge generation, what are the bottlenecks and inefficiencies, and how can these be addressed?

- Limited progress has been made against this research question due to limitations of existing data and alignment of data sets for each stage in the FSM chain. Effort was made to collect data and extrapolate information. However, this will not give an accurate summary of the actual situation in camps.
- The total sludge generation (at point of desludging) is estimated at 1.1 l/h/d giving a total estimated monthly production of 29,718m^3 of FS. Wet season impact is 26% more volume.
- The total containment volume was not calculated as part of this study. Therefore, it is not known if this can meet the generation rate. Given the number of latrines (from existing data) and population, coverage should be sufficient, and the installed capacity should not be a bottleneck. However actual available capacity is governed by desludging frequency and this was not determined as part of this study. From anecdotal data, latrines are desludged more often either because of insufficient capacity for the number of users, mixed use (black and grey water), operational defects and/or poor infiltration.
- The transport/transfer capacity for the area included in this study was used to determine the sludge generation hence this will show that capacity is met. However, this may not give the full picture as there maybe unserved areas not covered in the data collected.
- The WASH sector Infrastructure data (2021) set shows the total FSTP daily treatment capacity of 879m^3 across the camps. For a population in RCs of 904,639 and a sludge generation rate of 1.1 l/h/day we get a daily sludge production of 995m^3.
- A majority of FSTPs (13 of 20 visited) were operating at 100% of their design capacity. This could indicate that available FSTP capacity just meets demand i.e., plant is already running at full flow. However, it is more likely this shows that capacity is below demand (plants running full and not whole catchment collected) and offers no room for (population) growth. Many FSTPs visited were not clear on their design life, and this could be evidence that growth had not be included in the design.
- Key bottlenecks identified were the FSTP infiltration capacity for disposal of the final liquid effluent; and the ability to access latrines in wet season for desludging and transporting the sludge.

2 Which type of FSTP is performing best against most assessment parameters? Including reasoning for improving or decommissioning FSTPs.

- The best overall performing technologies against the DoE standards are the centralised and aeration.
- It was noted during the core team meetings that many FSTPs dispose of treated liquid final effluent via a soakaway or infiltration system. Risk

assessment of contamination of ground water is required to properly design the FSTP and define the size and capacity of the treatment and associated FSM chain.

- Final solids handling, and potentially reuse, could be consolidated/ centralised. This would help to move solids off FSTP sites where storage is sometimes unplanned.
- The centralised FSTPs are the most expensive to build (initial Capex) but the lower Opex means the WLC is lower compared to decentralised plants. When the Capex per m^3 of sludge treated is also considered, this technology is again the best solution.
- The Capex of treatment per m^3 ranged from approximately $1,000 to $14,000 USD and Opex from $1 to $44 USD.
- A majority of FSTPs fail to meet the DoE effluent standards for most parameters, hence the effluent can pose a risk to human health and the environment. It is noted that there is limited benefit in in optimising the efficiency and cost of the upstream FSM chain if the FSTPs are not achieving good effluent quality or have inadequate capacity or space to expand to improve performance.
- Many FSTP types use low/no energy or chemicals and therefore are good for long term sustainability. Sites with a lower use of construction materials such as the simple lined earth structures used in Mega FSTP 1, or lagoons in Kutupalong FSTP 2, will have a lower environmental impact from construction. FSTPs such as the ABR and biogas use lined brick or concrete for watertight structures which have a higher embodied energy and associated environmental impact.
- Sites that are easily scalable provide further resilience to change in population e.g., DEWATs or UFF. Though these technologies appear attractive options for sustainability and flexibility, they are not providing the best quality effluent. The treatment performance of these small/ decentralised biological systems can be more sensitive to changes in quality or quantity of raw sludge e.g., impacting retention times and process stability. Care should be taken in the FSTP design sizing to ensure the required retention time can be achieved throughout the year, and that the required dimensions to allow settlement and biological treatment are provided. Additional space for this is a challenge.
- Given that available space is one of the largest constraints to FSTPs in the camps, and finding a large available area for a larger (centralised) FSTP is challenging, it is likely that this will be a less central location. If large volumes of sludge need to be transferred long distances, the design of the transfer system must be included in the costing, and a pipe network should be considered as this has shown relatively low Opex costs. Considering both treatment and transfer, this is likely to be most cost effective option in the long term.
- Lime sites had high pH and generally poor performance for COD/BOD and nutrients removal. Lime sites are not appropriate for this stage of the emergency, given their high Opex and low treatment performance, and a majority are being decommissioned.
- GeoTubes and Constructed Wetlands are poorly performing and not appropriate for use as a standalone technology and should be decommissioned.

3 Which mode of transfer/transport is most cost effective and resilient?

- IFSTN data showed this was the lowest Opex per m^3 transported, and can transport a relatively large volumes of sludge. The key influencing factors for the cost effectiveness of the existing IFSTN were achieving the economy of scale, e.g. camp 4 is transferring over 100m^3 sludge per day meaning that a piped system was more cost effective than other transfer modes. Limited data on other size of IFSTN was available for this report therefore it is not clear if the system would be as cost effective at smaller scale.
- The data shows that the transportation mode that is preforming better at transporting the increased volumes during the wet season is the IFSTN. However, the pinch point is at the treatment (final liquid disposal), meaning an efficient transfer chain might not perform to its best capacity because the sludge transported cannot be treated.
- Other transfer systems faced challenges in wet season due to access and the condition of roads, meaning they are less resilient than a piped network. However, transfer systems not showing an increase in sludge volume in wet season, does not mean they are not accommodating the population they service e.g. some level of pit emptying still occurs to keep the containment functional.
- Transfer networks with lots of tanks did not show any significant change in solids in the downstream sludge (at the FSTP raw inlet), and therefore it is believed these are reasonably well managed to avoid solids accumulation in the network/tanks.

4 Does the containment type influence the sludge chain and which containment is best?

- No detailed review of containment performance was included. Single pit latrines are the type of latrine with the highest frequency of desludging because of their lower storage volume/capacity (ranging from once a month to 4/5 times a month if located in a low land)
- Factors such as inadequate design for the number of users, connection of black and grey water, sludge settling and solidification, and poor infiltration also increase the frequency of desludging.
- Rainy season and latrines located in low lying areas are also associated with highest frequencies of desludging and risks of overflowing, hence risk to public health.
- There is no camp area with uniform containment type, and so the type of containment does not influence the downstream FSM chain i.e. all FSTPs were receiving a mixed flow.

5 Is the centralised or decentralised approach of FSM more cost effective?

- Reviewing the whole chain Opex, the most cost-effective system is the IFSTN and centralised treatment. Although centralised had a high overall Capex, the Capex per m^3 capacity and Opex per m^3 treated were generally lower than other FSTPs. Noting that no Capex information was included for desludge or transportation.

- From the data collected and analysed, the centralised plants are shown to be performing above average in the capacity utilisation, area and cost performance ratios, while treating to a relatively good standard compared with DoE effluent standards.
- Analysis of long-term data (over several years) showed centralised treatment technology can cope with a wider range of variation of incoming sludge, which caters for the diverse transportation modes currently used in CxB. Noting that only one centralised plant (Mega FSTP 1) had long term data available for this analysis.
- The whole chain operational cost of the centralised (Mega FSTP 1) would be significantly higher with a different form of sludge transfer i.e. not a piped network. Nevertheless, before any decision to build new centralised plants, an assessment of camp wide needs must be undertaken, as the current available data shows that existing FSTP capacity just meets sludge generation in the dry season.

4.2 COMPARISON TO PHASE 1 STUDY

Reflecting on the phase 1 study conclusions, the progress is noted below.

- During the phase 1 study decentralised systems (particularly DEWATS and UFF) scored best overall against the assessment parameters. Although these still perform well for construction and scalability, given the effluent quality data available in this phase 2 study, there are concerns over the treatment performance of these technologies.
- The aerobic (aeration) and anaerobic lagoons showed good treatment performance during phase 1 and continue to do so. The long-term FE monitoring data showed consistent, and relatively good, performance over time.
- Lime was identified in phase 1 as a good technology in the immediate phase of the emergency. This still holds but the evidence collected on OPEX shows that the lime systems are not sustainable in the long term. In addition, FE data reviewed in phase 2 raised concerns over the relatively poor treatment performance of this technology.
- Phase 1 noted that final disposal of liquids and solids was not always adequately designed/sized. This was investigated again in phase 2 and it was found that this issue can be a pinch point to the whole FSM chain i.e. infiltration area of final liquid effluent was a pinch point to treatment and hence collection. In addition, some NGOs were still storing solids on site, and this will become an increasing space challenge. There may be opportunity to centralise final solids handing disposal/reuse and gain value from usable sludge products e.g. the planned Omni processor.

4.3 KEY CONSIDERATIONS

- Naming convention of FSTPs, and whole chain – there were multiple reference systems and naming conventions in existence for FSTPs and FSM chain. Where possible it is recommended to unify these references/names, to avoid double counting or missing information.
- The existing data, and that collected as part of the study, did not allow an accurate estimation of whether sludge collection and treatment are meeting sludge generation i.e. supply meeting demand. This is due to a range of factors, noted below. Recommendations for how these data gaps could be filled are included:
    - Latrine data set includes many types that are not in the Unified/ Standard Design for latrines. This should be rationalised, and attempt could be made to assign average volume and population to each type or group.
    - Different sludge generation rates are adopted which gives a range of sludge produced camp wide. Based on rationalising the existing rates used by NGOs, and reviewing the average generation rate calculated in this study, a range of 0.8 to 1.5 l/h/d could be used.
    - Transportation data was collected under this study for a portion of the whole camp. Data for the whole camp could be collected and used to verify findings. Capex data for transport/transfer systems should be collected and added to the WLC analysis of the whole FS chain.
    - There is evidence that not all the FSTP sites are in the current (2022(WASH sector dataset, and for the ones listed in the dataset, not all have a volume associated to them. The DPHE monitoring plan includes collecting data on capacity (90% of DPHE sample results have the FSTP capacity noted) and, as the monitoring rounds continue this dataset will become populated. The WASH sector data and DPHE should be aligned, and this can limit the need for two sets of field data collection.
- Bottlenecks/ pinch points to whole FSM chain should be identified when planning new or decommissioning old FSM infrastructure. This study has shown that, during wet season, the pinch point is often the infiltration capacity of the FSTP for final liquid effluent disposal, or challenges to transportation from the wet weather conditions. DEWATs had good design practice for infiltration sizing. This should be shared with the sector and final disposal planned during the FSTP design (not a standard size at each site). Some guidance to infiltration testing is shared in Appendix G. Where sites discharge to surface watercourses, plant requires improvement or additional steps to disinfect final liquid effluent to DoE standards. This may reduce capacity i.e., space needed to achieve adequate FE.
- Simplified pipe networks (IFSTN) can be the most cost-effective transfer system, but scale and topography need review for each FSTP catchment. Available treatment capacity at a FSTP level will dictate how much volume is transferred and if an IFSTN can be cost effective (along with topography and site-specific factors). The full FSM chain should be investigated when assessing the transportation mode costs. Care should be taken if storage tanks are included as these are susceptible to solids settlement if not managed.

- Care should be taken in the FSTP design sizing to ensure the required retention time can be achieved throughout the year, and that the required dimensions to allow settlement and biological treatment are provided. The design loading rates should allow for seasonal changes e.g. wet season higher volume, lower pollution load; dry season lower volume and more concentrated/higher pollutant loads. This may mean plant is underutilised during the dry season. An ‘underutilisation’ of 0-20% (by volume) was noted in the FSTPs visited.
- Data was collected manually during the site visits for this study. A more efficient method would be to use a digital questionnaire to avoid double handling of information e.g. the kobo app or similar could be used for further studies.
- This report covered technical only, with no consideration of social context, management, and governance. This needs to be considered in the FSM strategy (by others) and when planning/delivering new FSM infrastructure.

5 REFERENCES

The following documents were used to inform this study. This does not include the questionnaire and data returns provided by stakeholders (collected as part of this study) but does note additional design information they supplied as supporting information.

Documents studied (title)	Owner/ supplied by	Author	Date
Oxfam VacTug vs. pipe OPEX - Comparison VacTug IFSTN-OXFAM v1 - IFSTS OXFAM Technical Document-OXFAM,V1 - Comparison - Sludge Transportation -Detailed data-5-8-21	Oxfam	Oxfam	*April 2021*
OXFAM , Centralzied Fecal Sludge Treatment Plant , KTP FSTP-1 Fact Sheet	Oxfam	Oxfam	*2021*
IFRC Lab Test Reports all FS Lab Results Camp-19 IFRC	IFRC	IFRC	*October 2021*
Compiled FSTP dataset	Oxfam	CxB Wash sector	*July 2021*
A new approach to communal wastewater treatment in an emergency response context – Waste water journal article	IFRC	IFRC	*2020*
IFRC Video on aerated FSM system in CXB	IFRC	IFRC	*2020*
UNICEF_ICDDRB FSM Progress Report rounds 5 to 9 and up to round 13	CxB Wash sector	Icddr,b	*To December 2021*
Feasibility Study_FSM_SWM_	CxB Wash sector	INT Buet / DPHE	*May 2020*
Oxfam FSTP data FSTP 1 (mega FSTP) - FSTP 1 CAPEX & OPEX - FSP 1 aera comparison - FSTP design documents - FSM monthly bulletins - FSTP 1 test results FSTP 2 - Kutupalong fecal Sludge Treatment Plant-2- Brief -30721 - FSM (UNHCR -OXFAM) - DPHE - 15-6-21 presentation - Site layout KTP -1 - Design files Oxfam and MSF (site layout, design drawings/ diagrams etc)	Oxfam	Oxfam and MSF and UNHCR	*2020 to 2021*
Wash sector reports from sites and stakeholders covered in this report - BRAC_DEFLT 01 Characterization of Faecal sludge - BRAC_DEFLT 2. faecal sludge laboratory - Key criteria for FSM Strategy Plan development - Lime stabilisation pond 1 (ISCG) - Oxfam FSM CXB Inception Report Feb 2020 WASH sector - FSTP centralized OXFAM	CxB Wash sector	*Various (Oxfam, BRAC, ITN Buet, Iccdr,b)*	*2019 to 2020*

Documents studied (title)	Owner/ supplied by	Author	Date
Latrine database - wash_infrastructures_gps_master_ spreadsheet_september_30_2021 AND WASH_Infra(LT_Bath_TW)_GPS_MArch_31_2022_Final_ta_rev FSM database - Compiled FSM dataset_July 27_2021 Sanitation TWG files	Oxfam	*Various*	*Various*
220113_DPHE Faecal Sludge Laboratory - Mode of operation	DPHE	*DPHE*	*January 2022*
IOM DEWATs information - Laboratory testing data - BoQ of DEWATS - Design of DEWATS - DEWATS fact sheet - Map_DEWATS_20220125 - WaSH SoP_DEWATS Installation Vfinal2 - WaSH SoP_DEWATS O&M Vfinal2	IOM	*IOM*	*Various*
Brac - FSTP mapping data - FSTP Opex data - Drawings ABR camp 21, LSP1W-Plan view - One pager_Fecal Sludge Transfer Network_C21 (UNHCR) - OPEX and CAPEX Data-FSTP - OPEX C_21	Brac	*Brac*	*2021*
DPHE Lab data and visit plan - Camp wise - Organisation wise - Technology wise - Visit plan (round 1) - Summary of Analysis Report and FSTP visit plan - 2022.03.24 DPHE FSM Strategy Meeting PPT slides	DPHE	*DPHE*	*2022*
WVI - Guidelines for WSPs - Influent and effluent testing data - WSP flow chart - WSP layout, plus more detailed layout of each element	WVI	*WVI*	*various*
Teknaf Sludge Transport Cost Analysis Format – example data collection spreadsheet	Oxfam		
VERC- FSM list and SL Number	Verc	*Verc*	*March 2022*
FSM Strategy Development Meeting Minutes FSM Strategy Development Meeting Compiled Slides	CxB Wash Sector	*CxB Wash Sector*	*March 2022*
GIS map of roads BGD_Camps_Access_Roads_Aug2020_LOGSector_Ver1	Oxfam	*sector*	*2020*
Unified Standard Design for Latrines	CxB Wash Sector	*CxB Wash Sector*	*2018*
Who guidelines for the safe use of wastewater, excreta and greywater	WHO	*WHO*	*2006*

CONTRIBUTORS

We are grateful that the following contributors were part of the study and provided evidence, guidance and their time to support the study. See Appendix I for a detailed list of contributors interviewees etc.

CxB Wash Sector, Oxfam, UNHCR, IOM, UNICEF, Brac, Verc, NGO forum, MSF, World Vision, IFRC and BDRCS, DPHE

OXFAM ARUP

Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix A

Appendix A Field assessments

A1 Field assessments by technology type

The following appendices outlines the information collected from the field visits of the 20 FSTPs (see Table 1 in main report) by technology type. The trends and key learning points are included in this chapter with detailed data provided in Appendix H2.

A.1.1 DEWATs and UFF

Four FSTPs, which were using technology based on UFF, were visited for this assessment. The sites visited have been in operation for between 2.5 and 3 years. The sites are in camp 9, camp 7, camp 8W and camp 12. Limited information was obtained from camp 7, hence costs of this plant have not been included in this section.

Two of the sites (camp 9 and 12) were using DEWATs where the FS is pumped from latrine pits or a transfer tank to receiver tanks at the FSTP site, followed by two settling tanks (septic tanks and bio digestion[1]); treated via two UFFs (plastic tanks with filter media made of coconut husks); followed by solids storage and liquid treatment (maturation /balancing tank and chlorination); and final liquid is infiltrated via infiltration trenches via a planted vertical gravel filter. See Appendix H2 for the DEWATs PFD and layout information.

Two sites (camp 7 and 8W) were using a series of three tanks, two settlement tanks and one UFF (filter media made of graded sand and gravel) with associated solids storage and further liquid treatment via a constructed wetland or filter bed and soakaway. For the purposes of this report these two variations of UFF systems have been assessed together.

The FSTPs visited were operated by four different NGOs. However, they all share similar process flows, where the sludge first enters a settlement chamber to remove solids and avoid blockages in the UFF. The sites visited were using one or two settlement tanks/chambers connected in series. After settlement, the sludge flows to the UFF.

The UFF are tanks where the inlet is below the outlet level, forcing upflow and anaerobic conditions. Usually, several filters are arranged in series with progressive solid removal. Solids are removed from the bottom of the tanks and stored and disposed. Liquids pass forward from the top of the tanks to further treatment or disposal. The treatment mechanism is solid/liquid separation by settlement and filtration as well as digestion of solids under anaerobic conditions.

The liquid effluent from the UFF and DEWATS was disposed by infiltration. The sites had different infiltration units. One had a gravel constructed wetland, two infiltration beds and soakaways, and DEWATS had infiltration trenches. One of the sites incorporated the provision to add chlorine upstream of infiltration in case of emergency/need. The DEWATS have vertical flow gravel filter with geotextile rapping, and the bottom on infiltration bed is more than above of 1.5m from water table. It's a site selection criteria that DEWATS should be constructed in the higher altitude to meet the standard elevation from the water table.

The final solids are currently stored in below ground pits in all sites. A manual gate valve at the bottom of the UFF is used to discharge the solids to the solids' storage pits. The sludge from one of the sites is sent to compost after being stored for three months. The other sites mentioned that there were plans to reuse the sludge in the future after adequate storage to achieve pathogen kill.

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[1] Bio-digestion in DEWATs systems is a sludge holding/settlement tank where sludge is help (for approximately one day), similar to a septic tank. Some digestion of solids occurs, and some settlement of solids also occurs. The tank is vented at the top but otherwise is a sealed tank.

The table below outlines information collected during the field visits for each parameter assessed.

Parameters	Key Findings
Capacity (m^3/d)	Design capacity 3-6 m^3/day
Area requirements and scalability (m^2/m^3 sludge treated)	- Technology that requires relativity low footprint area/ land take. - Area required in the sites visited ranged from 20-39m^2/m^3 treated (treatment areas of the sites range between 76-116 m^2). - The difference in areas is due to different dimensions of UFFs, multiple UFF instead of one, and different infiltration techniques used. For example, the infiltration trench in one site needs 35m^2 whilst the constructed wetland uses 22m^2. - If space allows, the system is easy to scale up by adding more tanks and filters in parallel. Building modules together has proved to be more space efficient - Prefabricated (plastic) tanks, used in DEWATs, reduces the need for large civil engineering works and are quick to deploy or remove. There is also a robust supply chain for these types of tanks. - One of the sites visited was treating double volume of sludge than the other three but it did not require double of space. By building two treatment modules together (two parallel process streams) they could save up to 40m^2 in space (do not need to double all the elements, such as the solid pits) i.e., space efficient.
Capex (USD/m^3 design capacity)	- Capex range 3,555-8,133 $/$m^3$ treated - DEWATS are in the low end of that range with £3,555 $/m - The variation between DEWATS and UFFs, technologies that share the same key compoments, can be due to the different materials used for the tanks, 'assemble on site' tanks, instead of pre-fabricated, resulted in a bigger cost. In addition, UFFs use constructed wetland, whilst DEWATS use infiltration trenches. The constructed wetlands may required more civils works and seem to need double of labour (than other sites).
Opex (USD/m^3 treated)	- Relatively low Opex, 0.7-1.4 $/$m^3$ treated - Opex a majority labour costs - Biological treatment - no chemical used (optional chlorination)
Whole life cost (USD/m^3/yr)	- $453-2,598
Speed of construction and setup/decommissioning	- Short installation time. - 20-45 days. - No major civil works required - The use of plastic tanks speeds the construction process - Commissioning and decommissioning is quick
Expertise required for setup and operations	- Setup: if 'assemble on site' tanks used (not plastic/prefabricated) workers need to be qualified to construct and assemble - Operation: qualified workers to operate the gate valve to desludge the tanks are needed
Operation and maintenance	- Low O&M. No main challenges found - Main regular operational activities are sludge loading, solids removal via gate valve, site cleaning. - Regular maintenance needed: periodic replacement of the gate valve and filter media.
Treatment performance	- Performing relatively poorly compared to other decentralised FSTPs and DoE standards. - BOD and COD removal was generally poor across all UFF. - Some (limited) evidence that the smaller systems (12m^3/d) had lower solids removal than the larger systems (21m^3/d) and hence lower BOD and COD removal.

	- Both DEWATs and UFF had added a stage of settlement ahead of filtration (since phase1 review) which is helping the process and avoid frequent filters blocking and should aid solids removal. - Chlorination was possible for DEWATs sites
Complexity of process and pinch points	- Liquid infiltration in rainy season can be challenging, particularly if site not properly selected looking at the ground water level. - Properly sized infiltration trenches at DEWATS sites
Disposal of final products	- Liquid infiltrated - Solid is stored with plan to reuse
Resilience to disaster	- Site selected considering flooding - Adequate drainage system for the stormwater - Tanks above ground level
Environmental impact	- Plastic tanks may not last as long (in the harsh camp environment) as brick or concrete (although sunlight resistant plastic employed). However they can be made from recycled (plastic) materials meaning a lower embodied carbon. - There is an established supply chain for standard sized plastic tanks e.g. gazi. Prefabricated tanks may need to be shipped from further away compared to locally available bricks. - Filter media is locally available. - Flexible modular construction leaves low amount of permanent infrastructure on the site

A.1.2 Anaerobic Baffled Reactors (ABR)

Six FSTPs, which were using technology based on ABR, were visited. The sites visited have been in operation for between 4 months and 3.5 years. They were in camp 21, camp 14, camp 18, camp 5, camp 12, camp 8W.

An ABR is an improved septic tank with a series of baffles under which the wastewater is forced to flow. The increased contact time (from flowing around baffles) with the active biomass (sludge) results in improved treatment. The treatment mechanisms are settlement and filtration, and biological, anaerobic degradation (biomass on the filter media, if used, and biological degradation in the active sludge blanket at the bottom of each chamber). ABRs do not provide a standalone sludge treatment solution. The liquid effluent requires further treatment prior to discharge to achieve pathogen kill, e.g., further filtration/polishing and/or disinfection. Separated solids also need to be stored for sufficient time to achieve pathogen die-off, or need to be disposed of appropriately, e.g., incineration or burial, which has implications on the cost and footprint area.

The sites visited were operated by five different NGOs. All sites had an initial solids/liquid separation in settlement tanks (sometimes two in series), followed by the anaerobic degradation and settlement in the ABR unit (units with five to six chambers). The filtration (downstream of the ABR) was different at each of the sites. Three sites were using planted gravel filter beds, one of them following the process with an upflow filter. The other two had filtration with a horizontal planted gravel bed, and a constructed wetland respectively. The liquid was them further treated in a polishing pond at all sites. The solid sludge was treated in drying beds at all the sites. The number of drying beds and area for solids handling had the largest impact on total footprint area.

Regarding the final disposal of the solids, only one site was dealing with the sludge on-site, through incineration. Three sites were storing the dry sludge, one was sending it to a landfill, and one was sending it to a composting site. The liquid effluent was being disposed into natural drains (surface water) or infiltrated.

The table below outlines information collected during the field visits for each parameter assessed.

Parameters	Key Findings
Capacity (m^3/d)	Design capacity 6-15 m^3/day Maximum volume treated is 10 m^3/day. Noted – challenge to collect enough sludge
Area requirements and scalability (m^2/m^3 sludge treated)	High treatment capacity by area in comparison with other technologies Area required in the sites visited varies from 9 - 175m^2/m^3 treated. However, 4 of the 6 sites visited required less than 28m^2/m^3. Most of the space on the sites was used by the final treatment stages e.g. polishing ponds and solids drying beds. There is one big different on-site requirement for camp 18. Camp 18 is designed to treat 15m^3 per day, and it has 40 drying beds which occupy 600m^2. This site is understood to be well sized. Not modular. The system is relatively difficult to scale up. ABR and AF are concrete or brick lined tanks with a number of chambers. To scale up would require new parallel constructions or bypass every treatment step to expand the existing stream.
Capex (USD/m^3 design capacity)	Capex 1,564 - 13,907 \$/m^3 treated There is a big variation in the Capex. Four of the sites have a Capex between 1,565-5,191 \$/m^3. The biggest Capex in camp 18 (13,907\$/m^3), where 68% of the Capex is for materials and equipment. This site has a treatment area of 2500m^2 to treat 15m^3 of sludge, with 60 drying beds. The second highest Capex (9,250\$/m^3) is for camp 12. Initially, this site was built as chemical treatment (lime), and it was modified in 2020 to make it biological. The Capex represents the two investments. The fact that this site was made in two phases and had to be upgraded has increased the cost.
Opex (USD/m^3 treated)	0.47-44.15 \$/m^3 treated Large variation in Opex. Four sites have an Opex between 0.47-3.64\$/m^3 The biggest Opex is camp 18 (9,271.66\$/month) however this is an estimated Opex as the FSTP is not fully operational yet. The site requires a pump to transfer sludge to the drying beds that used 200 l of fuel leading to high Opex. However, there is a plan to be replaced by solar. The second largest Opex is camp 12 (4700\$/month) and includes land rental for a site that is 1,871m^2 (note the smallest site visited was 140m^2)
Whole life cost (USD/m^3/yr)	\$419 - \$8,530
Speed of construction and setup	2 to 8 months Civil constructions works relatively significant e.g. in situ tanks. ABRs, filtration units and liquid effluent treatment units required excavation and concrete or brick construction, plus interconnecting pipework.
Expertise required for setup and operations	Setup: workers able to do masonry work. Relatively complicated due to internal chambers/baffles.

Parameters	Key Findings
	Operation: workers able to desludge the tanks and drying beds, to operate the pump and control the flow and to clean the filter media
Operation and maintenance	Main challenges are blockage of the flow control / valves. Main regular activities are: desludging, flow control, operating pumps, site cleaning. Other maintenance needed: replacement filter media, re-planting in gravel planted beds. Safe to operate – contained/ limited contact with sludge
Treatment performance	ABRs generally achieved an FE BOD between 100-250mg/l. Although this is above the standard (30 mg/l) it is relatively low compared to other decentralised/small capacity FSTPs. Results showed that approximately 60% of the BOD and COD removal is achieved in the ABR with further removal achieved in the d/s processes i.e., filter and polishing pond 13% of FE samples passing the DoE standard for solids. Coliform data from ABRs was limited. Recent data shows all FE samples are in breach of the DoE standards.
Complexity of process and pinch points	Low operational complexity In the sites with high treatment capacity, collecting enough sludge to reach treatment capacity is challenging. Common blockages in the flow control.
Disposal of final products	Environmentally friendly and sustainable Liquid to the natural environment Solid is stored, incinerated, or sent to other sites for compost
Resilience to disaster	Common measures taken in the sites are: Elevated platforms/ Top of concrete of tanks above ground level Slope protection and retaining/protection wall One site had no action taken against flooding or other disasters (location specific)
Environmental impact	Medium to long lasting materials (brick and concrete) but with higher embodied carbon.

A.1.3 Aeration

Two sites visited were using aerobic treatment as the main technology. The sites were in camp 18 and camp 19. The site from camp 19 has been operational since October 2021. The site in camp 18, operational since 2018, is currently changing process to operate as an ABR, after being modified and after aeration being decommissioned. This technology is not considered very adequate for the context due to its complexity. The data presented in this section is from the time it was operating as aerobic treatment.

Both sites were operated by the same NGO and shared similar units and multi-stage treatment process – see H2 Individual Site Assessments for PFD.

The inlet has a coarse screen filter to remove larger objects (such as plastic bags and female hygiene products) and coarse particles that could impact the process. The sludge passes to a primary settlement tank via an upflow pipe. The settlement tank then flows to the aeration tank. The aeration tank is a large, mixed, aerobic reactor. A mechanical aerator provides oxygen and keeps the aerobic organisms suspended, and a mixer helps to achieve a high rate of organic degradation.

The solids are further separated in a secondary settlement tank, the supernatant (liquid effluent) is pumped into a glass beads filter for final solid-liquid separation, the backwash water is returned (pumped) to the aeration tank. The sludge from the bottom of the settlement tanks undergoes further lime treatment before it is disposed. Camp 18 currently incinerates the solids and disposes the final liquid effluent into a natural stream via a planted area. Camp 19 is currently storing the solids, but it is planning to install a flexidigester. Both camps chlorinate the final liquid before discharging.

The table below outlines information collected during the field visits for each parameter assessed.

Parameters	Key Findings
Capacity	Design capacity 15-30 m^3/day Actual volume treated 4-7 m^3/day. Challenge to collect enough sludge (manual transport).
Area requirements and scalability	Most of the site area is used for the treatment units. Efficient space per m^3 treated. Area required varied from 18-28m^2/m^3 treated. It is more land efficient to treat bigger volumes. For example, one site visited could treat the double capacity of the sludge, needing only to increase the site by 30%. Modular system, easy to scale up. Prefabricated tanks (Oxfam), good supply chain.
Capex/m^3	Capex 3,333$-4,633 \$/m^3 treated. Both sites have similar Capex for m^3. The site with higher capacity has higher Capex as it needs more treatment units (two more glass bed filters and an additional primary settlement tank). However, it is more cost-efficient to treat bigger volumes
Opex/m^3	26.75-31.4\$/m^3 treated Both sites have similar labour costs for operation. The site with higher Opex is operated with the generator whilst the other plant is operated by solar during day and generator at night.
Whole life cost (USD/m^3/yr)	$1,553 -5,604
Speed of construction and setup	8-10 months Easy to build if material available, noting a majority of the mechanical equipment is imported from outside CxB area; could take only one month. Minimum civils work. Tank kits and prefabricated tanks are used for main units. Challenge to transport materials to site due to the equipment size and access.
Expertise required for setup and operations	Needs skill engineers and process expert to set up the system and for commissioning.

Parameters	Key Findings
	Needs to train skilled labour for FSTP operation, process is sensitive and if it goes off track it can take some time to re-establish full treatment.
Operation and maintenance	Sophisticate and complex technology Main regular activities are: inlet screen cleaning, operating pumps, cleaning of the solar panel or adding fuel to the generator depending on energy source, inlet and scum cleaning, chlorination, desludge of settlement tanks.
Treatment performance	Good treatment quality. Passes most parameters against DoE standards. Consistent performance over time.
Complexity of process and pinch points	Not enough available sludge collected and transported to the site. Bottleneck with the transfer network (manual). Energy consumption
Disposal of final products	Liquid to the natural environment Solid is stored or incinerated. One site plant to install a flexidigester.
Resilience to disaster	Common measures taken in the sites are: Elevated to avoid flooding Tanks can be half buried or elevated which provides flexibility
Environmental impact	Operational energy use needs to be from renewables to reduce environmental impact (currently from fossil fuel) Tanks are from metal i.e. long lasting material but with relatively high embodied carbon, but can be dismounted and re-used for many (20) years in other locations.

A.1.4 Lime (LSP)

Three sites visited were using variations of lime treatment. The sites were in camp 4, camp 1W and camp 26. The FSTP in camp 4 has been operating for 4 years, the FSTP in camp 1W for three years and the one in camp 26 for two years.

Lime treatment achieves pathogen reduction by mixing sludge with hydrated lime to raise pH of above 12 and create an alkaline environment where pathogens cannot survive. Literature suggests a lime dose of 10-17 kg of lime per m^3 of faecal sludge is required to reach a pH above 12[2], with a contact time of at least two hours. The amount of time required depends on the quality of the lime and the characteristics of faecal sludge. This technology is good for a rapid response phase due to its short treatment time and simple process. The dose and contact time were not investigated in detail in this study. The three sites reportedly used 12 kg lime per m^3 of sludge[3].

The FSTPs were operated by two different NGOs, but all sites visited have similar process flow. The sludge is mixed with lime in a lagoon or series of ponds. The retention time is approximately one day. Then the flow passes to the dewatering beds for solids and liquid separation. The dewatering beds have different

[2] EAWAG Compendium of Sanitation Systems and Technologies, and Metcalf and Eddy Wastewater Engineering

[3] An average lime dosing rate of 20 kg/ m^3 sludge was recorded in phase 1 study.

layers of filter media e.g. sand, stone chips and are lined with geotextile. The retention time in the dewatering beds differs in the site from 1-2 days to 5 days. This depends on the sludge consistency and water content. The solids are further processed on drying beds. In camp 4 the final solids are incinerated; in the other two the solids are stored. One of these sites is considering incineration of solids. It is important to mention that in camp 4 they highlighted it was controversial to incinerate the solids so close to the community. The liquid is infiltrated in camp 4 through two infiltration ponds to reduce the pH, whilst in the other sites it goes to a polishing pond and is then discharged to a natural channel or evaporated.

The table below outlines information collected during the field visits for each parameter assessed.

Parameters	Key Findings
Capacity	5-10 m^3/day
Area requirements and scalability	Area required in the sites visits varied from 17-98m^2/m^3 treated. The site that required most area is treating the largest volume of sludge. Their components are considerably larger and more spread out over the available site area (as allocated). To scale up more treatment units need to be constructed, which require significant space but relatively simple construction work .
Capex/m^3	Capex 1,554.4$-4,060 $/$m^3$ treated. The site with highest Capex is the largest capacity and treatment area. This site area also includes an incinerator, two storerooms and bathing and latrines facilities for the staff. Overall, this treatment type has low Capex, no major civils works are required.
Opex/m^3	3.44 - 9.57 $/$m^3$ treated
Whole life cost (USD/m^3/yr)	$1,607 - 2,858
Speed of construction and setup	1-2 months. Fast construction and sett up. Good for rapid response Simple civils work. Lined earth bunds/ponds can be used for the main treatment processes. Chemical treatment does not require time to activate treatment i.e. fast to commission. Higher construction time for the smallest site, because it did not have as much skilled labour involved.
Expertise required for setup and operations	Needs to train skilled labour for FSTP operation but it is not a complex process
Operation and maintenance	Main regular activities are: lime mixing and, regular pH readings and management of the final solid product. There are health risks when handling hydrated lime; the staff need to be trained in H&S protocols and use adequate PPE
Treatment performance	Recent data showed poor treatment performance verses DoE standards i.e. currently not good treatment quality. Limited data was available for long term monitoring of COD, BOD and nutrients for lime FSTPs. The recent monitoring shows most of the lime sites (circa 90%) fail the DoE standards.

Parameters	Key Findings
	Lime treatment is not designed to remove phosphorus or nitrogen, hence the lime FSTPs did not perform well for these parameters. Some evidence that required pathogen kill can be achieved but final effluent results are not consistent. As noted in phase 1 care should be taken to optimise the lime dose to achieve the required treatment but not lead to unnecessarily high Opex or fail the pH in final effluent
Complexity of process and pinch points	Low complexity but chemical reliance and H&S risks for the operators Filter media blockage Management of solid final product i.e. available space at FSTP is a pinch point.
Disposal of final products	Liquid to the natural environment (infiltrated or discharge in channel) Solid is stored or incinerated
Resilience to disaster	Common measures taken in the sites are: Units on elevated platform to avoid flooding Drainage system in the FSTP to manage surface water from rain
Environmental impact	Production of (hydrated) lime is an energy intensive process with relatively high environmental impact / carbon. The simple construction of the FSTP has relatively low impact but depends on acle of units and axillary buildings etc.

A.1.5 Waste Stabilisation Ponds (WSPs)

Two sites visited were using WSPs. The FSTPs were in camp 7 and camp 8W. The treatment plant in camp 7 was built 1 year ago and the one in camp 8W has been in operation for 1.5 years. The FSTPs were built by the same NGO and had the same process flow and components. However, they are currently being managed from two different organisations. See **Appendix H2** for a PFD.

WSPs are one of the more globally established natural wastewater treatment methods of those used in the camps. They are formed by a series of three ponds, which can be simple lined earth basins. The primary treatment is in the anaerobic pond, secondary treatment in the facultative pond, and tertiary treatment in maturation pond. Anaerobic and facultative ponds are for the removal of organic matter (BOD), Vibrio choleras and helminth eggs; and maturation ponds for the removal of faecal viruses, faecal bacteria and nutrients (nitrogen and phosphorus). WSP have the potential to achieve high removal of excreted pathogens (based on global experience and literature), meaning effluents may be suitable for reuse in agriculture and aquaculture; or discharged into surface water or infiltrated. However, it should be noted the WSPs visited were not consistently achieving the DoE pathogen standards. WSPs are particularly suited to tropical and subtropical countries since sunlight and ambient temperature are key factors in their process performance. The dimensions (length:width:depth) are important to consider in the design to ensure the correct retention times and settlement can be achieved. This impacts the layout and area required.

After a preliminary screening, the sludge is applied into three dryings beds to separate solids and liquids. The sludge remains from 10 to 20 days there. The liquid from the beds passes to the WSP. The anaerobic pond, that operate in the absence of oxygen, provide pre-treatment and remove organic loads and settled solids. After a minimum of 2-3 days the liquid passes to two facultative ponds in series to improve settlement. The effluent remains for 1 day in each pond. The effluent from the second facultative pond passes to two maturation ponds (in series) for further BOD and nutrient removal. The last step is for the effluent to go through a plantation bed. The flows between each pond are by gravity and controlled by a manual gate valve, installed in each stage and maintained by an operator.

The final effluent is then infiltrated through a soakaway. The final solids are stored and sent offsite for further composting.

The table below outlines information collected during the field visits for each parameter assessed.

Parameters	Key Findings
Capacity	2.5-5 m^3/day
Area requirements and scalability	Area required varied from 9-18 m^2/m^3 treated. Relativity low area required To scale up more treatment units can be added which requires significant space i.e. need to add parallel process stream
Capex/m^3	Capex 2,600-7,888 \$/m^3 treated. The large variation is due to one site including the sludge transfer costs in the Capex, and we were unable to get a break down during the study period. Capex for the two WSPs is expected to be similar i.e. \$2,600.
Opex/m^3	2.6-4.02 \$/m^3 treated The Opex for FSTP in camp 8W is double the Opex in camp 7. This may be because it is treating half of the sludge with the same infrastructures. There may be scope for camp 8W to increase the treatment volume/throughput. The same Opex is expected. Does not required any electrical or mechanical equipment
Whole life cost (USD/m^3/yr)	\$1,248-1,921
Speed of construction and setup	2-3 months Easy to build, not very skilled labour needed. Materials locally available. Simple masonry pond structures, could also be formed from earth lined ponds.
Expertise required for setup and operations	Easy to operate Require one person full time to control the wastewater flows/ pass to the next pond.
Operation and maintenance	Main regular activities are: sludge loading, control gate valve. No use of chemicals, safe operation. Environmentally friendly technology
DOE standards and pathogen inactivation Treatment performance	Relatively poorly performing decentralised. Performance maybe improved at larger scale (global evidence for large WSPs) Some evidence that COD and BOD removal has improved over time, this could be that as the sites were commissioned and the biological process is established, removal rates improve For the WSP site visited this showed it was achieving a 90 to 100% reduction in BOD and SS.

Parameters	Key Findings
	Nitrogen and phosphorus were meeting DoE standards. The only coliform information is available from 2022, some in breach of standards, with the exception of one site, showing there is potential to achieve pathogen removal with WSPs.
Complexity of process and pinch points	Low complexity, no pinch points noted.
Disposal of final products	Liquid infiltrated (potential to reuse if WHO standards are met?) Solid is sent to compost off site
Resilience to disaster	Common measures taken in the sites are: Units on elevated platform to avoid flooding, top of walls is above ground level / semi buried to prevent surface water drainage entering the ponds. Slope protection
Environmental impact	Simple structures using brick and concrete i.e. relatively high embodied carbon. WSPs can be made from other material and simple lined earth ponds.

A.1.6 Anaerobic digester system (ADS)

One site ADS site was visited, located in camp 26. The FSTP has been operational for 3 years.

An anaerobic digester is an anaerobic treatment technology that produces digested slurry that can potentially be used as fertiliser; and biogas that can be used for energy (direct fuel or converted to electricity with additional equipment).

In this case, the FSTP was not only composed by the digesters, but additional components were added to treat the sludge further. The FSTP site had five anaerobic digesters, five drying beds, one horizontal planted filter unit, one constructed wetland and one polishing pond. The sludge is retained in the digesters for five days, before being moved to the drying bed for further treatment. See Appendix H2 for a PFD.

The dried solids from the drying beds are currently stored on site. There has not been the need to dispose the effluent from the polishing pond yet (evaporation likely to play a large role). No data was obtained for gas generation or whether it is used by the community. In previous visits for phase 1, it was found that the community was not using the gas as they were commonly receiving free gas canisters from other NGOs. Some more established camps, visited in Phase 1, were using biogas in communal kitchens.

The table below outlines information collected during the field visits for each parameter assessed.

Parameters	Key Findings
Capacity	5 m^3/day
Area requirements and scalability	Area required 61 m^2/m^3 treated. To scale up more treatment units can be added which requires significant space i.e. new parallel plant
Capex/m^3	Capex 1,392\$/m^3 treated. Relatively low initial investment required

Parameters	Key Findings
Opex/m^3	0.39 \$/m^3 treated Relatively low Opex required
Whole life cost (USD/m^3/yr)	\$306
Speed of construction and setup	2 months Easy to build, limited skills requirement. Materials locally available: filter media, stone chips, canaidica plant, sand bricks chips
Expertise required for setup and operations	Easy to operate
Operation and maintenance	Main regular activities are sludge to drying beds, polishing pond cleaning. Filter media is changed every 6-12 months. Replantation of the trees/plants (planted filter) is needed at times No use of chemicals, safe operation – limited contact with wastewater/sludge. Environmentally friendly technology
Treatment performance	Currently not meeting DoE standards, but increasing quality over time. Showed relatively good performance for BOD, COD, nutrients and TSS removal. The sites also showed a low / no helminth in the FE although E. coli standards is only achieved 50% of the time. This shows the treatment process has potential to achieve the required pathogen kill.
Complexity of process and pinch points	Low complexity Main issues: filter blockage (change media every 6-12 months)
Disposal of final products	Liquid not disposed yet Solid is stored
Resilience to disaster	Units on elevated platform/ walls to avoid flooding (1.5 m)
Environmental impact	Biogas has a high methane content which is a potent greenhouse gas, so likely has an overall negative impact when used as fuel or released to atmosphere. However maybe lower impact than cooking on virgin/natural gas canisters – assessment outside scope of this study. Units are generally brink or concrete again with a relatively high embodied carbon but available locally with a secure supply chain.

A.1.7 Centralised treatment / multi-technology

Two centralised FSTPS were visited for this study. They were in camp 4 and in Kutupalong camp.

Both centralised FSTPs were using a combination of technologies to treat the sludge. The FSTP in camp 4 was operated by one NGO, whilst the FSTP in Kutupalong was divided in three modules (all with the same components in parallel), each of them operated by a different organisation.

The FSTPs were designed to treat a volume of sludge significantly higher than the volume treated in the other (decentralised) treatment plants visited, with a capacity of 150 and 180 m^3/day respectively. However, neither of them was reaching the design capacity at time of this study. The treatment plant in camp 4 was almost reaching design capacity with 120 m^3/day. The FSTP in Kutupalong has started to operate in March 2022 and was under commissioning, treating 31m^3 /day. This plant uses a biological process which requires time to commission and reach full capacity.

The FSTPS has different process flows and treatment units. See Appendix H2 for a PFD.

The FSTP in camp 4 was composed of: inlet screening, two covered anaerobic lagoons that provided solid-liquid separation, anaerobic digestion and biogas generation; then a UFF and a trickling filter, both providing anaerobic treatment. The liquid is finally treated in a polishing pond, optional chlorination, and discharge to the natural stream. The solids are moved to planted drying beds. The plan is to use it as stabilised fertiliser after storage.

The FSTP in Kutupalong was composed by three modules with the same components. The sludge goes through a screen chamber and two settlement tanks (shared by the three modules); the solid are passed to planted drying beds; whilst the liquid passes through a distribution chamber, a syphon chamber, anaerobic filter reactor, a vertical flow constructed wetland and a horizontal flow constructed wetland. The final liquid treatment is in a polishing pond. The liquid is discharged into the environment, but it was also noted that a large volume evaporated from the polishing pond. The solids will be retained in the drying beds for 3-5 years to allow for safe reuse. The volume of final solids will be reduced through decomposition. However final expected volumes (for potential reuse) were not reviewed.

The table below outlines information collected during the field visits for each parameter assessed.

Parameters	Key Findings
Capacity	Design capacity: 150-180 m^3/day Actual throughput: 31-120 m^3/day
Area requirements and scalability	Technology has a large footprint area. Area required for treatment units in the sites visited varies from 33-58m^2/m^3 treated Modular systems easy to scale if land available. Existing parallel stream allows some flexibility to take elements off line for maintenance, and mange flows.
Capex/m^3	Capex 4,646-6,388 \$/m^3 treated The initial investment required is significant but the Opex associated to the plants is relatively low.
Opex/m^3	Low Opex, 0.60-6.7 \$/m^3 treated The difference in Opex is because the cost is shown in relation to m^3 treated and the FSTP in Kutupalong is not operating at full capacity (under commissioning at time of study). The Opex on full capacity will be 1.15 \$/m^3 (significantly lower than camp 4) Opex mostly labour costs and electricity Biological treatment – no chemical used
Whole life cost (USD/m^3/yr)	$474-831
Speed of construction and setup	12 months. Significant civil engineering works with large construction equipment required.

Parameters	Key Findings
Expertise required for setup and operations	Large teams of skilled and unskilled labour needed to construct the plants.
Operation and maintenance	Minimal use of mechanical and electrical equipment to reduce failure and maintenance operations Main regular activities for each plant can be found in Appendix H2 – Individual Site Assessments Gravity flows once arrived at inlet.
Treatment performance	Data only assessed for camp 4 Camp 4 is one of best performing plant for BOD, COD and pathogen reduction. Results for these parameters were not significantly higher than standards i.e., reasonably close and showed consistent performance across the year.
Complexity of process and pinch points	No pinch points found Requires a large volume to process but does not suffer too much if it is underutilised.
Disposal of final products	Liquid discharge to the environment Solid is stored with plan to reuse; available space is adequate (to date).
Resilience to disaster	Adequate drainage system for the stormwater Elevated tanks Site is located at the top of a hill away from flood prone areas.

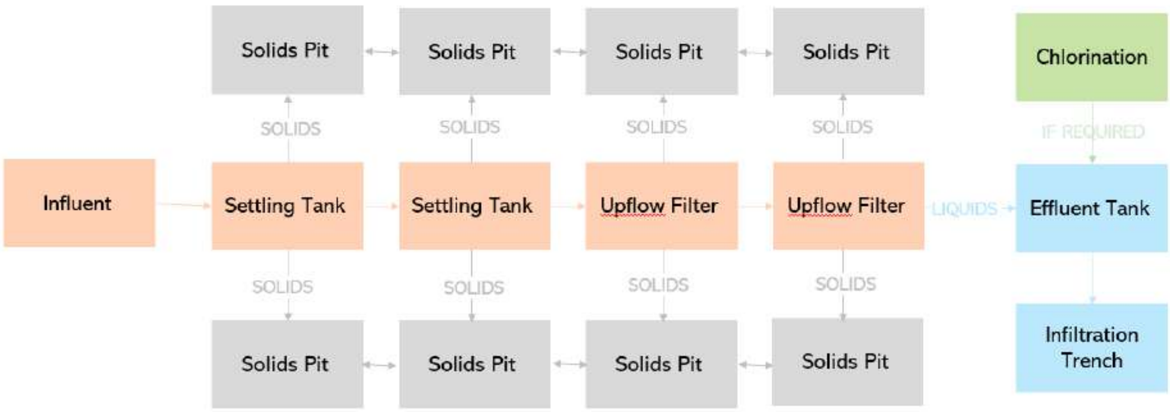
A2 Individual Site Assessment

A.2.1 DEWATS, Camp 9

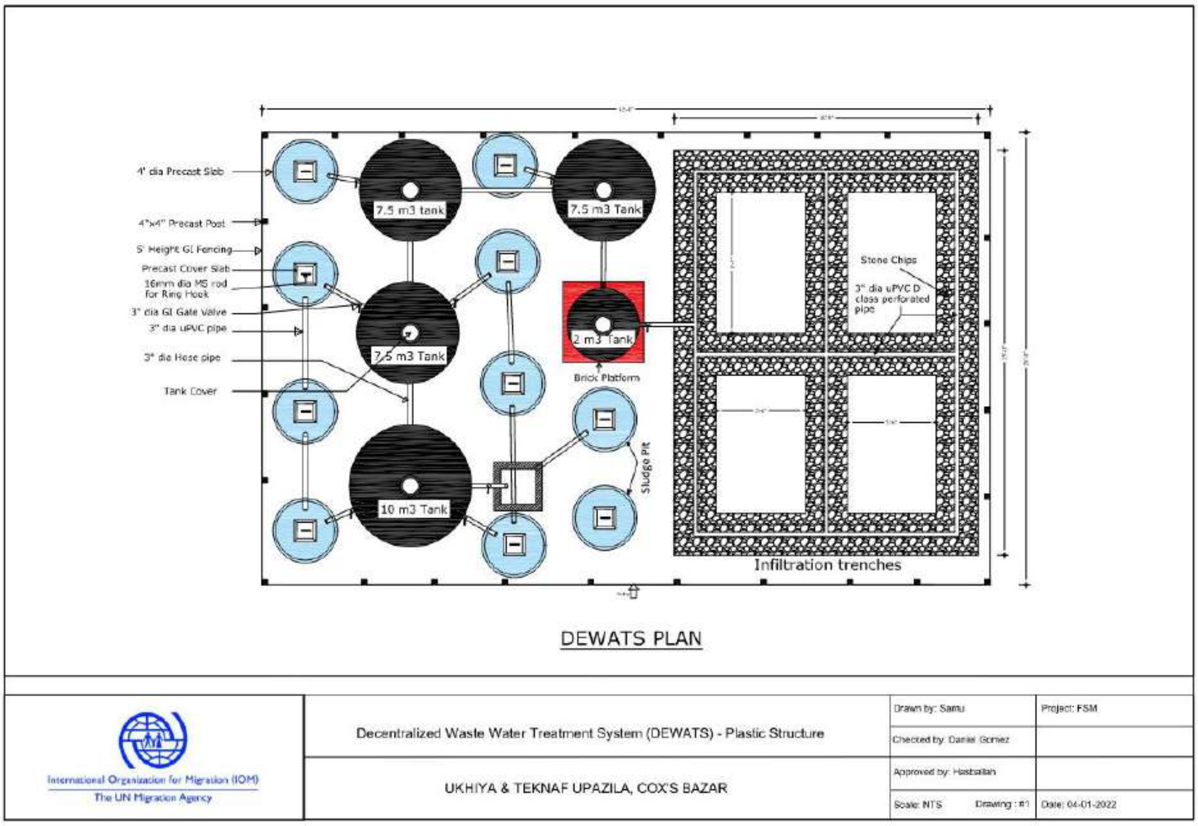
Details

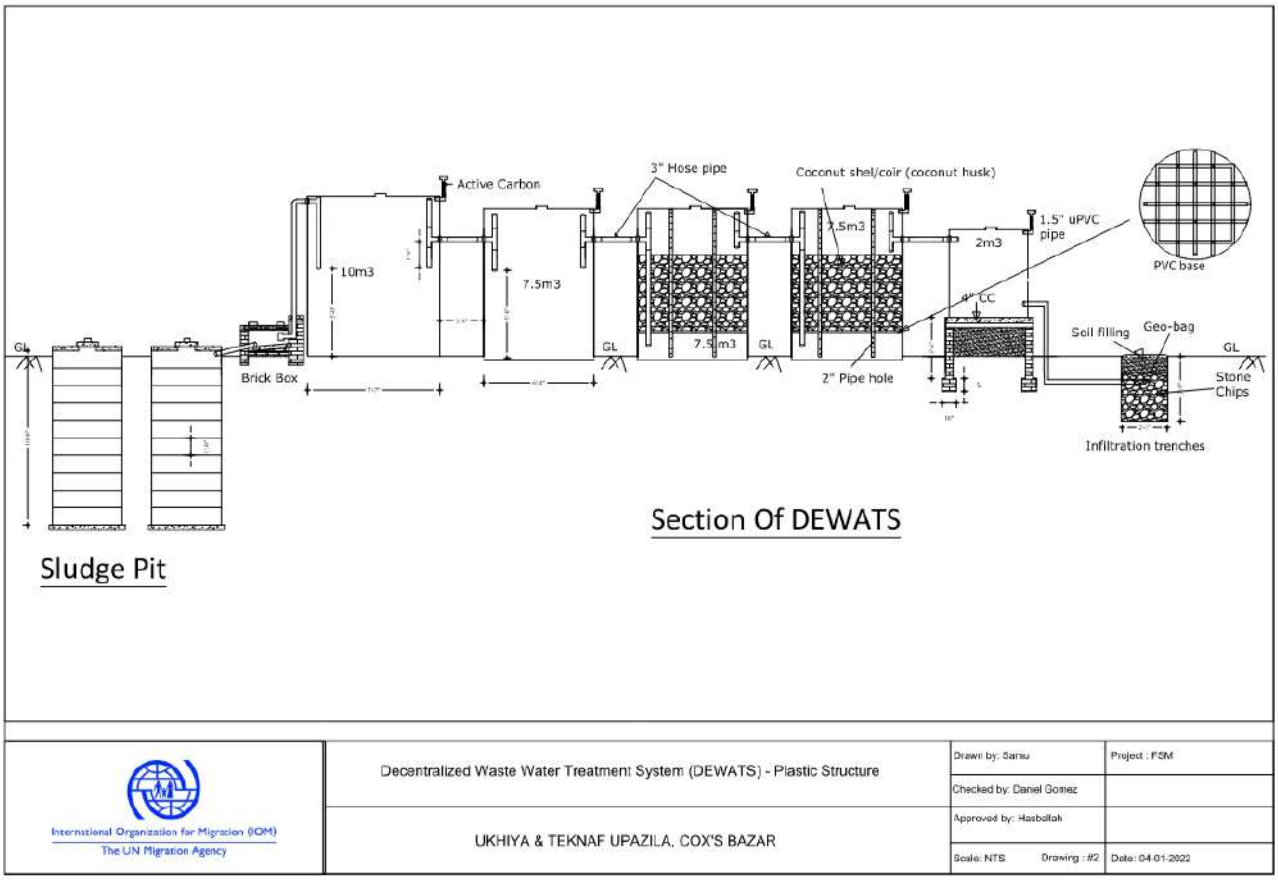
Parameters	Key Findings
Location & construction date	Camp 9 September 2019
Capacity	Design capacity 3m^3/day
Area requirements and scalability	- Total area 76 m2 - Treatment area 111 m2, included underground infiltration area - Area required 39 m2/m3 treated - **If space allows, the system is easy to scale up by adding more tanks and filters in set.**
Capex USD/m^3	- Capex 3,555 $/m^3 treated
Opex USD/m^3	- 0.9 $/m^3 treated
Whole life cost	- $ 548
Speed of construction and setup	- **15-20- days.** - **No major civil works required.** - **Local materials used** - The use of plastic tanks speeds the construction process
Expertise required for setup and operations	- Setup: 1 engineer, 1 technician, 5 non -skilled labour - Operation: 2 trained skilled labour, 1 supervisor.
Operation and maintenance	- **Low O&M. No main challenges found** - Main regular operational activities are: sludge loading, solids removal via gate valve, site cleaning. - Regular maintenance needed: periodic replacement of the gate valve and filter media.
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- **Liquid infiltration in rainy season** can be challenging, particularly if site not properly selected looking at the ground water level.
Disposal of final products	- Liquid infiltrated - Solid is dried in a pit. Plan for landfilling
Resilience to disaster	- Site selected considering flooding

Process flow diagram



Site Layouts





FSTP photographs

Biodigester and UFF tanks

Biodigester and UFF tanks

Biodigester and UFF tanks

Solids storage pits

A.2.2 DEWATS, Camp 12

Details

Parameters	Key Findings
Location & construction date	Camp 12 September 2020
Capacity	Design capacity 6m³/day
Area requirements and scalability	- Total area 196 m2 - Treatment area 121 m2 - Area required 20 m2/m3 treated - Scalable. **Two modules constructed together, space is saved and double volume can be treated. If you build one module separately it will take space around 116 to 121 m2 but building together saved space around 40m2.**
Capex USD/m³	- Capex 3,555 $/m³ treated
Opex USD/m³	- 0.69 $/m³ treated
Whole life cost	- $ 453
Speed of construction and setup	- **15-20- days.** - **No major civil works required.** - **Local materials used** - The use of plastic tanks speeds the construction process
Expertise required for setup and operations	- Setup: 1 engineer, 1 technician, 5 non -skilled labour - Operation: 2 trained skilled labour, 1 supervisor.
Operation and maintenance	- **Low O&M. No main challenges found** - Main regular operational activities are: sludge loading, solids removal via gate valve, site cleaning. - Regular maintenance needed: periodic replacement of the gate valve and filter media.
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- **Liquid infiltration in rainy season** can be challenging, particularly if site not properly selected looking at the ground water level.
Disposal of final products	- Liquid infiltrated - Solid is dried in a pit. Plan for landfilling
Resilience to disaster	- Site selected considering flooding

Process flow diagram

Site Layout

As camp 9

FSTP photographs

Raw inlet

Biodigester and UFF tanks

Overall site view

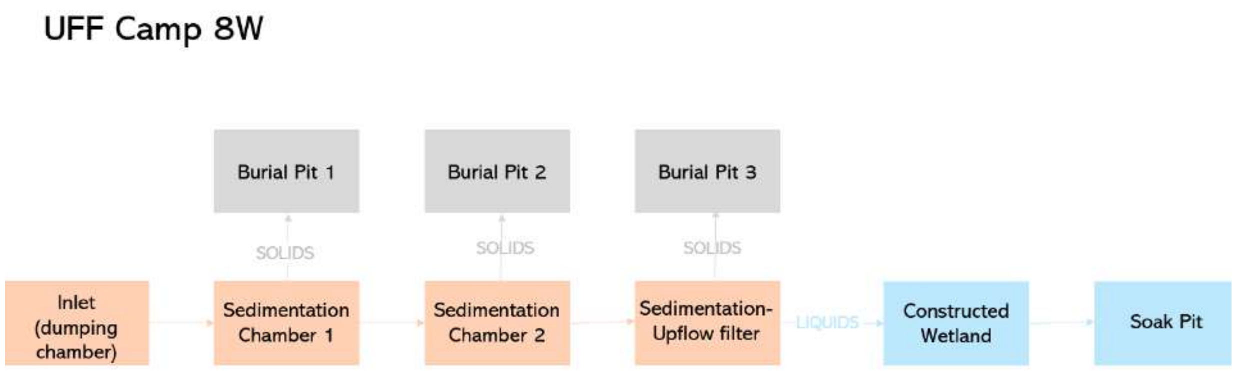
Infiltration (FE) beds

A.2.3 Upflow Filter, Camp 8W

Details

Parameters	Key Findings
Location & construction date	Camp 8W January 2019
Capacity	Design capacity 2.85m³/day
Area requirements and scalability	- Total area 120 m2 - Treatment area 80 m2 - Area required 28 m2/m3 treated - Scalable
Capex USD/m³	- Capex 8,984 $/m³ treated - Number of labour required to construction 17 (DEWATS required only 7)
Opex USD/m³	- 1.39 $/m³ treated
Whole life cost	- $ 939
Speed of construction and setup	- 45 days. - **Civil works required for constructed wetland and pits.**
Expertise required for setup and operations	- Setup: 2 site engineers, 1 supervisor, 4 skilled-labour, 10 non - skilled labour - Operation: 1 engineer, 1 WASH officer, 5 workers
Operation and maintenance	- **Low O&M. No main challenges found** - Gravity system used - Main regular operational activities are: sludge loading, solids removal via gate valve, site cleaning. - Gate valve need to be replaced periodically
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- **No pinch point identified**
Disposal of final products	- Liquid infiltrated - **Solid send to compost**
Resilience to disaster	- Plant elevated - Considering building drainage system and retention walls

Process flow diagram



Site Layout

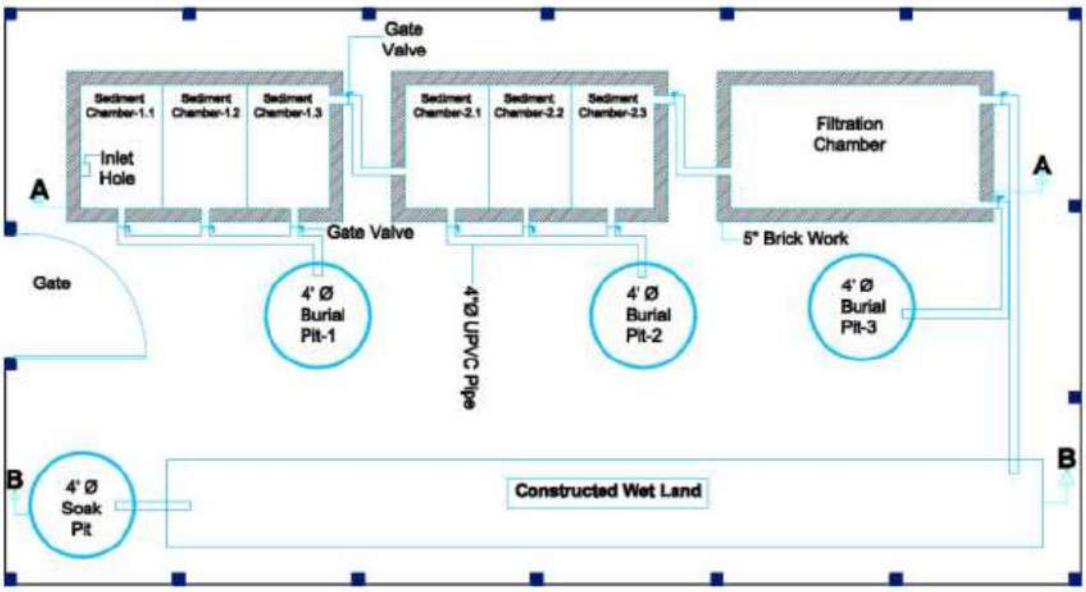


Figure 9: Plan view of the 4th generation system

FSTP photographs

Overall site view

UFF

Planted filter and solids pits

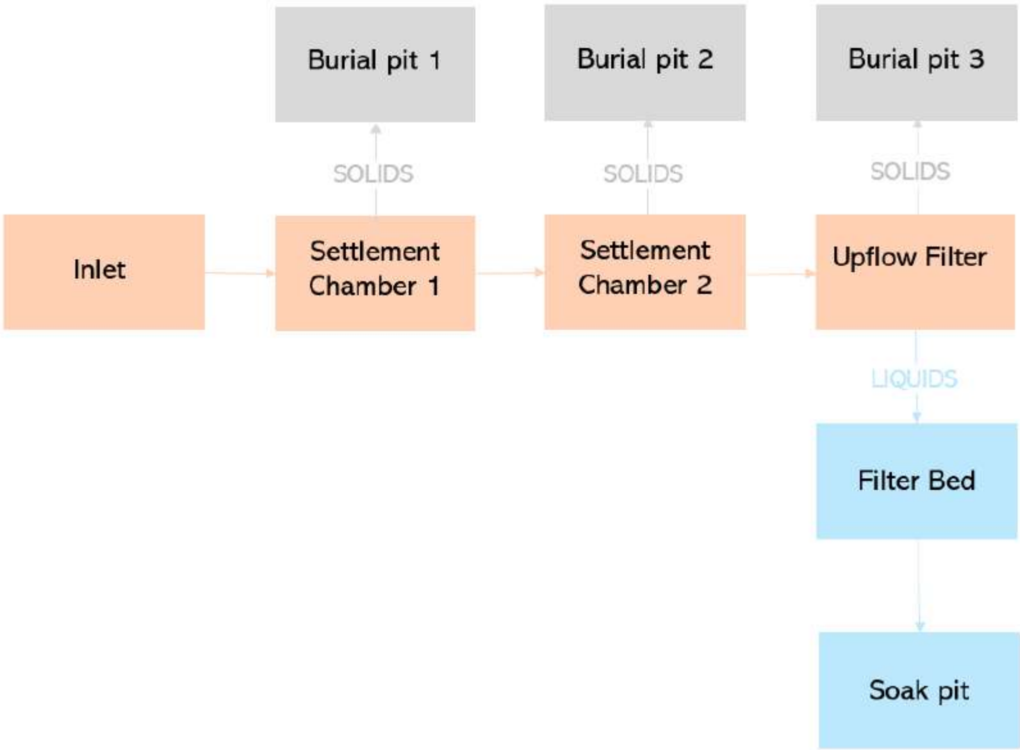
Planted filter and solids pits

A.2.4 Upflow Filter, Camp 7

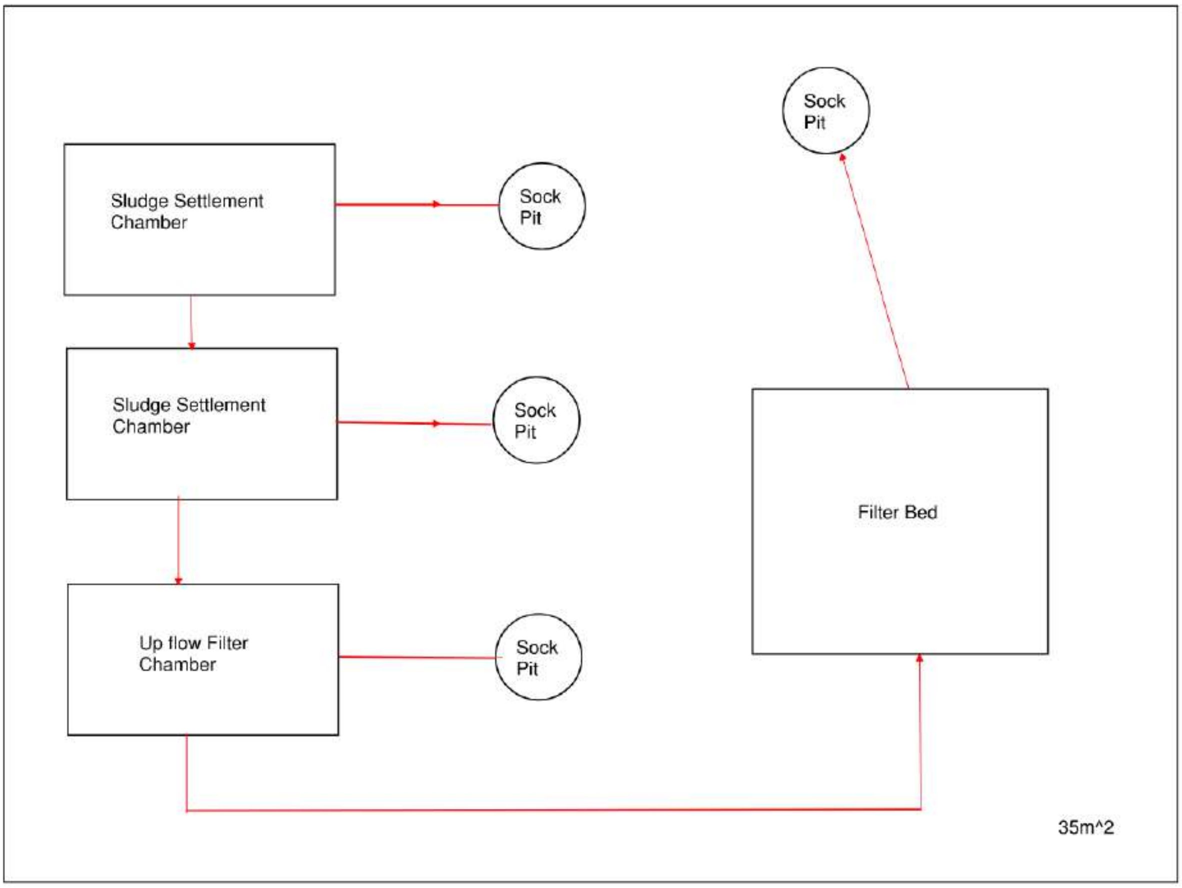
Details

Parameters	Key Findings
Location & construction date	Camp 7 September 2020
Capacity	Design capacity 3m^3/day
Area requirements and scalability	- Total area 35 m2 - No available data on treatment area
Capex USD/m^3	- No available
Opex USD/m^3	- 7.22 \$/m^3 treated. Not enough data to understand what the cost is covering
Whole life cost	- No available
Speed of construction and setup	- No available
Expertise required for setup and operations	- No available
Operation and maintenance	- Main regular operational activities are: sludge loading, solids removal via gate valve, site cleaning. - **Regular maintenance needed: periodic replacement of the filter media (every 3 months)**
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- No pinch point identified
Disposal of final products	- Liquid discharge to the environment - Solid stored
Resilience to disaster	- Drainage system established

Process flow diagram



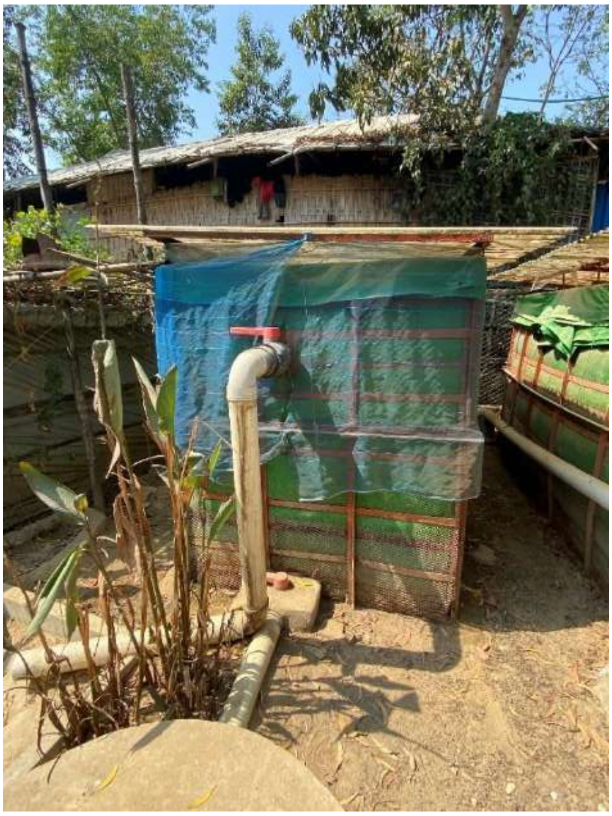
Site Layout



FSTP photographs

General site view

UFF



UFF

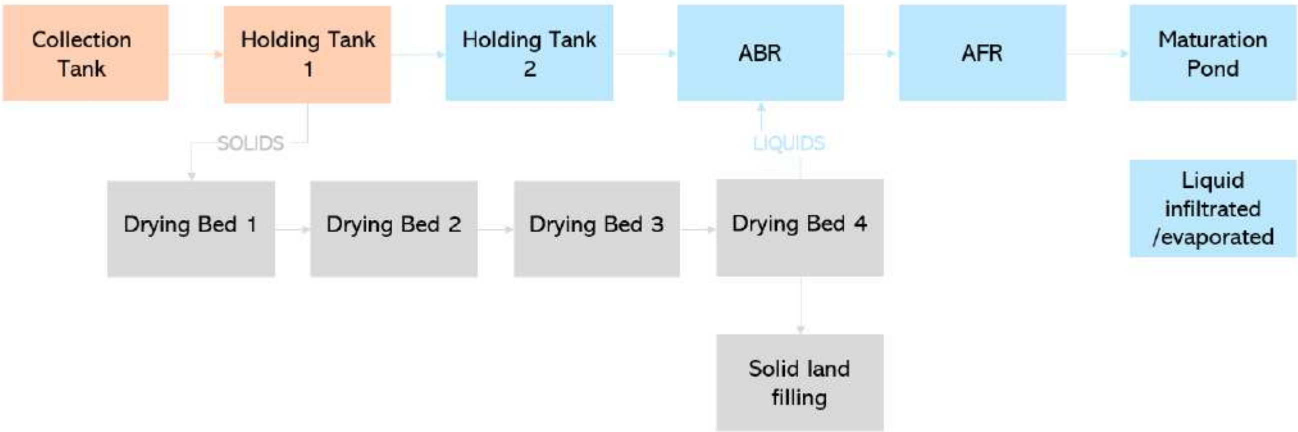
Solids pits

A.2.5 Anaerobic Baffled Reactor (ABR), Camp 21

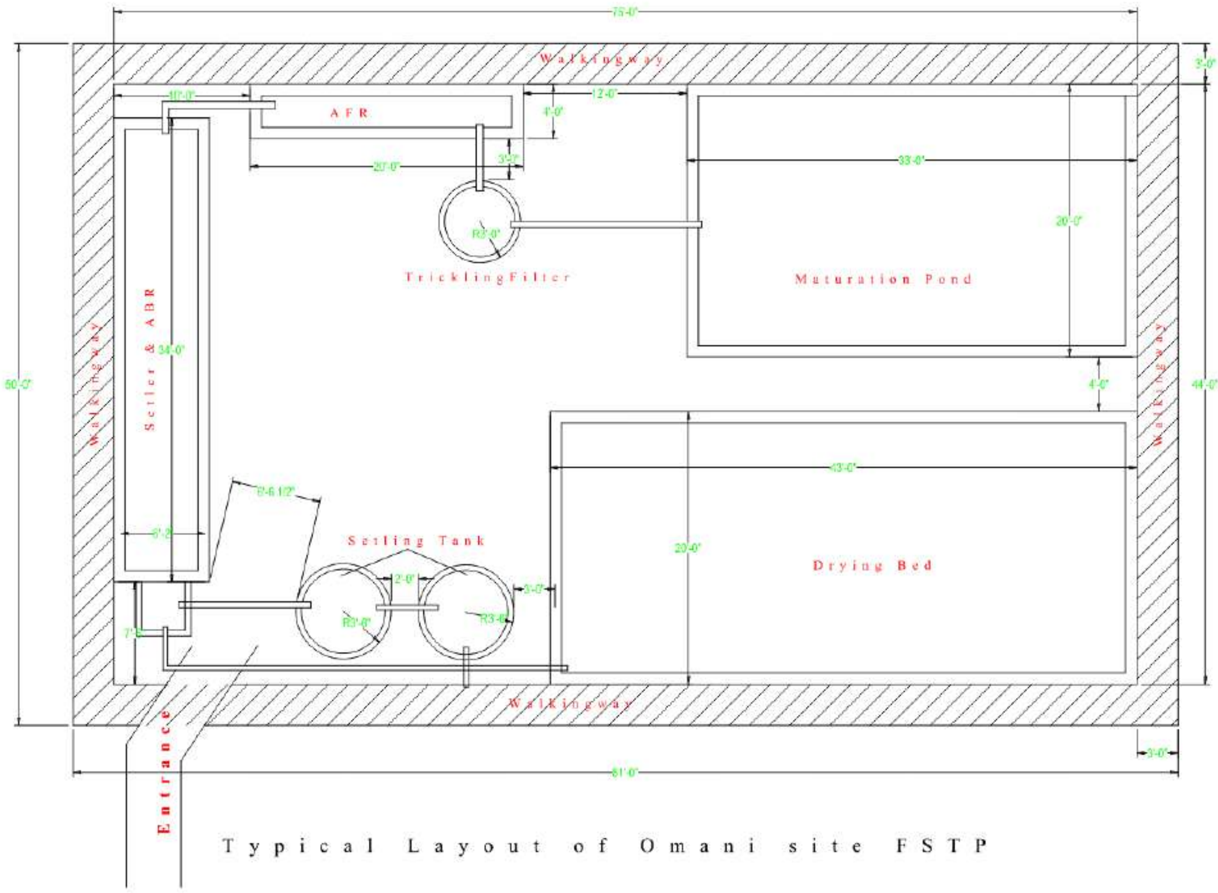
Details

Parameters	Key Findings
Location & construction date	Camp 21 February 2021
Capacity	Design capacity 6m³/day
Area requirements and scalability	- Total area 414 m2 - Treatment area 378 m2 - Area required 63m2/m³ - Most of the space in the sites is used by the final treatment units, polishing ponds and drying beds. - Not modular.
Capex USD/m³	- Capex 5,192 $/m³ treated
Opex USD/m³	- 0.35 $/m³ treated
Whole life cost	- $ 1,110
Speed of construction and setup	- 5 months
Expertise required for setup and operations	- Setup: civil engineer, project engineer, unskilled labour. - Operation: civil engineer, operator and security guard.
Operation and maintenance	- **Main challenges found block of the flow control** - Main regular activities are: desludging, flow control, operate pump, site cleaning. - **Other maintenance needed: replacement coconut husk of filter media.** - Safe to operate
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- **Low operational complexity** - Common blockages in the flow control.
Disposal of final products	- Environment-friendly and sustainable - Liquid to the natural environment - Solid goes to landfill
Resilience to disaster	- Elevated platform - Slope protection around the site

Process flow diagram

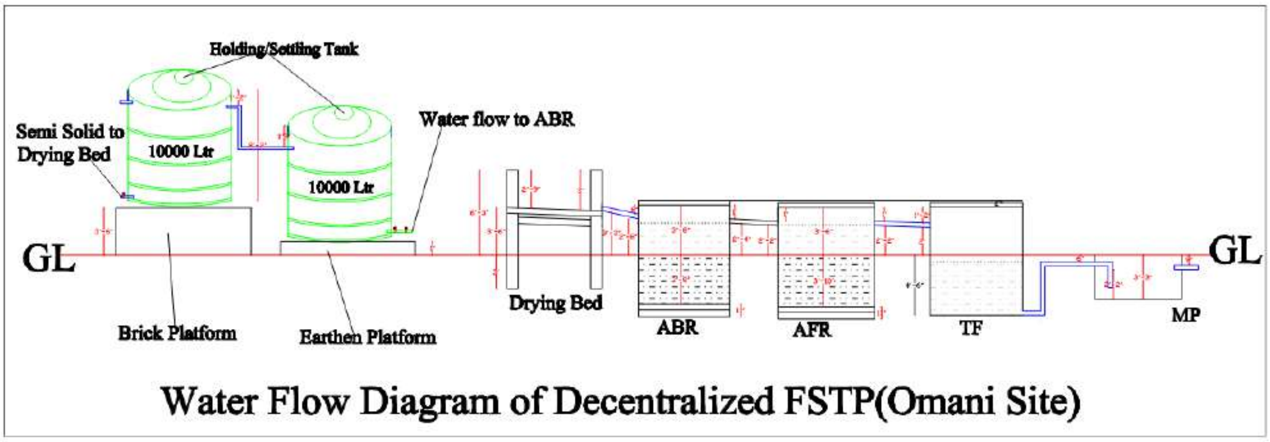


Site Layouts



Typical Layout of Omani site FSTP

Site hydraulic section



FSTP photographs

Holding tanks

ABR

Drying bed

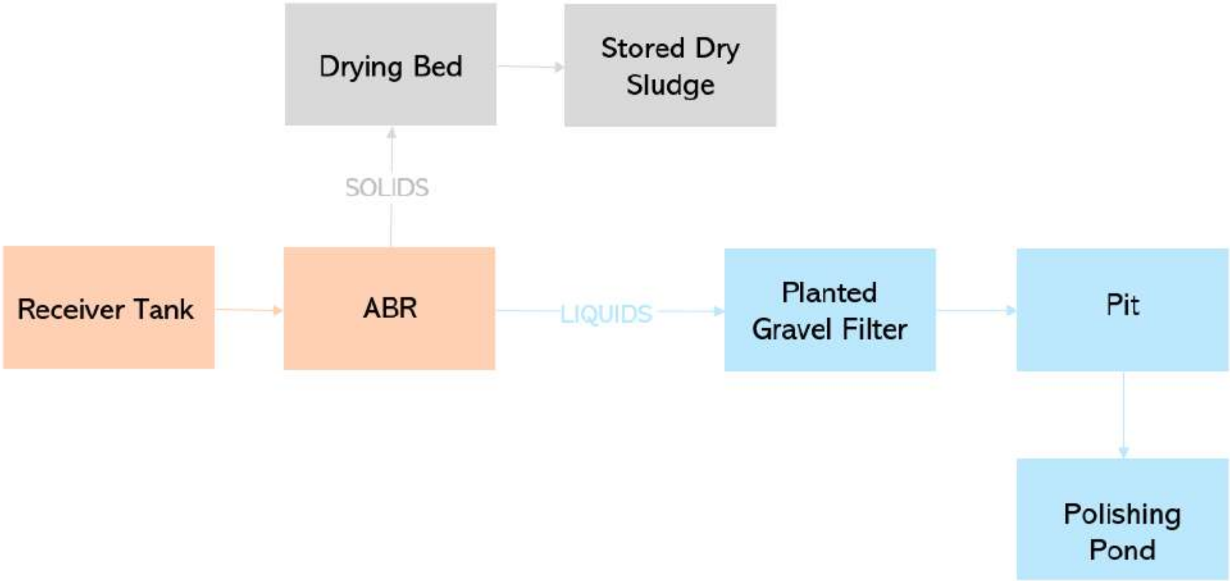
Planted filter

A.2.6 Anaerobic Baffled Reactor (ABR), Camp 14

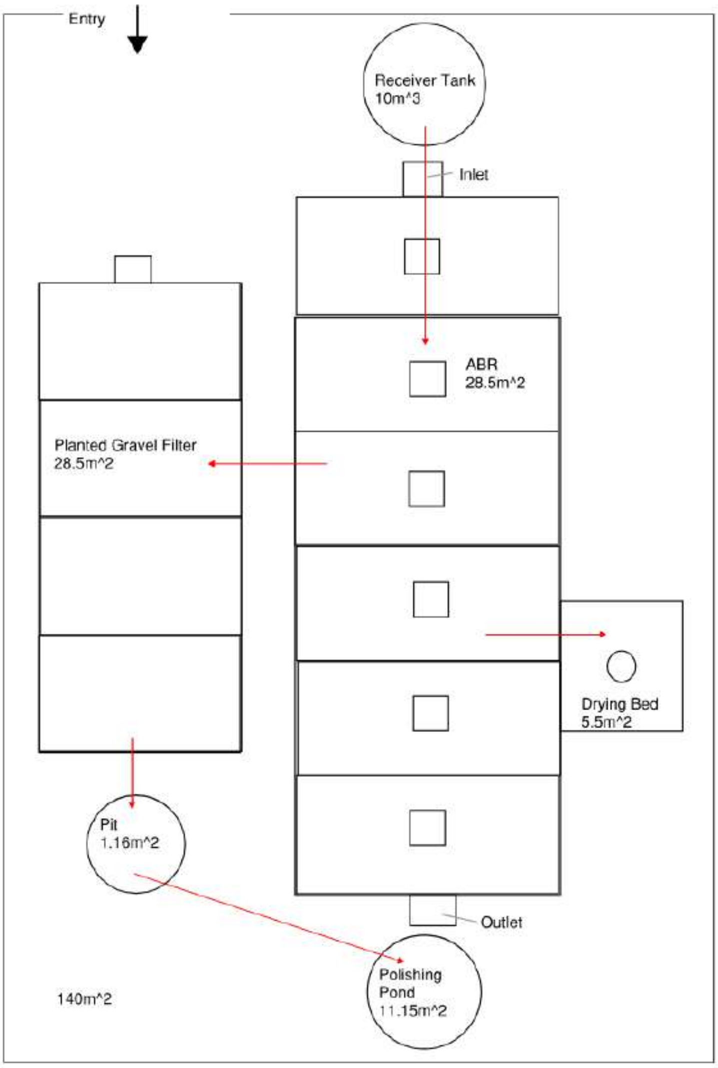
Details

Parameters	Key Findings
Location & construction date	Camp 14 June 2019
Capacity	Design capacity 10m³/day
Area requirements and scalability	- Total area 140 m2 - **Treatment area 78 m2** - **Area required 8m2/m³**
Capex USD/m³	- Capex 2,087 $/m³ treated
Opex USD/m³	- **0.47 $/m³ treated**
Whole life cost	- $ 418
Speed of construction and setup	- 2 months
Expertise required for setup and operations	- Setup: 1 engineer, 1 site engineer, 1 supervisor, 5 skilled, 30 non-skilled labour. - Operation: 1 site engineer, 1 supervisor, 1 FSTP worker.
Operation and maintenance	- Main regular activities are desludging, flow control, filter media cleaning. - **Other maintenance needed: pipe that carry sludge is sometimes cut or steal and needs replacement.** - Safe to operate
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- No pinch points identified
Disposal of final products	- Environment-friendly and sustainable - Liquid to the natural environment - Solid package and stored off site
Resilience to disaster	- Guide wall

Process flow diagram



Site Layout



FSTP photographs

Holding tank

ABR

Planted filter

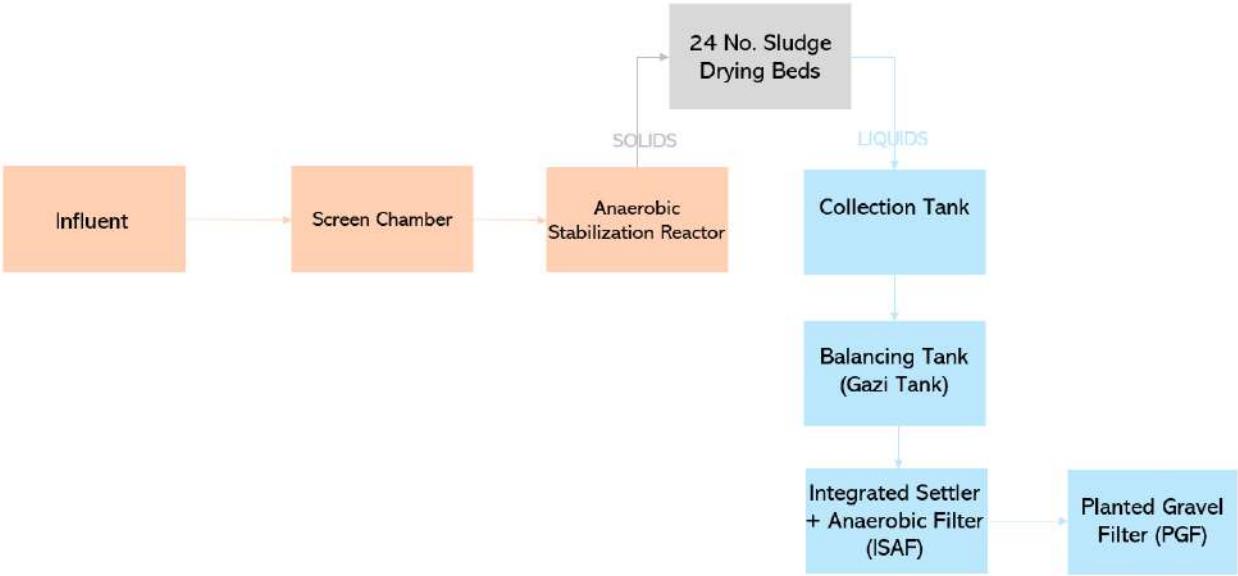
Soak pit

A.2.7 Anaerobic Baffled Reactor (ABR), Camp 18

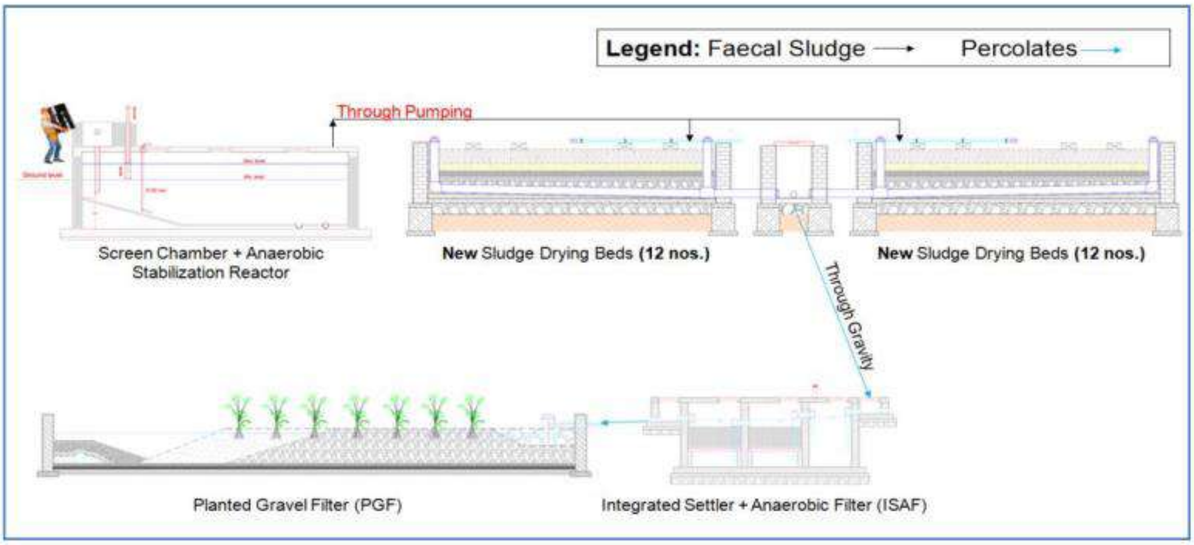
Details

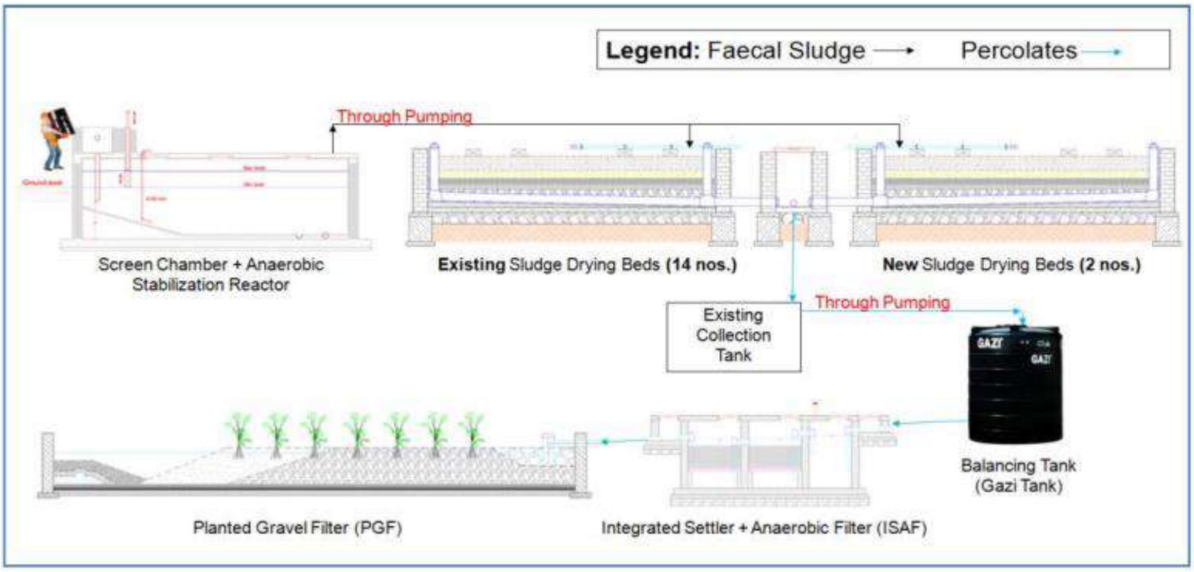
Parameters	Key Findings
Location & construction date	Camp 18 2021
Capacity	Design capacity 15m³/day **Actual sludge treated 7m³/day, not all component has been commissioned**
Area requirements and scalability	- Total area 3,300 m2 - Treatment area 2,625 m2 - **Area required 167m2/m³** - **The FSTP has 14 existing plus 26 new drying beds, which occupy 600m2.**
Capex USD/m³	- Capex 13,907 $/m³ treated - 32% Capex as labour cost, the rest materials and equipment
Opex USD/m³	- **44.15 $/m³ treated (include desludge operation and treatment)** - **Currently using a pump, plan to change by solar energy**
Whole life cost	- $8,592
Speed of construction and setup	- **Can be done in 8 months Took 1 year due to pandemic restrictions**
Expertise required for setup and operations	- Setup: 1 engineer, labours for masonry work
Operation and maintenance	- Operation and maintenance activities: screening clean, pumping, incinerator, cleaning of inlet chamber - Maintenance required spare parts
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- **Not enough capacity to collect enough faecal sludge**
Disposal of final products	- Liquid to the natural environment - **Solid incinerated, ashes use in gardens** - **Plan to compost the solid in the future**
Resilience to disaster	- Elevated units

Process flow diagram



Site Layout


Legend: Faecal Sludge
Percolates
Through Pumping
Screen Chamber + Anaerobic Stabilization Reactor
New Sludge Drying Beds (12 nos.)
New Sludge Drying Beds (12 nos.)
Through Gravity
Planted Gravel Filter (PGF)
Integrated Settler + Anaerobic Filter (ISAF)


Legend: Faecal Sludge
Percolates
Through Pumping
Screen Chamber + Anaerobic Stabilization Reactor
Existing Sludge Drying Beds (14 nos.)
New Sludge Drying Beds (2 nos.)
Existing Collection Tank
Through Pumping
Balancing Tank (Gazi Tank)
Planted Gravel Filter (PGF)
Integrated Settler + Anaerobic Filter (ISAF)

FSTP photographs

Inlet

ASR

Gravel filter

Drying beds

General site view

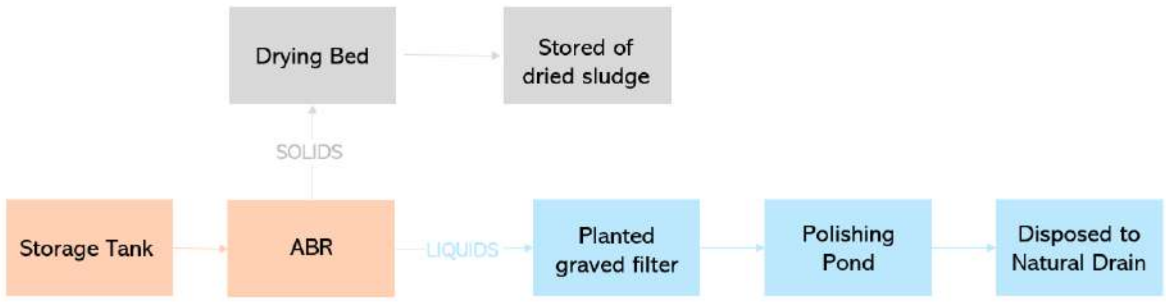
Solids incineration

A.2.8 Anaerobic Baffled Reactor (ABR), Camp 5

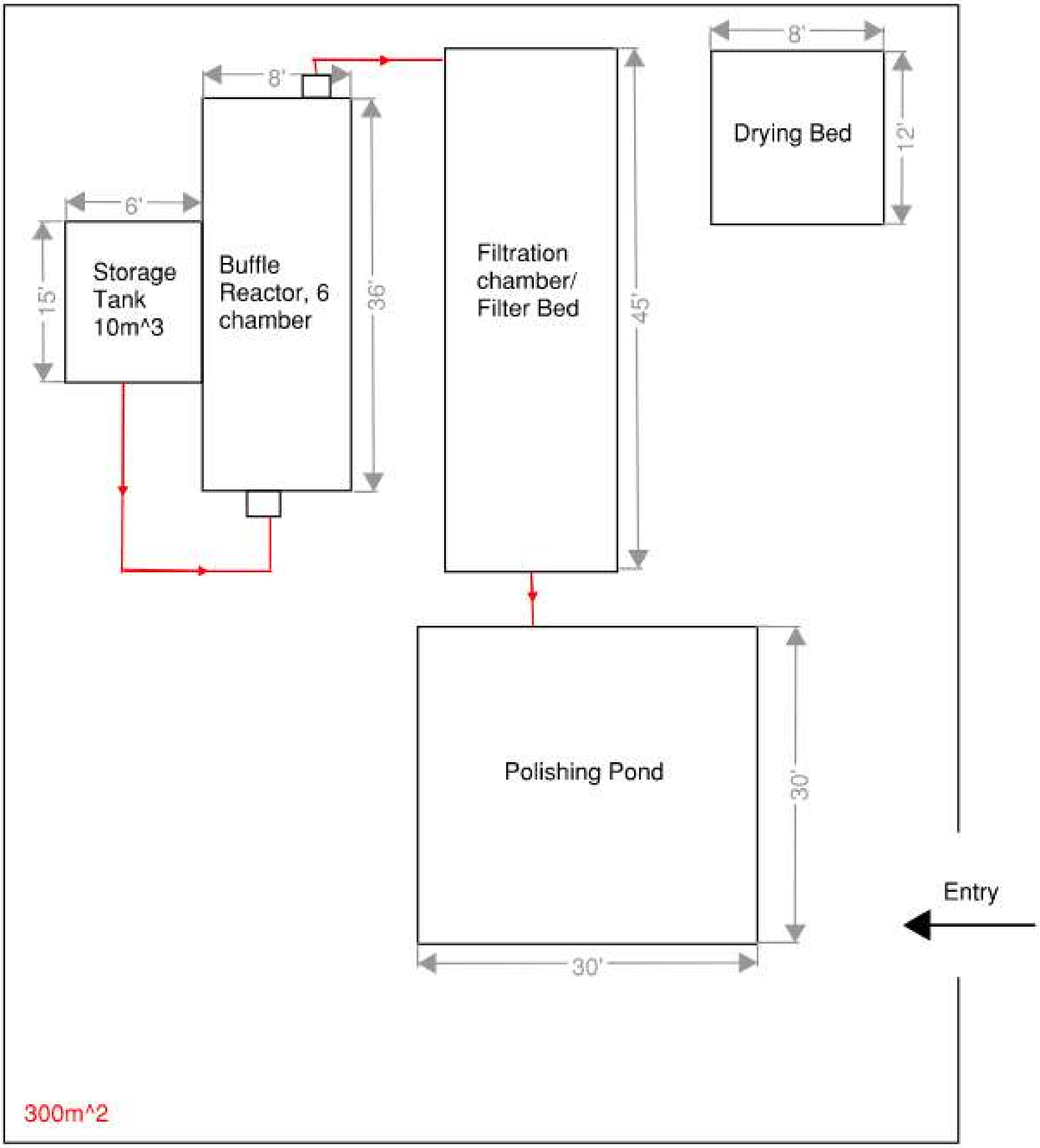
Details

Parameters	Key Findings
Location & construction date	Camp 5 March 2019
Capacity	Design capacity 10 m^3/day
Area requirements and scalability	- Total area required 300 m2 - Treatment area 160m2 - Area required 16m2/m3
Capex USD/m^3	- Capex 1,564 \$/m^3 treated -
Opex USD/m^3	- 1.17 \$/m^3 treated -
Whole life cost	- $ 607
Speed of construction and setup	- 2 months - Significant constructions work. - ABRs, filtration units and liquid effluent treatment units required excavation and concrete construction.
Expertise required for setup and operations	- Setup: 1 engineer, 1 site engineer, 1 supervisor, 5 skilled, 20 non-skilled. - Operation: 1 engineer, 1 supervisor, 1 skilled labour,5 non-skilled labour. Need to know how to operate and maintain the pump and generator.
Operation and maintenance	- Easy O&M - **Main challenges found Kolaboti tree not sustainable. Need to be replanted every months, haven't found a solution yet.** - Main regular activities are: desludging, flow control, operate pump, site cleaning.
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- Filter bed clogged
Disposal of final products	- Environment-friendly and sustainable - Liquid to the natural environment - Solid is stored in stored room inside the plant
Resilience to disaster	- Elevated platform to protect from flooding

Process flow diagram



Site Layout



FSTP photographs

Holding tanks

ABR

Gravel filter

Planted gravel filter

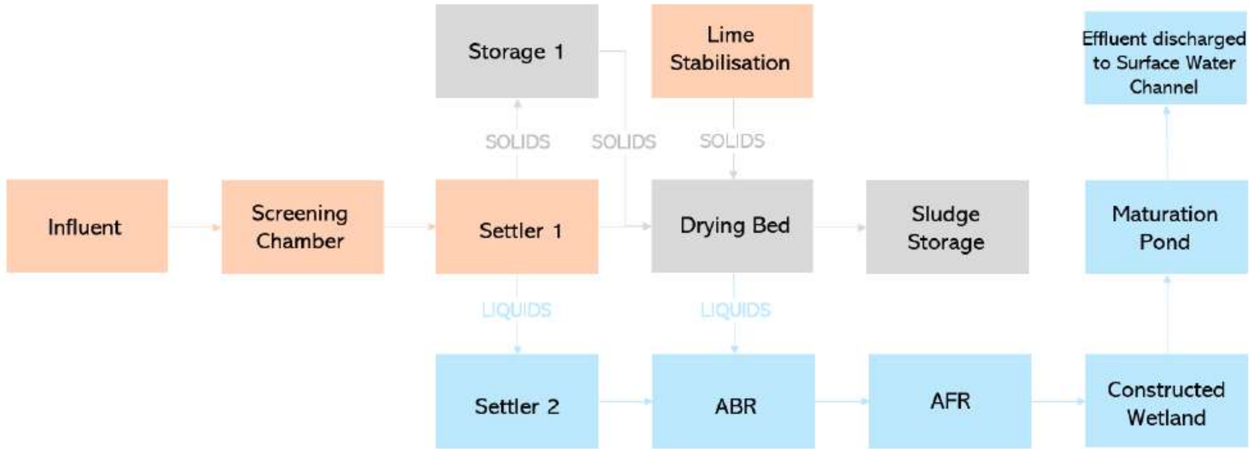
Polishing pond

A.2.9 Anaerobic Baffled Reactor (ABR), Camp 12

Details

Parameters	Key Findings
Location & construction date	Camp 12 November 2028 – Upgrade to biological June 2020
Capacity	Design capacity 10 m^3/day Actual volume treated 8 m^3/day Issues with the TSS in the effluent prevent the FSTP to work full capacity Plant initially design for chemical treatment but converted into biological in June 2020.
Area requirements and scalability	- Total area required 1,871 m2 - Treatment area 283 m2 - Area required 28m2/m3 - Not scalable, each treatment step has only one chamber. - In case of future expansion probably need the area to be rearrange.
Capex USD/m^3	- Capex 9,250 \$/m^3 treated - Initially, this site was built as chemical treatment, and it was modified in 2020 to make it biological. The Capex represents the two investments. The fact that this site was made in two phases and had to be upgraded may have increase the cost.
Opex USD/m^3	- 19.58 \$/m^3 treated - HR (\$1,000 USD), electricity, land rental, consumables (\$3,700 USD)
Whole life cost	- \$ 6,195
Speed of construction and setup	- 5.5 months (4 months first phase, plus 1.5 to convert to biological)
Expertise required for setup and operations	- Setup: 1 supervisor, 2 skilled labour, 2 non skilled labour - Operation: 1 supervisor, 1 skilled labour,1 non-skilled labour.
Operation and maintenance	- Easy O&M - Main regular activities are: desludging tanks and dispose sludge in drying beds. pumping - Canna indica plants needs replanting
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- No pinch points identified.
Disposal of final products	- Environment-friendly and sustainable - Liquid discharge into a channel - Sludge is dried an stocked. Exploring the idea of future composting
Resilience to disaster	- No actions taken to increase resilience to flooding. FTSP located in flat area close to road drainage, flooding occurs in rainy season.

