THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF WATER

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THE PROPOSED CONSTRUCTION OF FECAL SLUDGE TREATMENT PLANT (FSTP) TO BE BUILT AT GOLANI MTAA, KIMBIJI WARD, KIGAMBONI DISTRICT, DAR ES SALAAM REGION

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ABBREVIATIONS

AAQ	Ambient Air Quality
AIDS	Acquired Immuno-Deficiency Syndrome
DAWASA	Dar es Salaam Water Supply and Sanitation Authority
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Monitoring Plan
GoT	Government of Tanzania
HIV	Human Infection Virus
IDA	International Development Association
LGA	Local Government Authority
NEMC	National Environment Management Council
NEP	National Environment Policy
OGSP	Off-Grid Sanitation Project
PPE	Personal Protective Equipment
PVC	Polyvinyl Chloride
RAP	Resettlement Action Plan
STDS	Sexual Transmitted Diseases

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1.0 BACKGROUND AND JUSTIFICATION

The Government of the United Republic of Tanzania (GoT) through the Dar es Salaam Water and Sewerage Authority (DAWASA) under the Ministry of Water intends to implement an Off Grid Sanitation Project (OGSP) in Dar es Salaam City to serve peri-urban areas not connected to the central sewerage system. DAWASA has received financing from the International Development Association (IDA) in the form of a credit to implement the project. Before implementing the project, the law in Tanzania requires an Environmental Impact Assessment to be conducted and approved by the relevant authorities. To comply with the law in Tanzania, the DAWASA intends to apply a portion of the proceeds of the credit to eligible payments for consulting services for the Preparation of Environmental and Social Impact Assessment (ESIA) and Resettlement Action Plan (RAP) Report for the construction of off-grid sanitation projects.

Dar es Salaam is the largest and most important commercial and industrial center in Tanzania. The city has an estimated population of about 5.0 million and is projected to double at the end of the project horizon of 25 years. About 10% of the population is served by sewers and the rest almost depend on on-site sanitation systems. The sewer coverage is only limited to the area within the city center with a total length of 67.8km and the system is based on separate systems that discharges their effluent into oxidation ponds, and into the sea through a sea outfall of about 1.03km long. The onsite sanitation systems result in Faecal sludge of which handling and management throughout the sanitation chain (from domestic containment, transportation as well as disposal, and treatment) is currently hygienically inadequate thus posing environmental and public health risks. The Off Grid project is intended to address these challenges. The Off Grid project is divided into several subprojects which will be implemented in the five municipalities of Dar es Salaam City. One of these is

the Construction of a Faecal sludge treatment plant at Golani, Kimbiji Ward-Kigamboni Municipality.

The ESIA study will be conducted following the Environmental Management (Environmental Impact Assessment and Audit) (Amendment) Regulations, 2018 along with the Environmental Impact Assessment and Audit Regulations of 2005. These Regulations provide legal procedures for implementing the requirements of the Environmental Management Act Cap.191 of 2004. The Regulations give a mandate to NEMC to oversee the EIA process, which culminates with an award of the EIA Certificate by the Ministry responsible for Environment.

Under the EIA Regulations, NEMC is mandated to screen projects and make decisions regarding the level of EIA required as well as evaluate the adequacy of respective environmental statements. Considering the nature and size of the proposed “Faecal Sludge Project in Kigamboni Municipality”, the project falls under Category “B2” (Non-Mandatory) under Reg.4 (1) (c) and First Schedule of the amended 2018 Regulations. The regulations require developers to prepare and submit to the National Management Council (NEMC) filled EIA registration forms and “Project Briefs” for all B2 projects. The preparation and content of the “Project Briefs” are provided under Reg.6 (1). The same has been followed in preparing this “Project Brief”. The study for preparing this project brief was conducted in August 2022.

1.1 NATURE OF THE PROJECT

The proposed project concerns the construction of an engineered fecal sludge treatment facility for public use at Golani Street, Kimbiji Ward-Kigamboni Municipality. The nature of the project enhances environmental protection through proper handling and disposal of domestic sewage, also the provision of alternative energy (biogas). According to the First Schedule of the EIA and Audit Regulations (Amended) of 2018, the nature of the project is small and entails no significant impacts. The project is categorized as Type B2, which

according to the regulations are “small-scale activities and enterprises that require registration but shall not require Environmental Impact Assessment. Further, the projects shall not require screening and scoping, rather, the Project Brief shall be examined and issued with an Environmental Impact Assessment Certificate”.

2.0 PROJECT DESCRIPTION

2.1 Project Location

The project site is located at Golani street, Kimbiji ward, Kigamboni Municipal within the Dar es Salaam Region. The project site is geographically located at 37M UTM zone with coordinates in Table 1. The site is 130 meters from the downstream water stream and 40 Kilometers from the Nyerere Bridge. (Refer to Figure 1, and Figure 2).

Table 1: The coordinates of the project area

S/No.	Coordinates	
	Easting	Northing
1.	557291.68	9225496.50

Figure 1: A Map of the Dar es Salaam region showing the project Municipal (Source Consultant, 2022)

Figure 2: An Extract of Google Image to show the Location of the project area (Source Google Earth Accessed 30th August 2022)

2.2 Accessibility

The project area is accessible through Pemba Mnazi Road from Dege-Kigamboni. The project site for construction of FSTP is about 1.5 km from Nyati Cement Factory, which is approximately 36 km from the Kigamboni Ferry.

2.3 Specific Features

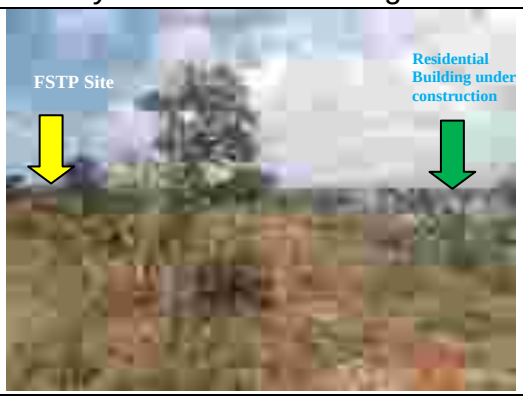
The proposed project site is characterized by natural vegetation. There are tall grasses, shrubs with climbers, *Eucalyptus* plant, and *Trachycarpus fortune* Palm trees and *Senna Siamea* species within the project site. The project site is bordered with roads on the northern and western sides whereas on the southern and eastern side is bordered by footpaths (Figure 3).

Figure 3: Natural Vegetation species and footways at the site (Source: Site visit August 24th 2022)

2.4 Adjacent Land Use

The proposed site for the establishment of FSTP is located at a less populated semi-urban area. However, the project site is surrounded by Residential plots, small scale farms (mainly cassava, peppers, vegetables and some paddy farming remains) adjacent to a stream for irrigation, Ongoing construction of residential buildings, firewood gathering and some old mud-walled with thatched roof buildings as indicated in Table 2. The proposed is about 98 meters from access road and 168 meters from the residential buildings.

Table 2: Adjacent Land use

	
Collected firewood	Locally constructed building
	
Footpath	Ongoing construction of residential buildings
	
Stream used for irrigation at the downstream of the project site	

(Source: Fieldwork August 2022)

2.4.1 Land Ownership

The proposed Faecal Sludge Treatment Plant at Golani Mtaa area, project site is sorely owned by Kigamboni District. The District has apportioned about 47 Acres piece of land for small size FSTP. There is a Memorandum of Understanding (MoU) that has been signed between DAWASA and Kigamboni

District for the implementation of the project (Appendix III). In this MoU, DAWASA is responsible for the construction and operation of the FSTP while the Kigamboni District avails land and benefit from the emptying fee as revenue.

2.5 PROJECT ACTIVITIES

2.5.1 Mobilization or pre-construction phase

This phase entails mobilization of labour force, and equipment as well as acquisition of various permits as required by the law.

Other activities during this phase include;

- Topographical Survey for setting out purposes,
- Geo-technical Investigation for the areas allocated with the balancing tank and Anaerobic Baffled Reactor (ABR)
- Construction Materials' source Investigation,
- Land acquisition,
- Material storage and material preparation,
- Masonry work
- Finishing works
- Painting works

Duration 1-2 months

2.5.2 Construction phase

This phase entails all the necessary installations, site grading and placement of the facility components. Construction phase is expected to be 18 months. The major activities include;

- Vegetation clearance and earthworks (foundations excavation),
- Dewatering and site access road formation and drainages construction;
- Construction of parking lot and access ramp for tankers;
- Construction of Garbage screen, balancing tank, Biogas digester,
- Construction of Plant Office, guard house and storage room;
- Preparation of planted gravel filter;
- Plumbing work connecting all treatment units up to the effluent

2.5.3 Demobilization phase

This phase will involve the dismantling of temporary structures such as scar fording and removing/spreading spoil materials for proper restoration of the site. Estimate duration 1 month

Other activities include;

- General cleanliness of the area, that is clearance of all sorts of solid wastes (plastics, wood, metal, papers, etc);
- Deposit all wastes to the authorized dumpsite;

2.5.4 Operation phase

The phase entails the actual usage of the Feacal sludge Plant. Faecal sludge will be desludged using vacuum takers and disposed of at the proposed facility for further treatment. DAWASA will decide on the mode of running the FSTP for instance instituting fee, Standby attendants will be positioned to oversee the day to day running of the facility. The facility is estimated to run for 30 years with subject to minor and major repair. The memorandum of understanding is attached as Appendix III.

2.5.5 Decommissioning Phase

Decommissioning is not anticipated in the foreseeable future as the completed facility will be serving a number of houses which at present incur many costs to dispose fecal sludge and if not so tend to discharge illegally. However, if this will happen, may entail change of use (functional changes) or demolition triggered by change of land use.