Process flow diagram



Site Layout

FSTP photographs

Inlet screen

General site view

Settler

Maturation pond

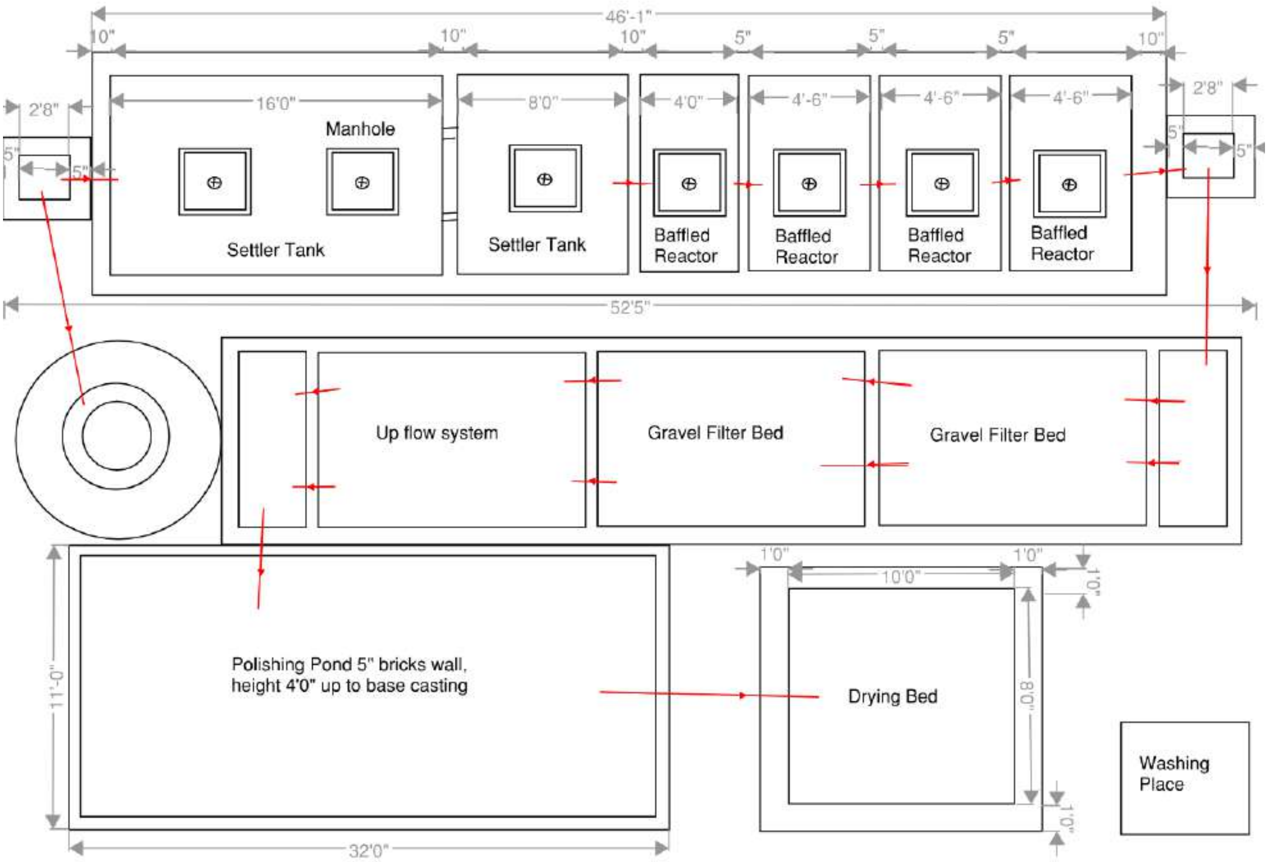
Solids drying and storage

A.2.10 Anaerobic Baffled Reactor (ABR), Camp 8W

Details

Parameters	Key Findings
Location & construction date	Camp 8W December 2021
Capacity	Design capacity 10 m^3/day
Area requirements and scalability	- Total area required 162.58 m2 - Treatment area 92 m2 - Area required 9m2/m3
Capex USD/m^3	- Capex 2,549 \$/m^3 treated
Opex USD/m^3	- 3.64 \$/m^3 treated
Whole life cost	- $1,515
Speed of construction and setup	- 4 months
Expertise required for setup and operations	- Setup: 1 Engineer, 1 Supervisor, 6 Skilled labour, 10 Non skilled labour - Operation: 1 Engineer (partial), 1 Supervisor (partial), 2 volunteer/skilled
Operation and maintenance	- Main issues: Blocking of flow control
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- No pinch points identified
Disposal of final products	- Liquid discharge into soak pit - Sludge is dried and transfer into a solid waste composting site
Resilience to disaster	- Protection wall to avoid land sliding during periods of heavy rain

Site Layout



FSTP photographs

Holding tank

ABR

UFF and gravel filter

Planted filter

Soakaway pit

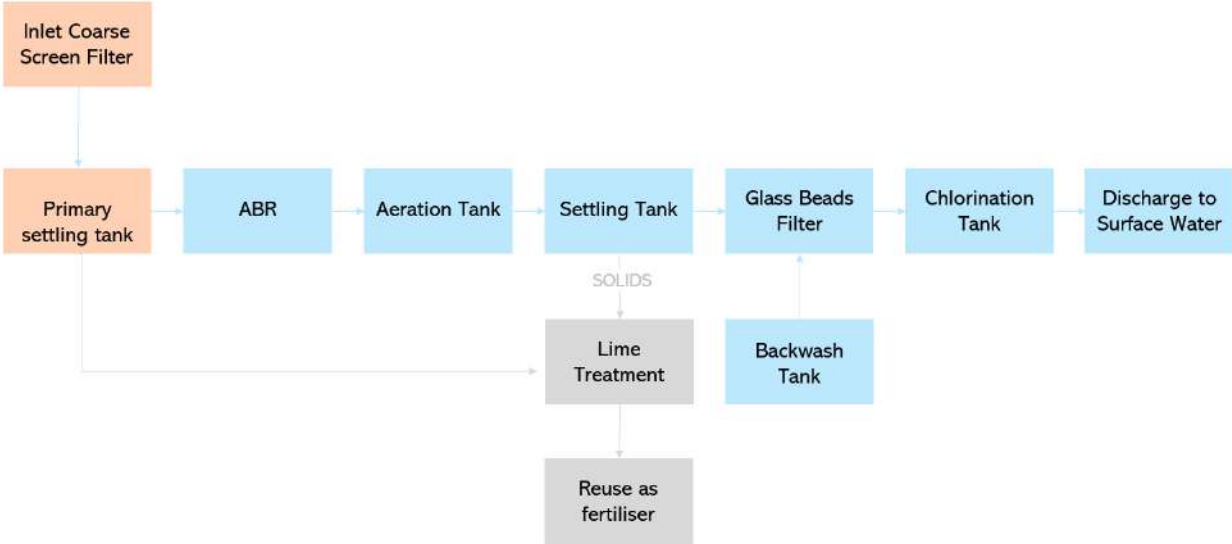
Natural drain

A.2.11 Aeration, Camp 18

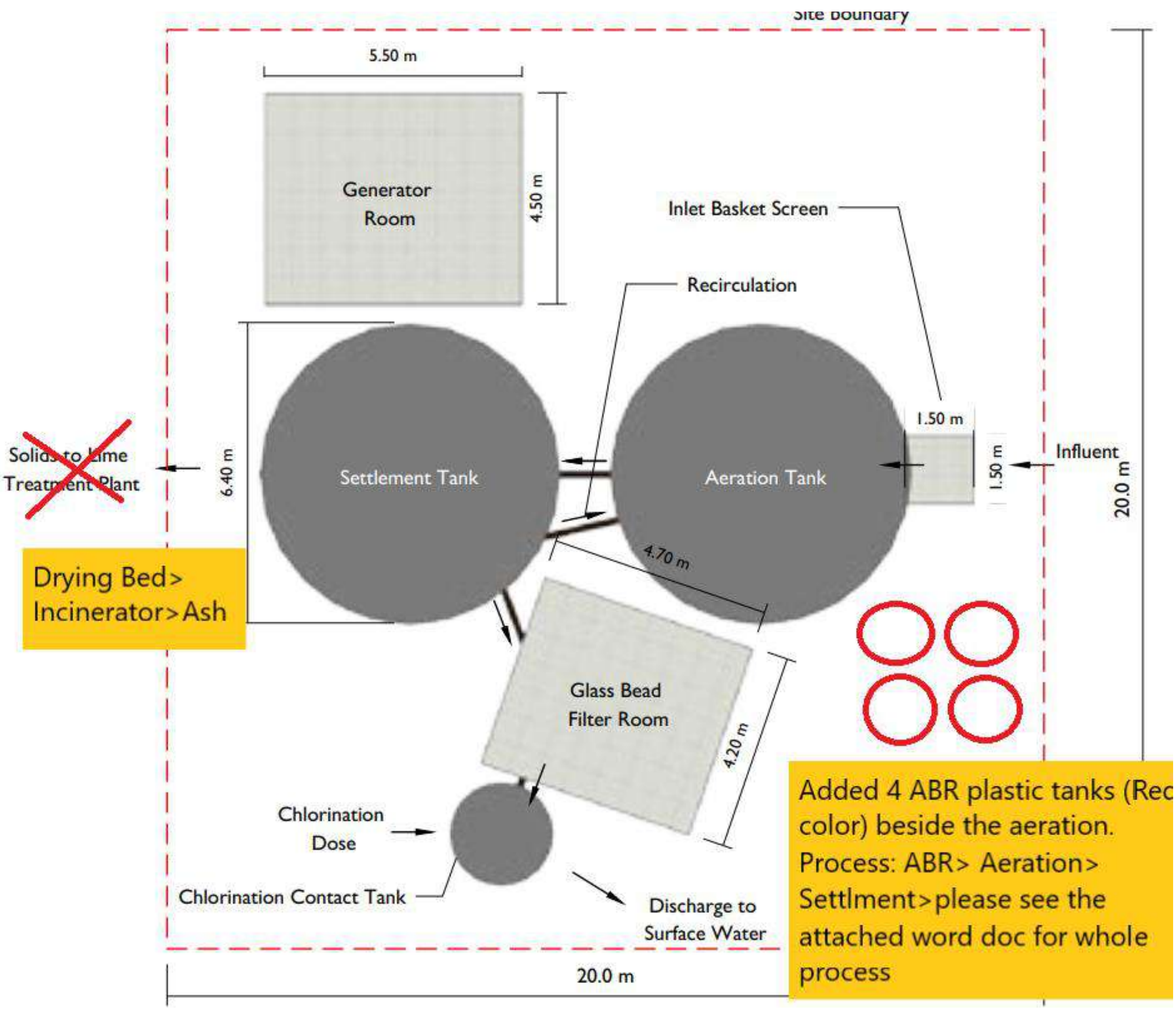
Details

Parameters	Key Findings
Location & construction date	Camp 18 2021
Capacity	Design capacity 15m^3/day Actual volume treated 7 m^3/day. Not all the components have been commissioned.
Area requirements and scalability	- Total area required 420 m2. All area used for treatment units. - Area required 28m^2/m^3. - Modular system, easy to scale up.
Capex USD/m^3	- Capex 4,633 $/m^3 treated.
Opex USD/m^3	- 31.4$/m^3 treated - The site is operated with a generator.
Whole life cost	- $ 5,604
Speed of construction and setup	- 1 month if all materials are available - Challenging to transport materials to site due to the equipment size
Expertise required for setup and operations	- Needs skill engineers and process expert to set up the system - Needs to train skilled labour for FSTP operation
Operation and maintenance	- Main regular activities are: screening cleaning, operate pump, adding fuel to the generator, inlet and scum cleaning, chlorination, desludge of tanks, cleaning of incinerator
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- Not enough available sludge collected and transported to the site. Bottleneck with the transfer network - Size if the aeration equipment
Disposal of final products	- Liquid to the natural environment - Solid is incinerated and the ashes reuse in the garden
Resilience to disaster	- Elevated drying beds to avoid flooding

Process flow diagram



Site Layout



FSTP photographs

General site view

Primary tank

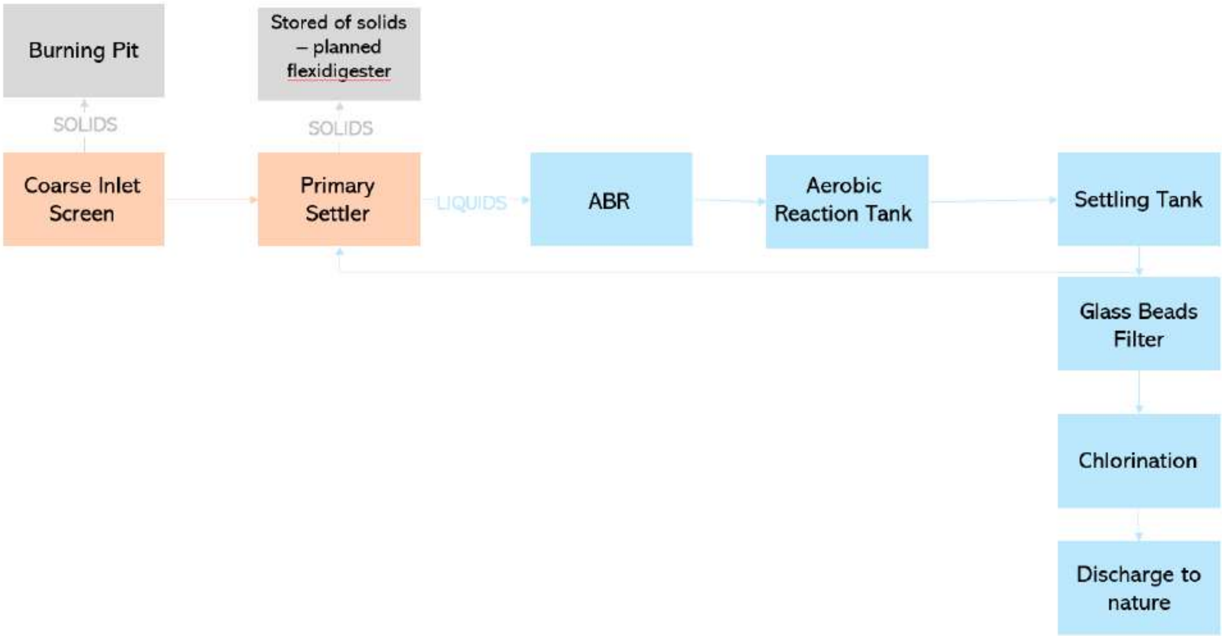
Final tank

A.2.12 Aeration, Camp 19

Details

Parameters	Key Findings
Location & construction date	Camp 19 2Sept 2021
Capacity	Design capacity 30m^3/day Actual volume treated 4 m^3/day. Not all the components have been commissioned.
Area requirements and scalability	- Total area required 546 m2. All area used for treatment units. - Area required 18m^2/m^3. - Modular system, easy to scale up.
Capex USD/m^3	- Capex 3,333 $/m^3 treated.
Opex USD/m^3	- 27.5$/m^3 treated - The site is operated by solar energy during the day and generator at night. - The fuel cost is fixed, but the labour cost is variable depending on demand.
Whole life cost	- $ 1,553
Speed of construction and setup	- 10 months
Expertise required for setup and operations	- Set up: 3 plumbers, 2 engineers, 5 skilled, 4 unskilled - Operation: 3 operators, 4 unskilled - Needs to train skilled labour for FSTP operation
Operation and maintenance	- Main regular activities are: screening cleaning, operate pump, solar panel cleaning, adding fuel to the generator, inlet and scum cleaning, chlorination, desludge of tanks
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- No pinch points recorded
Disposal of final products	- Liquid to the natural environment - Solid is stored but they are planning to compost it or flexidigester
Resilience to disaster	- Elevated platform for tanks

Process flow diagram



Site Layout

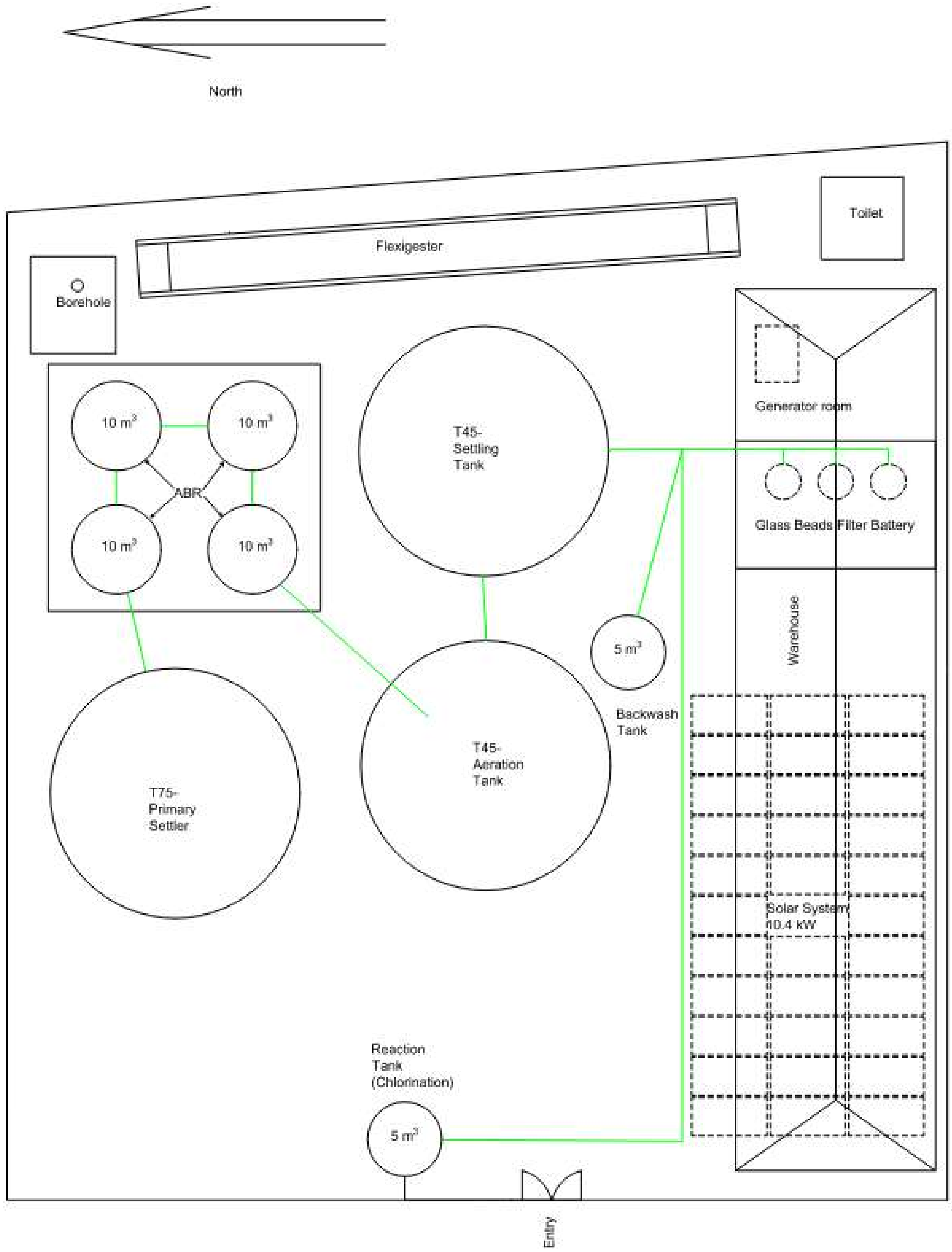


Figure: Layout of FSM Plant at Camp 19

FSTP photographs

Primary tank

Aeration tank

Final settlement tank

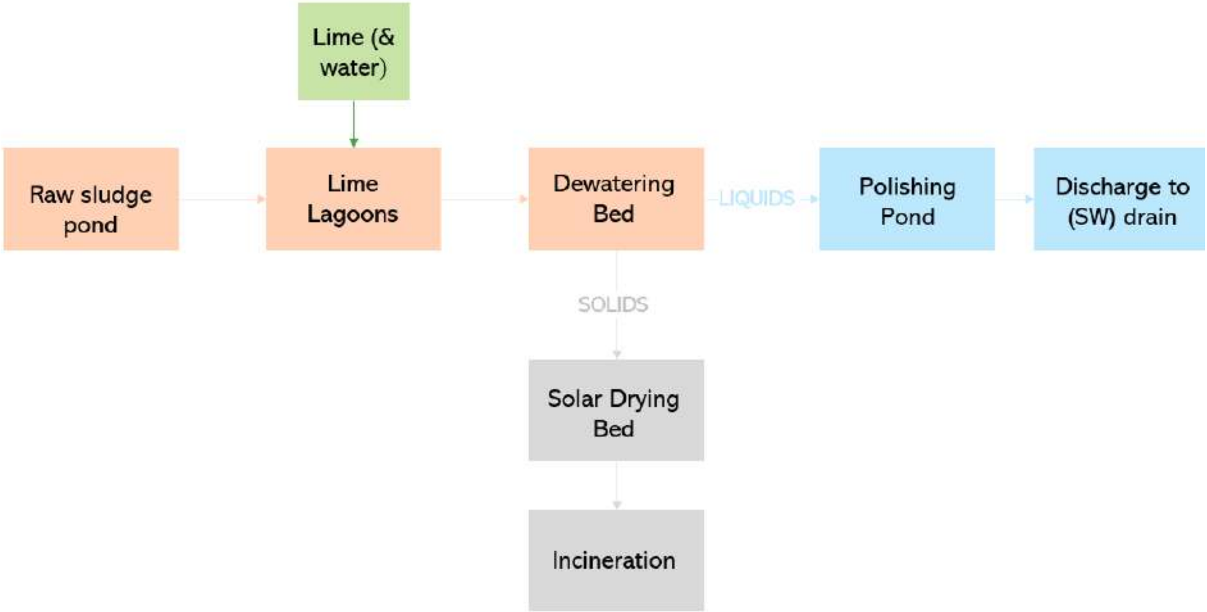
Glass bead filter

A.2.13 Lime, Camp 4

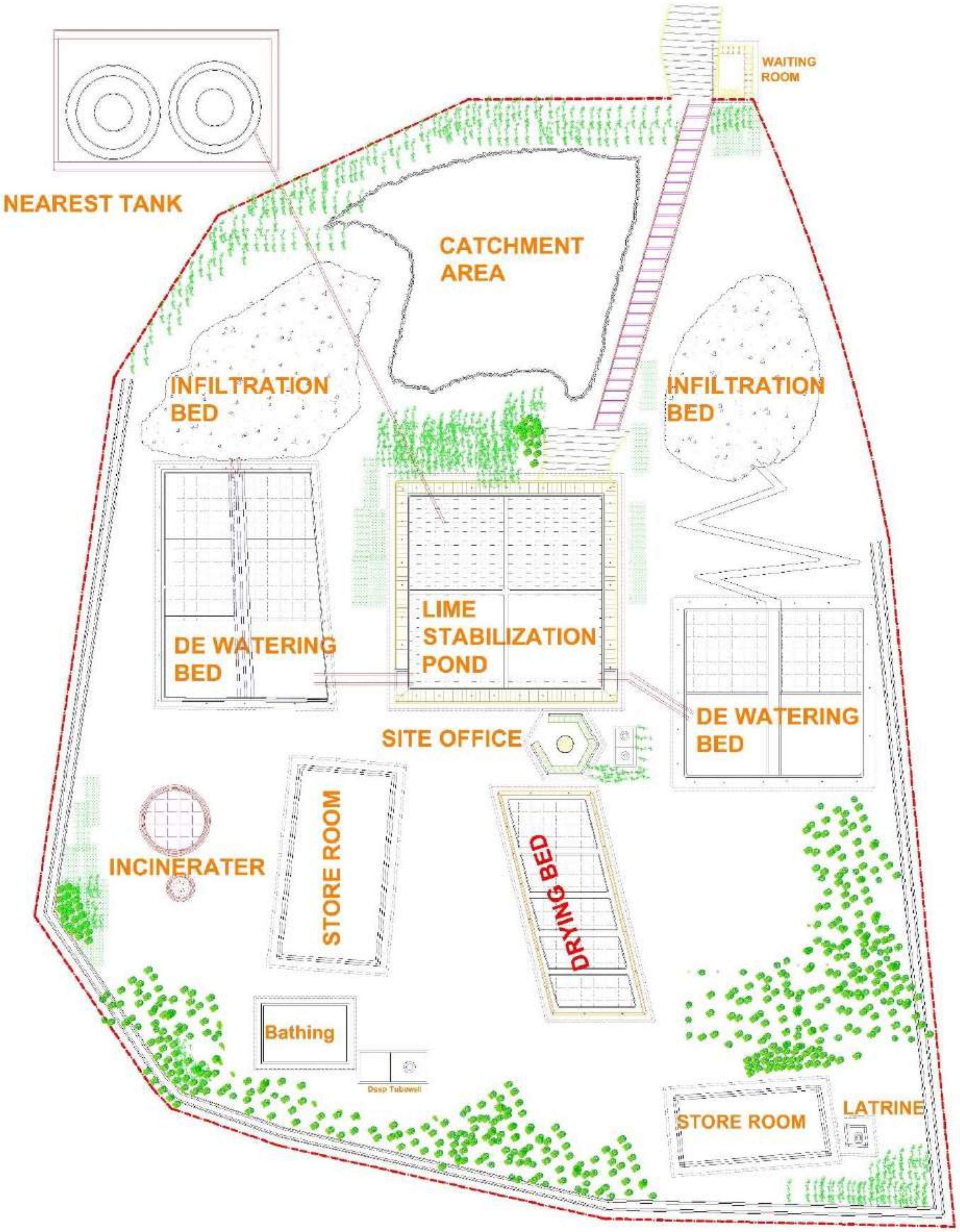
Details

Parameters	Key Findings
Location & construction date	Camp 4 February 2018
Capacity	Design capacity 10 m^3/day Actual volume treated 7 m^3/day
Area requirements and scalability	- Total area 1,330 m^2 - Treatemnt unit area required 978 m^2 - Area required 98 m^2/m^3 treated. - To scale up more treatment units needs to be constructed, which required significant space and simple construction work
Capex USD/m^3	- Capex 4,060 \$/m^3 treated. - This treatment type has very low Capex, no major civils works are required.
Opex USD/m^3	- 9.57 $/m3 treated
Whole life cost	- $ 2,858
Speed of construction and setup	- 1 month. Fast construction and setting. Good for rapid response - Simple civils work. - Chemical treatment do not required time to activate treatment
Expertise required for setup and operations	- Needs to train skilled labour for FSTP operation but it is not a complex process
Operation and maintenance	- Main regular activities are: lime mixing and, regular Ph readings and management of the final solid product. - There are health risks when handling hydrated lime, the staff needs to be trained in H&S protocols and used adequate PPE
Treatment performance	- Refer to Appendix G
Complexity of process and pinch points	- Low complexity but chemical reliance and H&S risks for the operators - Filter media blockage - Management of solid final product
Disposal of final products	- Liquid infiltrated - Solid is incinerated
Resilience to disaster	- Units on elevated platform to avoid flooding - Drainage system in the FSTP to manage surface water from rain

Process flow diagram



Site Layout



OXFAM LIME STABILIZATION POND

FSTP photographs

Lime dosing ponds

Dewatering beds

Drying beds

Infiltration / polishing pond

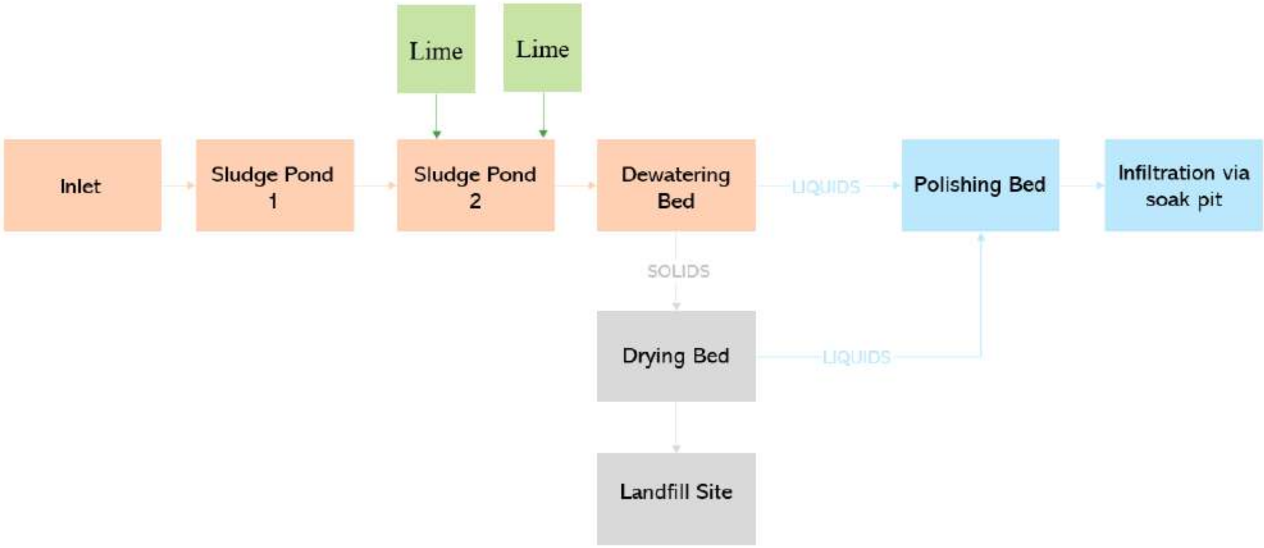
A.2.14 Lime, Camp 1W

Details

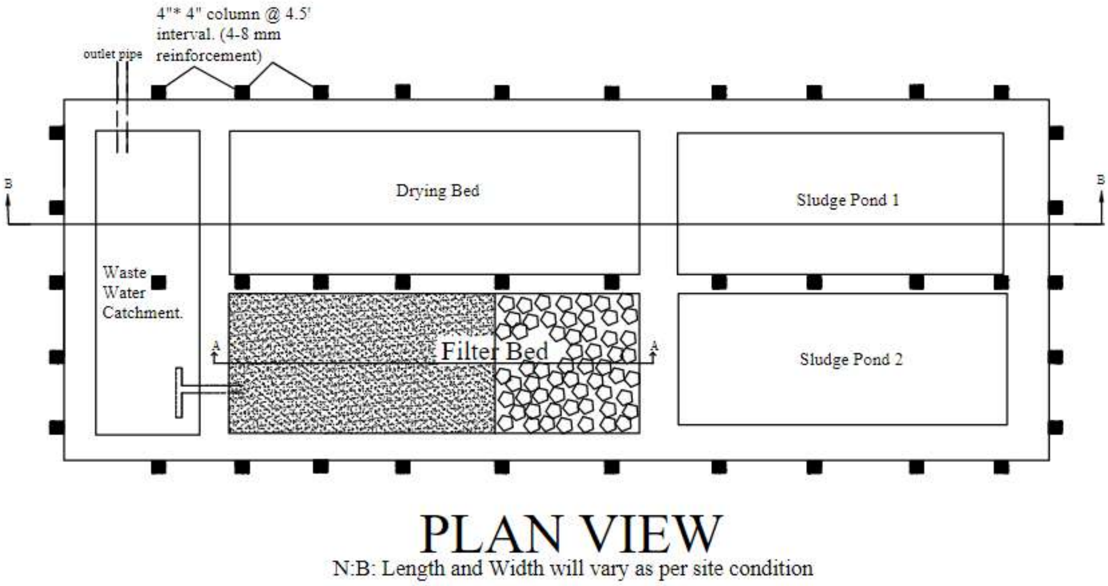
Parameters	Key Findings
Location & construction date	Camp 1W January 2019
Capacity	5.5 m^3/day
Area requirements and scalability	Total area 312.31 m^2 Treatment area 140 m^2 Area required 27 m^2/m^3 treated. To scale up more treatment units need to be constructed, which require significant space but relatively simple construction work.
Capex/m^3	Capex 3,058 \$/m^3 treated.

Parameters	Key Findings
Opex/m^3	3.44 \$/m^3 treated
Whole life cost (USD/m^3/yr)	\$1,607
Speed of construction and setup	1 month. Fast construction and sett up. Good for rapid response Simple civils work. Lined earth bunds/ponds can be used for the main treatment processes. Chemical treatment does not require time to activate treatment i.e. fast to commission.
Expertise required for setup and operations	Needs to train skilled labour for FSTP operation but it is not a complex process
Operation and maintenance	Main regular activities are: lime mixing and, regular pH readings and management of the final solid product. Main issues: clogged filer media There are health risks when handling hydrated lime; the staff need to be trained in H&S protocols and use adequate PPE
Treatment performance	Refer to Appendix G
Complexity of process and pinch points	Low complexity but chemical reliance and H&S risks for the operators Filter media blockage Management of solid final product i.e. available space at FSTP is a pinch point.
Disposal of final products	Liquid discharge in a canal Solid to landfilling
Resilience to disaster	No measures recorded

Process flow diagram



Site Layout



FSTP photographs

Drying bed

Sludge ponds

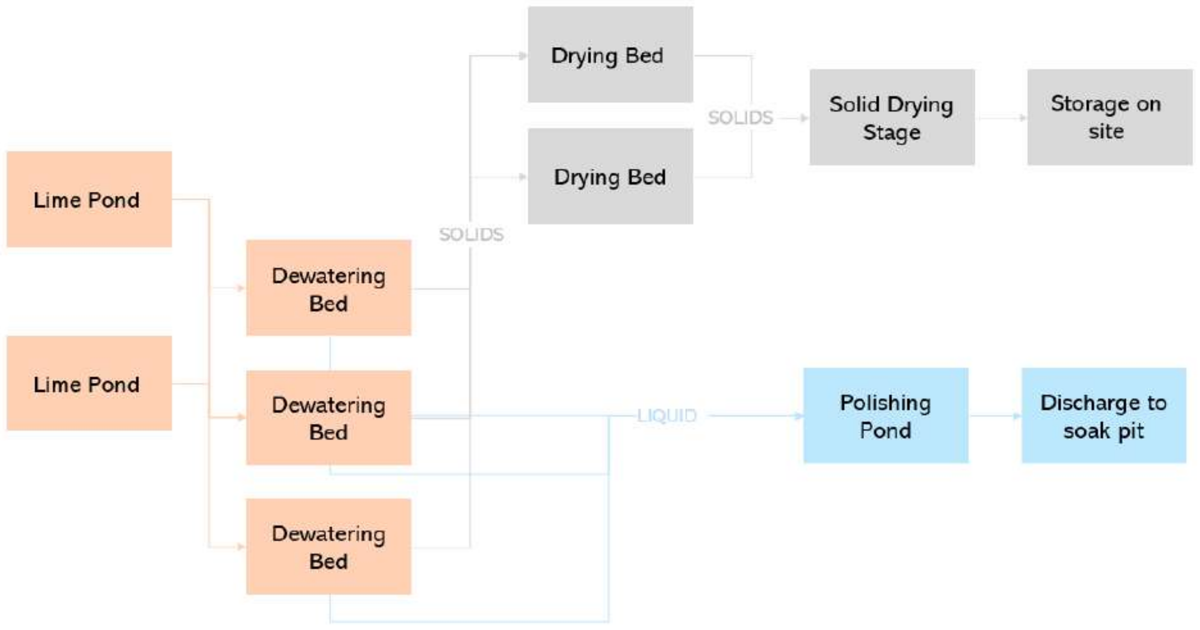
Infiltration pit

Treatment plant

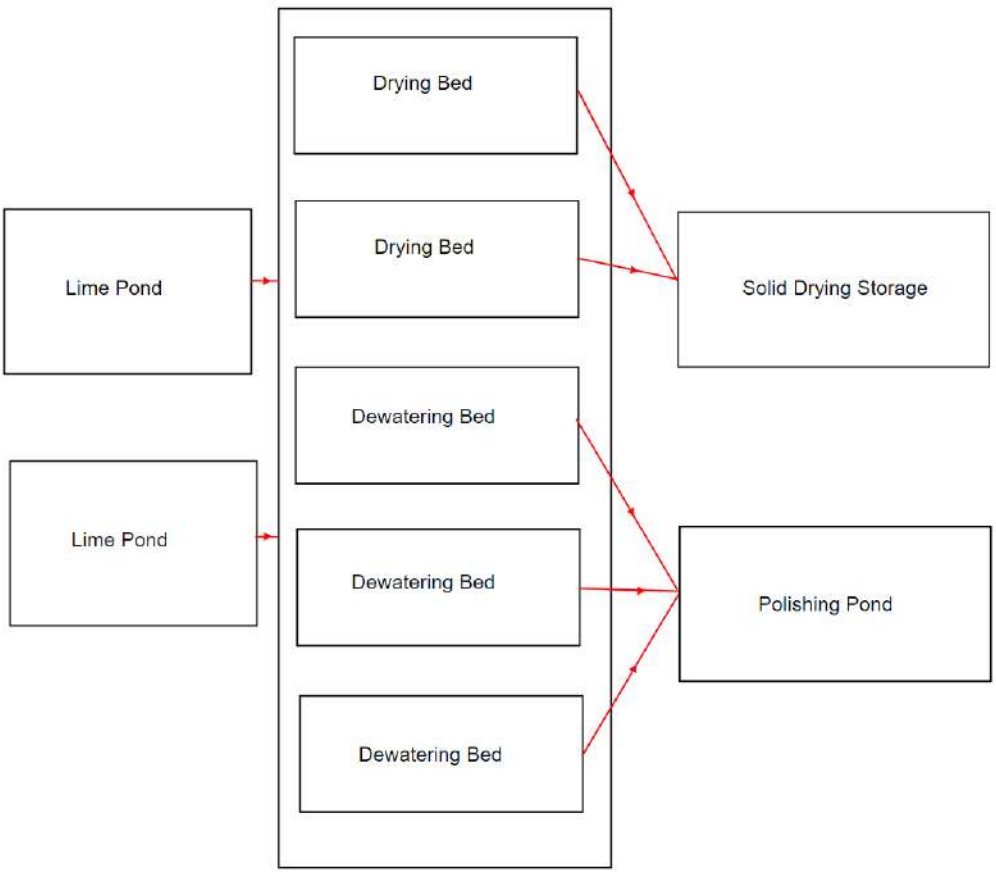
A.2.15 Lime, Camp 26

Parameters	Key Findings
Location & construction date	Camp 26 July 2019
Capacity	5 m^3/day
Area requirements and scalability	Total area 253 m^2 Treatment area required 85 m^2 Area required 17m^2/m^3 treated. To scale up more treatment units need to be constructed, which require significant space but relatively simple construction work .
Capex/m^3	Capex 1,554.4$/$m^3$ treated.
Opex/m^3	4.79 $/$m^3$ treated
Whole life cost (USD/m^3/yr)	$2,099
Speed of construction and setup	2 months. Fast construction and sett up. Good for rapid response Simple civils work. Lined earth bunds/ponds can be used for the main treatment processes. Chemical treatment does not require time to activate treatment i.e. fast to commission.
Expertise required for setup and operations	Needs to train skilled labour for FSTP operation but it is not a complex process
Operation and maintenance	Main regular activities are: lime mixing and, regular pH readings and management of the final solid product. Main issue: Clogging of drying bed filter media There are health risks when handling hydrated lime; the staff need to be trained in H&S protocols and use adequate PPE
Treatment performance	Refer to Appendix G
Complexity of process and pinch points	Low complexity but chemical reliance and H&S risks for the operators Filter media blockage Management of solid final product i.e. available space at FSTP is a pinch point.
Disposal of final products	Liquid evaporates Solid is stored on site
Resilience to disaster	No measures recorded.

Process flow diagram



Site Layout



FSTP photographs

Drying and dewatering beds

Solid drying

Polishing pong

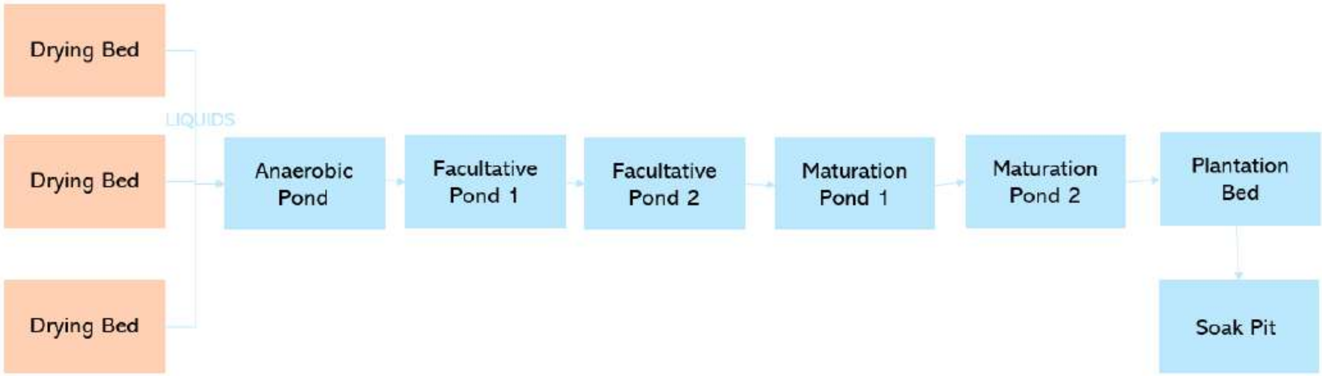
Dewatering bed

A.2.16 Waste Stabilisation Ponds, Camp 7

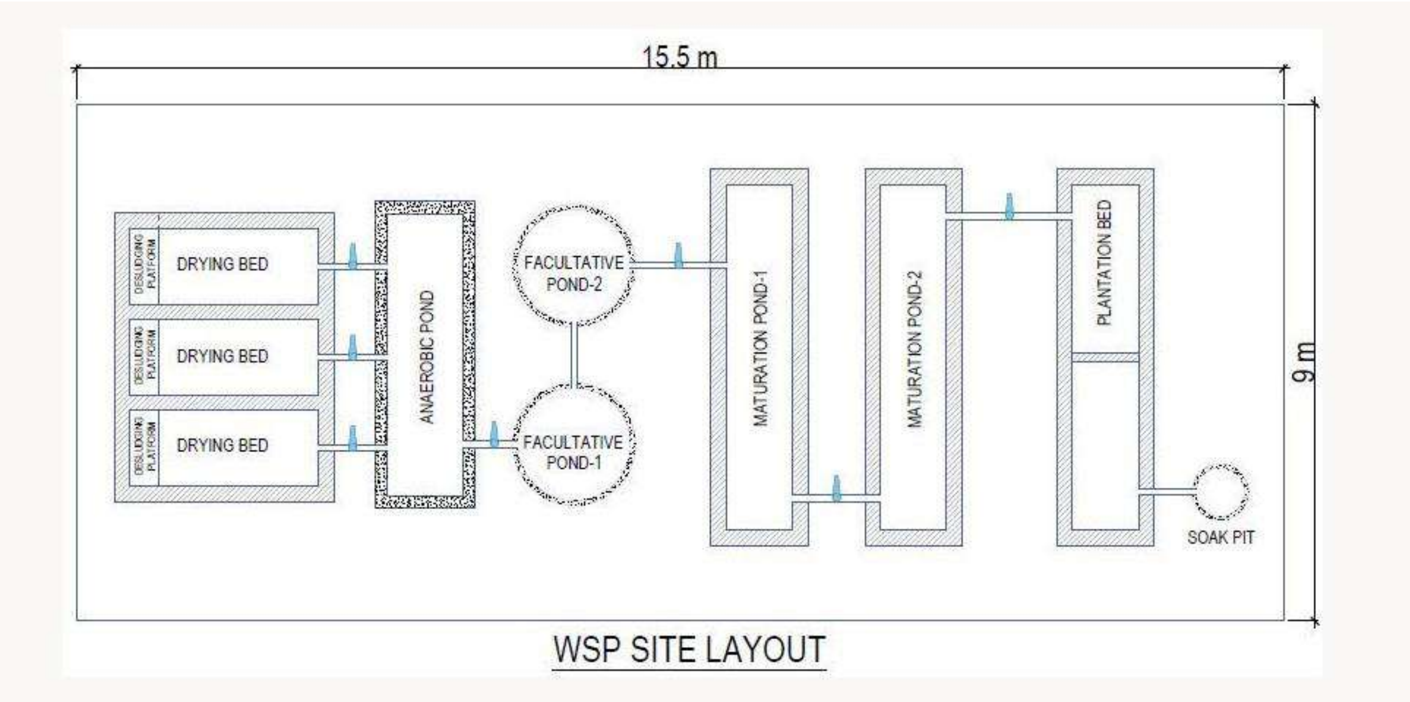
Details

Parameters	Key Findings
Location & construction date	Camp 7 December 2020
Capacity	5 m^3/day (design and actual)
Area requirements and scalability	Total area 139.5 m^2 Treatment are required 44.10 m^2 Area required 9 m^2/m^3 treated. Relativity low area required To scale up more treatment units can be added which requires significant space i.e. need to add parallel process stream
Capex/m^3	Capex 2,600 \$/m^3 treated.
Opex/m^3	2.6\$/m^3 treated Does not required any electrical or mechanical equipment
Whole life cost (USD/m^3/yr)	\$1,248
Speed of construction and setup	3 months Easy to build, not very skilled labour needed. Materials locally available. Simple masonry pond structures, could also be formed from earth lined ponds.
Expertise required for setup and operations	Easy to operate Require one person full time to control the wastewater flows/ pass to the next pond.
Operation and maintenance	Main regular activities are: sludge loading, control gate valve. No use of chemicals, safe operation. Environmentally friendly technology
Treatment performance	Refer to Appendix G
Complexity of process and pinch points	Low complexity, no pinch points noted.
Disposal of final products	Liquid infiltrated Solid is sent to compost off site
Resilience to disaster	Common measures taken in the sites are: Slope protection to reduce landslide risk

Process flow diagram



Site Layout



FSTP photographs

Sludge tank

Maturation pond

Plantation bed

General view

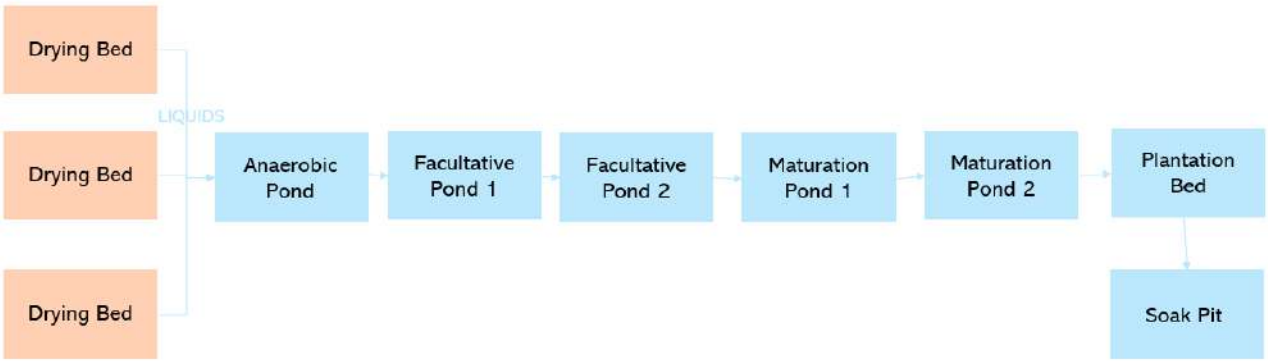
A.2.17 Waste Stabilisation Ponds, Camp 8W

Details

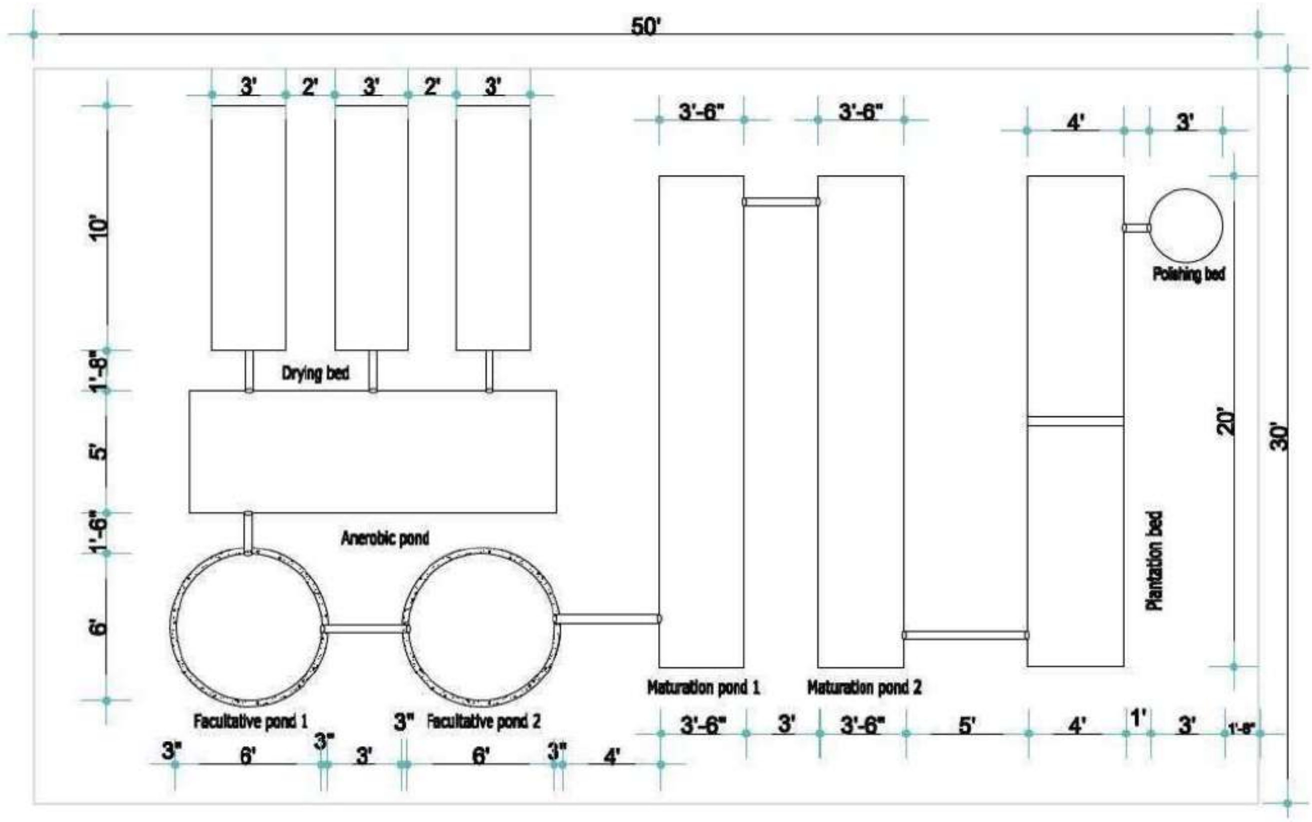
Parameters	Key Findings
Location & construction date	Camp 8W June 2020
Capacity	2.5 m^3/day

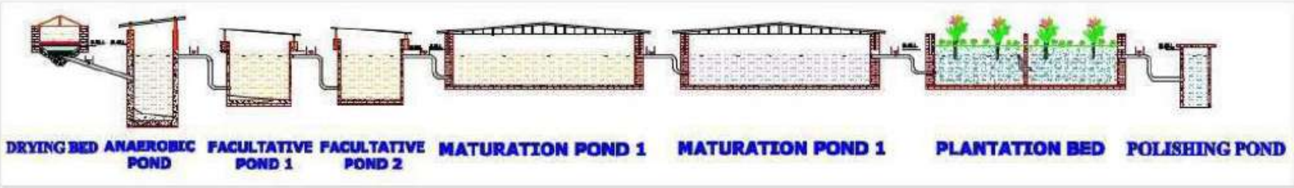
Parameters	Key Findings
Area requirements and scalability	Total area 140 m^2 Treatment area required 44.10 m^2 Area required varied from 18 m^2/m^3 treated. Relativity low area required To scale up more treatment units can be added which requires significant space i.e. need to add parallel process stream
Capex/m^3	Capex 7,888 \$/m^3 treated.
Opex/m^3	4.02 \$/m^3 treated Does not required any electrical or mechanical equipment
Whole life cost (USD/m^3/yr)	$ 1,921
Speed of construction and setup	2 months Easy to build, not very skilled labour needed. Materials locally available. Simple masonry pond structures, could also be formed from earth lined ponds.
Expertise required for setup and operations	Easy to operate Require one person full time to control the wastewater flows/ pass to the next pond.
Operation and maintenance	Main regular activities are: sludge loading, control gate valve. No use of chemicals, safe operation. Environmentally friendly technology
Treatment performance	Refer to Appendix G
Complexity of process and pinch points	Low complexity, no pinch points noted.
Disposal of final products	Liquid infiltrated (potential to reuse if WHO standards are met?) Solid is sent to compost off site
Resilience to disaster	Common measures taken in the sites are: Units on elevated platform to avoid flooding, top of walls is above ground level / semi buried to prevent surface water drainage entering the ponds.
Environmental impact	Simple structures using brick and concrete i.e. relatively high embodied carbon. WSPs can be made from other material and simple lined earth ponds.

Process flow diagram



Site Layout





FEACUL SLUDGE TREATMENT PLANT

FSTP photographs

Plantation bed and maturation ponds

Plantation beds

Maturation pond

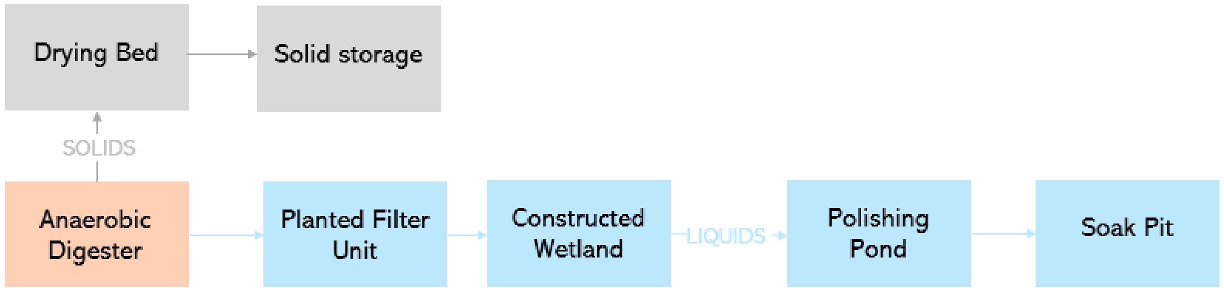
General view

A.2.18 Anaerobic digester system, Camp 26

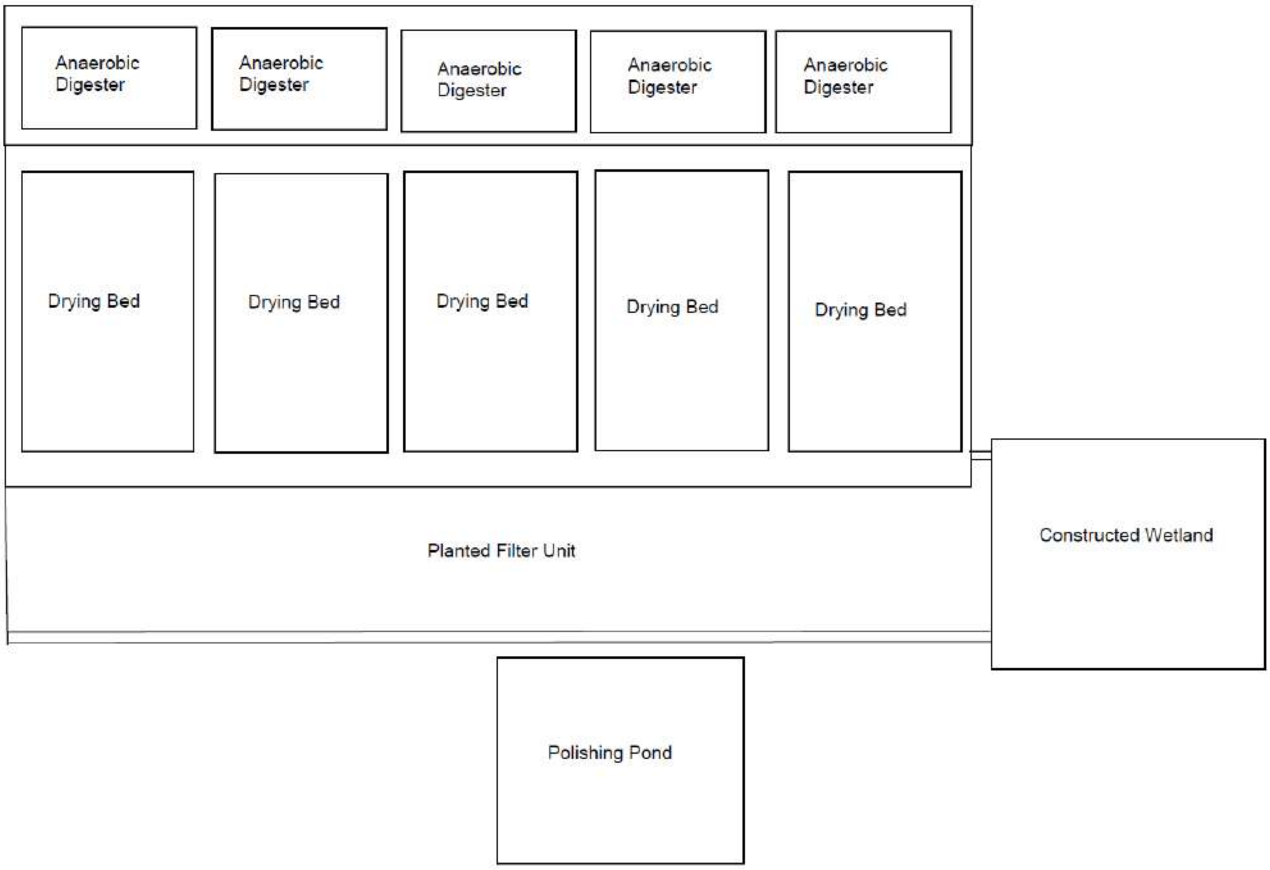
Details

Parameters	Findings
Location & construction date	Camp 26 December 2018
Capacity	5 m3/day
Area requirements and scalability	- Total area 670 m2. - Treatment area 304 m2 - Area required 61 m2/m3 treated. - To scale up more treatment units can be added but requires significant space
Capex USD/m³	- Capex $6,960. 1,392$/m3 treated. - **Low initial investment required**
Opex USD/m³	- Opex $58. 0.39 $/m3 treated - **Low Opex required**
Whole life cost	- **$ 306**
Speed of construction and setup	- **2 months** - Easy to build. - Materials locally available: stone chips, canaidica plant, sand bricks chips
Expertise required for setup and operations	- **Easy to operate. Not very skilled labour needed** - Skilled labour required for construction 3 (senior engineer, camp engineer, supervisor). Unskilled 20. - Skilled labour required for operation 3 (camp engineer, supervisor, labour)
Operation and maintenance	- Main regular activities are: sludge to drying beds, polishing pond cleaning. - Filter is changed every 6-12 months. - Replantation od the trees is needed at times - **No use of chemicals, safe operation.** - **Environmentally friendly technology** - Photographs showed the polishing pond, similar to other types of FSTP, was not in a great state.
DOE standards and pathogen inactivation	- **Showed relatively good performance** for BOD, COD, nutrients and TSS. The sites also showed a low / no helminths in the FE although good E.coli only achieved 50% of the time.
Complexity of process and pinch points	- Low complexity - **Main issues: filter blockage (change every 6-12 months)**
Disposal of final products	- **Liquid not disposed yet** - Solid is stored
Resilience to disaster	- Units on elevated platform to avoid flooding (1.5 m)

Process flow diagram



Site Layout



FSTP photographs

Drying bed

Polishing pond

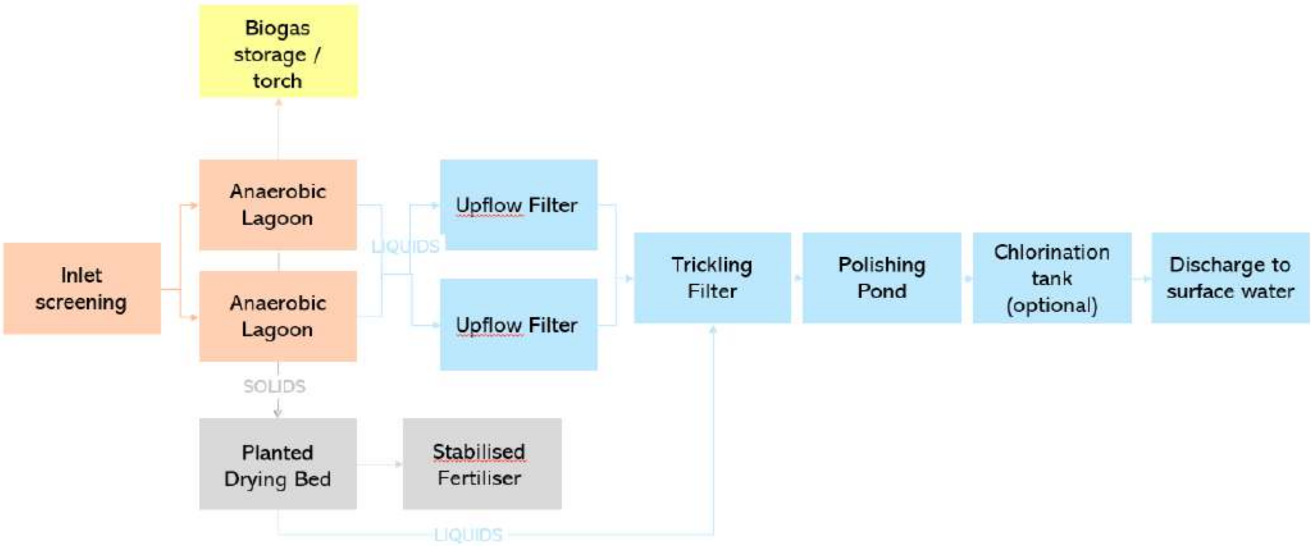
A.2.19 Centralised system FSTP 1, Camp 4

Details

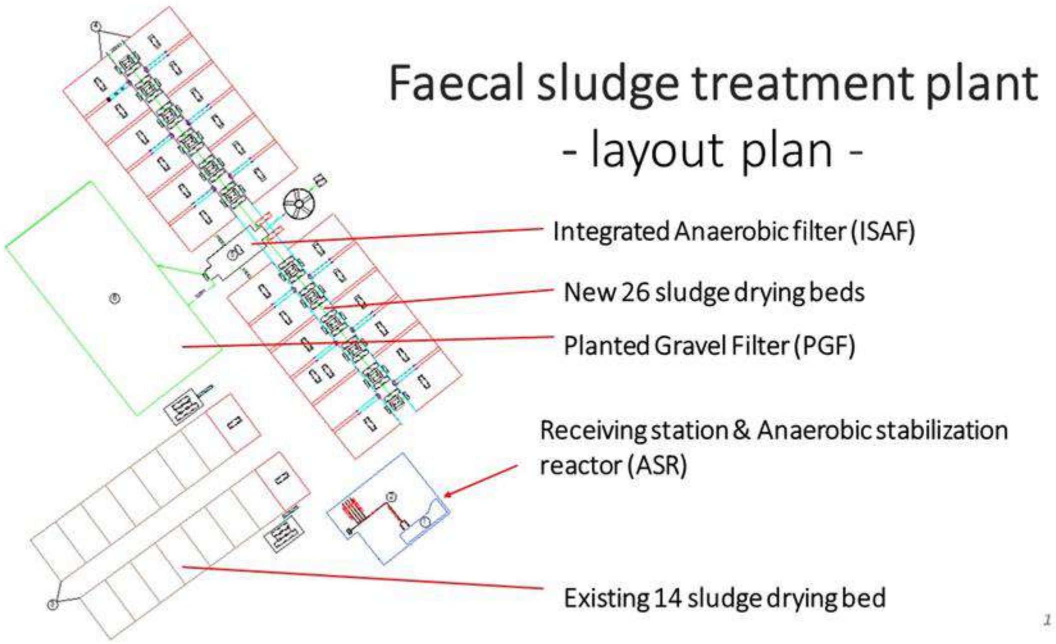
Parameters	Key Findings
Location & construction date	Camp 4
Capacity	Design capacity: 150 m^3/day Actual throughput: 120 m^3/day
Area requirements and scalability	Total area 165268 m^2 Area treatment unit 8,696 m^2 Area required for treatment units 58m^2/m^3 treated Technology has a large footprint area. Modular systems easy to scale if land available. Existing parallel stream allows some flexibility to take elements off line for maintenance, and mange flows.

Parameters	Key Findings
Capex/m^3	Capex 4,646 $/$m^3$ treated The initial investment required is significant but the Opex associated to the plants is relatively low.
Opex/m^3	Low Opex, 0.60 $/$m^3$ treated
Whole life cost (USD/m^3/yr)	$474
Speed of construction and setup	Significant civil engineering works with large construction equipment required.
Expertise required for setup and operations	Large teams of skilled and unskilled labour needed to construct the plants.
Operation and maintenance	Main operation and maintenance activities: - Daily operation of the receiving station and cleaning of the screen , checking pH ,TDS etc. - Regular operations include 1-3 times emptying of settled sludge from the anaerobic lagoons and placing the sludge evenly onto drying beds. - Cleaning, replacement of the bristle filter in the anaerobic lagoon outlet - Periodic backwash of upflow filter. - Removal of the mineralized sludge from the planted sludge drying after 8 – 10 years - Weekly control of the chlorine concentration and optional replacement of the chlorine tablets at the disinfection unit
Treatment performance	Camp 4 is one of best performing plant for BOD, COD and pathogen reduction. Results for these parameters were not significantly higher than standards i.e., reasonably close and showed consistent performance across the year.
Complexity of process and pinch points	No pinch points found Requires a large volume to process but does not suffer too much if it is underutilised.
Disposal of final products	Liquid discharge to the environment Solid is stored with plan to reuse; available space is adequate (to date).
Resilience to disaster	Adequate drainage system for the stormwater Elevated tanks Site is located at the top of a hill away from flood prone areas.

Process flow diagram



Site Layout



FSTP photographs

Anaerobic covered Lagoon

Liquid outlet

Polishing pond

Planted drying bed

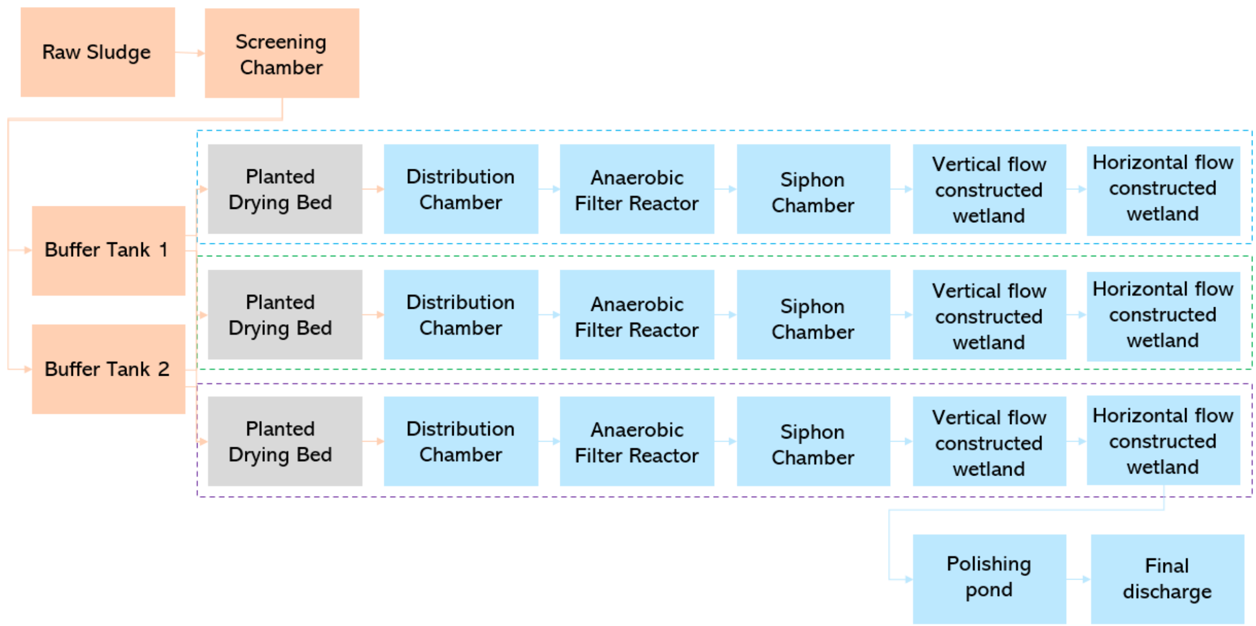
A.2.20 Centralised system FSTP 2, Kutupalong

Details

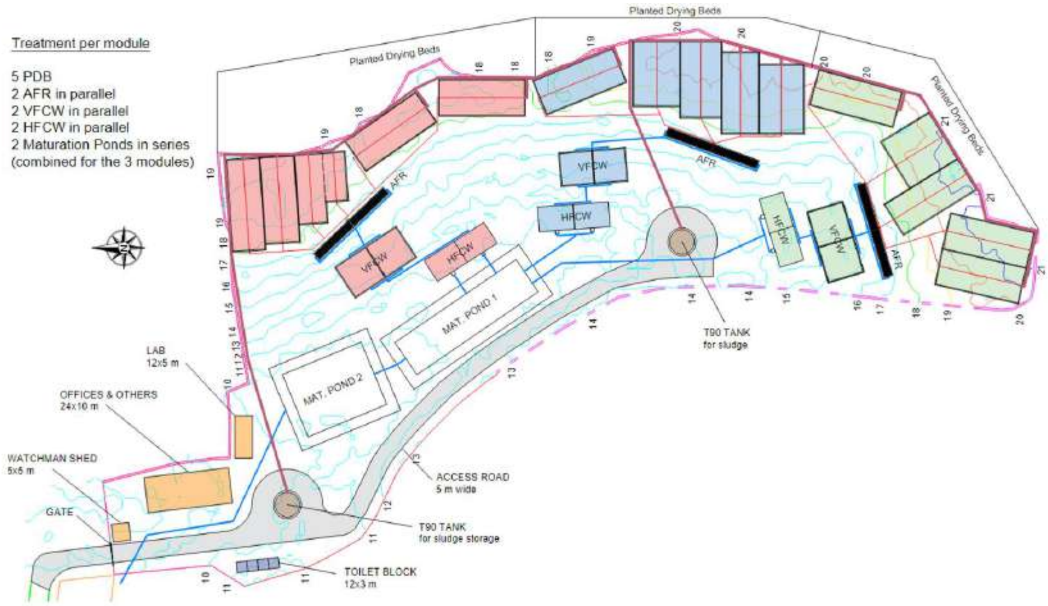
Parameters	Key Findings
Location & construction date	Kutupalong December 2021
Capacity	Design capacity: 180 m^3/day Actual throughput: 31 m^3/day
Area requirements and scalability	Total area 18,700 m^2 Area required for treatment units 5,985 m^2 Area required for treatment units 33 m^2/m^3 treated Technology has a large footprint area. Modular systems easy to scale if land available. Existing parallel stream allows some flexibility to take elements off line for maintenance, and mange flows.
Capex/m^3	Capex 6,388 \$/m^3 treated
Opex/m^3	Opex, 6.7 \$/m^3 treated
Whole life cost (USD/m^3/yr)	$831

Parameters	Key Findings
Speed of construction and setup	12 months. Significant civil engineering works with large construction equipment required.
Expertise required for setup and operations	Large teams of skilled and unskilled labour needed to construct the plants.
Operation and maintenance	Main regular activities: Cleaning all the outlet chambers twice a week to avoid formation of algae and to remove leaves. Remove unwanted roots in PDB and CW, every 3 months. Cleaning the filter net in the screening chamber, one for a week, with reverse flow. Cleaning pipe from screening chamber to tanks using the reverse flow and a pump, pipe size is limitated and clogging events are frequent with sludge, every 2 weeks. Cleaning the main line with reverse flow when it is clogged, pipe size is limitated and settle of solid could block the pipe.
Treatment performance	No data available
Complexity of process and pinch points	No pinch points found Requires a large volume to process but does not suffer too much if it is underutilised.
Disposal of final products	Liquid discharge to the environment Solid is stored with plan to reuse; available space is adequate (to date).
Resilience to disaster	Adequate drainage system for the stormwater Elevated tanks Site is located at the top of a hill away from flood prone areas.

Process flow diagram



Site Layout



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Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix B

FSTP sites phase 2 vs phase 1 sites

The table below highlights the differences between FSTP visited in phase 1 and 2 of this study,

Phase 1 (initial study)	Phase 2 (this study) and comment
Constructed wetlands	No standalone constructed wetlands were included in phase 2 study. Constructed wetlands were being used as part of the treatment process within some of the FSTPs included.
GeoTubes	No included
Lime (lagoon, in barrel and three tanks)	Included – lagoon (camp 4 and 1W) and three tanks (camp 26). In barrel lime not commonly used in this stage of the emergency so not included. Three lime sites were included in this study (camp 26).
Anaerobic Lagoons	Included. There is one Anaerobic Lagoon FSTP in camp 4 extension. This had been expanded since phase 1 to include UFF, trickling filters, planted drying beds and a polishing pond. All elements are included in the assessment.
Aerobic Treatment	Included. Two FSTPs were included in this study, one was the same site as phase 1 and the other was a newly commissioned FSTP with the same process stages. i.e. • aeration tank • settlement tank • liquid filtration and chlorination • solid drying/ incineration
Upflow Filters (Two main types: with and without pre-settlement)	UFF included in phase 2 and DEWATs (where the main treatment is via UFF) were also assessed. Two designs were included, both with pre-settlement, but with varying materials and filter media and slightly different process upstream and downstream of the UFF.
Biogas Plants	Included
Anaerobic Baffled Reactors	Included
Waste Stabilisation Ponds	Waste Stabilisation Ponds – not included in phase 1 but are being used by several NGOs in the camps and are a proven wastewater treatment technology, hence were reviewed under this study.

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Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix C

C1 Treatment performance review summary

Summary Table

Worst (5)	4	3	2	Best (1)

	Data reviewed	pH	BOD (mg/l)	COD (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Total Nitrogen (mg/l)	Solids	Pathogens	FE disposal route
DoE Standard	N/A	6 to 9	30	200	250	35	15	Suspended solids 100 mg/l	1000 CFU/100ml	Surface water
Lime	Data for 26 LSP reviewed, most only available via DPHE from Feb 2022. Long term data was available for two (of the 26) FSTPs. Three sites visited included in lab data review.	pH 7 to 13 Lime process will result in a high ph.	Range from 22-6500 mg/l. with most recent samples exceeded DoE standard. Limited long-term data (one site). Hard to tell seasonal variation.	Range from 50-48000 mg/l (generally in range 500 to 1000 mg/l) With most recent samples exceeded DoE standard.	All within standard. Influent already below standard.	Range from 0-225 mg/l Majority of DPHE 2022 samples are passing. One site with long-term data shows failing circa 75% of time. Lime process has limited P removal.	Range from 180- 3700 mg/l All samples failed.	Range from 1 to 800 mg/l. Three sites with long-term monitoring available show general breach of standards and majority of DPHE 2022 samples fail	Long term shows camp 4 is close to target but still slightly over. Majority of DPHE 2022 data fails. Both long-term monitored plants (1E and4) show potential to remove helminth with zero and low numbers recorded i.e., some samples met this.	Largely infiltration. Some overflow from infiltration ponds (rain) or to surface water channel - needs proper design.

	Data reviewed	pH	BOD (mg/l)	COD (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Total Nitrogen (mg/l)	Solids	Pathogens	FE disposal route
ABR	Data for 13 ABRs reviewed. Five ABR FSTP have available data for intermittent stages in the process i.e., not just effluent. Note only one of the sites with full data was visited during the study.	Generally, within standard. Consistently 7 to 10 through the process.	Range 100-250mg/l. All sites effluent exceeded DoE standard, 1 outlier (1770 mg/l - could be an error but also shows high coliform, etc). Majority (35% to 90%) reduction of BOD occurs in ABR (ahead of "filter inlet").	Range 130 - 1500mg/l All sites effluent above standard, with two expectations (which are just below at 130 and 190 mg/l). Majority of COD removal (i.e., approx. 60%+ removal) occurs in ABR	All within standard.	Range 0-110mg/l generally higher than standard. No obvious seasonal variation. Removal in the ABR and filter. Filter is important (probably bound in solids which are removed here).	Range 25-2150 mg/l. All fail on TN.	TSS typically 100 - 400 mg/l with circa 13% of FE samples pass solids standard. Majority removed in ABR (70%) then further reduction in filter and polishing pond. For the ABR visited generally 70 to 90% reduction through whole FSTP.	Only recent data (late 2021 and early 2022) All over standard.	Largely infiltrated
Mega FSTP	Data for 1 FSTP reviewed. Data available from Nov 2020 to present. Site was visited during study.	Within standard	40-240mg/l in FE. Reasonably consistent across year. best	Range 85 to 850mg/l. Higher Sept to Nov (2020 and 2021).	All within standard.	All within standard.	Tn –	Range 0-175mg/l. TSS of FE within or close to standards majority of time. Majority of solids, pathogens removed in	Pathogen in FE within or close to standards majority of time. Generally in 0-8000cfu/ml E. coli. Majority of samples pass, perhaps some data errors.	

	Data reviewed	pH	BOD (mg/l)	COD (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Total Nitrogen (mg/l)	Solids	Pathogens	FE disposal route
								Anaerobic lagoons step.		
DEWATs	DEWATs sites were visited in camp 9 and 12. I,cddrb data from round 2 to 12 was used to inform this review.	Within standard	Generally fail Range 50 to 1600 mg/l	Generally fail Range 8 – 520 mg/l	Phosphate – Generally Within standard. 2/3rds of samples fail in later rounds of testing. Range 15 to 200 mg/l	Nitrate Generally Within standard Generally in range 1 to 40mg/l	All fail on TN.	Latest rounds of testing show two out of three sites within standards. Sites have improved from generally failing. Range 1 to 500mg/l, with some high spot samples (could be errors)	Majority of sites with 0 Helminth Eggs E.Coli present in all sites in level about WHO standards for irrigation.	Infiltrated via infiltration bed
UFF	Two UFF sites were visited in camps 7 and 8W.	Within standard	Range 80 to 850mg/l. With some higher spot results. Failing BOD standards and relatively poorly performing.	Range 150 - 3000mg/l. Failing COD standards and relatively poorly performing. The smaller capacity have slightly lower solids	All within standard with two exceptions. General range 8 – 100 mg/l	A majority within standard. 8-50mg/l. Some higher samples which correspond to other nutrient failures.	All fail on TN.	Range 20-850mg/l. breaching standards Solids performance reasonably consistent over time.	E.coli range 600-23x10^6 plus cfu/100ml. Some sites, including one visited, show low value samples however performance is not consistent.	Infiltrated

	Data reviewed	pH	BOD (mg/l)	COD (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Total Nitrogen (mg/l)	Solids	Pathogens	FE disposal route
				removal hence lower BOD and COD removal.						
ADS	Data from one site available, over long term and at intermittent process points as well as raw sludge and final effluent. This was for ad ADS in camp 26 which was visited during the study.	Within standard	Range 47-180mg/l Breaching BOD standard but not significantly. Relatively low compared to other FSTP types.	Range 196-385mg/l Breaching COD standard but not significantly. Relatively low compared to other FSTP types.	Range 5-270mg/l	Range 6-62mg/l All passing the standard for nitrate and phosphate (with exceptions Aug and Sept 2021).	No data for TN.	TSS range 47-124mgl/ consistently good. TSS is below standards most of the time. All stages act to remove solids, majority ahead of the constructed wetland (final)	Good Helminth removal (0) and 50:50- E. coli removal (0-20000cfu/100ml)	Low volume of liquid for disposal. Soak pit.
WSP	Monitoring data was available 13 WSPs FSTPs, managed and operated by four different NGOs. Two of the sites with available data were	Within standard	Range 10-1600mg/ l Ave 300mg/l COD and BOD (and SS) improved removal over time but still above standards.	Range 16-2500mg/l. Improved removal over time but still above standards	Ave 50mg/l. All passing the standard.	Range 2-20mg/l. All passing the standard.	All fail on TN.	TSS range 10-500mgl/ generally good (Ave 135mg/l).	Range 240 - 35mill+ cfu/100ml. Limited data available. All FE results are high (i.e., above standard and relative to other FSTP types).	To natural drain (assume linked to surface water system) and soak pits

	Data reviewed	pH	BOD (mg/l)	COD (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Total Nitrogen (mg/l)	Solids	Pathogens	FE disposal route
	visited during this study (camp 7 and 8W). Only raw sludge and FE data was available with no intermediate site monitoring. Limited coliform data available.									
Aeration	Data from one FSTP. Sampling is conducted of raw sludge and effluent as well as at key point through the process flow. Long term monitoring data was provided for seven months of 2021.	Within standard Consistent around 8.5	Assume good alongside COD results	FE range 80 – 600mg/l. Some evidence of seasonal variation – lower COD in FE between June to Sept.	0mg/l for FE	FE higher than influent but still within standard (16mg/l)		TS 500mg/l.	All below 100 CFU/ml and show 'no growth after chlorination.	Surface water stream via banana plants

Table 1: Summary of treatment performance review

Data sources used in treatment performance review

Data source	Date range of data included in this study	Number of FSTPs covered	Camps covered	Number of sample results included in this study	Parameters monitored and sample data included in this study	Comment
DPHE	All data provided for Dec 2021 and Jan to March 2022 i.e., four months. Samples taken approx. three times per month.	145, of which 130 included in this study. DPHE visit plan states FSTP visited 166 (Operational FSTPs, with samples analysed 150 FSTPs under maintenance, not analysed 16)	Seven (KRC, Camps 1, 2, 4, 7, 12 and 18) Note: FSTPs where data was available in camps 1W, 7, 8W, 9, 12 and 14 were visited during this study.	130	Data for 130 samples were provided on the following parameters (i.e., FSTP types covered by study): pH and Temperature (Degree C) Nutrients: TN, Nitrate and Phosphate (all in mg/l) BOD and COD (mg/l) E. coli (cfu/100 ml) and Total Coliform (Cfu/100 ml) Conductivity (mS/cm) TSS (mg/l)	DPHE Round 1 sampling provided at time of collecting data (March 2022), monitoring plan provided showing wider coverage and ongoing sampling regime. Final effluent monitoring only. 145 sample results provided by DPHE of which 130 were for technologies covered in this study. Other data was available for SSUs and CWs however these are not included in this study. Technologies covered; ABR, LSP, CW, UFF, ODP, Anaerobic Lagoon, DEWATS, ASTT, SSU and WSP.
ICCDRB	October 2020 to Dec 2021 exec May and July 2021 Samples taken approx. monthly.	11	Seven (Camps 1E,4,5, 17, 26, 27 and NYP RC) Note: camps 4 (2No. FSTPs), 5 and 26. were visited during this study.	Available sample data ranged from 11 to 685 depending on the parameter and month.	Data for samples was provided on the following parameters, the number of samples ranged from 685 to 11 depending on the parameter and month, details given in Appendix C, Treatment performance review report Pathogens: E. coli (cfu/100ml, Helminth eggs (eggs/L), V. cholerae (present/absent) Solids: Total Solids (g/L), Total Suspended Solids (g/L), Total Dissolved Solids (g/L), Volatile Solids (g/L) COD and BOD (mg/L) Nutrients: Total Nitrogen and Total Phosphorus (mg/L), Nitrate, Phosphate and Ammonia as nitrogen (all in mg/L) pH and Temperature(°C)	60 sample points across 11 FSTPs monitored over 14 months. Generally, five sampling points on each FSTP including influent, effluent and intermittent process stages. Technologies covered; ABR, LSP, Anaerobic digester and Anaerobic Lagoon,
IFRC	IFRC camp 18 FSTP 1 (Aerobic treatment) provided	Four (including the two IFRC plants)	Five (camps 6,13,15,18 and 19).	Max sample results 113. See available	IFRC lab monitors the following parameters, the sample data numbers are the total provided.	IFRC lab provides services for other NGOs. i.e., data for seven samples from

Data source	Date range of data included in this study	Number of FSTPs covered	Camps covered	Number of sample results included in this study	Parameters monitored and sample data included in this study	Comment
	approx. every two weeks for 2021. Other NGOs FSTP data was limited to one sample from Feb and May 2019 and from September and Oct 2021		Note: camps 18 and 19 were visited during this study.	data points used for each parameter.	Coliform, Enterococcus and Salmonella (all in log CFU/mL) - data for 111 samples available i.e., 97 from IFRC FSTP1 and 7 for other FSTPs pH - data for 113 samples available i.e., 101 from IFRC FSTP1 and 12 for other FSTPs Conductivity (mS/cm) - data for 113 samples available i.e., 101 from IFRC FSTP1 and 12 for other FSTPs COD (mg/L) - data for 113 samples available i.e., 101 from IFRC FSTP1 and 12 for other FSTPs Sludge volume (mL/L) - data for 108 samples available i.e., 101 from IFRC FSTP1 and 7 for other FSTPs SVI (mL/g) - data for 96 samples available i.e., 89 from IFRC FSTP1 and 7 for other FSTPs Total Solids (g/kg) - data for 96 samples available i.e., 89 from IFRC FSTP1 and 7 for other FSTPs Nitrate-N, Nitrite-N Phosphate and Ammonia-N (all mg/L) - data for 111 samples available i.e., 97 from IFRC FSTP1 and 7 for other FSTPs Total Nitrogen (mg/L) - data for 40 samples available i.e., 35 from IFRC FSTP1 and 5 for other FSTPs.	two FSPTs operated by others included in results provided. IFRC camp 19 FSTP 2 – only data for 4 samples provided as plant being commissioned. Sample data numbers relate to the IFRC FSTP1and2, plus the other seven samples from two non-IFRC FSTPs, Results are for 'Daily mixed samples and each sampling point. Intermittent processes were sampled in addition to effluent.
IOM	Oct/Nov/Dec 2020 March/April/ May/ Aug/Sept 2021 Samples taken approx. monthly.	Six 'Plastic DEWATs'	Four (camps 9, 12, 13 and 24) Note: camps 9 and 12 were visited during this study.	44	Coliform (FCU/100ml) – data for 44 samples available i.e., 22 raw sludge and 22 for FE pH – data for 44 samples available i.e., 22 raw sludge and 22 for FE Turbidity (NTU) – Not used in the analysis. Data for 36 samples available i.e., 18 raw	332 sample results provided by IOM of which 44 were for operation 'plastic DEWATS' hence used in this study. Other

Data source	Date range of data included in this study	Number of FSTPs covered	Camps covered	Number of sample results included in this study	Parameters monitored and sample data included in this study	Comment
					sludge and 18 for FE, however, states 200+ or 400+. BOD and COD (mg/l) - data for 22 samples available i.e., only monitored prior to infiltration so 22 samples for FE TOC (mg/l) – Not used in the analysis. Data for 16 samples available i.e., 8 raw sludge and 8 for FE, however, states 600 or 900, so data questionable. Nitrate Nitrogen mg/l and Nitrates mg/l – data for 44 samples available i.e., 22 raw sludge and 22 for FE Phosphate mg/l and Ammonia– data for 4 samples available i.e., 2 raw sludge and 2 for FE Suspended Solid (mg/l) – no data available.	data was available for SSUs however these are not included in this study. Data was for Raw and FE prior to infiltration provided. Data was in units that aligned with the DoE standards so no calculation was required to normalise data, File name: 20211230_IOM_EQM_W52.xls provided by IOM.
WVI	Sept to Dec 2020 and April 2021	Seven WSPs	Three (camp 7, 8E and 15)	40 (of which 4 are from site visited during study)	BOD5 (mg/l) Total Suspended Solid (mg/l) Total Coliform (CFU/100ml) COD (mg/l) pH	Influent and effluent monitoring only. No data since April 2021.

C2 Treatment performance review

FSTP Treatment performance Appendix

| 1 September 2022

Click or tap here to enter text.

Contents

1. Introduction

The following report outlines the performance of the FSTP technologies covered under this study, there is a section on each technology type, incorporating available existing data and information collected during site visits. The performance data is compared against the 2019 Bangladesh Department for Environment (DoE) standards for wastewater effluent.

Available government standards for discharge of wastewater effluent:

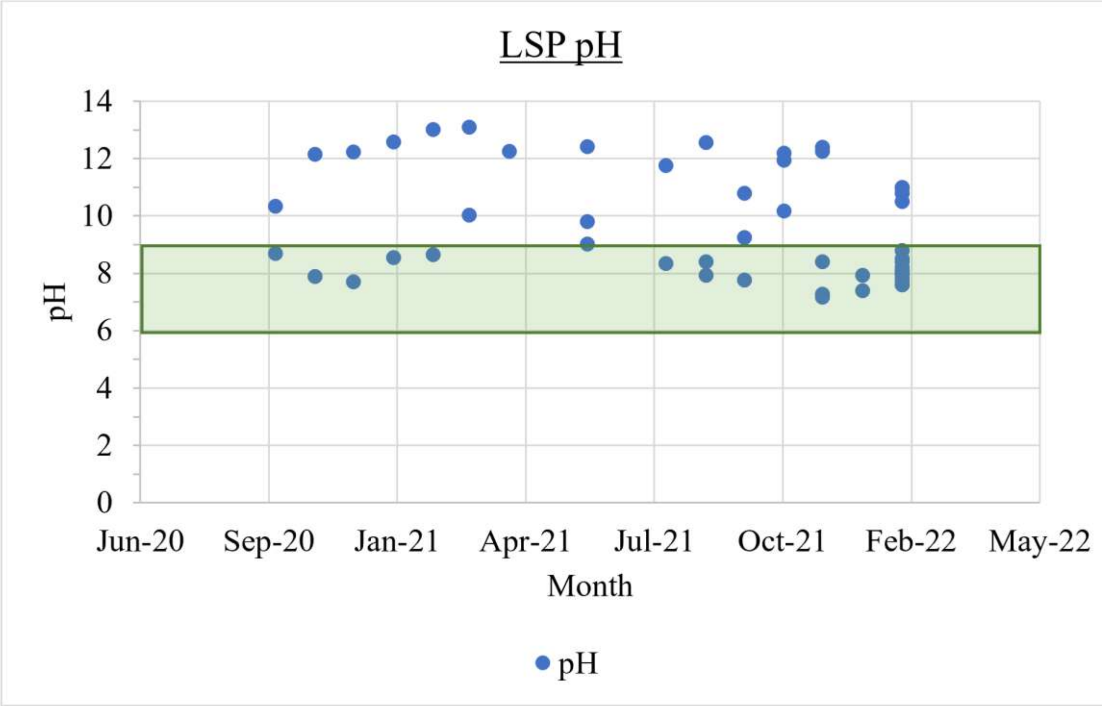
Parameter	Unit	The Environment Conservation Rules, 1997, Ministry of Environment and Forest. **Schedule 9 – Standards for Sewage Discharge** *Maximum value*	Department of Environment Guidelines update 2019, **Schedule 7 – Standards for Sewage Discharge** *Maximum value*
pH	-	-	6-9 (range)
BOD	mg/L	40	30
COD	mg/L	-	200
Nitrate	mg/L	250	250
Phosphate	mg/L	35	35
Total Nitrogen	mg/L	-	15
Suspended Solids	mg/L	100	100
Temperature	°C	30	30
Coliform	CFU/100mL	1000	1000
Oil & Grease	mg/L	-	10

2. Lime stabilisation

Data for 26 LSP reviewed, most data was only available via DPHE from February 2022. Three of the sites visited included in effluent data review. Long term data only available for two FSTPs, both of which were covered in the site visit.

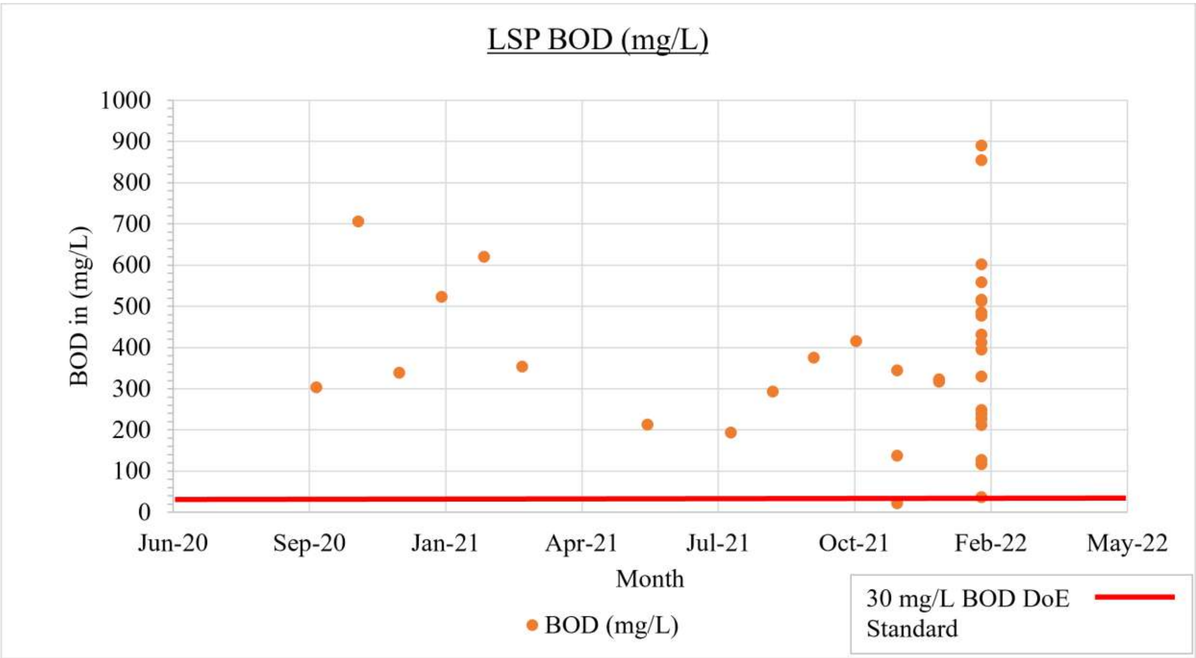
2.1 pH

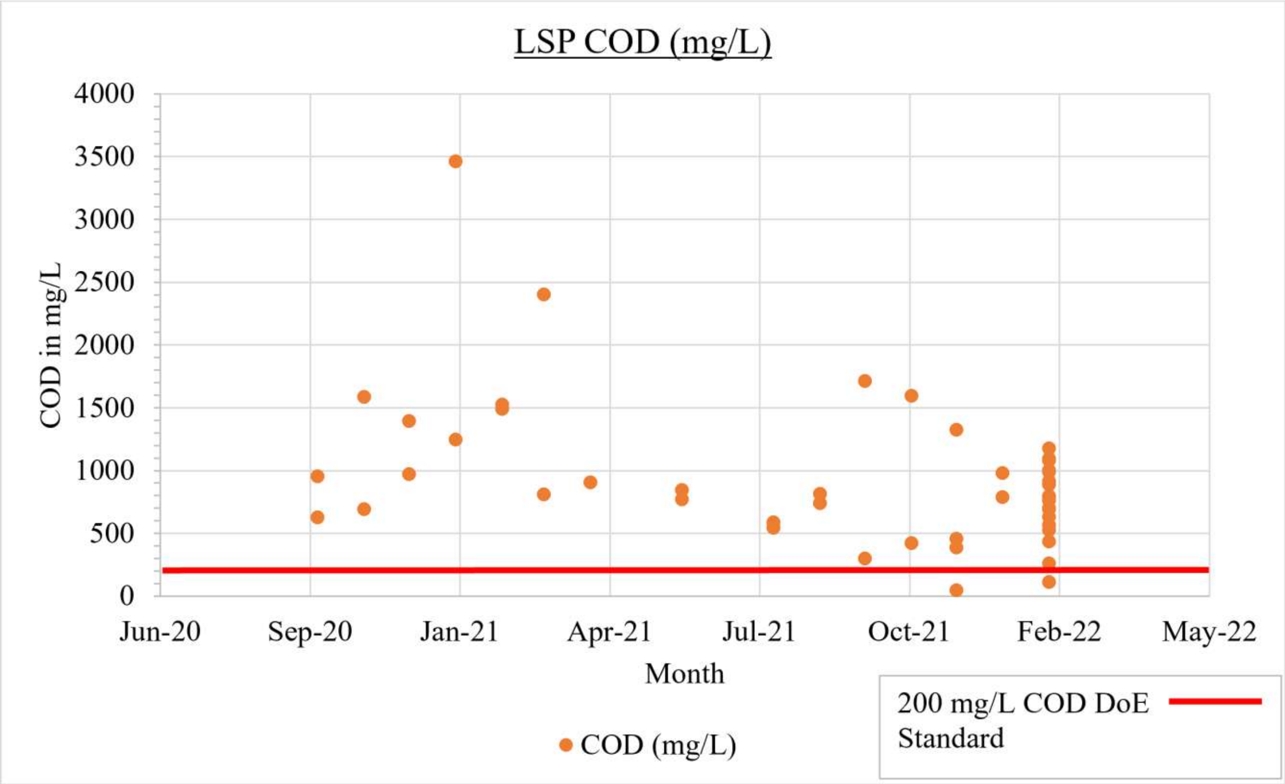
- Lime causes high pH i.e., 10+.
- Generally higher than DoE standard.
- Camp 4 lime consistently over standards, Camp 1E lime generally within standard – No significant difference in process flow or layout. The camp 4 plant is assumed to be larger (no data on capacity of camp 1E). Likely to be due to lime dosing or type of lime used.



2.2 BOD and COD

- Long term data (i.e., more than two months) only available for two sites. Not possible to tell any significant changes in treatment performance e.g., seasonal or by raw sludge quality.
- Camp 4 lime closer to standard (30mg/l and 200mg/l), Camp 1E lime also breaching standard (but more significantly).
- Most (90%+) of other FSTPs data for Feb 22 are in breach of standards. COD are generally in range 500 to 1000 mg/l.





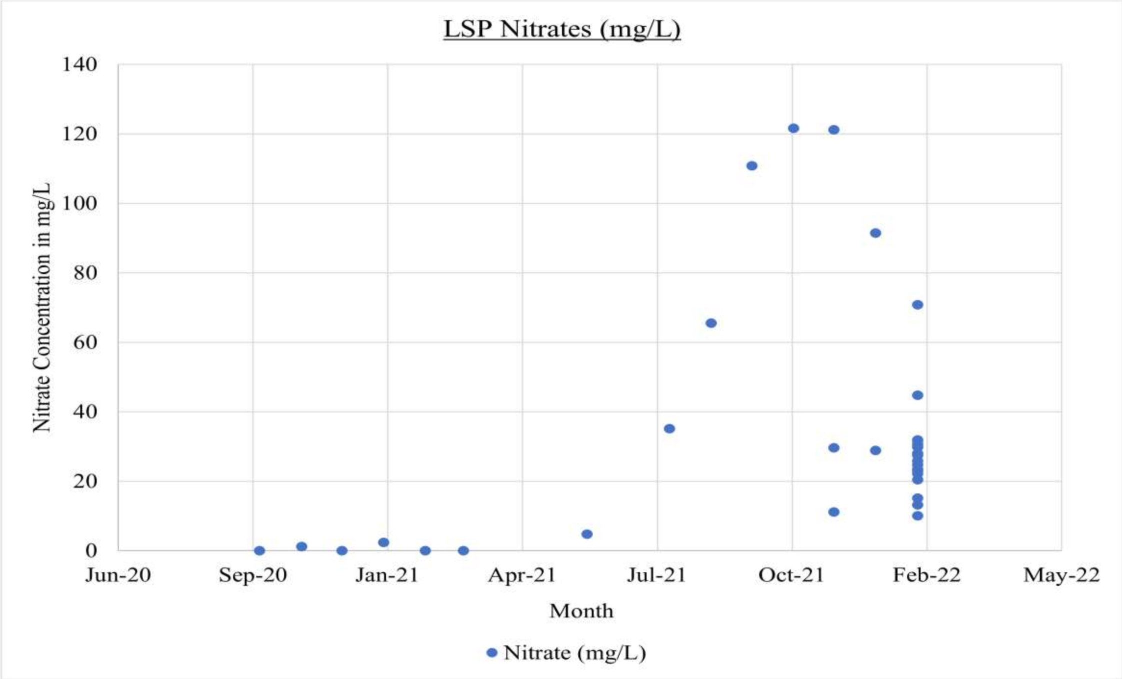
2.3 Nutrients

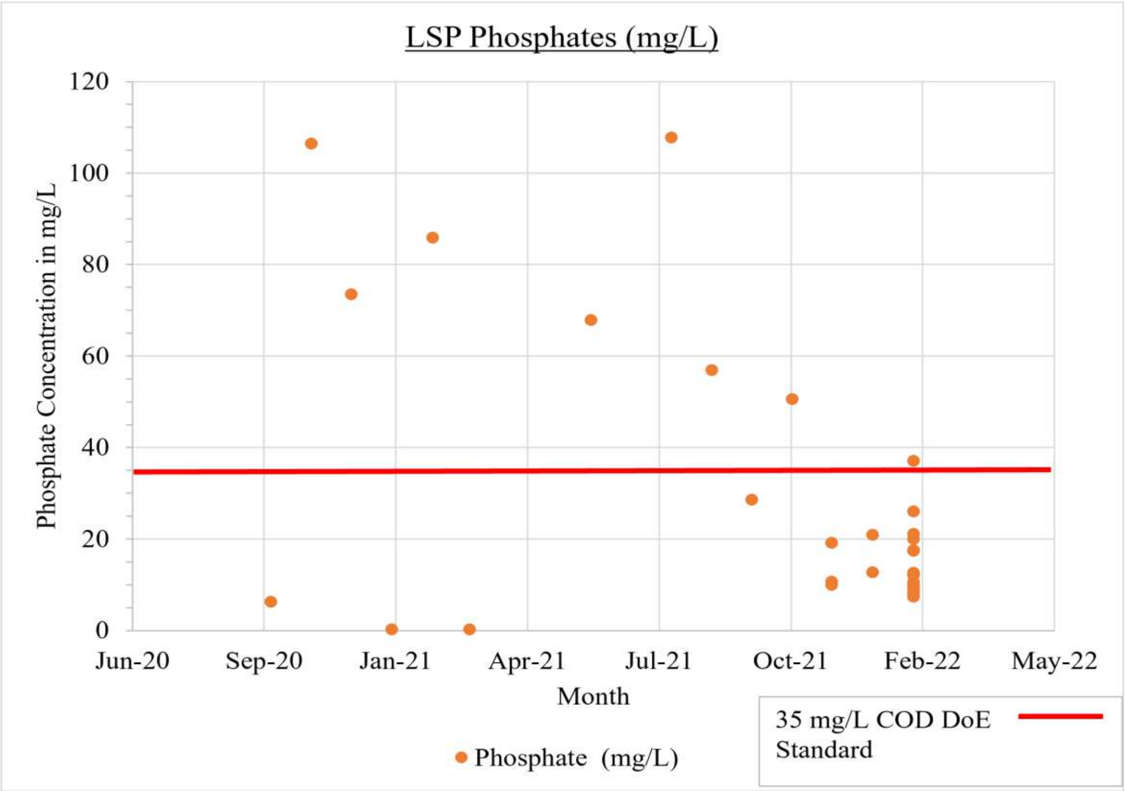
Nitrate

- All within standard. Influent data for each LSP already below standard - Nitrates generally from agriculture not domestic WW.

Phosphate

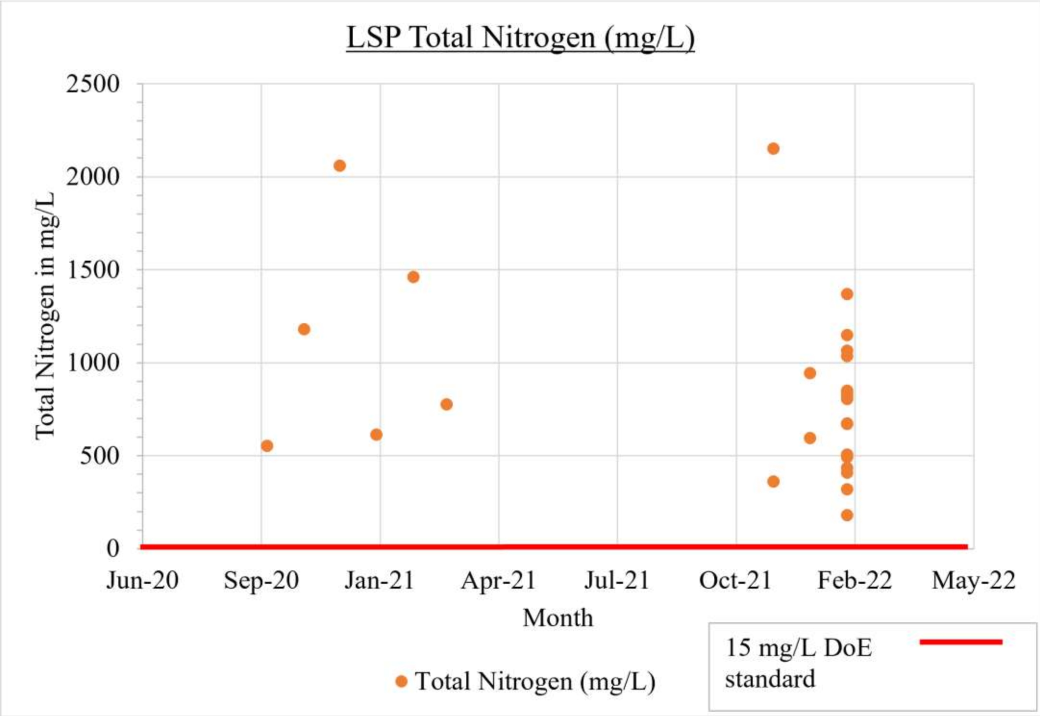
- DPHE Feb 22 data shows most LSPs are compliant with standard.
- Only one long term data set (camp 1E), which shows above standard circa 70% of time
- The two sites visited meet standard.
- Lime treatment does not remove P - only via that associated with solids removal.