2.6 PROJECT DESIGN

2.6.1 Design criteria

The proposed public design was obtained partly using criteria stipulated in the Tanzania national documents, specifically, the National Guideline for Water, Sanitation and Hygiene for Tanzania Schools prepared by the Ministry of Education, Science and Technology (2016); and the Design, Construction Supervision, Operation and Maintenance (DCOM) Manual Volume II, Design of

Sanitation Projects, Fourth Edition, prepared by the Ministry of Water (2020).
The plant structures are ground surface structures hence it is accessible.
The proposed technology and construction design follow the objective to execute an engineering design of fecal sludge management facility (one in number at the stated site) which will be simple, cost effective/efficient, easy to operate and maintain performance standards which conform to NEMC.
Technology selection was based on the following four main aspects;

- Land availability
- Context of the location of the treatment sites (existing infrastructures)
- Local operation and maintenance management capacity
- Revenue generation through by-products

2.6.2 Technology description

2.6.2.1 Garbage screen

Domestic sludge is dispersed directly onto the screening inlet chamber to retain the incoming debris before it goes to the preliminary treatment process.

2.6.2.2 Balancing tank

The incoming wastewater is stored in the balancing tank to allow sludge stabilization and controlling flow when it goes to the next treatment units. This tank play key role to reduce shocking loads towards the system especially when the hydraulic loading surpasses plant designed holding capacity.

2.6.2.3 Biogas digester

This unit is designed to separate the incoming wastewater in liquid and solid form as well as the biologically digestion of organic solids. The digestion process takes place without oxygen input, under anaerobic conditions, and generates biogas useful for cooking, lighting and heating. Therefore, the project will produce biogas which will be harvested and used by the nearby facilities ie the nearby residents, but the number of users depends on the volume produced from the nature of the wastewater received in the facility.

2.6.2.4 Anaerobic Baffled Reactor (ABR)

The baffled reactor consists of series of chambers in which the wastewater flows up-stream. Here, the suspended and dissolved solids in the pre-settled waste water undergo anaerobic degradation. The activated sludge settles at the bottom of each chamber and the influent wastewater is forced to flow through this sludge blanket where anaerobic bacteria make use of the pollutants for their metabolism. Progressive decomposition occurs in the successive chambers. A part of the last chambers can optionally be filled up with coarse filter material like, stones, cinder or plastic rings. The filter materials act as carrier material for an attached bio-film, which consumes the organic water pollutants. In ABR plants the BOD removal efficiency is up to 90% and the pathogen removal ranges between 40-75%. The baffled reactor is resistant to shock load and variable inflow. It operates by gravity and maintenance is reduced to desludging of the chambers at intervals of 1-2 years. This unit is advantageous since its sub-soil construction saves space.

2.6.2.5 Constructed Wetland

Constructed wetland or Planted Gravel Filter (PGF) is suitable for wastewater with low percentage of suspended solids that have already been removed by pre-treatment. The main removal of treatment mechanisms are biological conversion, physical filtration and chemical absorption. The PGF is made of planted filter bodies consisting of graded gravel. The bottom slope is 1% and the flow direction is mainly horizontal. The main plants used in this filter bed are; *Canna indica, Reed juncus, Papyrus, Phragmites* and *Arundo donax*. The plant selection is mainly based on their ability to grow on waste water and have their roots go deep and spread wide. Plants transport oxygen via their roots into the ground. However, in the present DEWATS design the use of plants is only to act as catalysts rather than actually be a treatment medium. BOD removal ranges between 75-90% efficiency on the other hand pathogen removal efficiency is over 95%. The operation and maintenance of the system are simple and spatial requirements for construction are compensated through beautifying landscapes.

2.6.2.6 Sludge Drying Bed (SDB)

This unit is designed for storage and drying of dislodged sludge after 3-6 months from the Biogas Settler, the sludge drying is mainly by using solar energy which kills pathogens. Sludge can then be used as compost in agricultural fields to grow various crops especially bananas.

2.7 Sludge loading intensity

There is a wide range of sludge loadings and intervals of reed beds according to previous researches, when operated with septage and pit latrine sludge. Maximal sludge loading rate of 250kg DM per m^2 and per years are recommended for septage, meaning sludge from septic tanks have a fairly good degree of stabilization. For this project with a mixture of sludge coming from septic tanks and lined and un-lined pit latrines, the receiving sludge is considered as partly anaerobic.

2.8 Health and Safety

The proponent is committed to protect the health and safety of its employees and those of its contractors, to ensuring that activities are conducted in a manner that protects the environment and people. The Contractor shall provide and enforce the use of appropriate personal protective equipment for all workers e.g. overalls, gloves, masks, etc. (wherever required). Tanzanian/international construction standards will be followed for quality and safety to workers. First aid facility will be installed at the construction site.

2.9 Proposed Processing steps

The treatment process of the proposed facility follows the cross-section flow diagram in figure 5 from the influents to the effluent.

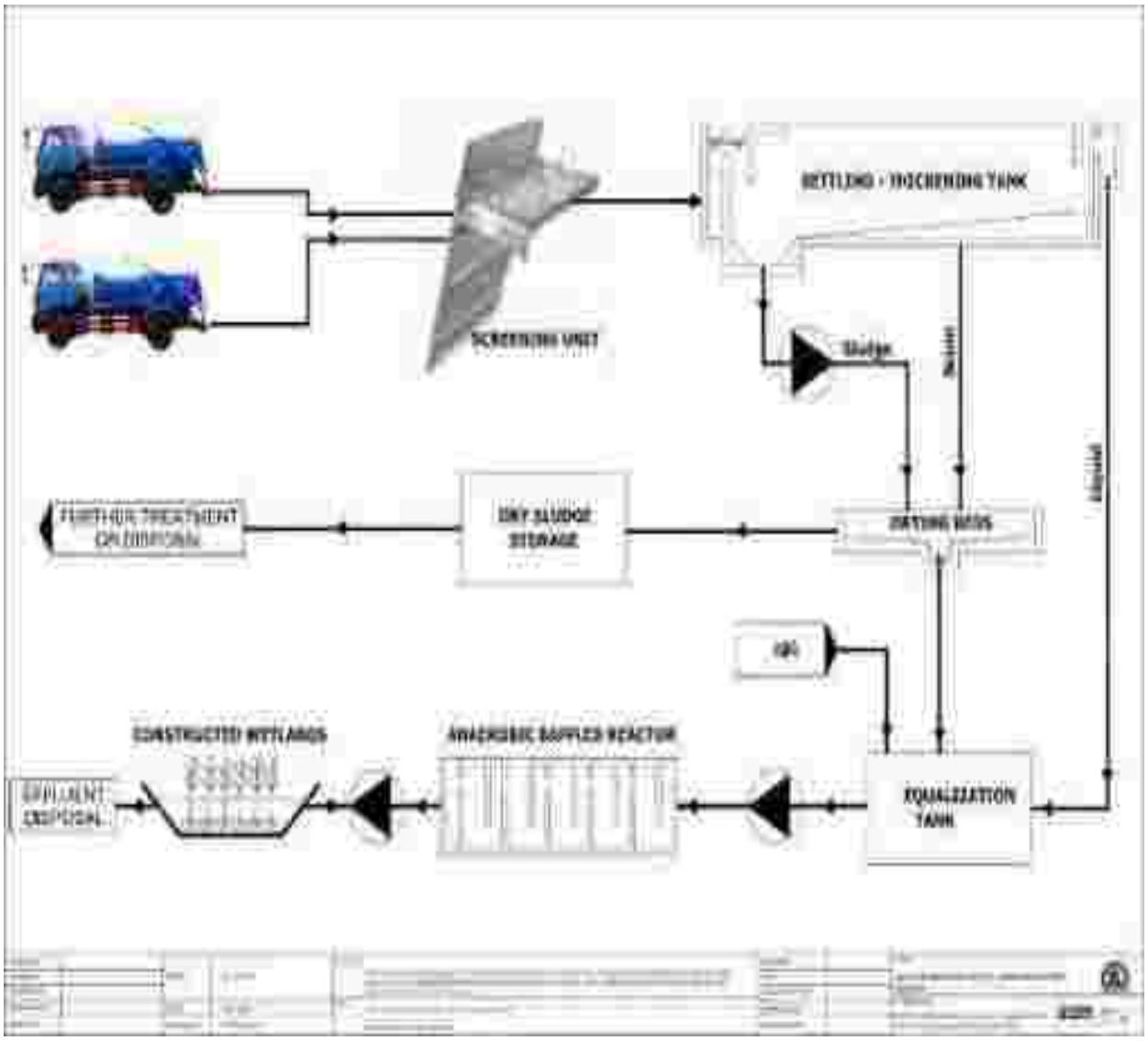


Figure 4: The Fecal Sludge Treatment Facility cross-section diagram

2.10 Project requirements and waste generation

2.9.1 Project requirements

2.9.1.1 Construction materials and labour force

The main materials for Faecal Sludge Treatment Plant include cement, aggregates (stones), water, steel, sand, timbers, blocks, uPVC pipes, IPS Pipes and gravels. All materials are available in the local sources in Tanzania. The estimated quantities of the materials to be included in the BoQ.

In addition to that, material such as stone and gravels can be acquired from registered dealers such as M/S Even Enterprises Company Limited who has a license to mine at Lugoba area in Bagamoyo District, Appendix VIII.

2.9.1.2 Labour force

The labour force will be determined by the Contractor; nevertheless, it is projected that during the construction phase the project will require not less than 50 workers both skilled and non-skilled laborers for each phase of project construction.

2.9.1.3 Machinery and Equipment

The proposed project development will employ various standard construction equipment and machinery. Equipment expected to be used during the construction works are Excavators, Tippers, Concrete Mixers, poker vibrators, Wheel barrow, Compactor, etc. All equipment and machineries for construction works needed by the proposed project will be determined when the bill of quantities (BoQ) and selection of Contractor is finalized. These equipments shall be temporary and shall be demobilized once project is completed.

2.9.2 Wastes generation

The major wastes generation associated with the project are spoil soils resulting from earthworks during the foundation excavations, solid wastes and liquid waste. The spoil soil shall be stock piled around the public toilet for further use in landscaping the site at the end of the project.