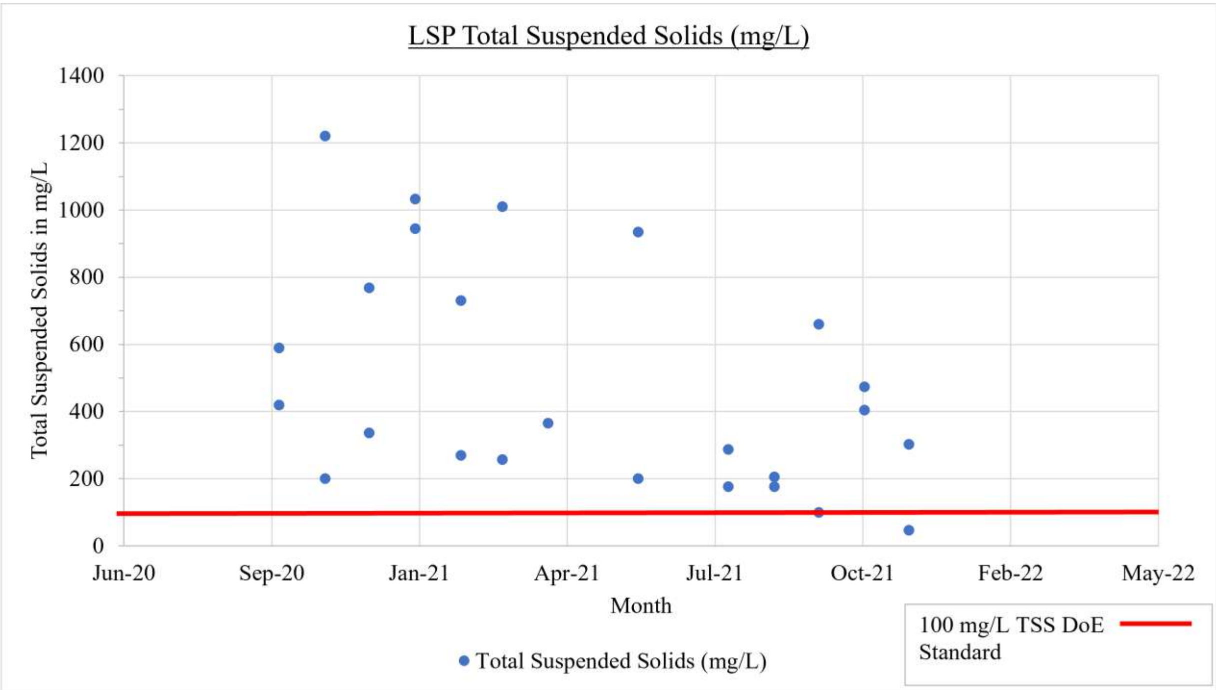
Total nitrogen

- All non-compliant with standard
- Lime treatment does not remove nitrogen (nitrify/ denitrify)



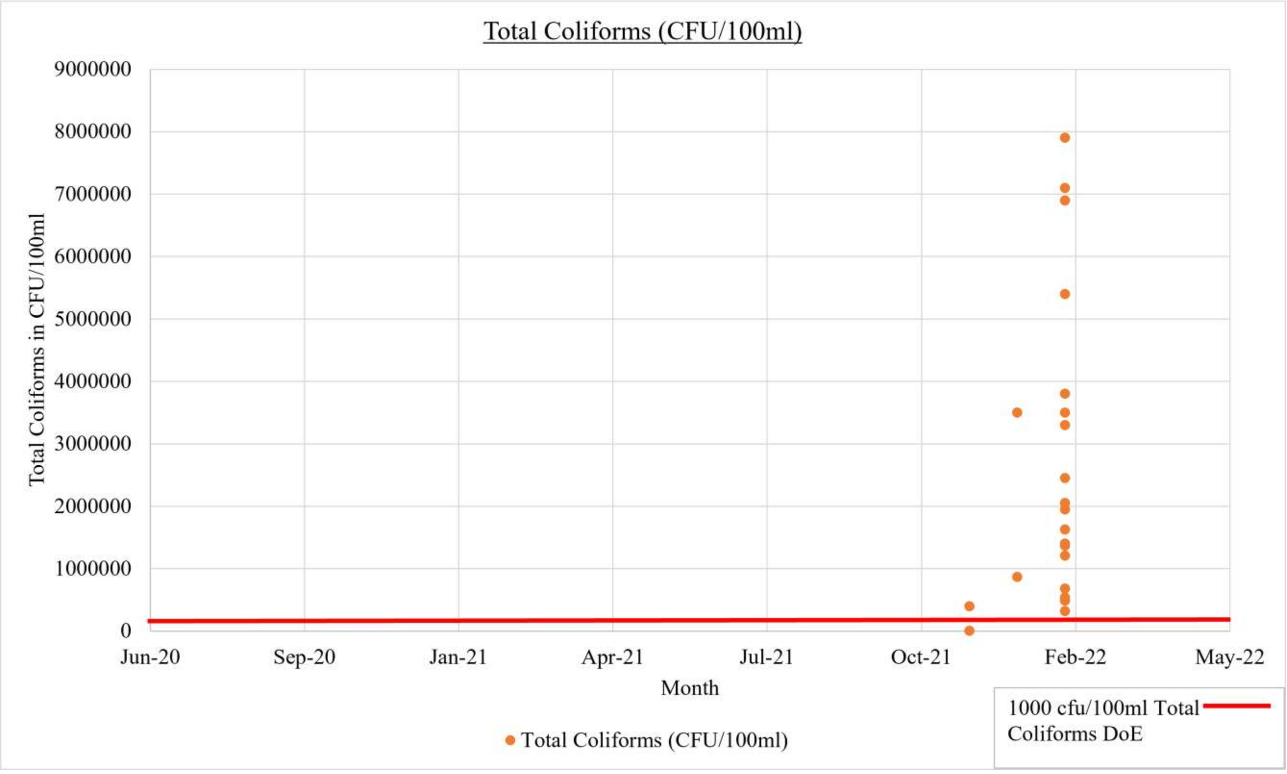
2.4 Solids

- 90% of ling term data breaches standards. Reason not investigated in detail, could be retention time, dewatering process, or polishing pond performance.



2.5 Coliforms

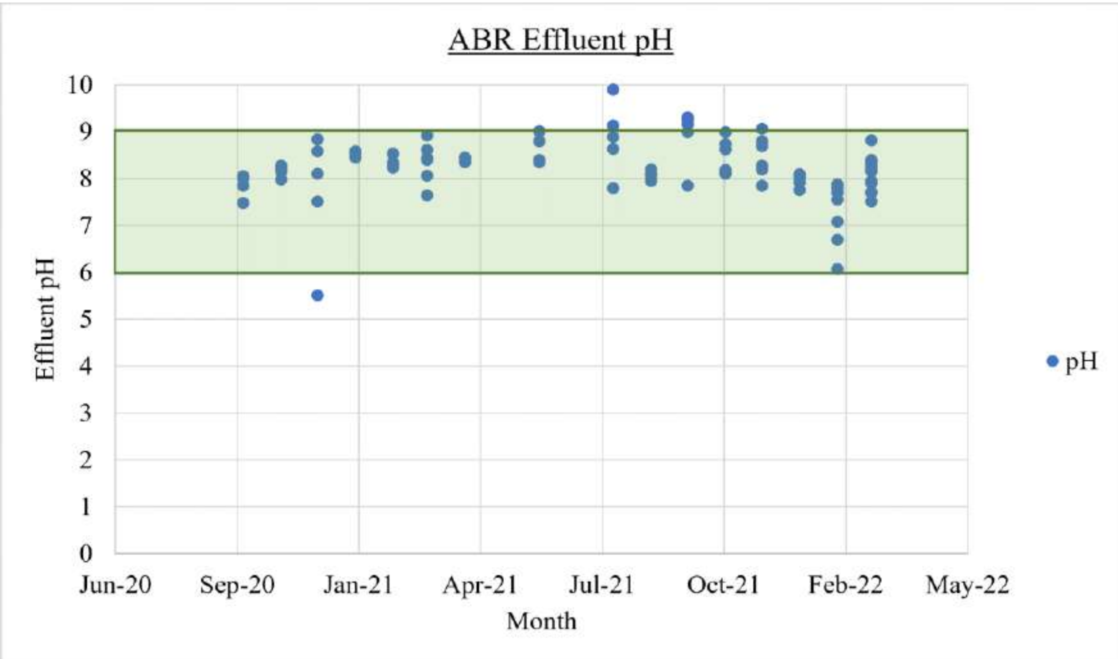
- All above standard of 1000 CFU/100ml – including two long term data sets and all Feb 2022 data.
- Camp 1E provided e coli data i.e. total coliforms not measured.
- Camp 4 close to target but still over (1,800 CFU/100ml), again likely due to lime dose and retention time.
- Both long-term monitored plants (Camps 1E and 4) show potential to remove helminth with zero and low numbers recorded i.e., some samples met/close to this.



3. ABR

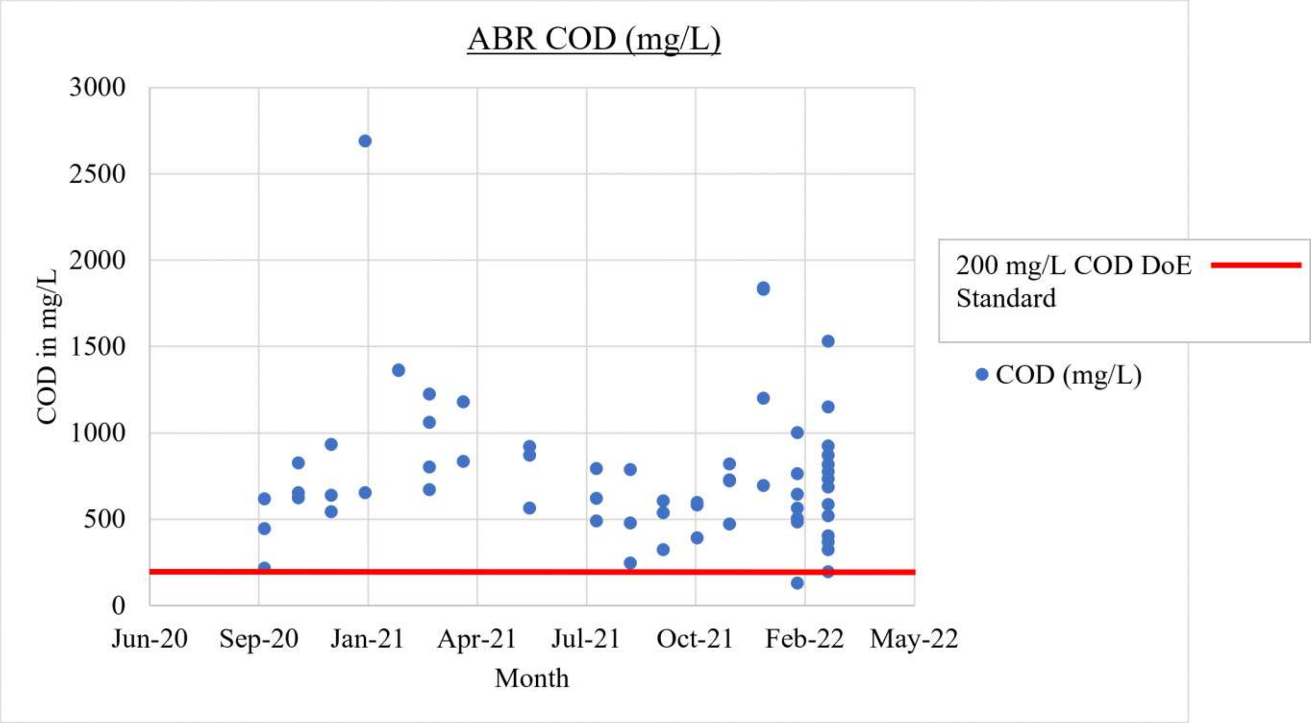
3.1 Ph

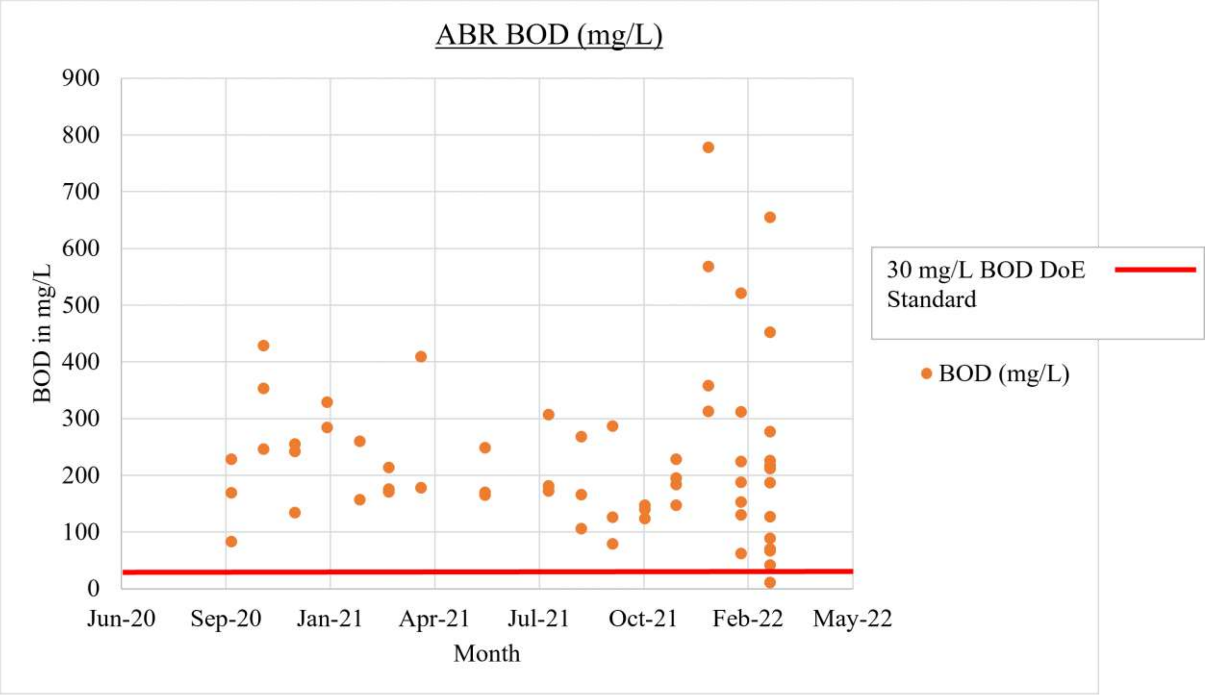
- All ABR data generally within standard (6-9), at high end. Field visit sites all within standard.
- One field site has data throughout the process - shows slight increase in pH within ABR (prior to filter) but process has no significant impact on ph.



3.2 BOD and COD

- All sites effluent above (in breach) BOD standard (30mg/l), generally in the range 100-250mg/l. One outlier (1770 mg/l - could be an error but also shows high coliform, etc).
- All sites effluent above COD standard (200mg/l), with two expectations (Camp 8W and Camp 20) which are just within standard i.e., 130& 190 mg/l.
- Field visit sites above BOD and COD standard.
- Data through the process shows majority of BOD removal (i.e approx. 35% to 90% removal) occurs in ABR (ahead of "filter inlet").
- Majority of COD removal (i.e. approx. 60%+ removal) occurs in ABR (ahead of "filter inlet").





3.3 Nutrients

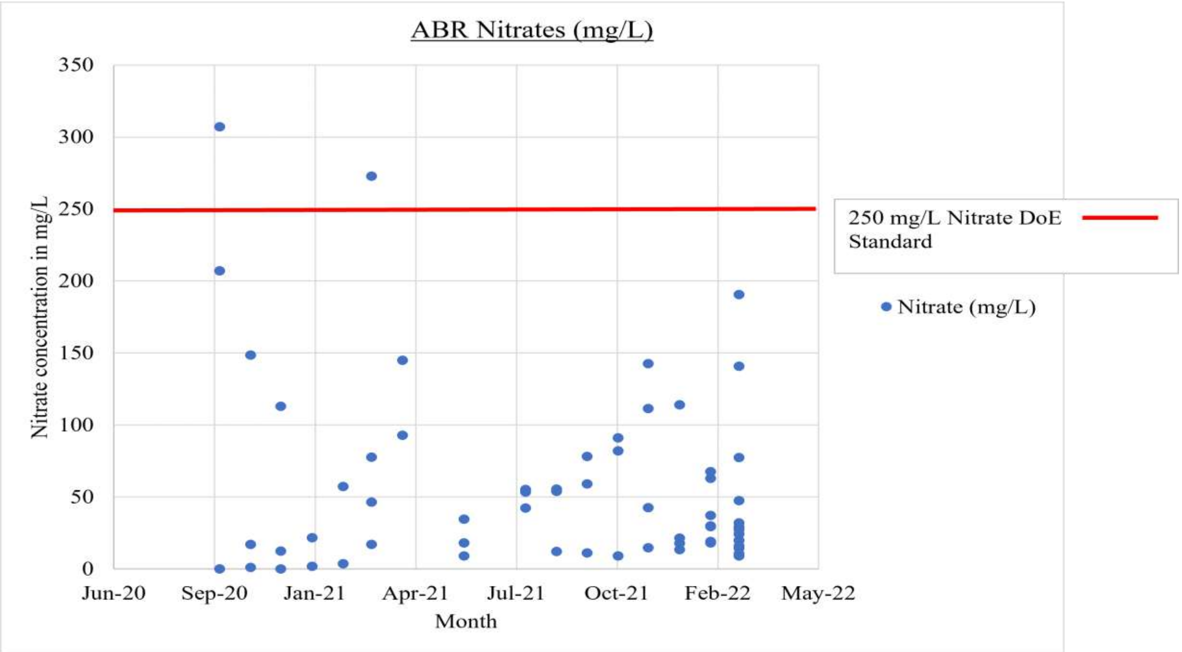
Nitrate

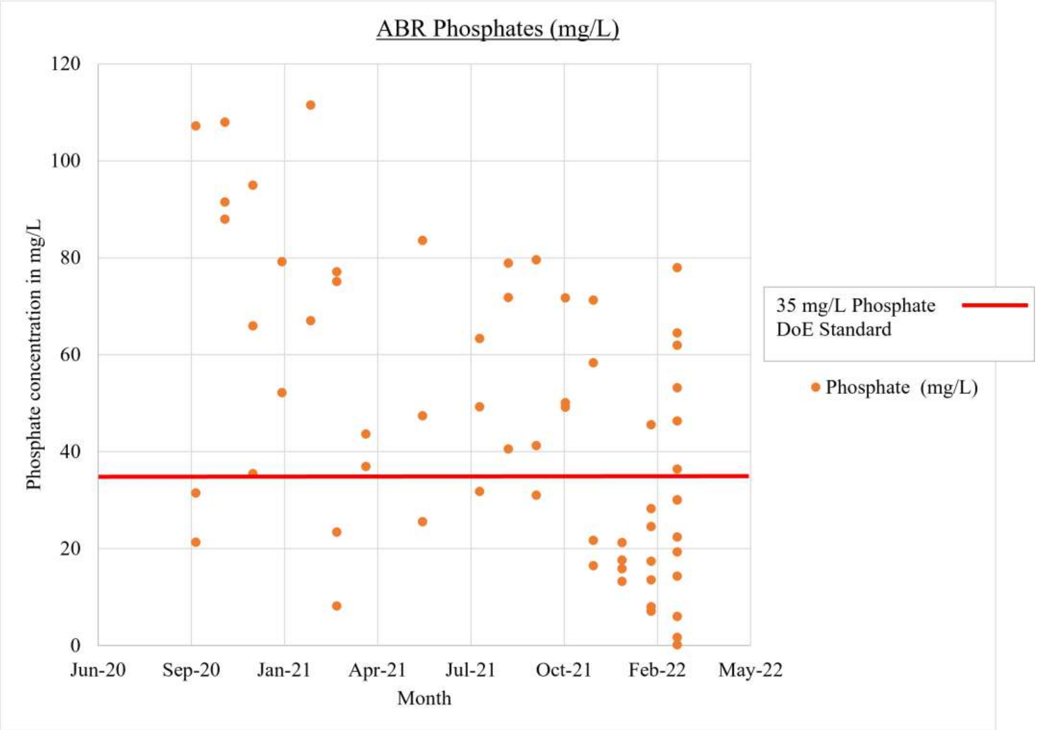
- All within standard with two expectations. Influent already below standard (with two expectations) no evidence of catchment to identify high source of nutrients in that FSTP catchment.
- Limited nitrate removal through process, some data shows an increase in the filter.

Phosphate

- Generally above standard for all sites and those visited. No obvious seasonal variation
- Removal in the ABR and filter. Filter is important (probably bound in solids which are removed here).

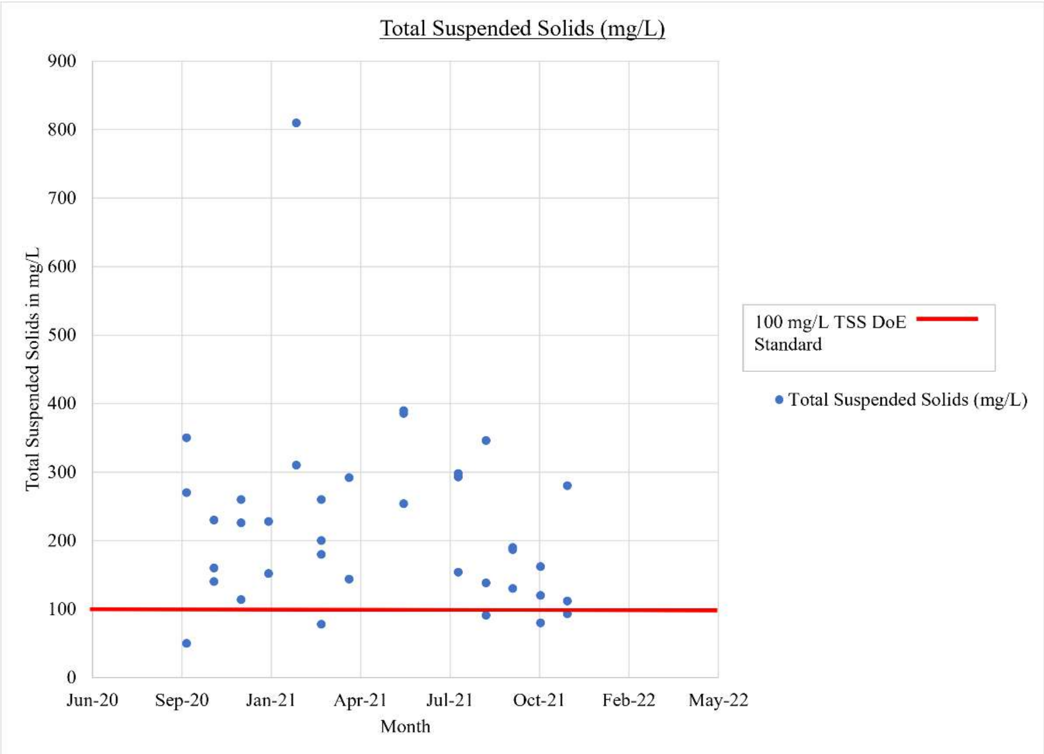
Total Nitrogen – limited data not worth review





3.4 Solids

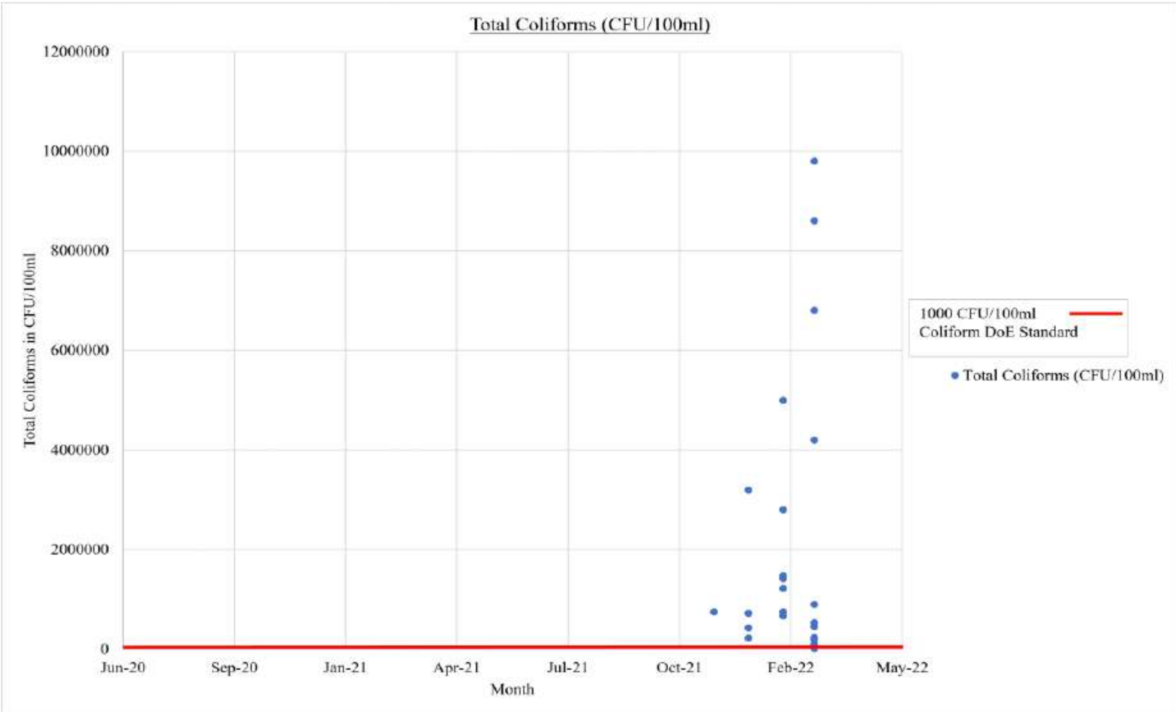
- TSS typically 100 - 400 mg/l (one FE sample at 800+) circa 13% of FE samples pass solids, four from camp 5 and 1E showing these are performing better for solids removal.
- Only have SS data for one of the field visits sites.
- Majority removed in ABR (70%) then further reduction in filter and polishing pond.



3.5 Pathogens

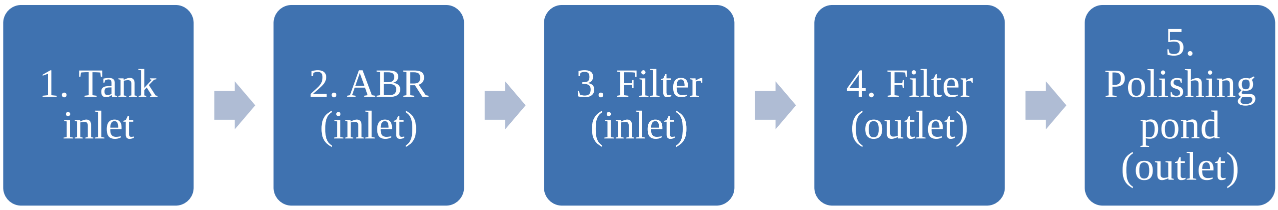
- Only recent data available i.e., late 2021 and early 2022.
- All in breach of standard (1000CFU/100ml).

- One site is measuring E. coli with no data for total coliforms therefore E. coli used as a proxy.
- Majority of coliforms are removed in ABR (with solids) then further reduction in filter and polishing pond. Some data show E.coli increase in polishing pond, possibly due to open pond being contaminated by surface water/drainage.

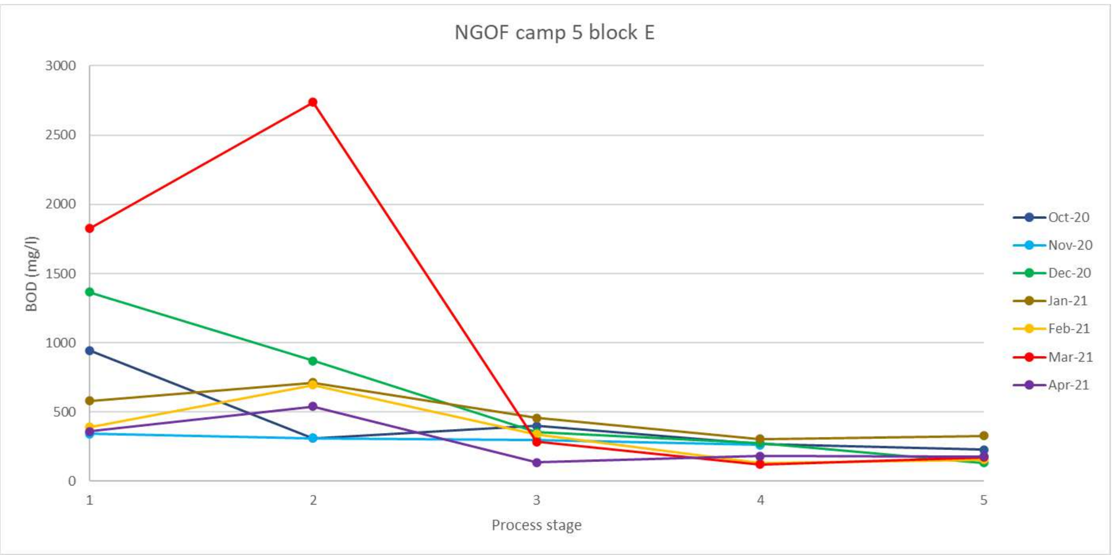


3.6 ABR process stages and performance

Five ABR FSTP are measuring at intermittent stages in the process i.e. not just effluent (covering two operators/NGOs). The data has been reviewed to show where the removal occurs for the various parameters and identify if any differences in the process flow impact the performance. Note only one of the sites with full data was visited during the study however the other ABRs visited have a similar/same process flow. Process stages that were monitored are:



BOD – overall removal ranged between 28% and 91%. Majority removal in ABR (35% to 90% reducing in ABR) but not consistent and in some cases goes up.



Suspended solids - for the site visited there was generally 70 to 90% reduction in solids through whole FSTP. Apart from one sample in Nov 2020 (only 30% removal).

Pathogens - Overall removal 80-100% across the whole FSTP, however effluent still often above standard. E. coli monitoring available for intermittent processes on one ABR (not visited). 2 of 12 Samples passed standard reading ‘0’. All others at least 10-fold of the standard.

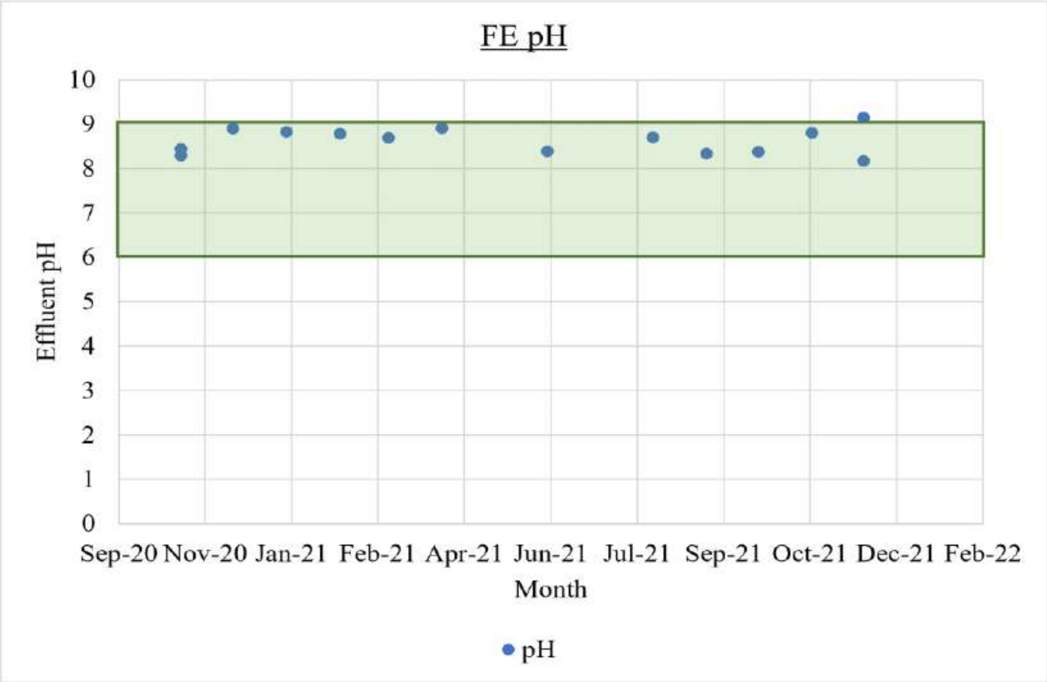
For site visited it was noted that Enterococcus increase in the polishing pond. It was always lower than standard from filter outlet then increases (above standard) in polishing pond. The pond looks secure and bunded so this should; prevent contamination form surface water run off etc.

Photograph 1: Polishing Pond for one ABR site visited

4. Mega FSTP (Anaerobic lagoons)

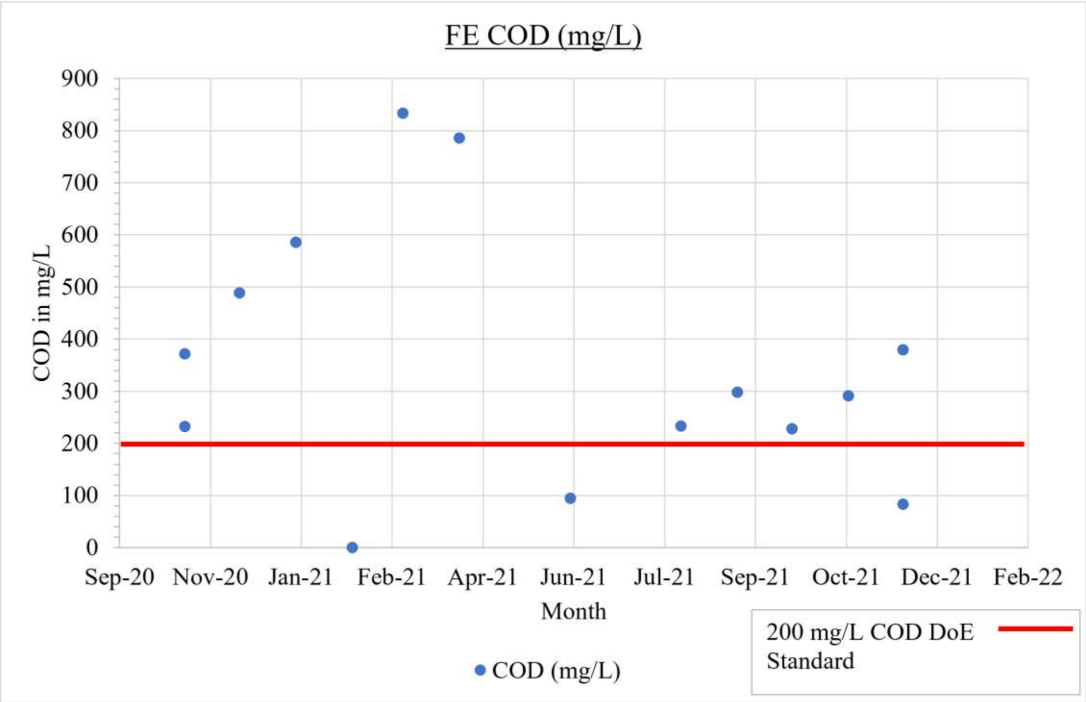
4.1 pH

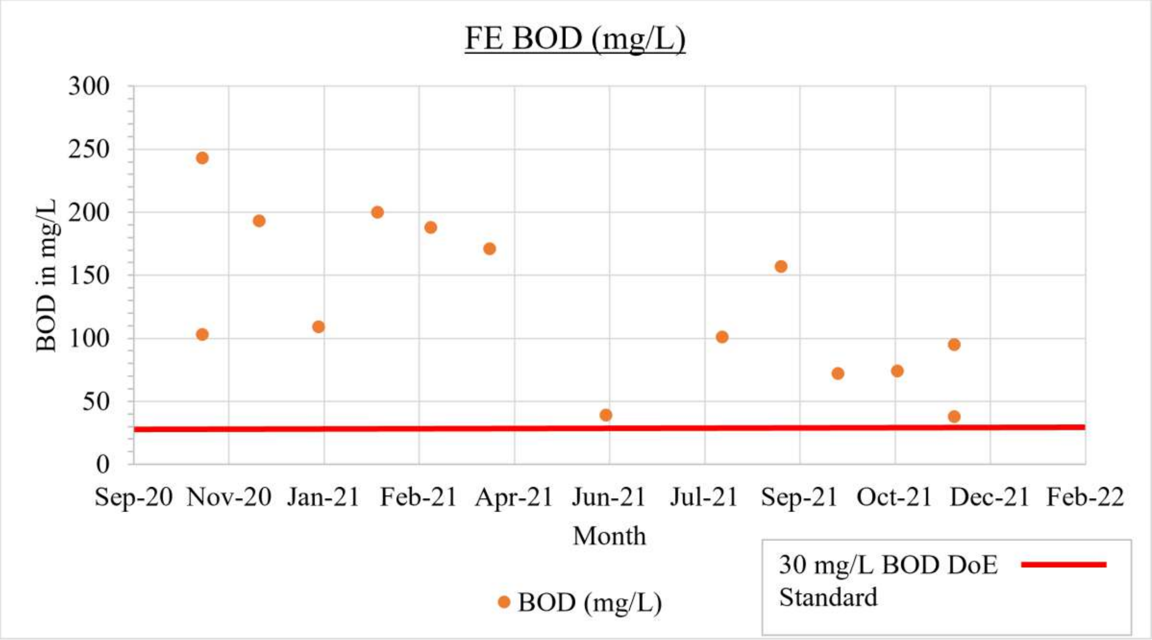
- Final effluent (FE) pH within standard range.



4.2 BOD and COD

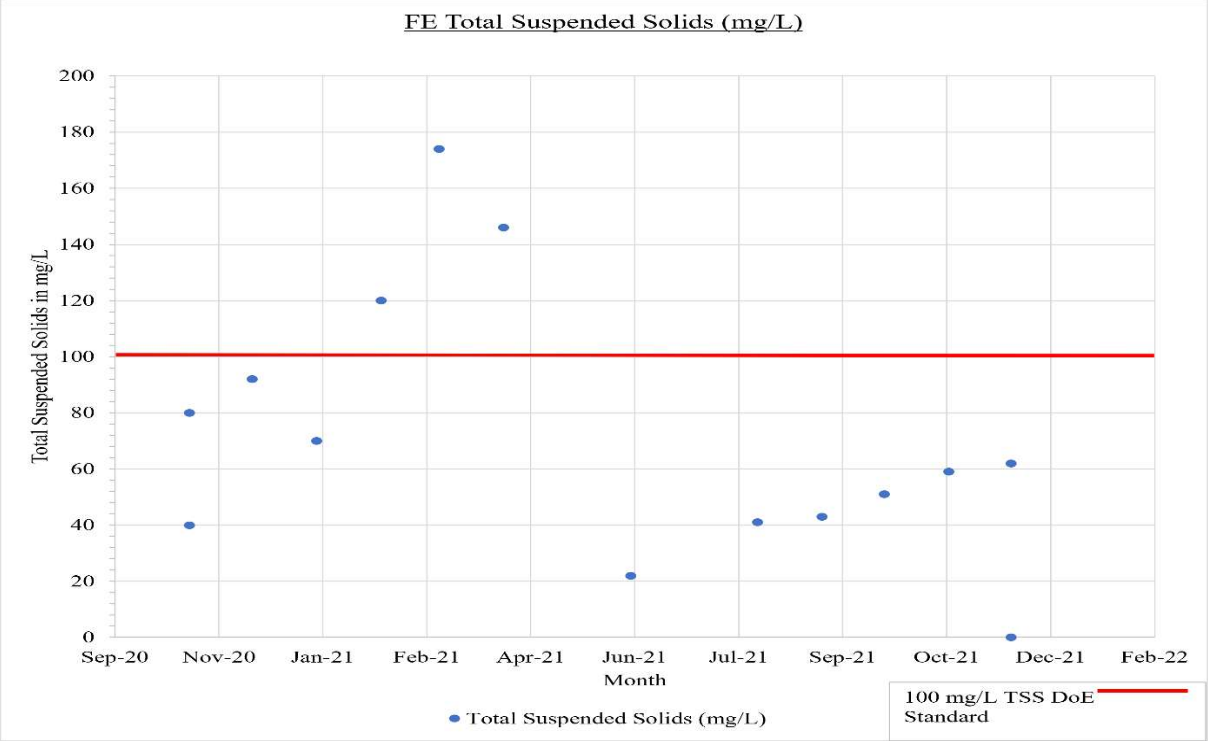
- Long term sampling available for the Mega FSTP.
- BOD and COD are generally in breach of standards but not significantly.
- FE BOD was generally consistent throughout the year but it was noted that COD was higher in Sept/Oct/ Nov for both 2020 and 2021.
- Relative to other FSTPs this is the one of the best performing FSTP for FE BOD and COD





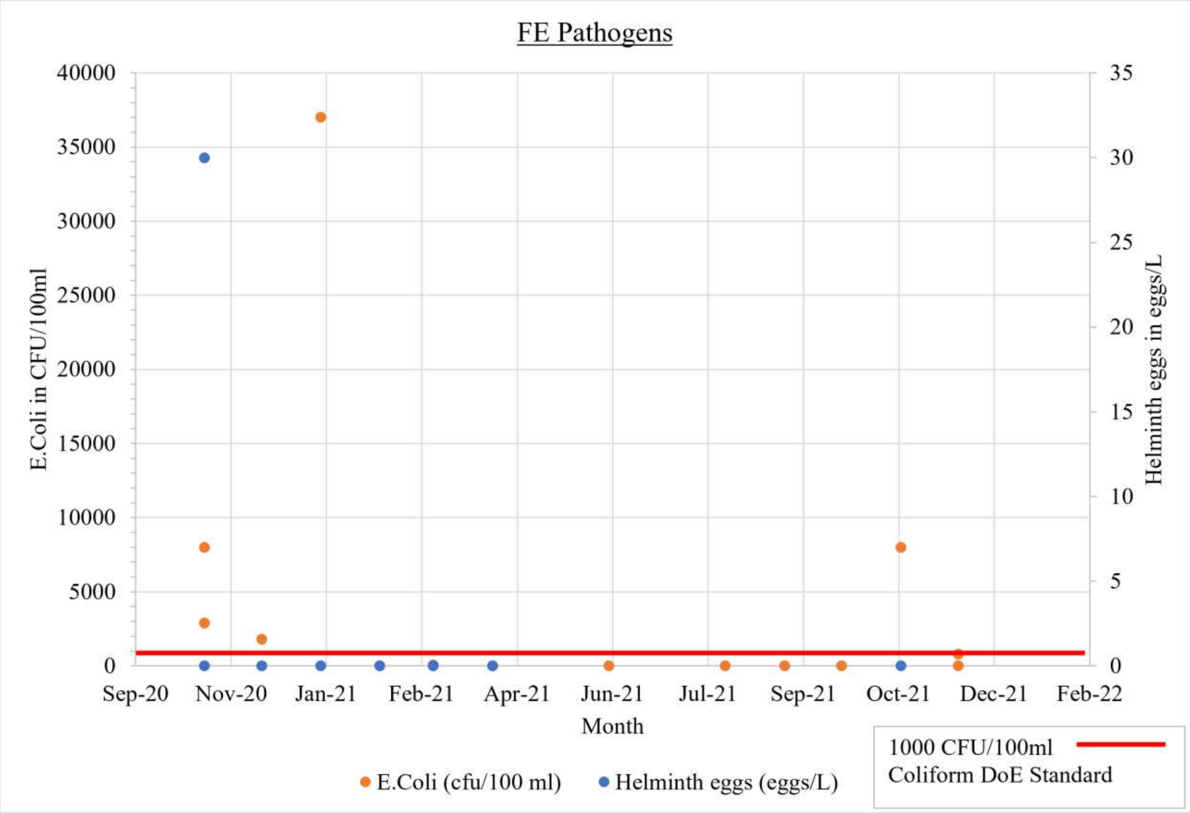
4.3 Solids

- TSS of FE within or close to standards majority of time.



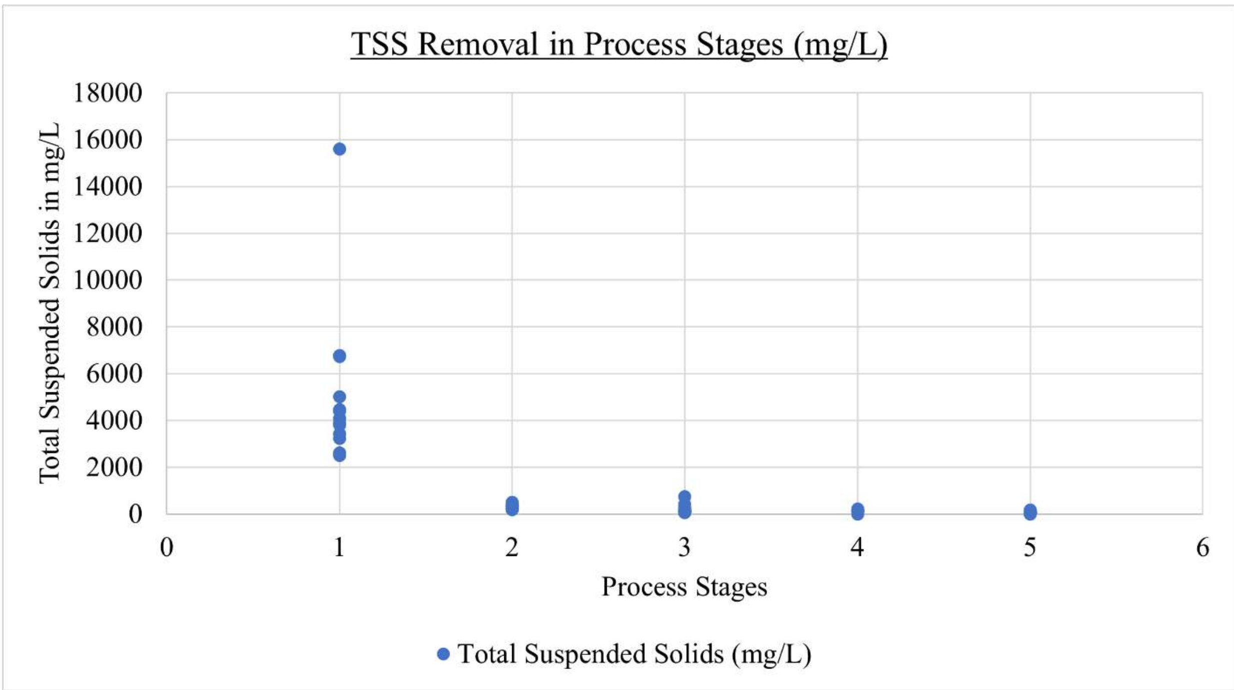
4.4 Pathogens

- Pathogen in FE within or close to standards majority of time.



4.5 Anaerobic lagoons process stages and performance

Majority of solids, pathogens removed in Anaerobic lagoons (stage2). Further BOD removal in follow on processes. The process stages monitored are: Inlet, Anaerobic lagoon 1 Liquids Outlet, Upflow outlet 1, Trickling Filter Outlet and final effluent after pond.



5. DEWATs

The following document outlines the performance of DEWATS, using available existing data and information collected by I,CCDRB and provided by IOM. The sampling dates range from 30th December 2019 to 14th February 2021, from rounds 2-9, 11 and 12 across three sites. Data is presented for each round of sampling. The performance data is compared against the Bangladesh Department for Environment (DoE) standards for wastewater effluent.

5.1 Summary

All sites are within DoE standards for pH, maintaining an outlet effluent pH of between 6-9. Large majority of sites fail BOD and COD standards, while most are within allowed Nitrate concentrations. Phosphate levels are varied with some sites within standard and some failing, while all sites fail Total Nitrogen (TN) standard. Total Suspended Solids (TSS) is varied with some within standard and some failing.

Table 1. Summary of DEWATs effluent quality

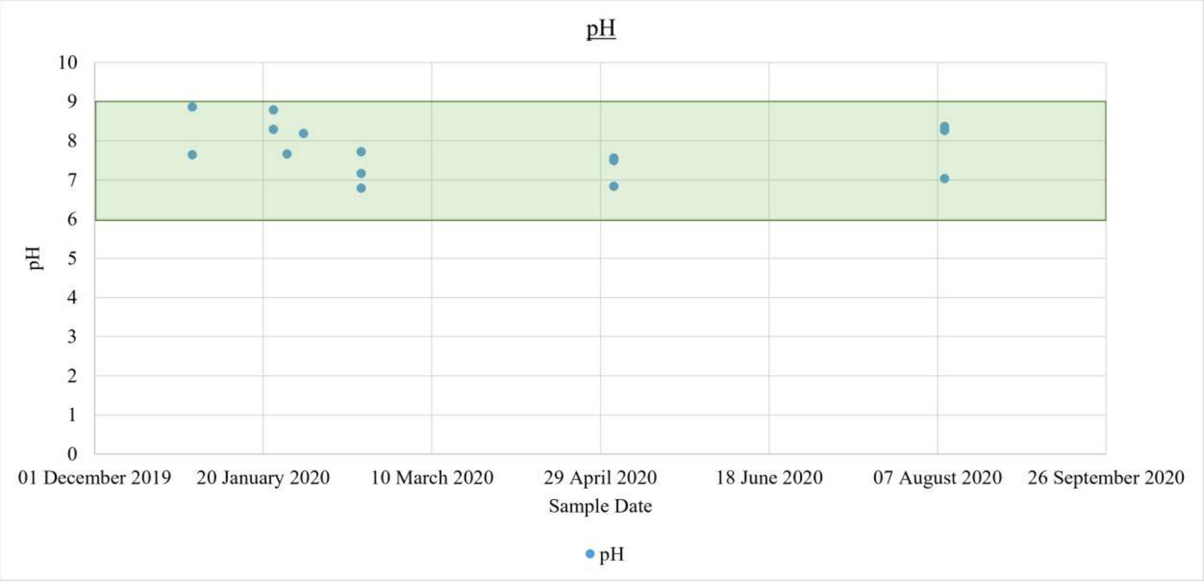
	Round 2-6	Round 5-8	Round 9	Round 11	Round 12
pH	Within standard	Within standard	Within standard	Within standard	Within standard
BOD and COD	Generally fail	Generally fail	FAIL	FAIL	FAIL
Nutrients	Nitrate- Within standard Phosphate – Generally within standard TN -FAIL	Nitrate and Phosphate – Generally Within standard TN – FAIL	Nitrate and Phosphate – Generally within standard TN- FAIL	Nitrate – PASS Phosphate – 2/3 within standard TN- FAIL	Nitrate – PASS Phosphate – 2/3 within standard TN-FAIL

	Round 2-6	Round 5-8	Round 9	Round 11	Round 12
Solids	Generally fail	Half within TSS allowance	Two out of three sites within standard	Two out of three sites within standard	Two out of three sites within standard
Pathogens	Majority of samples show 0 Helminth Eggs present and no E.Coli present	Majority of samples show 0 Helminth Eggs present Half of the samples with no E.Coli present	Majority of samples showing 0 Helminth Eggs present Majority of sites with higher levels of E.Coli	Majority of sites with 0 Helminth Eggs E.Coli present in all sites	Majority of sites with 0 Helminth Eggs E.Coli present in two out of three sites

5.2 Rounds 2-6

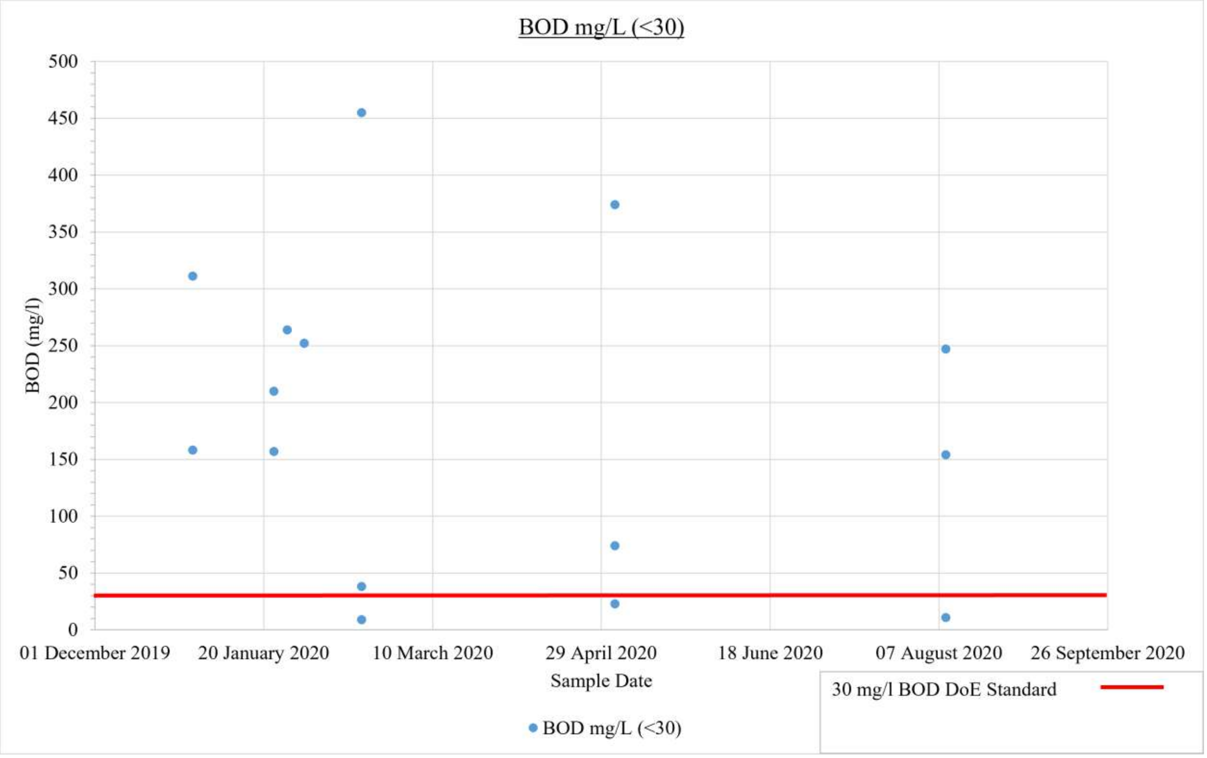
5.2.1 pH

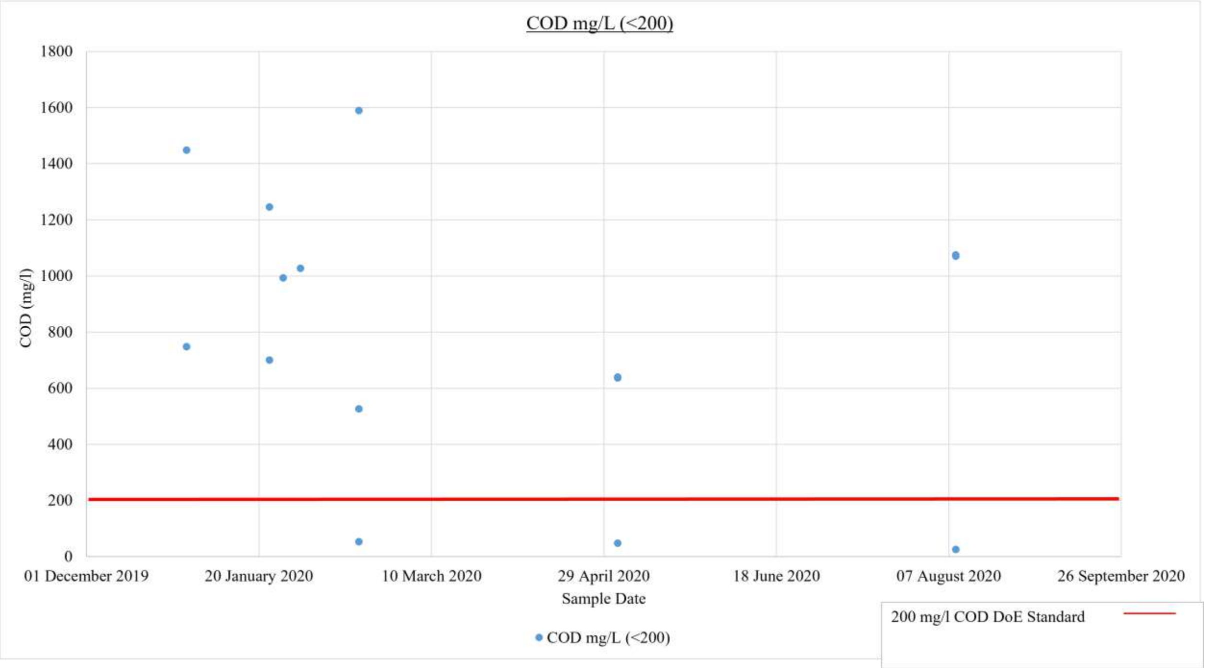
- pH was all within DoE standard



5.2.2 BOD and COD

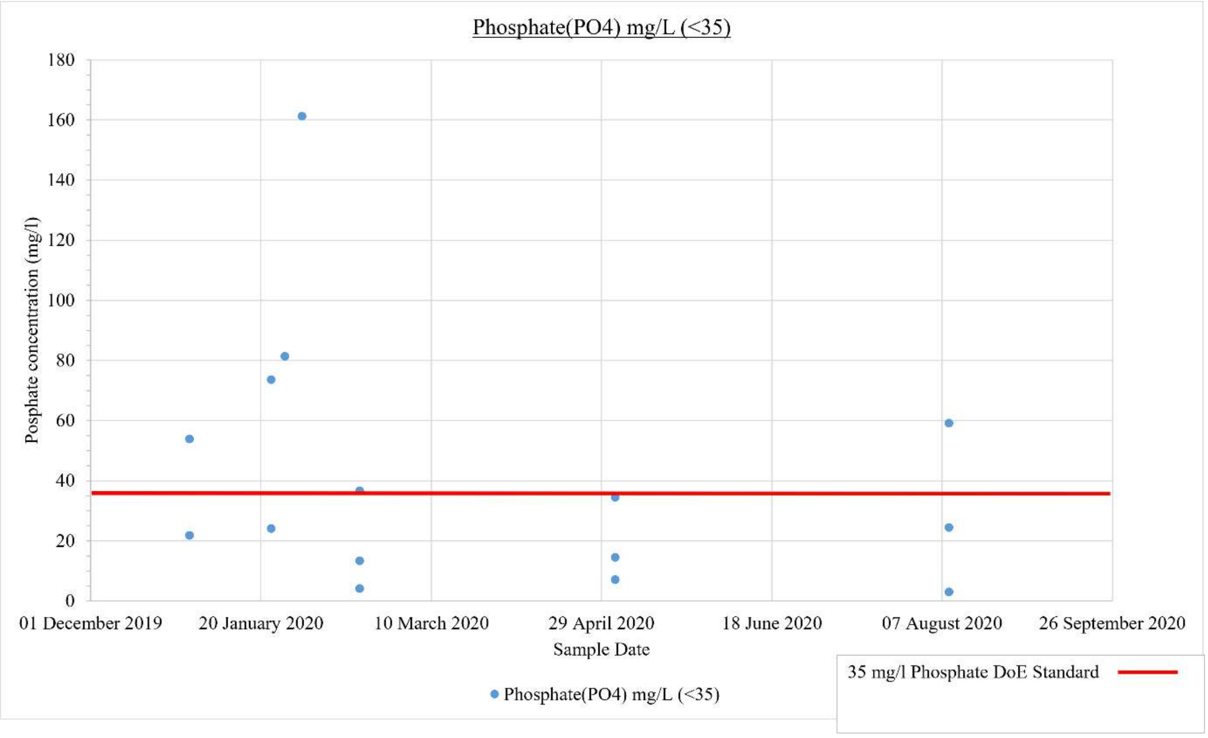
- Breaching both BOD and COD DoE standards

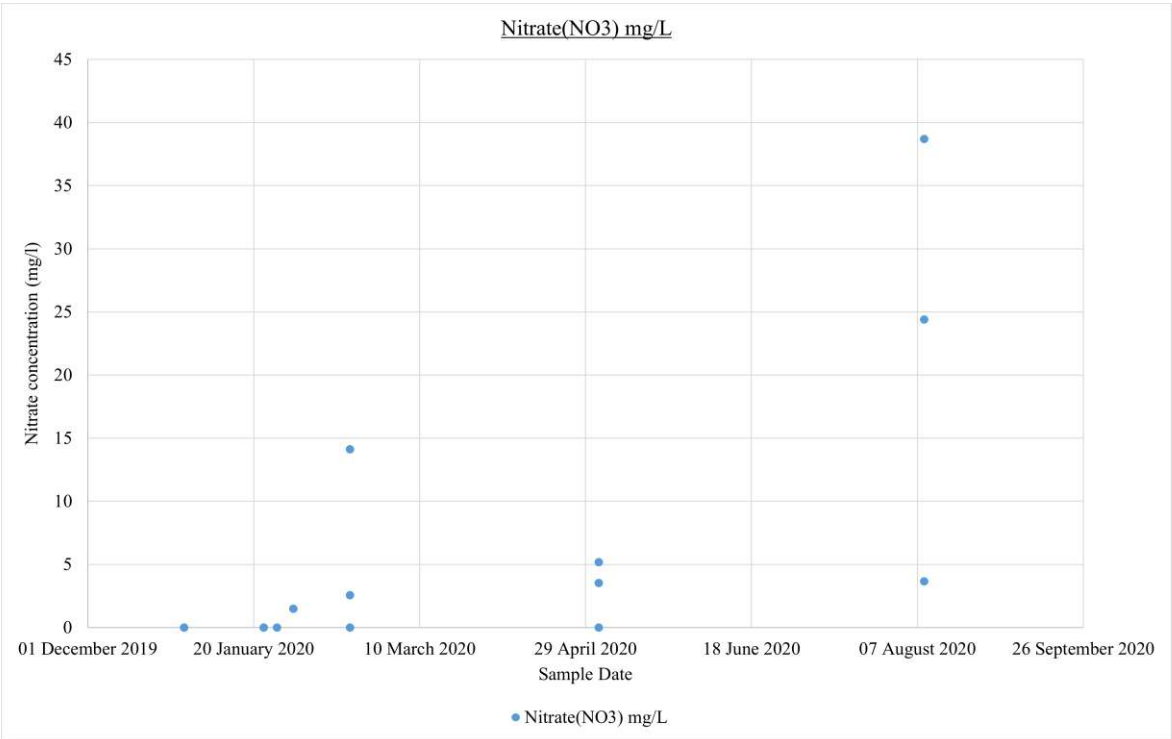


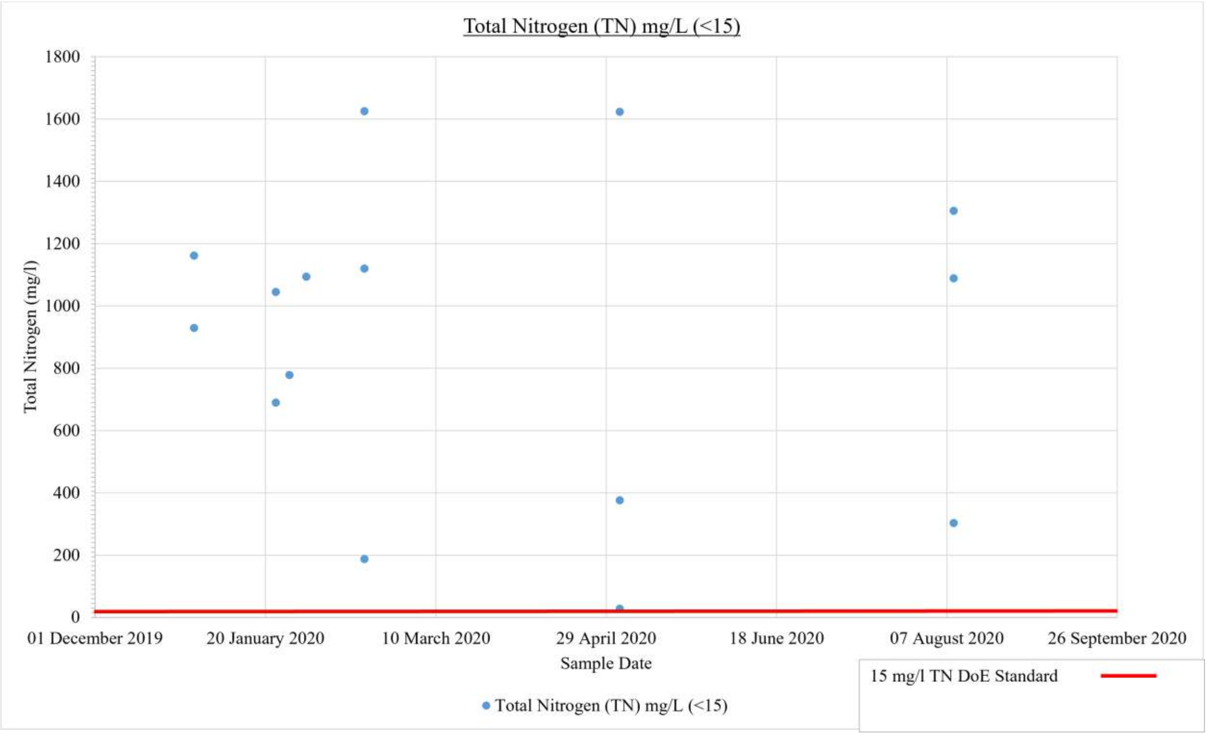


5.2.3 Nutrients

- All passing the standard for nitrate
- Majority of samples within phosphate DoE standard with a few over the limit
- All fail Total Nitrogen DoE standard

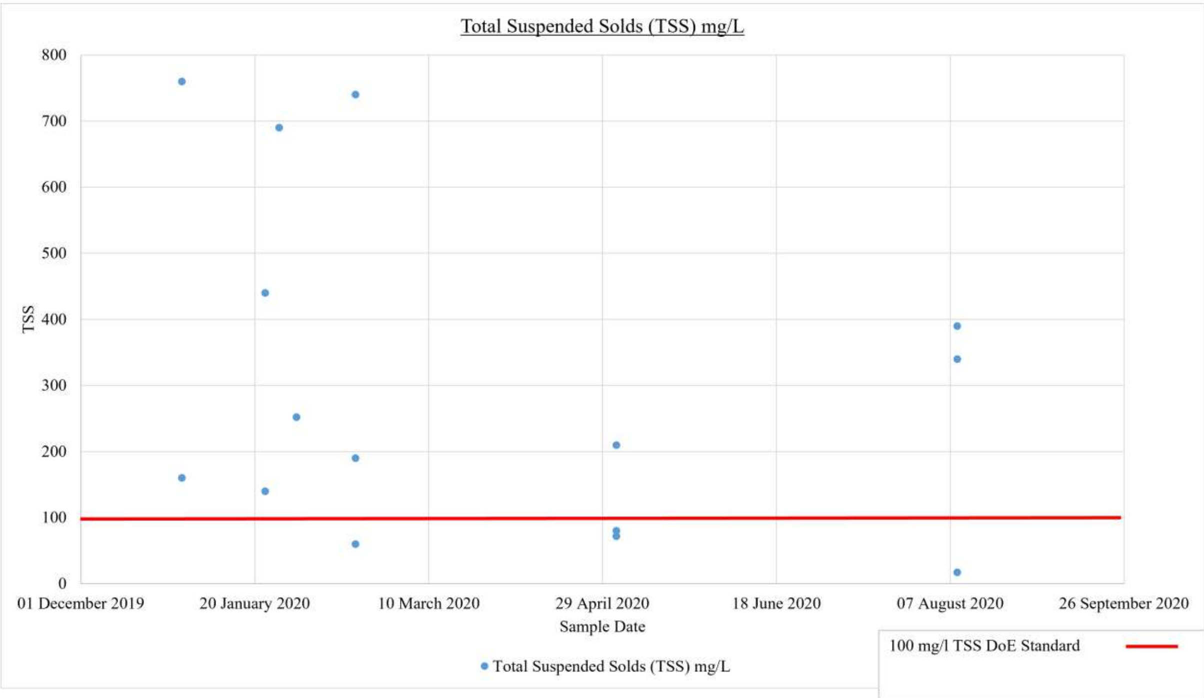






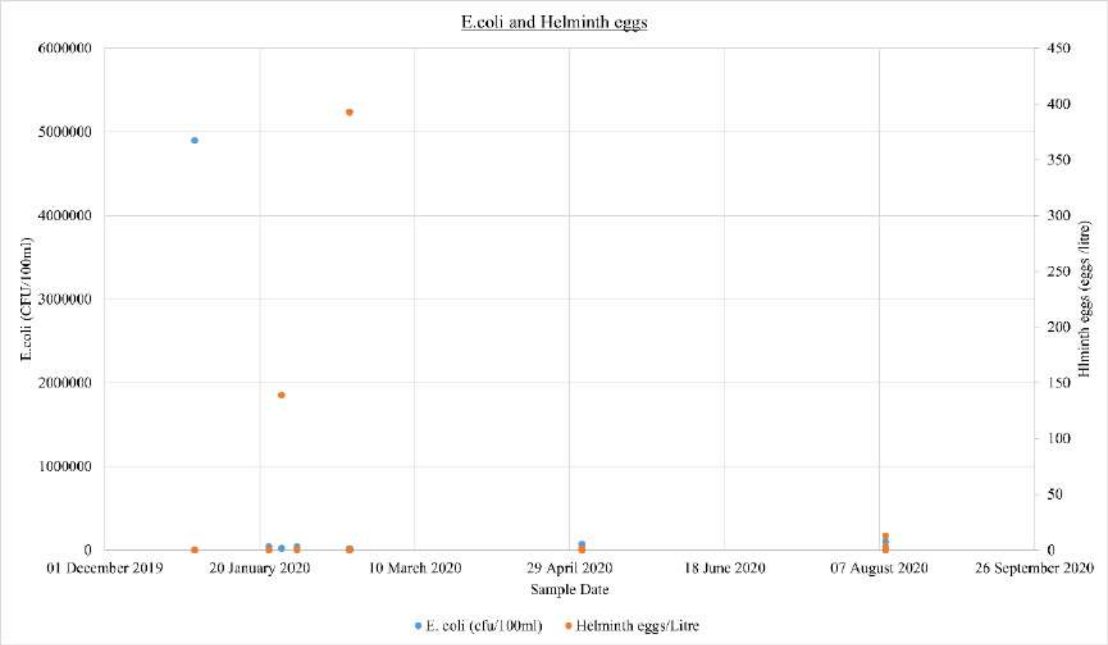
5.2.4 Solids

- Majority of samples not within DoE standards for TSS



5.2.5 Pathogens

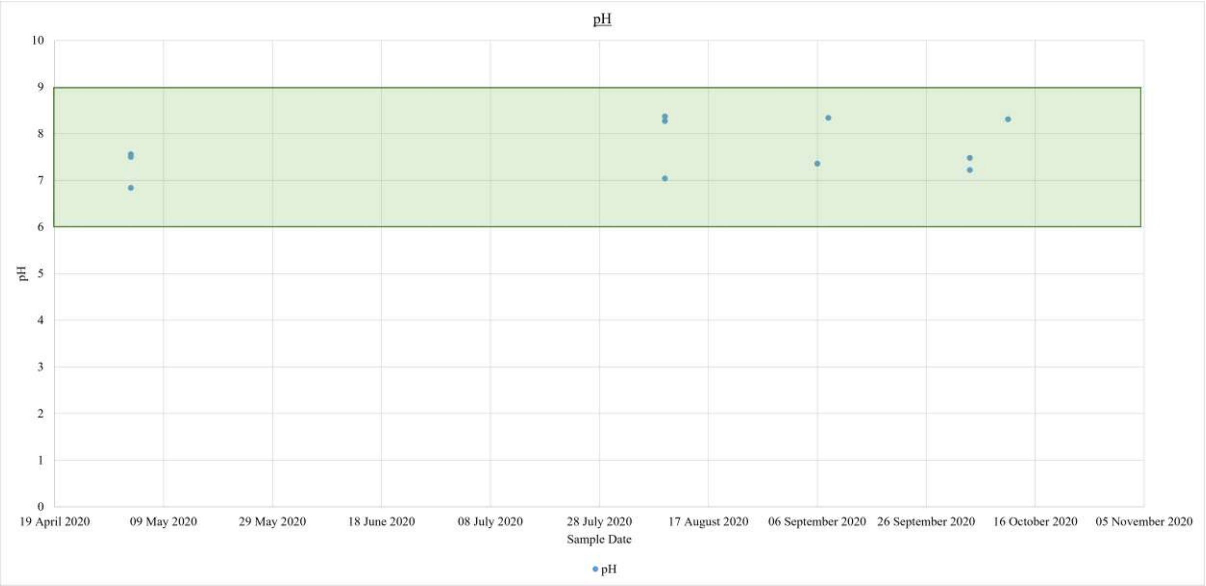
- Good Helminth removal i.e. majority of data showing zero eggs
- Two-thirds of samples show complete E.coli removal



5.3 Rounds 5-8

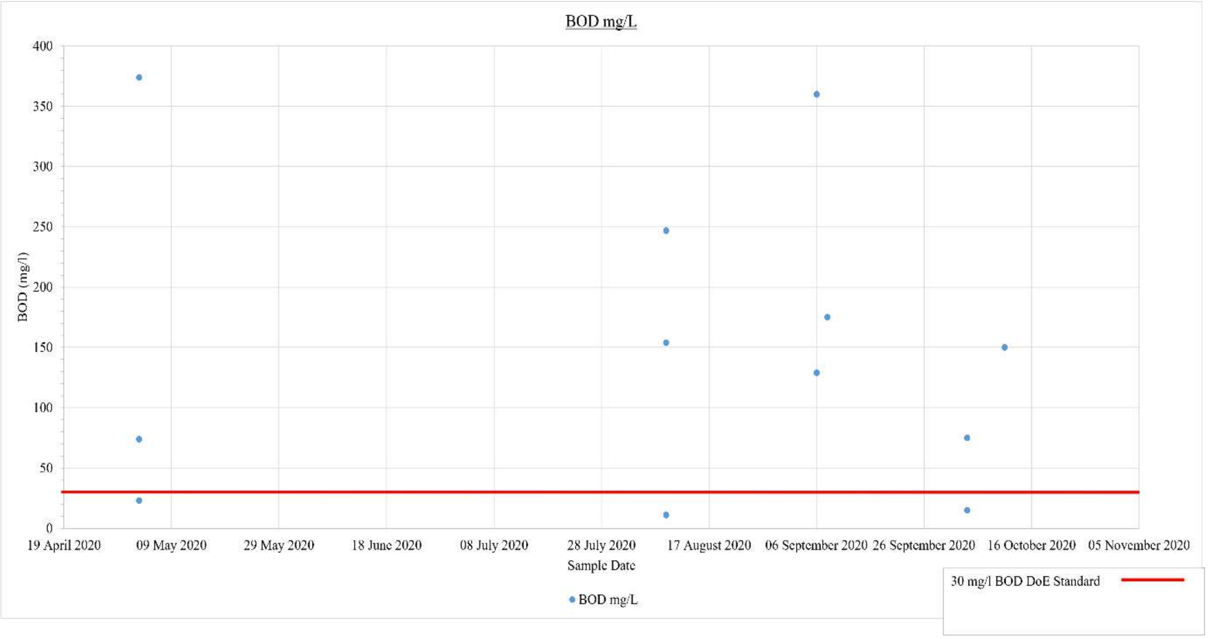
5.3.1 pH

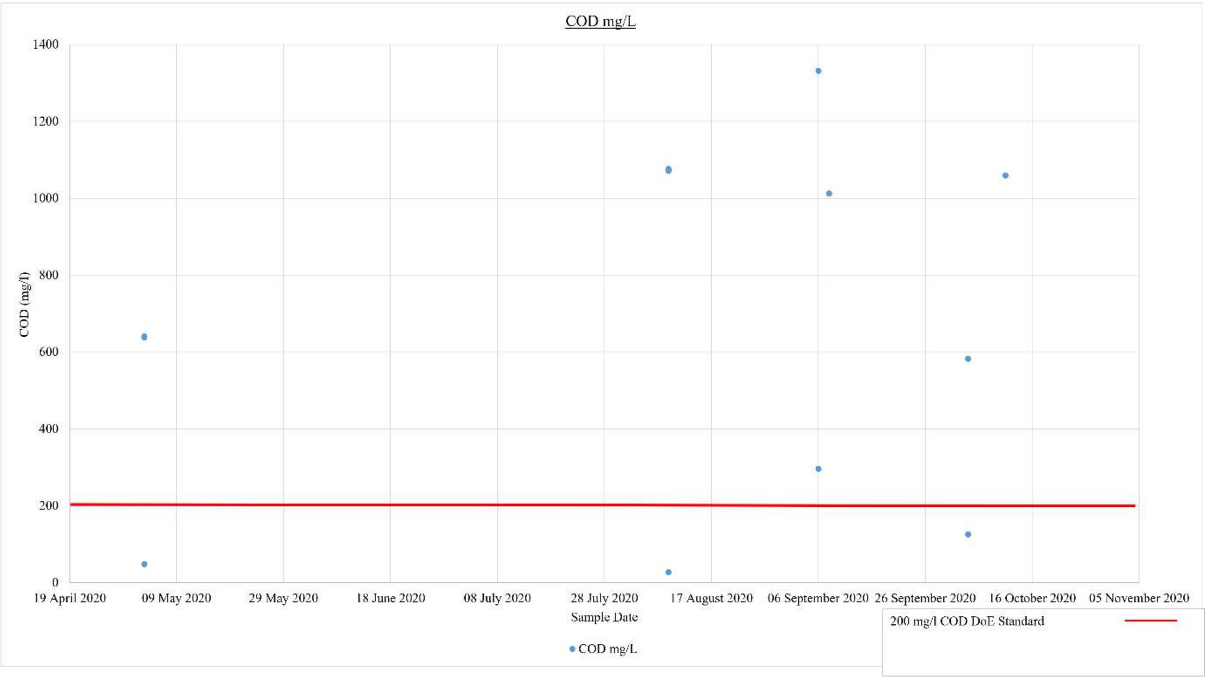
- pH was all within DoE standard



5.3.2 BOD and COD

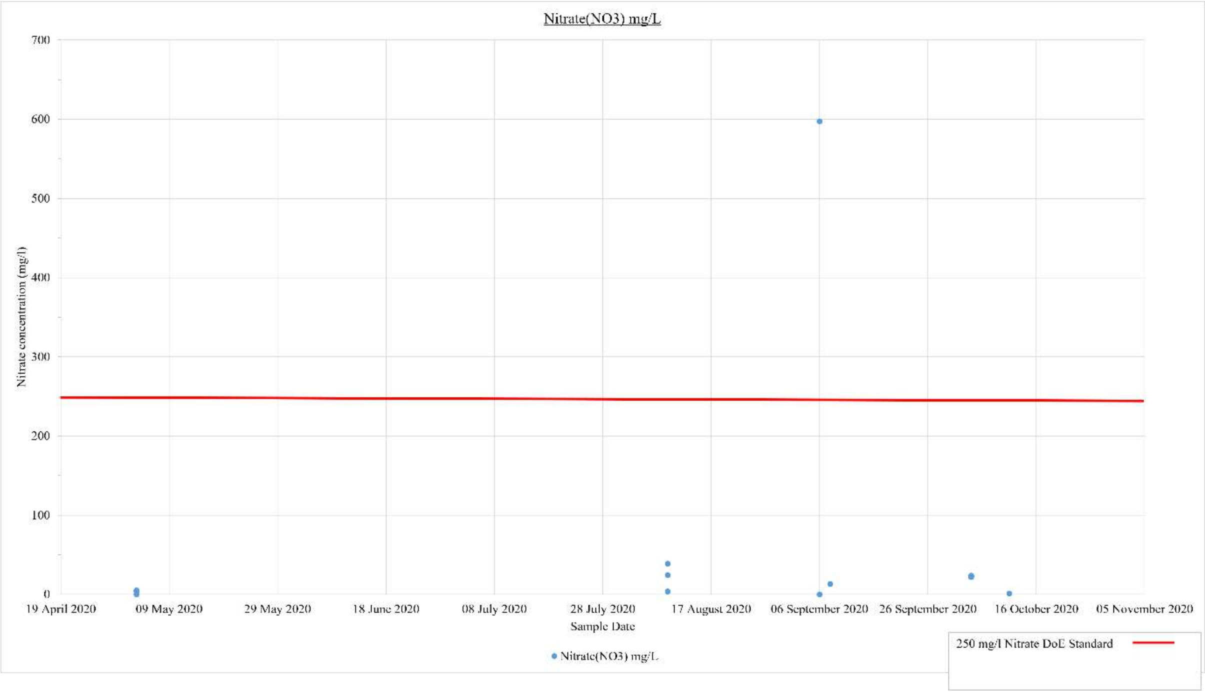
- Majority fail BOD and COD standards

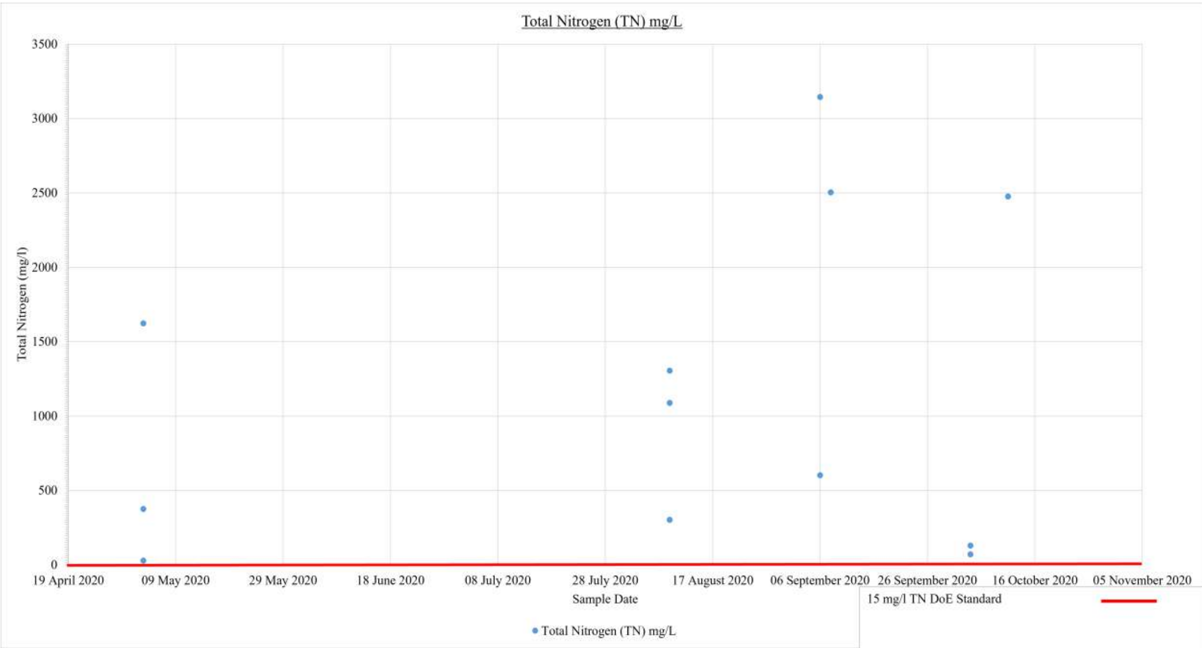


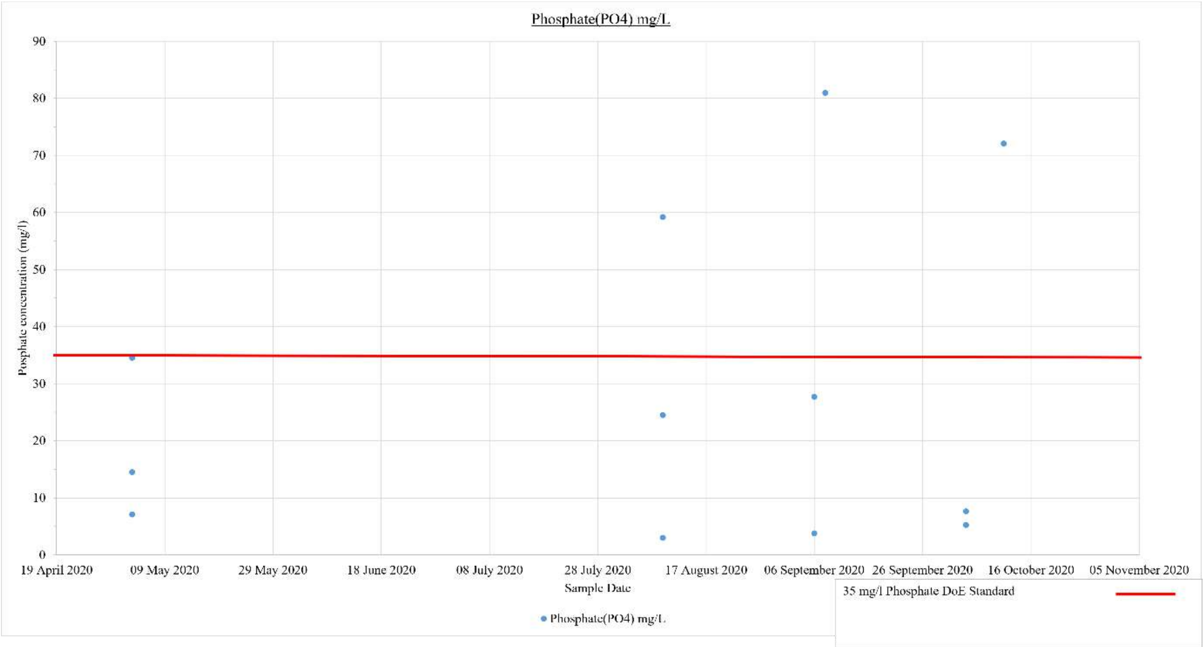


5.3.3 Nutrients

- Majority of sites within nitrate and phosphate DoE standards
- All fail Total Nitrogen

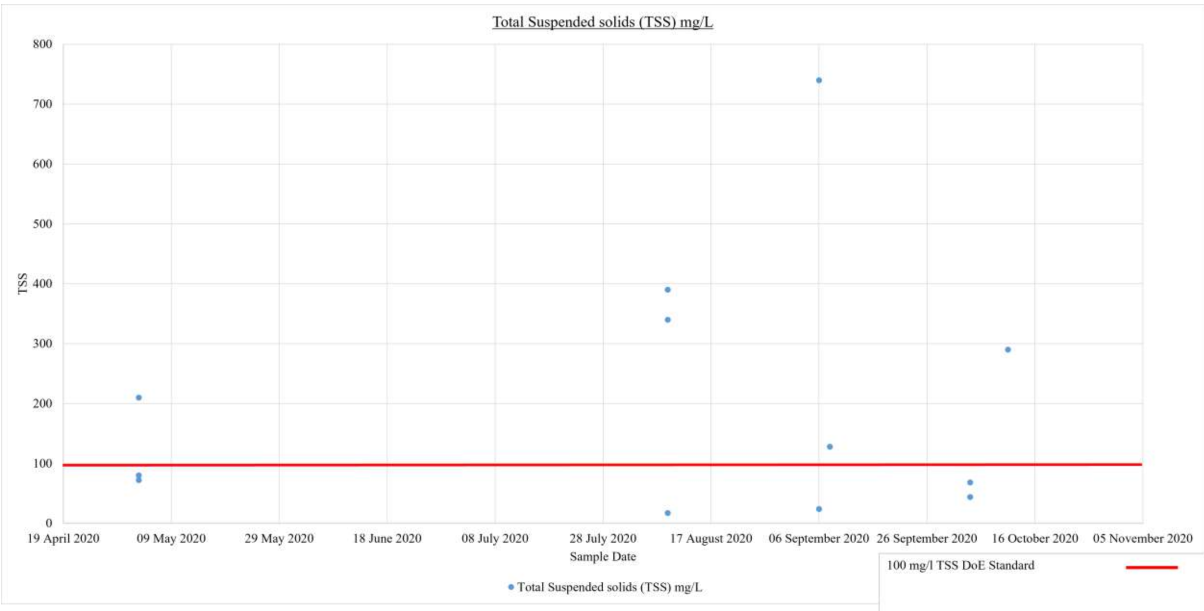






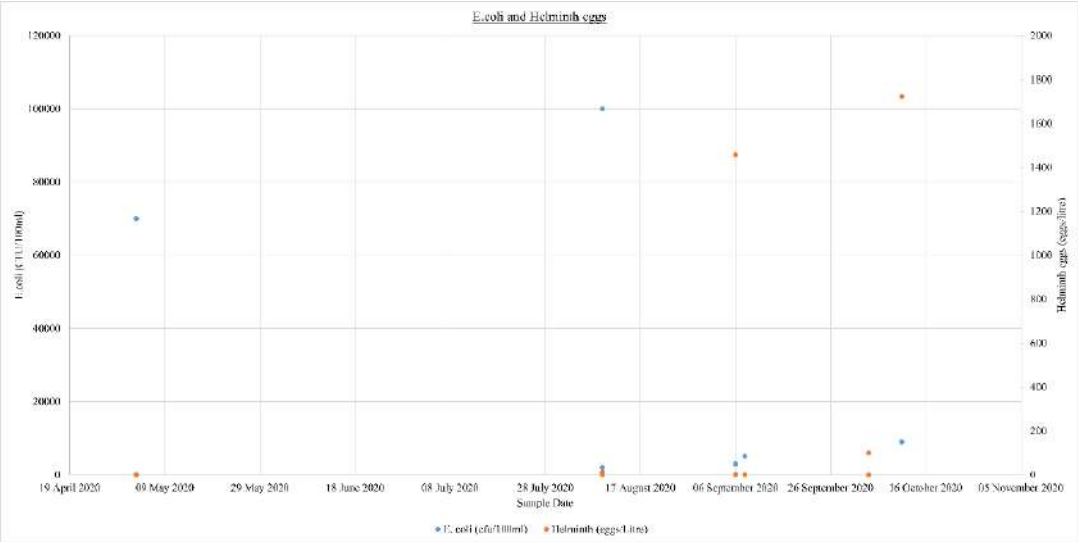
5.3.4 Solids

- Half of the samples within TSS DoE standard



5.3.5 Pathogens

- Good Helminth egg removal i.e. majority of data showing zero eggs or small concentrations
- Varying E.coli concentrations with half of the samples showing zero present



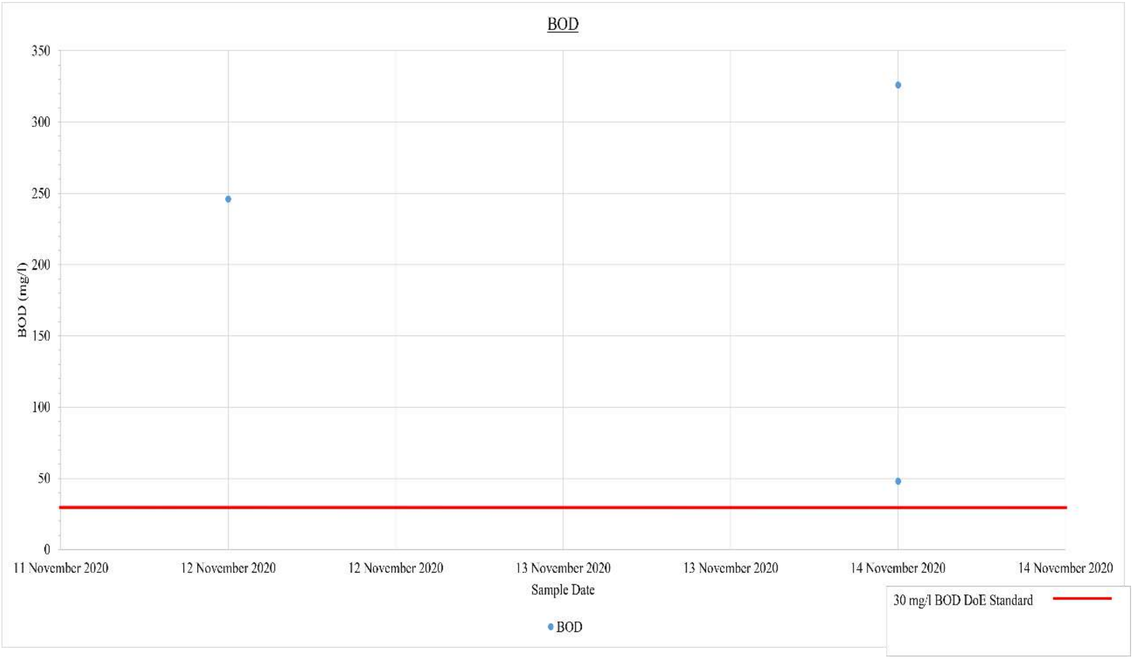
5.4 Round 9

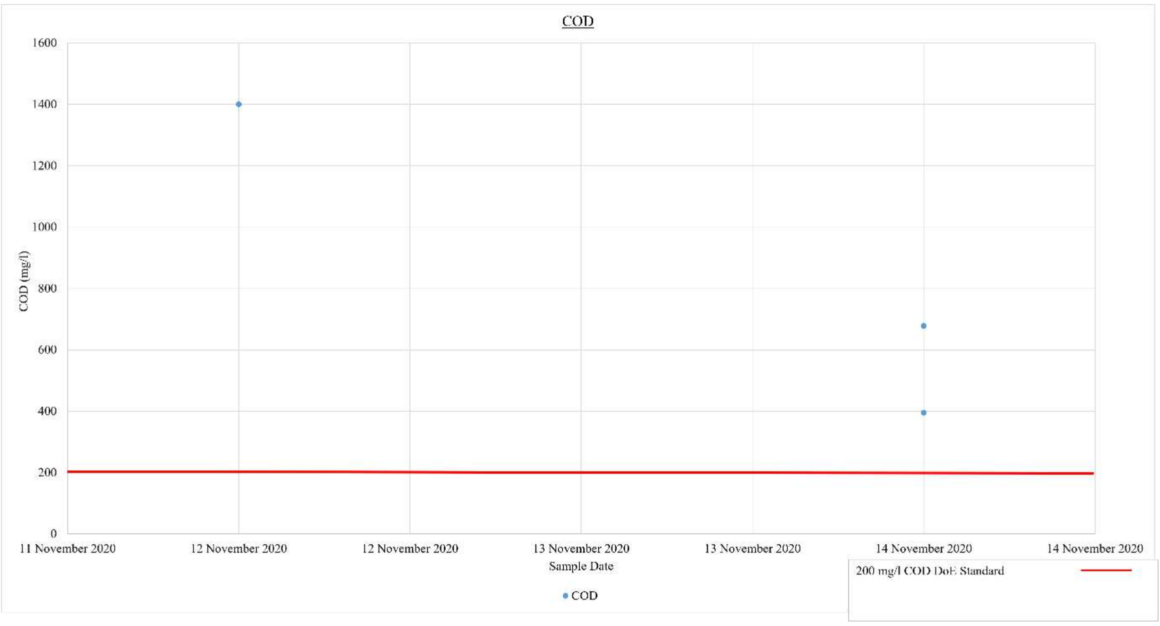
5.4.1 pH

- pH all within DoE standard

5.4.2 BOD and COD

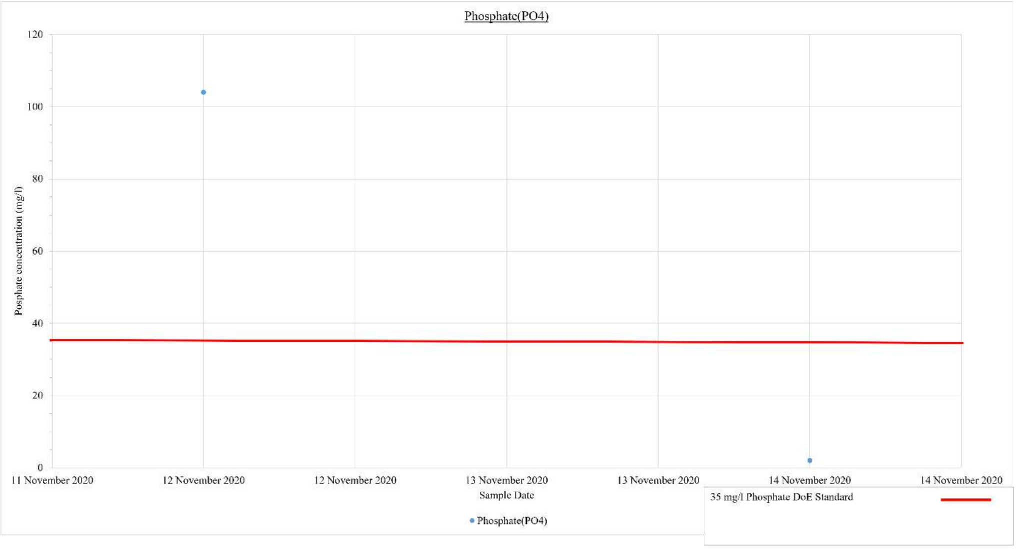
- All sites fail BOD and COD standards

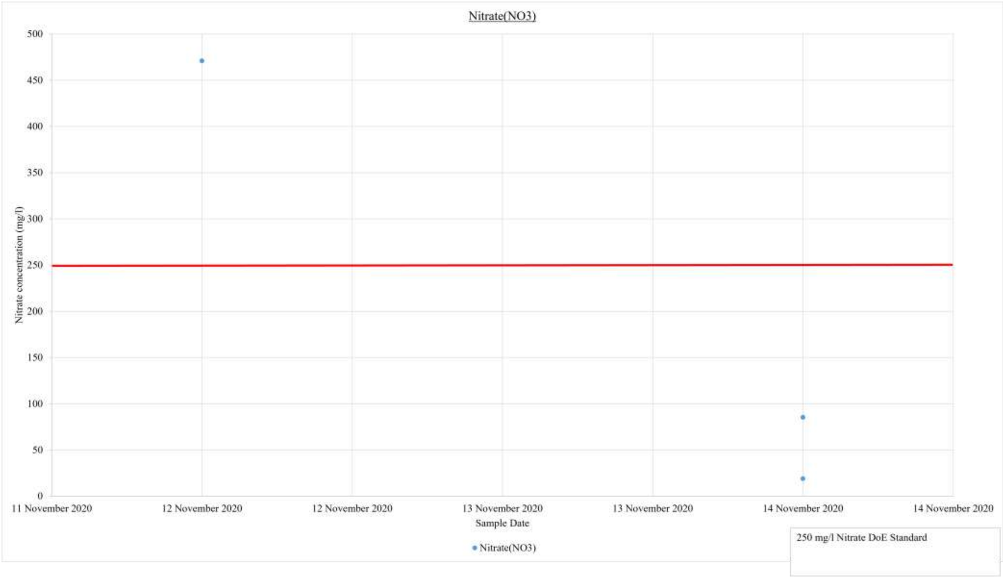


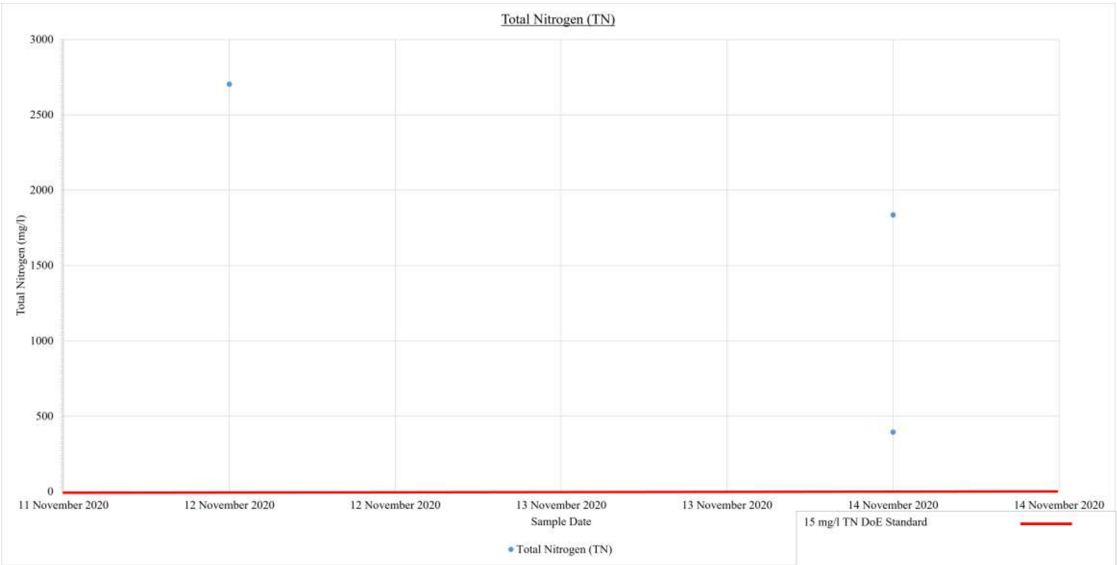


5.4.3 Nutrients

- Two out of three sites comply with DoE standards for Nitrate and Phosphate concentrations
- All sites exceed TN standard

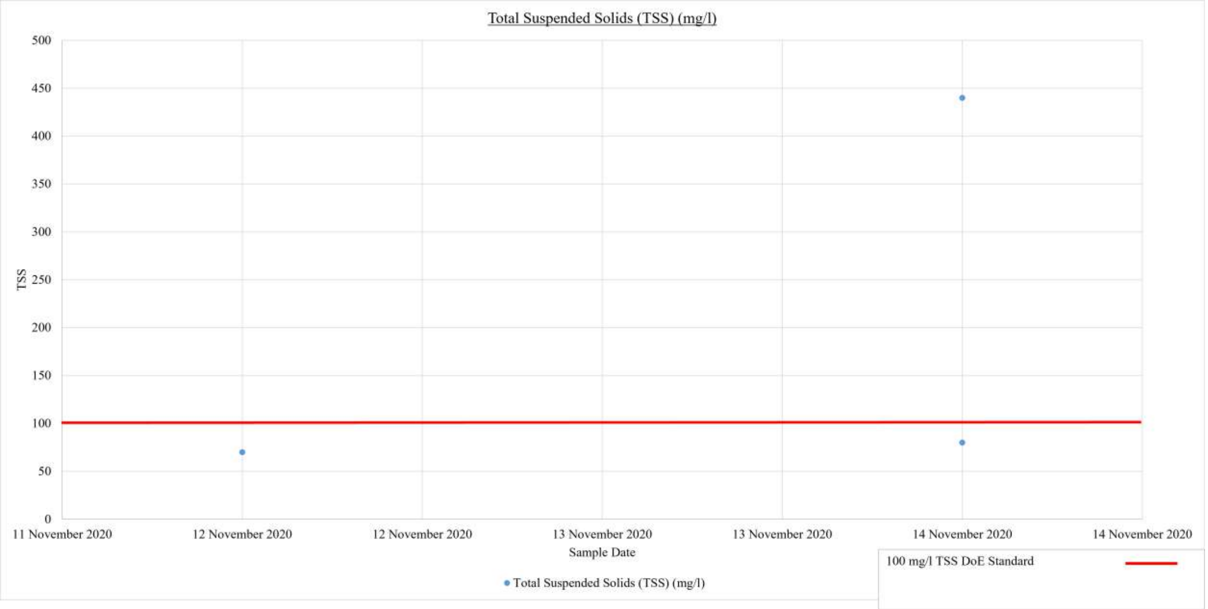






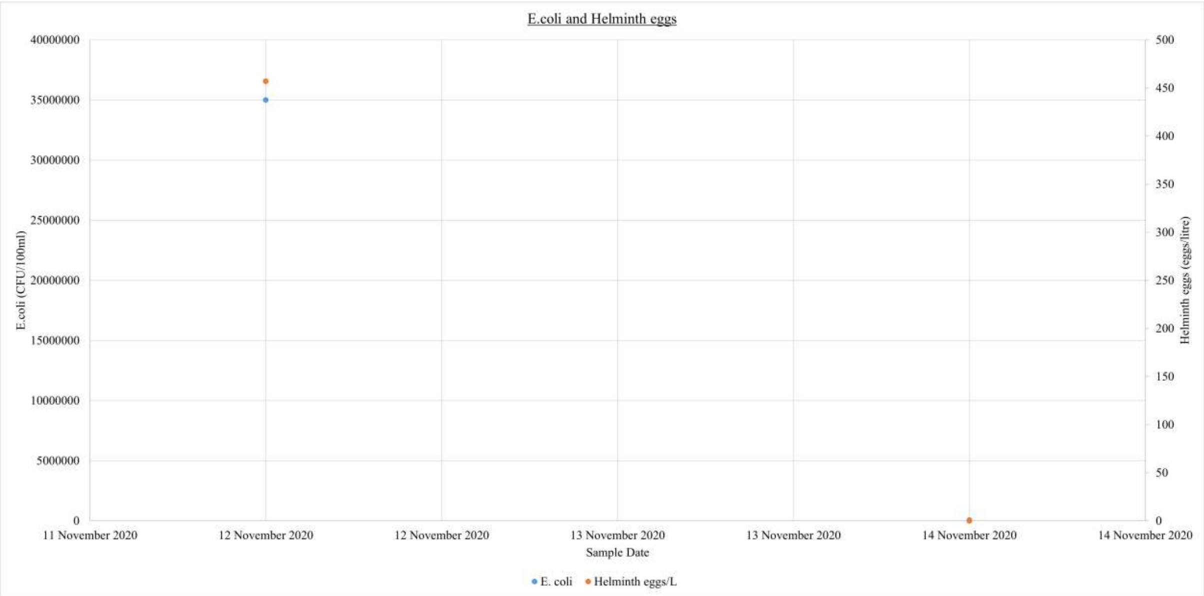
5.4.4 Solids

- Two out of three site comply with TSS DoE standard



5.4.5 Pathogens

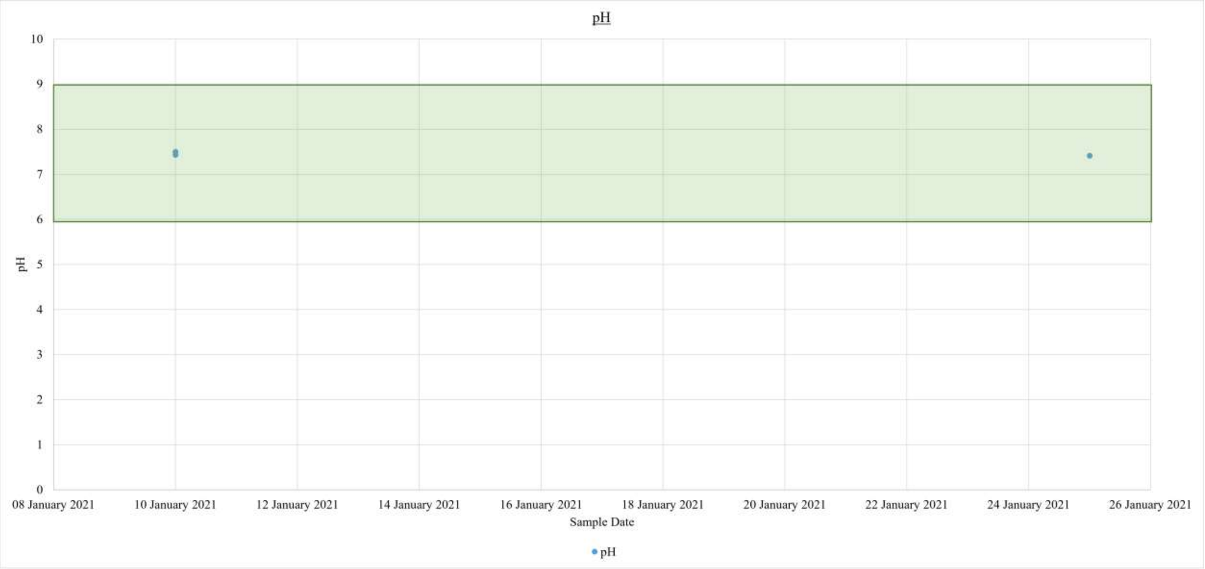
- Good Helminth egg removal with two out of there sites showing zero eggs