2.9.2.1 Liquid waste management

A total of 50m^3 per day of liquid waste is estimated to be received at the receiving chamber of the proposed facility during the maximum operation phase. The project operations will conform to the National Effluent Standard of Tanzania with regard to waste water produced by the plant. After the treatment process is done, the effluent which is rich in nutrients is expected to cater for irrigation taking the advantage of the ongoing agriculture fields adjacent to the project site. However, in case the nutritious effluent will not be used for irrigation, there is a possibility of discharging direct to the river within the marsh which drains to Indian Ocean. The site is about 65m from the River Ng'ombe before discharge all relevant authorities will be consulted by the operator.

2.9.2.2 Solid waste management

About 0.5-1 tonnes per month of domestic refuse and other solid wastes is estimated to be generated and trapped at the garbage screen during the project construction and operation phase respectively. A well-established solid waste collection system will be instituted. The system will involve among other things wastes segregation at source, recycling or reuse of some wastes and final disposal to the approved city/municipal dumpsite.

The project management team will provide waste bins and recycling receptacles of different type to enable sorting. Compostable materials will be sent direct to the city dumpsite area. Table 2 below shows solid and liquid waste wastes to be generated by the project and the methods of their disposal.

Table 3: Management of construction and operation wastes

Solid waste			
Type of waste	**Sources**	**Estimated Quantity (Kg)**	**Disposal / Management procedure**
Debris and Rubble (overburden)	Site clearance	3,000-5,000	Fill material for road potholes, etc.
Biodegradable materials mainly domestic waste	- Construction crew i.e. Masonry,		Accessible litter bins within the camp site and later to the city waste disposal

(food, paper, wood etc.)	Carpentry & Painting	(50-100Kg) per Month	system (engage a registered private company), Final disposal will be at Municipal dumpsite
Non-biodegradable materials (plastic, glass)	- Construction crew ie Masonry, Carpentry & Painting	(2-5) kg per day	Recycling/ reuse (Plastics to be sent to authorised plastic recyclers and glass bottles and scrape to be sent to the recyclers)
Hazardous waste, Scrap metals	- Worn out Machinery parts and other metal cuttings, oil, etc	(10-15kg) per day	Sold to authorised Scrap metal and waste oil dealers respectively.
Liquid waste			
Type of waste	**Sources**	**Estimated Quantity (m^3) per day**	**Disposal / Management procedure**
- Excreta (domestic) human - Grey water /cleaners	- Toilets and floor cleaning	1.6	Use of septic tanks and when full will empty to the wastewater treatment facility
- Oils and greases	Machinery parts and trucks	- None	- Car maintenance will be done at proper garages

3.0 POLICIES, LEGISLATION AND INSTITUTIONAL ASPECT

According to the fundamental principles of environment, any developmental activities of this nature such as construction of Public Toilet would have socio-economic and somehow environmental impacts that must be addressed and governed in order to serve public interest and sustainable development. Given the many existing and developing environmental laws, regulations and standards in Tanzania, it is worth considering resorting to constitutional provisions to protect and manage the environment. With increasing environmental awareness in recent decades, the environment has become a higher political priority and many constitutions now expressly guarantee a 'right to a healthy environment', as well as the procedural rights necessary to implement and enforce the substantive rights granted. The public or national interest in this aspect is addressed through government Policies and regulated by Principal Acts and Regulations. The implementation of the proposed project shall touch various sectors; therefore, the developer has to comply with number of cross-sectorial policies and legislations relevant to this project. Also, the listed institutions involved in environmental management for the project is included in this chapter.

3.1 RELEVANT POLICIES

This section focuses on various policies which guide the development aspects for sustainable vision, apart from the national environmental policy, there are numbers of sector policies that are to be reviewed when executing the proposed development and these include;

3.1.1 National Environment Policy 2021

The National Environmental Policy of 2021 has just been launched in February 2021. The new policy formulation is a revision of the National Environmental Policy of 1997. The Policy serves as a national framework for planning and sustainable management of the environment in a coordinated, holistic and adaptive approach taking into consideration the prevailing and emerging environmental challenges as well as national and international development issues. Effective implementation of this policy requires mainstreaming of

environmental issues at all levels, strengthening institutional governance, and public participation in environmental management regimes. The long-term vision of this policy is geared towards the realization of environmental integrity, assurance of food security, poverty alleviation, and increased contribution of the environmental resources to the national economy. It also recommends strong institutional and governance measures to support the achievement of the desired objectives and goals.

The policy seeks to promote the economy and livelihoods of people while promoting sustainable utilization of natural resources in the country. The policy provides the framework for the formulation of plans, programmes, and guidelines for the achievement of sustainable development.