5.5 Round 11

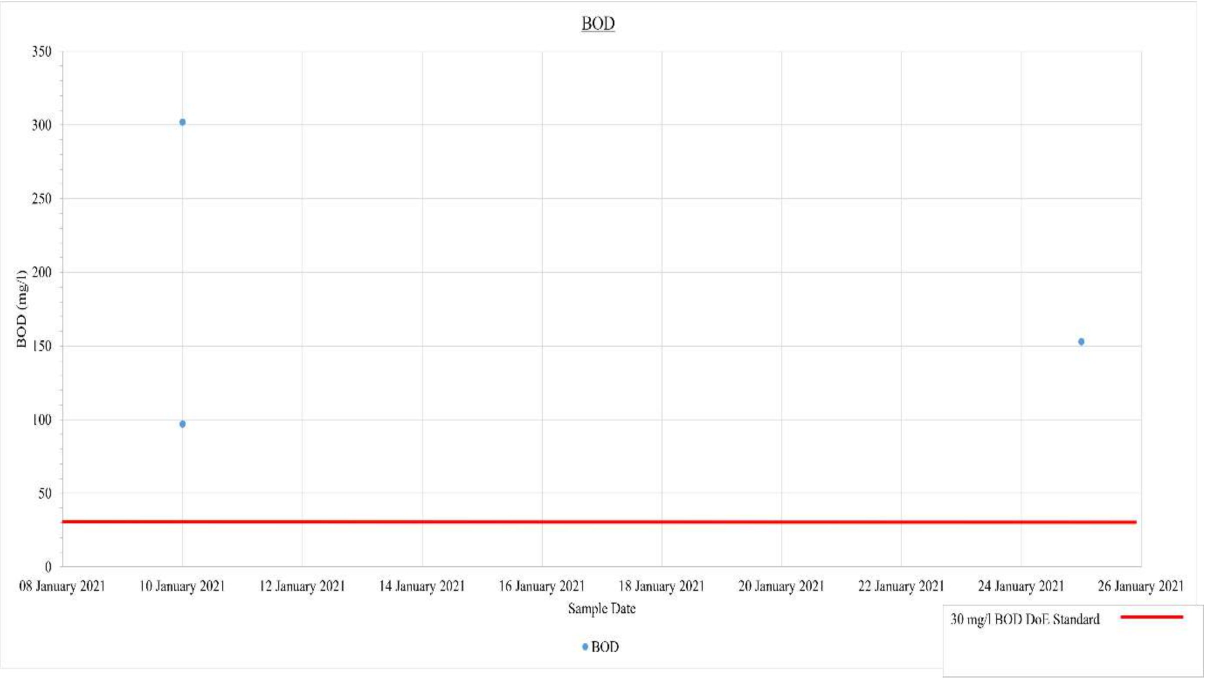
5.5.1 pH

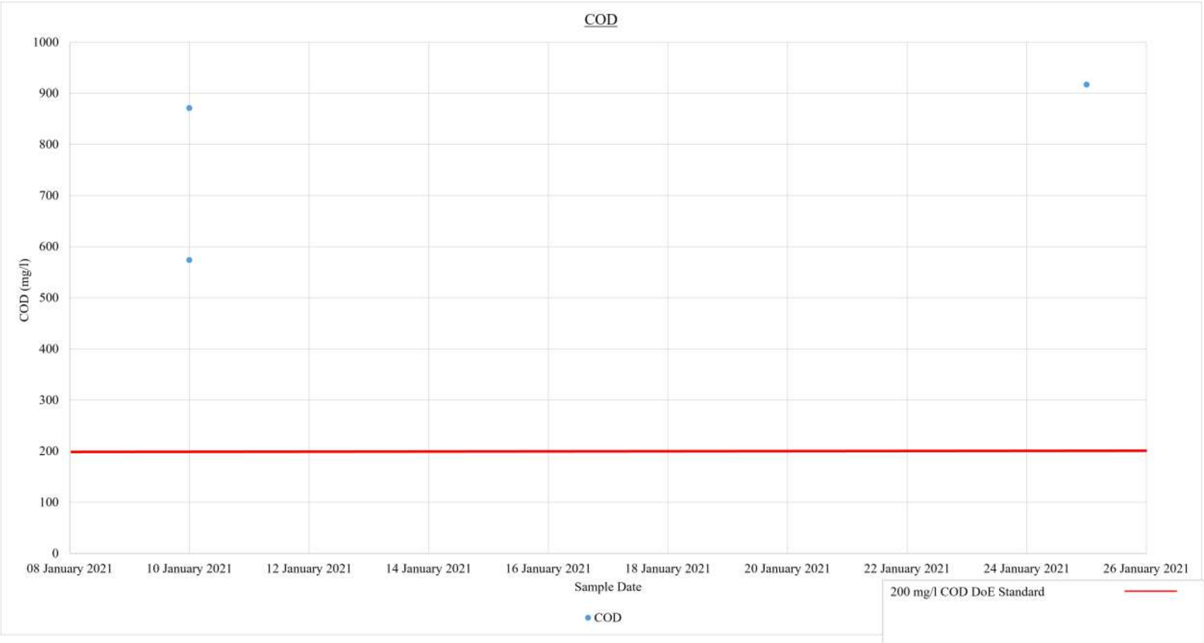
- pH all within DoE standard



5.5.2 BOD and COD

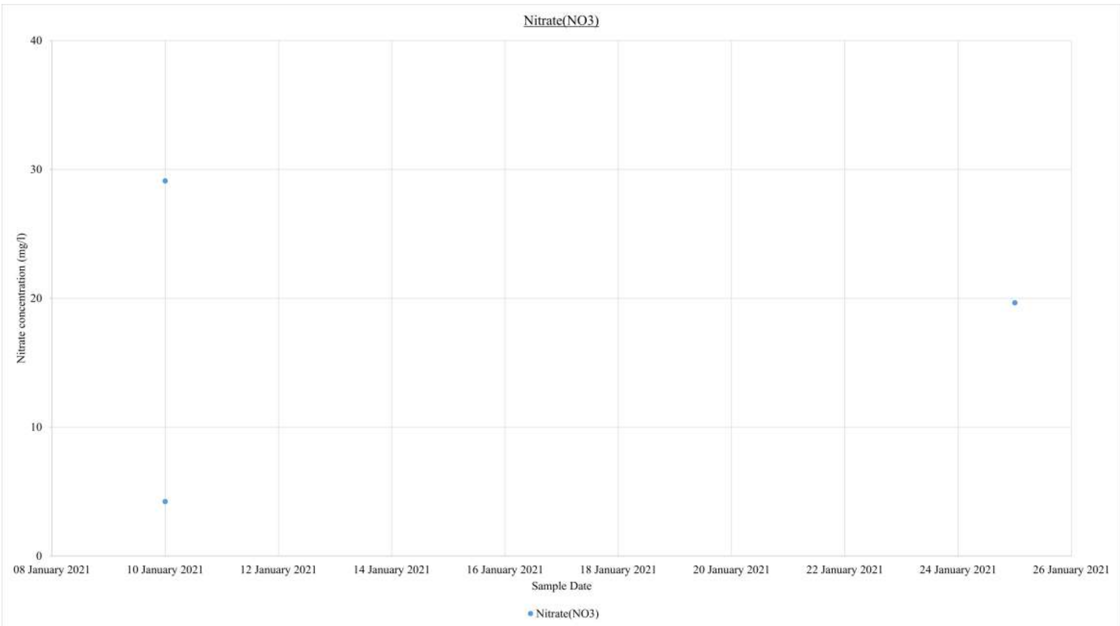
- All fail BOD and COD DoE standards

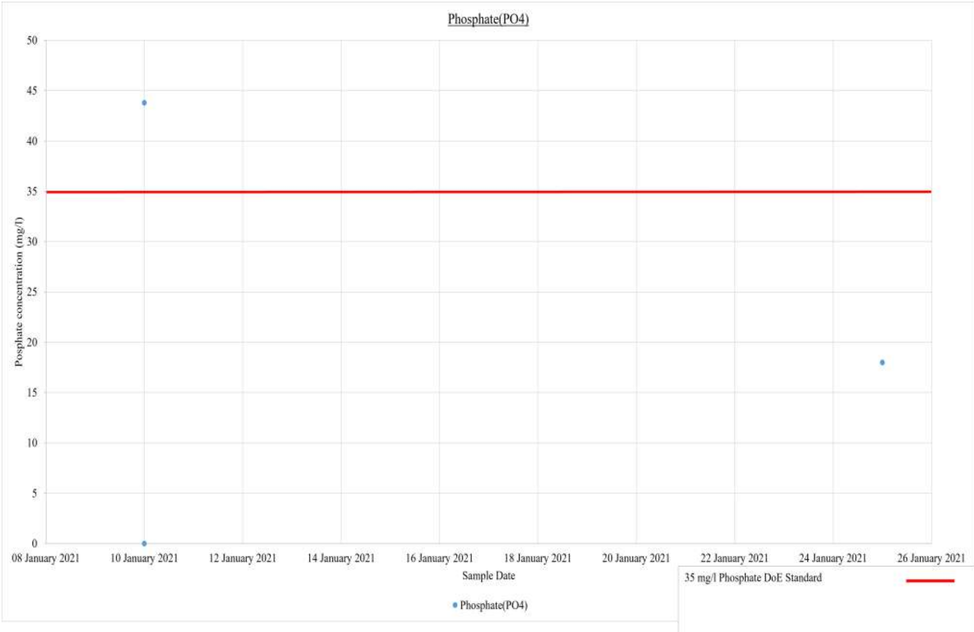


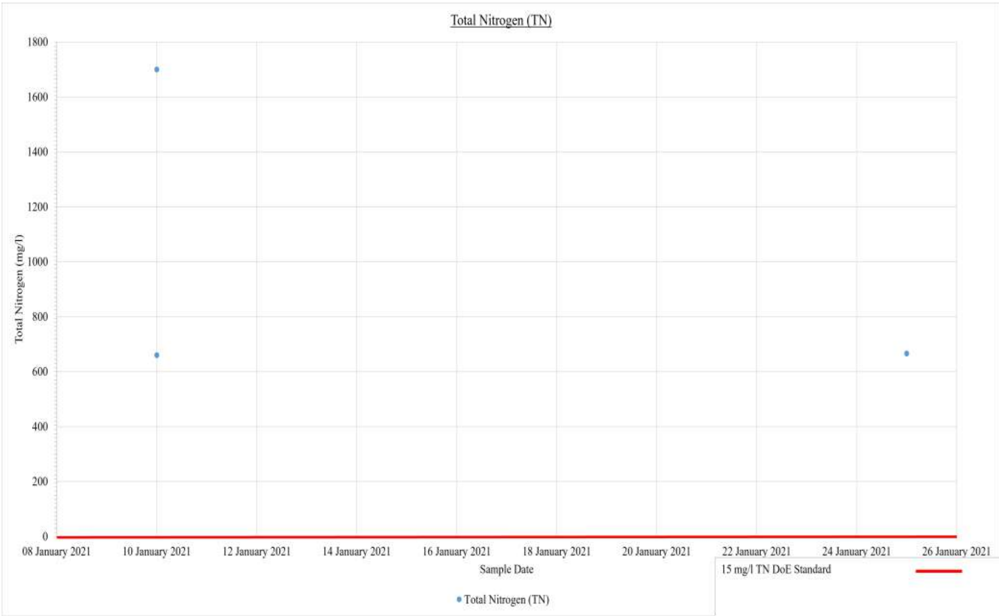


5.5.3 Nutrients

- All within nitrate DoE standard
- Two out of three sites comply with phosphate DoE standard
- All sites fail Total Nitrogen

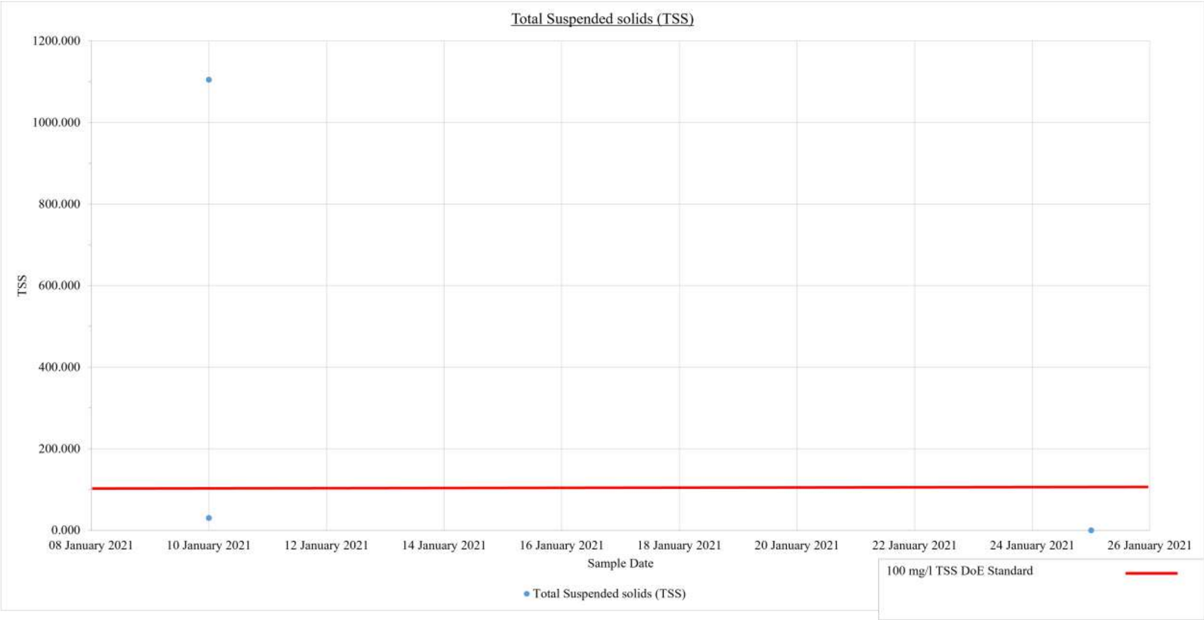



Phosphate(PO4)
Posphate concentration (mg/l)
50
45
40
35
30
25
20
15
10
5
0
08 January 2021
10 January 2021
12 January 2021
14 January 2021
16 January 2021
18 January 2021
20 January 2021
22 January 2021
24 January 2021
26 January 2021
Sample Date
Phosphate(PO4)
35 mg/l Phosphate DoE Standard


Total Nitrogen (TN)
Total Nitrogen (mg/l)
1800
1600
1400
1200
1000
800
600
400
200
0
08 January 2021
10 January 2021
12 January 2021
14 January 2021
16 January 2021
18 January 2021
20 January 2021
22 January 2021
24 January 2021
26 January 2021
Sample Date
Total Nitrogen (TN)
15 mg/l TN DoE Standard

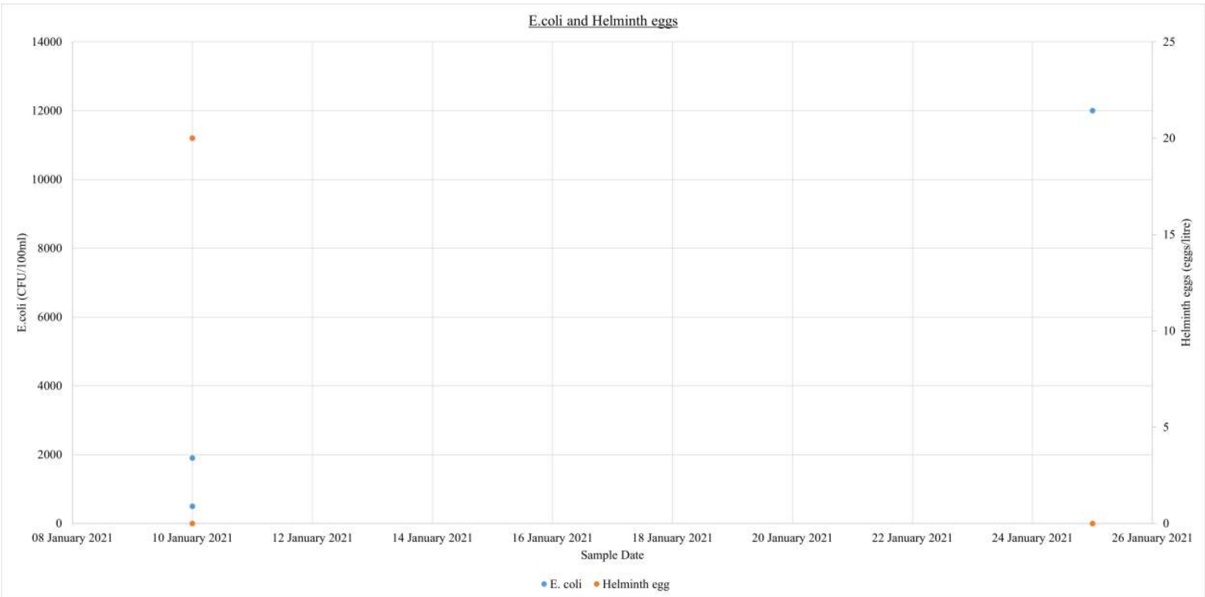
5.5.4 Solids

- Two out of three sites within TSS DoE standard



5.5.5 Pathogens

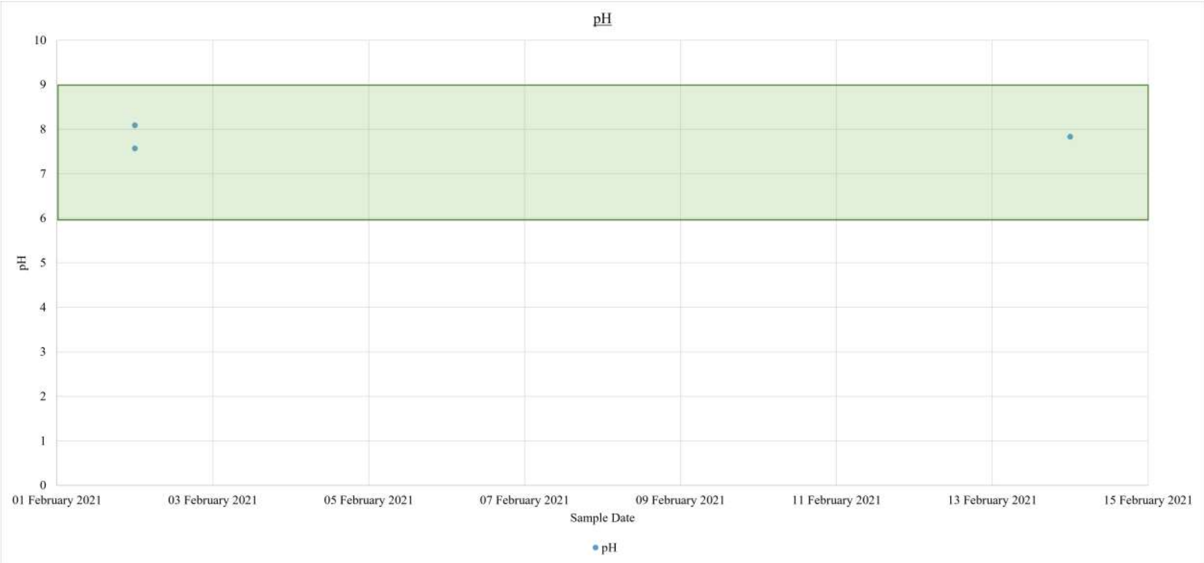
- Only one site with Helminth eggs present
- E.coli present in all sites



5.6 Round 12

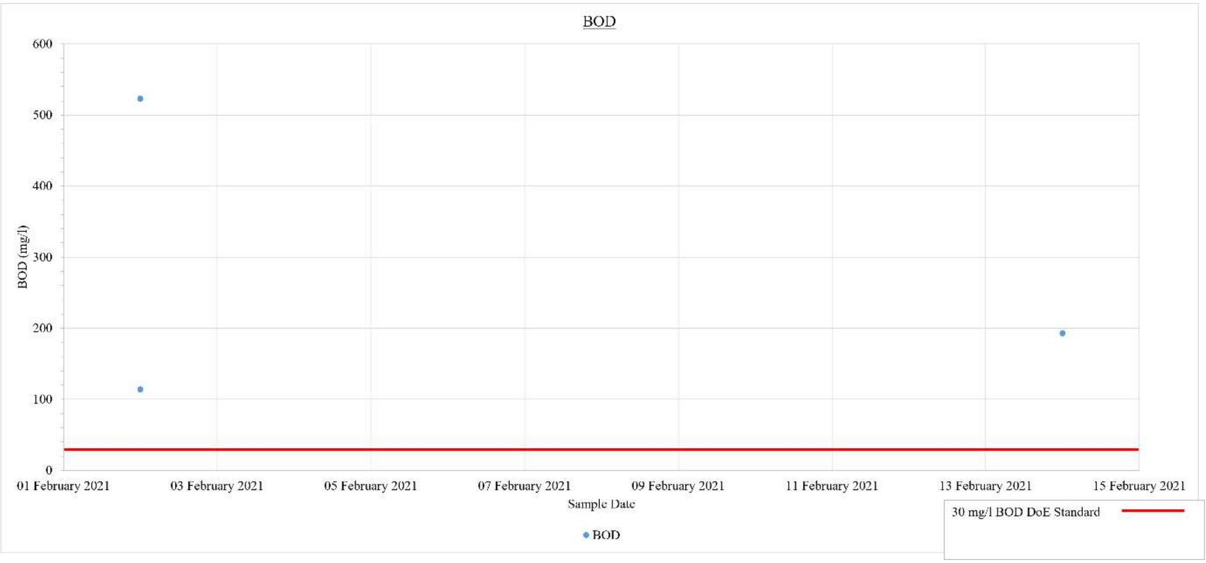
5.6.1 pH

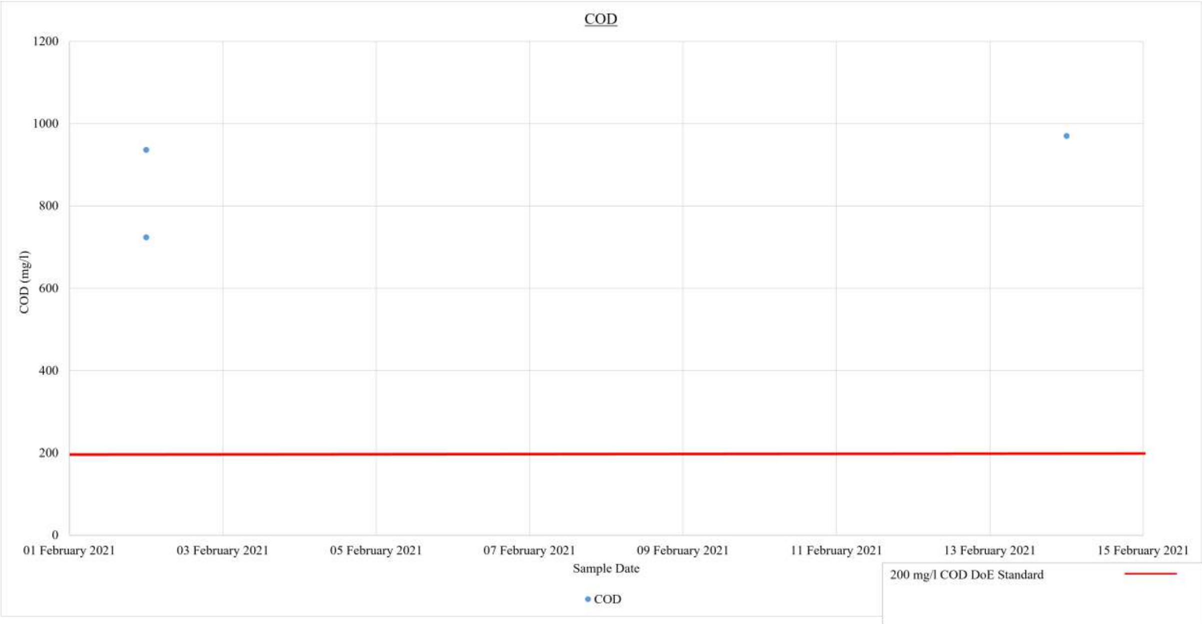
- pH all within DoE standard



5.6.2 BOD and COD

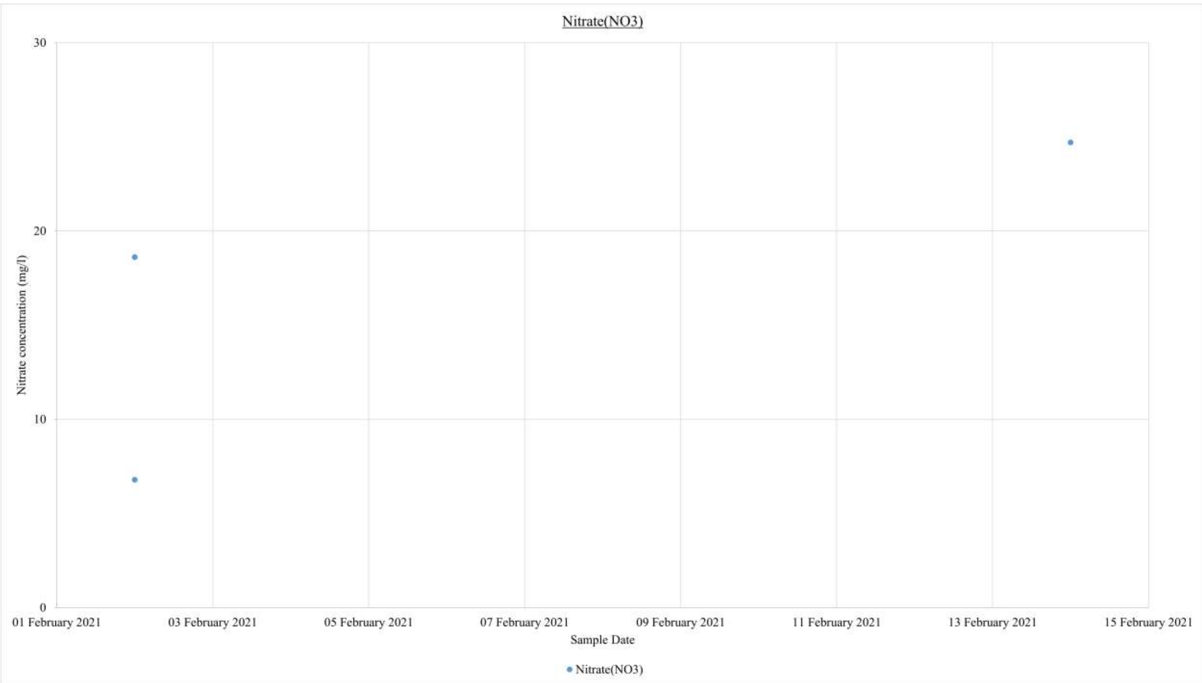
- All sites fail BOD and COD standards

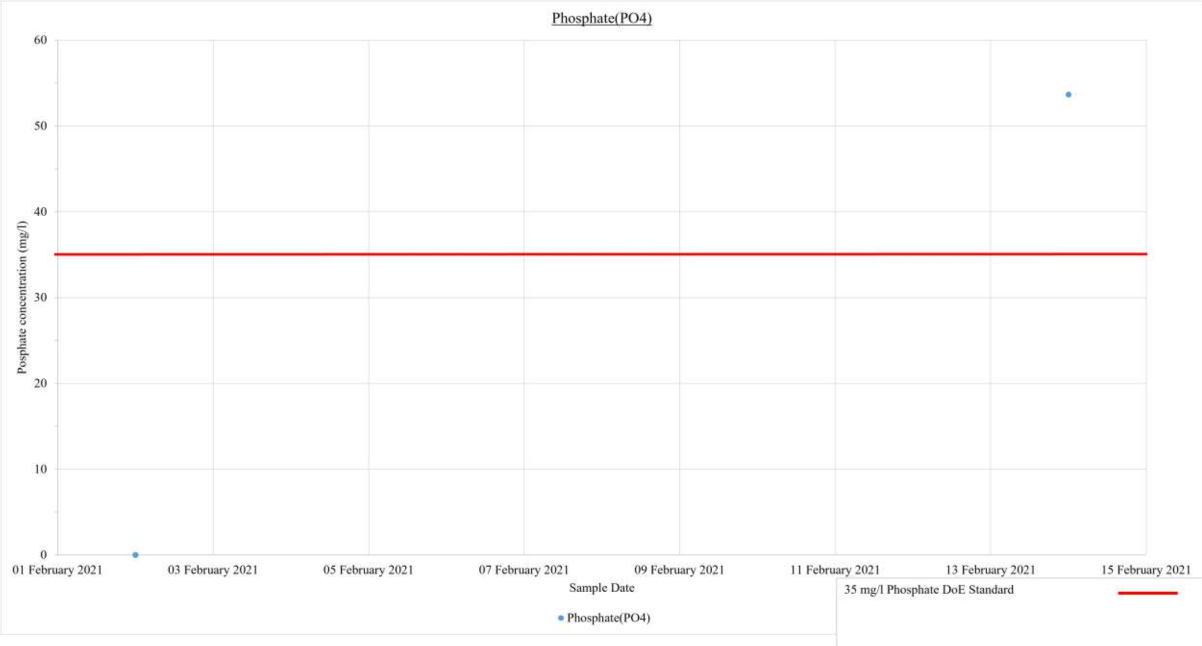


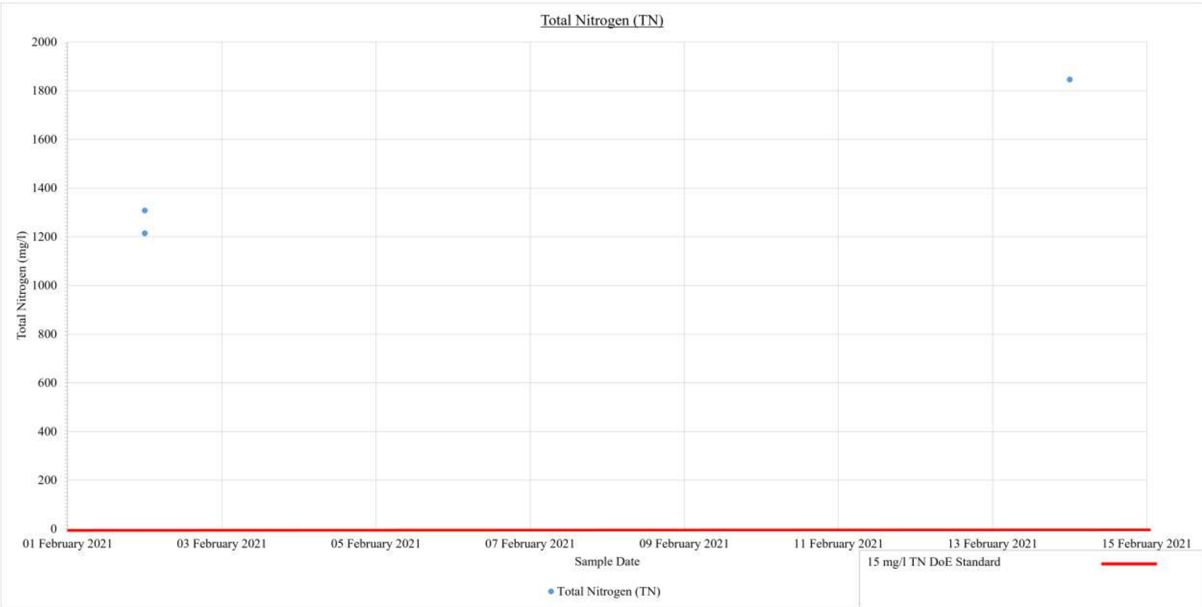


5.6.3 Nutrients

- All sites within nitrate DoE standard
- Two out of three sites within phosphate DoE standard
- All sites fail Total Nitrogen

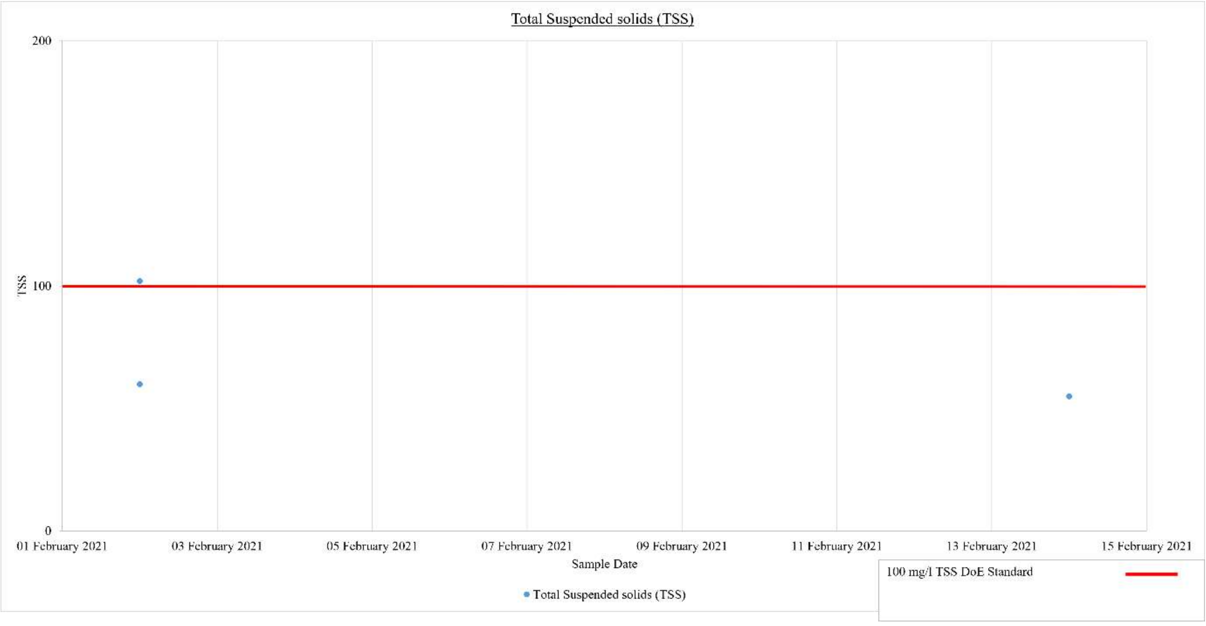



Phosphate(PO4)
60
50
40
30
20
10
0
Posphate concentration (mg/l)
01 February 2021
03 February 2021
05 February 2021
07 February 2021
09 February 2021
11 February 2021
13 February 2021
15 February 2021
Sample Date
Phosphate(PO4)
35 mg/l Phosphate DoE Standard


Total Nitrogen (TN)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Total Nitrogen (mg/l)
01 February 2021
03 February 2021
05 February 2021
07 February 2021
09 February 2021
11 February 2021
13 February 2021
15 February 2021
Sample Date
Total Nitrogen (TN)
15 mg/l TN DoE Standard

5.6.4 Solids

- Two out of three sites within TSS DoE standard



5.6.5 Pathogens

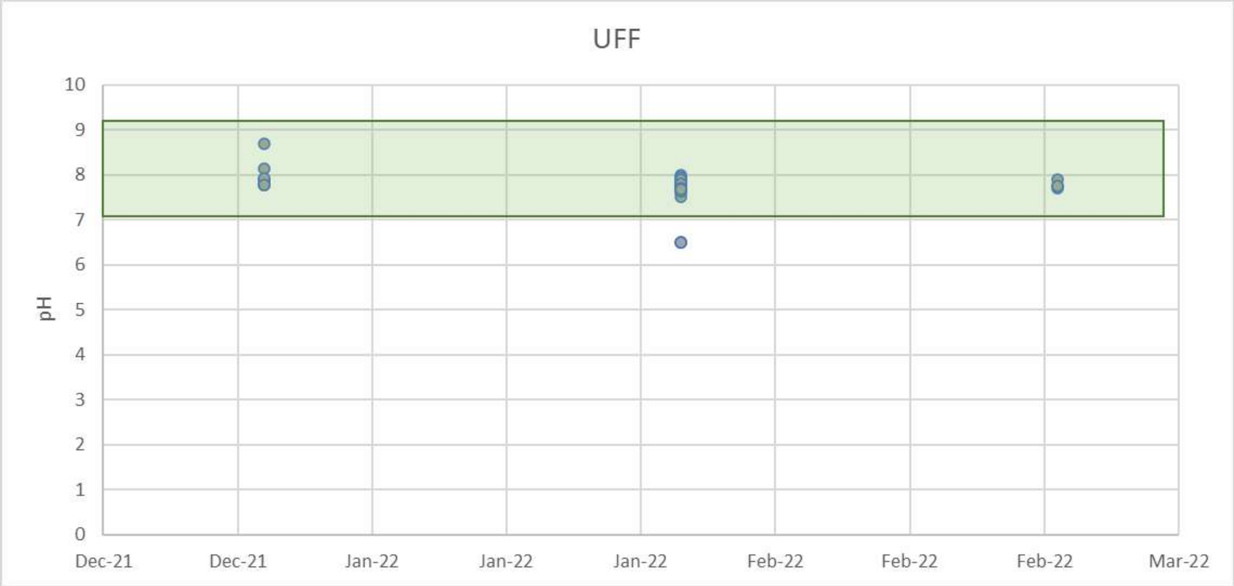
- Good Helminth removal i.e. data showing zero eggs present
- Data shows two out of three sites with E.coli present

6. UFF

UFF process flow (storage/settlement/bio digestion tank, UFF, filter bed/CW, infiltration/soak pit). Two UFF sites were visited in camps 7 and 8W.

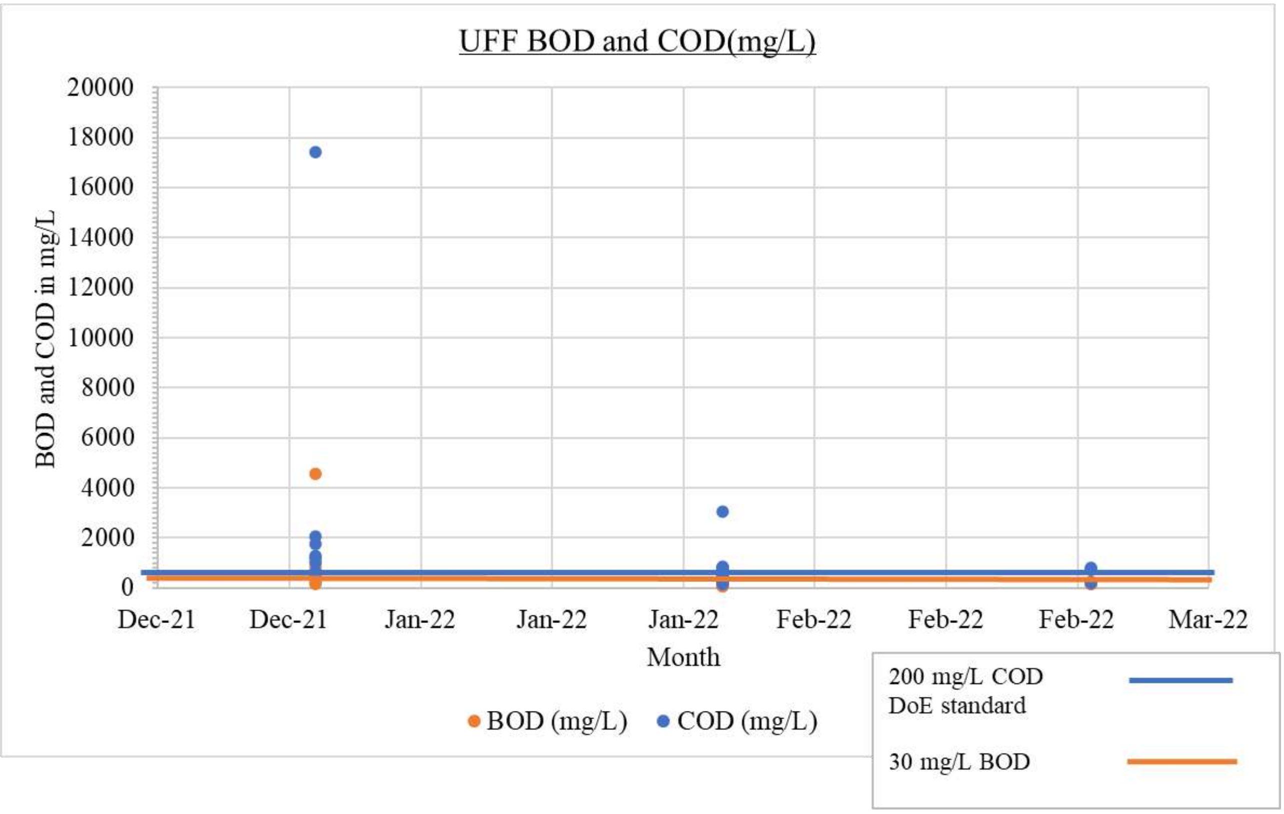
6.1 pH

- pH was within the standard across both types and a large majority of data points.



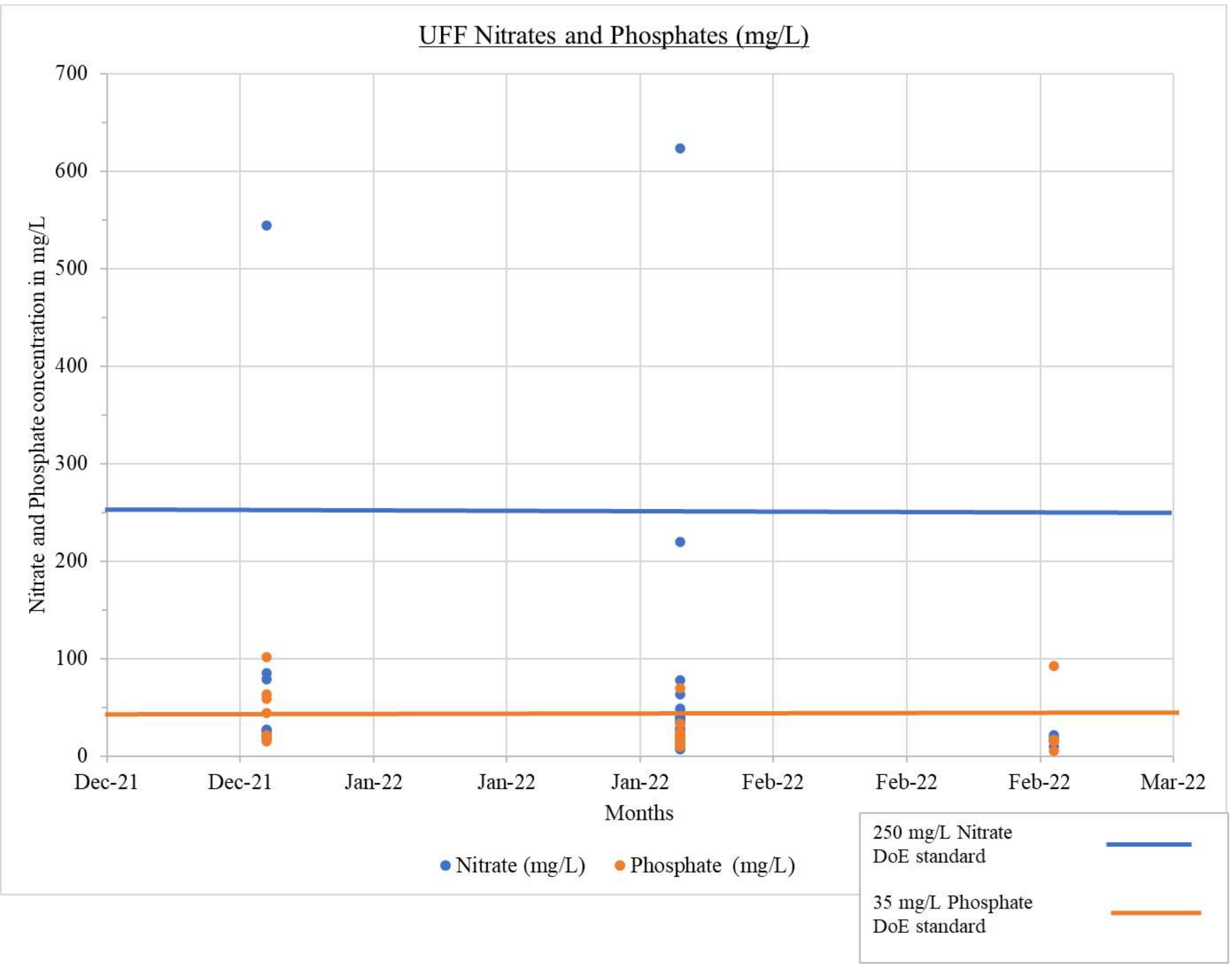
6.2 BOD and COD

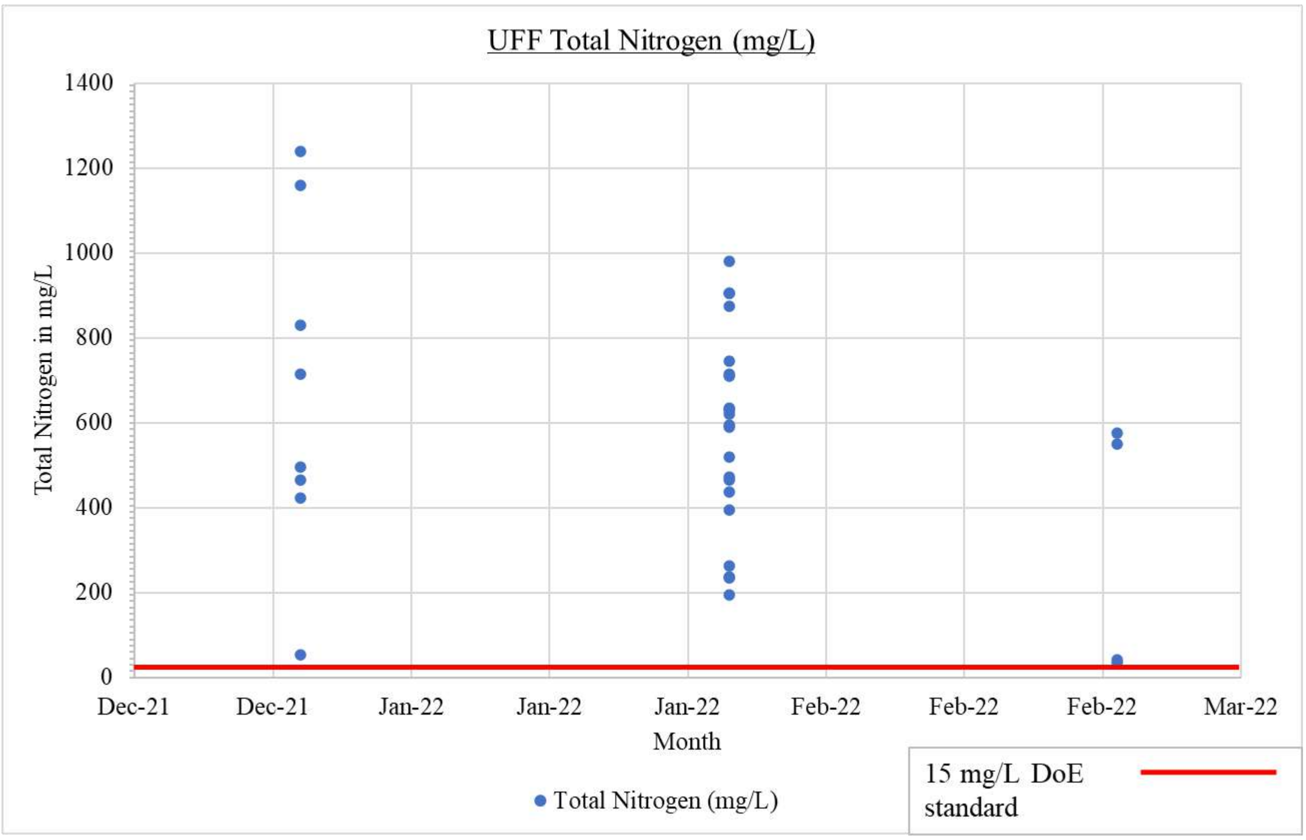
- Failing both COD and BOD standards and relatively poorly performing compared to other FSTPs types.
- The smaller capacity have lowest solids removal hence lower BOD and COD removal. But not a significant difference.



6.3 Nutrients

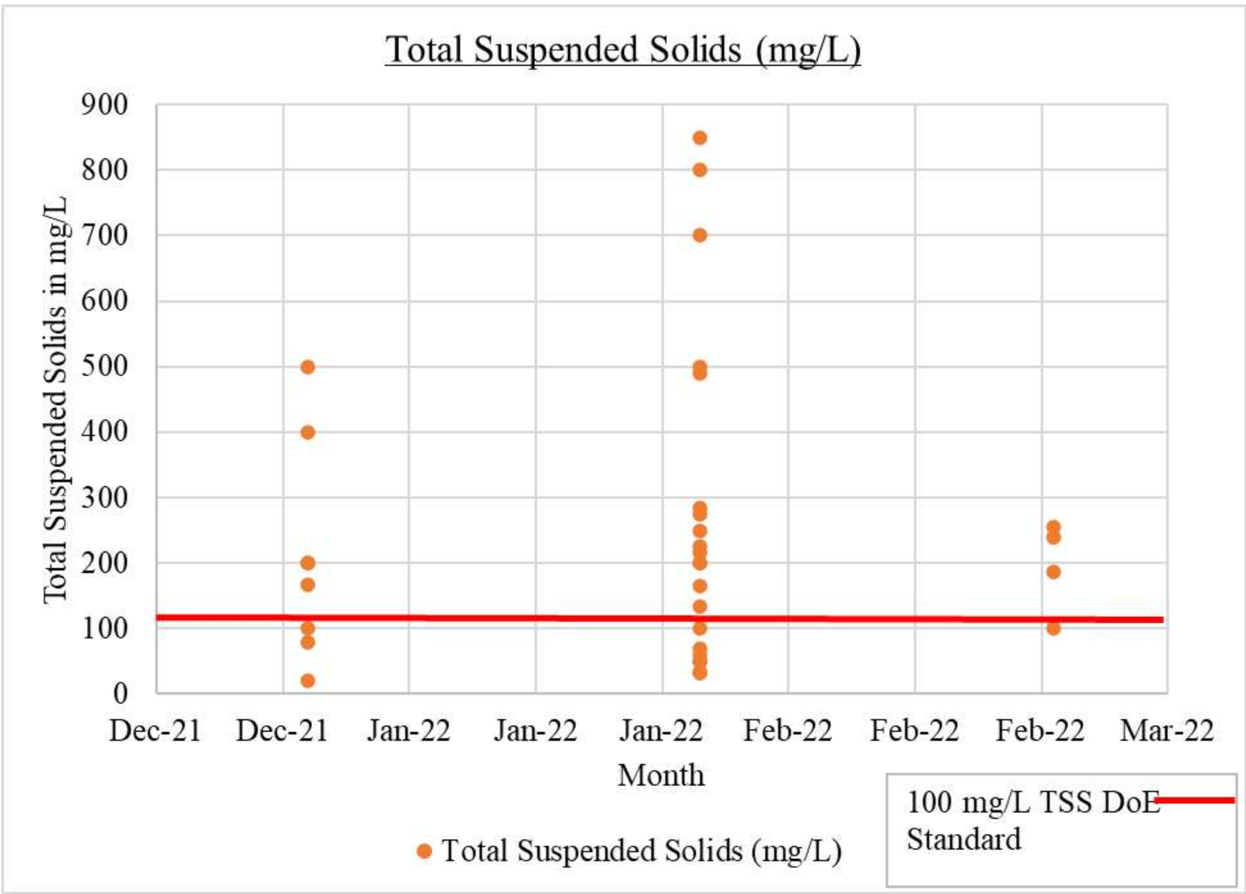
- A majority sites are within standards for nitrate and phosphorus
- Failing Total Nitrogen.


UFF Nitrates and Phosphates (mg/L)
Nitrate and Phosphate concentration in mg/L
700
600
500
400
300
200
100
0
Dec-21
Dec-21
Jan-22
Jan-22
Jan-22
Feb-22
Feb-22
Feb-22
Mar-22
Months
Nitrate (mg/L)
Phosphate (mg/L)
250 mg/L Nitrate DoE standard
35 mg/L Phosphate DoE standard


UFF Total Nitrogen (mg/L)
Total Nitrogen in mg/L
1400
1200
1000
800
600
400
200
0
Dec-21
Dec-21
Jan-22
Jan-22
Jan-22
Feb-22
Feb-22
Feb-22
Mar-22
Month
Total Nitrogen (mg/L)
15 mg/L DoE standard

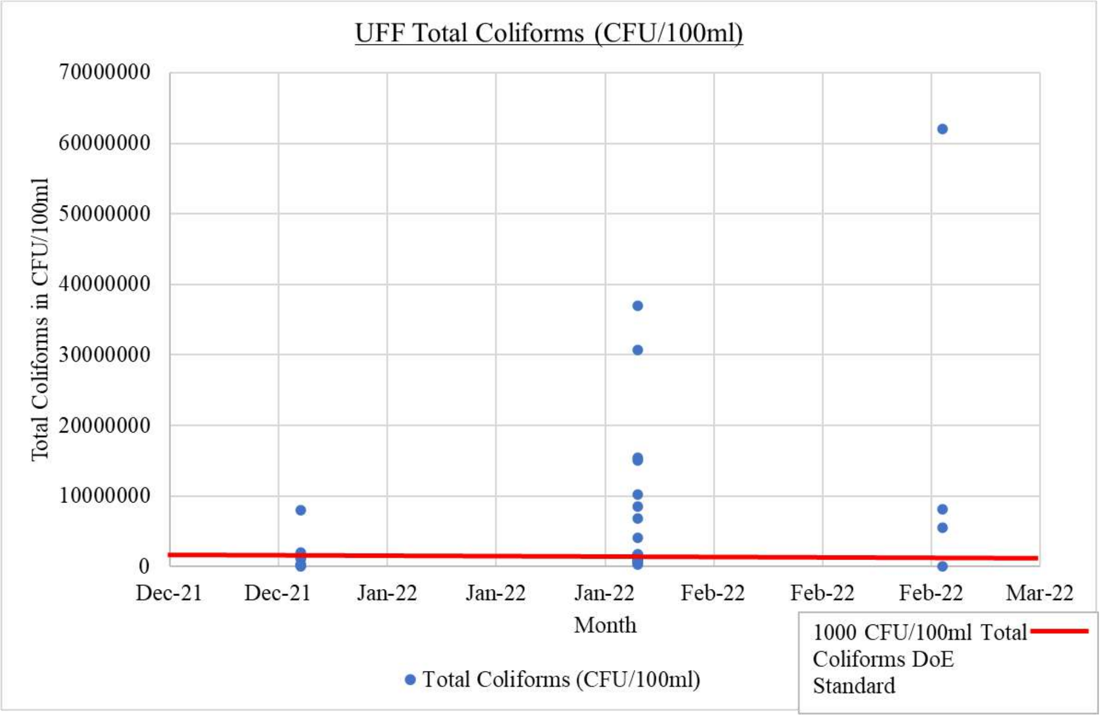
6.4 Solids

- Solids performance reasonably consistent over time for each UFF site.
- Generally in the range 20-300mg/l, so above standards but relatively not too bad.
- Some UFF site show solids up to 800mg/l, the site was not visited so it was clear if this included the pre settlement stage or was solely an UFF (as visited in phase 1 study).



6.5 Pathogens

- Pathogen levels in FE do not meet the DoE standards and relatively poor compared to other types of FSTPs.
- Large range of coliforms in FE i.e., 600-23x10^6 plus cfu/100ml. This demonstrates the inconsistency of the pathogen results seen across this type of FSTP.
- Most of this type of FSTP are achieving 95% plus reduction in pathogens but this is not sufficient to meet the DoE or health/reuse standards for discharge to surface water.

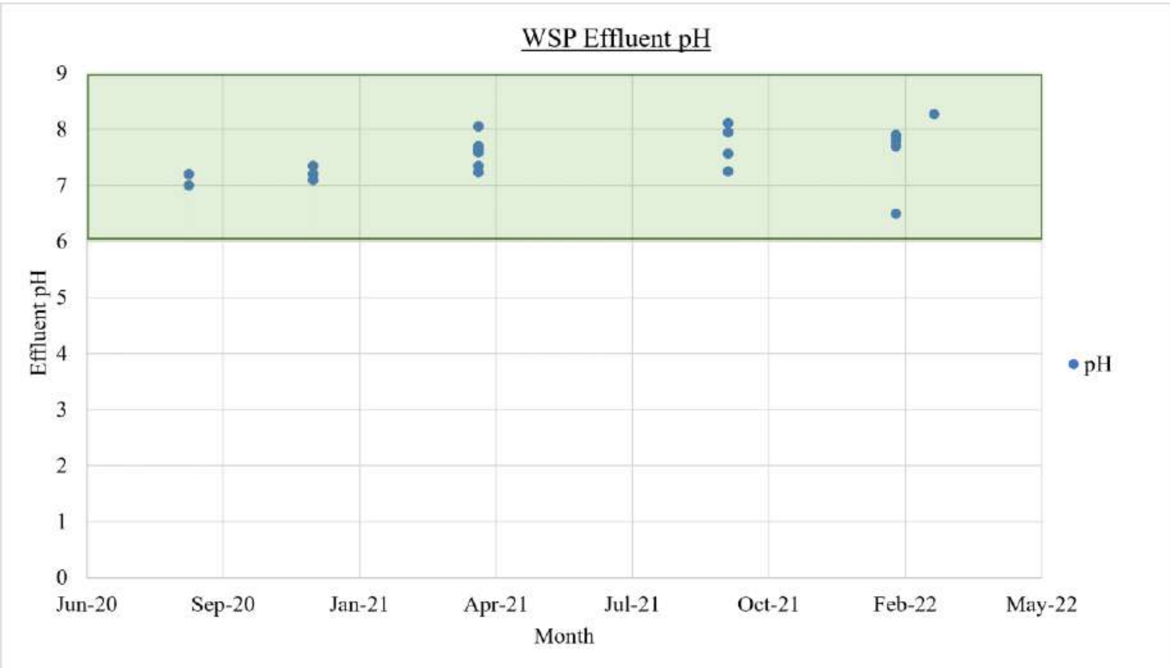


7. Waste Stabilisation Ponds

Monitoring data was available 13 WSPs FSTPs, managed and operated by four different NGOs. Two of the sites with available data were visited during this study (camp 7 and 8W). Only raw sludge and FE data was available with no intermediate site monitoring. Each FSTP had the same process flow, sites were small (decentralised) scale ranging from 5m3/d (design capacity) to 8m3/d.

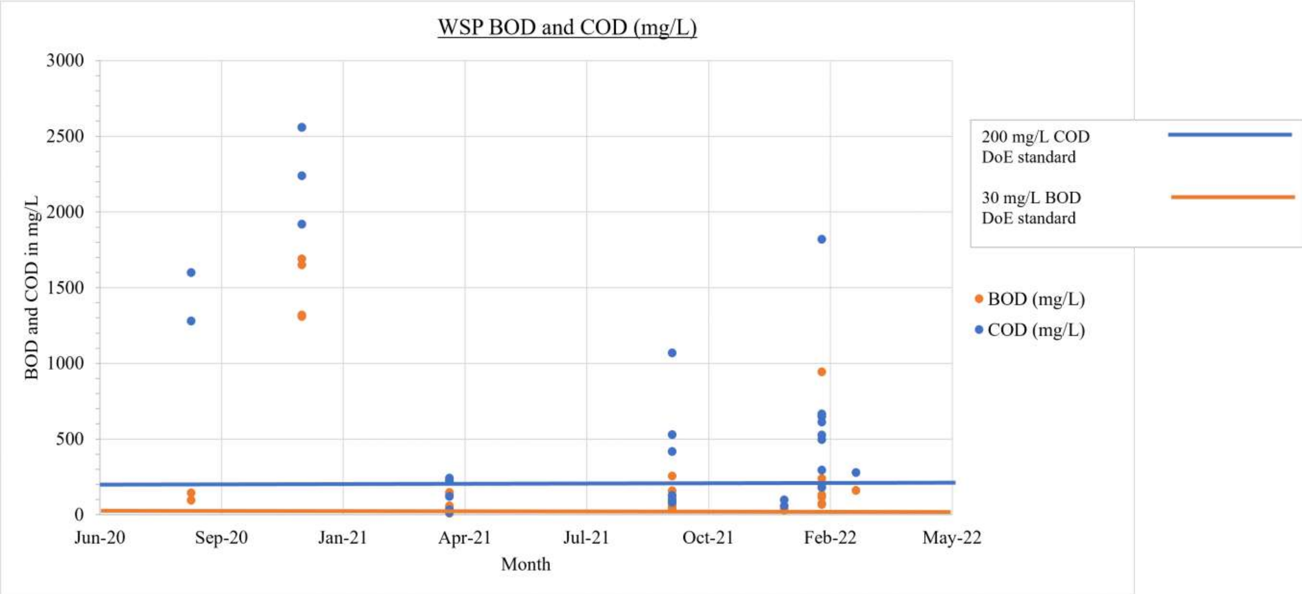
7.1 pH

All samples within the standards range



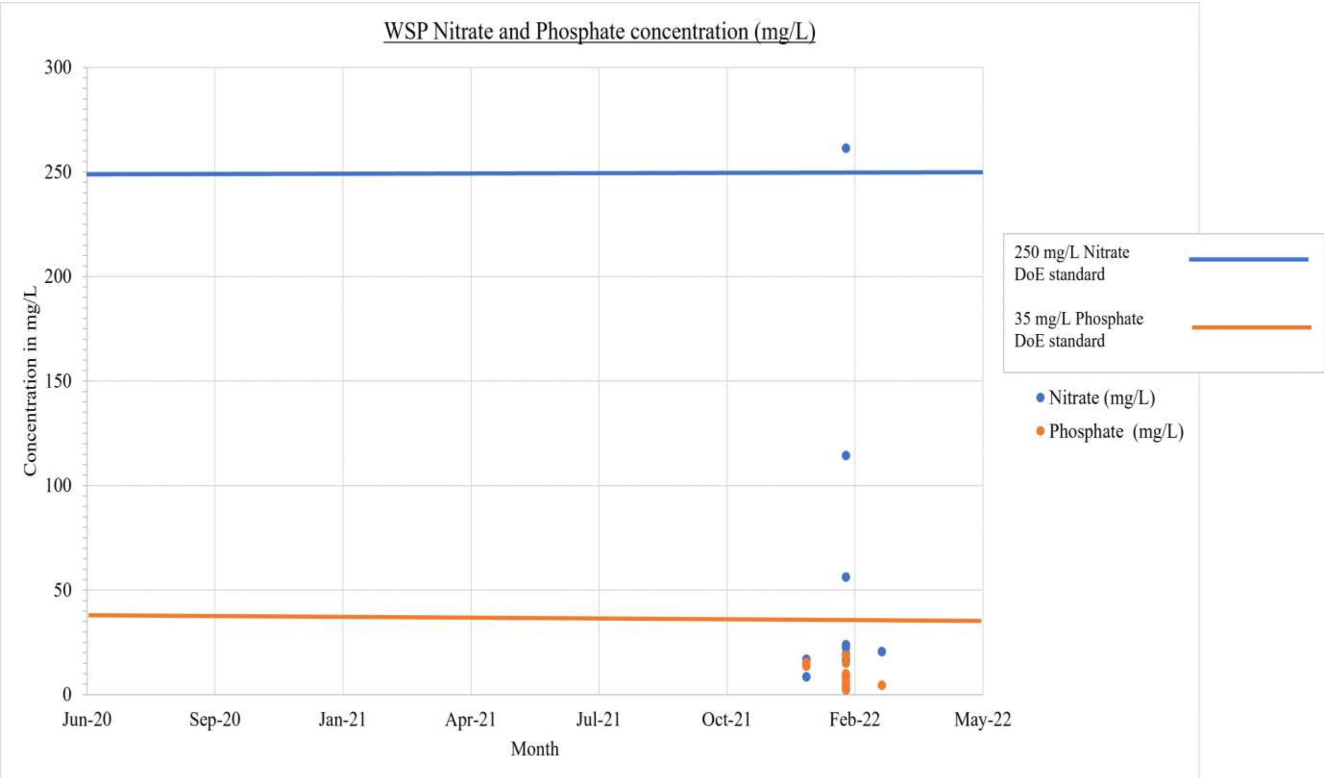
7.2 BOD and COD

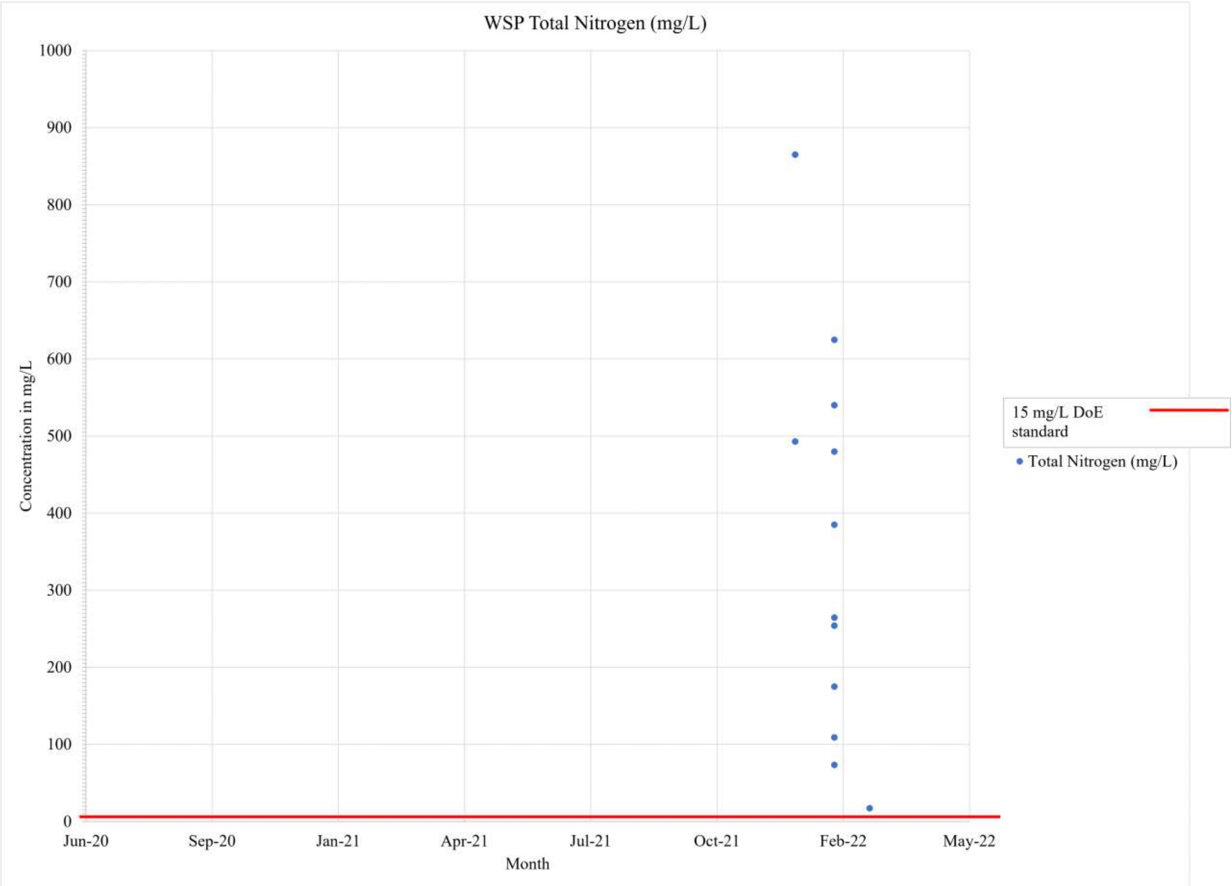
- BOD generally above DoE standards.
- COD has some meeting the standard however some failing, this was spread across the plants (so not likely due to a design feature of a specific plant) and seasons (so not likely seasonal variation).
- Both BOD and COD level in FE show some improvement over time i.e., samples closer to target from Oct 2021 onwards.
- Site visited (Camp 7) is achieving 90 to 100% BOD removal.



7.3 Nutrients

- All passing the standard for phosphate and nitrate (with one exception form a sample in camp 13).
- All fail on TN.

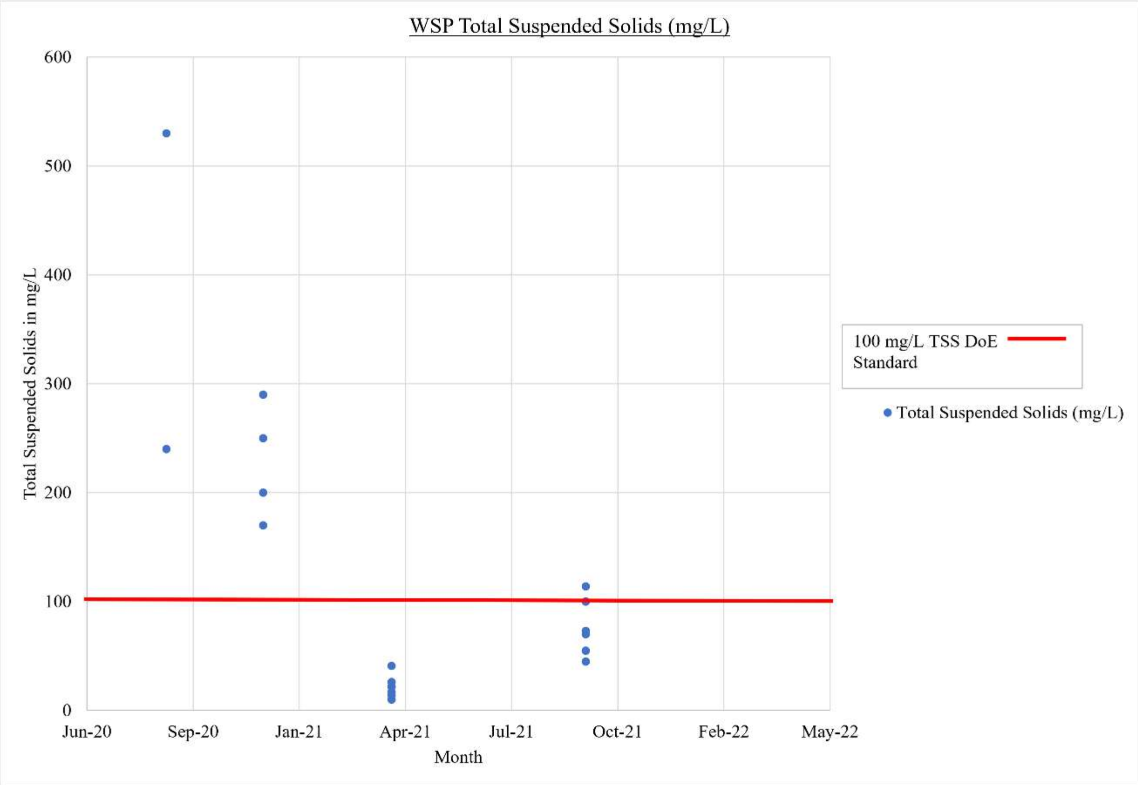




7.4 Solids

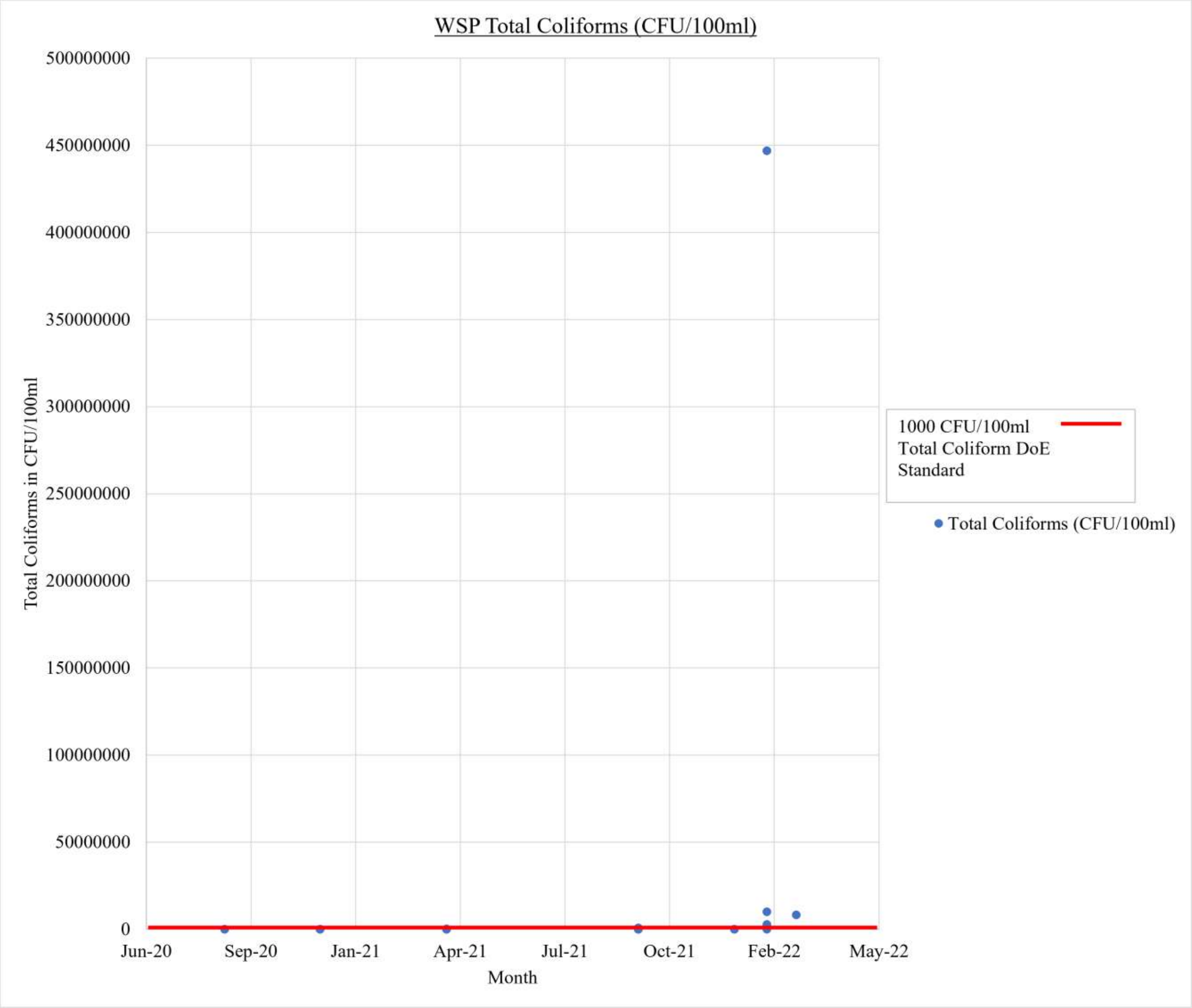
- FE TSS 10-500mgl/ generally good since 2021 (average is 135mg/l both DPHE &WVI sampling).

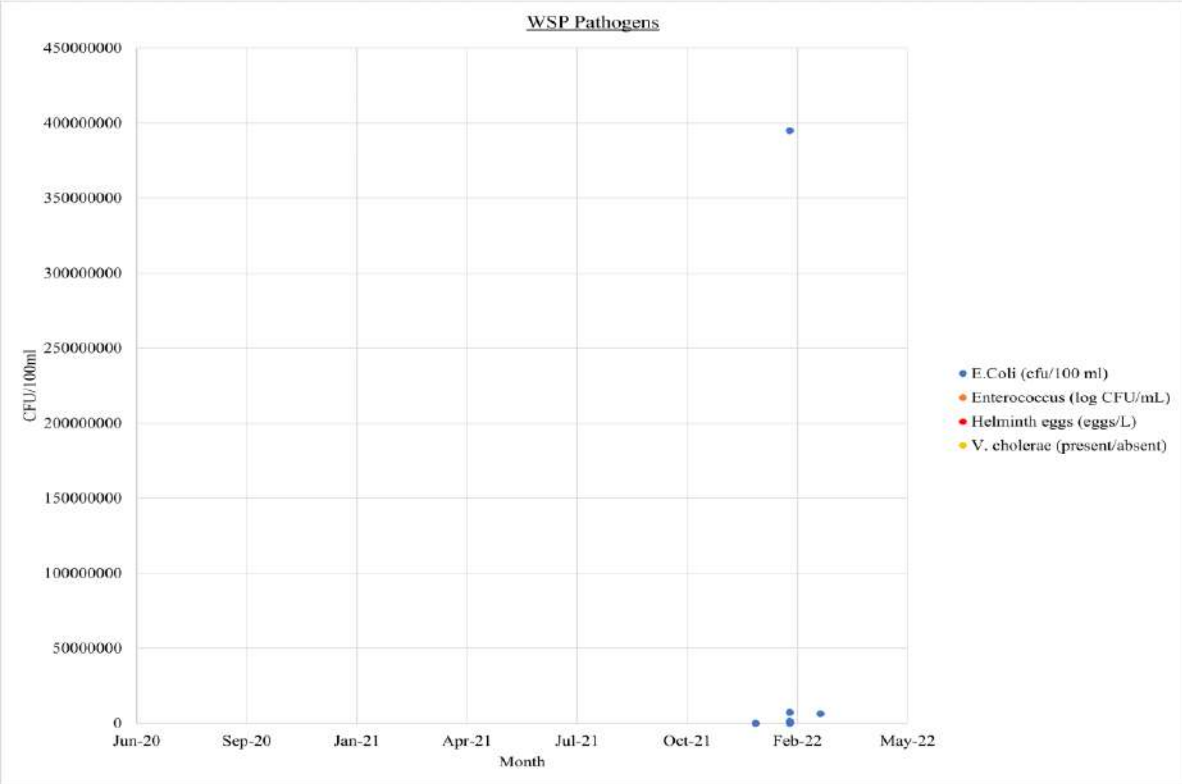
- Similar performance across WSPs.



7.5 Pathogens

- Limited data available. Some Total Coliform data available for longer term (samples every 2 to 3 months). Only E.coli samples from DPHE monitoring in 2022.
- All FE results are high (i.e., above standard and relative to other FSTP types). Camp 15 shows lower results than the other WSPs but is still in breach of target.



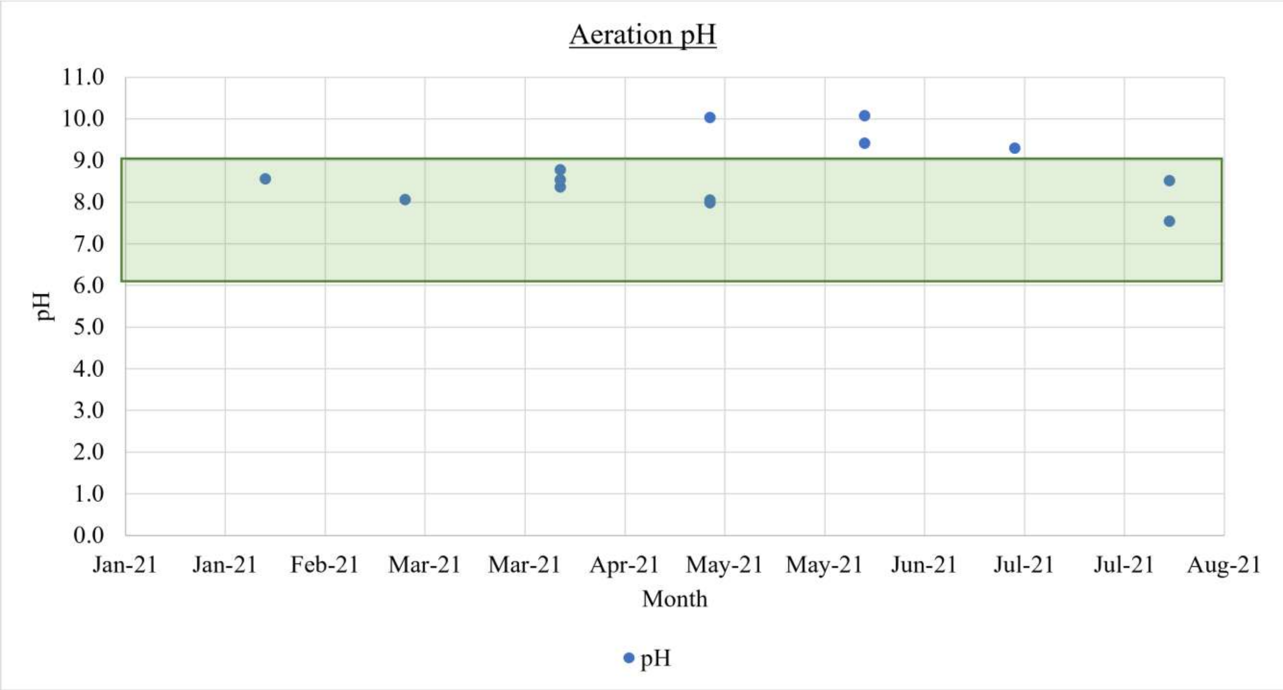


8. Aeration

Sampling is conducted of raw sludge and effluent as well as at key point through the process flow. Long term monitoring data was provided for seven months of 2021.

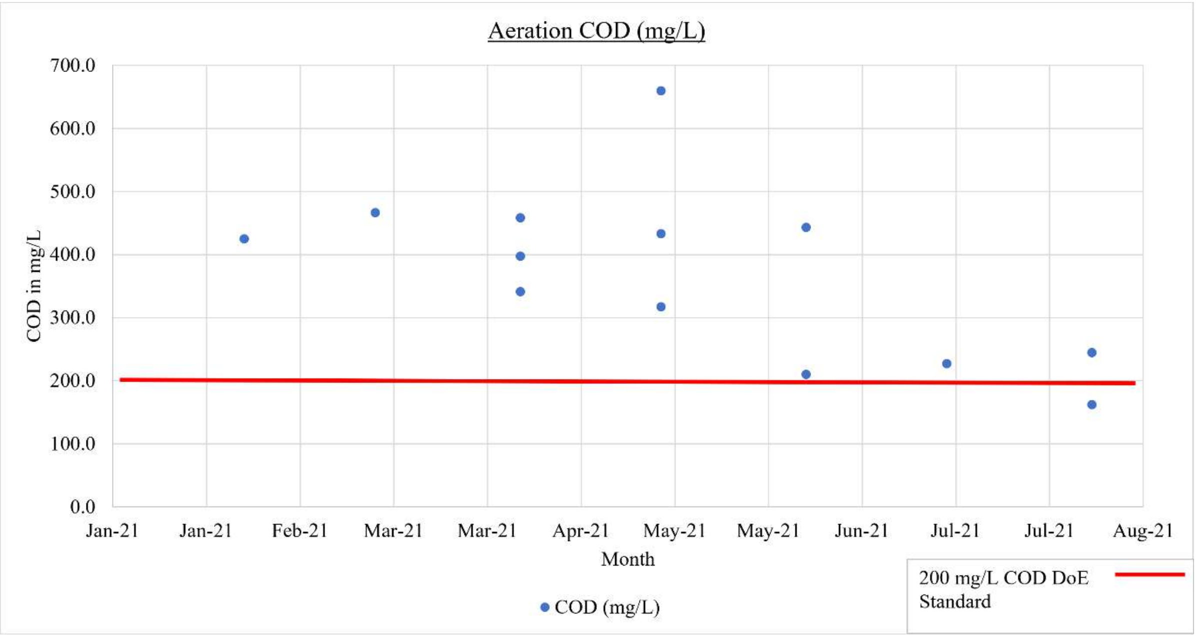
8.1 pH

- Majority of pH data within DoE standards.



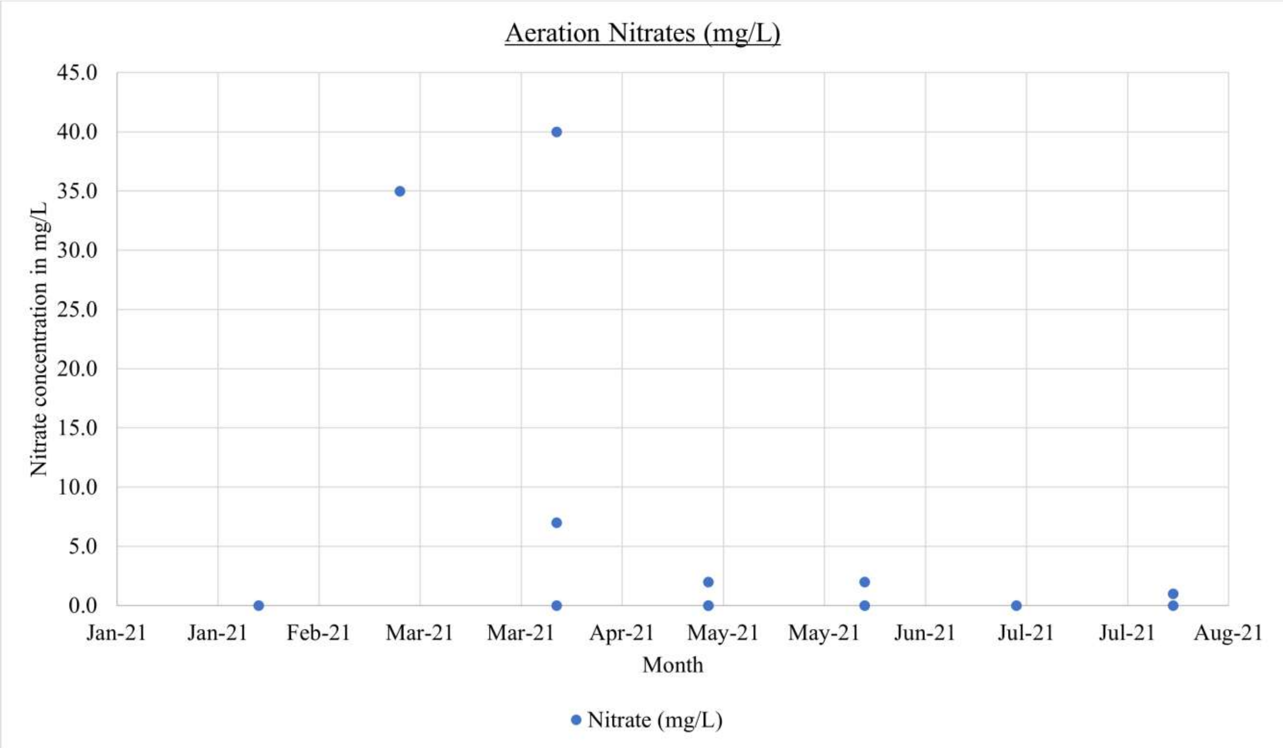
8.2 BOD and COD

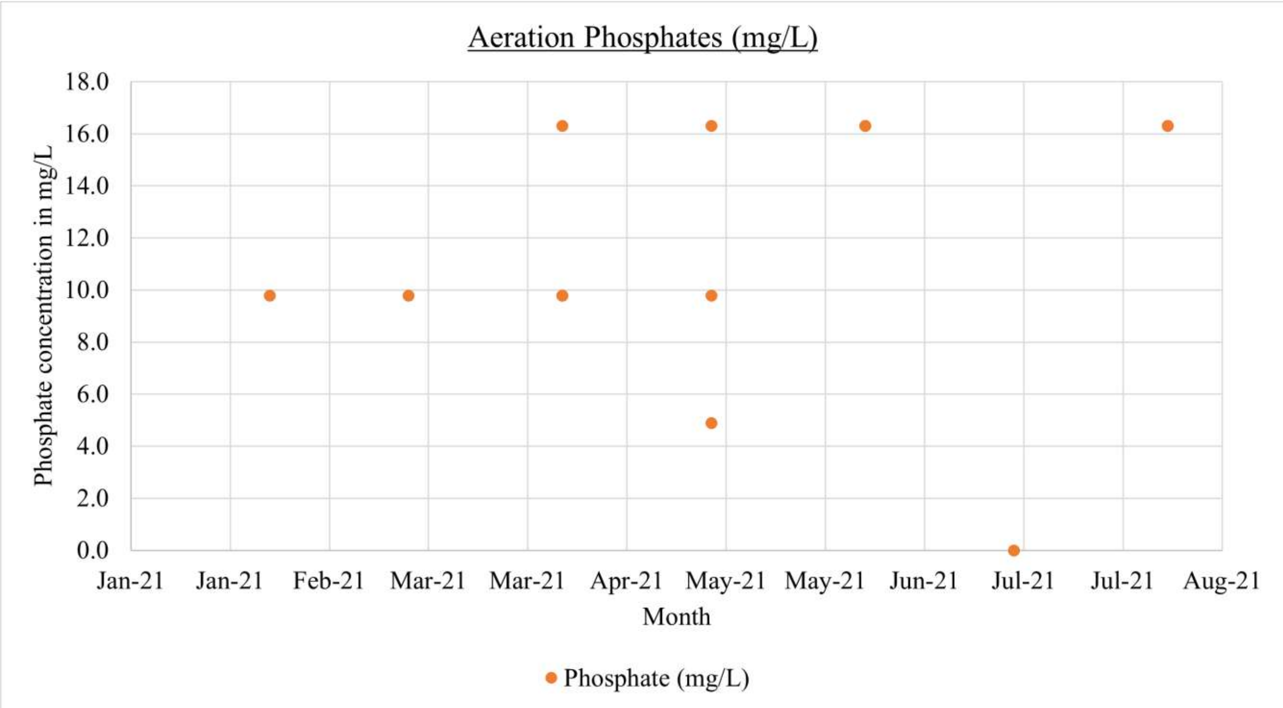
- No data available for BOD, COD available so used as proxy.
- COD data shows generally above standards but not significantly.
- Some evidence of seasonal variation – lower COD in FE between June to Sept.



8.3 Nutrients

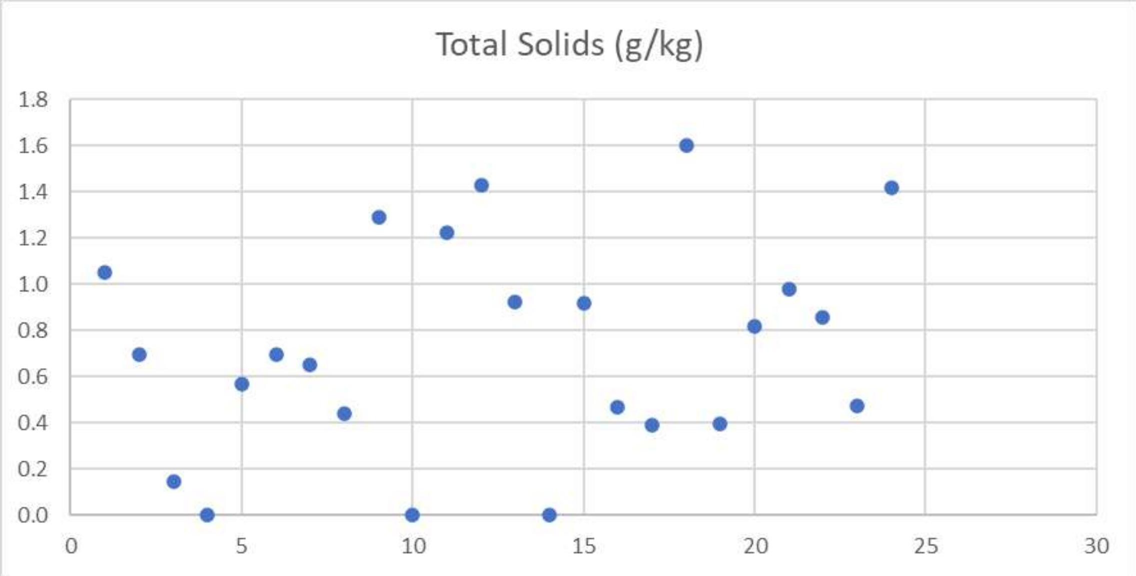
- Achieving 0 mg/l nitrate in FE
- Phosphate FE higher than influent but still within standard (16mg/l)





8.4 Solids

- Data provided for total solids in g/kg
- Generally above standard (but for SS 100 mg/l)



8.5 Pathogens

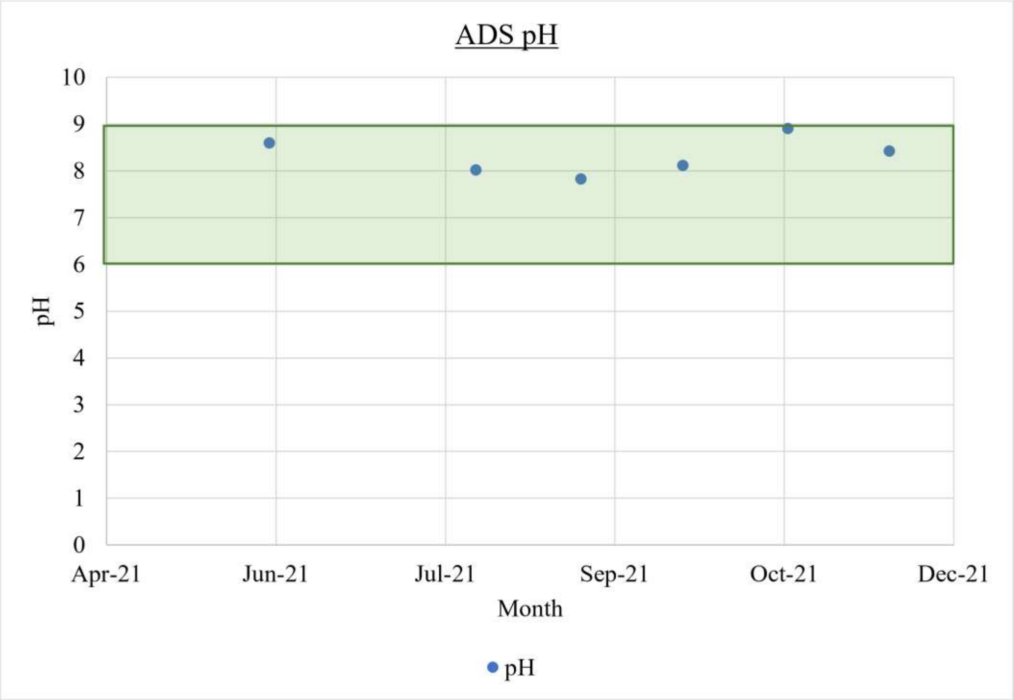
Sample Date	Coliform (CFU/100ml)
28/02/2021	0
14/03/2021	7100
05/04/3021	0
14/04/2021	0
19/04/2021	0
05/05/2021	0
18/05/2021	0
30/05/2021	1650
20/06/2021	0
29/06/2021	0
11/07/2021	0
11/08/2021	0
18/08/2021	0

9. Anaerobic Digestion System (ADS)

Data from one site available, over long term and at intermittent process points as well as raw sludge and final effluent. This was for ad ADS in camp 26 which was visited during the study. The site capacity is 5m3 per day.

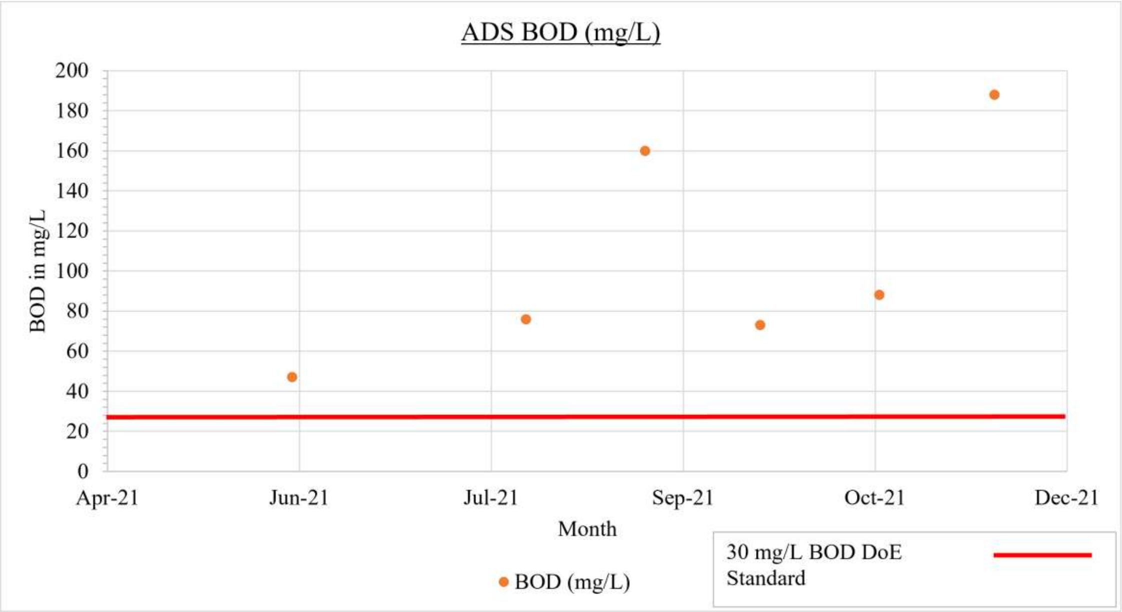
9.1 pH

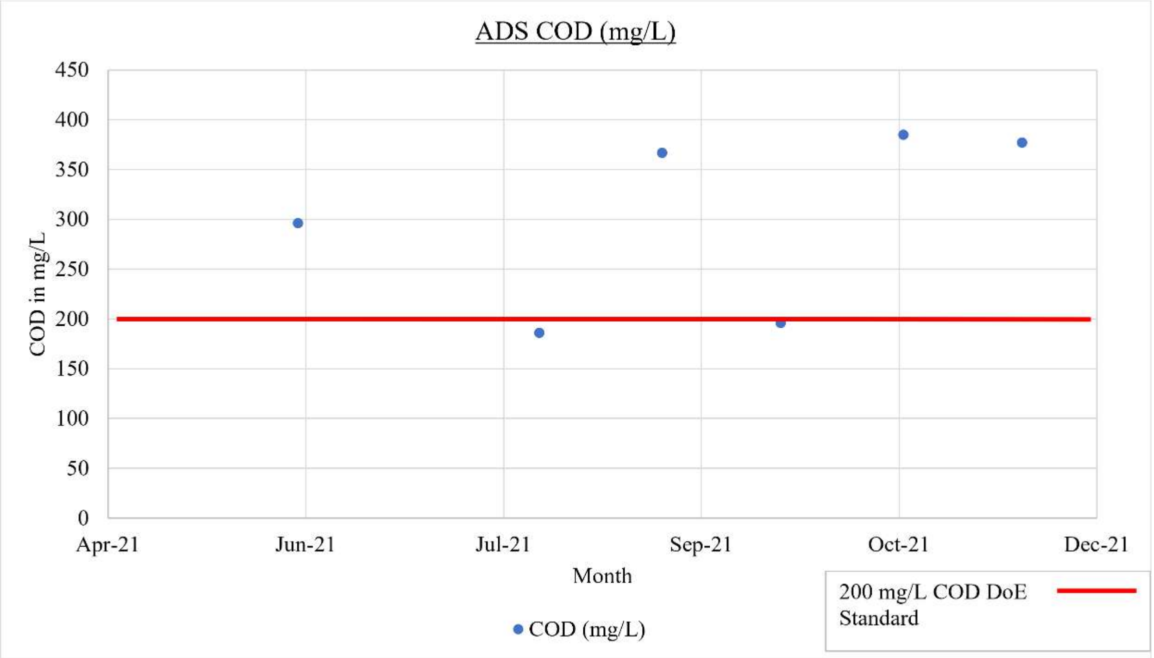
pH was all within DoE standards.



9.2 BOD and COD

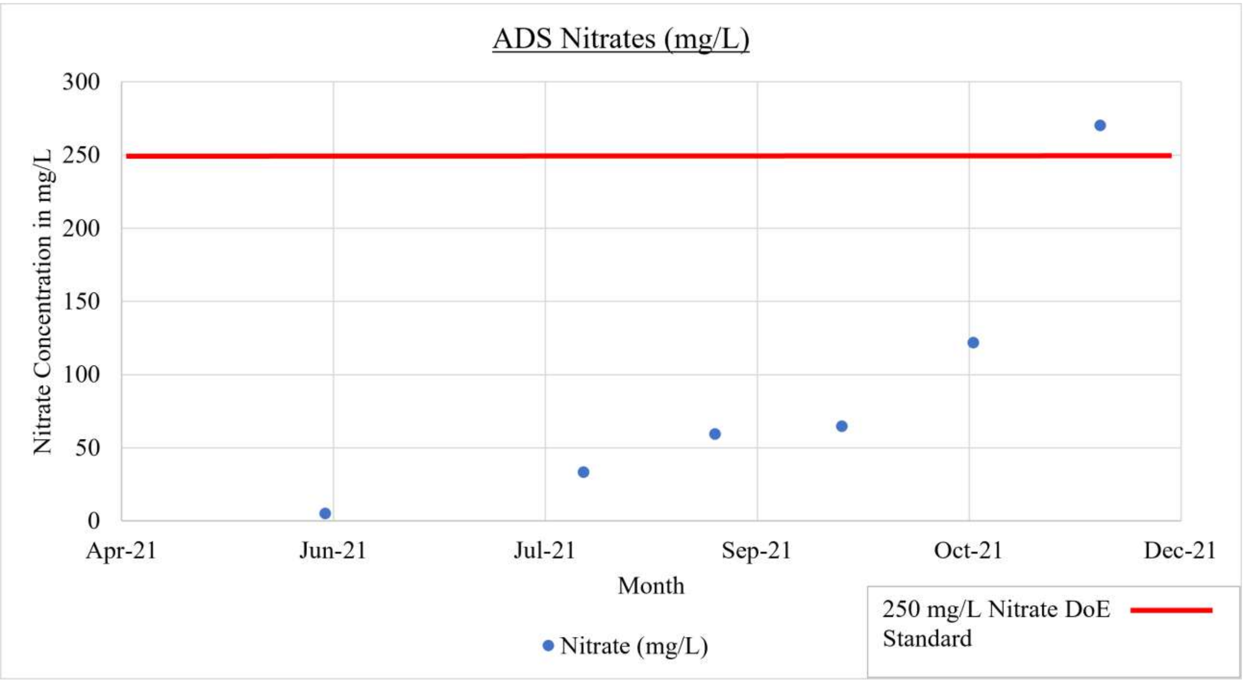
- Breaching BOD and COD standards but not significantly.
- Relatively low BOD and COD in FE compared to other FSTP types.

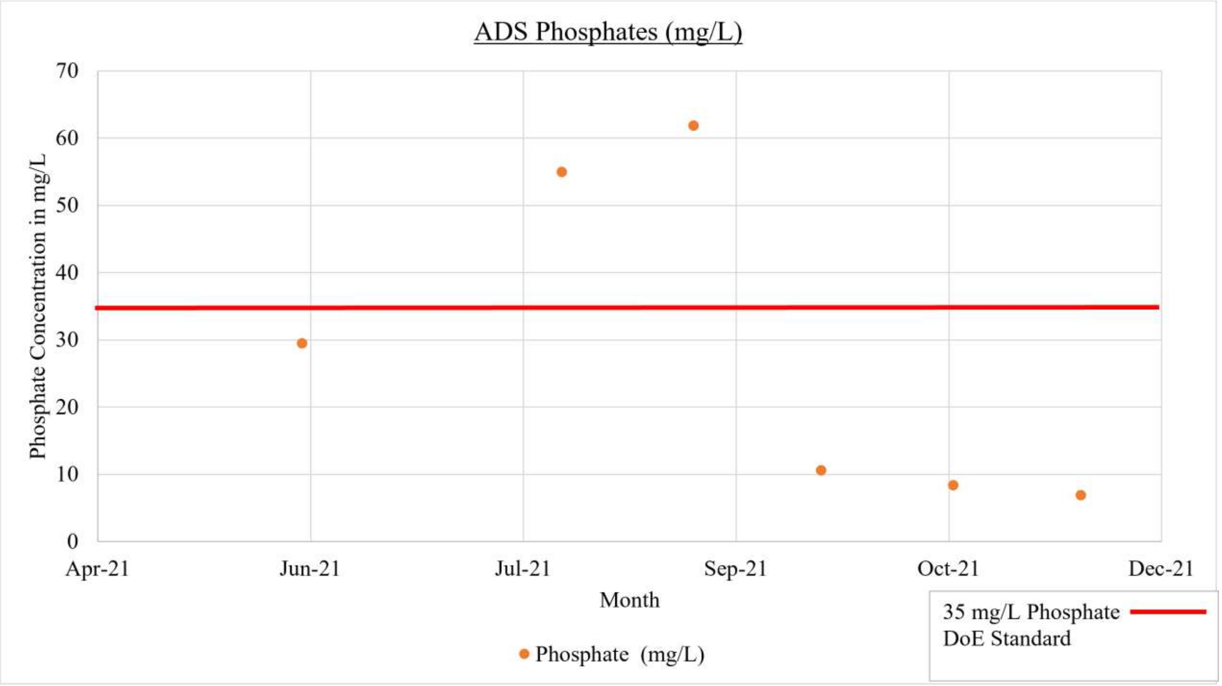




9.3 Nutrients

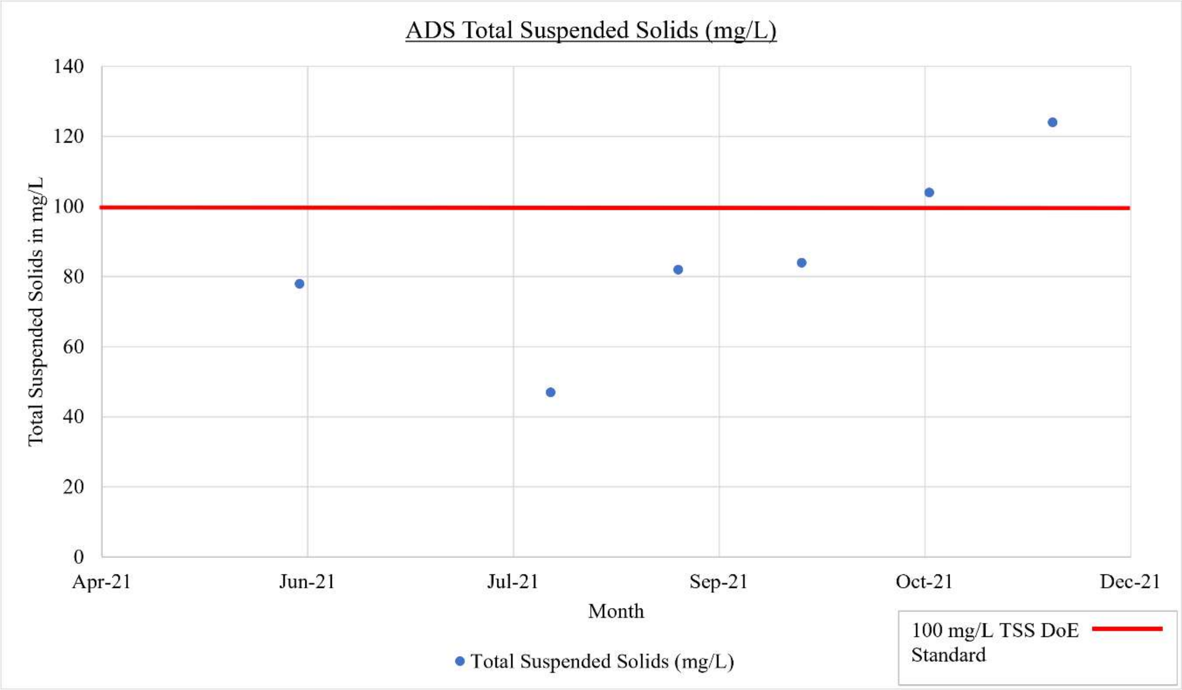
- All passing the standard for nitrate and phosphate (with exceptions Aug and Sept 2021).
- No data for TN.





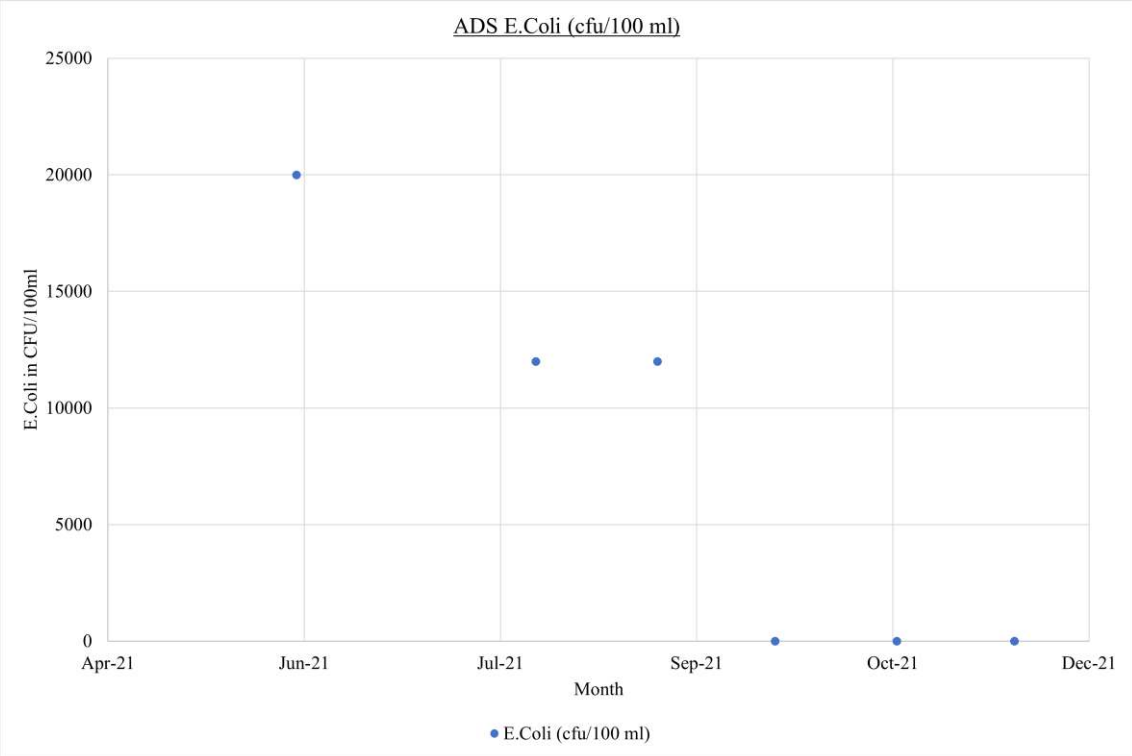
9.4 Solids

- TSS is below standards most of the time.



9.5 Pathogens

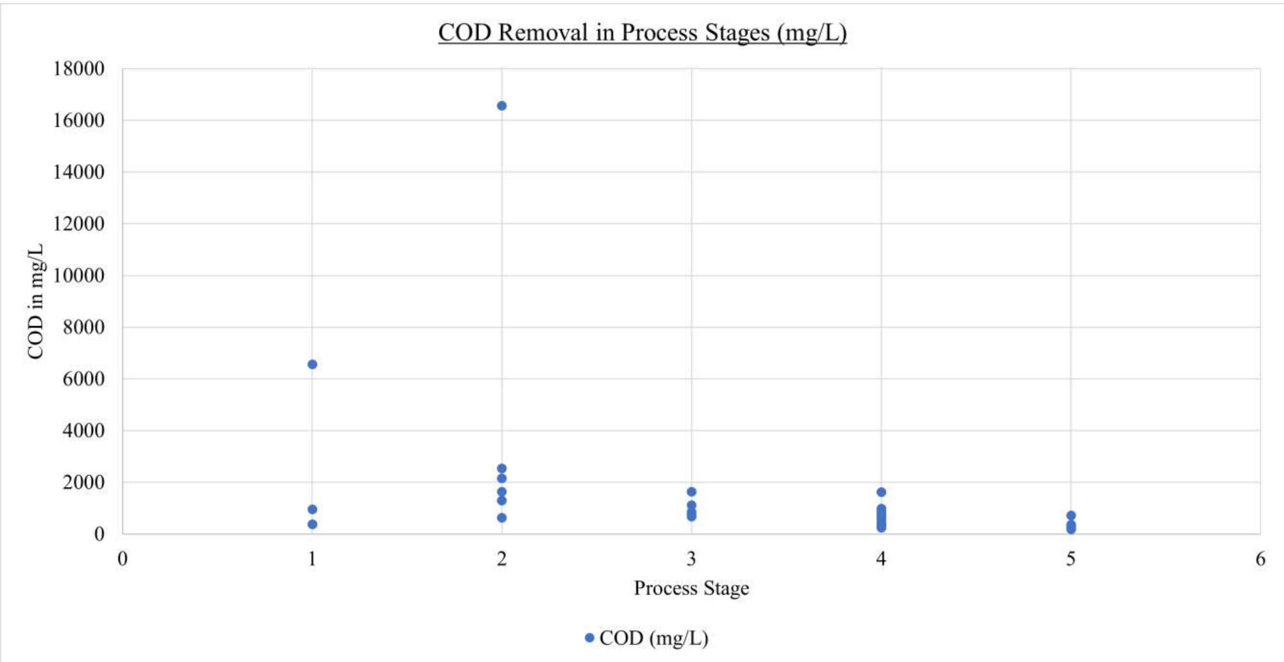
- Good Helminth removal, i.e., data showing zero eggs.
- 50:50- E.coli removal with no clear reason for pass/fail.

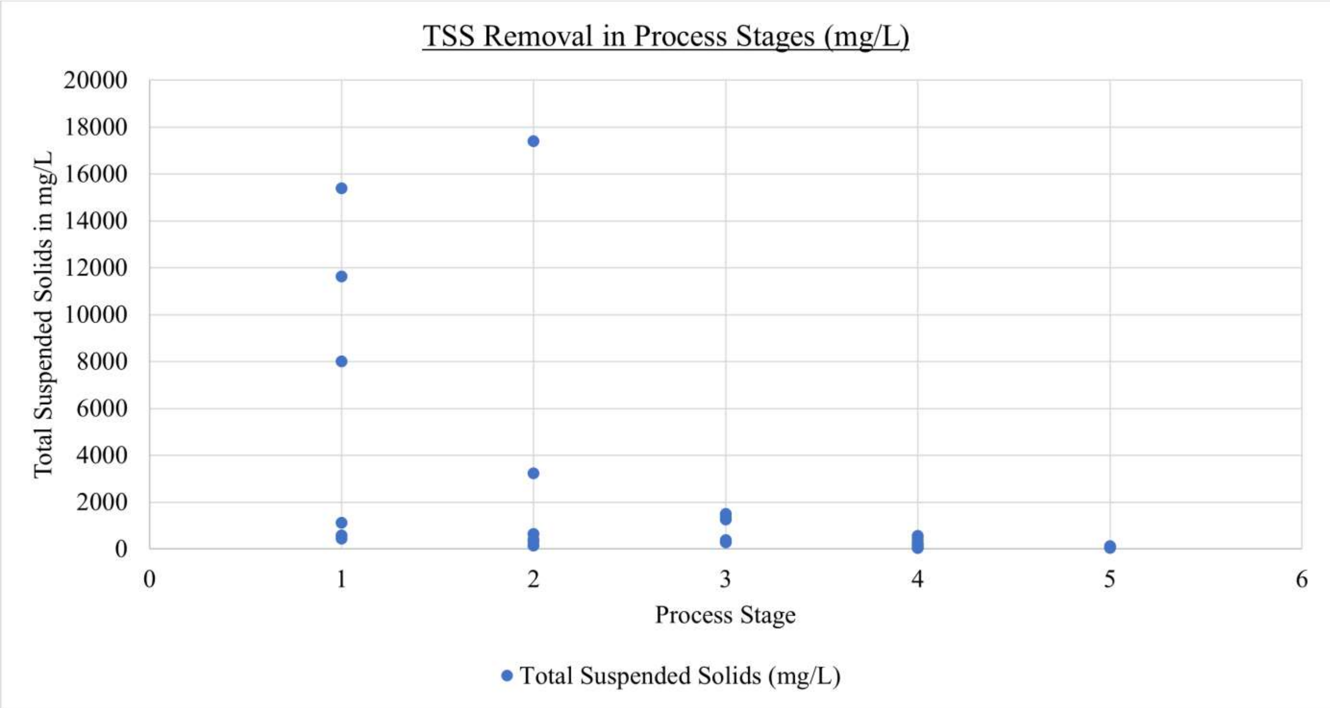


9.6 ADS process stages and performance

Monitoring data was available through the stage of the ADS treatments, these monitoring points were: 1. Inlet, 2. Digester chamber outlet, 3. Drying bed outlet, 4. Filter bed outlet and 5. Polishing Pond outlet. This review showed most of the reduction of solids and COD in the digestion and also filter/drying bed.

Review of E.coli showed some increase (potential for regrowth after digestion?).





TSS Removal in Process Stages (mg/L)
Total Suspended Solids in mg/L
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0
1
2
3
4
5
6
Process Stage
Total Suspended Solids (mg/L)

OXFAM ARUP

Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix D

Sludge Transportation Data collection forms

Form	Camp	Block	Agency Name	Donor	Transportation mode Single chain: Vacutug/IFSTN/Pit Transfer/Manual Desludging/Others or Mixed chain	How many Days (Avg) require per Month to desludge this block	Target FSTP (Name)	FSTP location - Camp	FSTP location -Block	Monthly Desludge Latrine Chamber (Nos)	Volume of Sludge m3 per month (annual ave)	Volume of Sludge ave m3 per month (wet season)	Volume of Sludge ave m3 per month (dry season)	Monthly desludging cost (annual ave)	Monthly Transportation Cost (annual ave)	Remarks
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	F & G	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DEWATS-2021-07-C09-003	CAMP-9	F	211	90	90	90	11723	25987	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	F & D	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	ABR_F_C9_01	CAMP-9	F	78	48	48	48	6252	13860	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	F & G	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DLT-2017-06-BMS-001	CAMP-9	F	38	18	18	18	2345	5197	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	A & G	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DLT-2017-06-BMS-002	CAMP-9	A	88	18	18	18	2345	5197	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	A & B	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DEWATS-2021-07-C09-001	CAMP-9	A	49	60	60	60	7815	17325	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	B & C	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DEWATS-2021-07-C09-002	CAMP-9	B	124	90	90	90	11723	25987	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	B, C & E	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DLT-2017-06-BMS-003	CAMP-9	C	142	18	18	18	2345	5197	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	D	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DLT-2017-06-BMS-004	CAMP-9	D	57	18	18	18	2345	5197	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 9	E & F	NGOF	IOM	Single: Pit transfer/ temporary pipe and pump	22	IOM-DEWATS-2021-11-C09-004	CAMP-9	F	94	90	90	90	11723	25987	
20220407_Camp 9 & 12_Sludge Transport data collection template	Camp 12	A	SHUSHILAN	IOM	Single: Manual Desludging and Transport	26	IOM-DEWATS-2020-09-C12-001,IOM-DEWATS-2020-09-C12-002	Camp12	A	145	156	156	156	27060	26125	
Sludge Transport data collection template, DSK, Camp 22	Camp 22	A	Dushtha Shasthya Kendra (DSK)	UNICEF	Single: Pit transfer/ temporary pipe and pump	22	DSK-UNICEF-FSM-01	Camp 22, Block A1	A	110	260	330	230	55000	10000	
Sludge Transport data collection template, DSK, Camp 22	Camp 22	B	Dushtha Shasthya Kendra (DSK)	UNICEF	Single: Pit transfer/ temporary pipe and pump	22	DSK-UNICEF-FSM-02	Camp 22, Block C3	C	130	290	330	255	55000	20000	
Sludge Transport data collection template, DSK, Camp 22	Camp 22	C	Dushtha Shasthya Kendra (DSK)	UNICEF	Single: Pit transfer/ temporary pipe and pump	22	DSK-UNICEF-FSM-03	Camp 22	C	130	290	360	290	55000	23000	
Sludge Transport data collection template, DSK, Camp 22	Camp 22	D	Dushtha Shasthya Kendra (DSK)	Oxfam	Single: Pit transfer/ temporary pipe and pump	22	DSK-UNICEF-FSM-03	Camp 22	C	150	340	360	330	60000	20000	
Sludge Transport data collection - BDRCS	Camp 18	B	BDRCS	IFRC/Swedish Red Cross	Mixed (Specify in Remarks with ratio of usage)	23	BDRCS FSTP-18B-Aerobic	Camp 18	M-19	50	60	65	60	5424	6563	Transportation mode : Mixed chain (Temporary Pipe+Pump and Manual Desludging+Transport)
Sludge Transport data collection - BDRCS	Camp 18	D	BDRCS	IFRC/Swedish Red Cross	Mixed (Specify in Remarks with ratio of usage)	23	BDRCS FSTP-18B-Aerobic	Camp 18	M-19	35	45	50	40	5424	6563	Working team is same for camp 18 Aerobic and Anaerobic Plant. So, all operating cost is also same for both plants. From year 2022 we are focusing more on Anaerobic Plant (New FSTP) to make it fully operational. Therefore, feeding in aerobic plant is less in year 2022. For Aerobic Plant data collected from year 2021 and Anaerobic Plant data collected from year 2022.
Sludge Transport data collection - BDRCS	Camp 18	E	BDRCS	IFRC/Swedish Red Cross	Mixed (Specify in Remarks with ratio of usage)	23	BDRCS FSTP-18B-Aerobic	Camp 18	M-19	25	30	35	30	5424	6563	
Sludge Transport data collection - BDRCS	Camp 18	B,D,E	BDRCS	Swedish Red Cross	Mixed (Specify in Remarks with ratio of usage)	23	BDRCS FSTP-18B-Anaerobic	Camp 18	M-19	110	140	150	135	5424	6563	
Sludge Transport data collection - BDRCS	Camp 19	D	BDRCS	IFRC	Mixed (Specify in Remarks with ratio of usage)	23	BDRCS FSTP-19D-Aerobic	Camp-19	D	92	120	125	110	9883	9583	Transportation mode : Mixed chain (Temporary Pipe+Pump and Manual Desludging+Transport) 50% Temporary Pipe+Pump and 50% Manual Desludging+Transport
Sludge Transport data collection template_Green Hill	Camp 1W	B	Green Hill	Community Partners International	Single: Pit transfer/ temporary pipe and pump	12	Oxfam mega FSTP	camp 04		60	120	200	100	350000	0	
Sludge Transport data collection template_Green Hill	Camp 4	D	Green Hill	Community Partners International	Single: IFSTN/ permanent pipe network and pump	12	Oxfam mega FSTP	Camp 04		40	100	140	80	30000	0	Camp 04 sludge Management system is centralized which is constructed by OXFAM and operated by NGO Forum. We are desludging latrines and dumping into intermediate pits
Sludge Transport data collection template_Green Hill	camp 17	C	Green Hill	Community Partners International	Single: Pit transfer/ temporary pipe and pump	16	NGOF- ABR-01 & ABR-02	Camp 17	A	30	80	100	60	30000	12000	
WVB_Sludge Transport data collection template	Camp 8E	A	WVB	UNICEF	Single: Pit transfer/ temporary pipe and pump	18	8E-A-B49-ABR-04	Camp 8E	A	78	279	310	208	28500	28500	
WVB_Sludge Transport data collection template	Camp 8E	B	WVB	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	8E-B-B42-UFF-03 8E-F-B37-ABR-08	Camp 8E	B & F	104	356	397	267	41500	41500	
WVB_Sludge Transport data collection template	Camp 8E	C	WVB	UNICEF	Single: Pit transfer/ temporary pipe and pump	18	8E-C-B65-WSP-01	Camp 8E	C	71	254	283	190	28000	28000	
WVB_Sludge Transport data collection template	Camp 8E	D	WVB	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	8E-D-B73-ABR-07 8E-F-B53-UFF-06	Camp 8E	D & F	87	311	347	238	34750	34750	
WVB_Sludge Transport data collection template	Camp 8E	E	WVB	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	8E-E-B86-WSP-02	Camp 8E	E	86	256	306	217	28000	28000	
WVB_Sludge Transport data collection template	Camp 8E	F	WVB	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	8E-F-B87-UFF-05 8E-F-B37-ABR-08	Camp 8E	F	88	307	345	224	35250	35250	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	A	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF LSP 09	Camp 2W	A	40	80	80	80	6763.02521	2718.907563	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	A	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF LSP 04	Camp 2W	A	28	60	60	60	5072.268908	2039.180672	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	A	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF ODP 15	Camp 2W	A	31	70	70	70	5917.647059	2379.044118	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	A	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF ODP 03	Camp 2W	A	20	48	48	48	4057.815126	1631.344538	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	B	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	DLT-IOM-06-KMS-2017-SSU	Camp 2W	B	38	70	70	70	5917.647059	2379.044118	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	B	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF ODP 05	Camp 2W	B	30	75	75	75	6340.336134	2548.97584	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	B	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF ODP 11	Camp 2W	B	60	140	140	140	11835.29412	4758.088235	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	B	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	WaterAid LSP 20	Camp 2W	B	40	80	80	80	6763.02521	2718.907563	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	C	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF LSP 12	Camp 2W	C	32	78	78	78	6593.94958	2650.934874	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	C	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	WaterAid LSP 21	Camp 2W	C	35	82	82	82	6932.10084	2786.880252	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	C	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	DLT-IOM-14-KMS-2017-SSU	Camp 2W	C	68	110	110	110	9299.159664	3738.497899	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	C	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	DLT-IOM-13-KMS-2017-SSU	Camp 2W	C	59	104	104	104	8791.932773	3534.579832	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	C	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	DLT-IOM-07-KMS-2017-SSU	Camp 2W	C	53	88	88	88	7439.327731	2990.798319	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	D	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	WaterAid LSP 23	Camp 2W	D	28	58	58	58	4903.193277	1971.207983	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	D	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF LSP 08	Camp 2W	D	30	70	70	70	5917.647059	2379.044118	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	D	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	ACF LSP 07	Camp 2W	D	28	65	65	65	5494.957983	2209.112395	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	D	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	WaterAid LSP 22	Camp 2W	D	25	60	60	60	5072.268908	2039.180672	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 2W	D	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	20	DLT-IOM-16-KMS-2017-SSU	Camp 2W	D	49	90	90	90	7608.403361	3058.771008	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 10	C	BRAC	IOM	Single: Manual Desludging and Transport	26	LSP-G41-01	Camp 10	C	120	160	160	160	122730	11670	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 10	C	BRAC	IOM	Single: Manual Desludging and Transport	26	LSP-F10-01	Camp 10	C	102	120	120	120	98730	11490	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 10	E	BRAC	IOM	Single: Manual Desludging and Transport	26	LSP-F40-01	Camp 10	E	152	196	235	220	144870	12030	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 10	F	BRAC	IOM	Single: Manual Desludging and Transport	26	LSP-G6-01	Camp 10	F	103	125	165	145	102090	11940	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 11	A,C,E,F	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	LSP-15	Camp11	A	205	57	57	57	37762.5	25175	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 11	B,D	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	LSP-14	Camp11	D	160	81	81	81	53662.5	35775	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 11	A,E	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	LSP-016	Camp11	E	252	87	87	87	57637.5	38425	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25_Sludge Transport data collection template	Camp 11	E,F	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	LSP-017	Camp11	E	253	57	57	57	37762.5	25175	

Form	Camp	Block	Agency Name	Donor	Transportation mode Single chain: Vacutug/IFSTN/Pit Transfer/Manual Desludging/Others or Mixed chain	How many Days (Avg) require per Month to desludge this block	Target FSTP (Name)	FSTP location - Camp	FSTP location -Block	Monthly Desludge Latrine Chamber (Nos)	Volume of Sludge m3 per month (annual ave)	Volume of Sludge ave m3 per month (wet season)	Volume of Sludge ave m3 per month (dry season)	Monthly desludging cost (annual ave)	Monthly Transportation Cost (annual ave)	Remarks
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 11	B,E,F	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	LSP-018	Camp11	E	137	81	81	81	53662.5	35775	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 11	D	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	LSP-019	Camp11	D	56	66	66	66	43725	29150	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 11	A	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	LSP-020	Camp11	A	104	57	57	57	37762.5	25175	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 11	C	ACF	IOM	Single: Pit transfer/ temporary pipe and pump	22	003KSR021	Camp 20	S3	50	90	90	90	59625	39750	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 12	B	SHUSHILAN	IOM	Single: Manual Desludging and Transport	13	IOM-DLT-2018-10-C20-003 (KSR-013)	Camp20	M30	50	38	40	38	13565	48126	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 12	B	SHUSHILAN	IOM	Single: Manual Desludging and Transport	13	IOM-DLT-2018-10-C20-004 (KSR-014)	Camp20	M35	50	38	40	38	13565	48126	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 12	C	SHUSHILAN	IOM	Single: Manual Desludging and Transport	13	IOM-DLT-2018-10-C20-007(KSR-017)	Camp20	M39	50	38	40	38	13565	48126	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 12	C	SHUSHILAN	IOM	Single: Manual Desludging and Transport	13	IOM-DLT-2018-10-C20E-012(KSR-30)	Camp20E	S2-B2	50	38	40	38	13565	48126	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 12	D	SHUSHILAN	IOM	Single: Manual Desludging and Transport	13	IOM-DLT-2018-10-C20E-005(KSR-015)	Camp20E	S2-B2	50	38	40	38	13565	48126	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 12	D	SHUSHILAN	IOM	Single: Manual Desludging and Transport	13	IOM-DLT-2018-10-C20-008(KSR-018)	Camp20	M31	50	38	40	38	13565	48126	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 13	B,C,D & E	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DEWATS-2020-09-C13-001	Camp-13	E	205	42	42	42	16249	7144	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 13	B,C,D & E	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DEWATS-2020-09-C13-002	Camp-13	E	205	42	42	42	16249	7144	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 13	B,C,D & E	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	WVI-C13-003	Camp-13	E	635	130	130	130	50297	22113	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DL-2018-10-C18-005-(KSR-001)	CAMP-18	A	72	11.664	11.664	11.664	7692	0	The latrines are near to the treatment plant and are desludged directly to the treatment plant.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DL-2018-10-C18-006-(KSR-002)	CAMP-18	A	22	3.564	3.564	3.564	2096	0	The latrines are near to the treatment plant and are desludged directly to the treatment plant.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DL-2018-10-C18-007-(KSR-003)	CAMP-18	A	69	11.178	11.178	11.178	5769	0	The latrines are near to the treatment plant and are desludged directly to the treatment plant.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DL-2018-10-C18-008-(KSR-004)	CAMP-18	A	30	4.86	4.86	4.86	2620	0	The latrines are near to the treatment plant and are desludged directly to the treatment plant.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	B	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DL-2018-10-C18-011-(KSR-007)	CAMP-18	B	38	6.156	6.156	6.156	3144	0	The latrines are near to the treatment plant and are desludged directly to the treatment plant.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	C + D	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DL-2018-10-C18-012-(KSR-008)	CAMP-18	C	213	34.506	34.506	34.506	9555	8785	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	C + D	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-07-C18-DSK-01	CAMP-18	C	206	33.372	33.372	33.372	9009	8283	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-07-C18-DSK-02	CAMP-18	A	31	5.022	5.022	5.022	2620	0	The latrines are near to the treatment plant and are desludged directly to the treatment plant.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-07-C18-DSK-03	CAMP-18	A	59	9.558	9.558	9.558	5240	0	The latrines are near to the treatment plant and are desludged directly to the treatment plant.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 18	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-07-C18-DSK-04	CAMP-18	A	93	15.066	15.066	15.066	4095	3765	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 19	A	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20Ex-001(KSR-019)	Camp20 EX	M39	14	32	32	32	26452	34540	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 20	A	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20-002(KSR-012)	Camp 20	A	2	2.5	2.5	2.5	882.6923077	98.07692308	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 20	A & B	SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20-006(KSR-016)	Camp 20	B	4	5	5	5	1765.384615	196.1538462	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 20 Extension		SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20E-005(KSR-023)	Camp 20	S3	8	10	20	4	3530.769231	392.3076923	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 20 Extension		SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20E-002(KSR-020)	Camp 20	S3	7	9	18	3	3177.692308	353.0769231	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 20 Extension		SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20E-004(KSR-022)	Camp 20	S2	16	22	50	8	7767.692308	863.0769231	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 20 Extension		SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20E-006(KSR-024)	Camp 20	S3	3	6	12	2	2118.461538	235.3846154	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 20 Extension		SHED	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DLT-2018-10-C20E-010(KSR-028)	Camp 20	S4	14	30	30	30	10592.30769	1176.923077	
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 24	A, B & C	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DEWATS-01	Camp-24	B	190	135	125	150	44923	24189.55	During dry season DEWATS (FSM) infiltration has increased that's why dry season average volume of sludge per month bigger than the wet season.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 24	A, B & C	DSK	IOM	Single: Pit transfer/ temporary pipe and pump	26	IOM-DEWATS-02	Camp-24	B	204	140	130	165	48068	32045.2	During dry season DEWATS (FSM) infiltration has increased that's why dry season average volume of sludge per month bigger than the wet season.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 24	D & E	DSK	IOM	Single: Manual Desludging and Transport	26	Lime stabilization	Camp-24	D	162	110	105	120	31268	20845.2	During dry season DEWATS (FSM) infiltration has increased that's why dry season average volume of sludge per month bigger than the wet season.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 24	E	ANANDO	WHH	Single: Manual Desludging and Transport	24	Lime Stabilization	24	D	103	120	110	130	72144	28857.6	During dry season DEWATS (FSM) infiltration has increased that's why dry season average volume of sludge per month bigger than the wet season.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 24	F	NABOLOK	Diakoni Katastrophenhilfe,	Single: Pit transfer/ temporary pipe and pump	24	DEWATS- 001	Camp 24	F	82	95	90	100			Nabolok didn't share any cost information During dry season DEWATS (FSM) infiltration has increased that's why dry season average
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 25	A & B	DSK	IOM	Single: Manual Desludging and Transport	22	Lime stabilization	Camp-25	D	160	128	120	136	33638	15137.1	During dry season DEWATS (FSM) infiltration has increased that's why dry season average volume of sludge per month bigger than the wet season.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 25	B	NGOF	NCA	Single: Pit transfer/ temporary pipe and pump	22	NGOF-LS Geotube	Camp25	B	97	110	103	117	42590	33540	During dry season DEWATS (FSM) infiltration has increased that's why dry season average volume of sludge per month bigger than the wet season.
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 25	B	Save the Children	Japan Platform	Single: IFSTN/ permanent pipe network and pump	22	SCI/25/Alikhali/DeWATS/FSTP-02	Camp 25	B	70	85	80	90	21810	2750	Dislodging by IFSTN with surface pipe network During dry season DEWATS (FSM) infiltration has increased that's why dry season average
20220427_Camp 2W, 9, 10, 11, 12, 13, 18, 19, 2020E, 24 & 25 Sludge Transport data collection template	Camp 25	B	BRAC	DFAT	Single: Manual Desludging and Transport	15	BRAC-ABR-001	Camp 25	B	25	100	100	100	90000	90000	BRAC didn't share breakdown about dislodging cost.
Sludge Transport data collection on March 2022 -NGOF	Camp 6	D	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 6	D	286	168.74	290	170	322222		
Sludge Transport data collection on March 2022 -NGOF	Camp 6	B	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 6	B	315	199.24	340	200	35490		
Sludge Transport data collection on March 2022 -NGOF	Camp 6	C	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 6	C	339	378	643	380	38194		
Sludge Transport data collection on March 2022 -NGOF	Camp 6	A	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 6	A	220	176.08	300	180	24786		
Sludge Transport data collection on March 2022 -NGOF	Camp 6	A	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Constructed Wetland	Camp 6	A	64	84.86	145	90	7210		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	E	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 7	E	224	721.75	1122	725	25237		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	G	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 7	G	212	586.28	996	590	23885		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	D	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 7	D	204	444.51	755	450	22984		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	G	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Anaerobic Baffled Reactor (ABR)	Camp 7	G	236	306.46	521	310	26590		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	B	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Up flow Filter	Camp 7	B	81	279.09	476	280	9126		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	B	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Up flow Filter	Camp 7	B	97	302.87	514	300	10928		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	A	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Up flow Filter	Camp 7	A	150	180.44	308	180	16900		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	F	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Up flow Filter	Camp 7	F	57	526.57	895	525	6422		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	E	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Up flow Filter	Camp 7	E	57	272.35	463	272	6422		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	D	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	UP-Flow	Camp 7	D	80	27.84	47	28	9013		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	C	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	C-7-C-C3-02	Camp 7	C	97	51.1	87	50	10928		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	D	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	C-7-D-D6-06	Camp 7	D	81	68.81	116	70	9126		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	C	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	UP-Flow	Camp 7	C	70	306.08	520	300	7890		
Sludge Transport data collection on March 2022 -NGOF	Camp 7	C	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	Waste stabilization pond (WSP)	Camp 7	C	98	67.3	114	68	11045		

Form	Camp	Block	Agency Name	Donor	Transportation mode Single chain: Vacutug/IFSTN/Pit Transfer/Manual Desludging/Others or Mixed chain	How many Days (Avg) require per Month to desludge this block	Target FSTP (Name)	FSTP location - Camp	FSTP location -Block	Monthly Desludge Latrine Chamber (Nos)	Volume of Sludge m3 per month (annual ave)	Volume of Sludge ave m3 per month (wet season)	Volume of Sludge ave m3 per month (dry season)	Monthly desludging cost (annual ave)	Monthly Transportation Cost (annual ave)	Remarks
Sludge Transport data collection on March 2022 -NGOF	Camp 7	C	NGO Forum for public health	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	UP-Flow	Camp 7	C	70	38.45	65	38	7890		
Sludge Transport data collection report_BRAC	Camp 1E	A	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	14	Kutupalong-FSTP-02			80	197.8	239.2	184	27692	46644	Vacu tug- 30%, Pit Transfer-70%
Sludge Transport data collection report_BRAC	Camp 1E	B	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	15	C01E-BRAC-ABR	Camp 1E	B	95	232.2	280.8	216	32508	54756	Vacu tug- 30%, Pit Transfer-70%
Sludge Transport data collection report_BRAC	Camp 1E	C	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	18	C01E-BRAC-LSP-1	Camp 1E	C	80	189.2	228.8	176	26488	48048	Vacu tug- 10%, Pit Transfer-90%
Sludge Transport data collection report_BRAC	Camp 1W	A	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	9	C01W-BRAC-LSP-2	Camp 1W	A	60	152.25	189	140	21315	41391	Vacu tug- 20%, Pit Transfer-80%
Sludge Transport data collection report_BRAC	Camp 1W	C	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	9	Kutupalong-FSTP-02			75	165.3	205.2	152	23142	370386	Vacu tug- 50%, Pit Transfer-80%
Sludge Transport data collection report_BRAC	Camp 1W	D	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	9	C01W-BRAC-LSP-1	Camp 1W	D	52	117.45	145.8	108	16443	28431	Vacu tug- 20%, Pit Transfer-80%
Sludge Transport data collection report_BRAC	Camp 1W	E	BRAC	UNHCR	Single: Pit transfer/ temporary pipe and pump	8	C01W-BRAC-ABR	Camp 1W	E	49	100.05	124.2	92	14007	31050	
Sludge Transport data collection report_BRAC	Camp 1W	F	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	8	C01W-BRAC-CW-1	Camp 1W	F	60	121.8	151.2	112	17052	29484	Vacu tug- 30%, Pit Transfer-70%
Sludge Transport data collection report_BRAC	Camp 2E	A	BRAC	UNHCR	Single: Vacutug	8	Kutupalong-FSTP-02			65	187.88	223.52	176	26303.2	75996.8	
Sludge Transport data collection report_BRAC	Camp 2E	B	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	8	C2E-BRAC-ODP-01	Camp 2E	B	62	145.18	172.72	136	20325.2	33680.4	Vacu tug- 30%, Pit Transfer-70%
Sludge Transport data collection report_BRAC	Camp 2E	C	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	20	C2E-BRAC-ODP-02	Camp 2E	C	146	273.28	325.12	256	38259.2	58521.6	Vacu tug- 20%, Pit Transfer-80%
Sludge Transport data collection report_BRAC	Camp 2E	D	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	16	C2E-BRAC-ODP-04	Camp 2E	D	115	226.31	269.24	212	31683.4	55194.2	Vacu tug- 40%, Pit Transfer-60%
Sludge Transport data collection report_BRAC	Camp 3	A	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	6	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		56	154	196	140	21714	17556	
Sludge Transport data collection report_BRAC	Camp 3	B	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	7	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		54	140.8	179.2	128	19852.8	16051.2	
Sludge Transport data collection report_BRAC	Camp 3	C	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	6	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		40	96.8	123.2	88	13648.8	11035.2	
Sludge Transport data collection report_BRAC	Camp 3	D	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	9	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		65	151.36	192.64	137.6	21341.76	17255.04	
Sludge Transport data collection report_BRAC	Camp 3	E	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	9	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		65	153.12	194.88	139.2	21589.92	17455.68	
Sludge Transport data collection report_BRAC	Camp 3	F	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	7	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		55	136.4	173.6	124	19232.4	15549.6	
Sludge Transport data collection report_BRAC	Camp 3	G	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	8	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		57	127.6	162.4	116	17991.6	14546.4	
Sludge Transport data collection report_BRAC	Camp 4 extension	A	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	2	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		4	10.8	14.4	9.6	1522.8	1231.2	
Sludge Transport data collection report_BRAC	Camp 4 extension	B	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	4	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		18	29.7	39.6	26.4	4187.7	3385.8	
Sludge Transport data collection report_BRAC	Camp 4 extension	C	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	6	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		24	64.8	86.4	57.6	9136.8	7387.2	
Sludge Transport data collection report_BRAC	Camp 4 extension	D	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	3	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		9	23.4	31.2	20.8	3299.4	2667.6	
Sludge Transport data collection report_BRAC	Camp 4 extension	E	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	2	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		2	10.8	14.4	9.6	1522.8	1231.2	
Sludge Transport data collection report_BRAC	Camp 4 extension	F	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	3	04EX-NGOF-Mega-FSTP-01	Camp 4 extension		6	16.2	21.6	14.4	2284.2	1846.8	
Sludge Transport data collection report_BRAC	Camp 4 extension	I	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	2	04EX-NGOF-Mega-FSTP-01	Camp-04 Ext		4	10.8	14.4	9.6	1522.8	1231.2	
Sludge Transport data collection report_BRAC	Camp 4 extension	H	BRAC	UNHCR	Single: IFSTN/ permanent pipe network and pump	2	04EX-NGOF-Mega-FSTP-01	Camp-04 Ext		6	10.8	14.4	9.6	1522.8	1231.2	
Sludge Transport data collection report_BRAC	Camp 21(Chakmarkul)	A	BRAC	UNHCR	Single: Manual Desludging and Transport	16	C21-ABR-Omani	Camp 21(Chakmarkul)	B	70	137.6	166.4	128	33024	46784	
Sludge Transport data collection report_BRAC	Camp 21(Chakmarkul)	B	BRAC	UNHCR	Single: Manual Desludging and Transport	14	C21-ABR-Omani	Camp 21(Chakmarkul)	B	55	86	104	80	20640	29240	
Sludge Transport data collection report_BRAC	Camp 21(Chakmarkul)	C	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	8	C21-ABR-Omani	Camp 21(Chakmarkul)	D	60	64.5	78	60	9675	21930	IFSTN-50%, Manual-50%
Sludge Transport data collection report_BRAC	Camp 21(Chakmarkul)	D	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	8	C21-ABR-Omani	Camp 21(Chakmarkul)	D	25	34.4	41.6	32	8256	11696	IFSTN-80%, Manual-20%
Sludge Transport data collection report_BRAC	Camp 21(Chakmarkul)	E	BRAC	UNHCR	Mixed (Specify in Remarks with ratio of usage)	6	C21-ABR-Omani	Camp 21(Chakmarkul)	D	30	55.04	66.56	51.2	8256	18713.6	IFSTN-30%, Manual-70%
Sludge Transport data collection report_BRAC	Camp 10	C	BRAC	IOM	Mixed (Specify in Remarks with ratio of usage)	10	LSP-G41-01	Camp 10	C	120	172.5	180	170	93000	13000	Vacu tug- 20%, Pit Transfer-80%
Sludge Transport data collection report_BRAC	Camp 10	C	BRAC	IOM	Mixed (Specify in Remarks with ratio of usage)	9	LSP-F10-01	Camp 10	C	91	141.25	205	120	87000	17000	Vacu tug- 25%, Pit Transfer-75%
Sludge Transport data collection report_BRAC	Camp 10	F	BRAC	IOM	Mixed (Specify in Remarks with ratio of usage)	8	LSP-G6-01	Camp 10	F	103	150	165	145	91000	11000	Vacu tug- 20%, Pit Transfer-80%
Sludge Transport data collection report_BRAC	Camp 10	E	BRAC	IOM	Mixed (Specify in Remarks with ratio of usage)	10	LSP-F40-01	Camp 10	E	152	223.75	235	220	94000	9000	Vacu tug- 15%, Pit Transfer-85%
Sludge Transport data collection report_BRAC	Camp 14(Hakimpara)	A	BRAC	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	ABR-01	Camp-14	A	220	240	280	220	55660	10000	pit trransfer ,temporary pipe and pump
Sludge Transport data collection report_BRAC	Camp 14(Hakimpara)	B	BRAC	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	ABR-02	Camp-14	B	220	230	270	210	55660	10000	pit trransfer ,temporary pipe and pump
Sludge Transport data collection report_BRAC	Camp 14(Hakimpara)	C	BRAC	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	ABR-05	Camp-14	C	140	240	280	220	35420	10000	pit trransfer ,temporary pipe and pump
Sludge Transport data collection report_BRAC	Camp 14(Hakimpara)	D	BRAC	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	ABR-03	Camp-14	D	140	223	270	200	35420	10000	pit trransfer ,temporary pipe and pump
Sludge Transport data collection report_BRAC	Camp 14(Hakimpara)	E	BRAC	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	ABR-04	Camp-14	E	80	220	260	200	20240	10000	pit trransfer ,temporary pipe and pump
Sludge Transport data collection report_BRAC	Camp 14(Hakimpara)	E	BRAC	UNICEF	Single: Pit transfer/ temporary pipe and pump	20	ABR-06	Camp-14	E	60	143	190	120	15180	10000	pit trransfer ,temporary pipe and pump
Sludge Transport data collection template	Camp 4	A	NGO Forum for public health	UNHCR	Single: IFSTN/ permanent pipe network and pump	6	Mega FSTP-01	Camp-4 EX		117	280	320	275	28280	23400	
Sludge Transport data collection template	Camp 4	B	NGO Forum for public health	UNHCR	Single: IFSTN/ permanent pipe network and pump	4	Mega FSTP-01	Camp-4 EX		58	145	175	133	13433	11500	
Sludge Transport data collection template	Camp 4	C	NGO Forum for public health	UNHCR	Single: IFSTN/ permanent pipe network and pump	3	Mega FSTP-01	Camp-4 EX		64	175	195	163	16463	13500	
Sludge Transport data collection template	Camp 4	E	NGO Forum for public health	UNHCR	Single: IFSTN/ permanent pipe network and pump	5	Mega FSTP-01	Camp-4 EX		120	260	300	225	22725	23500	
Sludge Transport data collection template	Camp 4	G	NGO Forum for public health	UNHCR	Single: IFSTN/ permanent pipe network and pump	4	Mega FSTP-01	Camp-4 EX		51	150	180	119	12019	15000	
Sludge Transport data collection template	Camp 5	A	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	9	ABR-2 & LSP-2	Camp-5	B & E	55	155	167	140	25620	16660	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 5	B	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	7	ABR-1 & LSP-2	Camp-5	B & E	33	80	101	59	10797	7021	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 5	C	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	7	ABR-2 & LSP-2	Camp-5	B & E	28	80	98	61	11163	7259	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 5	D	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	9	ABR-1 & ABR-2	Camp-5	E	51	135	144	127.5	23325	15172.5	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 5	E	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	7	ABR-1 & LSP-1	Camp-5	E	32	90	109	75	13176	8568	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 26	A	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	19	ABR & Geotex Tube, LSP-01	Camp 27, Camp 26	C & B, E	99	110	135	90	29998	19999	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 26	B	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	9	ABR & Geotex Tube, LSP-01	Camp 27, Camp 26	C & B, E	56	70	84	56	14912	9941	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 26	C	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	10	ABR & Geotex Tube, LSP-01	Camp 27, Camp 26	C & B, E	44	50	60	40	12658	8439	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 26	D	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	9	ABR & Geotex Tube, LSP-01	Camp 27, Camp 26	C & B, E	25	45	53	35	13178	8785	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 26	E	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	4	ABR , LSP-01	Camp 27, Camp 26	C & E	15	30	38	25	8323	5549	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 26	G	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	5	ABR , LSP-02	Camp 27, Camp 26	C & G	18	40	48	32	12658	8439	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used

Form	Camp	Block	Agency Name	Donor	Transportation mode Single chain: Vacutug/IFSTN/Pit Transfer/Manual Desludging/Others or Mixed chain	How many Days (Avg) require per Month to desludge this block	Target FSTP (Name)	FSTP location - Camp	FSTP location -Block	Monthly Desludge Latrine Chamber (Nos)	Volume of Sludge m3 per month (annual ave)	Volume of Sludge ave m3 per month (wet season)	Volume of Sludge ave m3 per month (dry season)	Monthly desludging cost (annual ave)	Monthly Transportation Cost (annual ave)	Remarks
Sludge Transport data collection template	Camp 26	H	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	13	ADS,ABR , Geotex Tube	Camp 26, Camp 27	I,C & B	37	100	119	79	27743	18496	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Camp 26	I	NGOF	UNHCR	Single: Pit transfer/ temporary pipe and pump	11	NGOF-C26-ADS-01	Camp 26	I	33	45	53	35	18380	12253	Transportation Mode: Desludged by machine & Pit to Pit Transfer & Vacutug also used
Sludge Transport data collection template	Nayapara RC	B	NGOF	UNHCR	Mixed (Specify in Remarks with ratio of usage)	2	ABR -NYP-RC & GEO Tube- Camp-27	NYP-RC & Camp-27	C &C	26	15	20	10	7500	3150	Pit transfer : Vacutug = 3:1
Sludge Transport data collection template	Nayapara RC	C	NGOF	UNHCR	Mixed (Specify in Remarks with ratio of usage)	4	ABR -NYP-RC & GEO Tube- Camp-28	NYP-RC & Camp-28	C &C	64	55	62.5	50	28125	11812	Pit transfer : Vacutug = 4:1
Sludge Transport data collection template	Nayapara RC	D	NGOF	UNHCR	Mixed (Specify in Remarks with ratio of usage)	4	ABR -NYP-RC & GEO Tube- Camp-29	NYP-RC & Camp-29	C &C	46	40	42	37.5	20000	8400	Pit transfer : Vacutug = 4:1
Sludge Transport data collection template	Nayapara RC	E	NGOF	UNHCR	Mixed (Specify in Remarks with ratio of usage)	4	ABR -NYP-RC & GEO Tube- Camp-30	NYP-RC & Camp-30	C &C	70	52.5	72.5	32.5	26250	11025	Pit transfer : Vacutug = 3:1
Sludge Transport data collection template	Nayapara RC	H	NGOF	UNHCR	Mixed (Specify in Remarks with ratio of usage)	5	ABR -NYP-RC & GEO Tube- Camp-31	NYP-RC & Camp-31	C &C	55	53.75	67.5	40	26875	11287	Pit transfer : Vacutug = 3:1
Sludge Transport data collection template	Nayapara RC	I	NGOF	UNHCR	Mixed (Specify in Remarks with ratio of usage)	2	ABR -NYP-RC & GEO Tube- Camp-32	NYP-RC & Camp-32	C &C	18	13.75	17.5	10	6875	2887	Pit transfer : Vacutug = 3:1
Sludge Transport data collection template	Nayapara RC	P	NGOF	UNHCR	Mixed (Specify in Remarks with ratio of usage)	1	ABR -NYP-RC & GEO Tube- Camp-33	NYP-RC & Camp-33	C &C	8	12.5	12.5	12.5	6250	2625	Pit transfer : Vacutug = 3:1
Sludge Transport data collection template	Kutupalong RC	A	NGO Forum	UNHCR	Mixed (Specify in Remarks with ratio of usage)	9	NGOF- ABR-1 & ABR-03 & NGOF-ASTT-1 & BRAC- MEGA FSTP-2	KTP-RC & Kutupalong	A & F & Kutupalong	85	83	79	83	30545	8520	Pit transfer : Vacutug = 4:6
Sludge Transport data collection template	Kutupalong RC	B	NGO Forum	UNHCR	Mixed (Specify in Remarks with ratio of usage)	7	NGOF- ABR-1 & ABR-03 & NGOF-ASTT-1 & BRAC- MEGA FSTP-2	KTP-RC & Kutupalong	B & F & Kutupalong	44	43	46	40	16265	3600	Pit transfer : Vacutug = 5:5
Sludge Transport data collection template	Kutupalong RC	C	NGO Forum	UNHCR	Mixed (Specify in Remarks with ratio of usage)	7	NGOF- ABR-2 & ABR-3 & NGOF- ASTT-1 & BRAC- MEGA FSTP-2	KTP-RC & Kutupalong	D & F & Kutupalong	24	26	32	20	9375	9820	Pit transfer : Vacutug = 3:7
Sludge Transport data collection template	Kutupalong RC	D	NGO Forum	UNHCR	Mixed (Specify in Remarks with ratio of usage)	11	NGOF- ABR-2 & ABR-3 & NGOF- ASTT-1 & BRAC- MEGA FSTP-2	KTP-RC & Kutupalong	D & F & Kutupalong	30	29	35	26	14975	14100	Pit transfer : Vacutug = 6:4
Sludge Transport data collection template	Kutupalong RC	E	NGO Forum	UNHCR	Mixed (Specify in Remarks with ratio of usage)	7	NGOF- ABR-2 & ABR-3 & NGOF- ASTT-1 & BRAC- MEGA FSTP-2	KTP-RC & Kutupalong	D & F & Kutupalong	35	34	53	25	10410	2450	Pit transfer : Vacutug = 3:7
Sludge Transport data collection template	Kutupalong RC	F	NGO Forum	UNHCR	Mixed (Specify in Remarks with ratio of usage)	8	NGOF- ABR-3 & NGOF- ASTT-1 & BRAC- MEGA FSTP-2	KTP-RC & Kutupalong	F & Kutupalong	69	70	79	61	17755	4675	Pit transfer : Vacutug = 5:5
Sludge Transport data collection template	Kutupalong RC	G	NGO Forum	UNHCR	Mixed (Specify in Remarks with ratio of usage)	4	NGOF- ABR-2 & ABR-3 & NGOF- ASTT-1 & BRAC- MEGA FSTP-2	KTP-RC & Kutupalong	D & F & Kutupalong	35	35	45	28	7280	6445	Pit transfer : Vacutug = 4:6

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Appendix E

CAPEX/ Volume of sludge m^3 per month for IFSTN/ permanent pipe network and pump transportation mode

Transportation mode	**Camp**	**Block**	**Volume of Sludge m^3 per month (annual ave)**	**Total population**	**CAPEX (USD/m^3)**
Single: IFSTN/ permanent pipe network and pump	Camp 25	B	85	606	31
Single: IFSTN/ permanent pipe network and pump	Camp 4	E	260	3,147	53
Single: IFSTN/ permanent pipe network and pump	Camp 4	G	150	2,498	73
Single: IFSTN/ permanent pipe network and pump	Camp 4	A	280	5,150	81
Single: IFSTN/ permanent pipe network and pump	Camp 4	C	175	3,449	87
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	D	23	527	99
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	A	11	258	105
Single: IFSTN/ permanent pipe network and pump	Camp 3	E	153	4,386	126
Single: IFSTN/ permanent pipe network and pump	Camp 3	D	151	4,455	130
Single: IFSTN/ permanent pipe network and pump	Camp 3	B	141	4,464	140
Single: IFSTN/ permanent pipe network and pump	Camp 3	G	128	4,632	160
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	F	16	647	176
Single: IFSTN/ permanent pipe network and pump	Camp 4	B	145	5,861	178
Single: IFSTN/ permanent pipe network and pump	Camp 3	F	136	6,031	195
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	C	65	2,923	198
Single: IFSTN/ permanent pipe network and pump	Camp 3	C	97	4,554	207
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	B	30	1,440	213
Single: IFSTN/ permanent pipe network and pump	Camp 4	D	100	5,350	235
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	H	11	599	244
Single: IFSTN/ permanent pipe network and pump	Camp 3	A	154	8,917	255
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	E	11	1,268	516
Single: IFSTN/ permanent pipe network and pump	Camp 4 extension	I	11	1,278	521
				Average	183

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Appendix F

Site survey – anecdotal evidence for latrines

Types of facilities	Type of facility desludged more often	Frequency of desludging	Reason for high frequency of desludging	Rainy/Dry season	Link with topography
Single pit (2.5m3) Twin pit (5m3) Septic tank	Direct pit and twin pit	Once a month	Low infiltration		
Septic tank (18m3) Direct pit with soak pit (3m3) Single pit (1.31m3)	Single pit latrines (1.31m3)	Twice a month	Less volume capacity	Sludge volume increases 60-70% in rainy season	
	Single pit latrines	Twice a month	Low land and high water table	Rainy season 1.5 times higher from dry season. Sand mud goes inside the pit	Sludge production link with topography low land area - quantity of liquid high land area - quantity of liquid low
Single pit Twin pit Septic tank	Single pit latrines	Low land 3 times a month High land 2 times a month		Water level in rainy season influences desludging	Desludging more frequent in low land
Twin pit latrine Biolfill latrine Septic tank Offset pit	Biolfill	Twice a month	Technology does not work, not operating as design Solids are going hard and not possible to desludge, so storage capacity decreases.	Higher desludging frequency in rainy season	Hilly area, sludge production is less. In low land, sludge production is more.
Single pit latrine Twin pit latrine Biogas latrine Septic tank Offset latrine	Single pit Twin pit and Septic tanks	Twice a month 1 to 1.5 times a month	Single pit: Solid deposition in pit and smaller ring size (32") Some septic tanks are desludged twice a month because of damage soak pits	Rainy season increases desludging need (mostly in valleys)	Rainy season increases desludging need (mostly in valleys)

One pit offset Direct pit Twin pit offset Septic tank	One pit offset	Twice a month	Smaller capacity	In rainy season desludging is more frequent, there is more sludge than in summer season	
Single pit latrine Septic tank Biofill	Septic tanks	1 to 2 times a month	Over population and leakage of soak pit	In rainy season, sludge production and desludging are more comparing with the dry season. Also, water absorption is lower in rainy season.	Higher sludge production in low land latrines when compared to hilly areas. Low land latrines are also used more than high land.
Single pit Twin pit Septic tank Wash block/Septic tank	Single pit latrines	2 to 3 times a month			
Pit latrine Septic tank	Septic tanks	Once a month	Septic tanks desludged more often because: - Design not adequate for the number of users - Connected to both black water and grey water		
Single pit latrine Septic tank	Single pit latrines	6 to 7 days in low land 20 to 25 days in high land		Rain and flood gets sand and mud inside the pit which difficult desludging.	
Single pit Twin pit Offset pit latrine Septic tank	Single pit latrines	Twice a month	Lowest capacity	Rainy/dry season has greatest influence on sludge.	Latrines at top of hill used less than those at the bottom.
Single pit Twin pit Septic tank	Single pit latrine	Three times a month	Lowest capacity		
Twin pit latrine Offset pit Biofill Septic tank	Offset pit	Three times a month	Depends on geography of land, water level and season and season	Rainy season - no soaking - more desludging demand	Flat area needs more desludge than hilly area
Direct pit latrine (1m3) Offset pit (2m3) Twin pit (6m3) Septic tank (8-10m3)	Single pit latrines	Four times a month	Lowest capacity	Less water absorption during rainy season	In the hilly area, sludge volume is lower than the low land area, soak of water is higher in hilly area then low land area.

Single pit (3m3) Twin offset (6m3) Septic tank (15m3)	Single pit latrines	Twice a month	Pits' capacity and more users per pit	In rainy reason, infiltration is less then comparing of the dry season and sludge volume is double comparing of dry season	More frequent desludging is required in low land areas.
Direct pit latrine (1m3) Offset pit (2m3) Twin pit (6m3) Septic tank (8-10m3)	Single pit latrines (Emergency latrines)	6 to 8 times a month	Lowest capacity	More sludge volume during rainy season because of decreased capacity of water absorption.	No link to topography.
Single pit (3m3) Twin offset (6m3) Septic tank (15m3)	Single pit latrines		Lowest capacity	Difficulty in soaking during monsoon season.	Better soaking at top of the hill than in bottom.

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Appendix G

Infiltration Test

This appendix contains information regarding infiltration test guidelines extracted from the 'Surface Water Management in Humanitarian Context' document (January 2019). The document was developed by Arup in collaboration with Oxfam, WEDC, Illman Young, EPG, CIRIA and funded by Elrha's Humanitarian Innovation Fund (HIF) programme. This section outlines three infiltration test methods and includes a guide to carry out the 'improved' infiltration test. The test is to be conducted and sized relative to the ground conditions and the likely depth of the infiltration component/soakaway. It is recommended that multiple tests are carried out if several infiltration components are to be used, giving an idea of how the infiltration rate changes on site.

GROUND CONDITIONS - INFILTRATION

WHY?

The site geology and ground conditions have a direct influence on the sub-surface drainage characteristics of a site.

The infiltration coefficient or permeability is a measure of the rate at which water drains through the ground. This will dictate whether infiltration solutions are possible or if outfalls are needed. The infiltration rate is usually expressed by the depth of the water layer that can drain through the soil per hour (also written as mm/hr).

Soakaway tests can be carried out in test pits located across the site. The test pits should be located in the places where an infiltration component is planned. The more areas tested the more confidence there can be in the likely drainage capacity, but this should be balanced with the resources available and the consequence of that infrastructure failing.

HIGHER PRECISION / LOWER UNCERTAINTY

Robust Method

INFILTRATION TEST

Ask an appropriately qualified person to conduct an infiltration test following BRE Digest 365. This test should be conducted and sized relative to ground conditions and the likely depth of the soakaway/infiltration component. If several infiltration components are to be used on the site, consider undertaking multiple tests to understand how the infiltration rate changes across the site.

Improved Method

BASIC INFILTRATION TEST (AS SHOWN IN APPENDIX 2)

This test should be conducted and sized relative to ground conditions and the likely depth of the soakaway. The minimum depth, width or length of the pit should be greater than 0.3m. The test location should be close to the anticipated infiltration point.

Tests may be conducted first at shallow depths. If infiltration rates are insufficient, the test may be repeated locally at deeper depths. If several infiltration devices are to be used on the site, consider undertaking multiple tests to understand how the infiltration rate changes on the site.

Basic Method

APPROXIMATE INFILTRATION RATE BASED ON SOIL TYPE

Review local ground condition information (see p.15-17) and complete exercises on soil type (p.18). Based on the above information choose infiltration rate below that is representative of the soil type on the site or specific area of the site.

Good infiltration → **Poor Infiltration**

SOIL TYPE	SANDS/ GRAVELS	SANDY LOAM	SILT	CLAY
Infiltration rate (mm/hr)	30-80	20-30	10-20	1-10

Verify with site observation/walkover. Does water typically pond on site or quickly drain away? (p.24)

HIGHER UNCERTAINTY / LOWER PRECISION

KEY INFORMATION

Make sure good records of infiltration test results are kept for future reference.

Use the infiltration rate to size infiltration devices/soakaways see p.40.

REMEMBER

- Verify the rate using more than one reference.
- Before testing, review local hazards (see Appendix 1) this may include contaminated ground, unstable ground and ground water.
- Note descriptions of made-ground and hazardous soils (see p.18) or areas impacted by previous infrastructure.
- It may be very difficult to drain if the water table is shallow. The infiltration device may also be prone to contamination.
- Consider groundwater protection water zones.
- Refer to Engineering in Emergencies (2002) p.677 and BRE Digest 365 for more info.

This sheet should be used to undertake the 'improved' infiltration test method. **Note that this is a simplified and less accurate method than the 'robust' method on p.20.**

Name of tester:.............................

Date:........./......../.........

Weather: Sun/Cloud/Rain/Snow/Windy/Humid (delete as appropriate)

Approx temp: ....degrees Celsius/Fahrenheit (delete as appropriate)

Weather and temperature may affect the results and may explain why the design works better or worse when implemented. This is worth reviewing at the 'review and adjust' stage if necessary.

Step 1 - Trial pit location

Choose location based on information on p.18

Step 2 - Test pit size

Dig the test pit to the minimum depth of the planned soakaway and at least 0.3m width and 0.3m length. The depth may not be from ground level if friable/desiccated soil or made ground is found (as per orange area in the figure below), the test pit depth (d4) should be below the level of this material (refer to p.18) to define the appropriate depth. It is preferable to dig pits with straight and equal sides. Once dug measure and calculate the following (to two decimal places):

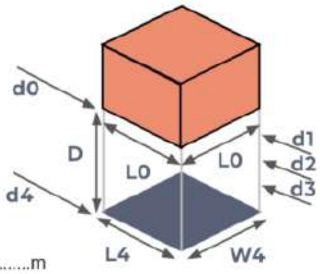
Depth (D)= ....m

Width top (W0)= ....m

Width bottom (W4)= ....m

Length top (L0)= ....m

Length bottom (L4) = ...m



Average width and depth:

W=(width top+width bottom)/2 = ...m

L=(length top+ length bottom)/2 = ...m

Step 3 - Infiltration test - Obtain a measuring stick or mark a length of timber equal to/greater than the depth of the test pit. Fill the pit quickly to d0 (see figure) and measure the water depth at the following intervals, to an accuracy of 0.01m:

MINUTES	*DEPTH (m)*	*MINUTES*	*DEPTH (m)*
0.25/ 15s		*9*	
0.5 / 30s		*10*	
0.75/ 45s		*15*	
1		*20*	
1.5		*25*	
2		*30*	
2.5		*40*	
3		*50*	
3.5		*60*	
4		*80*	
4.5		*100*	
5		*125*	
6		*150*	
7		*175*	
8		*200*	

Abandon test if it takes longer than 200min for all water to infiltrate.

Step 4 - Calculation (refer to figure left)

Total time for infiltration of all the water=........min (200min if test abandoned)

t1= Total time/4 =...........min

d1= water depth at t1=...........m (can be interpolated from the table above)

V1= Volume at d1=d1xLxW=...........m^3

t3= Total time - Total time/4 =...........min

d3= depth at t3=...........m (can be interpolated from the table above)

V3= Volume at d3=d3xLxW=...........m^3

d2= mid depth = d2+((d1-d3)/2)=...........m

a=surface area for half the depth = 2(d2xL)+2(d2xW)+(LxW)=...........m^2

(60,000 x (V1-V3)) / (a x (t3-t1))=...........mm/hr

Where possible repeat test and take the lowest rate.

OXFAM ARUP

Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix H

Introduction

This appendix contains the finalised standard designs for Latrines in Rohingya settlements. The designs were collectively agreed upon on 19th February 2018, ensuring the proposed options were in line with globally accepted humanitarian standards. Technical drawings and details of the designs are provided for each option.

The minimum design criteria state that the latrine is required to have a diameter of at least 4 feet and a depth of 10 feet in all cases – irrespective of the type or design. Three latrine designs minimize the desludging requirements and have the capacity to be linked with bio-gas plants. It was suggested that the energy produced can be used as cooking fuel.

Bill of Quantities

for the Twin Pit Latrine Construction

Latrine Option-1

Location: Cox's Bazar

Date: 10/01/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation of Foundation** for twin pit latrine, carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cft	450	7	3150.00
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	30	22	660.00
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	20	5	100.00
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	38	31	1,178.00
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	18.2	236	4,295.20
6	**Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4)and making bond with connected walls & stair in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	3.36	190	638.40
7	**125mm (5") Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	11	70	770.00
8	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, plastering work on the outer surface of precast column ,all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	174	18	3,132.00
9	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer.	sft	56	45	2,520.00
10	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	138	30	4,140.00

11	**Wood Work (Gorjon/Akashmoni/Mehogini):** Timber used for wood work shall be well seasoned, kiln dry containing not more than 8% to 12 % moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, shakes, saps, upsets, wane edge and twisted fiber. It shall also be free from all disease such as decay, wet rot, dry rot and woodworms and white and timber should be finished to the exact dimension shown on the drawing or as per Engineer direction.	cft	7.2	1200	8,640.00
12	10ft 6 inch height pre-cast pile (5" x 5" size) with reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 Mpa, and satisfying specified compressive strength f'c = 25 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM best quality coarse sand (F.M.2.2), 20 mm down well graded stone chips conforming to ASTM C-33, mixing in standard mixture machine and centering and shuttering with M.S sheet, M.S angle, F.I bar, nuts and bolts, preparation of bed, laying polythene, placing of reinforcement cage in position, casting, compacting by vibrators and tapered rods, curing for 28 days etc. including cost of reinforcement, water, electricity and other charges as per design and drawing, etc. all complete as per design, drawing and accepted by the Engineer.	Nos	4.00	950.00	3,800.00
13	**Supply, fittings & fixing of 48" dia. RCC Ring**, 2.25" thickness and 6 mm bar used as reinforcement as per the drawing and instruction of EIC.	Nos	20	950	19,000.00
14	**Sato pan** with footrest with good quality	Nos	1	200	200.00
15	Supply, fittings & fixing of pre-cast ring cover 5'x4', thikness-3" made of 1:2:4 mixing ratio, 8mm dia ms rod (60G) 6" C/C both way as per the drawing and instruction of EIC.	Nos	2	750	1,500.00
16	**Other Supplies & Accessories fitting, fixing & supplying**				
a	Stud Nail (2.5 inch)	kg	2	80	160.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
c	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	PVC pipe (1.5 dia) Gas Pipe	ft	20	25	500.00
h	uPVC Long Trap (4" dia)	Nos	1	250	250.00
i	uPVC pipe (4" dia)	ft	20	85	1,700.00
	Grand Total (BDT) =				**57,154**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

26.2.18

Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

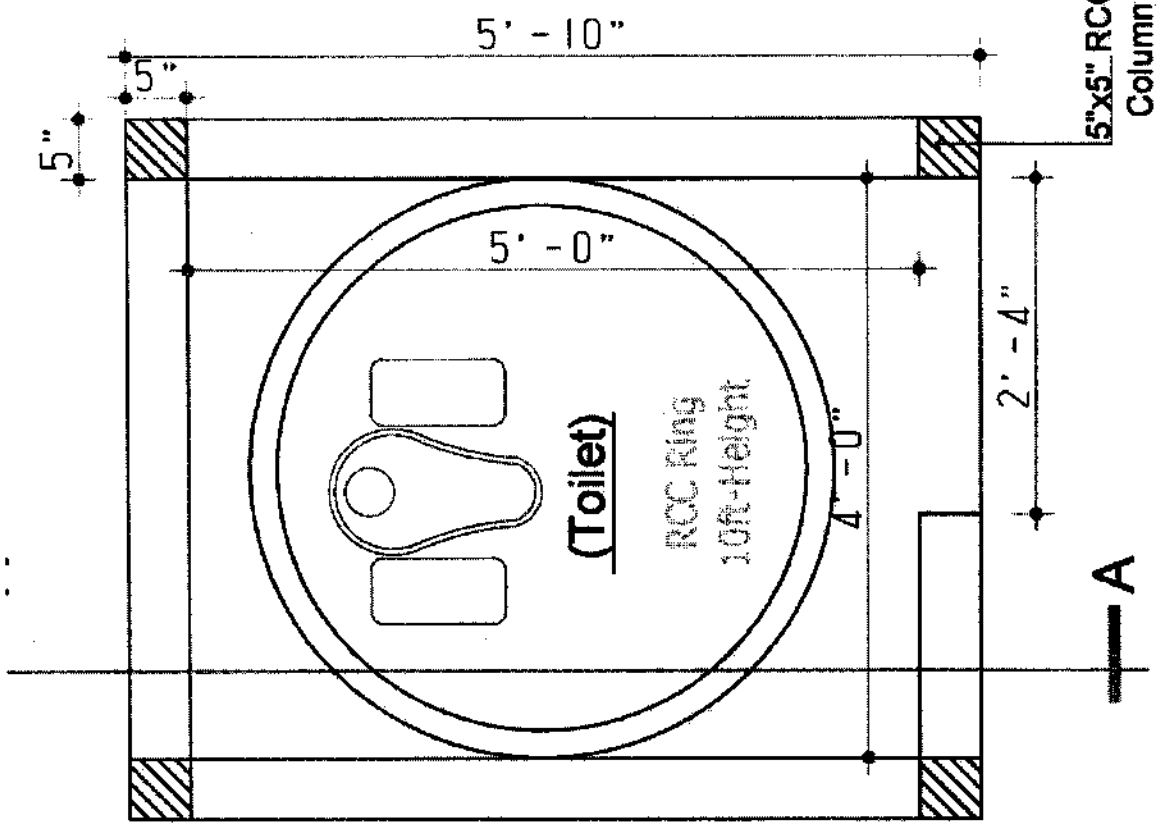
Approved By

26.02.18

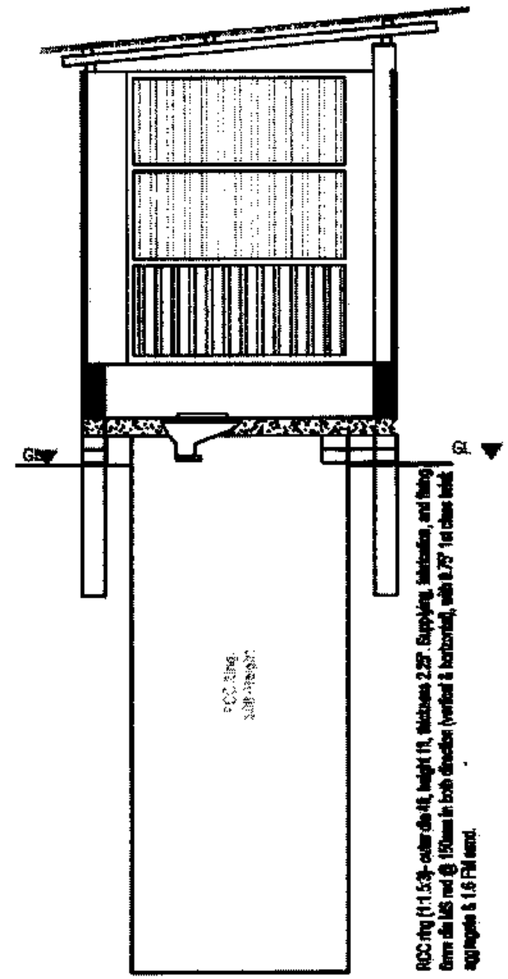
Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

3

Option 1



PLAN OF LATRINE WITH SINGLE CUBICLE



DIRECT PIT WITH SINGLE CUBICLE

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Plan of Latrine	17-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

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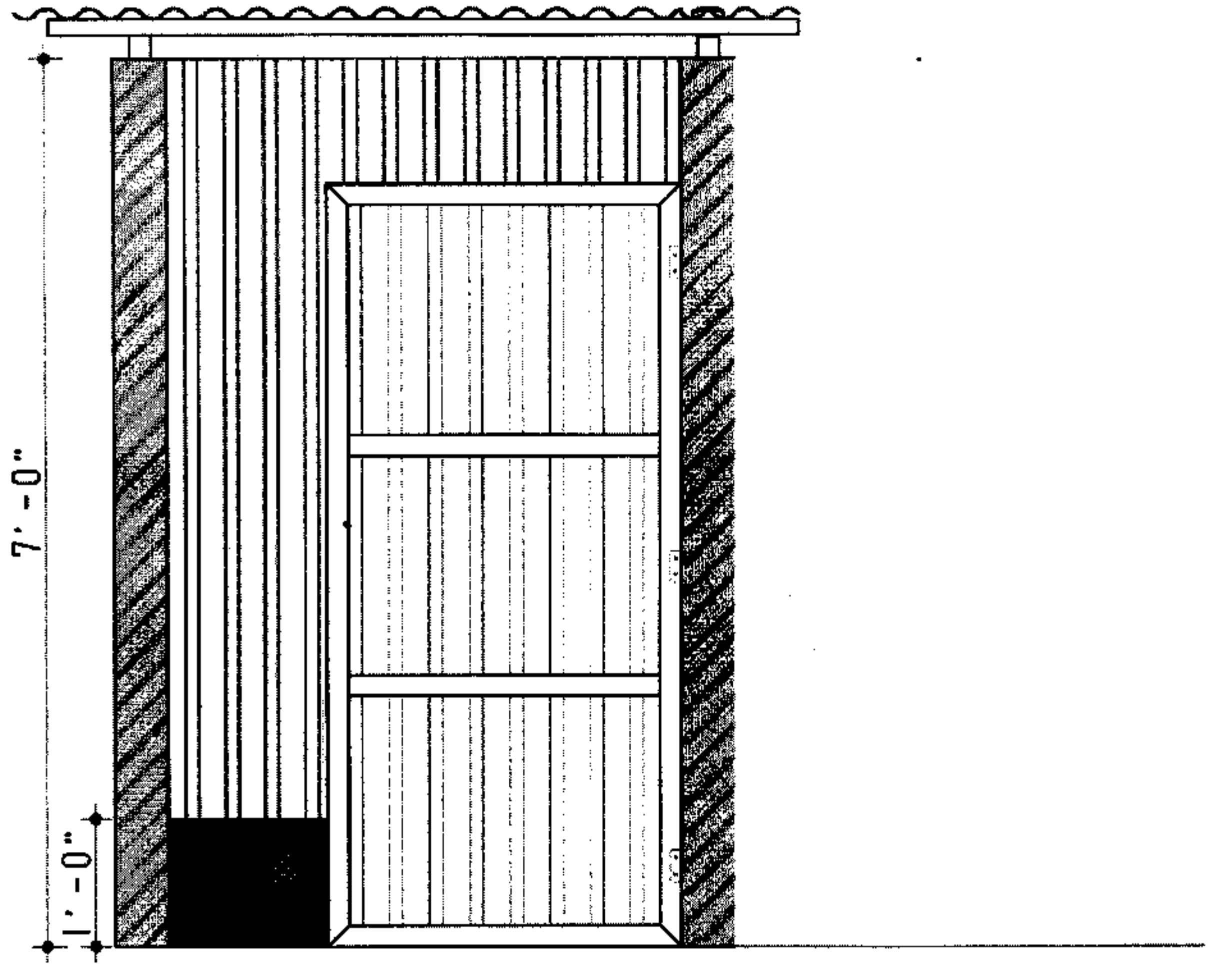

FRONT ELEVATION OF LATRINE

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Front Elevation	17-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

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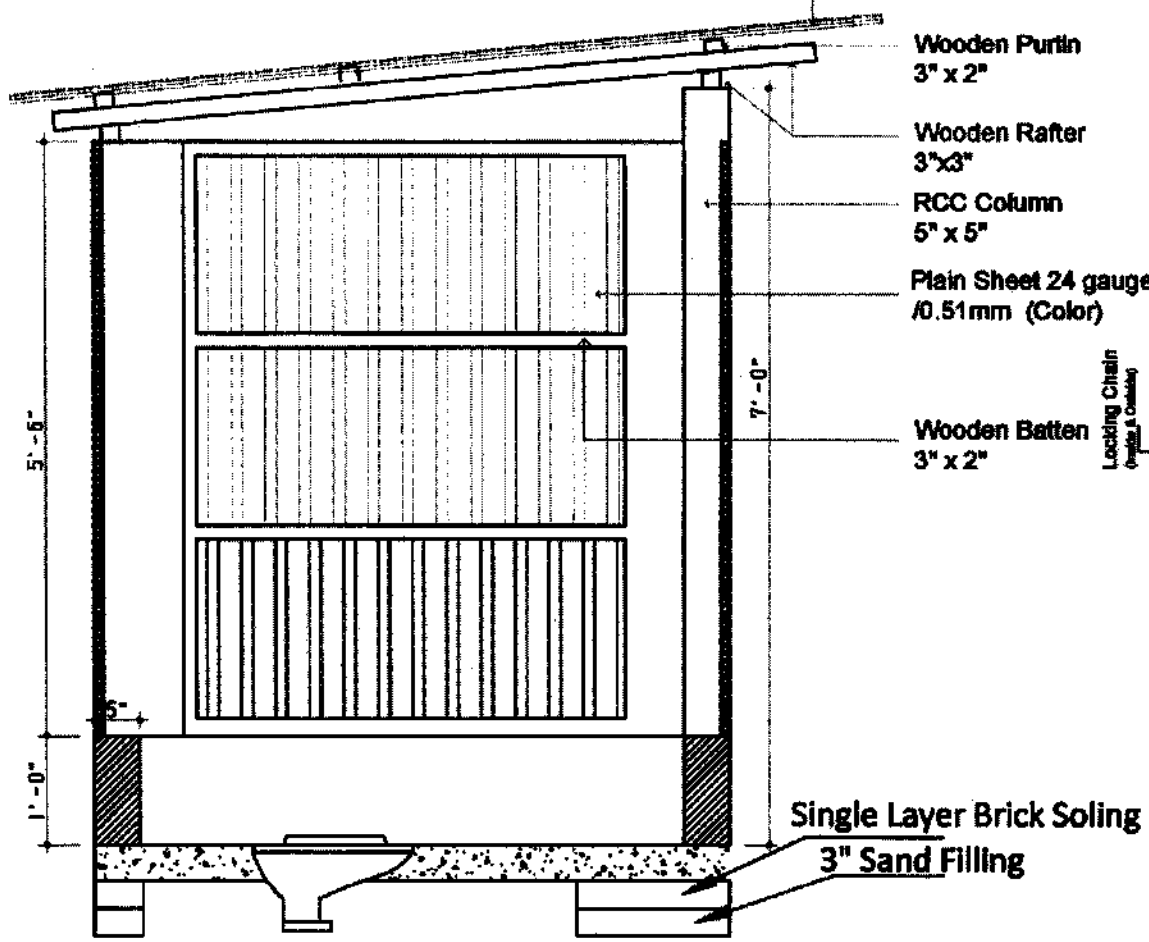
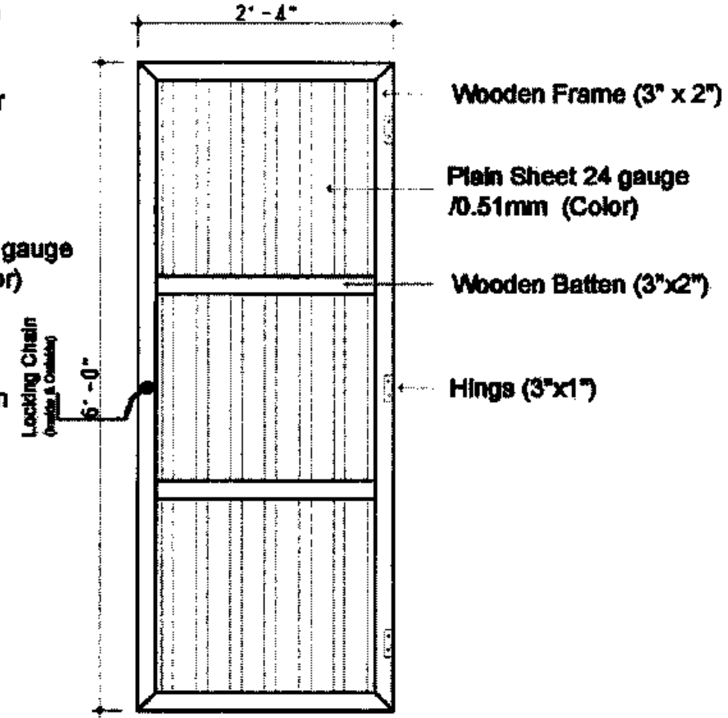
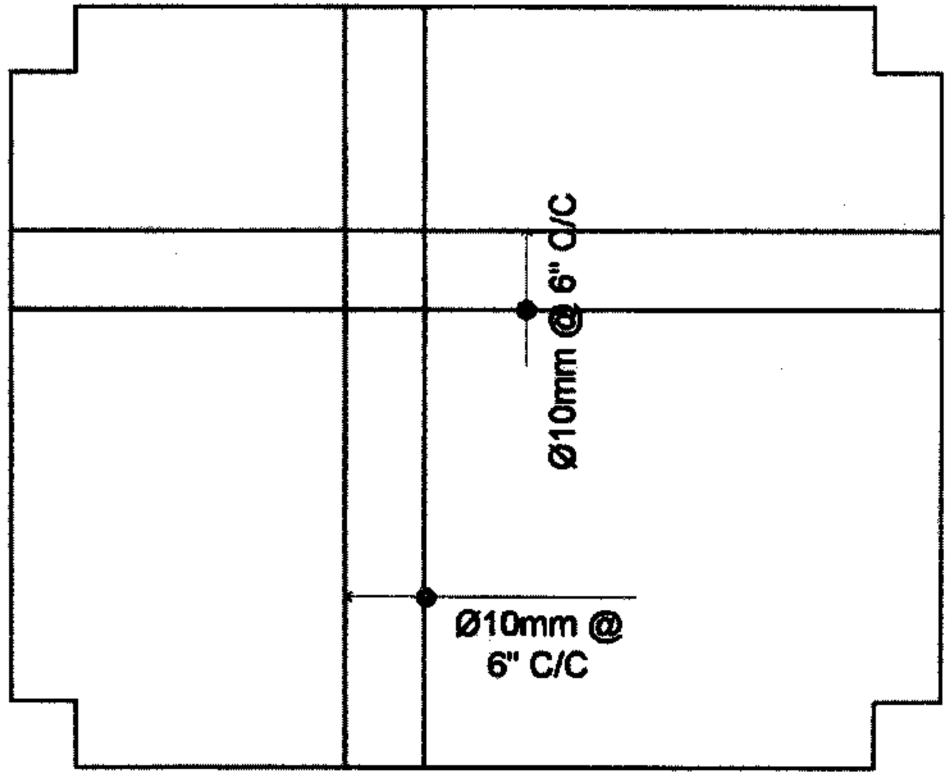


A-A Section

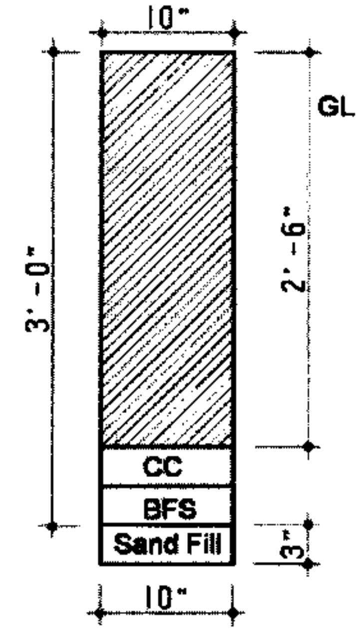


Door Elevation

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Section A-A	17-01-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

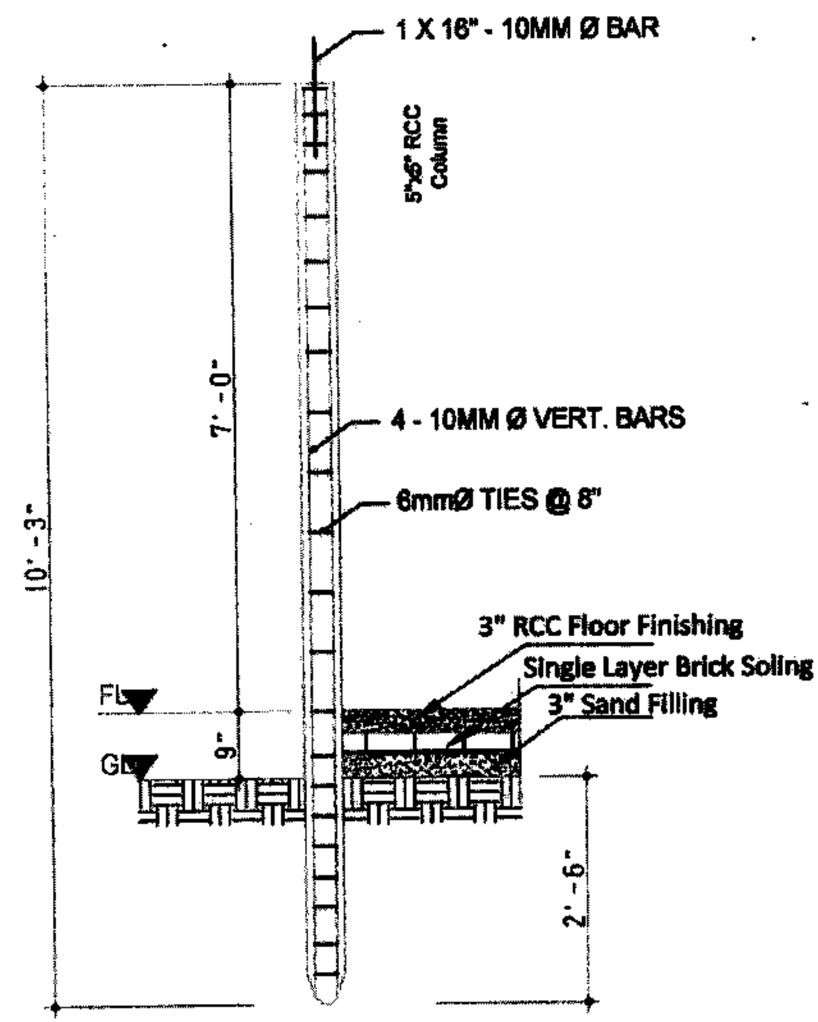


SLAB REINFORCEMENT



FOUNDATION

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Slab & Foundation Details	17-01-2018	04	UNHCR



DETAIL OF R.C.C POST

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Drawn by
WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed (UNHCR)	Murray Burt (UNHCR)	RCC Column Details	17-01-2018	05	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

Bill of Quantities

for the Direct Pit (Single) Latrine Construction

Latrine Option-2

Location: Cox's Bazar

Date: 25/01/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation of Foundation** for twin pit latrine, carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	cft	614.15	7	4299.07
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	7.80	22	171.59
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	20	5	100.00
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	15.60	31	483.57
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	5.15	236	1,214.84
6	**250mm (10") Brick work with mortar 1:4:** 10" Brick work with 1st class bricks in cement mortar (1:4)and making bond with connected walls & stair in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	65.82	168	11,057.59
7	**125mm (5") Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	38	70	2,660.00
8	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	180.00	18	3,240.00
9	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer.	sft	95.16	45	4,282.20
10	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	48	30	1,440.00

11	**Wood Work (Gorjon/Akashmoni/Mehogini):** Timber used for wood work shall be well seasoned, kiln dry containing not more than 8% to 12 % moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, shakes, saps, upsets, wane edge and twisted fiber. It shall also be free from all disease such as decay, wet rot, dry rot and woodworms and white and timber should be finished to the exact dimension shown on the drawing or as per Engineer direction.	cft	7.3	1200	8,760.00
12	**Supply, fittings & fixing of 48" dia. RCC Ring**, 2.25" thickness and 6 mm bar used as reinforcement as per the drawing and instruction of EIC.	Nos	20	950	19,000.00
13	**Sato pan** with footrest with good quality	Nos	1	200	200.00
14	Supply, fittings & fixing of pre-cast 48" ring cover thikness-3" made of 1:2:4 mixing ratio, 8mm dia ms rod (60G) 6" C/C both way as per the drawing and instruction of EIC.	Nos	2	750	1,500.00
15	10ft 3inch height pre-cast pile (5" x 5" size) with reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 Mpa, and satisfying specified compressive strength f'c = 25 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM best quality coarse sand (F.M.2.2), 20 mm down well graded stone chips conforming to ASTM C-33, mixing in standard mixture machine and centering and shuttering with M.S sheet, M.S angle, F.I bar, nuts and bolts, preparation of bed, laying polythene, placing of reinforcement cage in position, casting, compacting by vibrators and tapered rods, curing for 28 days etc. including cost of reinforcement, water, electricity and other charges as per design and drawing, etc. all complete as per design, drawing and accepted by the Engineer.	Nos	4	500	2,000.00
16	**Other Supplies & Accessories**				
a	Stud Nail (2.5 inch)	kg	2	80	160.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
c	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	PVC pipe (1.5 dia) Gas Pipe	ft	20	25	500.00
h	uPVC Long Trap (4" dia)	Nos	1	250	250.00
i	uPVC pipe (3" dia)	ft	20	75	1,500.00
	Grand Total (BDT) =				**63,639**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

26.2.18

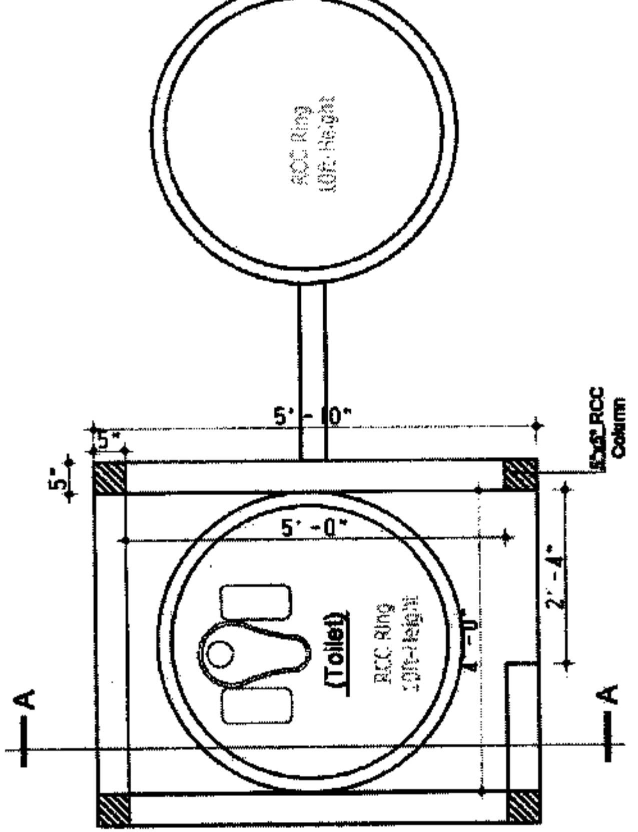
Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

Approved By

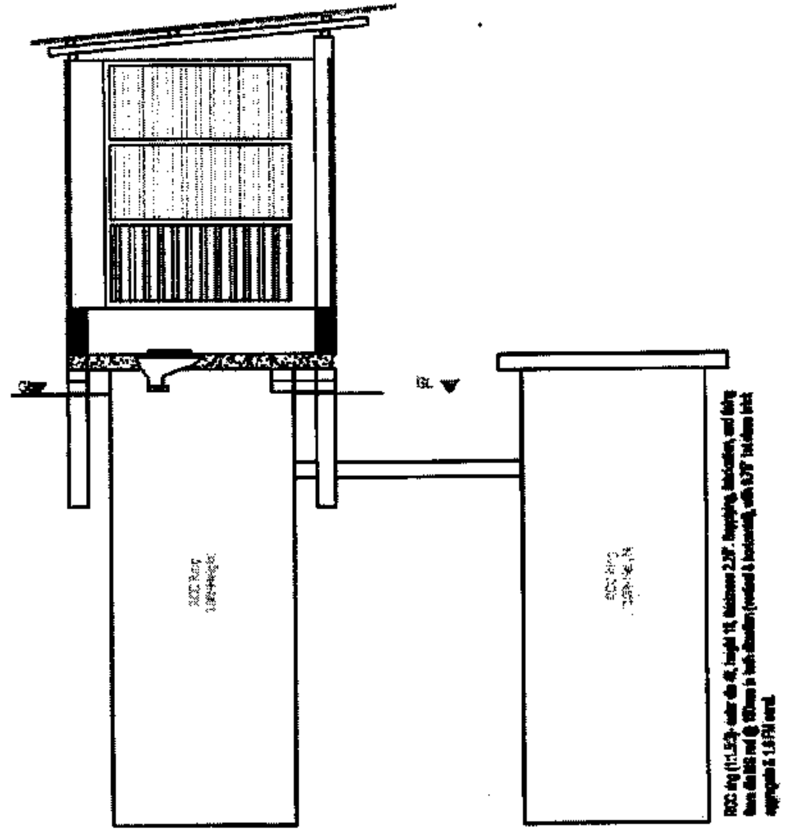
26.02.18

Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

Option 2

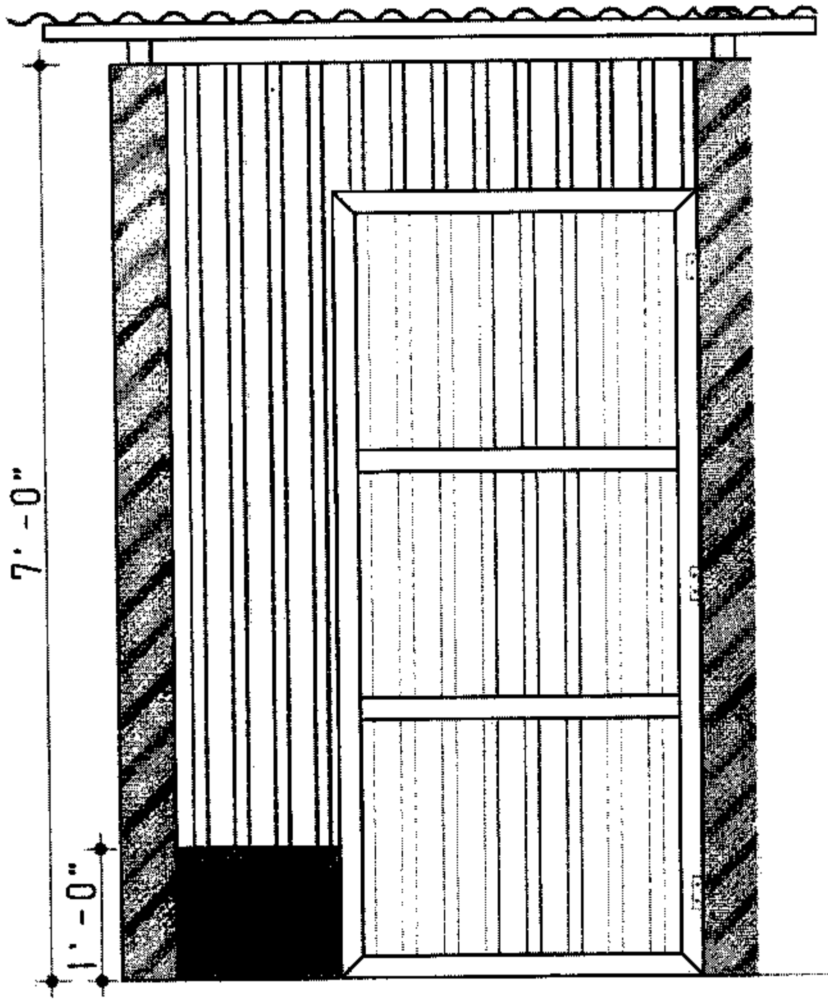


PLAN OF DIRECT LATRINE WITH SINGLE CUBICLE



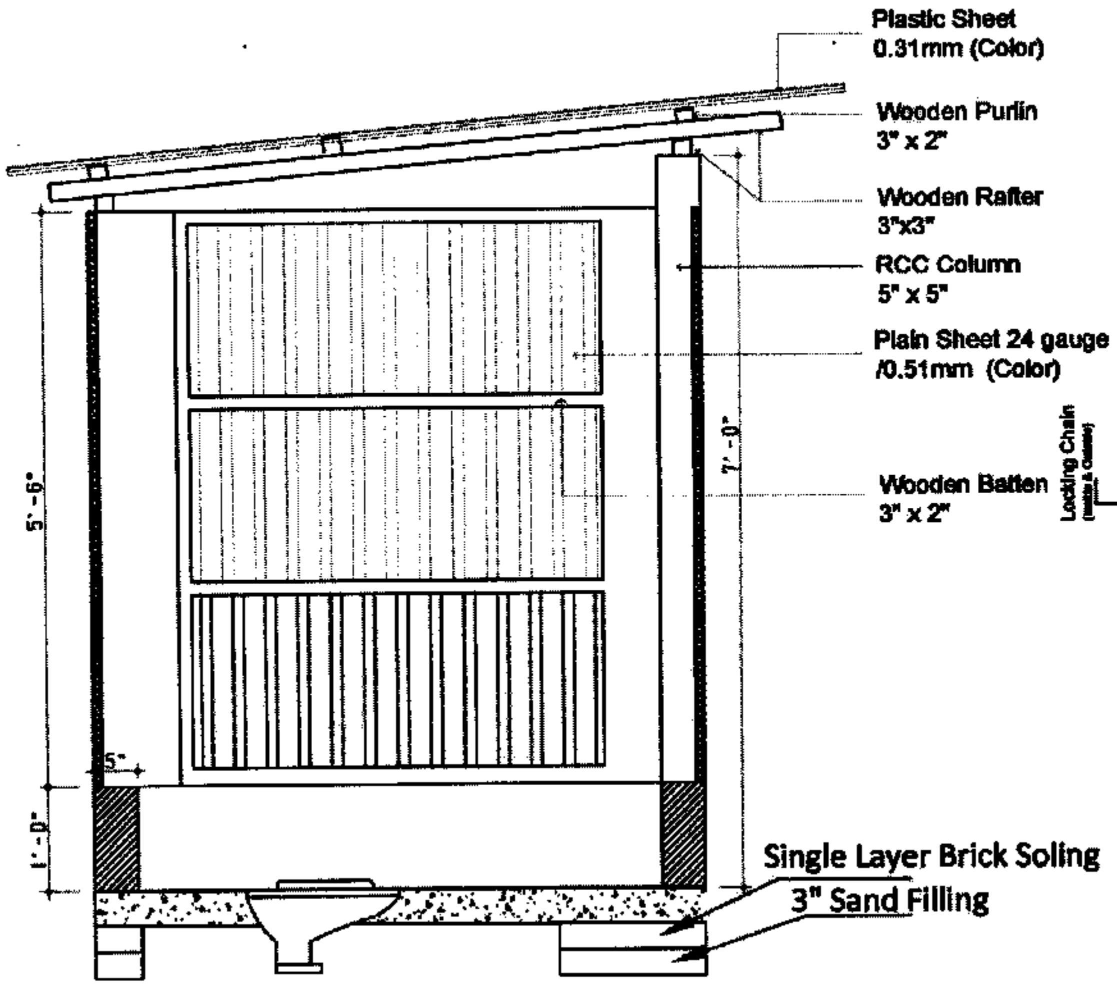
DIRECT PIT WITH SOAK PIT (SINGLE CUBICLE)

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit with Soak Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNCHR	Plan of Latrine	17-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

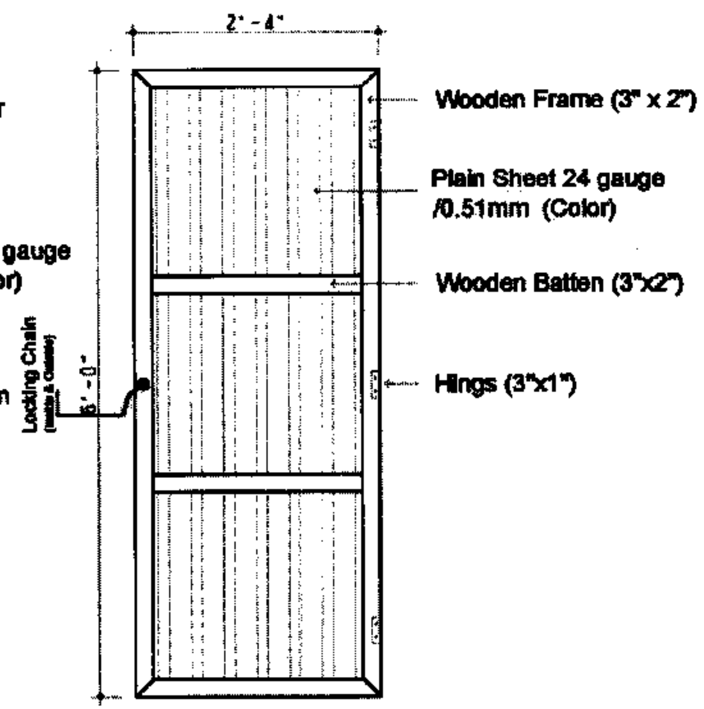


FRONT ELEVATION OF LATRINE

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit with Soak Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNCHR	Front Elevation	17-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

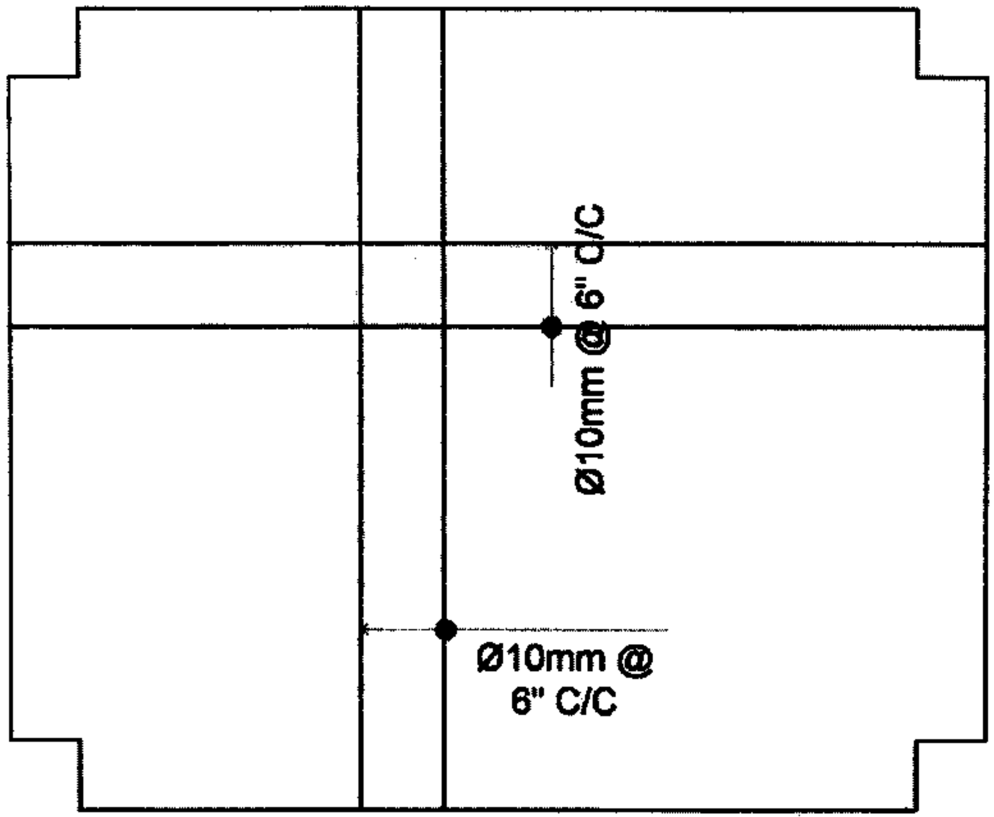


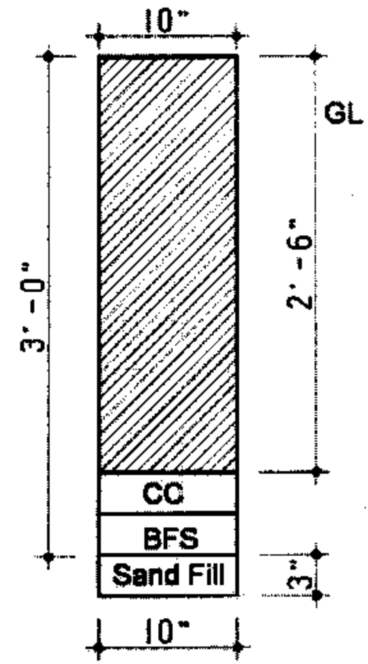
A-A Section



Door Elevation

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit with Soak Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNCHR	Section A-A	17-01-2018	03	UNHCR United Nations High Commissioner for Refugees / Haut Commissariat des Nations Unies pour les réfugiés

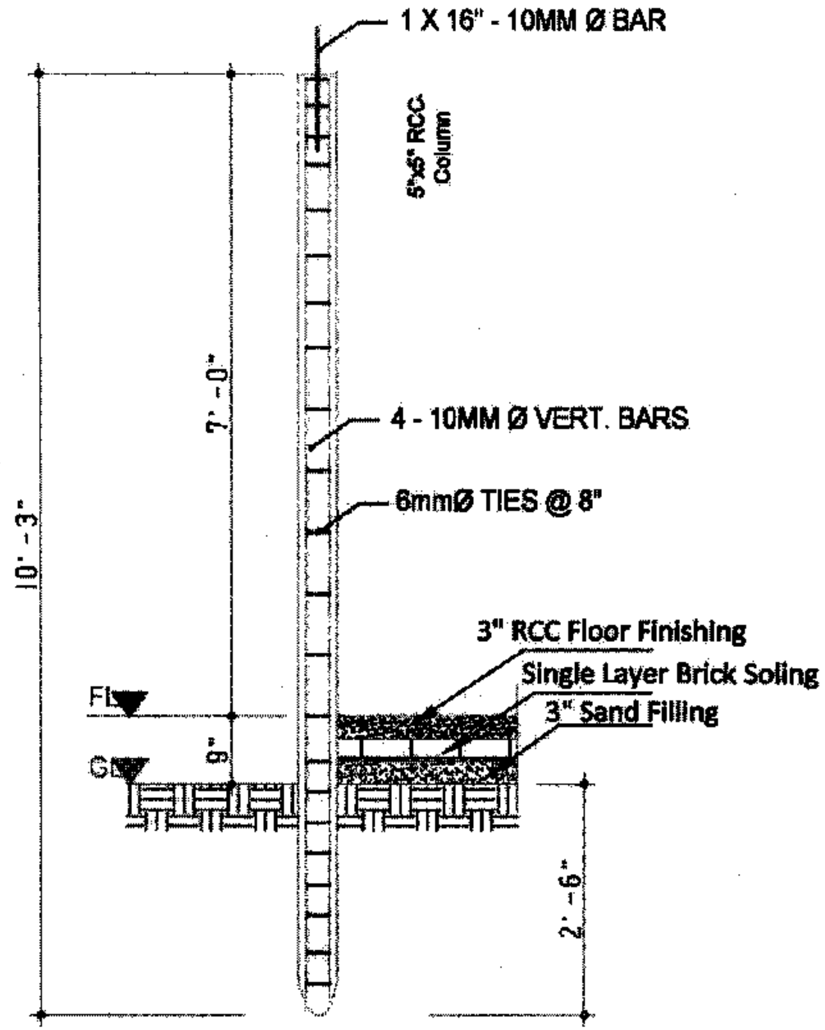




FOUNDATION

SLAB REINFORCEMENT

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit with Soak Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNCHR	Slab & Foundation Details	17-01-2018	04	UNHCR United Nations High Commissioner for Refugees



DETAIL OF R.C.C POST

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine (Oxfam Model)	Single Cubicle with Direct Pit with Soak Pit	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNCHR	RCC Column Details	17-01-2018	05	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

Bill of Quantities
for the Twin Pit Latrine Construction
Latrine Option-3

Location: Cox's Bazar

Date: 10/01/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation of Foundation** for twin pit latrine, carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cft	450	7	3150.00
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	30	22	660.00
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	20	5	100.00
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	38	31	1,178.00
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	18.2	236	4,295.20
6	**Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4)and making bond with connected walls & stair in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	3.36	190	638.40
7	**125mm (5") Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	11	70	770.00
8	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, plastering work on the outer surface of precast column ,all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	174	18	3,132.00
9	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer.	sft	56	45	2,520.00
10	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	138	30	4,140.00

11	**Wood Work (Gorjon/Akashmoni/Mehogini):** Timber used for wood work shall be well seasoned, kiln dry containing not more than 8% to 12 % moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, shakes, saps, upsets, wane edge and twisted fiber. It shall also be free from all disease such as decay, wet rot, dry rot and woodworms and white and timber should be finished to the exact dimension shown on the drawing or as per Engineer direction.	cft	7.2	1200	8,640.00
12	10ft 6 inch height pre-cast pile (5" x 5" size) with reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 Mpa, and satisfying specified compressive strength f'c = 25 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM best quality coarse sand (F.M.2.2), 20 mm down well graded stone chips conforming to ASTM C-33, mixing in standard mixture machine and centering and shuttering with M.S sheet, M.S angle, F.I bar, nuts and bolts, preparation of bed, laying polythene, placing of reinforcement cage in position, casting, compacting by vibrators and tapered rods, curing for 28 days etc. including cost of reinforcement, water, electricity and other charges as per design and drawing, etc. all complete as per design, drawing and accepted by the Engineer.	Nos	4.00	950.00	3,800.00
13	**Supply, fittings & fixing of 48" dia. RCC Ring**, 2.25" thickness and 6 mm bar used as reinforcement as per the drawing and instruction of EIC.	Nos	20	950	19,000.00
14	**Sato pan** with footrest with good quality	Nos	1	200	200.00
15	Supply, fittings & fixing of pre-cast ring cover 5'x4', thikness-3" made of 1:2:4 mixing ratio, 8mm dia ms rod (60G) 6" C/C both way as per the drawing and instruction of EIC.	Nos	2	750	1,500.00
16	**Other Supplies & Accessories fitting, fixing & supplying**				
a	Stud Nail (2.5 inch)	kg	2	80	160.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
c	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	PVC pipe (1.5 dia) Gas Pipe	ft	20	25	500.00
h	uPVC Long Trap (4" dia)	Nos	1	250	250.00
i	uPVC pipe (4" dia)	ft	20	85	1,700.00
	Grand Total (BDT) =				**57,154**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