The policy overall objective is to provide a national framework for guiding harmonized and coordinated environmental management for the improvement of the welfare of present and future generations. The specific objectives are i) to strengthen coordination of environmental management in sectors at all levels; ii) to enhance environmentally sound management of land resources for socioeconomic development; iii) to promote environmental management of water sources; iv) to strengthen conservation of wildlife habitats and biodiversity; v) to enhance conservation of forest ecosystems for sustainable provision of environmental goods and services; vi) to manage pollution for the safe and healthy environment; vii) to strengthen the national capacity for addressing climate change impacts; viii) to enhance conservation of aquatic system for the sustained natural ecosystem; ix) to ensure safety at all levels of application of modern biotechnology; x) to promote gender consideration in environmental management; xi) to promote good governance in environmental management at all levels; and xii) to ensure predictable, accessible, adequate and sustainable financial resources for environmental management.

3.1.2 National Land Policy of 1997

The National Land Policy states that “the overall aim of a National Land Policy is to promote and ensure a secure land tenure system, to encourage the optimal use of land resources, and to facilitate broad-based social and economic

development without upsetting or endangering the ecological balance of the environment". This study partly responds to this requirement.

3.1.3 Construction Industry Policy (2003)

Among the major objectives of the policy, which supports a sustainable building development sector, include the promotion and application of cost effective and innovative technologies and practices to support socio-economic development activities such as sanitation, water supply, buildings, road-works, shelter delivery and income generating activities and to ensure application of practices, technologies and products which are not harmful to either the environment or human health. Proposed project is in-line with this policy as ultra-modern technology is used during construction and its operation.

3.1.4 National Health Policy (2003)

The Health Policy is a vital guide towards health development of any country. It is particularly, important in a country like ours where resources and technology are more limited than in other countries, which are relatively better off in both technology and resources. This Policy is a revision of the 1990 Health Policy, which emphasized on the need for increasing community involvement in health development and improved access and equity in health and health services.

The Policy recognizes the challenges of consolidating the principles of the previous health policy in community involvement, improved health services provision, access and equity while addressing the different dimensions of reforms that are taking place in the Public Sector.

The proposed project will adhere to policy requirements to ensure no transmission of such communicable diseases between construction workers and the community, protect workers from all sorts of health risks and hazards; and provide adequate sanitation services within the project and ensure that its activities are not a source of health issues.

3.1.5 National Gender Policy of 2000

The overall objective of the Gender and Development Policy is to promote gender equality and equal participation of men and women through facilitation

of access to education, child care, and employment and decision making. Also this policy is to provide guidelines that will ensure that gender-sensitive plans and strategies are developed in all sectors and institutions. While the policy aims at establishing strategies to eradicate poverty, it emphasizes gender quality and equal opportunity of both men and women to participate in development undertakings and to value the role played by each member of society. The proposed project will adhere the requirements addressed under this policy.

3.1.6 National Human Settlements Development Policy (2000)

Among the objectives of this policy is to improve the level of the provision of infrastructure and social services for the development of sustainable human settlements and to make serviced land available for shelter to all sections of the community. Such infrastructure and services constitute the backbone of urban/rural economic activities. Public Toilet is one among of the important infrastructure for Kampochea market, Charambe ward community and country at large

3.2 PRINCIPAL LEGISLATIONS AND REGULATIONS

The ESIA team reviewed several legislations relevant to the construction of public toilets. These encompass Principal Acts that support and provide guidelines to implement the intended project as discussed below.

3.2.1 Environmental Management Act (2004)

Among the major purposes of the EMA are to provide the legal and institutional framework for sustainable management of the environment in Tanzania; to outline principles for management, impact and risk assessment, the prevention and control of pollution, waste management, environmental quality standards, public participation, compliance, and enforcement; to provide the basis for the implementation of international instruments on the environment; to provide for the implementation of the National Environmental Policy; to provide for the establishment of the National Environmental Fund and to provide for other related matters.

Part III, Section 15(a) states that "*in matters about the environment, the Director of Environment shall coordinate various environment management activities being undertaken by other agencies to promote the integration of environmental considerations into development policies, plans, programs, strategies projects and undertake strategic environmental assessments to ensure the proper management and rational utilization of environmental resources on a sustainable basis for the improvement of the quality of human life in Tanzania*".

Part X of the law deals with Environmental Quality Standards. Section 140 of this act states that "*The National Environmental Standards Committee of the Tanzania Bureau of Standards established under the Tanzania Bureau of Standards Act, 1975 shall develop, review and submit to the Minister proposal for environmental standards and criteria concerning; water quality; discharge of effluent into the water; air quality; control of noise and vibration pollution; sub-sonic vibrations; soil quality, control of noxious smells; light pollution; and any other environmental quality standard*" Some of these standards have already been published in the government *gazette* while others are not in place. This project shall consider all the standards specified by this act.

3.2.2 The Environmental Management (Fees and Charges) Regulations, 2021

These Regulations shall apply in relation to an act or service in respect of which fees and charges are payable under the Act and Regulations made thereunder. The regulations emphasize that "a person shall not, upon payment of fees and charges prescribed in the Schedule to these Regulations, carry on any of the following":

- Environmental Impact Assessment;
- Environmental Compliance Monitoring and Audit;
- Registration of Environmental Experts;
- Environmental Quality Standards;
- Noise and Vibrations; or
- other activities related to the environment

This project complies with the regulations since the proponent has already paid registration fees and review charges as directed by NEMC.