26.2.18

Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

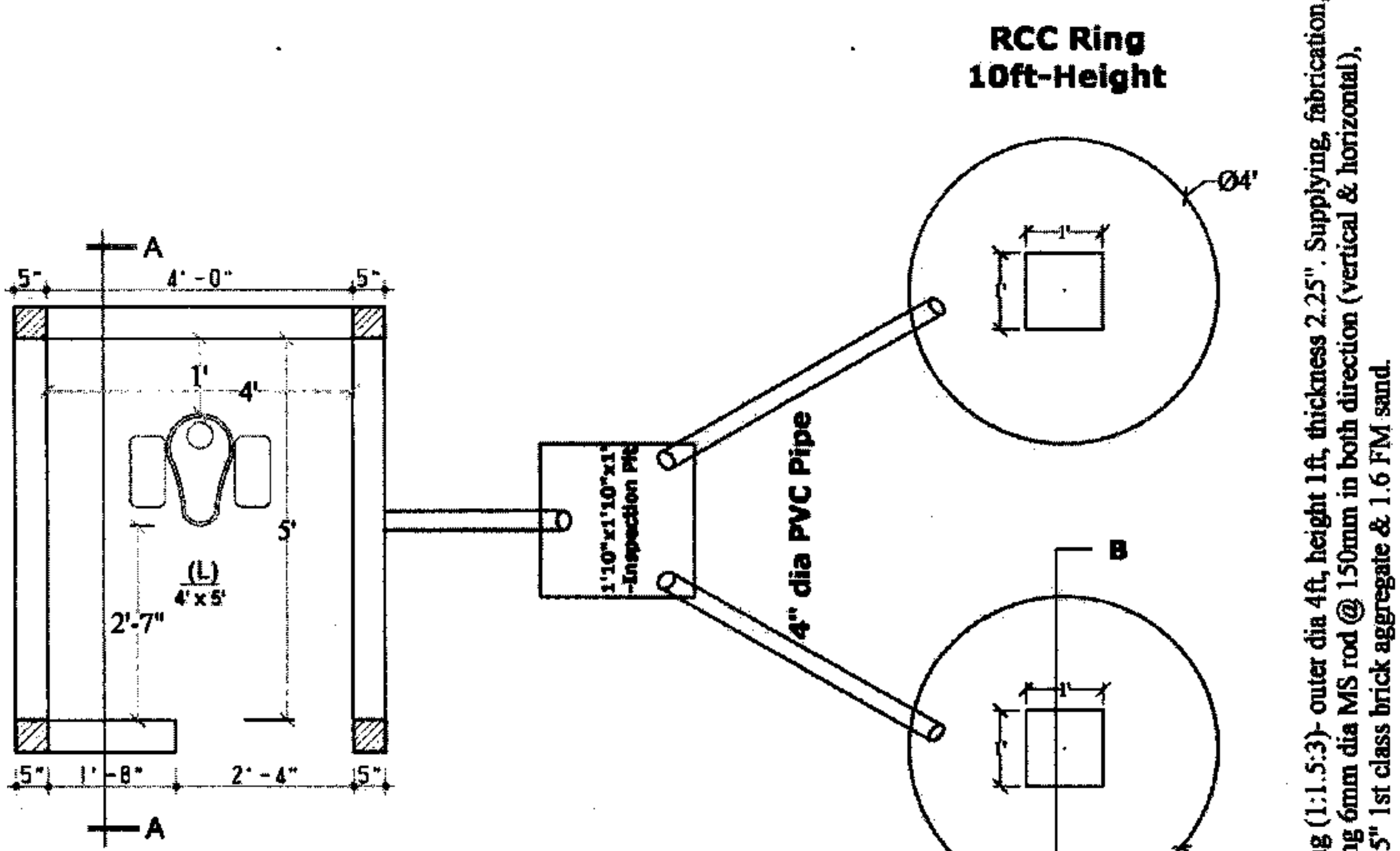
Approved By

26.02.18

Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

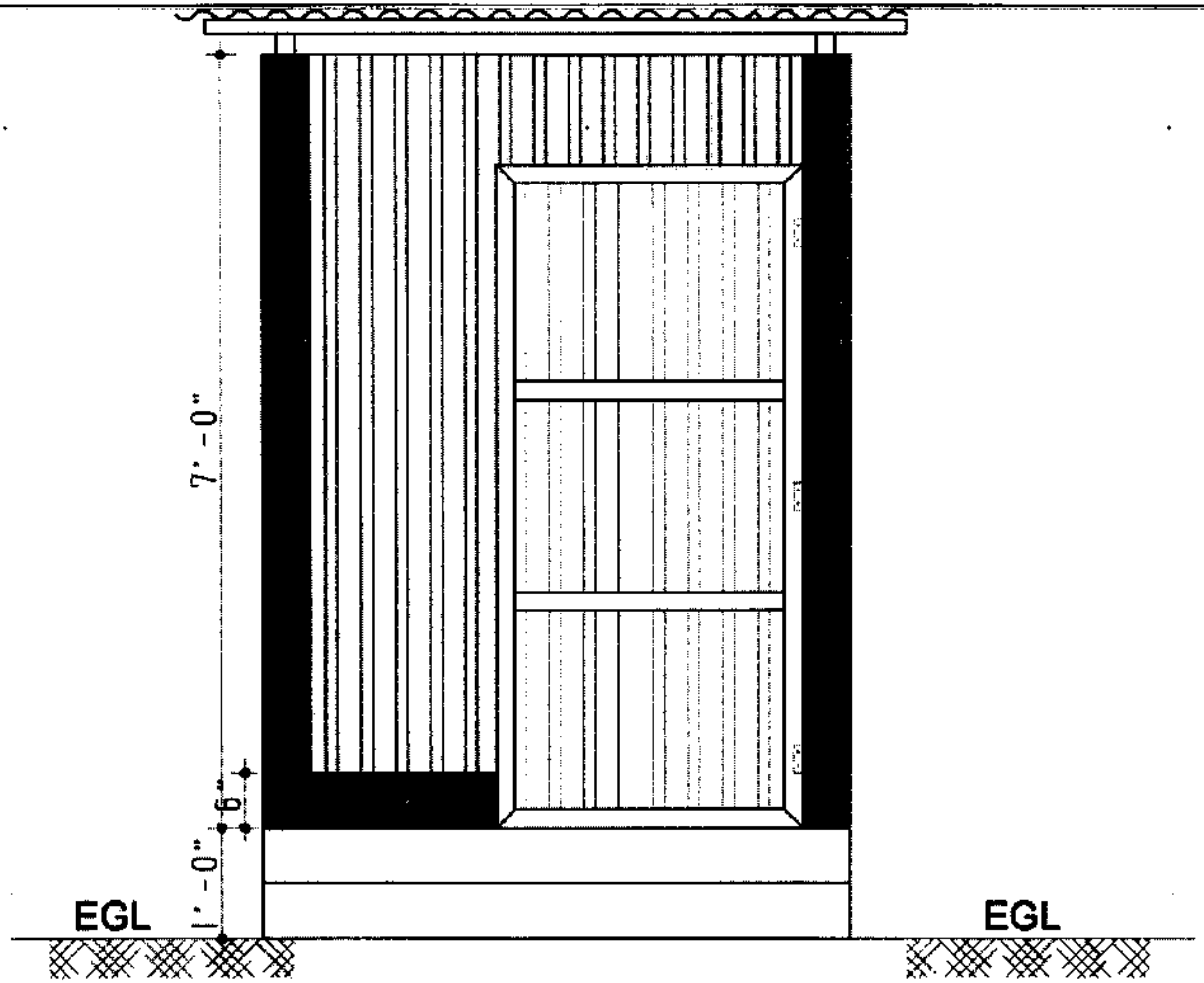
17

Option 3



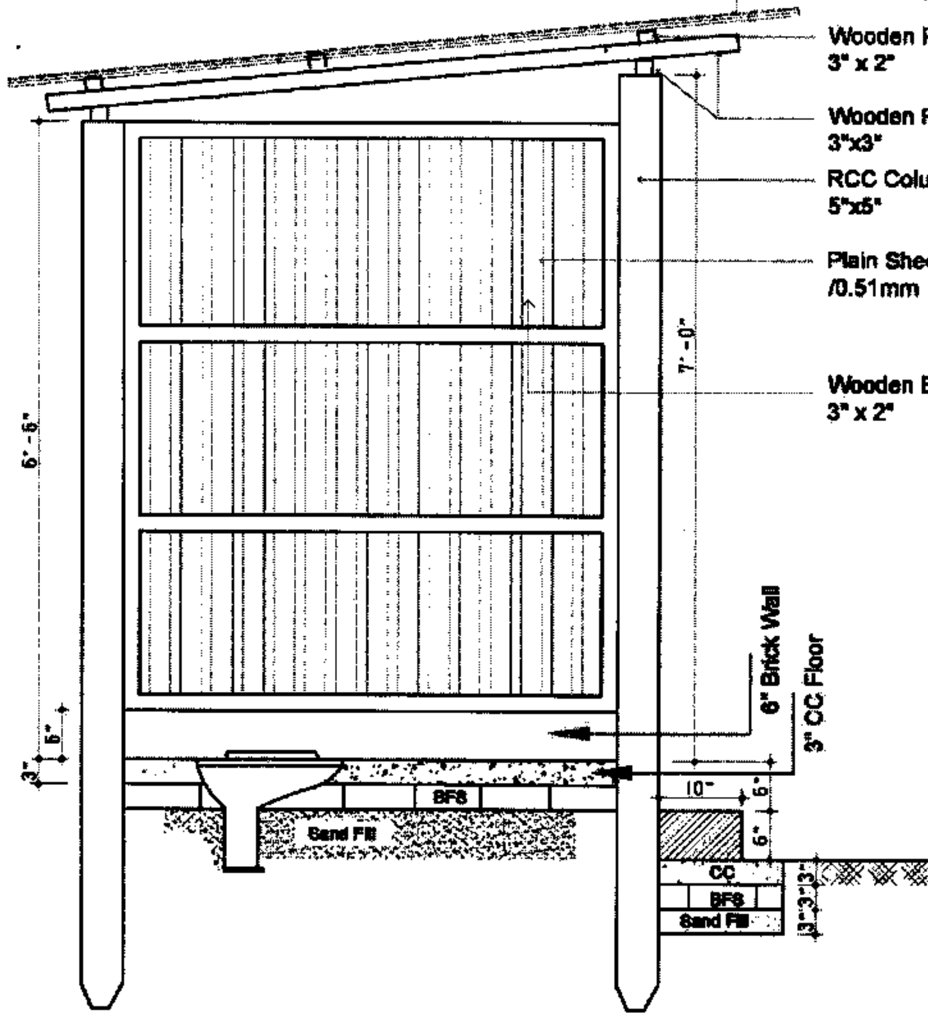
PLAN OF LATRINE WITH TWIN PIT

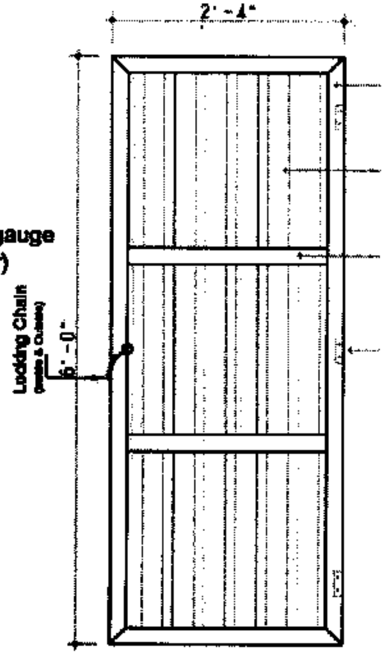
		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit with Single Cubicle	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan of Latrine	08-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



FRONT ELEVATION OF LATRINE

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit with Single Cubicle	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Elevation of Latrine	08-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



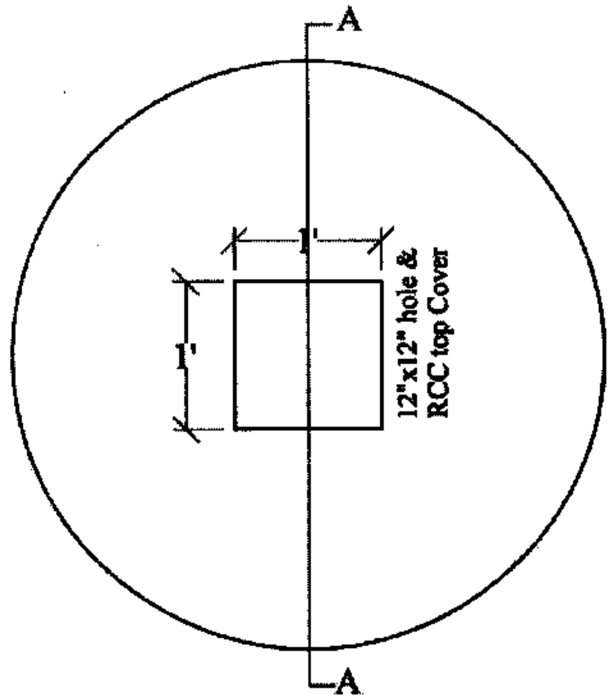


Door Elevation

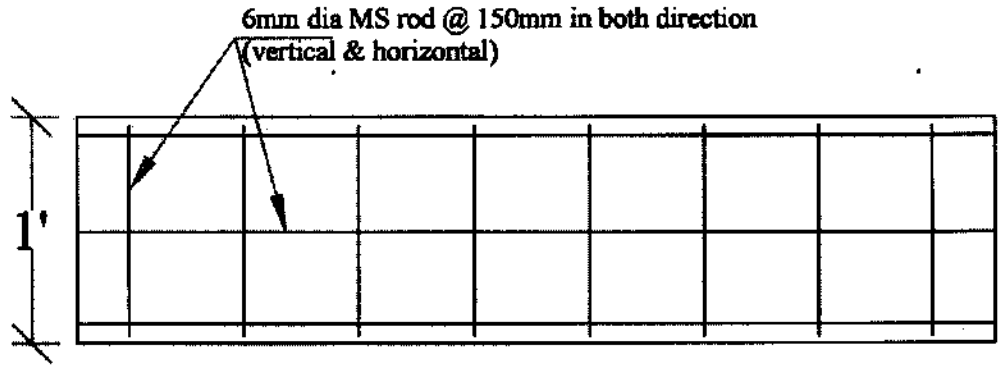
A-A SECTION

Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Latrine	Twin pit with Single Cubicle	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section of Latrine	08-01-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

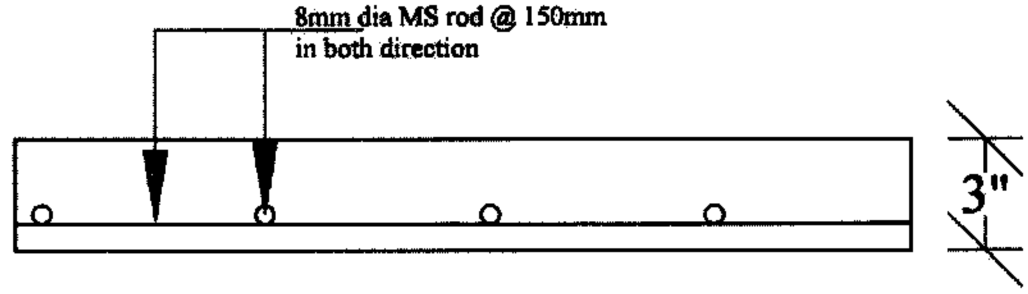
WASH Sector Cox's Bazar



Plan: Top Slab of Ring

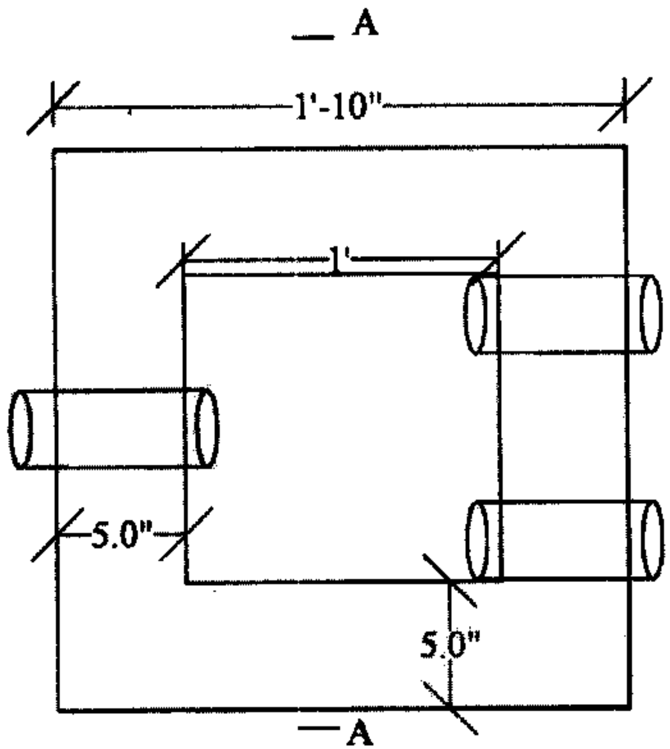


Section: BB (Ring)

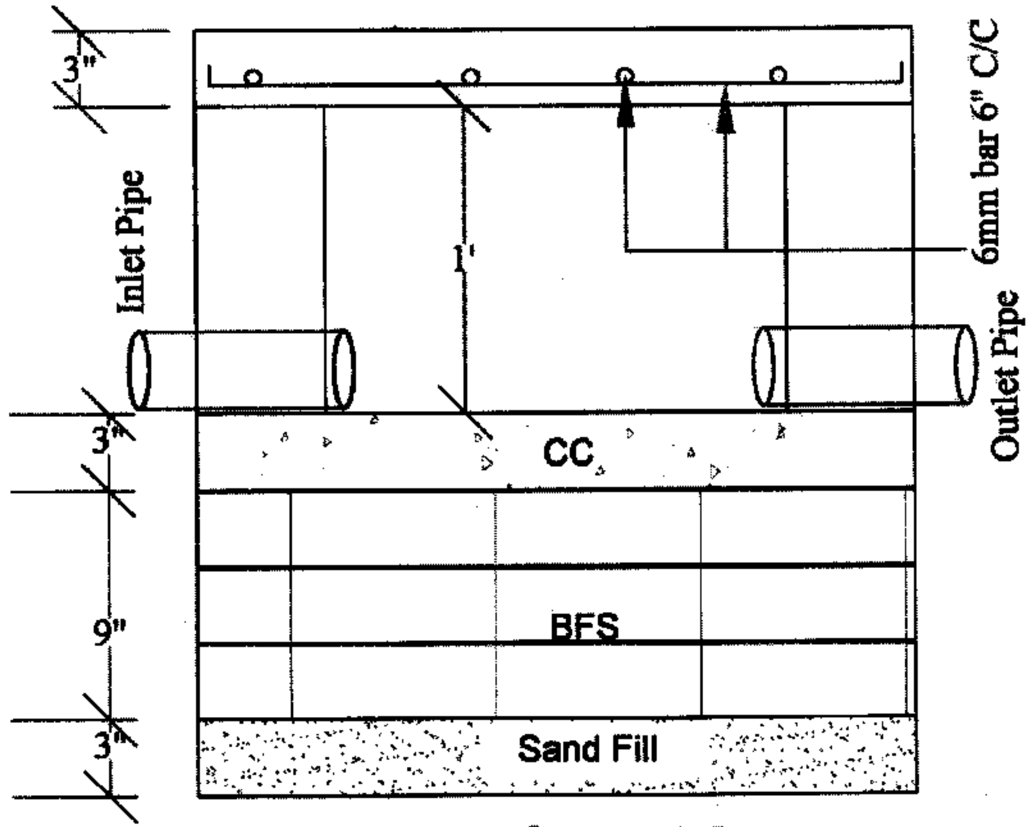


Section: AA (Top Slab of Ring)

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit with Single Cubicle	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Ring & Top Slab Detail	08-01-2018	04	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

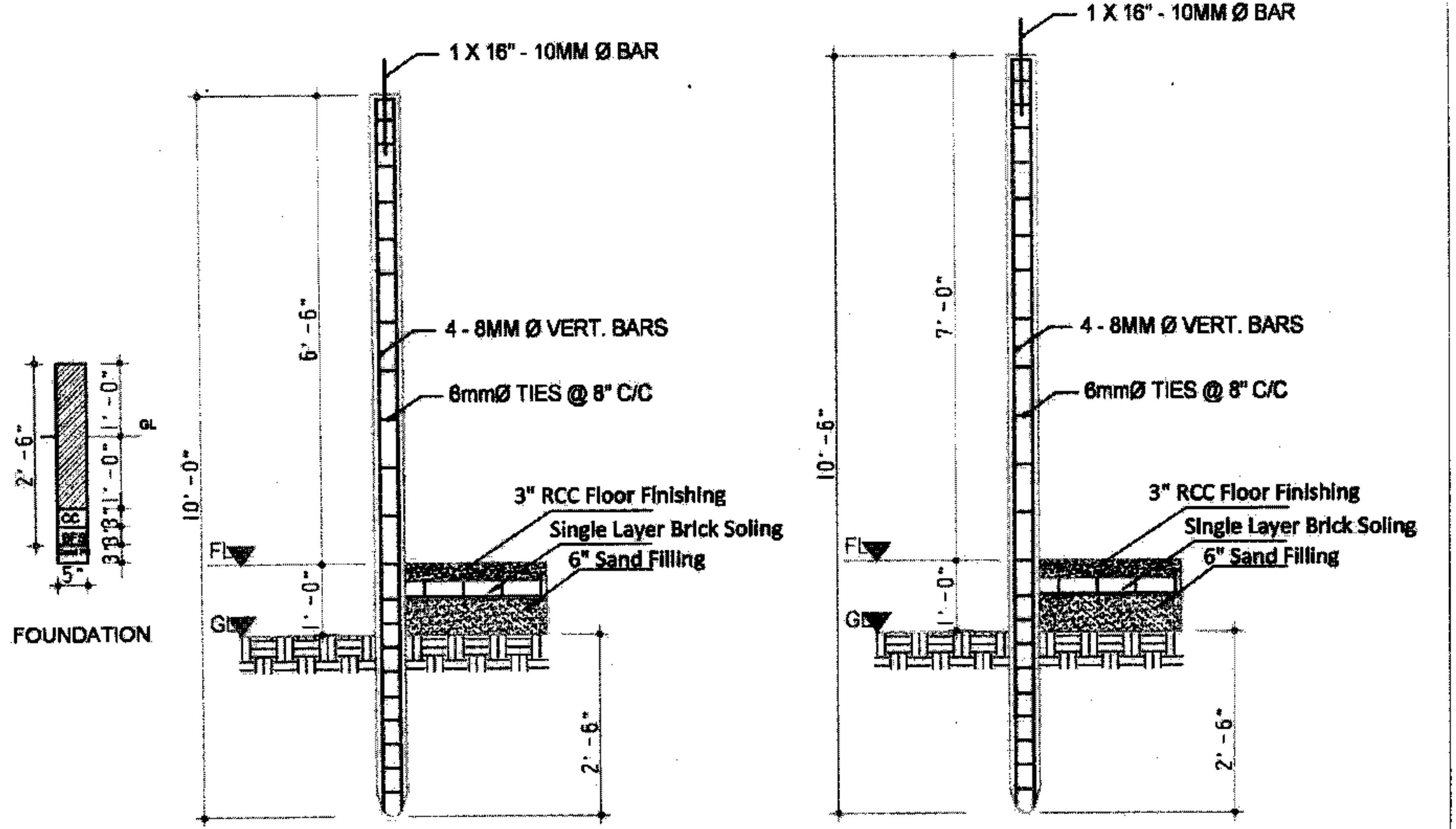


Plan: Inspection Pit



Section: AA

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit with Single Cubicle	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Inspection Pit Details	08-01-2018	05	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



DETAIL OF R.C.C POST

Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Latrine	Twin pit with Single Cubicle	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Precast Column & Foundation Details	08-01-2018	06	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

WASH Sector Cox's Bazar

Bill of Quantities

for the Twin Pit Latrine Direct Construction

Latrine Option-4A

Location: Cox's Bazar

Date: 10/01/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation of Foundation** for twin pit latrine, carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cft	520.00	7	3640.00
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	36	22	792.00
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	36	5	180.00
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	48.32	31	1,497.92
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	19.83	236	4,678.70
6	**Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4)and making bond with connected walls & stair in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	42.78	190	8,128.20
9	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, plastering work on the outer surface of precast column ,all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	127.05	18	2,286.90
10	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer.	sft	72	45	3,240.00
11	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	190.58	30	5,717.40

12	**Wood Work (Gorjon/Akashmoni/Mehogini):** Timber used for wood work shall be well seasoned, kiln dry containing not more than 8% to 12 % moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, shakes, saps, upsets, wane edge and twisted fiber. It shall also be free from all disease such as decay, wet rot, dry rot and woodworms and white and timber should be finished to the exact dimension shown on the drawing or as per Engineer direction.	cft	9.67	1200	11,604.00
13	10ft 6 inch height pre-cast pile (5" x 5" size) with reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 Mpa, and satisfying specified compressive strength f'c = 25 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM best quality coarse sand (F.M.2.2), 20 mm down well graded stone chips conforming to ASTM C-33, mixing in standard mixture machine and centering and shuttering with M.S sheet, M.S angle, F.I bar, nuts and bolts, preparation of bed, laying polythene, placing of reinforcement cage in position, casting, compacting by vibrators and tapered rods, curing for 28 days etc. including cost of reinforcement, water, electricity and other charges as per design and drawing, etc. all complete as per design, drawing and accepted by the Engineer.	Nos	7.00	950.00	6,650.00
14	**Supply, fittings & fixing of 48" dia. RCC Ring,** 2.25" thickness and 6 mm bar used as reinforcement as per the drawing and instruction of EIC.	Nos	20	950	19,000.00
15	**Sato pan** with footrest with good quality	Nos	2	200	400.00
16	Supply, fittings & fixing of pre-cast half circle (4 ft dia) ring cover, thikness-3" made of 1:2:4 mixing ratio, 8mm dia ms rod (60G) 6" C/C both way as per the drawing and instruction of EIC.	Nos	2	350	700.00
17	Supplying and fabrication of M.S. bar reinforcement of required size and length for all types of RCC slab including straightening the rod, removing rust, cleaning, cutting, hooking, bending, binding with supply of 22 B.W.G GI wire, placing in position including lapping spacing and securing them in position by concrete blocks (1:1) including cost of all materials, labor to complete the work as per specifications, drawings and to the satisfaction of the EIC.	Kg	19.50	85.00	1,657.50
18	**Other Supplies & Accessories fitting, fixing & supplying**				
a	Stud Nail (2.5 inch)	kg	3	80	240.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	8	100	800.00
c	Nail Different size (1.5 to 4 inch)	kg	2	80	160.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	uPVC Long Trap (4" dia)	Nos	1	250	250.00
	Grand Total (BDT) =				**71,923**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

26-2-18

Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

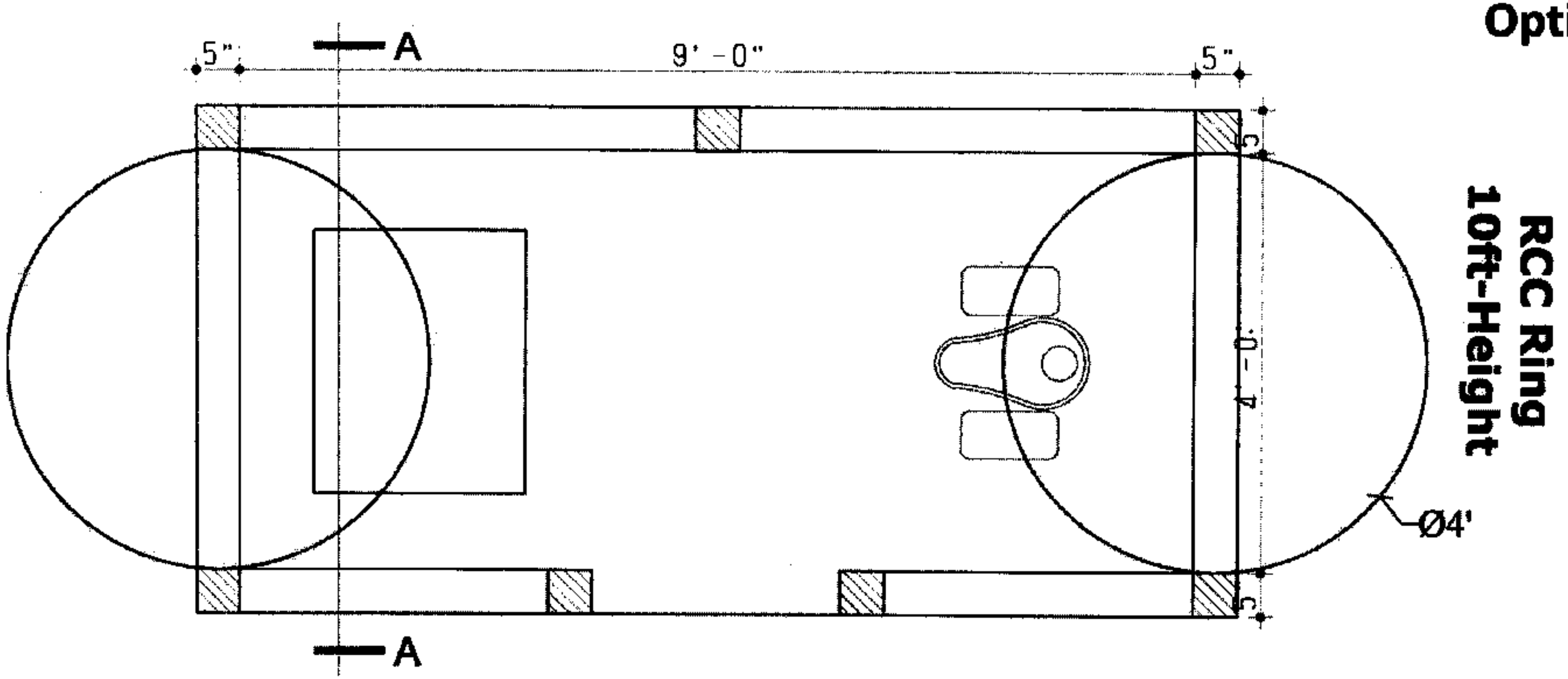
Approved By

26.02.18

Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

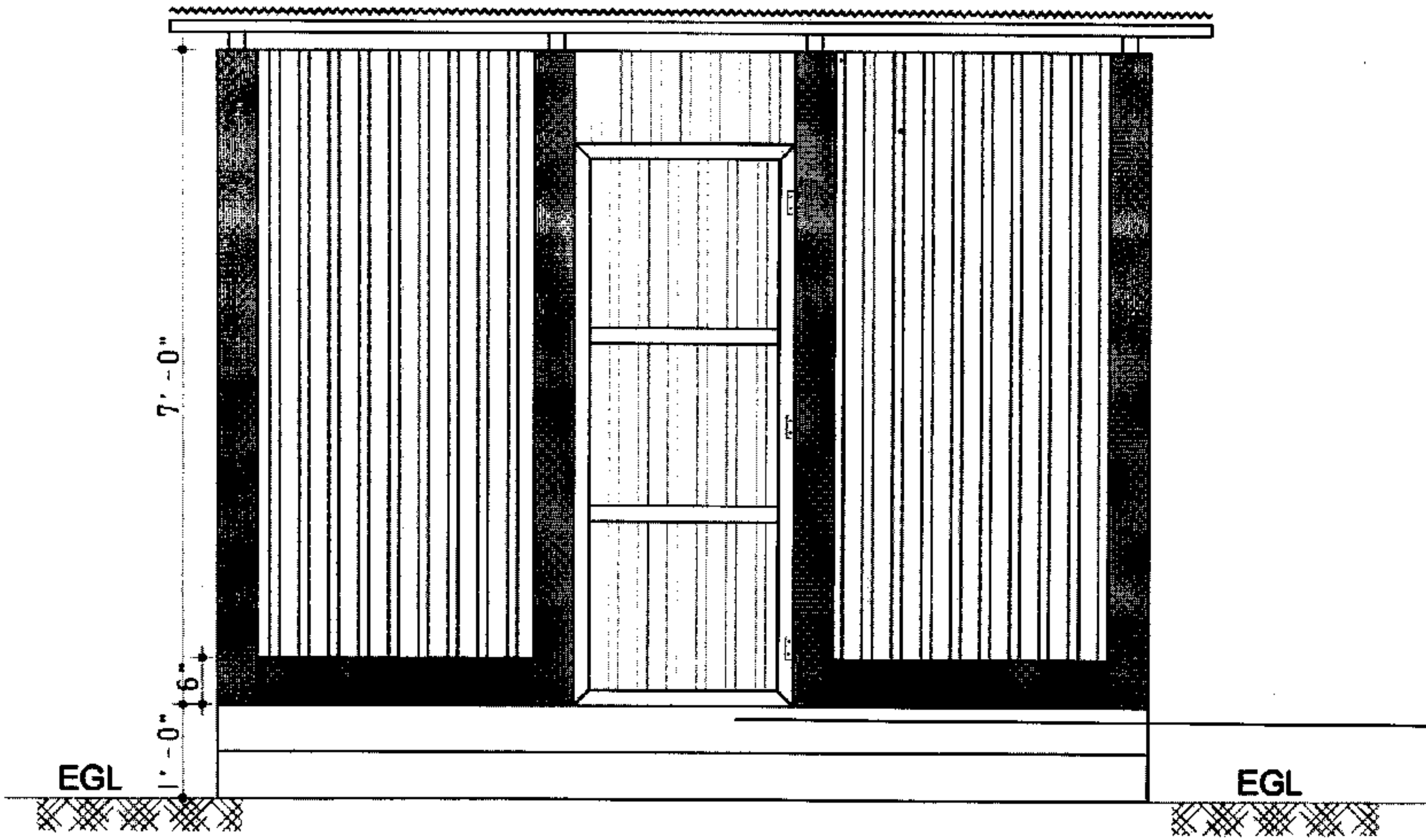
RCC ring (1:1.5:3)- outer dia 4ft, height 1ft, thickness 2.25". Supplying, fabrication, and fixing 6mm dia MS rod @ 150mm in both direction (vertical & horizontal), with 0.75" 1st class brick aggregate & 1.6 FM sand.

Option 4A



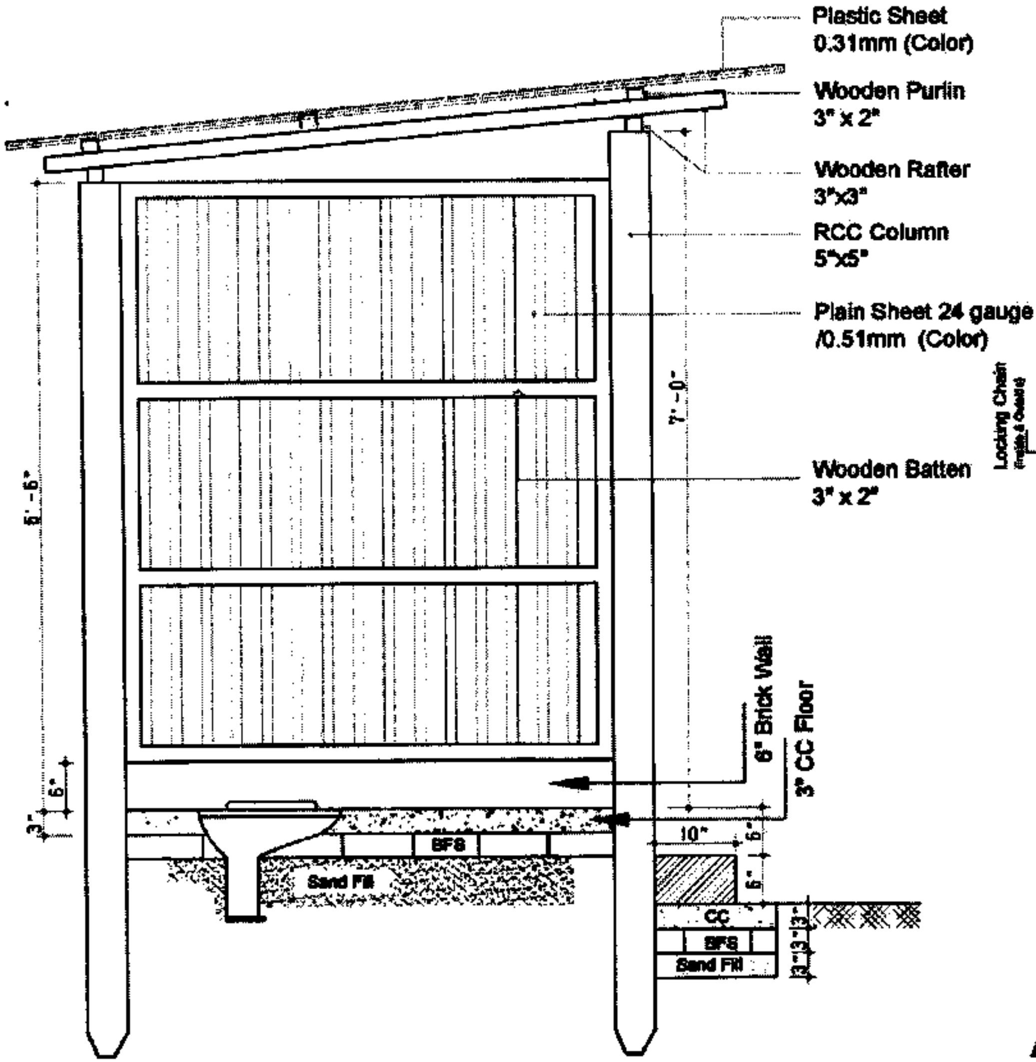
PLAN OF LATRINE WITH TWIN PIT

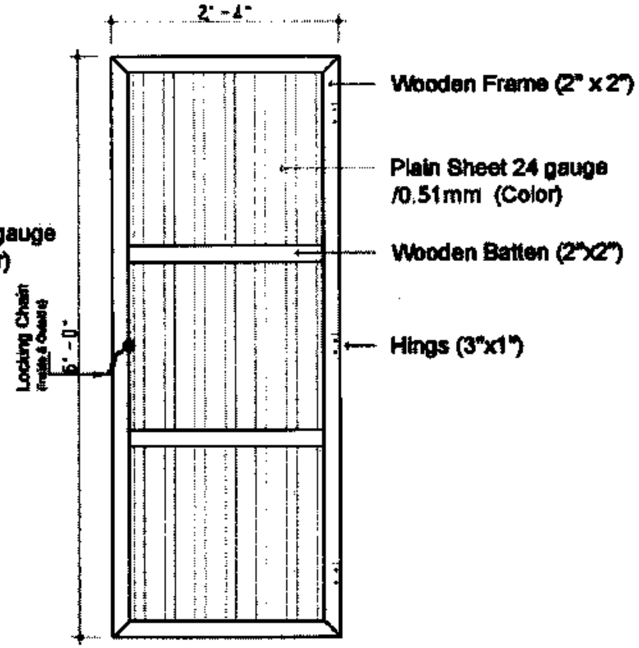
		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan of Latrine	08-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



FRONT ELEVATION OF LATRINE

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Elevation of Latrine	08-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

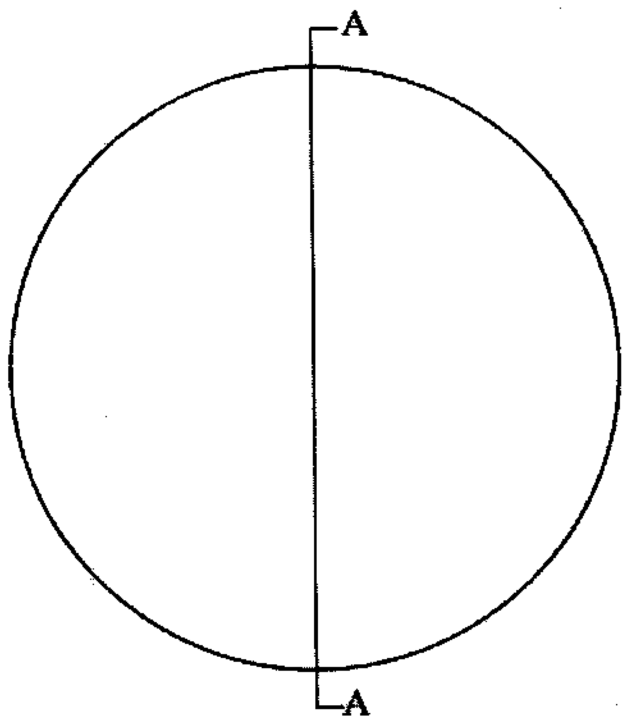




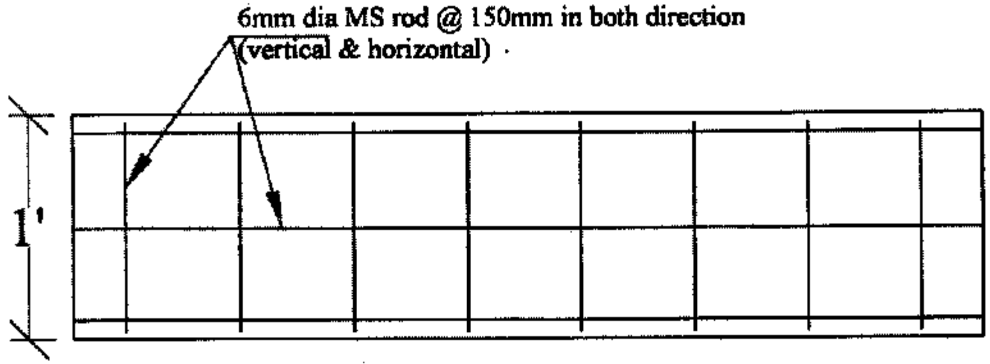
Door Elevation

A-A SECTION

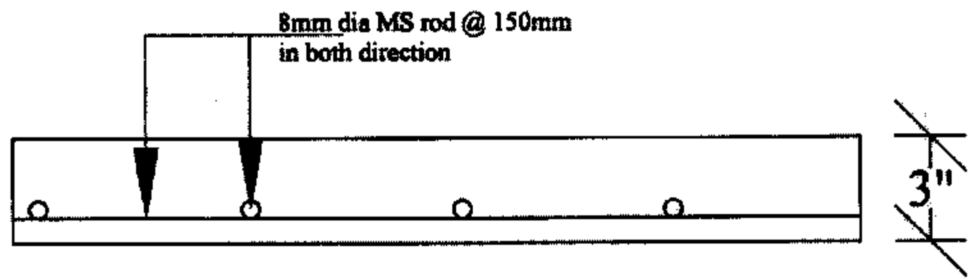
		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section of Latrine	08-01-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



Plan: Top Slab of Ring

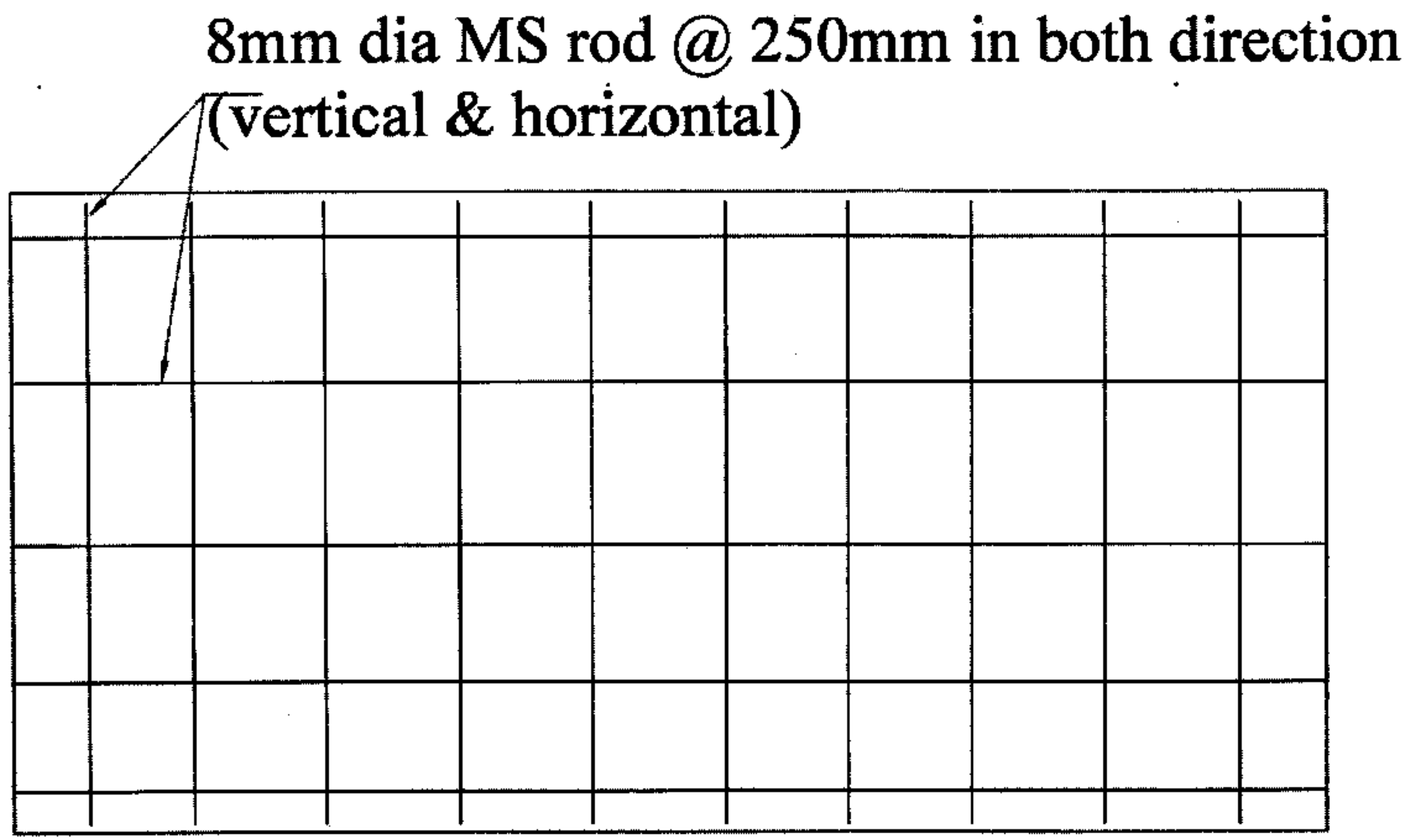


Section: Ring



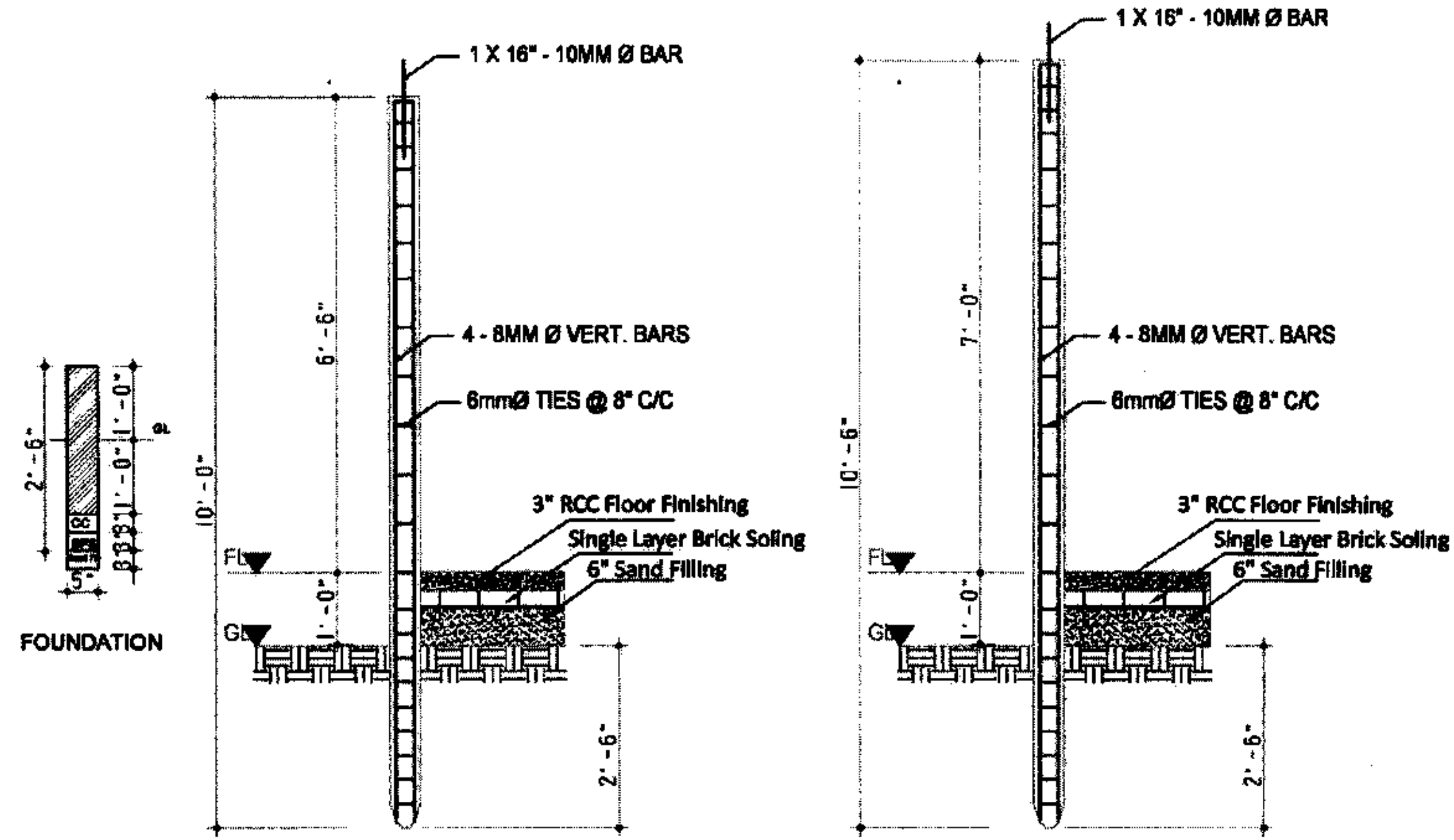
Section: AA (Top Slab of Ring-Half Circle)

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Ring & Top Slab Details	08-01-2018	04	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



SLAB REINFORCRMENT

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Slab Details	08-01-2018	05	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



DETAIL OF R.C.C POST

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Precast Column & Foundation Details	08-01-2018	06	UNHCR United Nations High Commissioner for Refugees

Bill of Quantities

for the Twin Pit Latrine Direct Construction

Latrine Option-4B

Location: Cox's Bazar

Date: 10/01/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation of Foundation** for twin pit latrine, carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cft	520.00	7	3640.00
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	36	22	792.00
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	36	5	180.00
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	36	31	1,116.00
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	30.00	236	7,080.00
6	**Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4)and making bond with connected walls & stair in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	42.78	190	8,128.20
9	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, plastering work on the outer surface of precast column ,all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	112.35	18	2,022.30
10	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer	sft	72	45	3,240.00
11	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	190.58	30	5,717.40
12	Supplying, fitting, fixing and colouring/painting of Column, Post Plate, Rafter, Purlin, Door Frame and etc. all complete to the satisfaction of the EIC/UNHCR.	Kg	93.87	110	10,326.05
13	**Supply, fittings & fixing of 48" dia. RCC Ring,** 2.25" thickness and 6 mm bar used as reinforcement as per the drawing and instruction of EIC.	Nos	20	950	19,000.00

14	**Sato pan** with footrest with good quality	Nos	2	200	400.00
15	Supply, fittings & fixing of pre-cast half circle (4 ft dia) ring cover, thikness-3" made of 1:2:4 mixing ratio, 8mm dia ms rod (60G) 6" C/C both way as per the drawing and instruction of EIC.	Nos	2	350	700.00
16	Supplying and fabrication of M.S. bar reinforcement of required size and length for all types of RCC slab including straightening the rod, removing rust, cleaning, cutting, hooking, bending, binding with supply of 22 B.W.G GI wire, placing in position including lapping spacing and securing them in position by concrete blocks (1:1) including cost of all materials, labor to complete the work as per specifications, drawings and to the satisfaction of the EIC.	Kg	19.50	85.00	1,657.50
17	**Other Supplies & Accessories fitting, fixing & supplying**				
a	Stud Nail (2.5 inch)	kg	3	80	240.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	8	100	800.00
c	Nail Different size (1.5 to 4 inch)	kg	2	80	160.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	uPVC Long Trap (4" dia)	Nos	1	250	250.00
	Grand Total (BDT) =				**65,749**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

26.2.18

Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

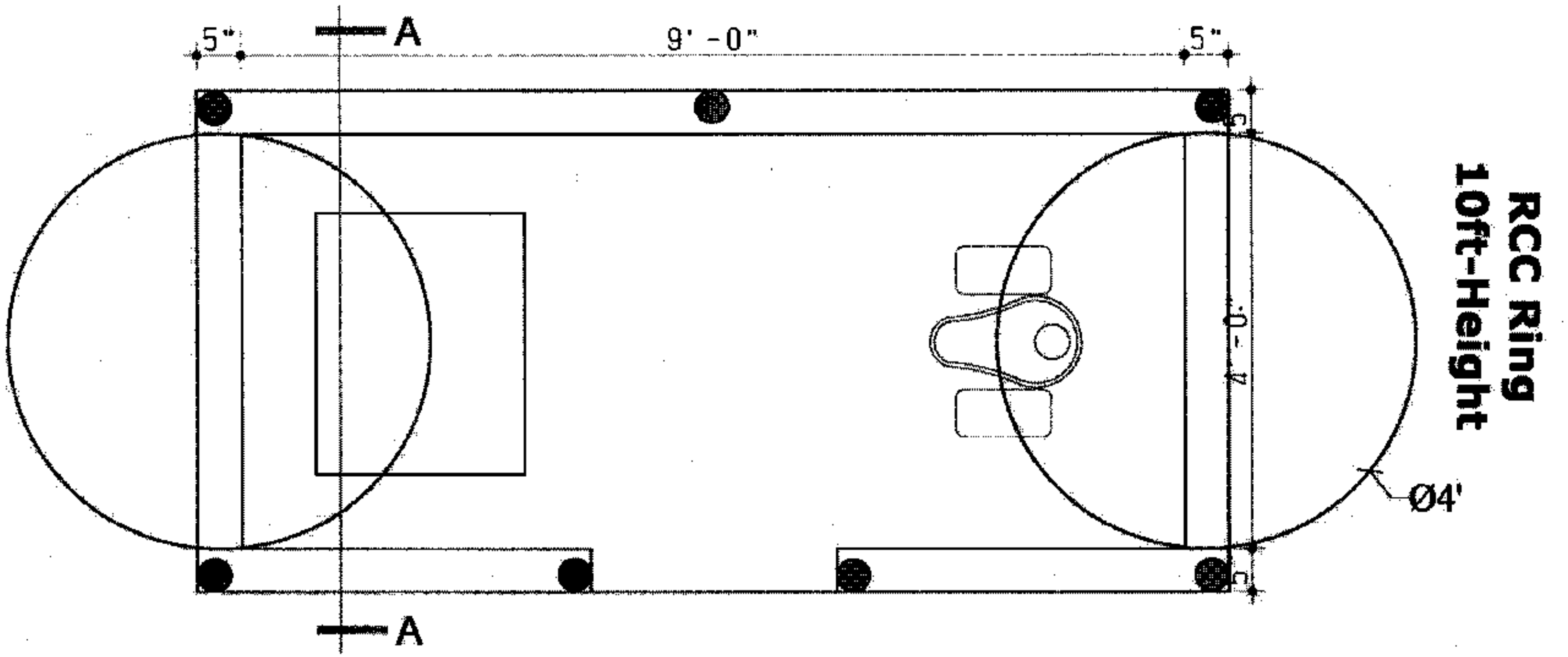
Approved By

26.02.18

Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

- RCC ring (1:1.5:3)- outer dia 4ft, height 1ft, thickness 2.25". Supplying, fabrication, and fixing 6mm dia MS rod @ 150mm in both direction (vertical & horizontal), with 0.75" 1st class brick aggregate & 1.6 FM sand.

Option 4B



PLAN OF LATRINE WITH TWIN PIT

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan of Latrine	08-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

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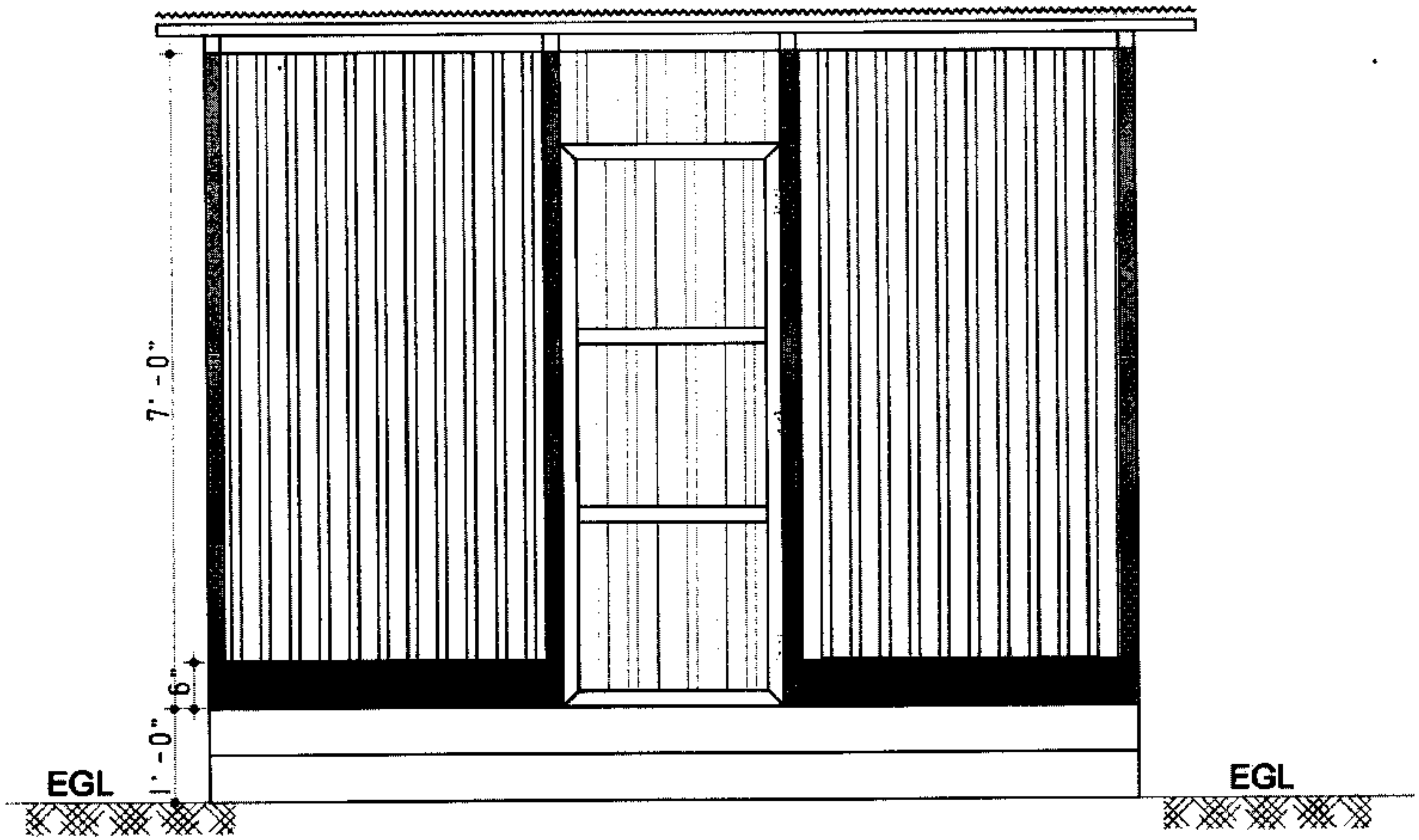
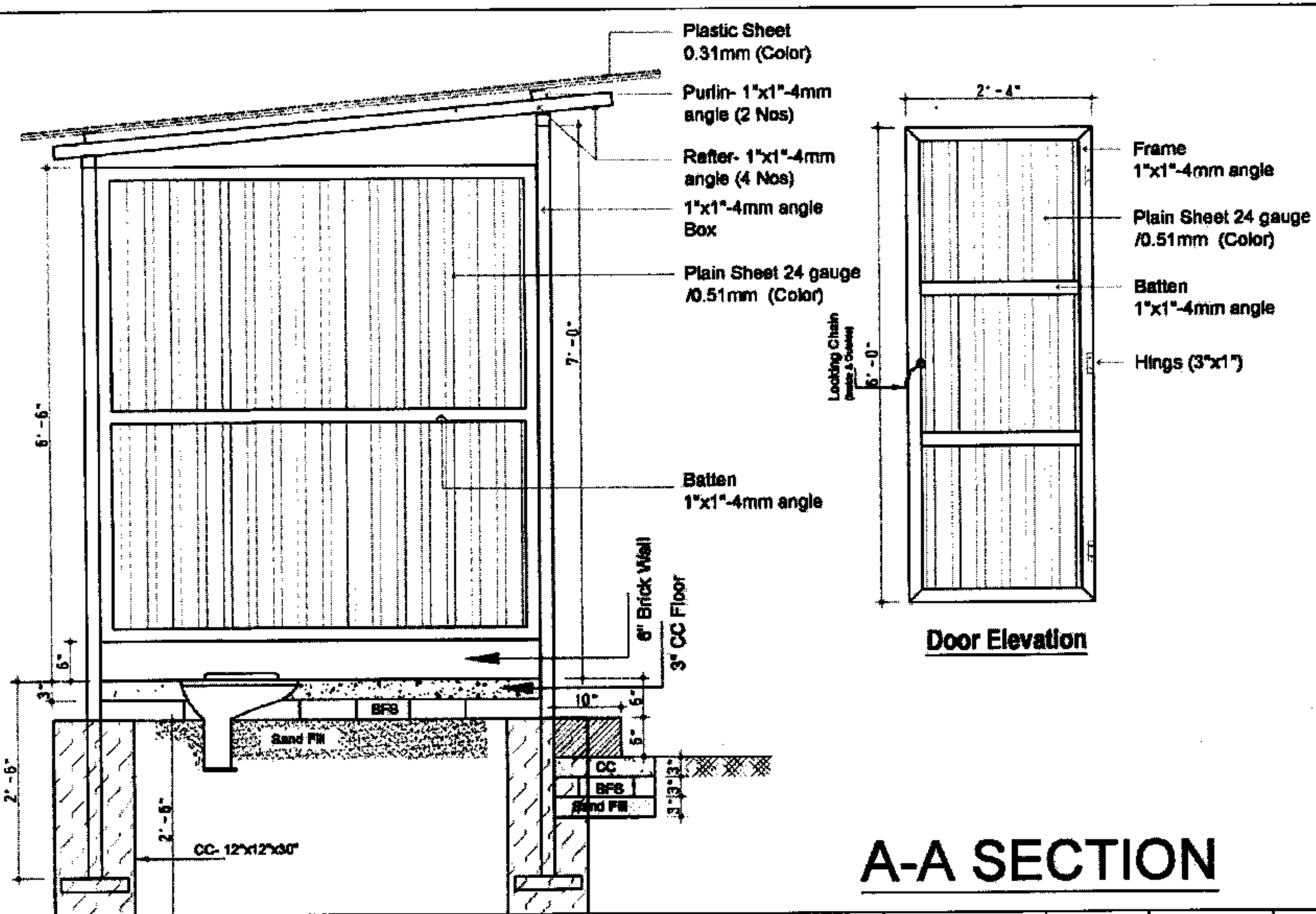


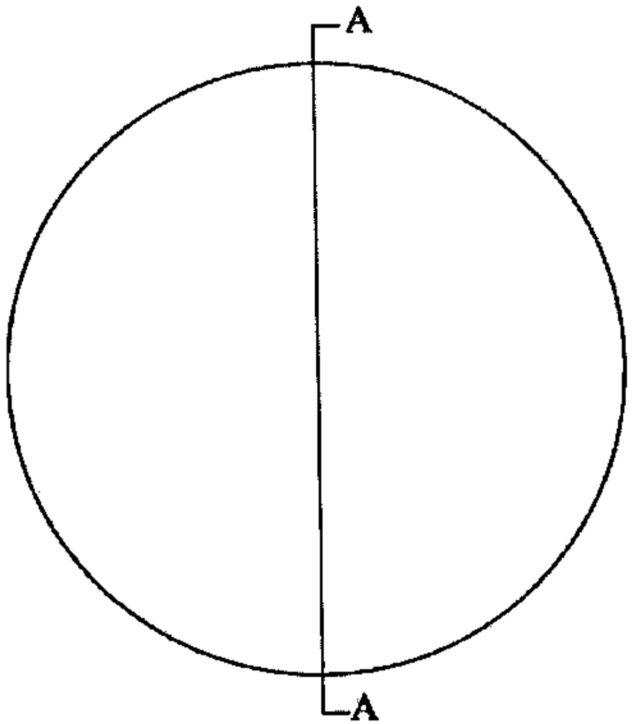
FRONT ELEVATION OF LATRINE

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Elevation of Latrine	08-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

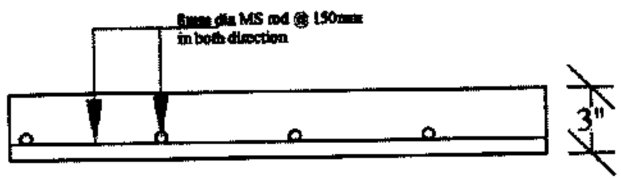


A-A SECTION

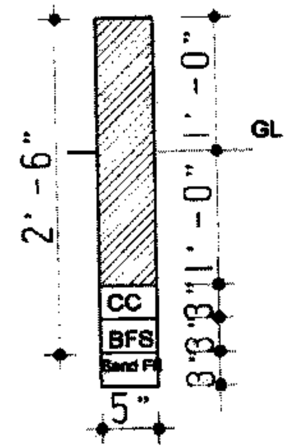
	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section of Latrine	08-01-2018	03	UNHCR United Nations High Commissioner for Refugees



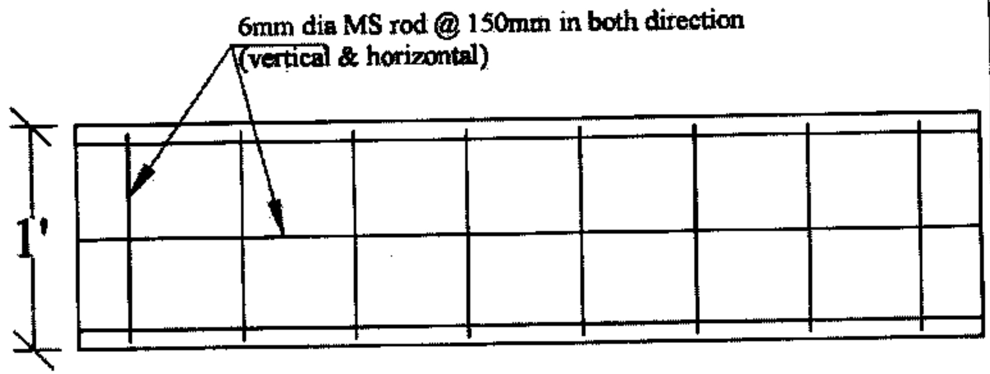
Plan: Top Slab of Ring



Section: AA (Top Slab of Ring-Half Circle)

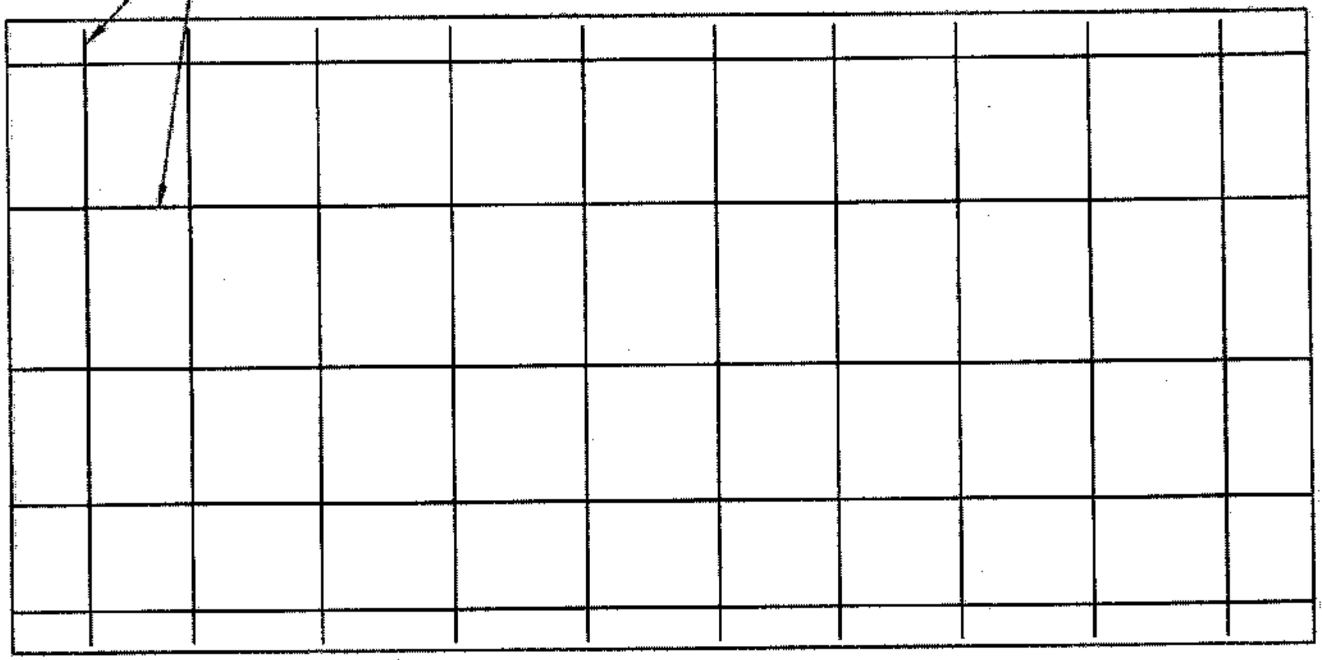


Foundation



Section: Ring

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Ring & Top Slab Detail	08-01-2018	04	UNHCR



SLAB REINFORCRMENT

Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Latrine	Twin pit (Direct) with Single Cubicle (CARITAS TYPE)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Inspection Pit Details	08-01-2018	05	UNHCR United Nations High Commissioner for Refugees

WASH Sector Cox's Bazar

Bill of Quantities

for the Septic Tank & Drain Field with Latrine (Four Cubicles)

Latrine Option-5

Location: Cox's Bazar

Date: 25/01/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
Septic Tank, Drain Field					
A: Septic Tank					
1.1	Earth work in excavation of Foundation for Septic Tank and latrine carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cu.m	30.86	125.00	3,858
1.2	Sand filling in foundation trenches and inside plinth with sand (minimum F.M. 0.80) in 150mm layers in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR. Dry density after compaction shall not be less than 95% of MDD.	Cu.m	2.13	980.00	2,086
1.3	Single layer brick flat soling with first class brick at the base of the foundation, including carrying bricks, filling the interstices tightly with sand of minimum FM 0.80, watering, levelling, dressing etc. all complete as per direction of the EIC/UNHCR.	Sq.m	13.97	300.00	4,191
1.4	Cement concrete work in foundation and floor with Portland cement, sand(Min FM 1.50) and first class /Picket Jhama brick chips 20mm down graded, in/c mixing appropriately, casting, laying, compacting and curing for the requisite period. The mixture proportion of cement sand and aggregate should be 1:2:4. All complete as per the instruction of the EIC/UNHCR.	Cu.m	1.40	6,500.00	9,131
1.5	1st class brick works with 1st class bricks in cement mortar (1:4) fitting the interstices tightly with mortar, raking out joint, cleaning and soaking bricks at least for 24 hours before use, washing of sand necessary scaffolding, curing for requisite period, etc. all complete as per direction of the EIC/UNHCR (Minimum F.M of sand: 1.2)	Cu.m	8.98	5,900.00	52,974
1.6	125 mm Brick work with 1st class bricks in cement mortar (1:4) in exterior walls including fitting the interstices tightly with mortar, raking out joint, cleaning and soaking bricks at least for 24 hours before use, washing of sand necessary scaffolding, curing for requisite period etc. all complete as per direction of the EIC.	Sq.m	2.97	800.00	2,380
1.7	Reinforced concrete cement works for the slab of the septic tank (1:2:4) having minimum cylinder crushing strength 17 MPa at 28 days with Portland cement (conforming to BDS 232), best quality coarse sand (50% quantity of sand minimum F.M. 1.2 and 50% quantity of coarse sand of minimum F.M. 2.5) 20 mm down graded picked jhama brick chips including breaking chips and screening, centering, shuttering, mixing casting, laying, compacting, curing up to the recommended time, making shuttering fully leak proof, etc including constructing manhole cover with a lifting hook and vent pipe . all complete to the satisfaction of the EIC/UNHCR.	Cu.m	1.40	8,700.00	12,221
1.8	Supplying and fabrication of M.S. deformed bar 10 mm and 6 mm, grade 40 billet) reinforcement of required size and length for all types of RCC work including straightening the rod, removing rust, cleaning, cutting, hooking, bending, binding with supply of 22 B.W.G GI wire, placing in position including lapping spacing and securing them in position by concrete blocks (1:1), metal chairs etc. complete including cost of all materials, labor, local handling incidentals necessary to complete the work as per specifications, drawings and to the satisfaction of the EIC/UNHCR.	Kg	108.63	82.00	8,907

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1.9	Minimum 12mm thick cement plaster (1:4) with neat cement fining & water proffing including washing of sand, cleaning of wall surface, curing for requisite period all complete as per direction of the EIC/UNHCR (F.M of sand:1.2)	Sq.m	49.73	200.00	9,946
1.10	UPVC pipe: Supplying best quality 6" dia UPVC pipe (RFL/Aziz/National Polymer D class) for connecting latrines and septic tanks including fitting, fixing etc. all complete as per direction of the EIC/UNHCR.	Rft	20.00	150.00	3,000
1.11	10 ft vent pipe (1.5" dia) and it's fixing	LS		680.00	680
A	**Sub Total**				**109,373**
B	**Drain Field**				
1.1	Earth work in excavation of Foundation for Septic Tank and latrine carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cu.m	6.56	125.00	820
1.2	Sand filling in foundation trenches and inside plinth with sand (minimum F.M. 1.2) in 150mm layers in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR. Bottom of the pit should be without compaction but bottom of the wall should be with appropriate compaction.	Cu.m	4.37	980.00	4,286
1.2	Clay filling at top of sand in trenches in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR.	Cu.m	1.09	650.00	711
1.7	UPVC pipe: Supplying best quality 3" dia UPVC perforated pipe (RFL/Aziz/National Polymer D class) for connecting septic tank to drain field including fitting, fixing etc. all complete as per direction of the EIC/UNHCR.	Rft	60.00	150.00	9,000
B	**Total Cost for Drain Field**				**14,816**
	Total Amount in Taka for Septic Tank & Drain Field (A+B)				**124,190**
C	**Superstructure**				
1.1	Earth work in excavation of Foundation for Septic Tank and latrine carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cu.m	0.69	125.00	87
1.2	Sand filling in foundation trenches and inside plinth with sand (minimum F.M. 0.80) in 150mm layers in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR. Dry density after compaction shall not be less than 95% of MDD.	Cu.m	0.08	980.00	81
1.3	Single layer brick flat soling with first class brick at the base of the foundation, including carrying bricks, filling the interstices tightly with sand of minimum FM 0.80, watering, levelling, dressing etc. all complete as per direction of the EIC/UNHCR.	Sq.m	0.54	300.00	162
1.4	Cement concrete work in foundation and floor with Portland cement, sand(Min FM 1.50) and first class /Picket Jhama brick chips 20mm down graded, in/c mixing appropriately, casting, laying, compacting and curing for the requisite period. The mixture proportion of cement sand and aggregate should be 1:2:4. All complete as per the instruction of the EIC/UNHCR.	Cu.m	0.15	6,500.00	961
1.5	1st class brick works with 1st class bricks in cement mortar (1:4) fitting the interstices tightly with mortar, raking out joint, cleaning and soaking bricks at least for 24 hours before use, washing of sand necessary scaffolding, curing for requisite period, etc. all complete as per direction of the EIC/UNHCR (Minimum F.M of sand: 1.2)	Cu.m	1.29	5,900.00	7,600

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1.6	**125mm (5") Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	Sq.m	12.33	800	9,864.00
1.7	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	m	5.40	200	1,080.15
1.8	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer.	sft	95.16	45	4,282.20
1.9	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	48	30	1,440.00
1.10	**Wood Work (Gorjon/Akashmoni/Mehogini):** Timber used for wood work shall be well seasoned, kiln dry containing not more than 8% to 12 % moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, shakes, saps, upsets, wane edge and twisted fiber. It shall also be free from all disease such as decay, wet rot, dry rot and woodworms and white and timber should be finished to the exact dimension shown on the drawing or as per Engineer direction.	Cu.m	0.25	65000	16,139.46
1.11	**Sato pan** with footrest with good quality	Nos	1	200	200.00
1.12	**Other Supplies & Accessories**				
a	Stud Nail (2.5 inch)	kg	2	80	160.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
c	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	PVC pipe (1.5 dia) Gas Pipe	ft	20	25	500.00
h	uPVC Long Trap (4" dia)	Nos	1	250	250.00
i	uPVC pipe (3" dia)	ft	20	75	1,500.00
	Sub-Total for One Unit				**36,236**
	Sub-Total for Four Units				**144,943**
	Grand Total =				**160,425**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

26.2.18

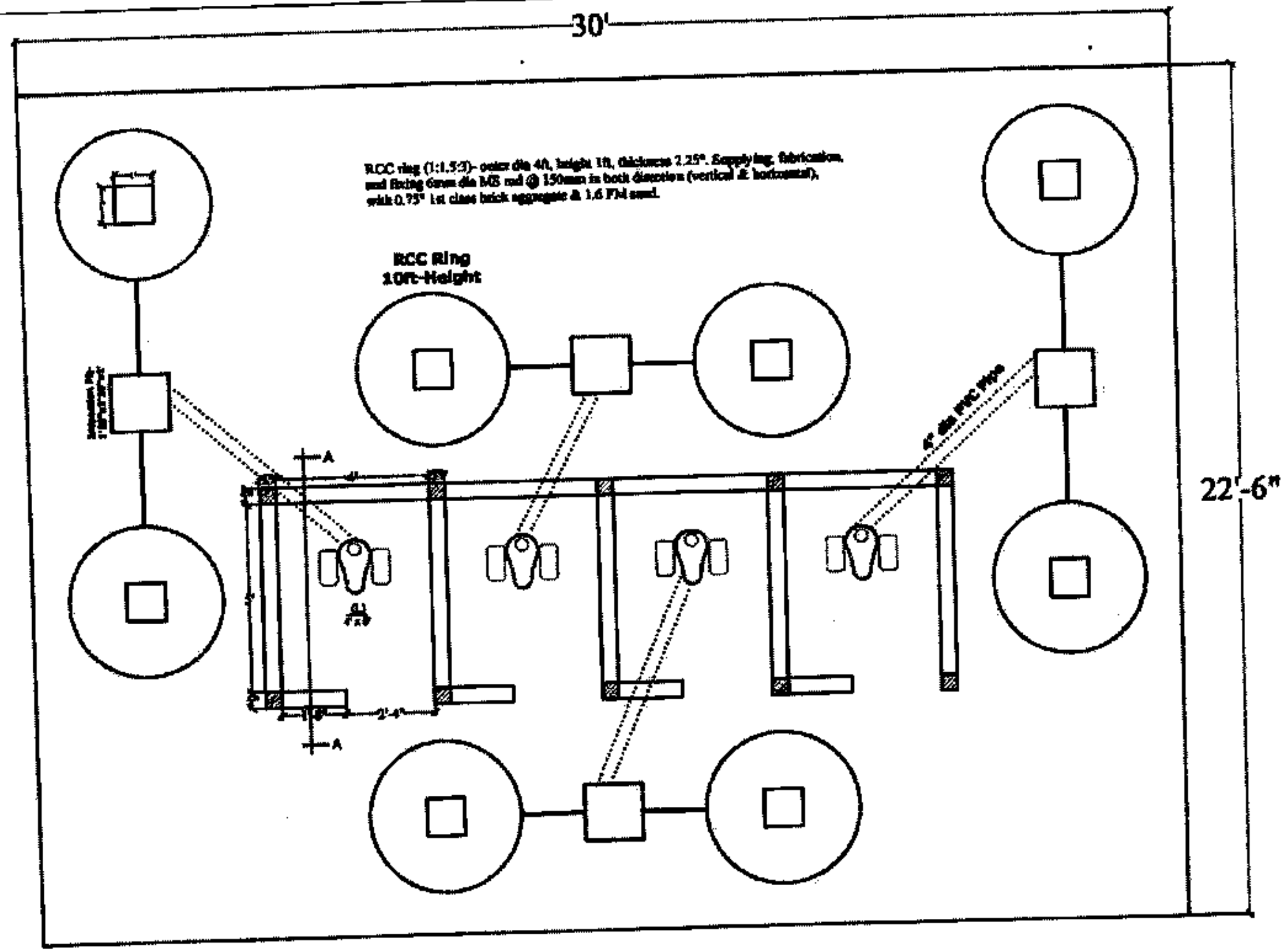
Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

Approved By

26.02.18

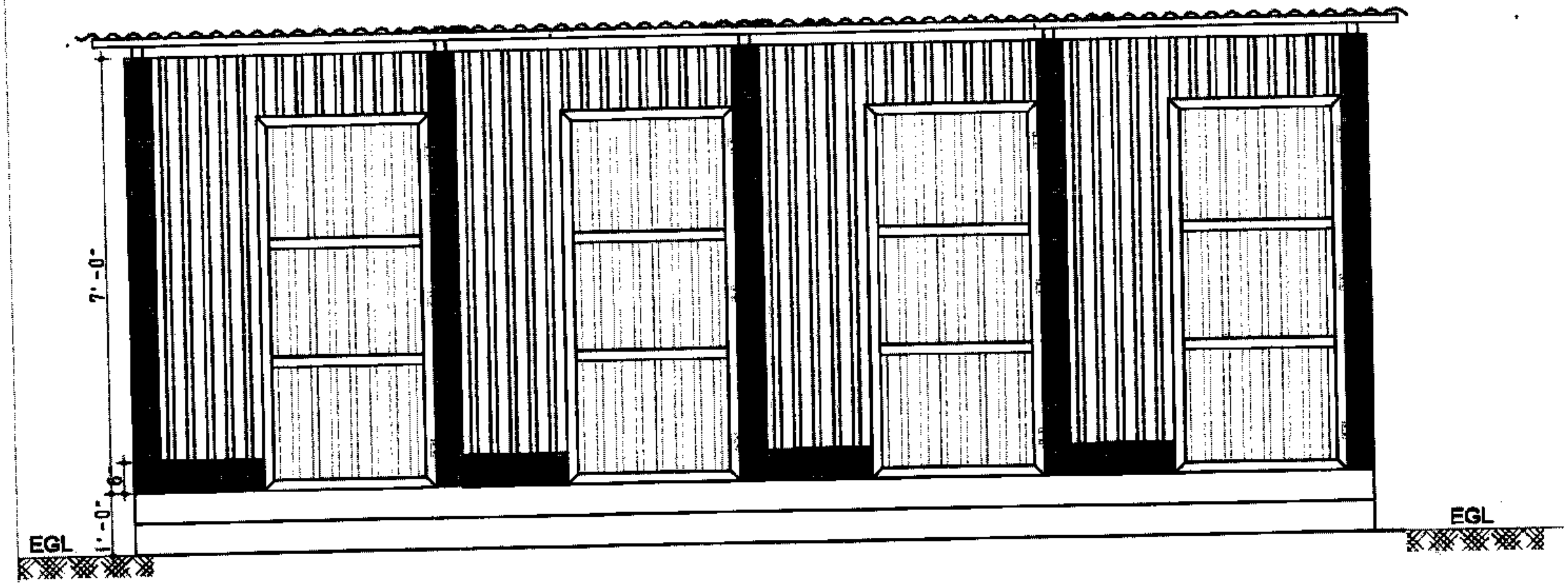
Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

Option 5



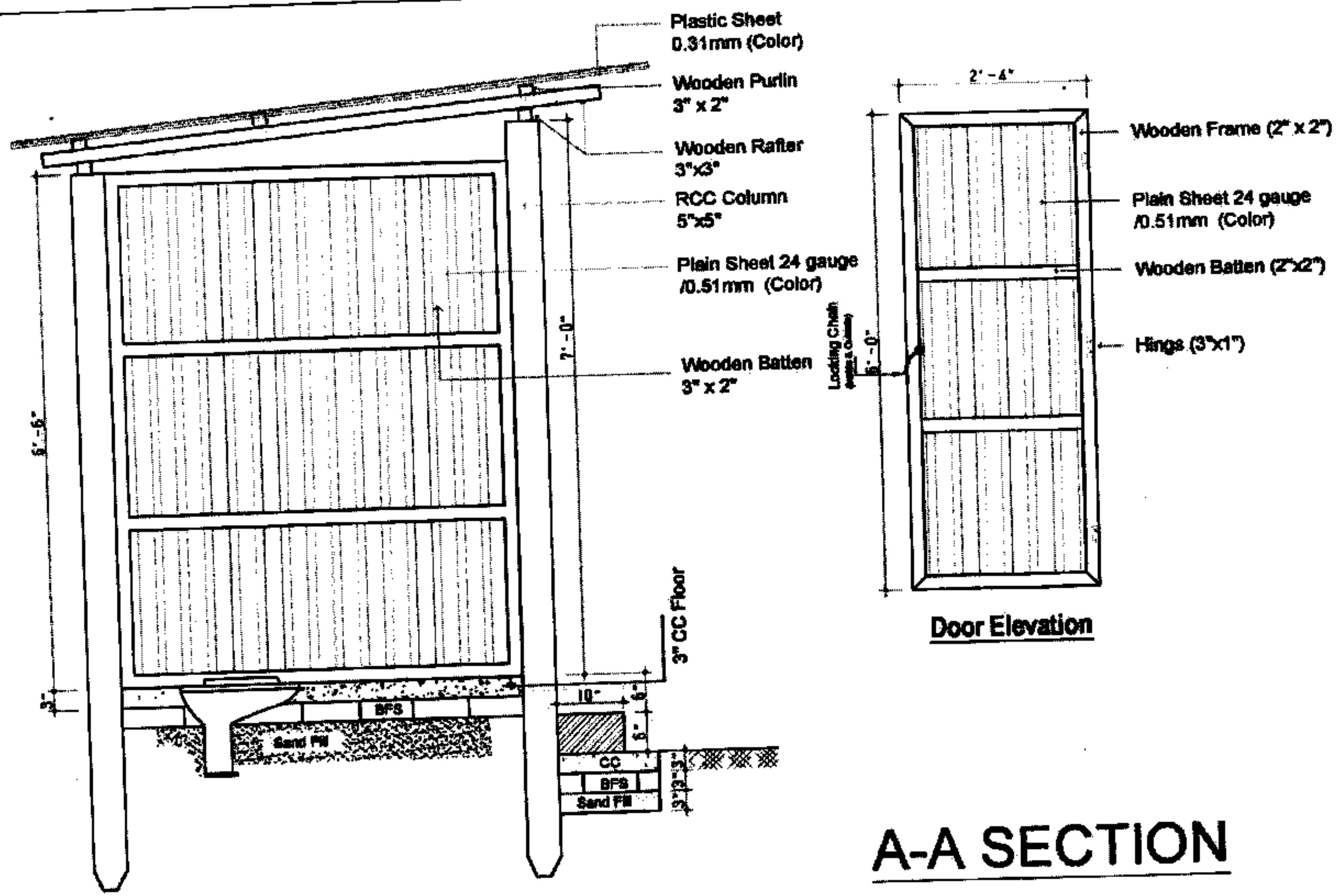
PLAN OF LATRINE WITH TWIN PIT FOUR CUBICLES

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin Pit Latrine with Four Cubicles (DPHE Type)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan of Latrine	08-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



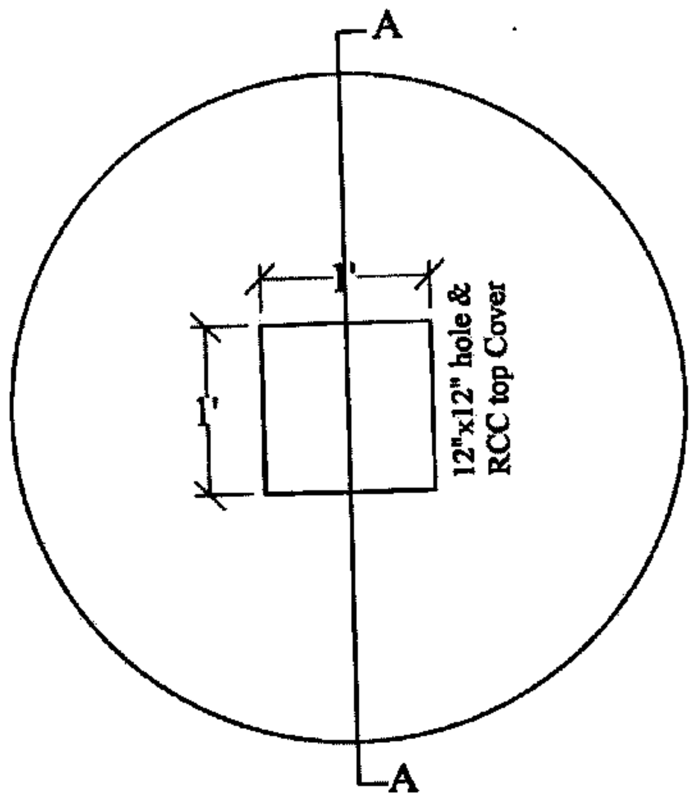
FRONT ELEVATION OF LATRINE

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin Pit Latrine with Four Cubicles (DPHE Type)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Elevation of Latrine	08-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

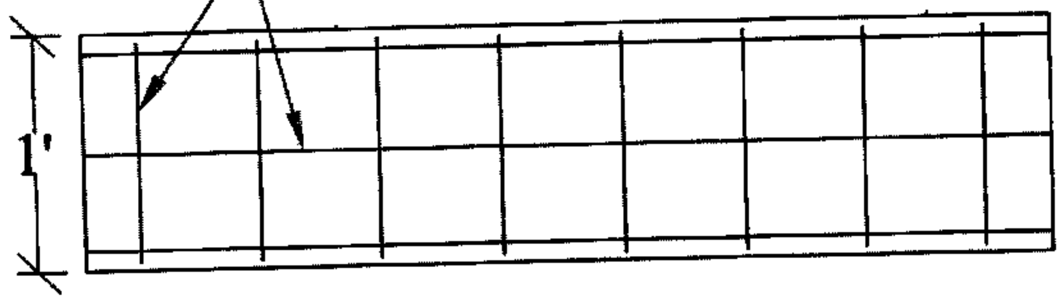


A-A SECTION

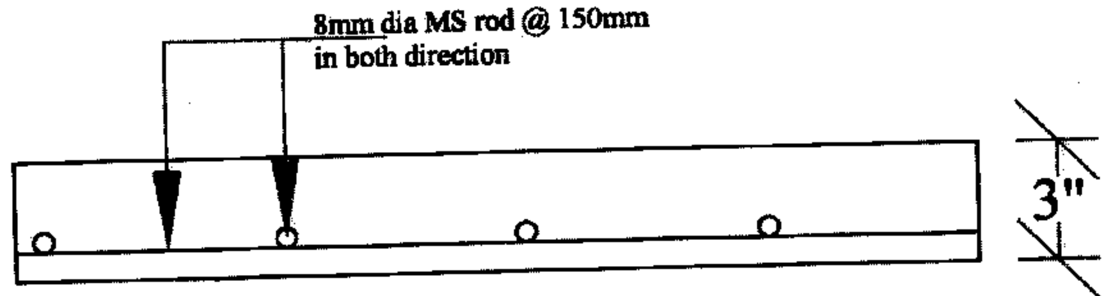
	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin Pit Latrine with Four Cubicles (DPHE Type)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section of Latrine	08-01-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



Plan: Top Slab of Ring

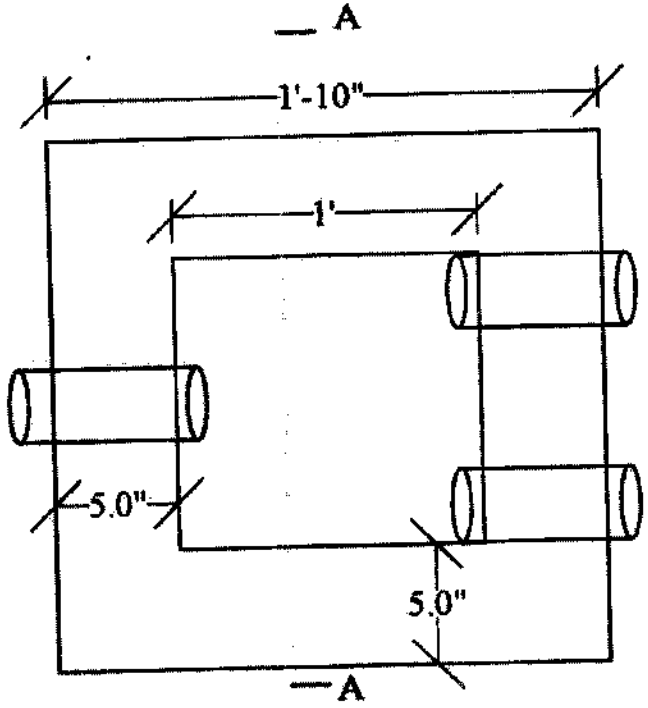


Section: BB (Ring)

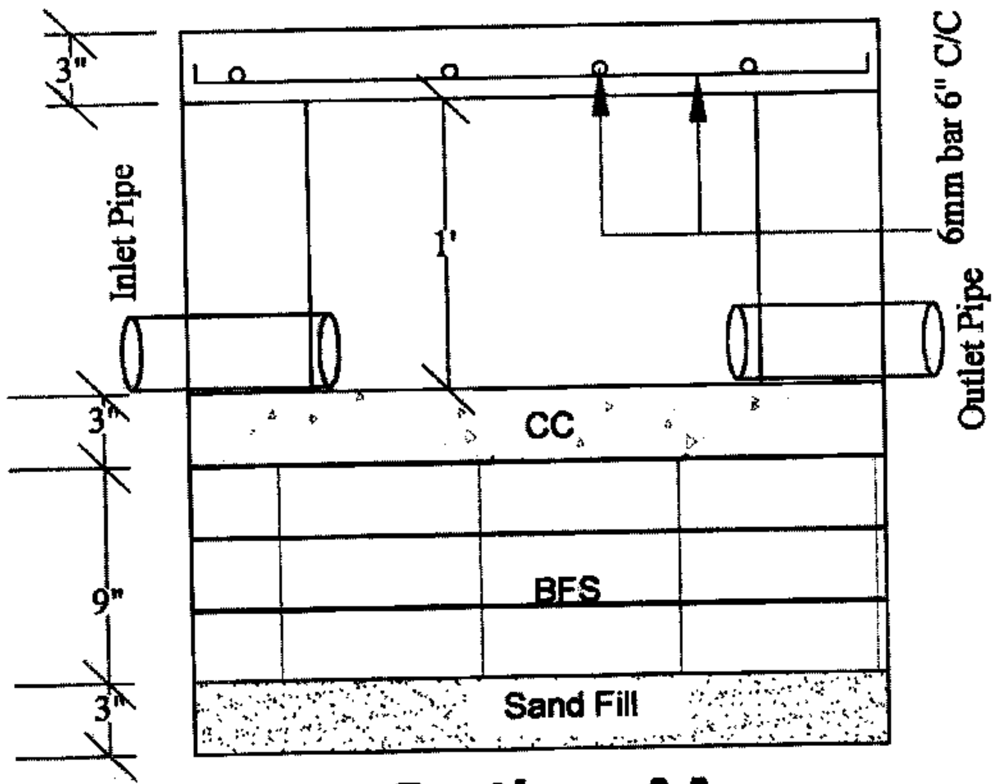


Section: AA (Top Slab of Ring)

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin Pit Latrine with Four Cubicles (DPHE Type)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Ring & Top Slab Details	08-01-2018	04	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

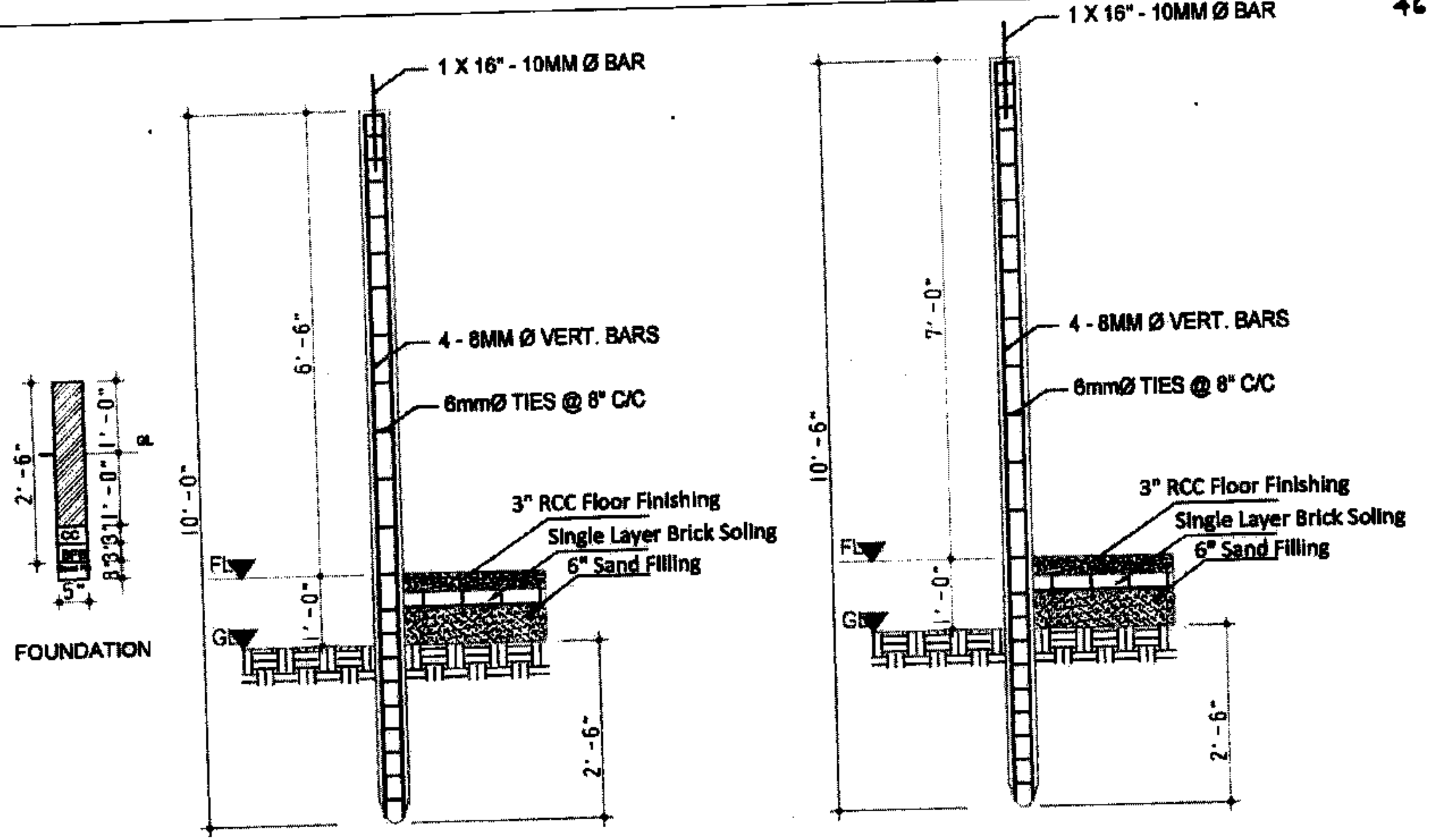


Plan: Inspection Pit



Section: AA

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin Pit Latrine with Four Cubicles (DPHE Type)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Slab Details	08-01-2018	05	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



DETAIL OF R.C.C POST

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Twin Pit Latrine with Four Cubicles (DPHE Type)	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Precast Column & Foundation Details	08-01-2018	06	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

Bill of Quantities

for the Septic Tank & Drain Field with Latrine (Four Cubicles)

Latrine Option-6

Location: Cox's Bazar

Date: 25/01/2018

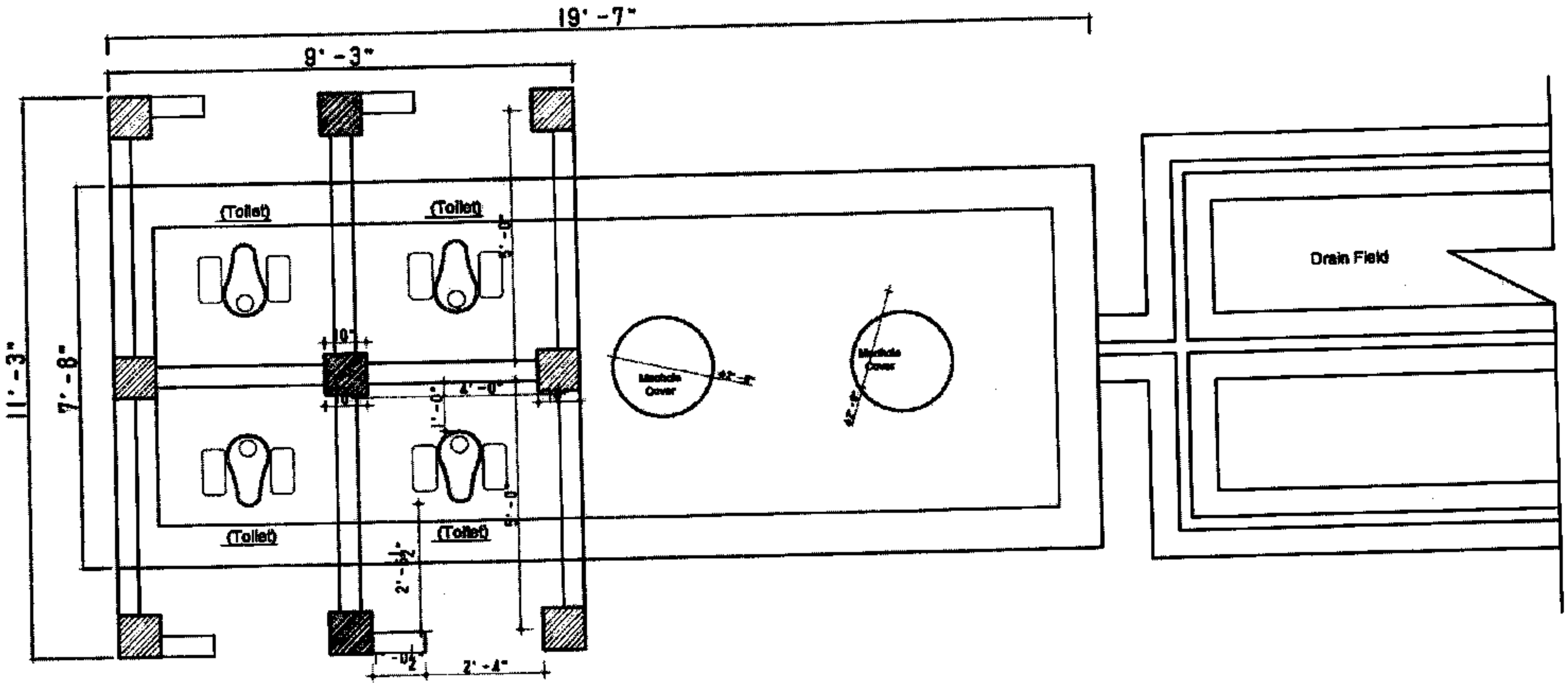
Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
Septic Tank, Drain Field					
A: Septic Tank					
1.1	Earth work in excavation of Foundation for Septic Tank and latrine carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cu.m	30.86	125.00	3,858
1.2	Sand filling in foundation trenches and inside plinth with sand (minimum F.M. 0.80) in 150mm layers in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR. Dry density after compaction shall not be less than 95% of MDD.	Cu.m	2.13	980.00	2,086
1.3	Single layer brick flat soling with first class brick at the base of the foundation, including carrying bricks, filling the interstices tightly with sand of minimum FM 0.80, watering, levelling, dressing etc. all complete as per direction of the EIC/UNHCR.	Sq.m	13.97	300.00	4,191
1.4	Cement concrete work in foundation and floor with Portland cement, sand(Min FM 1.50) and first class /Picket Jhama brick chips 20mm down graded, in/c mixing appropriately, casting, laying, compacting and curing for the requisite period. The mixture proportion of cement sand and aggregate should be 1:2:4. All complete as per the instruction of the EIC/UNHCR.	Cu.m	1.40	6,500.00	9,131
1.5	1st class brick works with 1st class bricks in cement mortar (1:4) fitting the interstices tightly with mortar, raking out joint, cleaning and soaking bricks at least for 24 hours before use, washing of sand necessary scaffolding, curing for requisite period, etc. all complete as per direction of the EIC/UNHCR (Minimum F.M of sand: 1.2)	Cu.m	8.98	5,900.00	52,974
1.6	125 mm Brick work with 1st class bricks in cement mortar (1:4) in exterior walls including fitting the interstices tightly with mortar, raking out joint, cleaning and soaking bricks at least for 24 hours before use, washing of sand necessary scaffolding, curing for requisite period etc. all complete as per direction of the EIC.	Sq.m	2.97	800.00	2,380
1.7	Reinforced concrete cement works for the slab of the septic tank (1:2:4) having minimum cylinder crushing strength 17 MPa at 28 days with Portland cement (conforming to BDS 232), best quality coarse sand (50% quantity of sand minimum F.M. 1.2 and 50% quantity of coarse sand of minimum F.M. 2.5) 20 mm down graded picked jhama brick chips including breaking chips and screening, centering, shuttering, mixing casting, laying, compacting, curing up to the recommended time, making shuttering fully leak proof, etc including constructing manhole cover with a lifting hook and vent pipe . all complete to the satisfaction of the EIC/UNHCR.	Cu.m	1.40	8,700.00	12,221
1.8	Supplying and fabrication of M.S. deformed bar 10 mm and 6 mm, grade 40 billet) reinforcement of required size and length for all types of RCC work including straightening the rod, removing rust, cleaning, cutting, hooking, bending, binding with supply of 22 B.W.G GI wire, placing in position including lapping spacing and securing them in position by concrete blocks (1:1), metal chairs etc. complete including cost of all materials, labor, local handling incidentals necessary to complete the work as per specifications, drawings and to the satisfaction of the EIC/UNHCR.	Kg	108.63	82.00	8,907

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1.9	Minimum 12mm thick cement plaster (1:4) with neat cement fining & water proffing including washing of sand, cleaning of wall surface, curing for requisite period all complete as per direction of the EIC/UNHCR (F.M of sand:1.2)	Sq.m	49.73	200.00	9,946
1.10	UPVC pipe: Supplying best quality 6" dia UPVC pipe (RFL/Aziz/National Polymer D class) for connecting latrines and septic tanks including fitting, fixing etc. all complete as per direction of the EIC/UNHCR.	Rft	20.00	150.00	3,000
1.11	10 ft vent pipe (1.5" dia) and it's fixing	LS		680.00	680
A	**Sub Total**				**109,373**
B	**Drain Field**				
1.1	Earth work in excavation of Foundation for Septic Tank and latrine carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cu.m	6.56	125.00	820
1.2	Sand filling in foundation trenches and inside plinth with sand (minimum F.M. 1.2) in 150mm layers in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR. Bottom of the pit should be without compaction but bottom of the wall should be with appropriate compaction.	Cu.m	4.37	980.00	4,286
1.2	Clay filling at top of sand in trenches in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR.	Cu.m	1.09	650.00	711
1.7	UPVC pipe: Supplying best quality 3" dia UPVC perforated pipe (RFL/Aziz/National Polymer D class) for connecting septic tank to drain field including fitting, fixing etc. all complete as per direction of the EIC/UNHCR.	Rft	60.00	150.00	9,000
B	**Total Cost for Drain Field**				**14,816**
	Total Amount in Taka for Septic Tank & Drain Field (A+B)				**124,190**
C	**Superstructure**				
1.1	Earth work in excavation of Foundation for Septic Tank and latrine carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cu.m	0.69	125.00	87
1.2	Sand filling in foundation trenches and inside plinth with sand (minimum F.M. 0.80) in 150mm layers in/c leveling, watering and consolidating each layer up to finished level etc. all complete as per directions of the EIC/UNHCR. Dry density after compaction shall not be less than 95% of MDD.	Cu.m	0.08	980.00	81
1.3	Single layer brick flat soling with first class brick at the base of the foundation, including carrying bricks, filling the interstices tightly with sand of minimum FM 0.80, watering, levelling, dressing etc. all complete as per direction of the EIC/UNHCR.	Sq.m	0.54	300.00	162
1.4	Cement concrete work in foundation and floor with Portland cement, sand(Min FM 1.50) and first class /Picket Jhama brick chips 20mm down graded, in/c mixing appropriately, casting, laying, compacting and curing for the requisite period. The mixture proportion of cement sand and aggregate should be 1:2:4. All complete as per the instruction of the EIC/UNHCR.	Cu.m	0.15	6,500.00	961
1.5	1st class brick works with 1st class bricks in cement mortar (1:4) fitting the interstices tightly with mortar, raking out joint, cleaning and soaking bricks at least for 24 hours before use, washing of sand necessary scaffolding, curing for requisite period, etc. all complete as per direction of the EIC/UNHCR (Minimum F.M of sand: 1.2)	Cu.m	1.29	5,900.00	7,600

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1.6	**125mm (5") Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	Sq.m	12.33	800	9,864.00
1.7	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	m	5.40	200	1,080.15
1.8	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer.	sft	95.16	45	4,282.20
1.9	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	48	30	1,440.00
1.10	**Wood Work (Gorjon/Akashmoni/Mehogini):** Timber used for wood work shall be well seasoned, kiln dry containing not more than 8% to 12 % moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, shakes, saps, upsets, wane edge and twisted fiber. It shall also be free from all disease such as decay, wet rot, dry rot and woodworms and white and timber should be finished to the exact dimension shown on the drawing or as per Engineer direction.	Cu.m	0.25	65000	16,139.46
1.11	**Sato pan** with footrest with good quality	Nos	1	200	200.00
1.12	**Other Supplies & Accessories**				
a	Stud Nail (2.5 inch)	kg	2	80	160.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
c	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	PVC pipe (1.5 dia) Gas Pipe	ft	20	25	500.00
h	uPVC Long Trap (4" dia)	Nos	1	250	250.00
i	uPVC pipe (3" dia)	ft	20	75	1,500.00
				Sub-Total for One Unit	**36,236**
				Sub-Total for Four Units	**144,943**
	Grand Total =				**160,425**

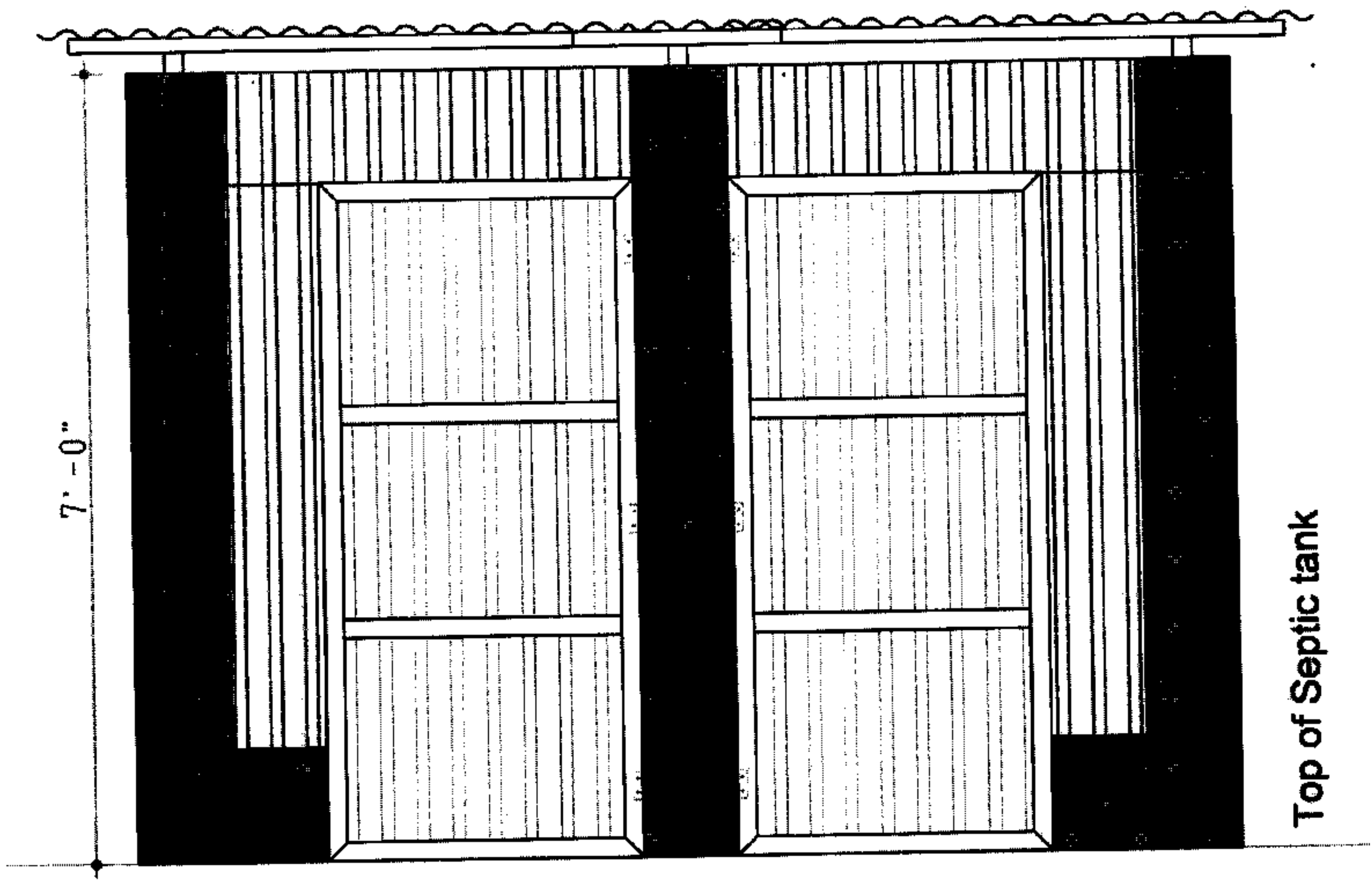
Recommended By	**Examined By**	**Approved By**
Abu Naim MD. Shafiullah Talukder Sector Coordinator-WASH *(Estimation developed by UNHCR)*	Md. Masum Kabir Nazrul Islam DRRO, RRRC Office	26.02.18 Mohammad Abul Kalam, ndc (Additional Secretary) Refugee Relief and Repatriation Commissioner, Cox's bazar

Option 6



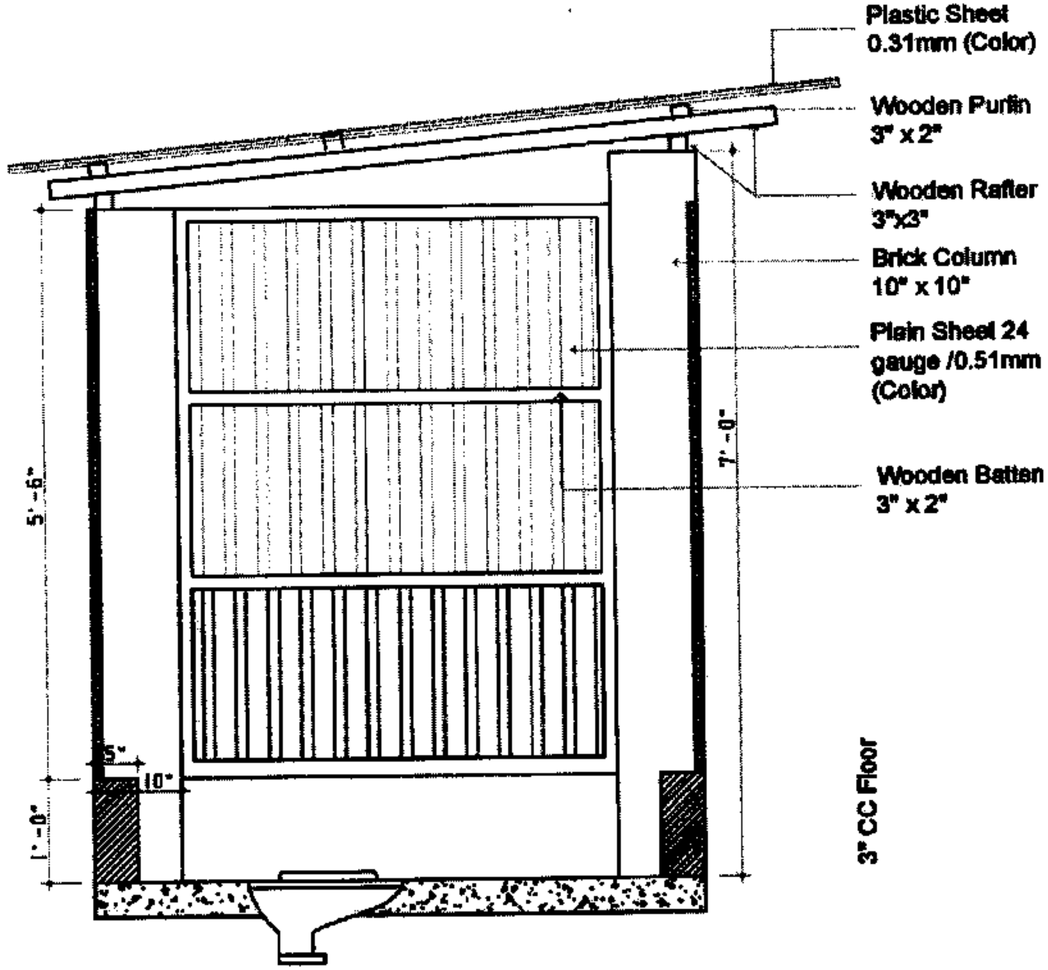
PLAN OF LATRINE WITH FOUR CUBICLES

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Four Cubicles with Septic Tank	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Plan of Latrine	17-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

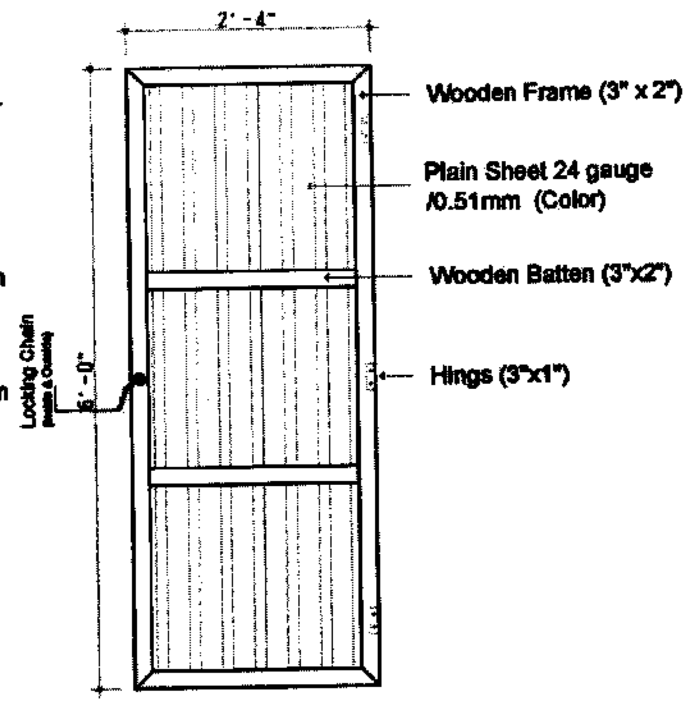


FRONT ELEVATION OF LATRINE

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Four Cubicles with Septic Tank	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Front Elevation	17-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



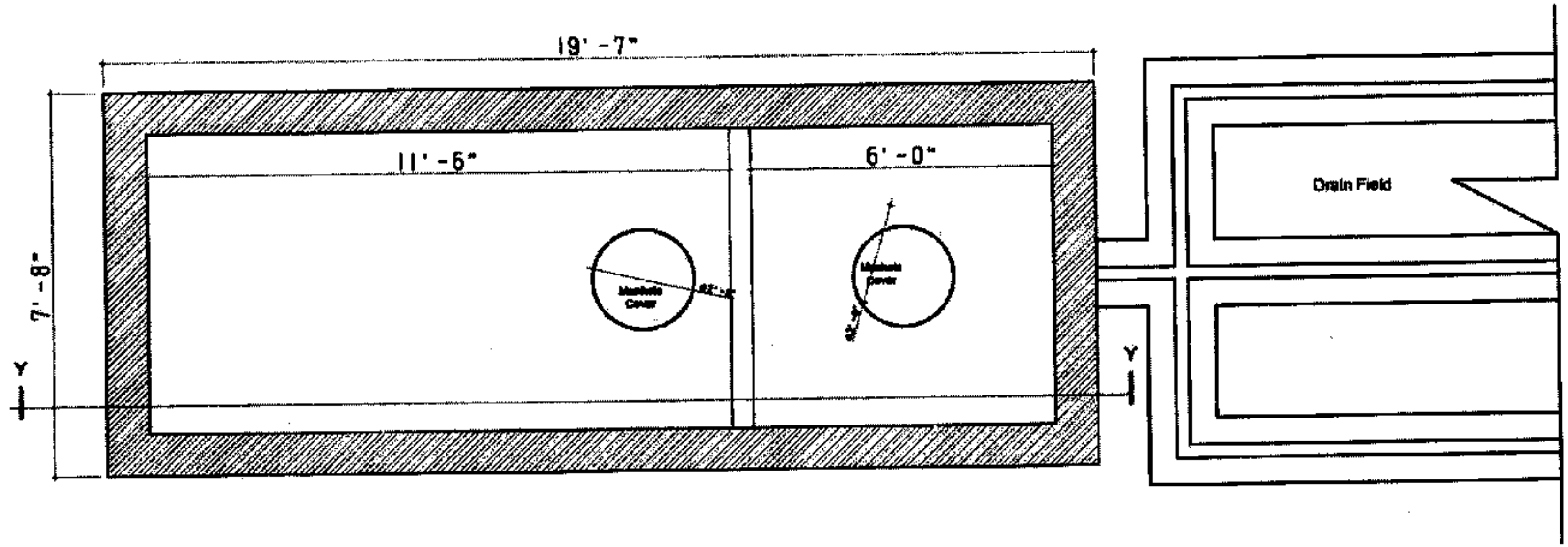
A-A Section



Door Elevation

Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Latrine	Four Cubicles with Septic Tank	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Section A-A	17-01-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

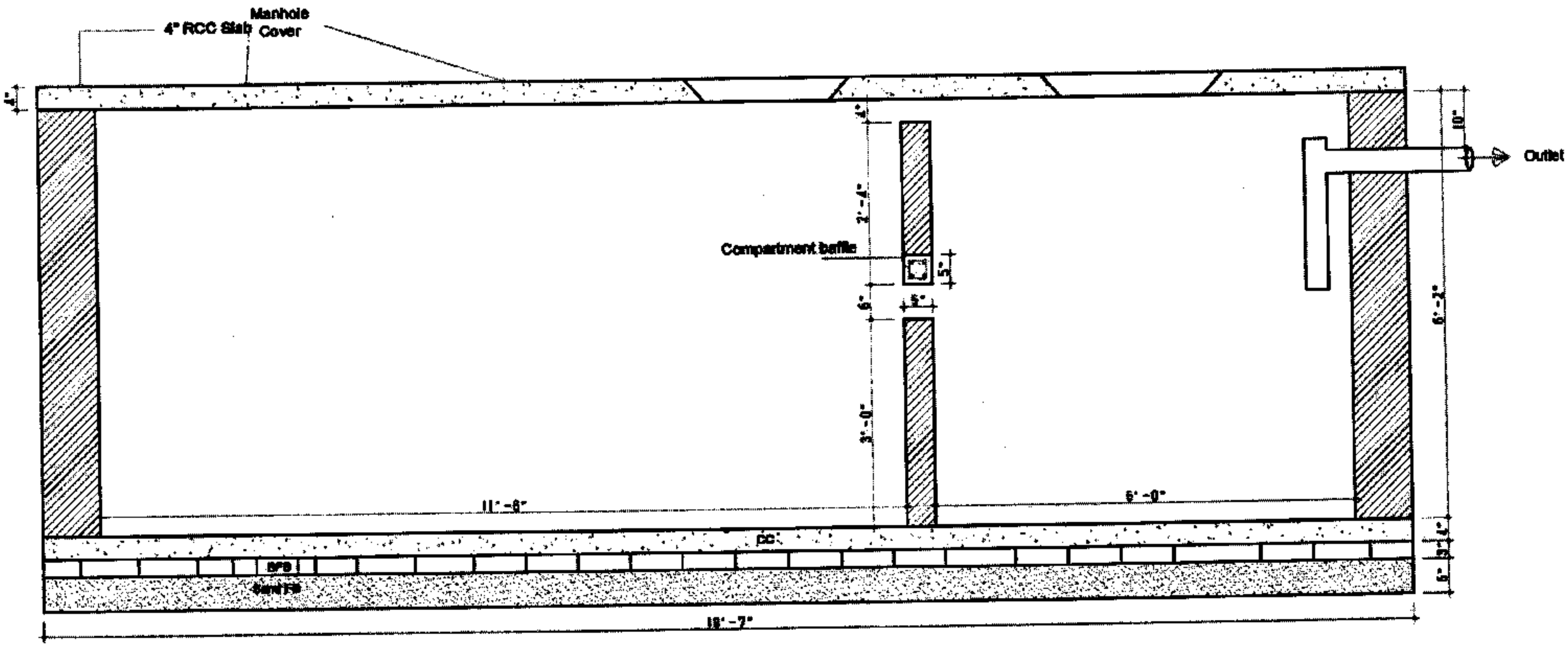
WASH Sector Cox's Bazar



PLAN OF SEPTIC TANK

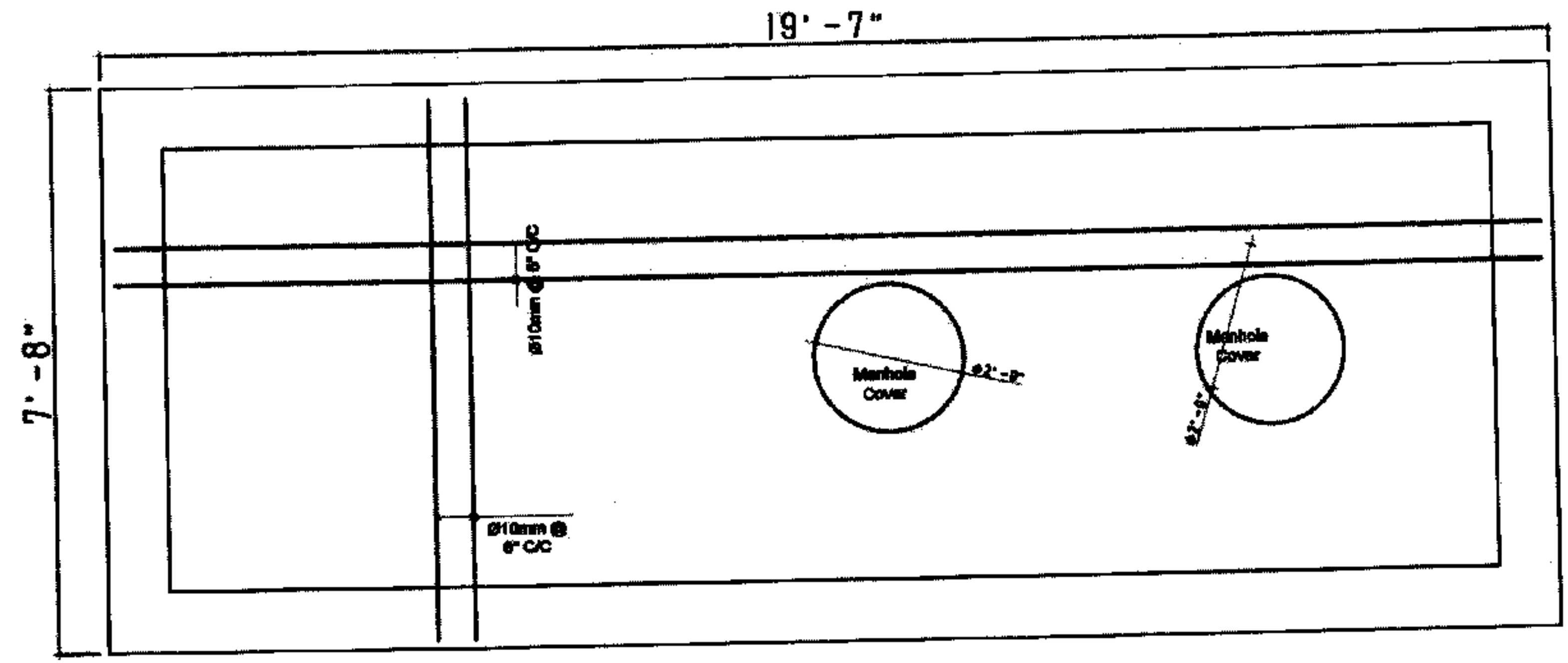
Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Latrine	Four Cubicles with Septic Tank	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Plan of Septic Tank with Soak Pit	17-01-2018	04	UNHCR United Nations High Commissioner for Refugees

WASH Sector Cox's Bazar



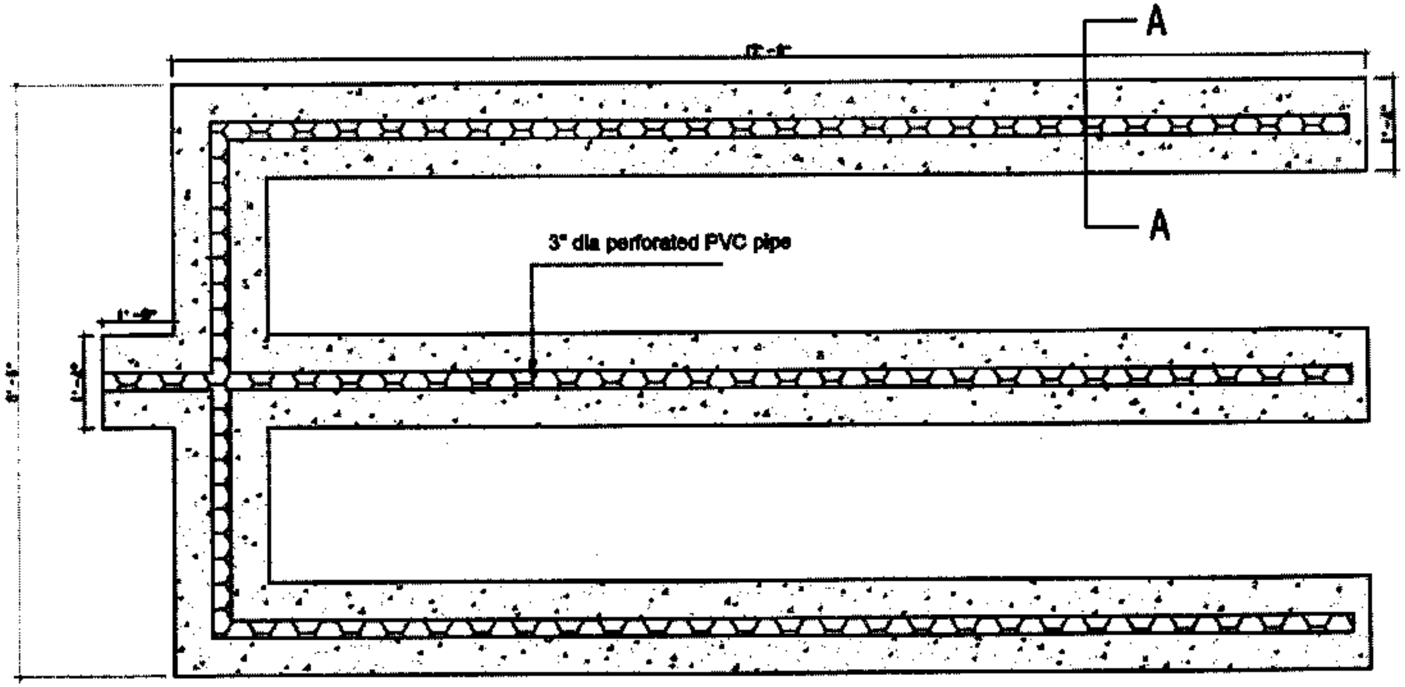
SECTION YY

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Four Cubicles with Septic Tank	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Section	17-01-2018	05	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

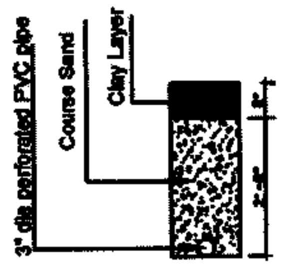


SLAB REINFORCEMENT OF SEPTIC TANK

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Latrine	Four Cubicles with Septic Tank	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Details of Slab	17-01-2018	06	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



Plan: Drain Field



Section AA

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Latrine	Four Cubicles with Septic Tank	ABM Sadiqur Rahman Minhaj Uddin Ahmed UNHCR	Murray Burt UNHCR	Details of Drain Field	17-01-2018	07	UNHCR United Nations High Commissioner for Refugees

Bill of Quantities

for the Biogas Plant (2m3) Construction

Biogas type-1

Location: Cox's Bazar

Date: 17/02/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation** in all kinds of soil to layout, providing center lines, local bench-mark pillars, leveling, ramming, prepaing the base, providing necessary tools and plants, protecting and maintaining the trench dry etc. stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer, subject to submit method statement of carrying out excavation work to the Engineer for approval. However, Engineer's approval shall not relieve the contractor of his responsibilities & obligations under the contract. Earth work excavation: Gas storage chamber, digester, hydraulic chamber, slurry pit.	cft	993.37	7	6953.59
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	344.7	24	8,272.80
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	168.56	5	842.80
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	170.8	33	5,636.40
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	71.59	236	16,895.24
6	**RCC (1:2:4) Work:** Reinforcement cement concrete work at different part of biogas plant with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all **reinforcement as per in details drawing,** shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	33.69	375	12,633.75
7	**Brick work with mortar 1:3:** Brick work as per drawing with 1st class bricks in cement mortar (1:3) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	134.3	225	30,217.50
8	**125mm (5") Brick work with mortar 1:3:** 5" Brick work with 1st class bricks in cement mortar (1:3) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	82.12	92	7,555.04
9	**75mm (3") Brick work with mortar 1:2:** 3" Brick work with 1st class bricks in cement mortar (1:2) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	75.85	80	6,068.00
10	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	351.5	22	7,733.00

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
11	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:3) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	191.98	24	4,607.52
12	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:2) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per dr awing and design. ••	sft	191.98	26	4,991.48
13	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:1) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	191.98	28	5,375.44
14	**0.32 mm thick (Colored) CGI Sheet for Roofing/Wall:** Supplying, fitting and fixing 0.32mm thick CGI sheet (Brand Quality), fitting and fixing on frame with screws. all complete and accepted by the Engineer.	sft	253.67	110	27,903.70
15	Supplying, fitting, fixing and colouring/painting of **MS Angle Bar (40mmx40mmx4mm)** - Post Plate, Rafter, Truss Member, Purlin and etc. all complete to the satisfaction of the EIC.	rft	249.17	90	22,425.30
16	**Other Suppl ies & Accessori es including fitting & fixing**				
a	Enamel paint	lb	5	100	500.00
b	Solvent Cement (100gm Kony Japan)	nos.	1	165	165.00
c	PVC Pipe dia 4" D Class with necessary fittings	ft	16.33	220	3,593.33
d	PVC elbow dia 4", 45 degree angle	nos	2	140	280.00
e	Best quality Padloo	kg	5	300	1,500.00
f	GI Wire 24	kg	0.5	140	70.00
g	Delivery flexible pipe, 0.5" dia	feet	70	45	3,150.00
h	Gas valve 2" RB Italy 1/2" Dia	nos	4	550	2,200.00
i	GI Nipple 1/2"	ft	2	50	100.00
j	Roof nail	kg	1	140	140.00
k	Biogas stove	nos	2	1500	3,000.00
l	GI nipple both pass 1/2"	nos	4	350	1,400.00
m	Seal Tape	nos	2	30	60.00
n	GI Clam 1/2"	nos	4	50	200.00
o	Pad lock (32mm)	nos	1	114	114.00
p	Cow dung 1st time Biogas plant feeding	kg	2500	25	62,500.00
	Grand Total (BDT) =				**247,084**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

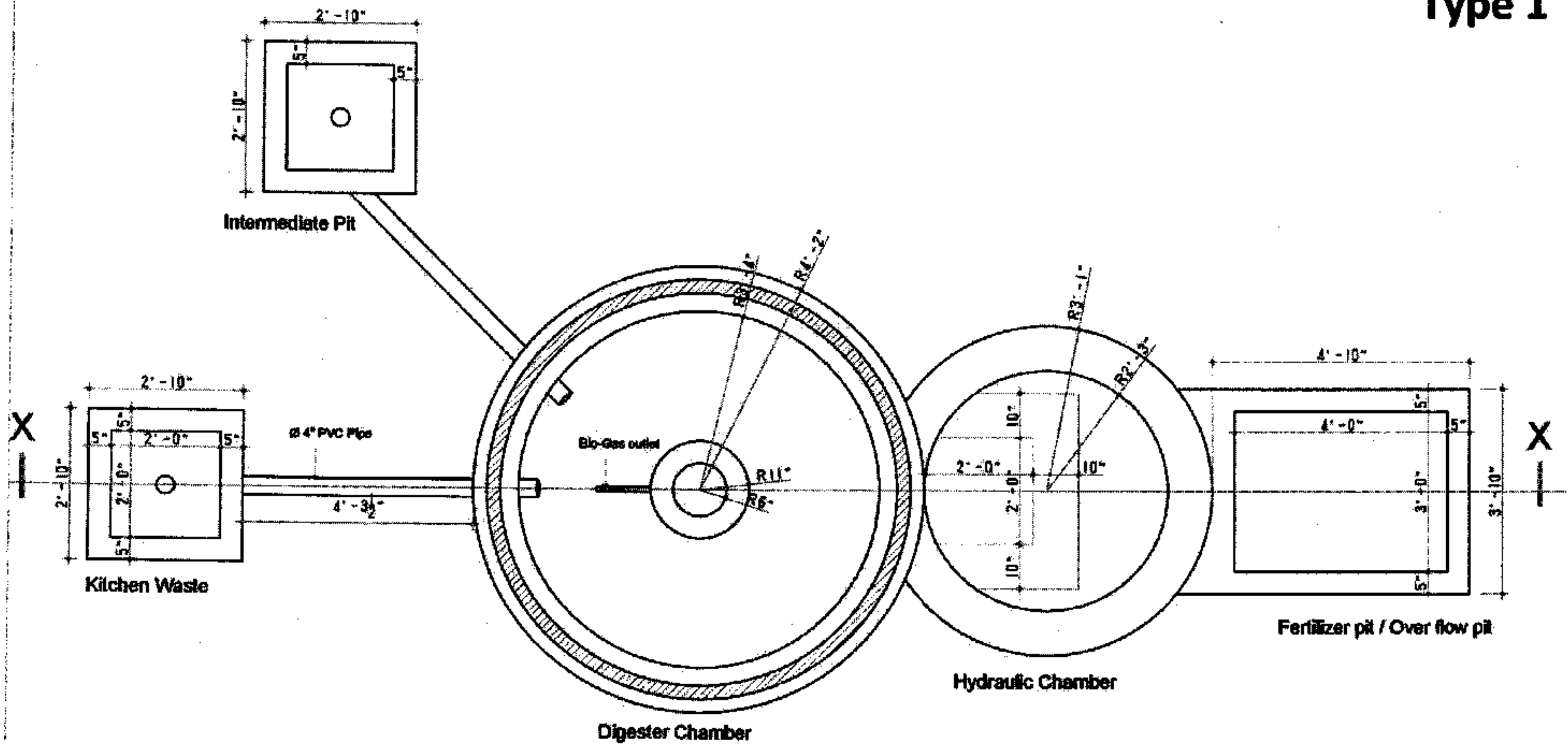
26.2.18

Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

Approved By

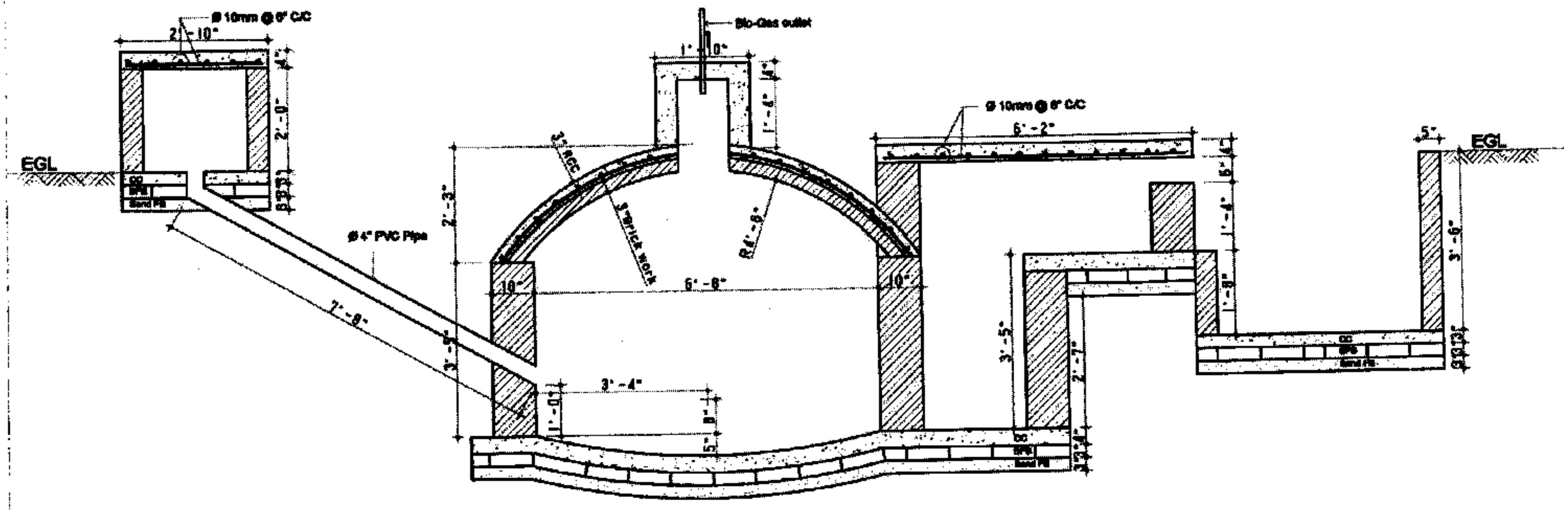
Mohammad Abul Kalam, ndc 26.02.18
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

Type 1



Plan of Bio-Gas plant

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fixed Dome Type Biogas-2m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan	18-02-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

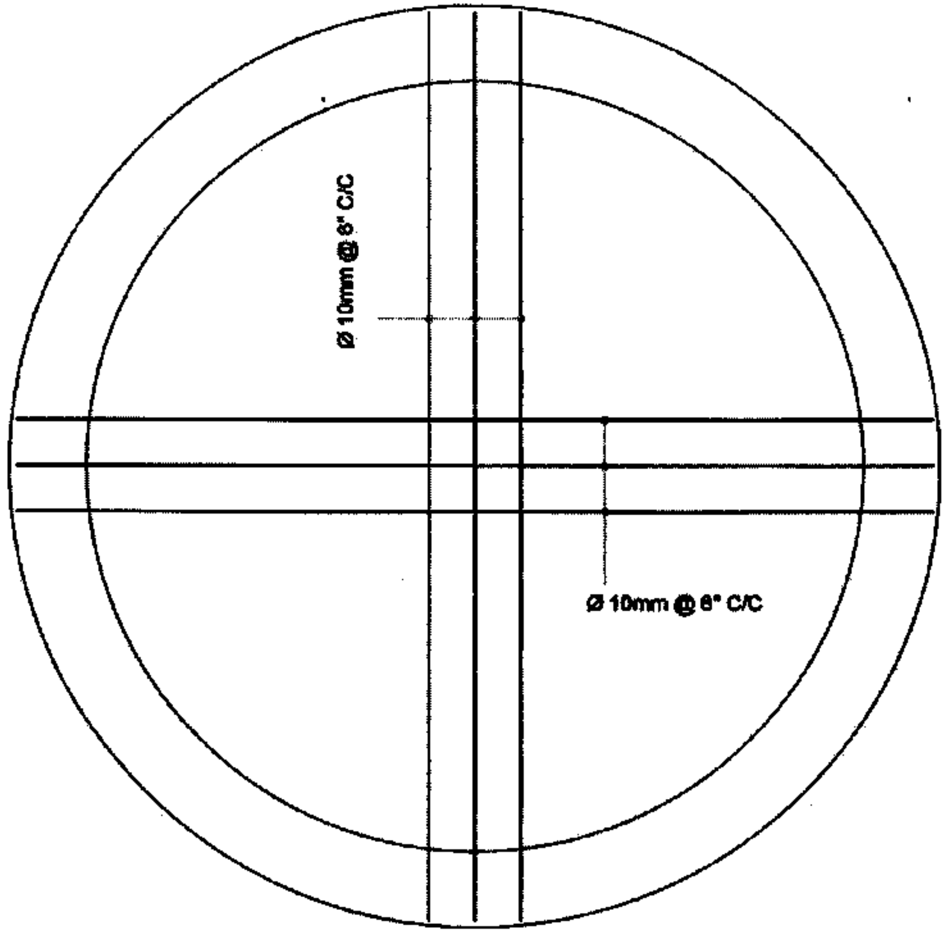


Section X-X

Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Biogas	Fixed Dome Type Biogas-2m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section	18-02-2018	02	UNHCR

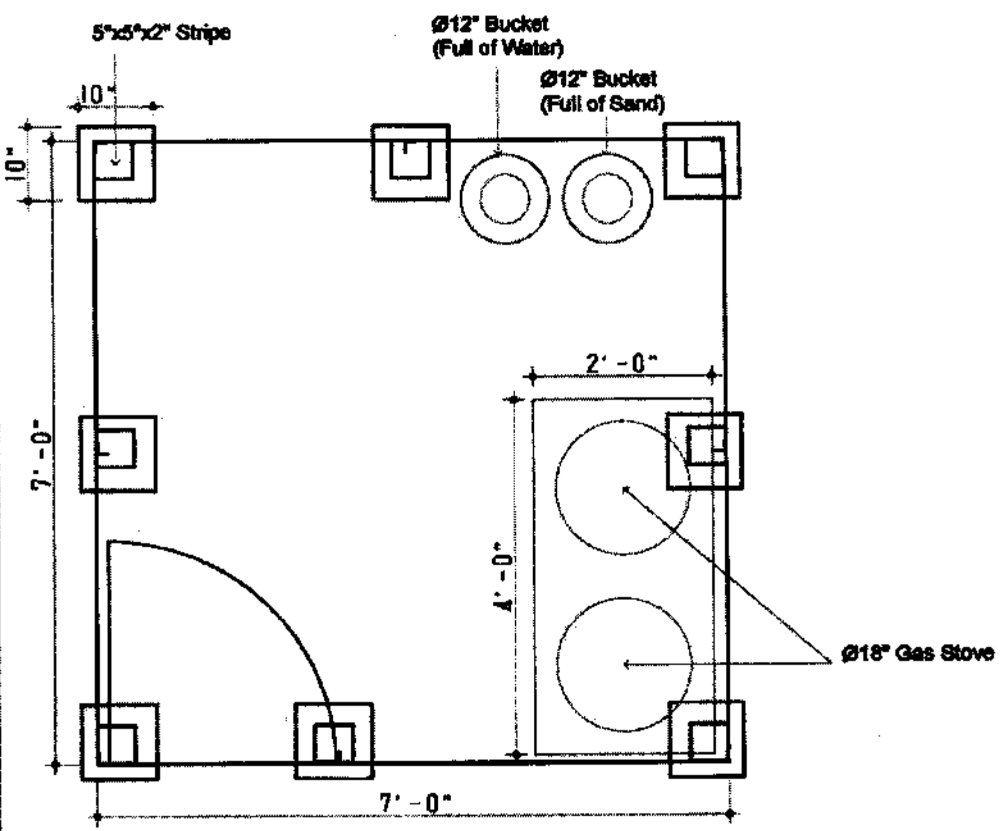
WASH Sector Cox's Bazar

UNHCR United Nations High Commissioner for Refugees / Haut Commissariat des Nations Unies pour les réfugiés

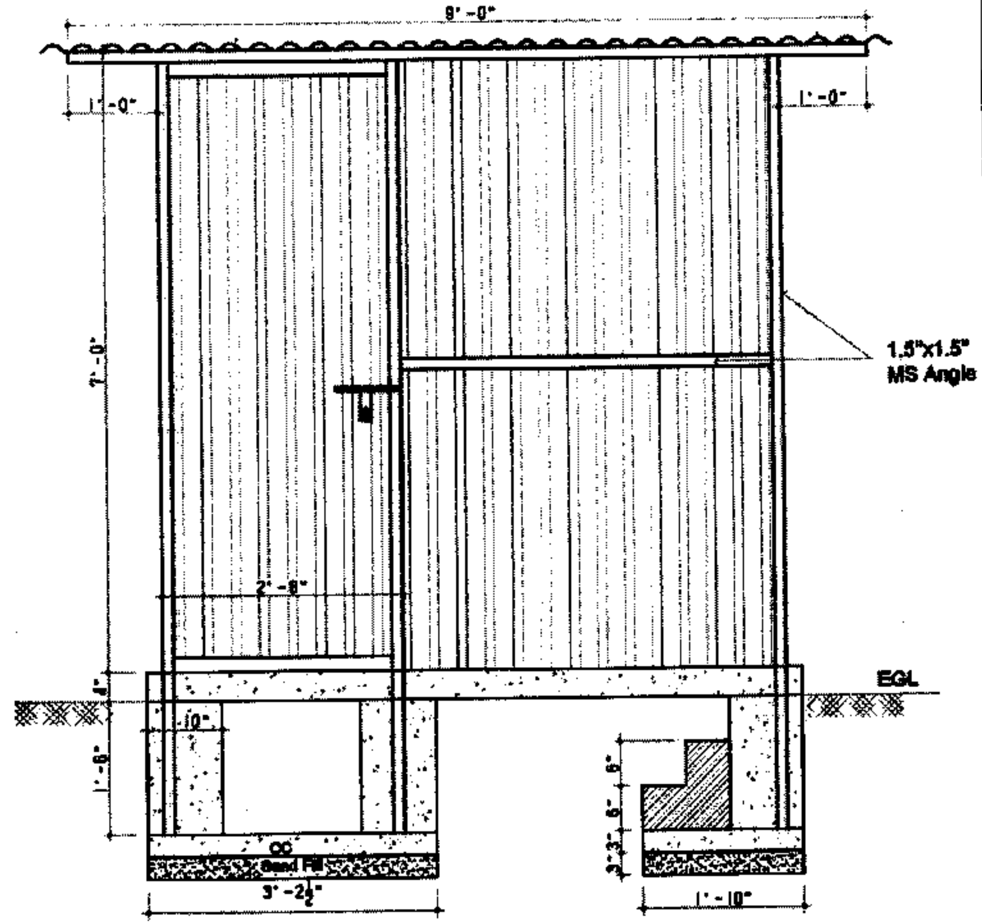


Reinforcement Details

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fixed Dome Type Biogas-2m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Details of Reinforcement	18-02-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



Plan of Kitchen



Sectional View of Kitchen

Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Biogas	Fixed Dome Type Biogas-2m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Details of Kitchen	18-02-2018	04	UNHCR United Nations High Commissioner for Refugees

WASH Sector Cox's Bazar

Bill of Quantities

for the Biogas Plant (4m3) Construction

Biogas- 2

Location: Cox's Bazar

Date: 17/02/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation** in all kinds of soil to layout, providing center lines, local bench-mark pillars, leveling, ramming, prepaing the base, providing necessary tools and plants, protecting and maintaining the trench dry etc. stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer, subject to submit method statement of carrying out excavation work to the Engineer for approval. However, Engineer's approval shall not relieve the contractor of his responsibilities & obligations under the contract. Earth work excavation: Gas storage chamber, digester, hydraulic chamber, slurry pit.	cft	1292.37	7	9046.59
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	423.45	24	10,162.80
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	197.56	5	987.80
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	199.8	33	6,593.40
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	81.45	236	19,222.20
6	**RCC (1:2:4) Work:** Reinforcement cement concrete work at different part of biogas plant with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all **reinforcement as per in details drawing,** shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	40.68	375	15,255.00
7	**Brick work with mortar 1:3:** Brick work as per drawing with 1st class bricks in cement mortar (1:3) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	153.01	225	34,427.25
8	**125mm (5") Brick work with mortar 1:3:** 5" Brick work with 1st class bricks in cement mortar (1:3) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	82.12	92	7,555.04
9	**75mm (3") Brick work with mortar 1:2:** 3" Brick work with 1st class bricks in cement mortar (1:2) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	103.82	80	8,305.60

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
10	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	419.07	22	9,219.54
11	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:3) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	273.36	24	6,560.64
12	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:2) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	273.36	26	7,107.36
13	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:1) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	273.36	28	7,654.08
14	**0.32 mm thick (Colored) CGI Sheet for Roofing/Wall:** Supplying, fitting and fixing 0.32mm thick CGI sheet (Brand Quality), fitting and fixing on frame with screws. all complete and accepted by the Engineer.	sft	253.67	110	27,903.70
15	Supplying, fitting, fixing and colouring/painting of **MS Angle Bar (40mmx40mmx4mm)**- Post Plate, Rafter, Truss Member, Purlin and etc. all complete to the satisfaction of the EIC.	rft	249.17	90	22,425.30
16	**Other Supplies & Accessories including fitting & fixing**				
a	Enamel paint	lb	6	100	600.00
b	Solvent Cement (100gm Kony Japan)	nos.	1	165	165.00
c	PVC Pipe dia 4" D Class with necessary fittings	ft	75	220	16,500.00
d	PVC elbow dia 4", 45 degree angle	nos	2	140	280.00
e	Best quality Padloo	kg	5	300	1,500.00
f	GI Wire 24	feet	70	140	9,800.00
g	Delivery flexible pipe, 0.5" dia	nos	4	45	180.00
h	Gas valve 2" RB Italy 1/2" Dia	ft	2	550	1,100.00
i	GI Nipple 1/2"	kg	1	50	50.00
j	Roof nail	nos	3	1500	4,500.00
k	Biogas stove	nos	4	70	280.00
l	GI nipple both pass 1/2"	nos	2	350	700.00
m	Seal Tape	nos	4	30	120.00
n	GI Clam 1/2"	nos	1	50	50.00
o	Pad lock (32mm)	nos.	1	20	20.00
p	Cow dung 1st time Biogas plant feeding	kg	4500	25	112,500.00
	Grand Total (BDT) =				**340,771**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

28.2.18

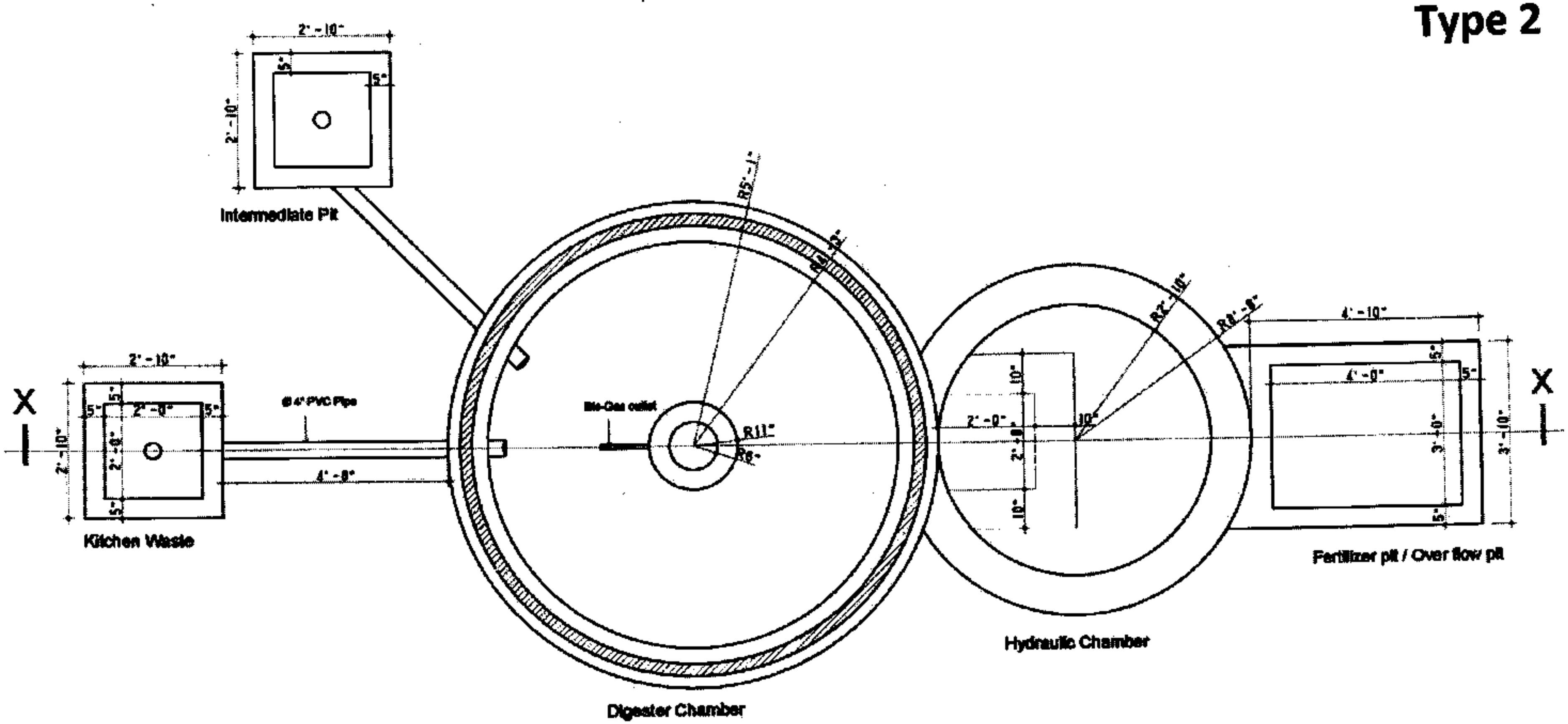
Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

Approved By

26.02.18

Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

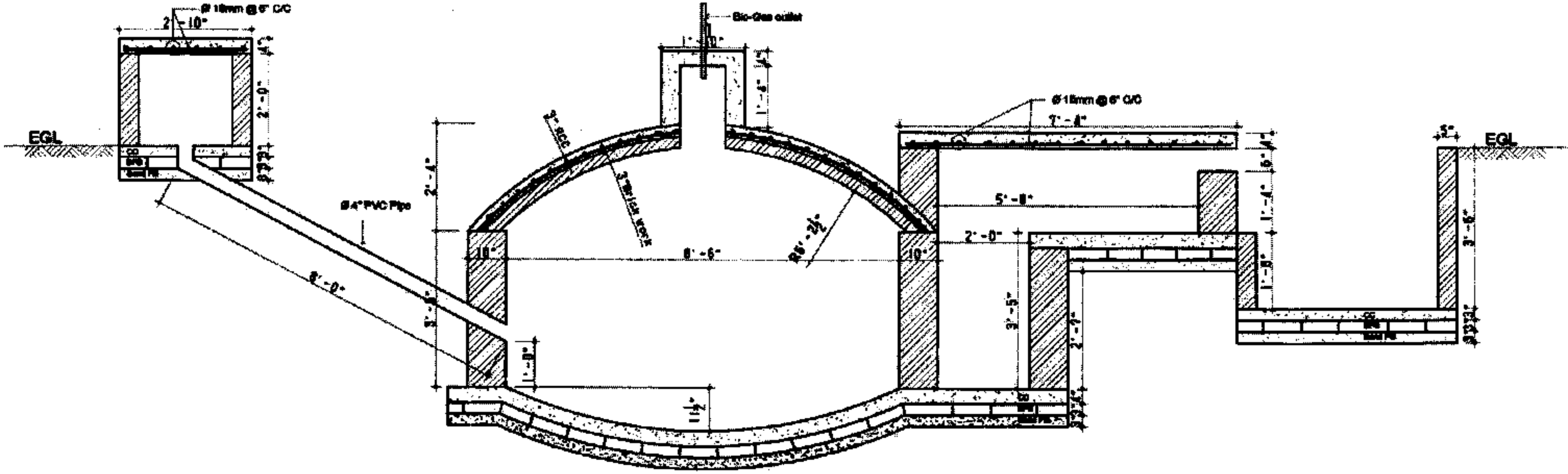
Type 2



Plan of Bio-Gas plant

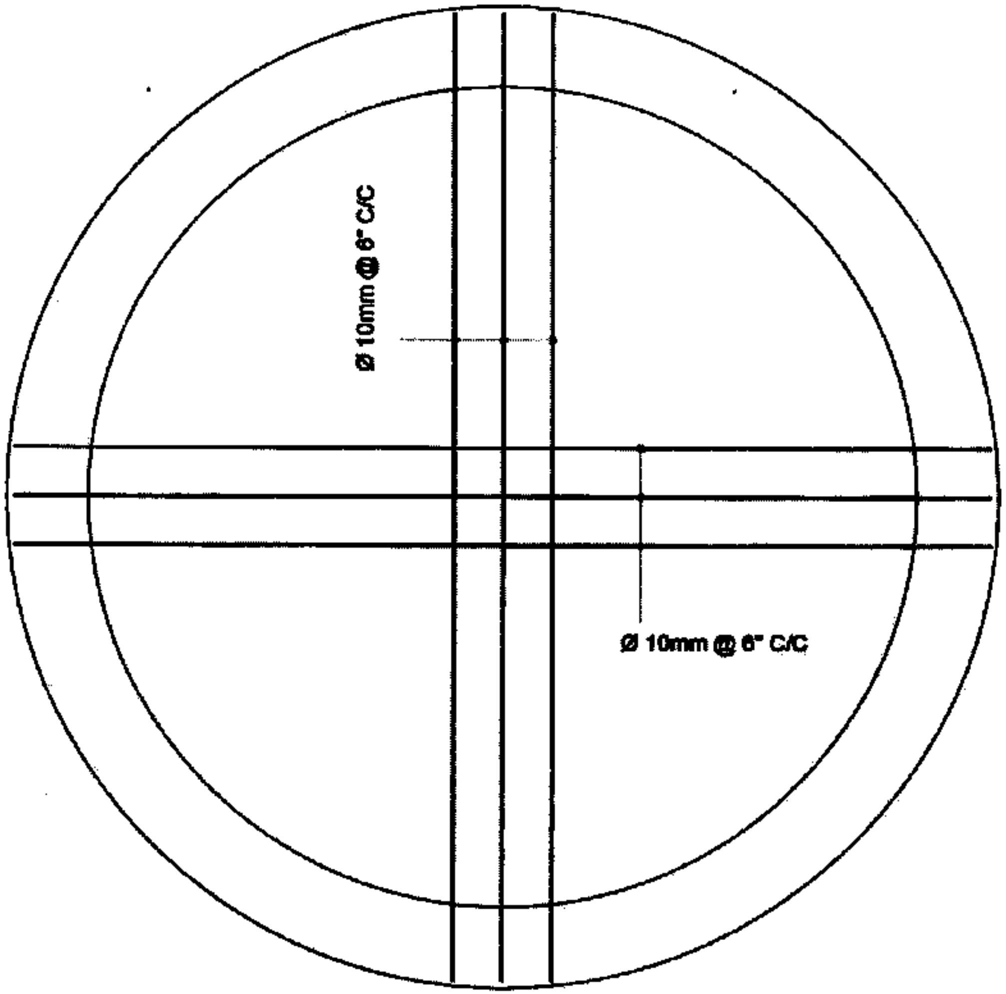
Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Biogas	Fixed Dome Type Biogas-4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan	18-02-2018	01	UNHCR United Nations High Commissioner for Refugees

WASH Sector Cox's Bazar



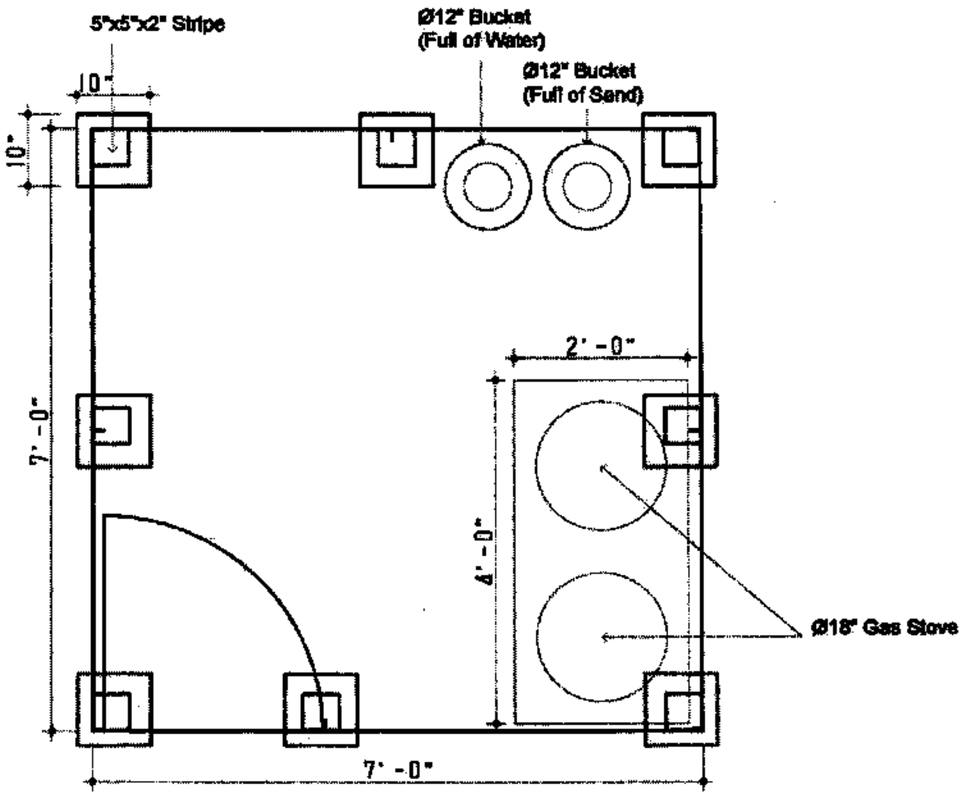
Section X-X

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fixed Dome Type Biogas-4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section	18-02-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

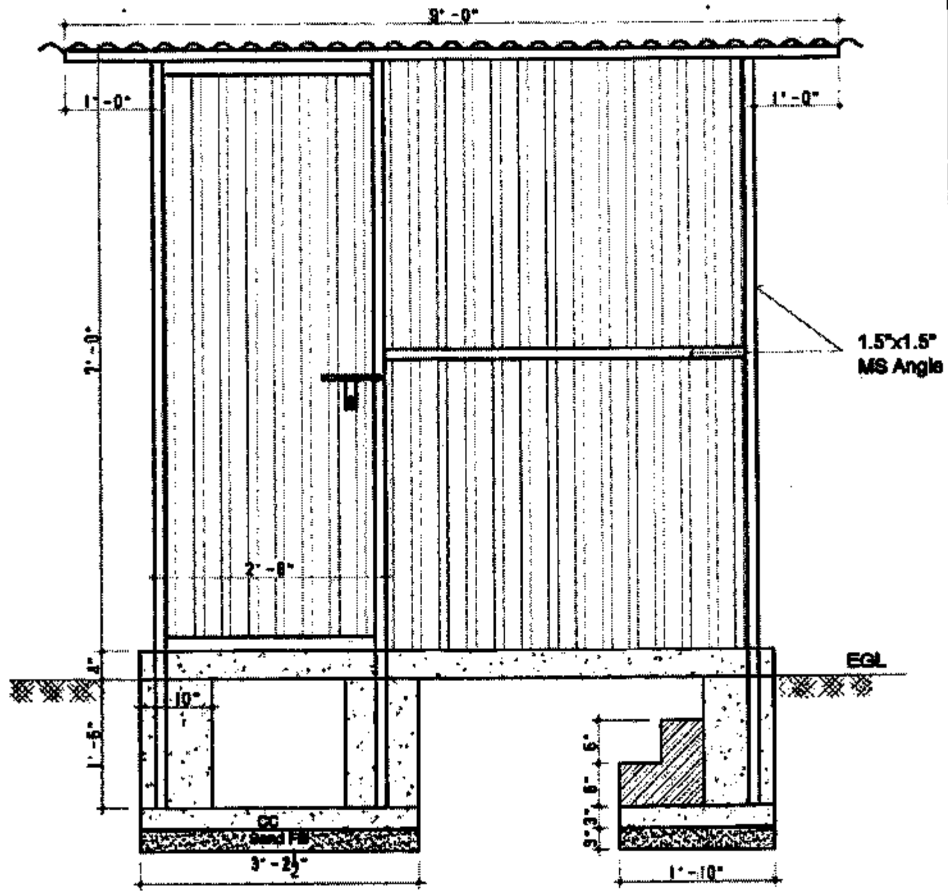


Reinforcement Details

	Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fixed Dome Type Biogas-4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Details of Reinforcement	18-02-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



Plan of Kitchen



Sectional View of Kitchen

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fixed Dome Type Biogas-4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Details of Kitchen	18-02-2018	04	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

Bill of Quantities

for the Fiber Biogas Plant (4m3) Construction

Biogas-3

Location: Cox's Bazar

Date: 17/02/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation** in all kinds of soil to layout, providing center lines, local bench-mark pillars, leveling, ramming, prepaing the base, providing necessary tools and plants, protecting and maintaining the trench dry etc. stacking, cleaning the excavated earth at a safe distance out of the area enclosed by the layout etc. all complete and accepted by the Engineer, subject to submit method statement of carrying out excavation work to the Engineer for approval. However, Engineer's approval shall not relieve the contractor of his responsibilities & obligations under the contract. Earth work excavation: Gas storage chamber, digester, hydraulic chamber, slurry pit.	cft	1063.71	7	7445.97
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	58	24	1,392.00
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	118	5	590.00
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	101	33	3,333.00
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	29.5	236	6,962.00
6	**RCC (1:2:4) Work:** Reinforcement cement concrete work at different part of biogas plant with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all **reinforcement as per in details drawing,** shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	3.8	375	1,425.00
7	**Brick work with mortar 1:3:** Brick work as per drawing with 1st class bricks in cement mortar (1:3) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In-charge.	cft	21	225	4,725.00
8	**125mm (5") Brick work with mortar 1:3:** 5" Brick work with 1st class bricks in cement mortar (1:3) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	60	92	5,520.00

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
9	**12 mm thick plaster with NCF mix with padllo 1:10:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	308	24	7,392.00
10	**0.32 mm thick (Colored) CGI Sheet for Roofing/Wall:** Supplying, fitting and fixing 0.32mm thick CGI sheet (Brand Quality), fitting and fixing on frame with screws. all complete and accepted by the Engineer.	sft	253.67	110	27,903.70
11	Supplying, fitting, fixing and colouring/painting of **MS Angle Bar (40mmx40mmx4mm)**- Post Plate, Rafter, Truss Member, Purlin and etc. all complete to the satisfaction of the EIC.	rft	249.17	90	22,425.30
12	**Pit Cover for Slurry pit (Size-4'-10"x3'-10")**- 18 gauge plain Sheet with angel 1"x1"x4mm ,flat bar 1"x4mm locking system Cover with green color. As per direction Engineer -in-charge and attached drawing.	nos	1	3500	3,500.00
13	**Digester Chamber & Hydraulic Chamber-** 8m3 internal volume 4m3 Gas Production/Day with inlet holes (6" Dia) in Inlet chamber. Hydraulic Chamber included. Body made of Fiber glass reinforced plastic (Thikness-3.5mm) and digester dia -2.40 Meter. All setup with all equipment's. Good quality with airproof. Top of Digester Chamber vertical gas outlet pipe. Hydraulic retention time-40-45 days. Hydraulic chamber outlet must need connectable with slurry pit. Must need maintain leveling in instalation time. (Technical specification:Capacity(Digester size)=8m3, Gas holder size=(Daily gas production x 0.45)m3=4.0x 35% =1.4, Diameter of Digester(m)=2.40, Amount of human excreta(Person)=200, Retention time(Day)=40-45, Plant size Gas production /day(m3/ day)= 4.07, Wall Thickness =3.5 mm	set	1	155000	155,000.00
14	**Other Supplies & Accessories including fitting & fixing**				
	Enamel paint	lb	6	100	600.00
	Solvent Cement (100gm Kony Japan)	nos.	1	165	165.00
	PVC Pipe dia 4" D Class with necessary fittings	ft	10	220	2,200.00
	PVC elbow dia 4", 45 degree angle	nos	2	140	280.00
	Best quality Padloo	kg	5	300	1,500.00
	GI Wire 24	feet	0.5	140	70.00
	Delivery flexible pipe, 0.5" dia	nos	70	45	3,150.00
	Gas valve 2" RB Italy 1/2" Dia	ft	4	550	2,200.00
	GI Nipple 1/2"	kg	2	50	100.00
	Roof nail	nos	1	1500	1,500.00
	Biogas stove	nos	2	70	140.00
	GI nipple both pass 1/2"	nos	4	350	1,400.00
	Seal Tape	nos	2	30	60.00
	GI Clam 1/2"	nos	4	50	200.00
	Pad lock (32mm)	nos.	1	20	20.00
	Cow dung 1st time Biogas plant feeding	kg	4500	25	112,500.00
	Grand Total (BDT) =				**373,699**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

26.2.18

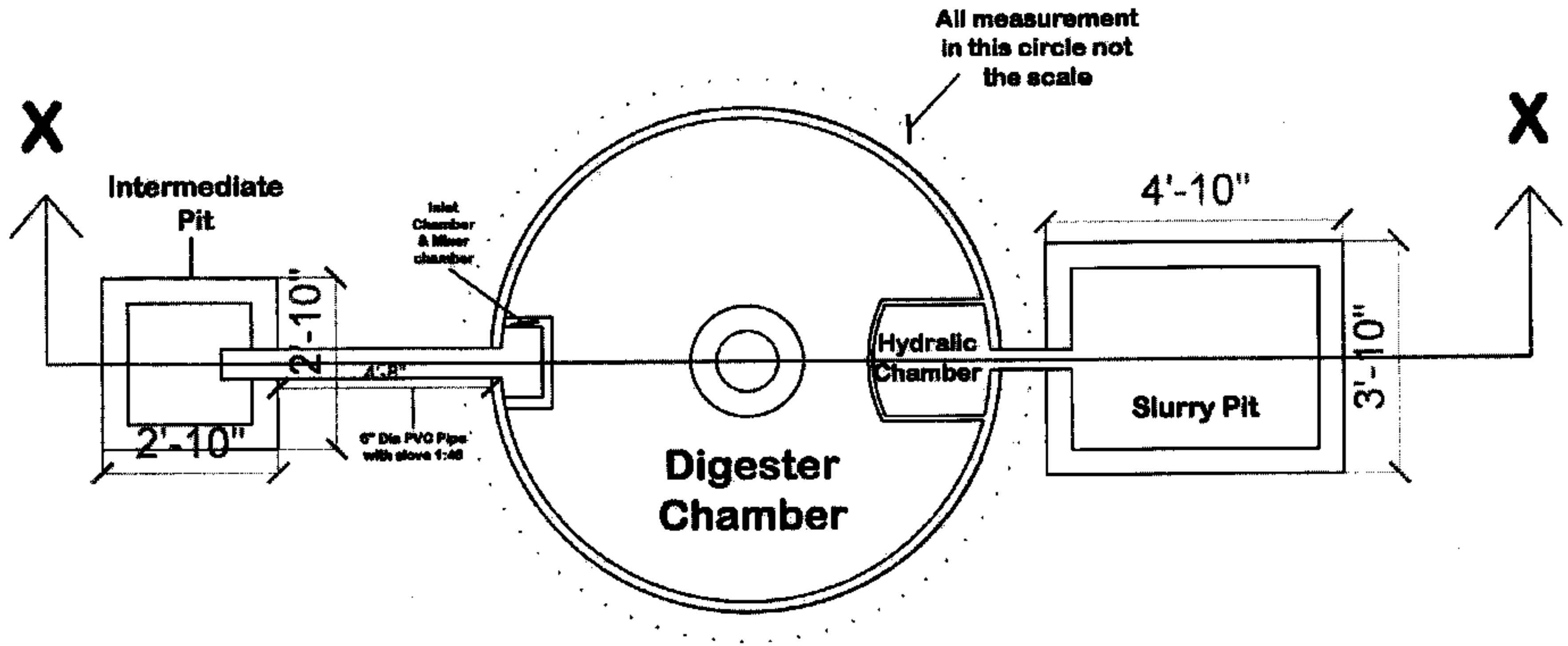
Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

Approved By

26.02.18

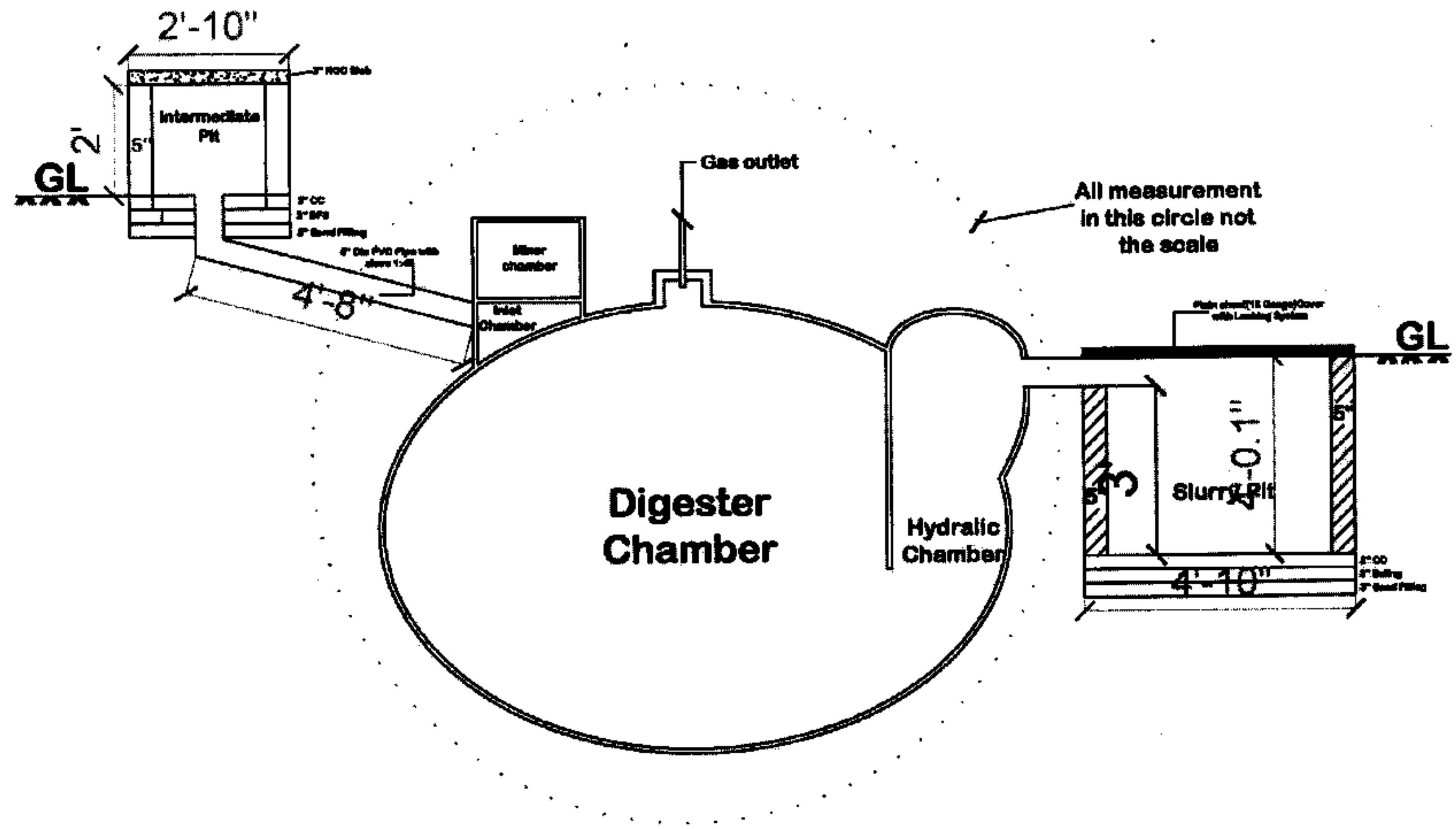
Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar

Type 3



Plan of Fiber Glass

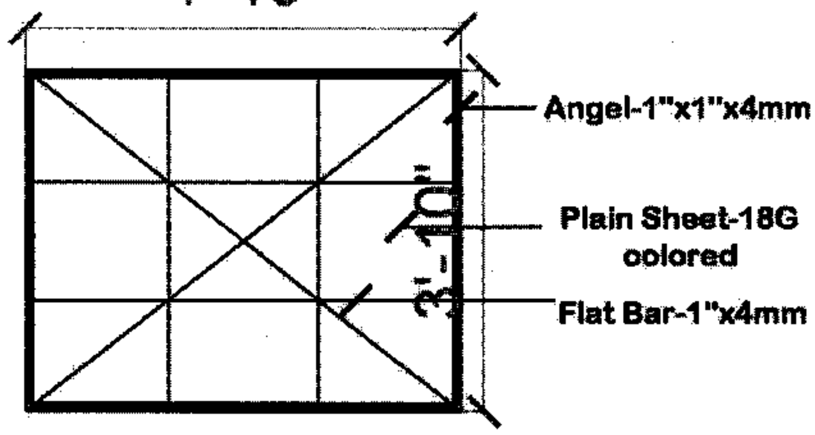
		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fiber Glass Dome Type Biogas- 4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan	18-02-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



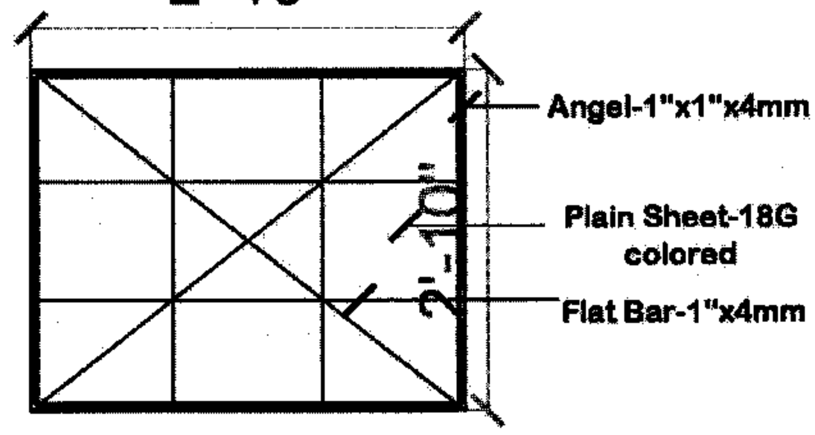
X-X Section-Fiber Glass

Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
Design and Drawing of Biogas	Fiber Glass Dome Type Biogas- 4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section	18-02-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

WASH Sector Cox's Bazar

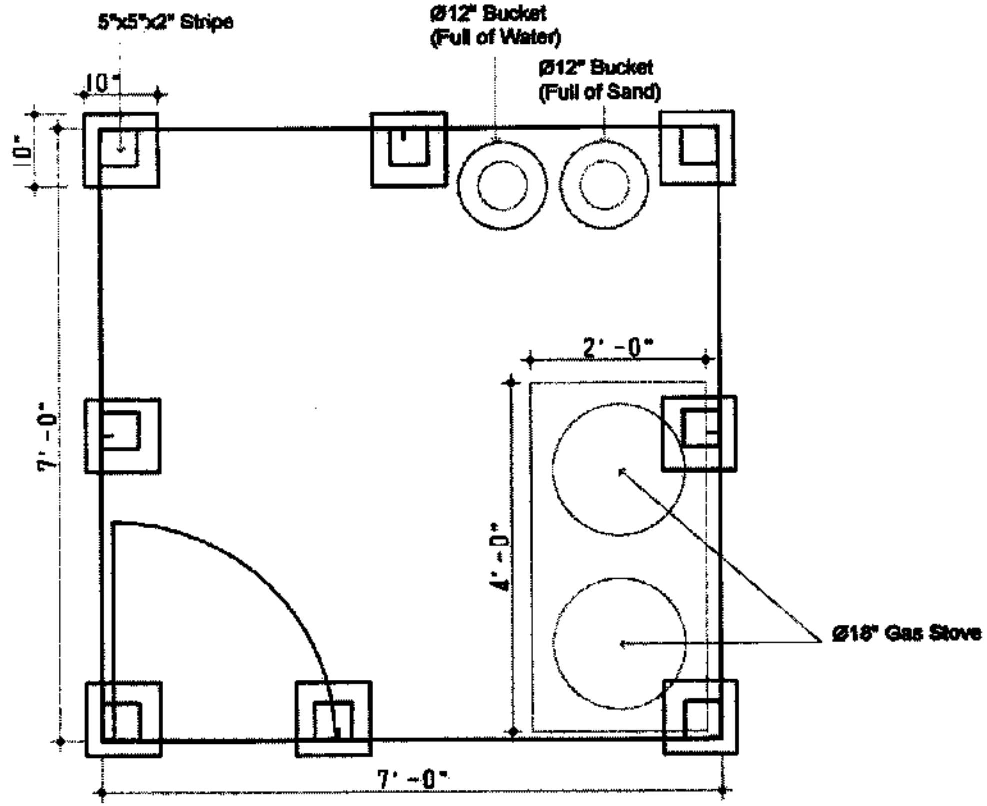


Slurry pit cover deteil

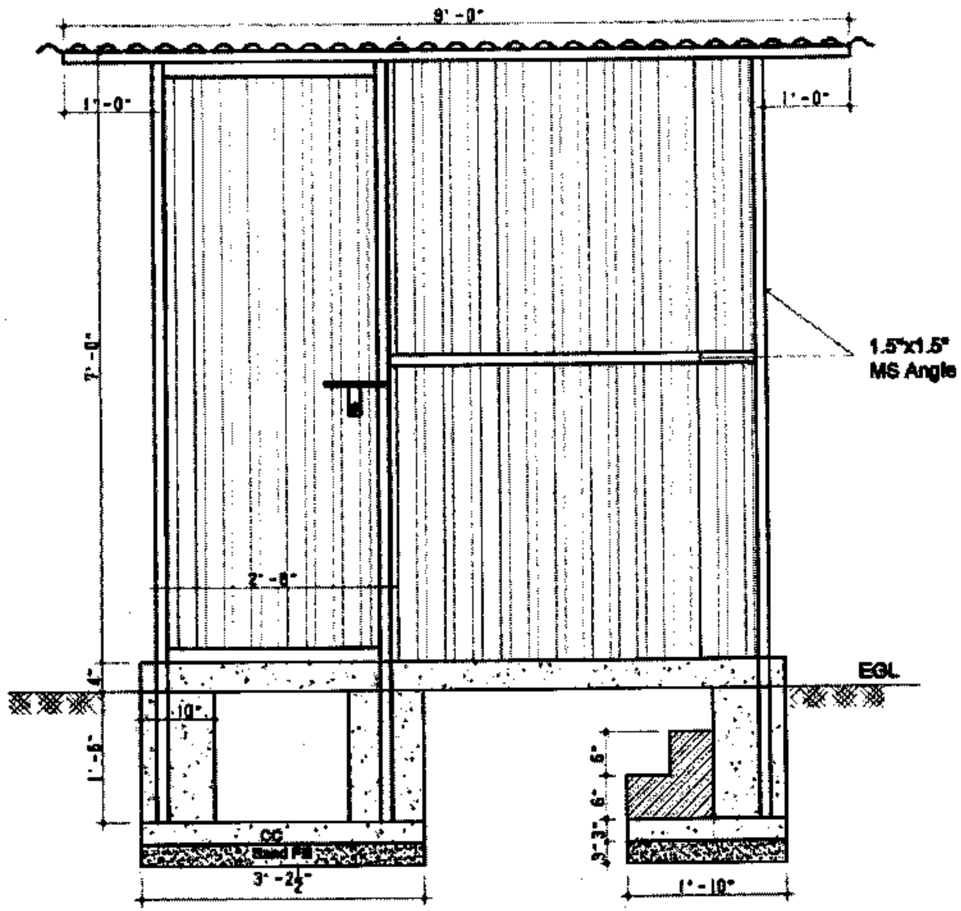


Kitchen waste pit cover deteil

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fiber Glass Dome Type Biogas-4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Details of Reinforcement	18-02-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



Plan of Kitchen



Sectional View of Kitchen

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Biogas	Fiber Glass Dome Type Biogas- 4m3	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Details of Kitchen	18-02-2018	04	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

Bill of Quantities
for the Bath House Construction

Location: Cox's Bazar

Date: 10/01/2018

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
1	**Earth work in excavation of Foundation** for twin pit latrine, carrying and disposing of all Excavated materials at a safe distance designated by the EIC/UNHCR, all types of soil except rocky gravelly, organic maintains proper slope, disposing of all back filling of sites of all excavated materials to a safe distance back filling of sites of original level etc, all complete to the direction of the EIC/UNHCR.	Cft	35	7	245.00
2	**Sand Filling:** Sand filling in foundation trenches and plinth with fine local sand having minimum fineness modulus (FM) of .50 in 150mm / 75 mm layers, leveling, watering and consolidating each layer by layer up to finished level, etc. All filling completed as per direction of engineer-in-charge and as per drawing and design	cft	38	22	836.00
3	**Polyethylene Sheet:** Providing single layer polythene sheet (0.18mm thick) weighting one kilogram per 6.5 square meter in floor or anywhere in ground floor underneath the cement concrete, etc. all complete as per specifications and direction of the Engineer In-charge.	sft	20	5	100.00
4	**Brick Flat Soling (3"):** Single layer of brick flat apron in foundation with 1st class or picked bricks preparation of bed and filling interstices with local sand, etc. All work completed as per direction of engineer-in-charge and as per drawing and design.	sft	48	31	1,488.00
5	**Mass Concrete (1:2:4):** Plain cement concrete work in foundation or floor with best quality Portland cement, sand (minimum FM 1.20) and 1st class/picked brick chips 20mm downgraded (LAA value not exceeding 40), including shuttering, (Shuttering works in/c centering, leveling, making shuttering fully leak proof, etc. Including all shuttering materials) mixing by concrete mixer machine/manually, casting, laying compacting and curing for 7 days etc. all complete as per direction of the engineer-in charge.	cft	17	236	4,012.00
6	**125mm (5") Brick work with mortar 1:4:** 5" Brick work with 1st class bricks in cement mortar (1:4) and making bond with connected walls in/c necessary scaffolding, racking out joints, cleaning and soaking the bricks at least for 24 hours before use, washing of sand, curing for requisite period etc. all complete as per direction of the Engineer In charge.	sft	65	70	4,550.00
7	**12 mm thick plaster with NCF:** Plastering interior and outer wall: minimum 1/2 in. thick cement plaster with (1:4) to outer wall; finishing corner and edges; cleaning the surface, plastering work on the outer surface of precast column ,all plastering completed as per direction of engineer-in-charge and as per drawing and design.	sft	85	18	1,530.00
8	**0.32 mm thick (Colored) Corrugated Plastic Sheet for Roofing:** Supplying, fitting and fixing 0.32mm thick corrugated plastic sheet (Brand Quality), fitting and fixing on wooden frame with screws. all complete and accepted by the Engineer.	sft	49	45	2,205.00
9	**0.51 mm/24 gauge thick (Colored) Plain Galvanized Iron Sheet for Wall Fenching & Door:** Supplying, fitting and fixing 0.51 mm /24 gauge thick plain galvanized iron sheet (Brand Quality) for fitting and fixing on wooden purlin with screws, limpet washers and putty etc. all complete and accepted by the Engineer.	sft	140	30	4,200.00

Item	Description	Unit	Quantity	UNIT PRICE	AMOUNT
10	**Wood Work (Gorjon/Akashmoni/Mehogini):** Timber used for wood work shall be well seasoned, kiln dry containing not more than 8% to 12 % moisture so as to ensure minimum tendency towards warping, shrinking and swellings. It shall be free from all defects such as large or loose knots, shakes, saps, upsets, wane edge and twisted fiber. It shall also be free from all disease such as decay, wet rot, dry rot and woodworms and white and timber should be finished to the exact dimension shown on the drawing or as per Engineer direction.	cft	9	1200	10,800.00
11	10ft 3inch height pre-cast pile (5" x 5" size) with reinforced cement concrete works with minimum cement content relates to mix ratio 1:1.5:3 having minimum f'cr = 30 Mpa, and satisfying specified compressive strength f'c = 25 Mpa at 28 days on standard cylinders as per standard practice of Code ACI/BNBC/ASTM best quality coarse sand (F.M.2.2), 20 mm down well graded stone chips conforming to ASTM C-33, mixing in standard mixture machine and centering and shuttering with M.S sheet, M.S angle, F.I bar, nuts and bolts, preparation of bed, laying polythene, placing of reinforcement cage in position, casting, compacting by vibrators and tapered rods, curing for 28 days etc. including cost of reinforcement, water, electricity and other charges as per design and drawing, etc. all complete as per design, drawing and accepted by the Engineer.	**Nos**	**4**	**950**	**3,800.00**
12	Other materials-				
a	Stud Nail (2.5 inch)	kg	2	80	160.00
b	MS Clamp Size 1-6" x 2.5"x3mm Thickness	Nos	4	100	400.00
c	Nail Different size (1.5 to 4 inch)	kg	1.5	80	120.00
d	Hinges	Nos	3	50	150.00
e	Screw for Hinges	Dozen	1	100	100.00
f	Lock Chain (Small for door lock inside & outside)	Nos	2	25	50.00
g	uPVC pipe (4" dia)	ft	10	85	850.00
	Grand Total (BDT) =				**35,596**

Recommended By

Abu Naim MD. Shafiullah Talukder
Sector Coordinator-WASH
(Estimation developed by UNHCR)

Examined By

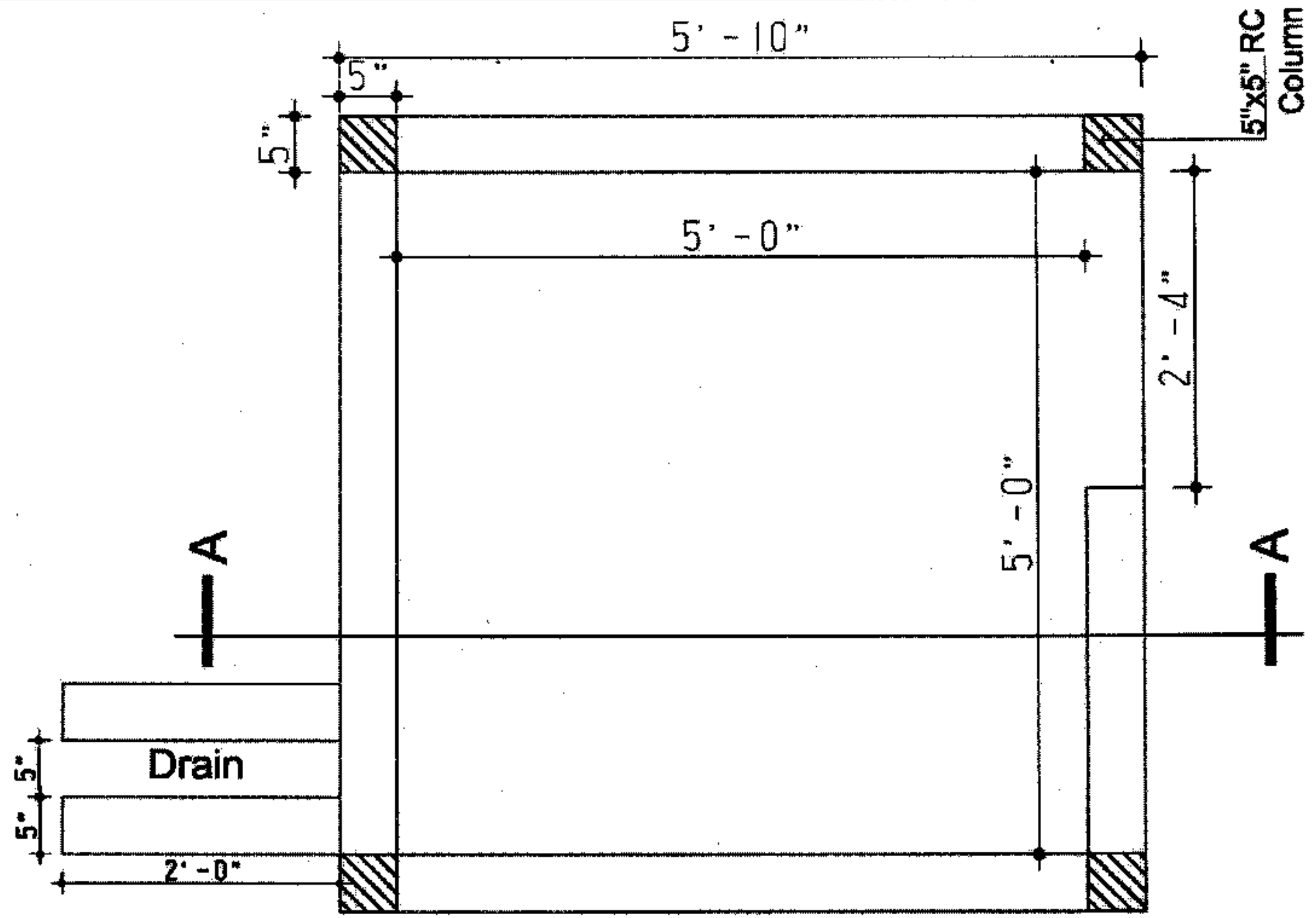
26.2.18

Md. Masum Kabir Nazrul Islam
DRRO, RRRC Office

Approved By

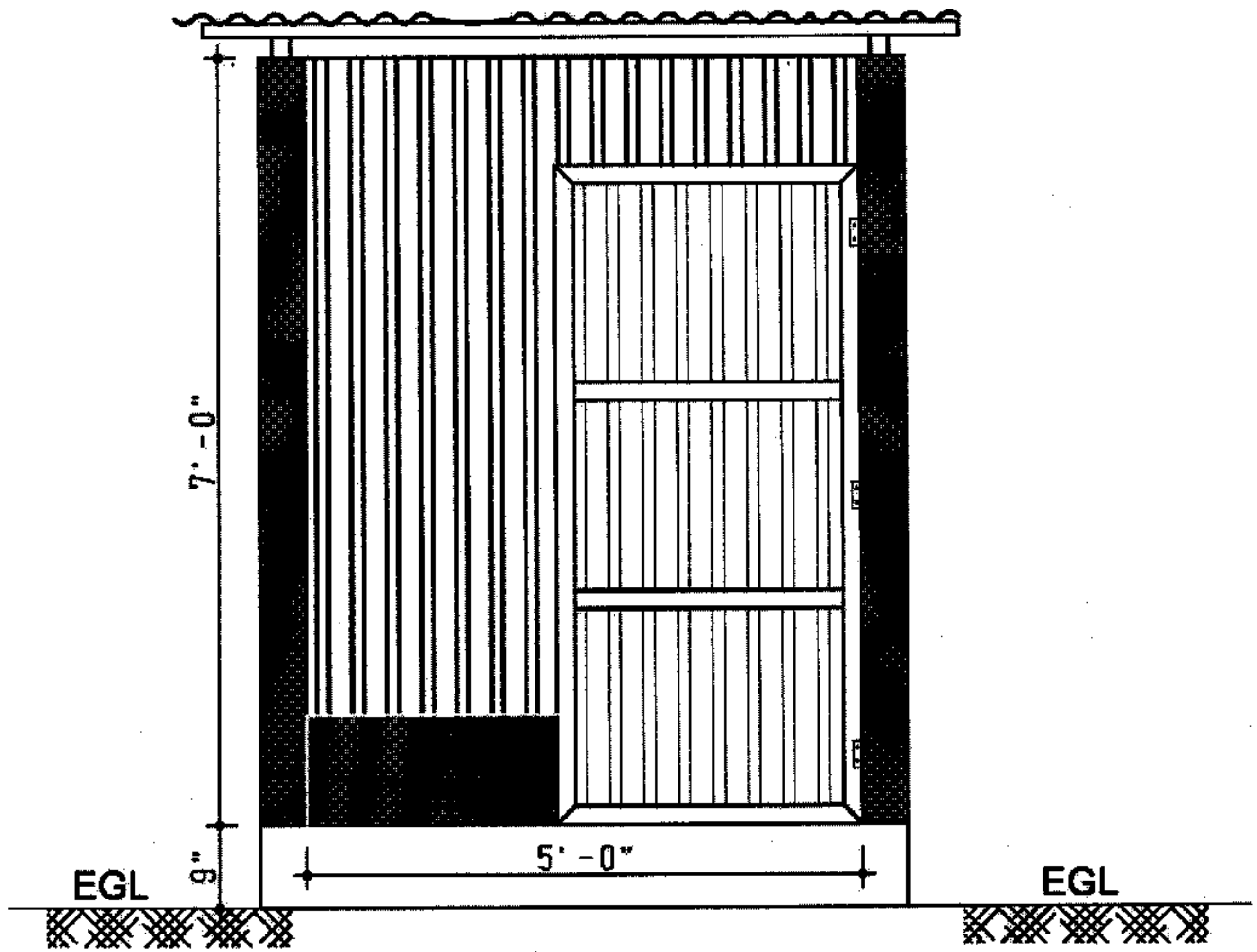
26.02.18

Mohammad Abul Kalam, ndc
(Additional Secretary)
Refugee Relief and Repatriation
Commissioner, Cox's bazar



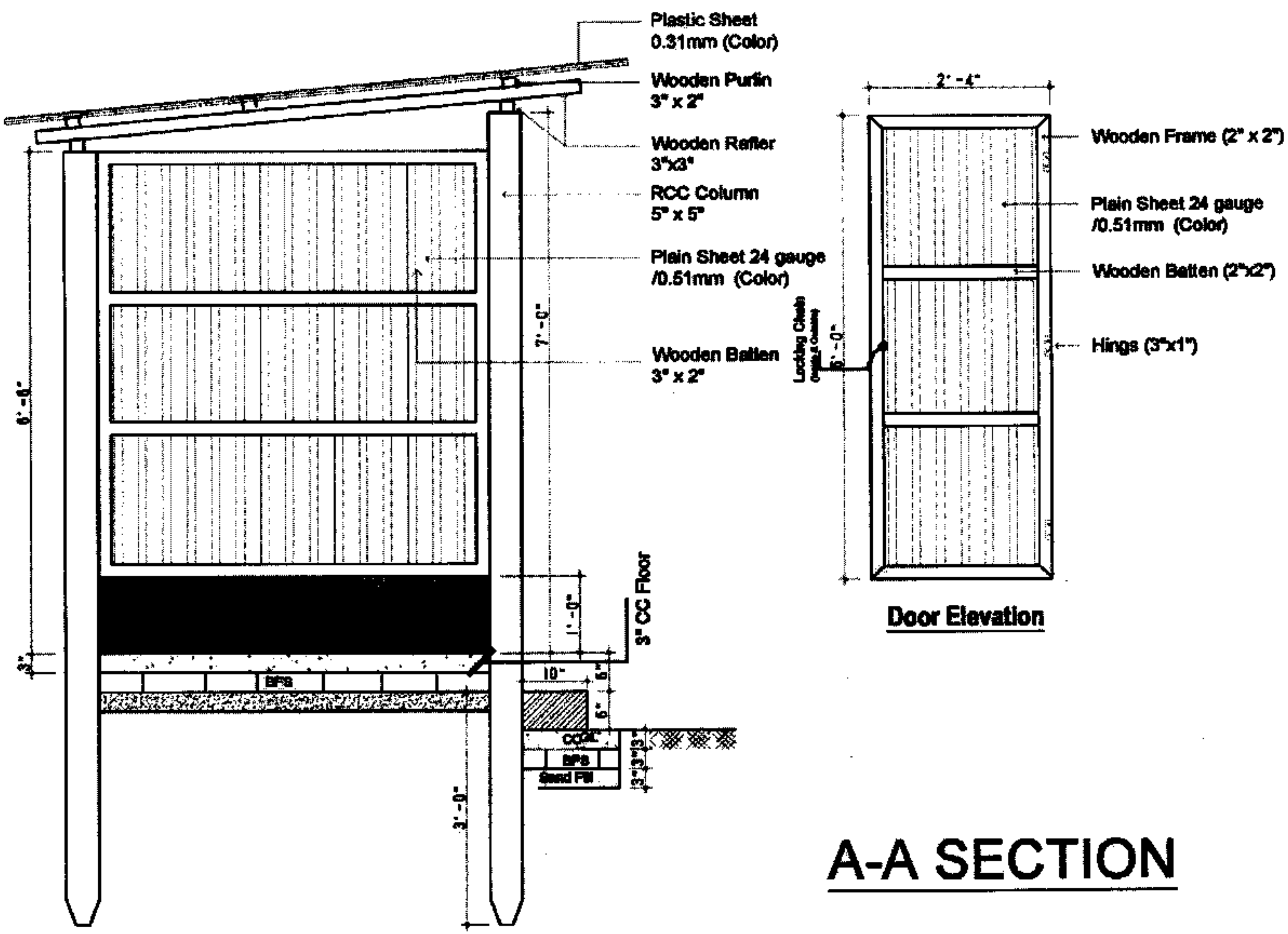
PLAN OF BATH-HOUSE

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Bath-house	Bath-house	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Plan	17-01-2018	01	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



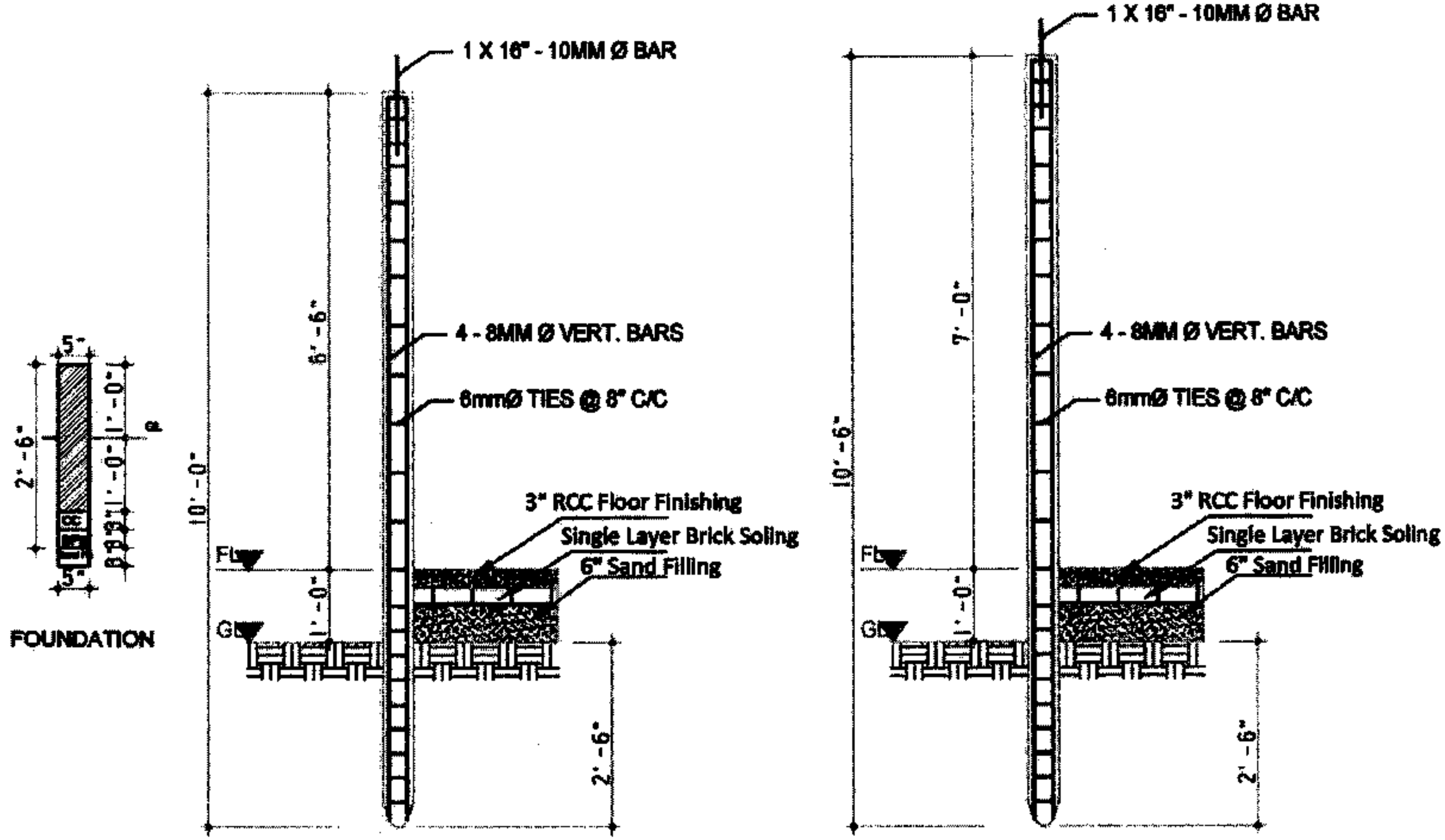
FRONT ELEVATION

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Bath-house	Bath-house	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Front Elevation	17-01-2018	02	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



A-A SECTION

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Bath-house	Bath-house	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Section A-A	17-01-2018	03	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés



DETAIL OF R.C.C POST

		Project	Model	Designed by	Checked By	Drawing Title	Date	Page	On Behalf of WASH Sector Developed by
	WASH Sector Cox's Bazar	Design and Drawing of Bath-house	Bath-house	Minhaj Uddin Ahmed UNHCR	ABM Sadiqur Rahman UNHCR	Column Details	17-01-2018	04	UNHCR United Nations High Commissioner for Refugees Haut Commissariat des Nations Unies pour les réfugiés

OXFAM ARUP

Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix I

Stakeholder Characterisation

Organisation	Type of Stakeholder	Name	Role	Involvement in this project	Notes
Arup	NA	Anna Grieve	Arup PM	Core team	Wastewater Engineer involved in various FSM project through Arup.
Oxfam	Constructor & Operator	Niloy Safwatul	Oxfam Project leader	Core team	Oxfam FSM plant designer and operator in CAMP 4.
CxB WASH cluster	Coordinating body	Damien Seal (UNICEF)	WASH Sector Coordinator Bangladesh	Core team	Wash sector coordinator - Key contact for organising stakeholders and CxB meetings etc.
FSM Global TWiG	Coordinating body	Marij Zwart	Global FSM lead	Core team	FSM global lead. Historic involvement with CxB FSM, good contacts and overview of studies that have been undertaken.
UNHCR	Donor/ Coordinating body	Didier Boissavi	UNHCR rep		
UNHCR	Donor/ Coordinating body	Grover Casilla	UNHCR rep/WASH officer	Core team	
IOM	Donor/ Coordinating body	Salahuddin Ahmmed	IOM rep	Core team	
IOM	Donor/ Coordinating body	Alessandro PETRONE	IOM rep	Core team	
UNICEF CxB	Donor/ Coordinating body	Bishnu Bishnu Pokhrel		Core team	
UNICEF CxB	Donor/ Coordinating body	Sojib Mohammad Ashfaqur Rahman		Core team	
UNICEF (Holland)	Academic	Cecilie Kolstad	Innovation Specialists -WASH	None	Developing spec for 'FSM in emergencies' standard product for UNICEF
BRAC	Constructor & Operator	Farukh Hossain	WASH Lead BRAC	Wider stakeholder	Operator for several of the sites visited
BDRCS Bangladeshi Red Crescent Society	Constructor & Operator	Khairul Basar Sr.	WASH Officer BDRCS	Wider stakeholder	Operator for several of the sites visited
IFRC CxB	Constructor & Operator	Mejbah Chowdry	Mejbah Chowdry IFRC Wash coordinator CxB	Wider stakeholder	Manages IFRCs WASH operations in Cox's Bazar
IFRC lab CxB	Constructor & Operator	Mohammed Saimon	Laboratory Technician (FSM)	Wider stakeholder	Available sample data
NGO Forum CxB	Constructor & Operator	Md. Abu Rafat Siddique	Deputy Project Coordinator	Wider stakeholder	Operator for several of the sites visited
NGO Forum CxB	Constructor & Operator	Ataur Rahman	Project Manager	Wider stakeholder	Operator for several of the sites visited
MSF CxB	Core team member Constructor & Operator	Adrian	Core team rep	Core team	Operator for several of the sites visited
MSF CxB	Core team member Constructor & Operator	Jackson M. LOCHOKON	WatSan Team Leader - Cox's Bazar		Operator for several of the sites visited
Practical Action CxB	Constructor & Operator	Mamun Chowdhury	Camp Coordination & Reporting Officer	Wider stakeholder	Design and built some of the plants visited but not operating them anymore
SI CxB Solidary international	Constructor & Operator	Farhad Bin Alam	Deputy WaSH Coordinator	Wider stakeholder	Design and built some of the plant visited but not operating them anymore
WaterAid CxB	Constructor & Operator	NOT ACTIVE IN WASH PROJECCT		Wider stakeholder	
SDC		Keller Mirco EDA KEMIR		Wider stakeholder	CxB solid waste strategy
Gates Foundation CxB / FSM cell Data		Shaila Shahid	Chief Operating Officer, Disaster Climate change support Unit	Wider stakeholder	
DPHE CxB	Government	Ritthick Chowdhury	Excutive Engineer	Wider stakeholder	
DoE CxB	Government	MD. Nazmul Huda	DoE CxB representative	Wider stakeholder	
ITN Buets	Academic	Azizur Rahman	Asistant director	Wider stakeholder	
ITN Buets	Academic	Professor Dr. Tanvir Ahmed	Director – ITN BUET	Wider stakeholder	
UPM	Academic	Roman Rydin		Wider stakeholder	
ICDDR'B	Academic	Dr. Zahid Hayat Mahmud	Scientist and Head	Wider stakeholder	
IHE Delft Institute for Water Education & IFRC	Academic	Berend Lolkema	Researcher	Wider stakeholder	Undertook study on CxB FSTP functionality for university pHD
World Vision International	Constructor & Operator	Nowshad Akram	Program Manager	Wider stakeholder	Operator for several of the sites visited
World Vision	Constructor & Operator	Jafar Ikbal	Engineering Section Lead (Technical)	Wider stakeholder	Operator for several of the sites visited
GUK Gana Unnayan Kendra	Constructor & Operator			Wider stakeholder	
ACF	Constructor & Operator	Ahajan Siraj	Project Manager	Wider stakeholder	
Verc	Constructor & Operator	Shamim Khan	Project Manager	Wider stakeholder	Operator for several of the sites visited
SHED Society for Health Extension and Development	Constructor & Operator	Showkat Ali	Deputy Director (WASH)	Wider stakeholder	
ADB		Marjana Chowdhury		Wider stakeholder	
DSK Dushtha Shasthya Kendra	Constructor & Operator	Alamgir Rahman	Join Director	Wider stakeholder	

Field visit stakeholders (interviewees)

FIELD SURVEY , SUMMARY

SL #	Organisation	Technology /Governing Component	Interviewee	AFA	Camp Name	Survey Date	Location
1	BRAC	ABR	Md. Azaz Ahamed	UNICEF	14	24th February,2022	Ukhiya
2	NGO Forum	ABR	Md. Faruk Islam	UNICEF	5	24th February ,2022	Ukhiya
3	VERC	ABR	Md. Mominul Islam	UNICEF	8W	13th march ,2022	Ukhiya
4	World Vision International	WSP	S.M Mamdudur Rahman	UNICEF	camp 7	28th February ,2022	Ukhiya
5	VERC	WSP	Md. Nurul Hasan	UNICEF	8W	20th March 2022	Ukhiya
6	World Vision International	UFF	S.M Mamdudur Rahman	UNICEF	camp 7	28th February ,2022	Ukhiya
7	VERC	UFF	Rukunul Hasan	UNICEF	8W	13th march ,2022	Ukhiya
8	NGO Forum	Anaerobic Lagoon	Asid Nur Dipto	UNHCR	4	15th February ,2022	Ukhiya
9	BRAC, UNHCR ,OXFAM, MSF	Biological , Planted Drying bed	Giacomo Vecchi , Module 1 (MSF) ,	UNHCR	Kutupalong	24th April,2022	Ukhiya
10	NGO Forum	LSP	Asid Nur Dipto	UNHCR	4	17th February ,2022	Ukhiya
11	BRAC	LSP	Md. Rokibul Islam Rabbi	UNHCR	1 W	17th February ,2022	Ukhiya
12	NGO Forum	LSP	Md. Soharab Ali	UNHCR	26	23rd February ,2022	TEKNAF
13	BRAC	ABR	Md. Rokibul Islam Rabbi	UNHCR	21	27th February ,2022	TEKNAF
14	NGO Forum	ADS	Asid Nur Dipto	UNHCR	26	23rd February ,2022	TEKNAF
15	MSF	Biological , Constructed Wetland	Giacomo Vecchi	IOM	next to camp 12	24th April,2022	Ukhiya
16	IFRC/BDRCS	Aeration	Mejbah Uddin Chowdhury	IOM	18	1st March ,2022	Ukhiya
17	IFRC/BDRCS	Aeration	Mejbah Uddin Chowdhury	IOM	19	1st March ,2022	Ukhiya
18	IFRC/BDRCS	Upflowfilter, Drying Beds , Constructed Wetland	Dr. David Thomas	IOM	18	16th February ,2022	Ukhiya
19	IOM / NGOF	DEWATs	Rashed Rana	IOM	9	3rd March ,2022	Ukhiya
20	IOM / Shushilan	DEWATs	Rashed Rana	IOM	12	3rd March ,2022	Ukhiya

OXFAM SURVEY TEAM

Name	Position
Safwatul Haque Niloy	Sanitation Coordinator
Md. Razwanul Islam Tomal	Public Health Engineering Team Leader
Adila Sultana	Public Health Engineering Officer
Al Rahat	Public Health Engineering Officer
Masud Rana	Public Health Engineering Officer

OXFAM ARUP

Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix J

Stakeholder questionnaire form

Number	Question
1	Which organisation do you work for?
2	What is the role/ responsibility of your organisation regarding FSM in the camp? (construction ,management, O&M, secure financing, monitoring and evaluation,capacity building information to stakehoders/community, other)
3	In which part or parts of the FSM chain does your organisation work: emptying, transport, treatment, disposal, reuse?
4	How long has your organisation been operating in the camp?
5	How many facilities/FSM sites does your organisation operate? Please indicate technology use. In the case of a service provided (such as collection and transport of sludge) please indicate how many and what type of services you provide?
6	In which area(s) of the camp does your organisation operate regarding FSM?
7	What other stakeholders do you work/ engage with? Please explain how.
8	What are the main successes achieved in relation to your organisation's work in FSM in the camp?
9	What are the main challenges faced by your organisation in relation to their work in FSM in the camp?
10	What are the main future opportunities in relation to your organisation's work in FSM in the camp?
11	Do you have any available data / recent work/ study you can share covering the following parameters?
a	Basis of design and key design features of the FSTPs and FSM chain.
b	Capital expenditure and operational costs (CAPEX and OPEX), in order to determine whole life cost.
c	Quality of liquid and solid effluent (pathogen inactivation), or any other sludge sampling/laboratory data.
d	Area requirements, layout, and scalability.
e	Speed of construction and commissioning.
f	Expertise required for setup and operation.
g	Operation and maintenance issues.
h	Treatment process complexity and pinch points.
i	Disposal of final products (liquid and solid), and
j	Resilience to flooding/natural disaster.