3.2.3 The Environmental Management (Control of hazardous Waste) regulations, 2021

The objective of these regulations is to protect the environment and human health by preventing or reducing the generation of Hazardous waste, the adverse impacts of the generation and management of hazardous waste and by reducing overall impacts of resource use and improving the efficiency of such use, which are crucial for the transition to a circular economy. The regulation requires that “any person generating, collecting, storing, transporting, treating, recycling, reusing, recovering and disposing of hazardous waste or any person exercising jurisdiction under these Regulations shall, assure that there are no adverse impacts to be generated or caused by the activity conducted. Project developer will comply with the requirements of this regulation by reducing the construction materials which may generate hazardous impacts, as well as proper handling of such waste such as in use of fuels for various purposes etc.

3.2.4 The Environmental Management (Control of Noise and vibration) regulations, 2015

The regulations focus on the maintenance of a healthy environment for all the people in Mainland Tanzania, the tranquility of their surrounding and their psychological well-being by regulating noise and vibration levels to prescribe the maximum permissible noise and vibration levels from a facility or activity to which a person may be exposed. The project developer will make sure that all the guidelines under this policy will be considered to ensure the healthy environment to everyone.

3.2.5 The Environmental Management (Prohibition of Plastic Carrier bags) regulations, 2019

Regulations are meant to impose a total ban on the import, export, manufacturing, sale, and use of plastic carrier bags regardless of their thickness. Plastic carrier bags has a wide definition in the Regulations, as a bag

made of plastic film, with or without handles, or gussets and to which its layer is in any thickness. The Regulations also categorically state that no person shall sell or offer for sale beverages or other commodities wrapped in plastics unless the nature of such commodities require wrappings by plastics, and restricts any licensing authority from issuing any licenses after the Regulations come into force. Project developer will make sure that there will be no use of plastic bags within the project site and the whole project life time, also in case of the need of carrier bags the proponent will make sure that there will be a n alternative bags which are allowed by the regulations. For the commodities that are wrapped in plastic, then the proponent will make sure that such plastic will be handled properly.

3.2.6 The Environmental Management (Solid Waste Management) regulations, 2007

The solid waste management regulation of 2007, provides general directive on management of solid waste as follows: -

Regulation detail the requirements and responsibilities for managing solid waste in Tanzania

Highlight waste minimization and cleaner production principles alongside the duty to safeguard the public health and the environment from adverse effects of solid waste. Detail permitting requirements, notably that any person dealing with solid waste as collector, transporter, waste depositor or manager of a transfer station will apply to the LGA for a permit. The local authority will also issue licenses to individuals or companies qualified to operate solid waste disposal sites; permit is required to operate an LGA waste disposal site. The proposed project is expected to generate solid waste in construction phase. Therefore, to comply with this regulation the Project developer will engage the registered solid waste collection contractor.

3.2.7 The Environmental Management (Water Quality) regulations, 2009

Regulations provide for institutional and legal framework for sustainable management and development of water resources; to outline principles for water resources management; to provide for the prevention and control of water

pollution; to provide for participation of stakeholders and the general public in implementation of the National Water Policy. These regulations require the sustainable management of water sources and proper use of the available sources without causing any damage towards such sources. Also, the regulations emphasize that it is every one's responsibility to conserve and preserve the available water sources in Tanzania. During all phases of the project there will be water demand, hence the project developer will make sure that there will be a sustainable use of water. Also during construction and maintenance phase the developer will make sure that the water supply pipes will not be damaged in either ways

3.2.8 The Environmental Management (Air Quality) regulations, 2009

The Regulations were formed in order to: -

- Prohibit emissions and releases of hazardous substances into the environment
- Prescribe permissible emission limits and quantities of emissions of sulphur oxide, carbon monoxide, black smoke and suspended particulate matters, nitrogen oxide, ozone, hydrocarbons, dust and lead
- Empower NEMC to issue air pollutant emission permits, enforce compliance, undertake emergency prevention and issue stop orders
- Set baseline parameters on air quality and emissions based on a number of practical considerations and acceptable limits and ensure protection of human health and the environment from various sources of pollution.

The proposed project will adhere the requirements of this Act, emission limits will be monitored to the permissible limits.

3.2.9 The Environmental Management (Soil Quality) regulations, 2009

These Regulations, made by the Minister of State under sections 143, 144 and 230 of the Environmental Management Act, concern soil pollution and soil quality standards and provide with respect to a soil protection permit and compliance system. They also concern measures of enforcement. The object of these Regulations is to

- Set limits for soil contaminants in agriculture and habitat;

- Enforce minimum soil quality standards prescribed by the National Environmental Standards Committee.

Also, the regulations require that, the contaminants of volatile organic compounds in habitat and agricultural soils shall comply with parameters and upper limits as prescribed and contaminants of heavy metals in habitat; agricultural soils shall comply with parameters and upper limits as prescribed and contaminants of pesticides in habitat and agricultural soils shall comply with parameters and upper limits as prescribed. Local government authority may prescribe special or specific measures and guidelines for soil conservation applicable to their respective areas of jurisdictions which are not below standards prescribed under these Regulations. The Project developer will comply with the requirements made under these regulations.