Sludge Transport Data Collection form

DATA COLLECTION FORMAT - Fecal Sludge Emptying and Transportation

“Technical and operational assessment of FSM systems in the Rohingya Refugee Response” - Cox's Bazar Rohingya Reponse.

	Sl #	**Camp**	**Block**	**Agency Name**	**Donor**	**Transportation mode** **Single chain: Vacutug/IFSTN/Pit Transfer/Manual Desludging/Others or Mixed chain** **If 'Single: Other' or 'Mixed', Please Mention in Remarks box**	**How many Days (Avg) require per Month to desludge this block**	**Target FSTP (Name)**	**FSTP location - Camp**	**FSTP location - Block**	**Monthly Desludge Latrine Chamber (Nos)**	**Volume of Sludge m3 per month (annual ave)**	**Volume of Sludge ave m3 per month (wet season)**	**Volume of Sludge ave m3 per month (dry season)**	**Monthly desludging cost (annual ave)**	**Monthly Transportation Cost (annual ave)**	**Remarks**
Guide for the WASH agencies Filling out the form →		*Which camp is sludge collected from?*	*Which block is sludge collected from?*			*If more than 1 single chain per block please complete a line for each.*	*Average days for a typical month*	*Specify if multiple FSTP is used*			*Annual average*	*Annual average*	*Average volume collected (m3) per month during wet season.* *Wet Season is June to September*	*Average volume (m3) collected per month during dry season.* *Dry Season is October to May*	*Ave BDT per month* *While calculating Monthly Avg Desludging cost agency need to add the following -* *1. HR Cost of desludging team working in emptying latrine pit and pumping to next transportation mode (vacutug/ next pit / barrel Etc)* *2. Fuel cost for latrine pit emptying only* *3. Other consumables (Lime / others) if requried* *4. Other cost invovled in latrine emptying if any* *If one desludging team opeartes in multiple block / camp , Please divide the total cost into block in a rational ratio.*	*Ave BDT per month* *While calculating Monthly Avg transportation cost agency need to add the following -* *1. HR Cost of Transportation team involved in sludge transportation* *2. Fuel cost for sludge transportation mode* *3. Other consumables (Lime / others) if requried* *4. Other cost invovled in latrine emptying if any*	
Example →	*Ex .*	*Camp 8W*	*D*	*XX*	*YY*	*Single: Vacutug*	*6*	*BRAC - LSP -1 & BRAC LSP - 2*	*Camp 8W & Camp 9*	*D & E*	*80*	*210*	*240*	*280*	*20100*	*12000*	
For completion →																	

Site Visit Template
THE INTERVIEWER MUST TAKE PHOTOGRAPHS OF THE SITE IN GENERAL, THE TREATMENT UNITS AND ANY OTHER RELEVANT SITE AREA

CONSENT CLAUSE FROM OXFAM - Ensure its signed by both interviewee and interviewer.

Data collection information
Date/time:
Interviewer:
Interviewee:
Interviewee email and phone number:
Site information
FSTP type (mark the FSTP type below) Lime ABR Aeration Lagoons Biological Upflow filter WSPs Constructed wetlands Geotubes Anaerobic digester
FSTP reference number:
Camp name:
Constructor name:
Construction date (month/year):
Operator name:
When did your organisation start operating the plant? (month/year):
When did the plant start functioning for the first time? (month/year):
Location (provide x,y coordinates). Mark in separate map provided by the interviewer.
What is the total area of the site (m2)? Please explain how have you measured it (google earth, physical measures…)
Please provide a drawing of the layout of the FSTP or do a sketch. Please describe the main components included.
What is the area of the treatment unit (m2)?
Describe briefly the topography of the site and how the topography influence the design of the FSTP?
Describe the different ways to access to the site. Include the number and type of accesses and their orientation.
What are the site limitations regarding its conditions and location? (ground water level, water sources nearby, roads or infrastructures close by, dwellers around…)

Design and key features of the FSTP
What is the treatment capacity of the plant? (m3/day)(according to design)
What is the actual volume treated per day? (m3/day) If the actual volume treated is less than the design volume, please explain why.
What is the population served? What assumptions have been made to get to that number?
Please describe the treatment technology (flow rate, retention times…)
Describe the general arrangement and the main elements of the treatment. Include the process diagram flow. Provide a drawing if available or do sketch
Why was the technology selected for this site?
What is the complexity of the treatment process (number of stages, liquid and solid treatment and operation, use of chemicals...?) Please explain if there is any pinch points we should be aware off i.e. items that restrict the capacity of the FSTP.
Is the system scalable? Please describe how could the system be scale up
Quality (sampling/laboratory data)
What is the daily input and output? (m3/day) Input: Output:
Is the system operating/performing as designed? Is it effective and meeting the DoE water discharge standards and reducing pathogens?
What quality parameters are collected for influent & effluent? e.g. BOD, pathogens, Nitrogen, Phosphorus
Do you have any data available on the quality of the effluents? What parameters are measured? & how often? Please share any available data with us
Cost
Would you be able to provide the CAPEX for the FSTP?
How long is the FSTP designed for i.e. what is the design life?

Would you be able to provide the OPEX for the FSTP? E.g. BDT per month and any breakdown
Operation and maintenance
How long did it take to build and set up the treatment plant? If there were several construction phases please specify.
What expertise was required to initially set up the system? (number and type of skilled labour and unskilled labour)
What expertise is required to operate and maintain the system? (number and type of skilled labour and unskilled labour)
What are the main operation and maintenance activities required by the treatment plant regularly? Please explain activities, frequency and any equipment needed.
Please explain the main issues that the FSTP has encountered regarding operation and maintenance
Has any modification on the treatment plant been planned to make it more long-term sustainable?
What materials have been used? Are they locally available?
Is there any Health & Safety risk associated with the treatment plant? (use of chemical, falling in tanks, pipes over the ground that can be a hazard…)
What resilience has the treatment plant to natural disasters (such as flooding, fire, earthquake…)? An example of this would be the tanks being elevated and therefore being resilient to flooding.
Environment
How is the final product disposed (liquid and solid)?

How is the final product disposed (liquid and solid)?

Has any special measure been taken to ensure environment protection? (& comply with DoE standards)

What is the community acceptance towards the FSTP?

Additional notes on FSTPs

Transfer of sludge

How is the sludge transferred to the site? (vactugs, transfer network with pumps, gravity…) Please describe the key features of the transfer system (include components, capacity and sludge conveyed per day (m3))

Where does the sludge come from? If possible mark the catchment area and differentiate between the types of transfer systems (use map provided by the interviewer)

How long does it take to the sludge to go through the transfer system?

During the transportation of sludge on the system, is there any point where the sludge get retained temporarily? How long does it stay retained?

How does the transfer system or systems (if there are more than one) for the sludge perform ? Please answer the question for the different existing systems separately, explain operation and main challenges/issues of the system
If the system is a vacutug, does it reaches all latrine containment for desludging inside block? If it doesn’t, please explain how are those latrines empty?
Does the system or systems affect the performance of the FSTP? Please talk about the different systems separately
Is there any cost data available (capex and Opex) that you could share on the transfer systems?
What expertise is required to operate the transfer system?
What is the resilience oft the transfer system to natural flooding?
Containment
Please describe the available type and size of latrine containment within its catchment (include main design features such as volume of sludge collected (m3))

Which type of latrine is desludged more ? What is the frequency of desludging?
What is the reason behind that?
What is the variation in sludge production and linkage with season ?
What is the variation in sludge production and linkage with topography ?

OXFAM ARUP

Technical Assessment of Faecal Sludge Management in the Rohingya Response

Phase 2 Final Report

Appendix K

ARUP

Technical and operational assessment of FSM systems in the Rohingya Refugee Response

Phase 2

Anna Grieve

29.10.21

ARUP

Objective

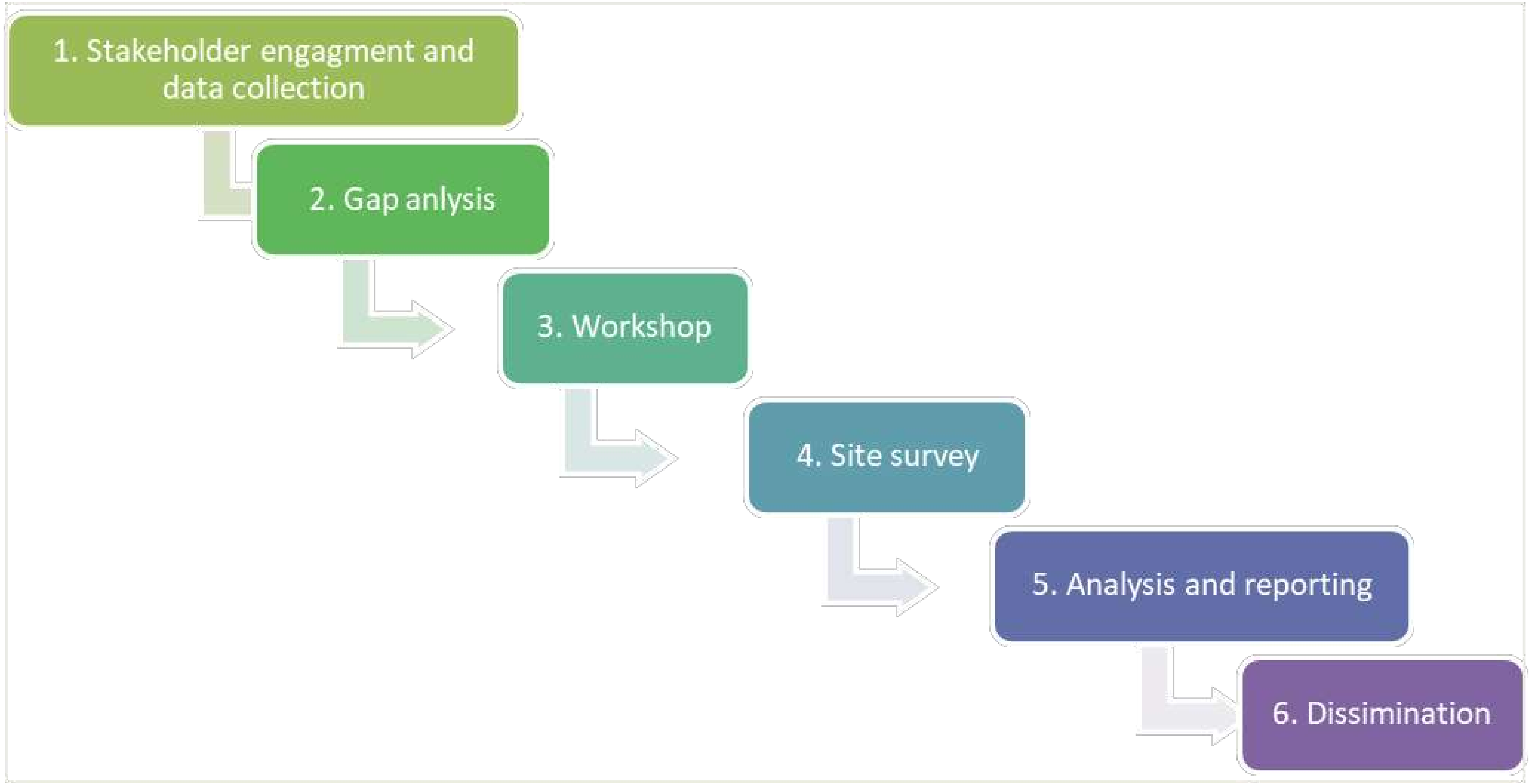
Project objective and Aims

To provide a Technical and Operational Assessment of FSM systems in CxB, building on the initial comparison study (Arup/Oxfam) and studies by UNICEF, UPM, ICDDR,B, UNHCR, DPHE, ITN Buet, MSF and other stakeholders.

Specific Aims:

- Build on initial study and include recent M&E studies - a review of how the different FSTPs are performing and identify challenges that have emerged. Additional data to be collected on FSTP design, operational performance, effluent quality and treatment effectiveness.
- Validate our initial study conclusions on which technologies are the most efficient and effective in the differing geographical and social contexts '*what is the efficiency, suitability based on local challenges, and long-term operation of each type of plant?'*
- The study will be broadened out to include assessment of costs associated with the full FSM chain & understand the key influencing factors when deciding if a centralised or decentralised FSTP is most appropriate

Project stages



ARUP

Timeline

Planned programme Nov 2021 to March 2022

		Nov					Dec				Jan					Feb				March			
TASK #	**DESCRIPTION**	1/11/21	8/11/21	15/11/21	22/11/21	29/11/21	6/12/21	13/12/21	20/12/21	27/12/21	3/1/22	10/1/22	17/1/22	24/1/22	31/1/22	7/2/22	14/2/22	21/2/22	28/2/22	7/3/22	14/3/22	21/3/22	28/3/22
0	Project Management																						
0.1	Project Setup																						
0.2	Internal Project Managment																						
0.3	Core team meetings																						
1	Study Update																						
1.1	Stakeholder engagement																						
1.2	Gap analysis																						
1.3	Review workshop																						
1.4	Site Survey and data collection (OXFAM)																						
1.5	Analysis and reporting (including 2 week stakeholder/client review "X")																			X	X		
1.6	Dismination																						

ARUP

Method

1. Stakeholder engagment and data collection
2. Gap anlysis
3. Workshop
4. Site survey
5. Analysis and reporting
6. Dissimination

a) Stakeholder identification and characterisation – FSM TWiG, list in ToR, dashboard
b) Kickoff meeting with stakeholders
c) Stakeholder engagement and information capture
d) Stakeholder information analysis

What information is missing?
i.e. Coverage of stakeholders, type of technology, specific data.

Plan site survey agenda

Agree with stakeholders on data collection / site survey stage

Conduct site survey to obtain data

Who needs to do what and when

1. Stakeholder engagment and data collection

Nov/Dec
Arup & core team

Via online meetings & structured interviews

2. Gap anlysis

Dec
Arup

3. Workshop

Jan
Arup to prepare
All to attend

4. Site survey

Jan (10th to 31st)
Oxfam
(Arup to prepare targeted site survey sheets)

5. Analysis and reporting

Feb/March
Arup

6. Dissimination

ARUP

Method – Data to be collected

Via stakeholder engagement and site survey (Oxfam)

- Basis of design and key design features of the FSTPs and FSM chain.
- Capital expenditure and operational costs (CAPEX and OPEX), in order to determine whole life cost.
- Quality of liquid and solid effluent (pathogen inactivation), in order to determine treatment efficiency and residual risk to public health (qualitive not quantative).
- Area requirements, layout, and scalability.
- Speed of construction and commissioning.
- Expertise required for setup and operation.
- Operation and maintenance issues.
- Treatment process complexity and pinch points.
- Disposal of final products (liquid and solid), and
- Resilience to flooding/natural disaster.

Sub Type	No.
Unknown	19
ABR	23
Lime stabilization pond	20
ADR	1
Constructed Wetland	22
FSM Site	3
Geotube	4
Upflow Filter	29
Soild Separation Unit (SSU)	28
Lime Stabilization	33
Aerobic Treatment	2
Waste Stabilisation Ponds	3
Decentralized Waste Water Treatment System (DEWATS)	4
ODP	17
Up-flow filtration	2
Anaerobic settler	1
TOTAL	**211**

Based on https://www.humanitarianresponse.info/en/operations/bangladesh/water-sanitation-hygiene

ARUP

Team and review group

Arup and Oxfam Team

Callum Newman
(Arup PD)

Anna Grieve
(Arup PM)

Gabrielle McGill
(Arup FSM strategy advisor)

Marianna Goncalves
(Arup wastewater Eng)

Tim White
(Arup International Development advisor)

Paula Morcillo de Amuedo
(Arup stakeholder engagement)

Andy Bastable
(Oxfam GB)

Brian McSorley
(Oxfam GB)

Enamul Hoque
(Oxfam Bangladesh)
Bangladesh team leader

Bangladesh survey team
(Oxfam Bangladesh)

Core Team (for discussion)

CxB Wash Cluster coordinator
Damien Seal

Global FSM TWiG
Marji Zwart

Arup
Anna Grieve

Oxfam

UNHCR

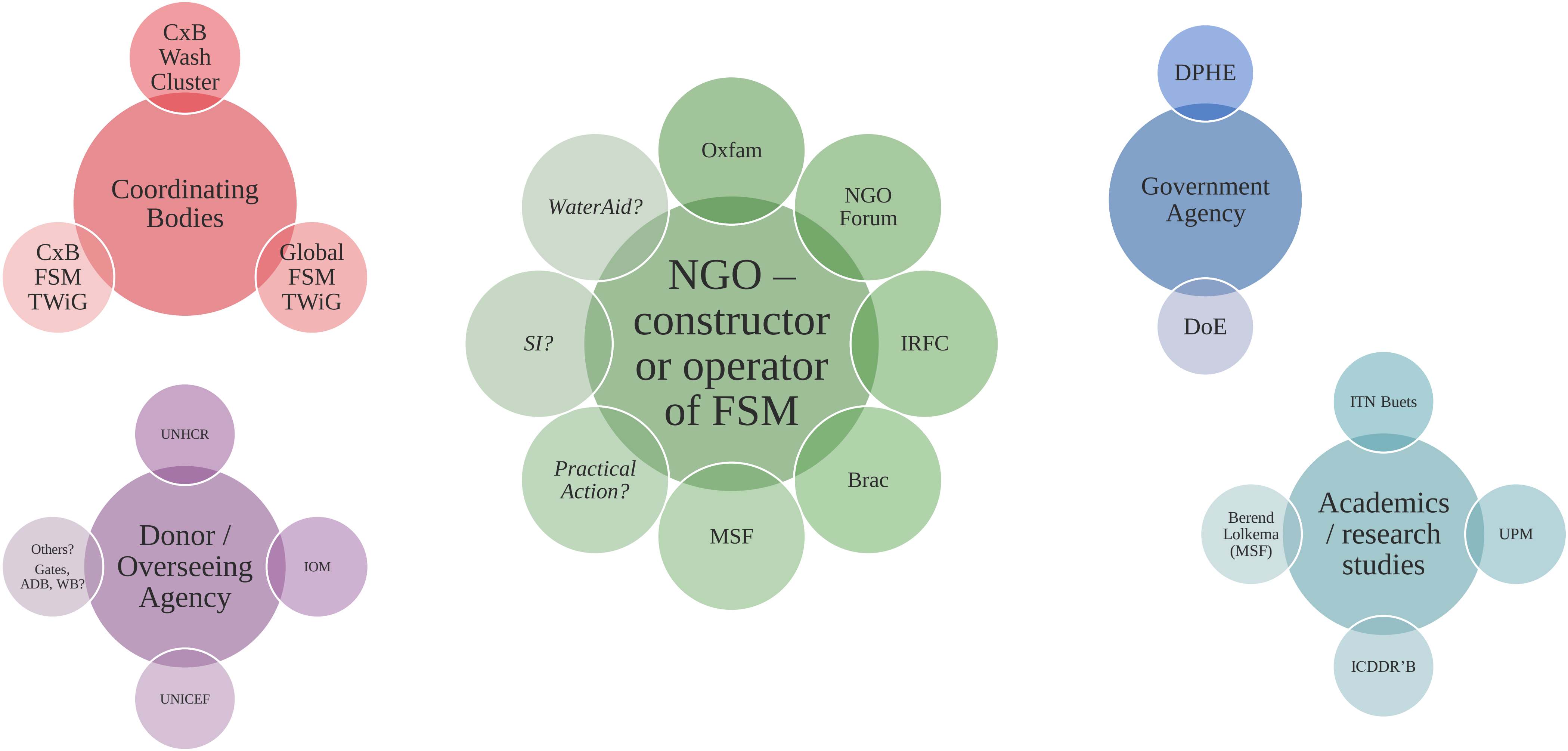
IOM

UNICEF

Others?

Stakeholder groups

Initial mapping for discussion



ARUP

Budget

- Arup budget £37,175

- Oxfam budget £14,800

Oxfam budget includes:

100 hours for surveys (4 people 25 hrs each)

Site transport 30 days x 2 (@£65/day)

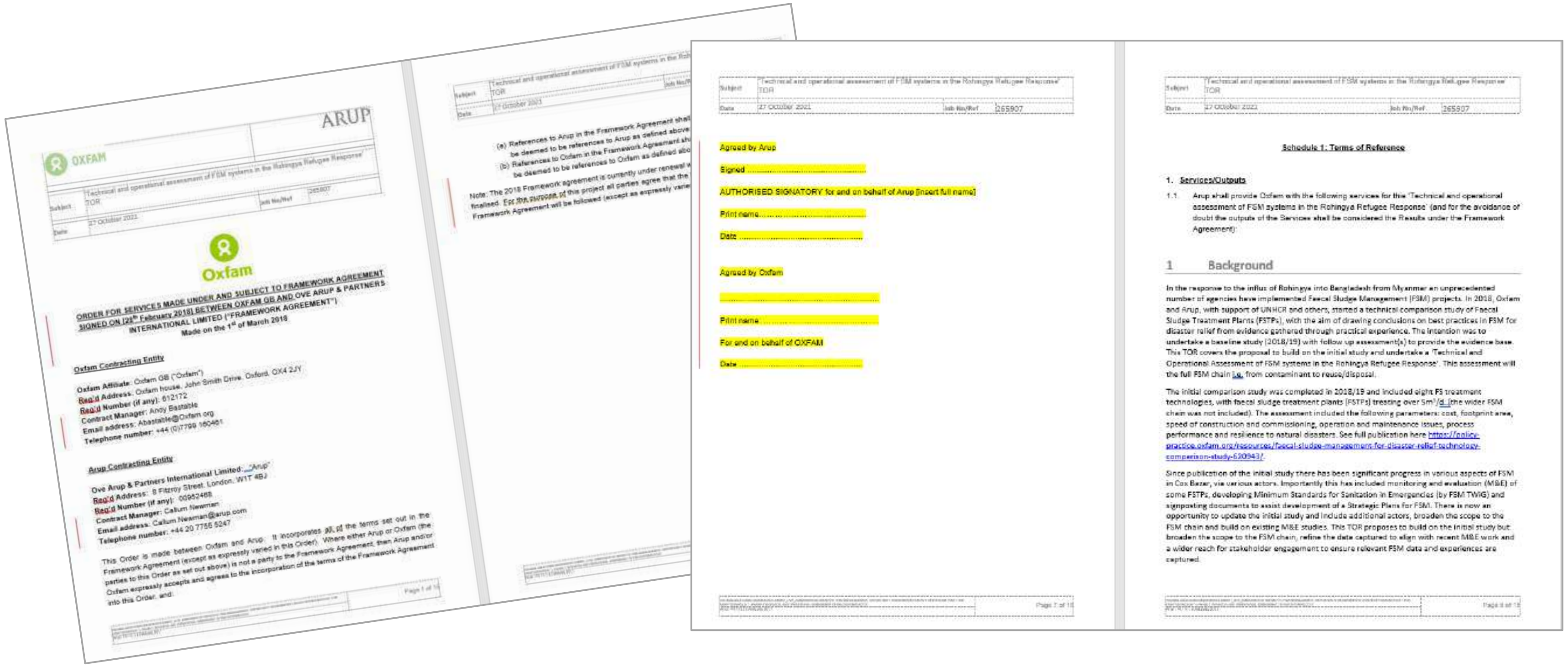
PPE, protocol & backup

Project Duration (months)	6
Project Duration (weeks)	26
Estimated weeks/month	4.3
Estimated workdays/month	21
GBP/USD	1.35

TASK #	DESCRIPTION	Sub tasks / details	FEES										
				Company:	ARUP						Oxfam		
				Fees per company	£37,175						£14,800		
				Role	PD	Project reviewer / client engagement	PM & FSM	Stakeholder Engagement	WASH Support	Graphic Design	PD (Oxfam GB)	Local team leader-consultant	Enumerator - survey associates
				Name	Callum Newman	Tim W	Anna Grieve	Paula Morcillo de Amuedo	Marianna Goncalves	Roman S	Andy Bastable		
		TOTAL COST OF THE PROJECT	**$ 70,436**	Rate (£/day)	£1,576	£553	£602	£338	£371	£297	£800	£150	£45
			£52,175	Total Cost / Person	£1,576	£1,658	£17,164	£8,795	£6,497	£1,485	£800	£4,500	£5,400
				Average dedication	**1%**	**2%**	**23%**	**21%**	**14%**	**4%**	**1%**	**24%**	**95%**
				Total Days: 232	**1.00**	**3.00**	**28.50**	**26.00**	**17.50**	**5.00**	**1.00**	**30.00**	**120.00**
0	Project Management		£ 2,191	2.50	0.50	0.00	1.50	0.00	0.00	0.00	0.50	0.00	0.00
0.1	Project Setup		£ 1,589	1.5	0.5		0.5				0.5		
0.2	Internal Project Management		£ 602	1.0			1.0						
1	FSM Study Update		£ 45,883	229.5	0.5	3	27	26	17.5	5	0.5	30	120
1.1	Stakeholder engagement	Stakeholder identification and characterisation	£ 2,979	25.5			1.00	2.00			0.50	2.00	20.00
		Kickoff meeting with stakeholders	£ 1,643	4.0		1.00	1.00	1.00				1.00	
		Stakeholder engagement and information capture	£ 4,893	16.0		1.00	1.00	4.00	4.00			6.00	
		Stakeholder information analysis	£ 4,100	9.0			4.00	5.00					
1.2	Gap analysis	Gap analysis of stakeholder information	£ 1,279	3.0			1.00	2.00					
		Checks against previous study and strategic FSM plan needs	£ 771	1.5			1.00	0.50					
		Identify and agree how to fill data gaps	£ 1,107	3.0			1.00	0.50	0.50			1.00	
1.3	Review workshop	With client and stakeholders outlining findings from 1 & 2 above	£ 8,779	123.0			1.00	2.00					
1.4	Site Survey and data collection		£ 6,625	15.0			5.00	3.00	7.00			20.00	100.00
1.5	Analysis and reporting	Allowance for incorporating 1 round of comments. Report format similar to initial study.	£ 12,396	26.5	0.50	1.00	10.00	5.00	5.00	5.00			
1.6	Dismination	Presnetation to client and stakeholders.	£ 1,312	3.0			1.00	1.00	1.00				
E	Expenses		£ 4,100										
E.1	Site transport - transport £65/dayx30 days x 2 vehicles=1,000		£ 3,900										
E.2	PPE, protocol and backup		£ 200										

Contract

- Contract between Arup and Oxfam GB
- Schedule 1 – ref T&Cs of previous (2018) framework and sign (ASAP)
- Arup/Oxfam Framework document – update and sign


Agreed by Arup

Signed ....

AUTHORISED SIGNATORY for and on behalf of Arup [insert full name]

Print name ....

Date ....

Agreed by Oxfam

....

Print name ....

For and on behalf of OXFAM

Date ....

Schedule 1: Terms of Reference

1. Services/Outputs

1 Background

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Upcoming tasks

‘front of mind’

- Schedule 1 – ref T&Cs of previous framework and sign (ASAP)
- Framework document – update and sign
- Stakeholder identification and mapping – Arup wth Oxfam input
- Set up stakeholder kickoff workshop
- Set up core team meetings – every 2 weeks

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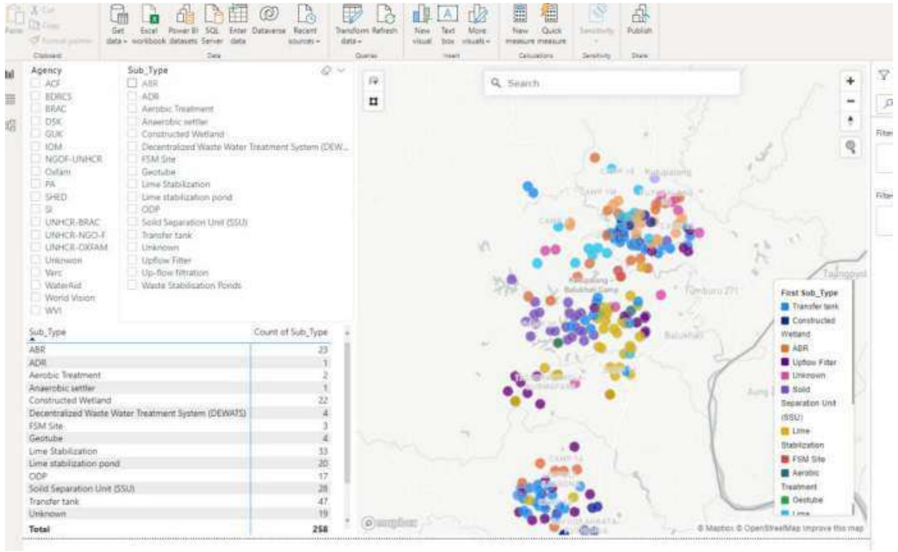
1. Stakeholder engagement and data collection

a) Stakeholder identification and characterisation – list from FSM TWiG), list in ToR, dashboard

b) Kickoff meeting with stakeholders

c) Stakeholder engagement and information capture

d) Stakeholder information analysis



Dashboard of FSM sites, including location, type and operator

Based on https://www.humanitarianresponse.info/en/operations/bangladesh/water-sanitation-hygiene/infographics

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Technical and operational assessment of FSM systems in the Rohingya Refugee Response

Stakeholder Introduction

Anna Grieve

Senior Water Engineer (Arup)

anna.grieve@arup.com

31.01.22

ARUP

Objective

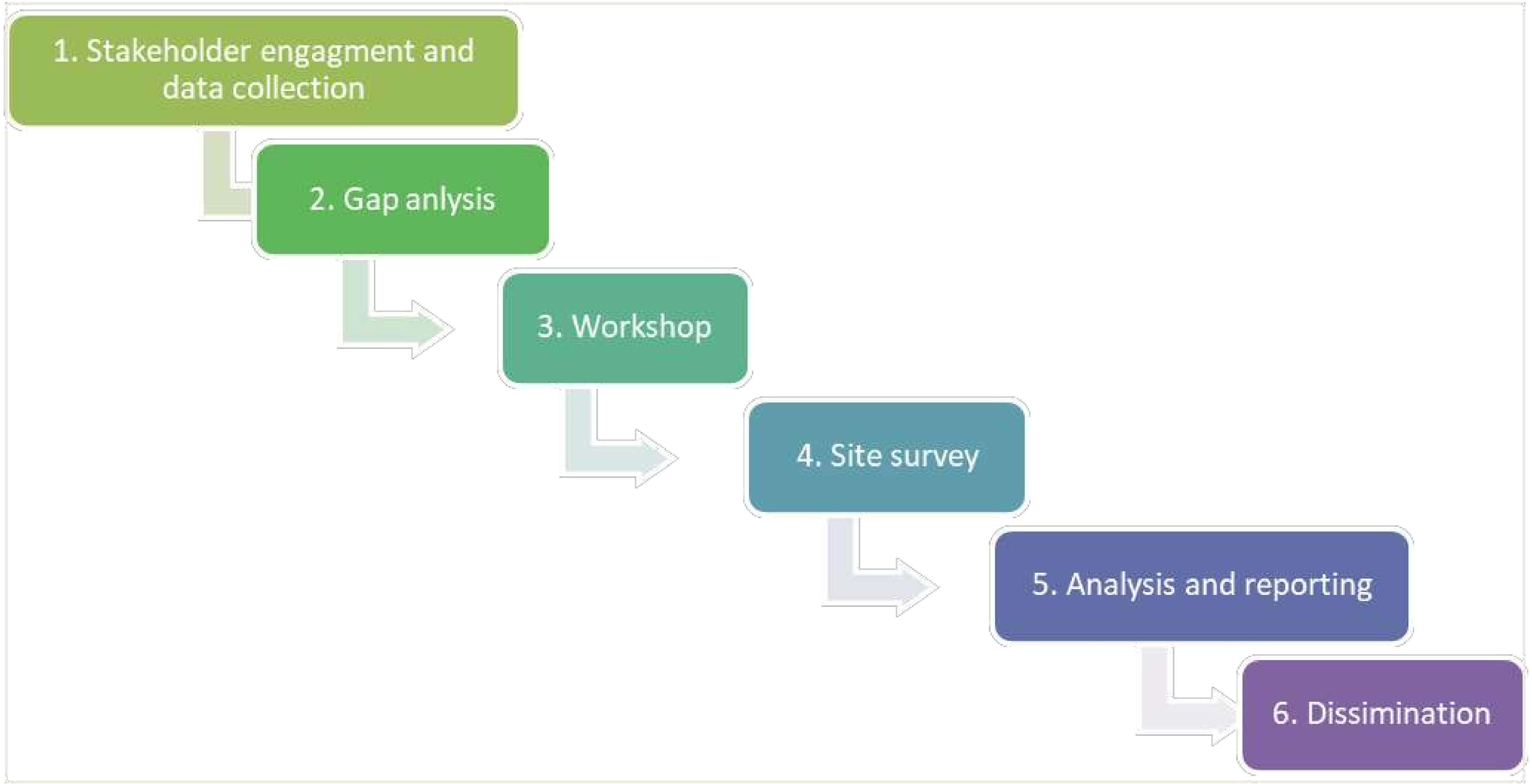
Project objective and Aims

To provide a Technical and Operational Assessment of FSM systems in CxB, building on the initial comparison study (Arup/Oxfam), recent operational experience by partner NGOs and studies by UNICEF, UPM, ICDDR_B, ITN Buet, MSF and other stakeholders.

Specific Aims:

- Build on initial study and include recent M&E studies - a review of how the different FSTPs are performing and identify challenges that have emerged. Additional data to be collected on FSTP design, operational performance, effluent quality and treatment effectiveness.
- Validate our initial study conclusions on which technologies are the most efficient and effective in the differing geographical and social contexts '*what is the efficiency, suitability based on local challenges, and long-term operation of each type of plant?*'.
- The study will be broadened out to include assessment of costs associated with the full FSM chain & understand the key influencing factors when deciding if a centralised or decentralised FSTP is most appropriate.

Project stages



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Outline programme

2022

January
- Stakeholder engagement
- Gap analysis
- Stakeholder workshop

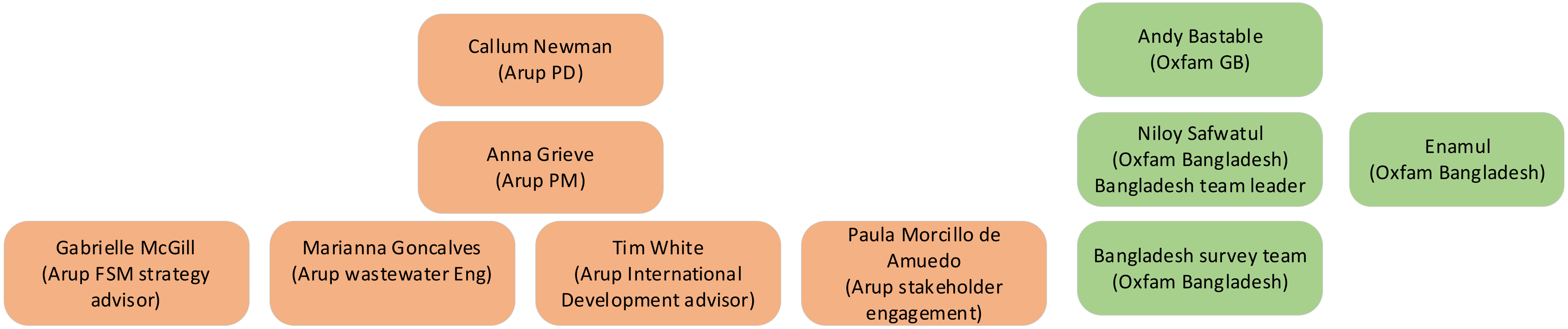
February
- Site survey (via Oxfam Bangladesh team)

March
- Analysis
- Draft report
- Stakeholder comments

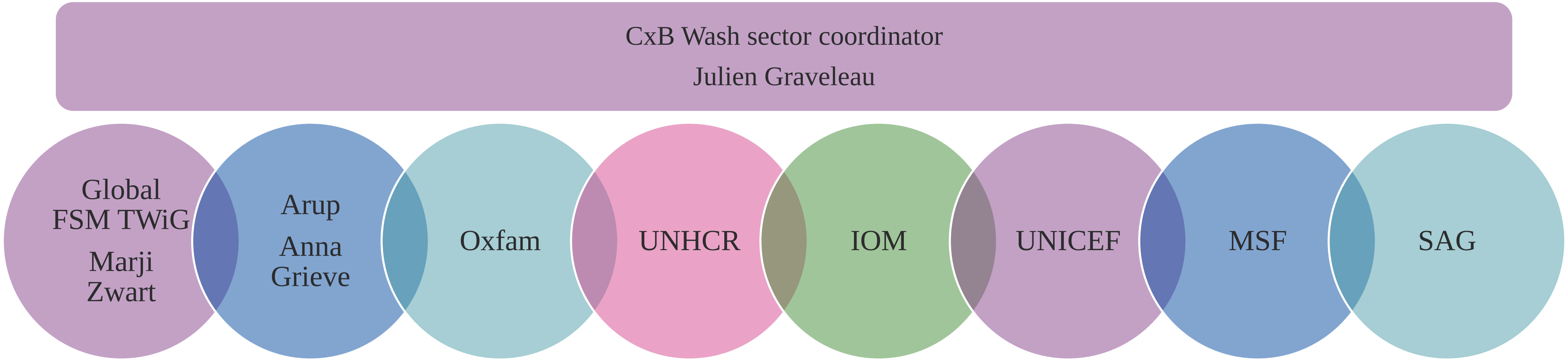
April
- Final report
- Dissemination

Team and review group

Arup and Oxfam Team



Core Team



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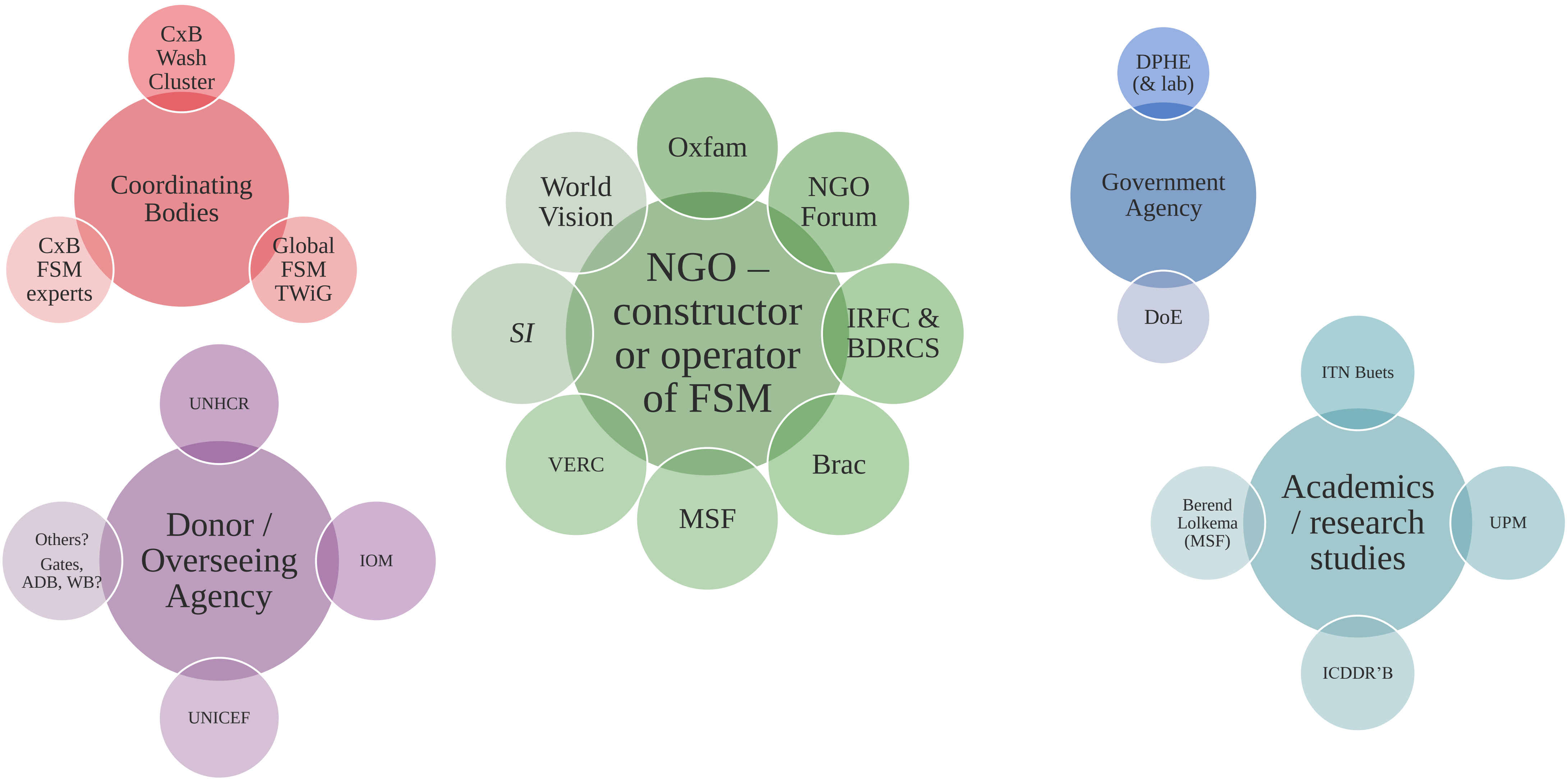
Stakeholder groups

Initial stakeholder mapping



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Stakeholder engagement and data collection

a) Stakeholder identification and characterisation
b) Kickoff meeting with stakeholders (today)
c) Stakeholder engagement and information capture (via questionnaire & phone interviews)
d) Stakeholder information analysis

Then site survey to close out information gaps – aiming for February 2022

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Thank you and questions

Key study contacts

Anna Grieve

anna.grieve@arup.com

Project Manager (Arup)

Safwatul Haque Niloy

sniloy@oxfam.org.uk

Sanitation Coordination (Oxfam)

Project Manager (Oxfam)

Paula de Amuedo

Paula.MorcilloDeAmuedo@arup.com

Stakeholder Engagement and Civil Engineer (Arup)

Mariana Gonvcalves

Mariana.Goncalves@arup.com

Wastewater Engineer (Arup)

ARUP

Technical and operational assessment of FSM systems in the Rohingya Refugee Response

DPHE Meeting

Arup

26/02/2022

ARUP

Objectives of study (ToR

Project objective and Aims

- **To provide a Technical and Operational Assessment of FSM systems in CxB, building on the initial comparison study (Arup/Oxfam) and studies by UNICEF, UPM, ICDDR,B, UNHCR, DPHE, ITN Buet, MSF and other stakeholders.**

Specific Aims:

- Build on initial study and include recent M&E studies - a review of how the different FSTPs are performing and identify challenges that have emerged. Additional data to be collected on FSTP design, operational performance, effluent quality and treatment effectiveness.
- Validate our initial study conclusions on which technologies are the most efficient and effective in the differing geographical and social contexts '*what is the efficiency, suitability based on local challenges, and long-term operation of each type of plant?'*
- The study will be broadened out to include assessment of costs associated with the full FSM chain & understand the key influencing factors when deciding if a centralised or decentralised FSTP is most appropriate

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For discussion

How to incorporate DPHE knowledge and information?

Studies/data is available?

Next steps

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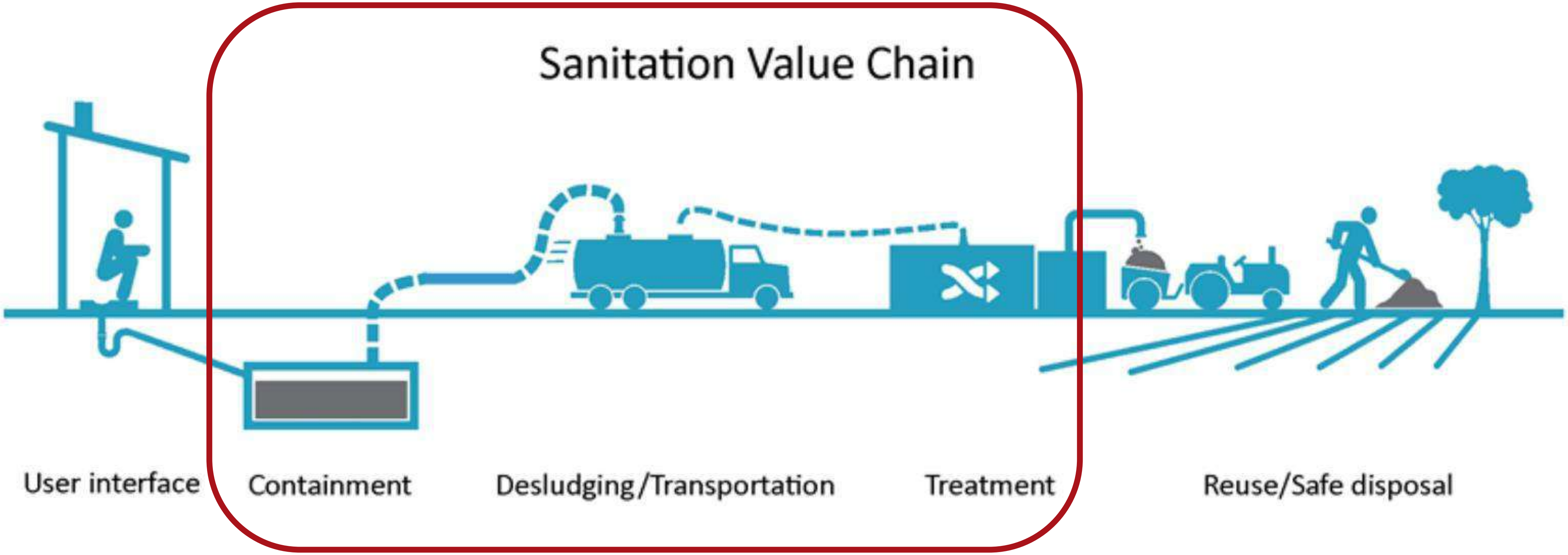
Sanitation Chain



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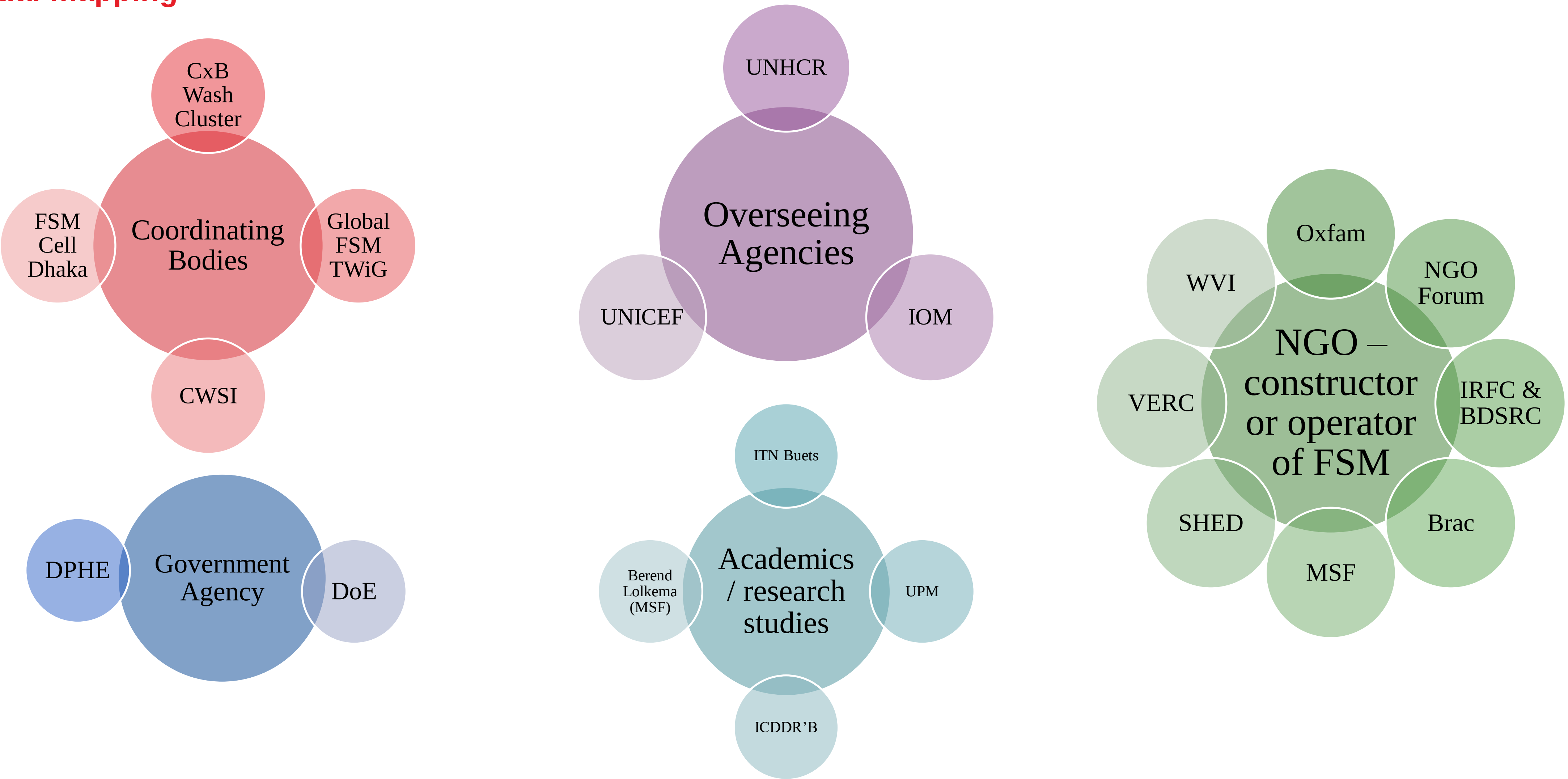
Stakeholder groups

Initial mapping



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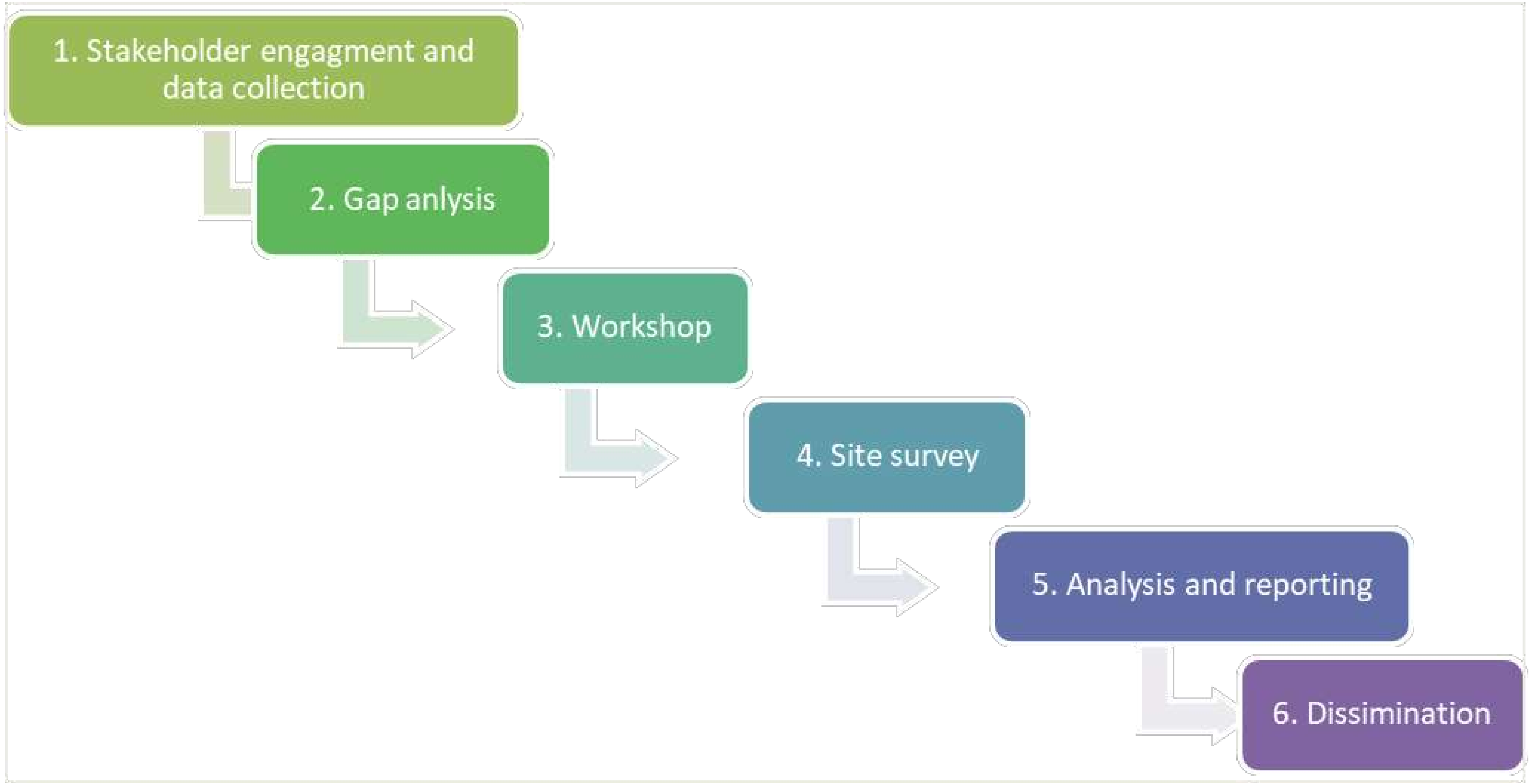
Study stages



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Work to date

February 2022

- Desktop information captured and reviewed
- FSTP list and mapping (dashboard)
- Stakeholder engagement interviews
- Field visit planning (with core team)
- Field visits (8 of 20 completed)

Work to date (2)

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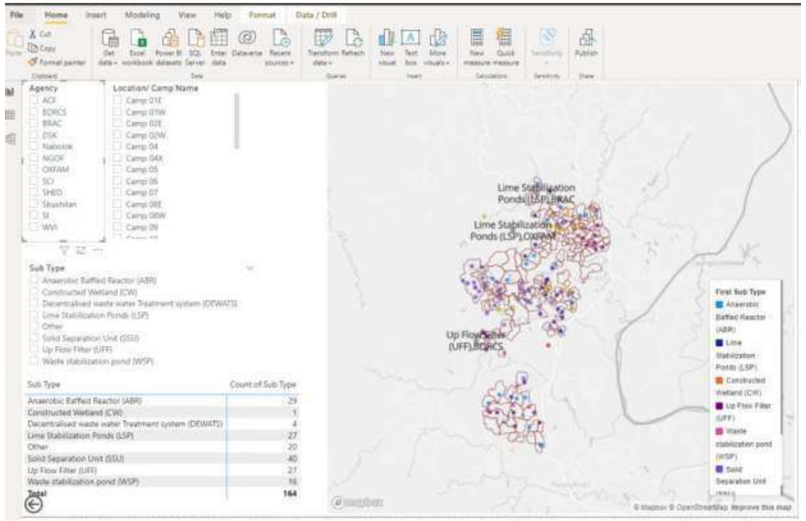
FSTP and conveyance list to include in study

Type of FSTP	FSTP (& FSM chain) to be included in this study
Lime	• Oxfam/NGO forum camp 4 • Brac LSP camp 1W • NGO forum camp 26
ABR	• Brac camp 14 & 21 with **OMNI-PROCESSOR** • NGO Forum camp 5 • VERC camp 8E
Aeration (centralised)	• IFRC / Bangladesh RC camp 18 (commissioning & camp 19 not operational)
FSTP 1 (mega FSTP) (centralised)	• FSTP 1 - Oxfam/NGO forum camp 4 (anaerobic lagoons, UFF, Trickling filter, polishing pond, planted drying bed)
FSTP 2 (Biological, centralised)	• FSTP 2 – Oxfam/MSF/Brac Kutupalong (planted drying bed, anaerobic filter, Verticle CW, Horizonal CW, polishing pond)
DEWATs	• IOM/Shed camp 13 (bio-digestion, UFF, liquid clarification & chlorination, Infiltration of liquid & storage of solids). • WVI camp 7
Upflow Filters	• VERC camp 8w • BDRCS/Practical Action Camp 13
WSPs	• VERC camp 8w • World vision Camp 7
Conveyance / Transfer network	• Brac camp 21 • UNICEF • Vacutug NGO Forum camp 17 and 5, Brac 3E F, and 4 • Intermediate faecal sludge transfer network (IFSTN) camp 3,4

Site selection based on:
Ideally sites – treat over 5m^3/day, have good quality information, readily available e.g., design drawings, cost data, M&E data, effluent sampling, information on the whole FSM chain etc.
Align with DPHE lab data

Latrine and FSTP dashboard



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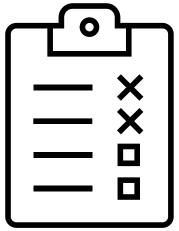
Work to date (3)

Information gaps from desk top review

	Lime treatment			ABR				Aeration		FSTP 1	FSTP 2	Upflow filters			WSP		GeoTubes	ADS	Constructed Wetlands	Gravity Transfer network	Vacutug	Vacutug	IFSTN
	4	1W	26	21	5	8E	18	18	19	4	Kutupalong	13	Camp 7	Unknown	TBC	TBC	TBC	26	7	21	5 and 17	3E, F, 4	3 and 4
Basis of design and key design features of the FSTPs and FSM chain.																							
CAPEX Cost																							
OPEX Cost																							
Quality of liquid and solid effluent (pathogen inactivation), or any other sludge sampling/laboratory data.																				N/A	N/A	N/A	N/A
Area requirements, layout, and scalability.																				N/A	N/A	N/A	N/A
Speed of construction and commissioning.																							
Expertise required for setup and operation.																							
Operation and maintenance issues.																							
Treatment process complexity and pinch points.																				N/A	N/A	N/A	N/A
Disposal of final products (liquid and solid).																							
Resilience to flooding/natural disaster.																							

Field visits – 8 of 20 complete

- Standard info – PFD, layout, photos
- Site specific based on desk study



ARUP

Thank you & Contacts

Key study contacts

Anna Grieve

Senior Water Engineer

Project Manager (Arup)

Safwatul Haque Niloy

Sanitation Coordination (Oxfam)

Project Manager (Oxfam)

Julien Graveleau

WASH Sector Coordinator

Bangladesh

jgraveleau@unicef.org

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FSM Study - Core team update

April 2022

Anna Grieve

25.04.22

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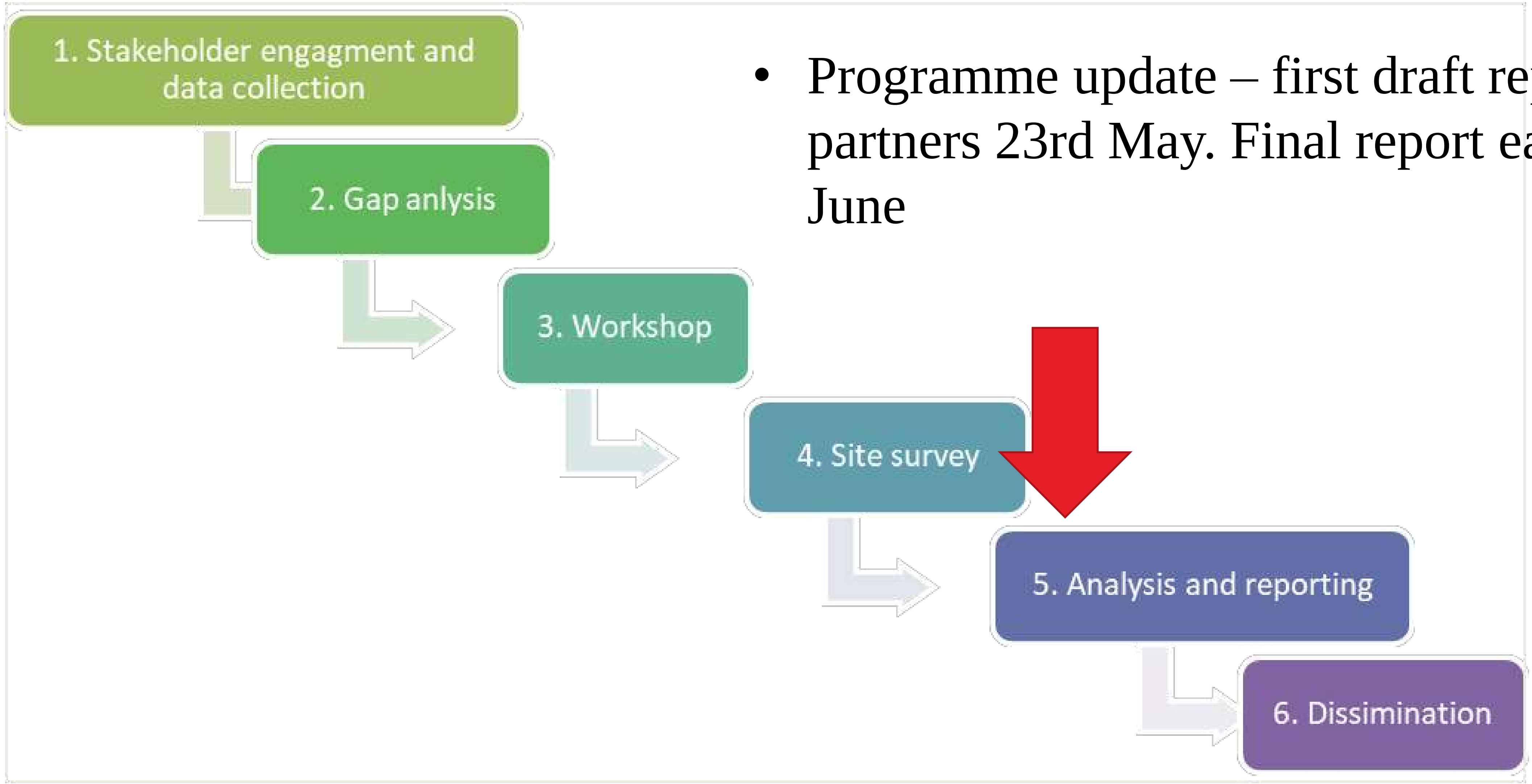
Agenda

- Introduction
- Field visit overview – map, success & limitations
- Data overview
- Field visit parameters
- Lab data review
- Sludge chain mapping – containment, transfer & FSTP
- Next steps

Introduction - Study stages



- Programme update – first draft report to partners 23rd May. Final report early June

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Field visit overview

Key highlights

- 17 FSTPs in Ukhiva and 3 in Teknaf
- Survey duration (15th February to 24th April)
- AFA (UNHCR – 7 FSTP, UNICEF – 7 FSTP, IOM – 6 FSTP)
- Each form took roughly 1.5 to 2 hours to fill

Field Survey Details

SL #	Organization	AFA	Camp	Survey Date	Location
1	BRAC	UNICEF	14	24th February	UKH
2	NGO Forum	UNICEF	5	24th February	UKH
3	VERC	UNICEF	8W	13th march ,2022	UKH
4	World Vision International	UNICEF	camp 7	28th February	UKH
5	VERC	UNICEF	8W	20th March 2022	UKH
6	World Vision International - UFF	UNICEF	camp 7	28th February	UKH
7	VERC - UFF	UNICEF	8W	13th march ,2022	UKH
8	NGO Forum	UNHCR	4	15th February	UKH
9	BRAC, UNHCR and MSF	UNHCR	Kutupalong (near to camp 2E)	24th April,22	UKH
10	NGO Forum	UNHCR	4	17th February	UKH
11	BRAC	UNHCR	1 W	17th February	UKH
12	NGO Forum	UNHCR	26	23rd February	TEKNAF
13	BRAC	UNHCR	21	27th February	TEKNAF
14	NGO Forum	UNHCR	26	23rd February	TEKNAF
15	MSF	IOM	Next to camp 12	24th April,22	UKH
16	IFRC/BDRCS	IOM	18	1st March ,2022	UKH
17	IFRC/BDRCS	IOM	19	1st March ,2022	UKH
18	IFRC/BDRCS	IOM	18	16th February ,2022	
19	IOM / NGOF - DEWATs	IOM	9	3rd March ,2022	UKH
20	IOM / Shushilan - DEWATs	IOM	12	3rd March ,2022	UKH

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Field visit overview

Successes and Limitations

- Successes
  - 18 FSTP sites surveyed
  - Cooperative behaviour and free time for interview by the agencies
- Limitations
  - Data unavailability at ground
  - Interviewee referring to senior management
  - Recent handover / takeover of the FSTP
  - Delays in reply to get the information

Survey Images

Camp 18 (Aeration)

Camp 9 (DEWATS)

Camp 7 (Upflow)

Camp 4 X, (Anaerobic lagoon)

Data overview

	Lime treatment			ABR					Aeration		FSTP 1	FSTP 2	MSF FSTP1	Upflow filters & DEWATs				WSP		ADS
	NGOF	BRAC	NGOF	BRAC	BRAC	IFR/BDRCS	NGOF	VERC	IFR/BDRCS	IFR/BDRCS	NGOF	BRAC, UNHCR and MSF	MSF	IOM	WVI	VERC	IOM/shushila	WVI	VERC	NGOF
	4	1W	26	21	14	18	5	8W	18	19	4	Kutupalong	next camp12	9	7	8W	12	7	8W	26
Basis of design and key design features of the FSTPs and FSM chain.																				
CAPEX Cost																				
OPEX Cost																				
Quality of liquid and solid effluent (pathogen inactivation), or any other sludge sampling/laboratory data.																				
Area requirements, layout, and scalability.																				
Speed of construction and commissioning.																				
Expertise required for setup and operation.																				
Operation and maintenance issues.																				
Treatment process complexity and pinch points.																				
Disposal of final products (liquid and solid).																				
Resilience to flooding/natural disaster.																				

- Some information still missing in expertise required for operation and maintenance. Break down of roles is needed, the team has followed up. We did not describe what it is consider skilled/unskilled labour which has led to not always clear answers. Desludging usually operators are considered skilled labour.
- There is inconsistency in some of the data for the area requirements (total area and treatment area). The team is trying to clarify this.
- Limited information in complexity of the process and pinch points. Not always a lot of detailed provided.
- Clarification is needed in data for aeration camp 18. Ensure the data collected is the historical data and not the data for the new Camp 18 ABR

Field visit parameters – review per FSTP type

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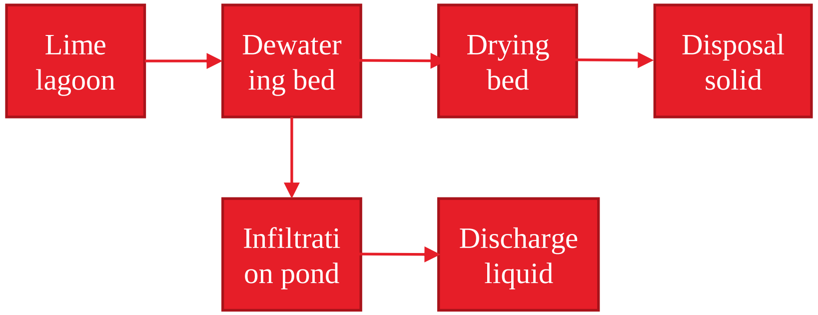
Lime Treatment



- Same key components and similar process flows
- Different number of lagoon and dewatering beds required according to treatment capacity

Parametres	Findings
Capacity	7-5m3/day 10-12 kg lime per m3 sludge
Population	10,000 - 5,000
Area requirements, layout and scalability	Total area of the site 1,330 -253 m2 Treatment unit area 932-81,76 m3 sludge treated daily/treatment unit area 0.007-0.06 Site with 4 limes ponds(instead of 2) do not seem to be much more efficient Easy to scale, addinf more lagoons but main limitation to scalability is space
Capex $	40,600-7,772 5,800 $ - 1,554$ per m3 treated per day
Opex $	2,009 - 719 monthly 12$ -6 $ per m3 treated
Speed of construction and setup	1-2 months. Fast, rapid response to emergency
Expertise required for setup operations	Set up- 2 to 3 skilled labour required. Civil engineers, project engineer. Unskilled labour for construction vary depending on the size of the site Operation - 1 engineer and 2 skilled labour. Unskilled labour variable (guards, lime mixing, sludge maangement…)
Operation and maintenance issues	Main operations: mixing of lime, PH check,sludge transfer, cleaning filter bed, incinerator Main issues: clogging of filter media, H&S risk mitigate by use of PPE
Treatment process complexity and pinch points	Low complexity Solids storage
Disposal of final products	Liquid evaporate and/or infiltrated. However, one site disposed into natural environment which was highlighted as an issue. Only one site incinerate the sludge. Others storage it.
Resilience to disaster	Only one stated some measures: site placed component elevated to avoid flooding and propoer drainage to resist fast flood. The FSTPs are located in hilly areas

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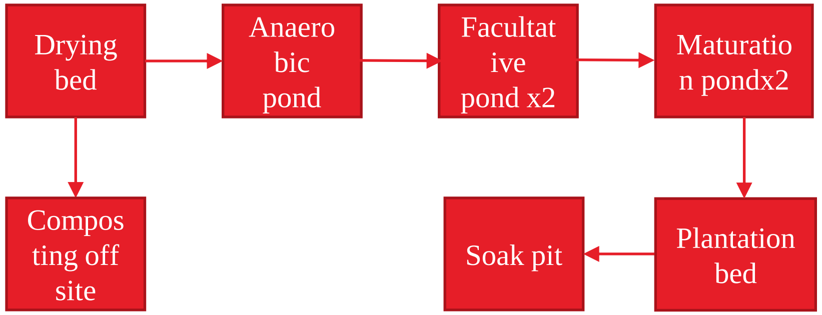
Field visit parameters – review per FSTP type

WSP

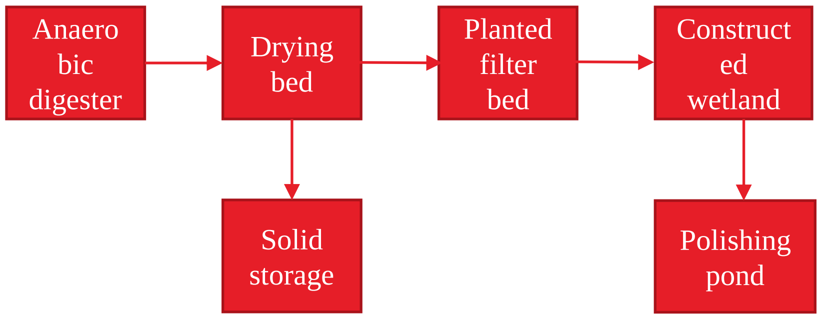


- Same key components and similar process flows

Parametres	Findings
Capacity	5-2.5 m3
Population	12,500 – 2,265
Area requirements, layout and scalability	Total area of the site 140-139.5 m2. Treatment unit area 85 m2 . Most of the site is used for treatment. Efficient use of the space. Sludge treated/treatment unit 0.03- 0.02 m3/m2 Same total area required for double treatment of sludge.
Capex $	19,000-13,000 2,600-7,888 capex/m3 treated
Opex $	390-301 monthly 2.6$ -4 $ per m3 treated
Speed of construction and setup	3 – 6 months
Expertise required for setup operations	Discrepancy in labour required for operate the sites 1-9.
Operation and maintenance issues	Main operations: loading sludge, manual gate valve operation and cleaning. No use of chemicals. Issues: gate valve damaged need replacement
Treatment process complexity and pinch points	Easy to operate
Disposal of final products	Liquid infiltrated. Solid composting off site
Resilience to disaster	Different measures in the sites include elevated plant for flooding and landslide protection

Field visit parameters – review per FSTP type

Anaerobic Digester System

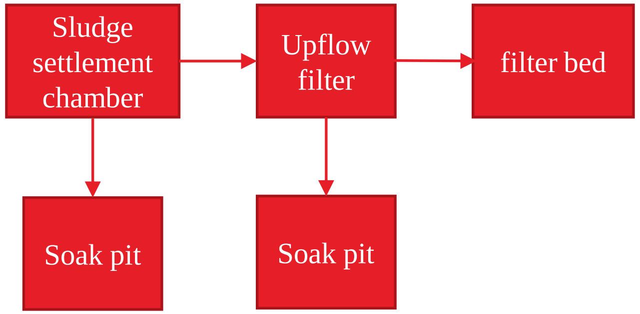


- Only one site of this technology visited

Parametres	Findings
Capacity	5 m3
Population	5,000
Area requirements, layout and scalability	Total area of the site 670 m2. Treatment unit area 290 m2 . m3 sludge treated daily/treatment unit area 0.017
Capex $	6,960 $ 1,392 $ per m3 treated
Opex $	58 $ monthly 0.39 $per m3 treated
Speed of construction and setup	2 months
Expertise required for setup operations	Easy to build. Senior engineer, camp engineer and supervisor needed for setup. One camp engineer, one skill labour and one supervisor needed for operation
Operation and maintenance issues	Main operations: regular cleaning of the polishing pond, filter media installation every 6 to 12 months Issues: Filter blockage
Treatment process complexity and pinch points	Easy to operate
Disposal of final products	Selected to get better effluent quality without the use of chemicals. Liquid not disposed yet. Solid stored
Resilience to disaster	Elevated plant

Field visit parameters – review per FSTP type

Upflow filter



- One site has the provision to add chlorine to the effluent if needed.

Parametres	Findings
Capacity	6-3 m3
Population	TBC
Area requirements, layout and scalability	Low land requirement Total area required 196-76 m2. Treatment unit area - data missing Easy to scale incorporating more units if space available
Capex $	Data missing
Opex $	124-82 $ monthly 1-3 $per m3 treated
Speed of construction and setup	Low installation time, portable, no major civil works required. 15-45 days
Expertise required for setup operations	Easy to build. For operation supervisor plus desludging workers needed
Operation and maintenance issues	Low O&M. No issues or concerns. Regular operations: sludge loading, gate valve control, site cleaning. Replacement of gate valve after time.
Treatment process complexity and pinch points	Liquid evaporation and infiltration in rainy season can be challenging, mostly if site not properly selected looking at the water level.
Disposal of final products	Liquid infiltrated Mostly of sites stored with plan to reuse. One site composting
Resilience to disaster	Drainage system and elevated plant

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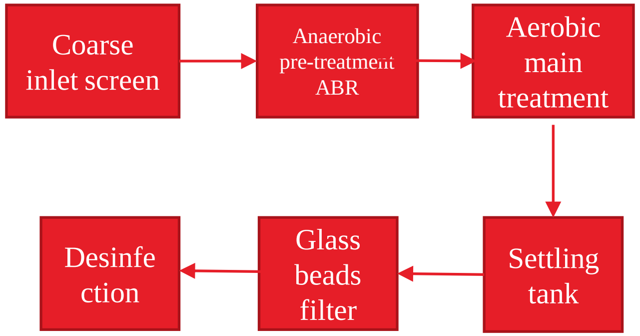
Field visit parameters – review per FSTP type

Aeration



- Similar process. Only difference is in the sludge from the settling tank that will goes to drying beds and get incinerate/ flexigester

Parametres	Findings
Capacity	7-4 m3 The design treatment capacity (15-30 m3) is not being reach – not enough sludge transferred
Population	TBC
Area requirements, layout and scalability	Area of the site 625-400 m2. Low footprint area for significant design capacity Most of the total area of the site is used for the treatment unit. Sludge treated per treatment unit area is currently low Easy to scale, module system
Capex $	Significant capex e.g. 160$ per m2 site / 25,000$ per m3 treated currently
Opex $	7 $per m3 treated Labour, fuel to run the pumps.
Speed of construction and setup	8-10 months
Expertise required for setup operations	Set up was not as fast as planned, challenging transporting equipment and need skilled engineers. Need significant training of skilled labour for operation
Operation and maintenance issues	Safe to operate (minimum contact with sludge) No operation issues yet
Treatment process complexity and pinch points	Size of aeration equipment. Available sludge and speed at which can be transferred
Disposal of final products	Liquid into nature Solid incinerated/ stored but both plan to compost
Resilience to disaster	Tank platform elevated. The tanks can be above or below ground which gives flexibility to the layout

Field visit parameters – review per FSTP type

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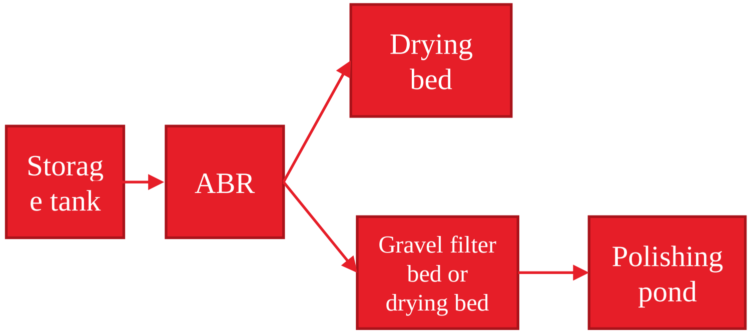
ABR



Parametres	Findings
Capacity	6-10m3
Population	TBC
Area requirements, layout and scalability	Area of the site 4,600- 160 m2. Area treatment unit 2,000- 88 m2. Significant different between the sites on area requirement for similar volume treated. No correlation between volume treated and area required. Scalable
Capex $	Capex 77,000- 25,000 $ 12,833-2,549 $ per m3 treated
Opex $	Opex 580-240 $ 3,6- 0,47 $ per m3
Speed of construction and setup	4-5 months
Expertise required for setup operations	1 engineer, 1 supervisor and 1-2 skilled workers needed to operate the systems
Operation and maintenance issues	Easy O&M No major issue identified
Treatment process complexity and pinch points	Available sludge (too high or to low) and capacity to transfer to the site
Disposal of final products	Environment friendly, biological treatment Liquid into nature (infiltrate or to stream) Solid store/composting of site/incinerated
Resilience to disaster	Protection walls to avoid landslide and elevated platforms

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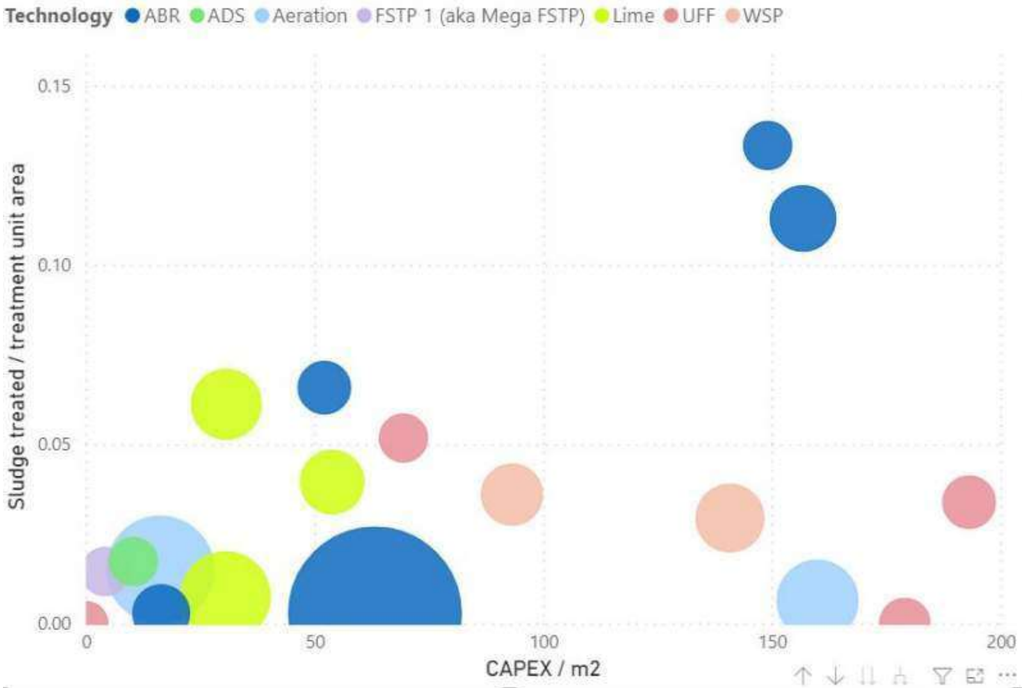
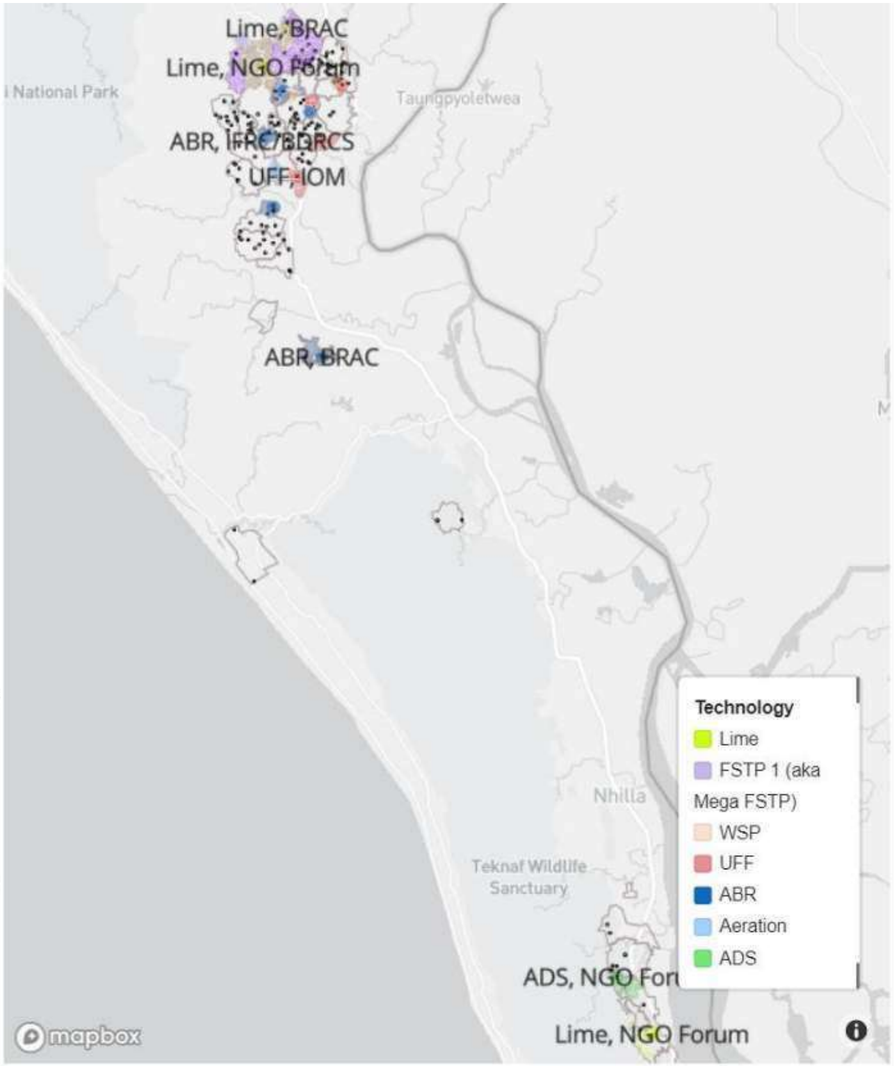
Cost data review

Dynamic dashboard



Technology	Population	Total area (m2)	Treatment area (m2)	Actual treatment capacity (m3
⊞ **FSTP 1 (aka Mega FSTP)**	**120000.00**	**165268**	**8282.43**	**120**
⊞ **Aeration**	**15250.00**	**400**	**400**	**4**
⊟ **ABR**				
IFRC/BDRCS	25000.00	3300	2500	7
NGO Forum	10000.00	300	152	10
VERC	6025.00	162.58	88.51	10
BRAC_Camp 14	4656.00	140	75	10
BRAC_Camp 21	4030.00	4675	2097	6
⊟ **Lime**				
NGO Forum_Camp 4	10000.00	1330	932	7
BRAC	9964.00	312.31	139.42	5.5



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Lab data review

Aim / method

- Do we have data on FSTPs visited? Yes influent & effluent for 17 and additional data points for 11 of those. (& note FSTP2 being commissioned so no data yet)
- Influent data – is this “Normal”? Any variation across camps, seasons etc
- Effluent data – which types of FSTP have best effluent quality?
- Operating within design parameters?
- Future – alignment with DPHE monitoring plan

	Lime treatment			ABR					Aeration		FSTP 1	FSTP 2	MSF FSTP1	Upflow filters & DEWATs				WSP		ADS
	NGOF	BRAC	NGOF	BRAC	BRAC	IFR/BDRCS	NGOF	VERC	IFR/BDRCS	IFR/BDRCS	NGOF	BRAC, UNHCR and MSF	MSF	IOM	WVI	VERC	IOM/shushila	WVI	VERC	NGOF
	4	1W	26	21	14	18	5	8W	18	19	4	Kutupalong	next camp12	9	7	8W	12	7	8W	26
Basis of design and key design features of the FSTPs and FSM chain.																				
CAPEX Cost																				
OPEX Cost																				
Quality of liquid and solid effluent (pathogen inactivation), or any other sludge sampling/laboratory data.																				

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FSTPs

Parameters tested and information to be included in study

- Treatment process performance
  - Treatment efficiency - Quality of liquid and solid effluent, % removal in & out (& at each stage for 11 FSTPs). COD, BOD, SS, Nitrate, total N, Phosphate (P), coliform. *ICCR,B, IFRC & DPHE data*
  - pathogen inactivation & residual risk to public health
  - Liquid effluent quality Vs Bangladesh Environmental Standards
- Treatment process complexity and pinch points (11 FSTPs)
  - underperforming elements/units & causes (narrative)
- Disposal of final products (liquid and solid)
  - Public health
  - Sustainability (circular economy)

Available government standards for discharge of wastewater effluent:

Parameter	Unit	The Environment Conservation Rules, 1997, Ministry of Environment and Forest. **Schedule 9 – Standards for Sewage Discharge** *Maximum value*	Department of Environment Guidelines update 2019, **Schedule 7 – Standards for Sewage Discharge** *Maximum value*
pH	-	-	6-9 (range)
BOD	mg/L	40	30
COD	mg/L	-	200
Nitrate	mg/L	250	250
Phosphate	mg/L	35	35
Total Nitrogen	mg/L	-	15
Suspended Solids	mg/L	100	100
Temperature	°C	30	30
Coliform	CFU/100mL	1000	1000
Oil & Grease	mg/L	-	10

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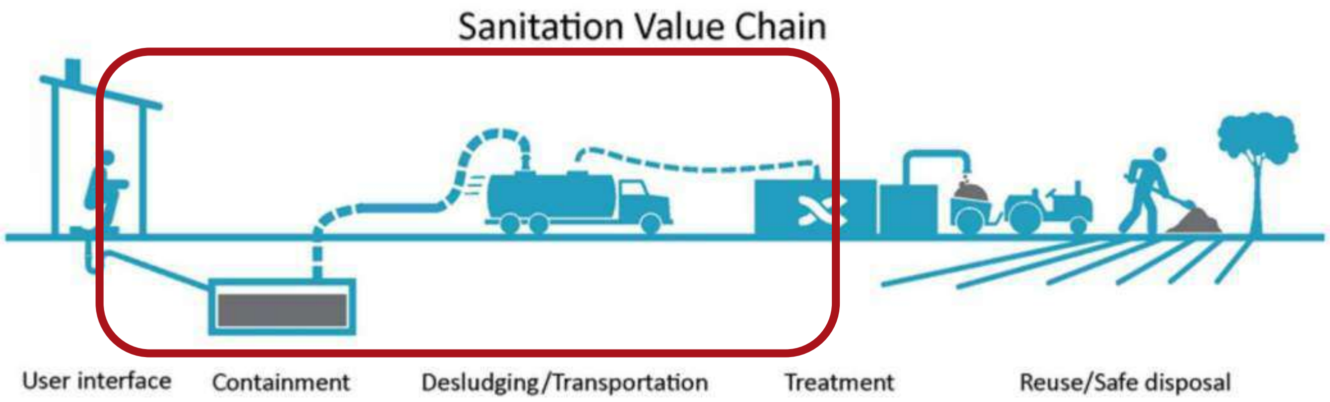
Sludge chain mapping

Method

- Sludge Transportation Data Collection circulated with key stakeholders

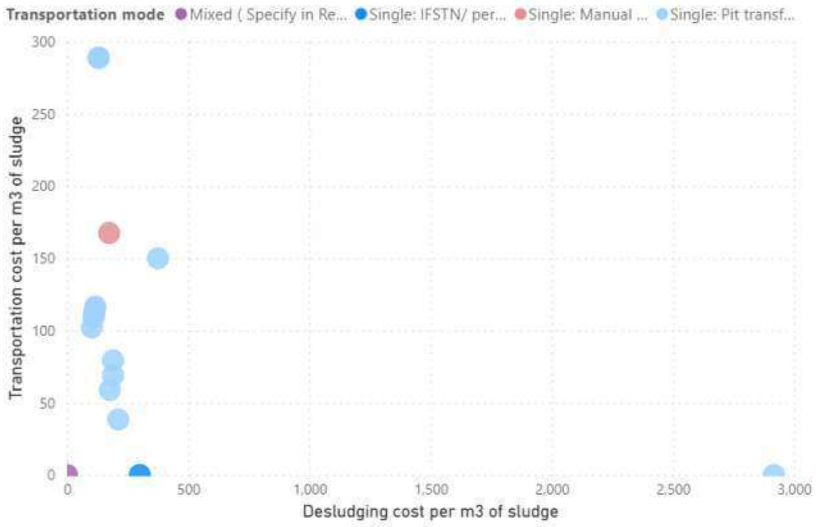
- Transportation mode per Camp / Block and Target FSTP
  - Single: Vacutug
  - Single: IFSTN/ permanent pipe network and pump
  - Single: Pit transfer/ temporary pipe and pump
  - Single: Manual Desludging and Transport
  - Single: Other
  - Mixed
  - Unknown / Not monitored

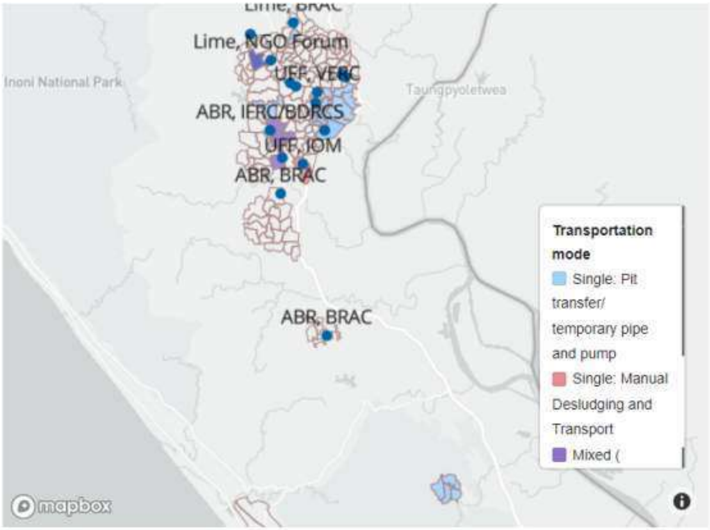


Sludge chain mapping

Aim

- Efficiencies and Inefficiencies of each Transportation mode / chain
  - Which is the most cost effective, why
- Influence of sludge chain on FSTP performance
- Parameters monitored
  - No.of Latrine chambers desludged
  - Volume of sludge
  - Desludging cost
  - Transportation cost





Transportation mode	Volume of sludge per month	Monthly transportation cost	Monthly desludging cost
⊟ **Mixed (Specify in Remarks with ratio of usage)**			
15	70.00	No additional transportation cost	1. HR Cost: 493,900 2. Fuel Cost: 71,250 3. Disinfectants and others: 11,250 4. Other Cost: 9,000
16	35.00		
17	64.00		
18	120.00	No additional transportation cost	1. HR Cost: 200,200 2. Fuel Cost: 8,550 3. Disinfectants and others: 6,000 4. Other Cost: 8,800
⊟ **Single: IFSTN/ permanent pipe network and pump**			

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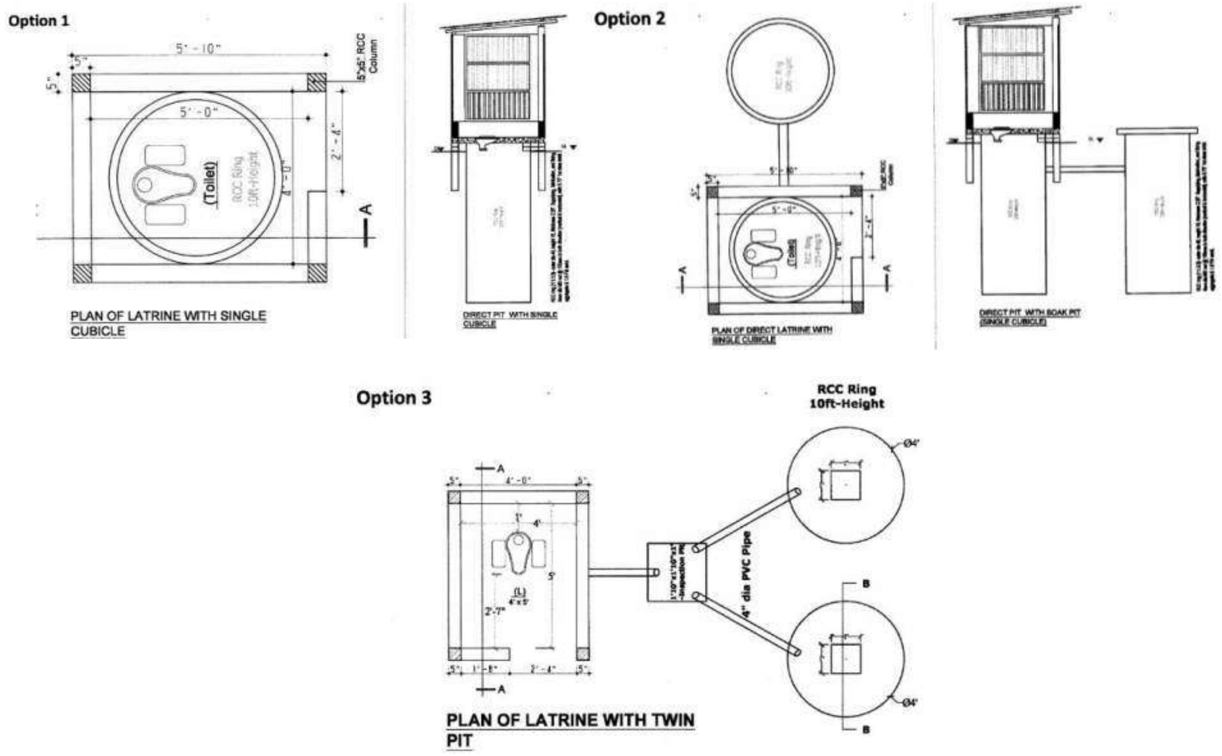
Containment

- Expectations vs reality
- Conclusions so far



Sep 30 21 WASH facility list

Sub Type of Facilities	Facilities				Total
	Bathing Cubicle	Both (Latrine & Bathing)	Latrine	Transfer tank	
Blank			36		36
Bio-Fill latrine			306		306
Biogas Plant			53		53
CGI_sheet_tin			2		2
Communal bathing cubicle	18828				18828
Communal Latrine			14902		14902
construction of bathing cubicle	26				26
Disabled Friendly Bathing Cubicle	10				10
Disabled friendly latrine			232		232
Durable		538			538
Durable Latrine			14524		14524
Emergency		5			5
Emergency latrine			1325		1325
Female segregated bathing cubicle	105				105
Female segregated shared latrine			20		20
FSM Staff Shower Center	3				3
Institutional	59		771		830
Latrine (Sub type Unknown)			274		274
Semi durable		40	2956		2996
Single Chember Direct Pit			1		1
Transfer tank				44	44
Twin Pit Latrine			155		155
Upgraded			6		6
WASH Block			37		37
Grand Total	**19031**	**583**	**35600**	**44**	**55258**

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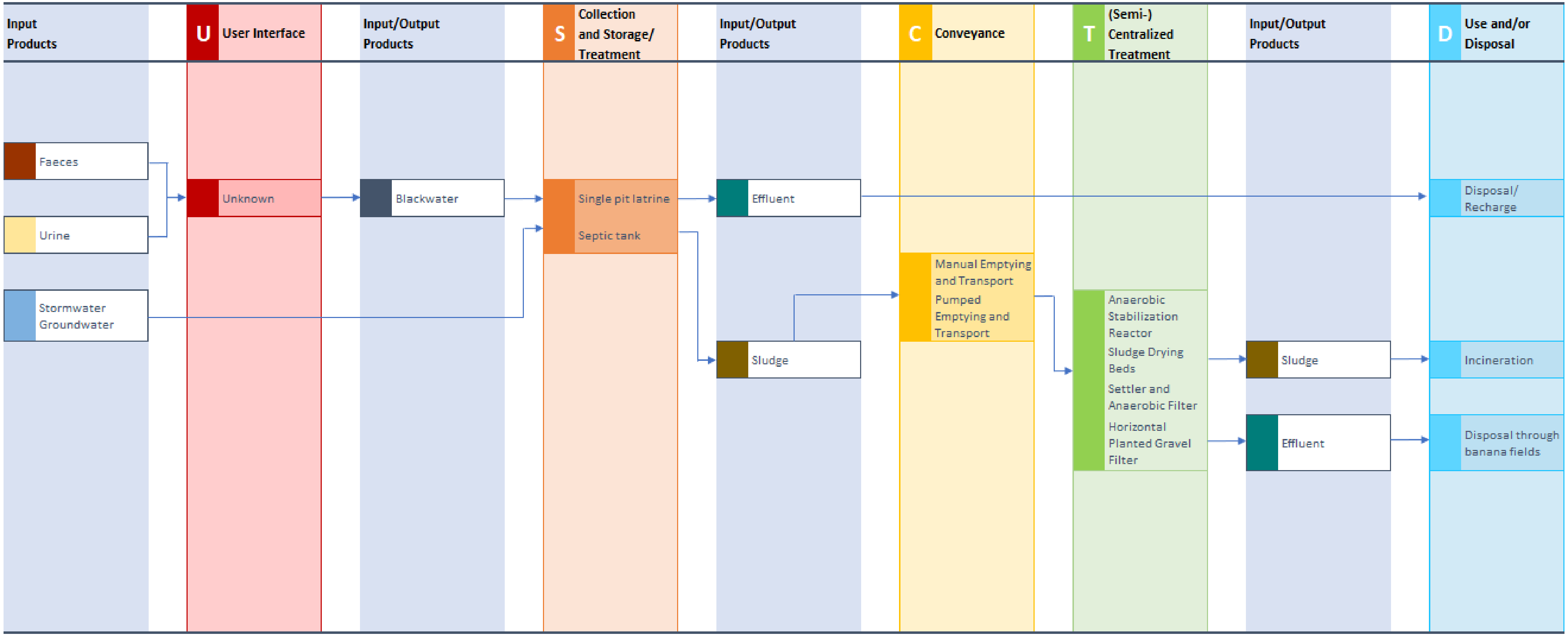
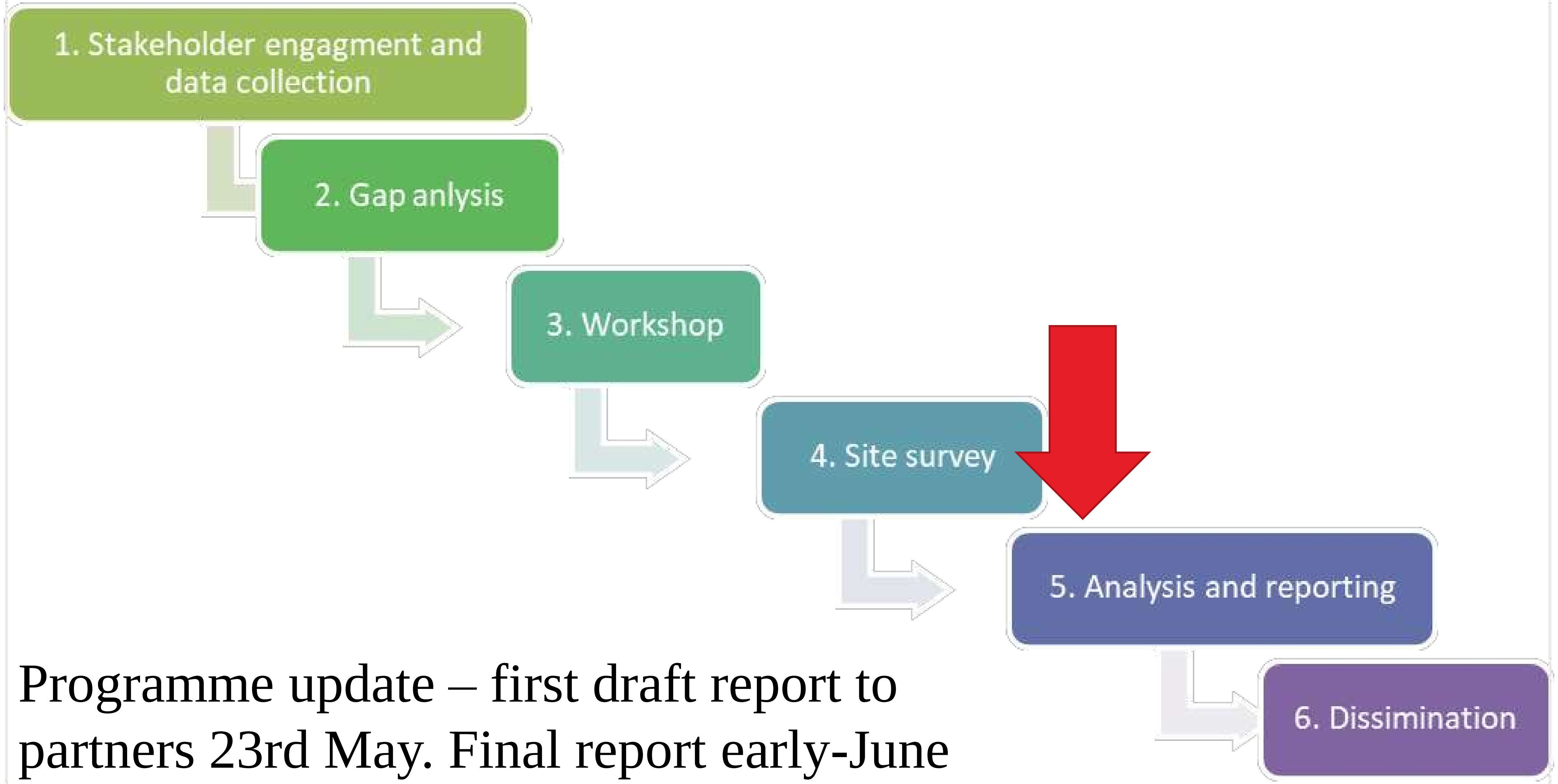
FSM chain mapping

Example



Next steps



Programme update – first draft report to partners 23rd May. Final report early-June

Questions / Discussion

- Who to issue draft report to?

Contacts

Key study contacts

Anna Grieve

Senior Engineer

Project Manager (Arup)

Safwatul Haque Niloy

Sanitation Coordination (Oxfam)

Project Manager (Oxfam)

Paula de Amuedo

Consultant, International Development

Stakeholder Engagement and Civil Engineer (Arup)

Mariana Gonvcalves

Wastewater Engineer and Modeller

Wastewater Engineer (Arup)