3.2.10 Occupational Health and Safety Act 2003

The provisions of this law require employers to provide decent working environment to employees to guarantee their health and safety. Occupational health and safety services are important for sustainable development of a country, as they reduce occupational accidents and diseases which can have huge economic burden to individuals, enterprises and the nation as whole. Improving health and safety of workers will significantly increase productivity at the workplaces to encourage more investments, increase job creation, higher morale, and job satisfaction hence industrial harmony. The law also entails employers to fulfil obligations of ensuring safety of the equipment's used by workers and providing proper safety gears as required.

3.2.11 The Water Supply and Sanitation Act No. 12 of 2009

This is also a new legislation that provides for sustainable management and adequate operation and transparent regulation of water supply and sanitation services; provides for establishment of water supply and sanitation authorities as well as community owned water supply organizations; and provides for appointment for service providers. The main aim of this law is to ensure the right of every Tanzanian to have access to efficient, effective and sustainable water supply and sanitation services for all purposes by taking into account

among others protection and conservation of water resources and development and promotion of public health and sanitation; and protection of the interest of customers. Under this law, the Minister responsible for water affairs shall establish water authority and cluster water authorities in order to achieve commercial viabilities.

3.12 Engineers Registration Act and its Amendments 1997 and 2007

The Acts regulate the engineering practice in Tanzania by registering engineers and monitoring their conduct. It establishes the Engineering Registration Board (ERB), the law requires any local or foreigner engineer to register with ERB before practicing in the country. Project developer will continue to comply as it has utilized the services of registered engineering firm for its structural designs which it will continue to use to supervise the construction process.

3.2.13 The Contractors Registration (Amendment) Act, 2008

The Contractors Registration Act requires contractors to be registered by the Contractors Board (CRB) before engaging in practice. It requires foreign contractors to be registered by the Board before gaining contracts in Tanzania. Project Developer shall comply with the law requirement during the recruitment of contractors for project implementation.

3.2.14 The Architects and Quantity Surveyors Act (1997)

The Act requires Architects and Quantity Surveyors to be involved in the project to be registered by the Architects and Quantity Surveyor Board (AQSB) before engaging in practice. It also requires foreign contractors to be registered by the Board before gaining contracts in Tanzania. Project Developer has complied with the law requirement during the recruitment of architects who have designed the project and will continue to utilize registered persons in the project implementation.

3.2.15 The Urban Planning Act (2007)

The law provides for the orderly and sustainable development of land in urban areas, to preserve and improve amenities; to provide for the grant of consent to develop land and powers of control over the use of land and to provide for

other related matters. Under Section 3, among others the law seeks to improve level of the provision of infrastructure and social services for sustainable human settlement development. This act established planning authorities which include the city, municipal, town and township councils in the country which have responsibilities including:

- Secure the orderly and environmentally sustainable development of area under its jurisdiction;
- Prepare general and detailed planning schemes;
- Control building densities and access to buildings;
- Recommending approval of building schemes and subdivision of plots by developers;
- Secure cooperation of all agencies, utility bodies, land owners and other bodies and institutions involved in the preparation and implementation of planning process;

3.2.16 Public Health Act (2009)

Provide for the promotion, preservation, maintenance of public health with a view to ensuring the provisions of comprehensive, functional and sustainable public health services to the general public. Part III (e) of the act requires premises owners to keep their premises free of mosquitoes and other disease vectors, vermin or causative agents; Section 54 prohibits causing or suffering from nuisance likely to be injurious or dangerous to health, land, premises, air or water; Part IV (c) assigns responsibility to City council to remove or appoint an agent to collect, transport and dispose solid and liquid waste and charge fees to beneficiaries of this service and responsibilities for prescribing types of wastes and guidelines for their collection and disposal; Section 101 it gives rights to any private sewer to connect it to any available public sewer to discharge foul or storm water therefore the project may connect to and discharge sewage or storm water into the available trunk main. However, the quality of the sewage should be as per agreed with the water authority.

The Contracting Authority will ensure that the project design, construction and operation does not constitute a nuisance; meets the requirements meets public health requirements

3.2.17 World Bank guidelines for Environmental Management

The main objective of this EMP is to establish a set of mitigation and monitoring measures to minimize the adverse social and environmental impacts that can take place during the implementation stage of the subproject. The measures especially focus on sensitive receptors or sensitive locations. The EMP also provides specific information about the monitoring program during construction stage including locations, frequency and reporting process. This project complies with these guidelines as it has ESMP which contains mitigation and monitoring plans of the identified impacts.

4.0 BASELINE INFORMATION

4.1 INTRODUCTION

This section provides baseline data on the relevant environmental characteristics of the project area. Much of the description of the environment is site specific. Other aspects such as that of climate and socio-economic issues are broad covering the whole Kigamboni District. The Consultant relied on primary data as collected from the site as well as secondary data and information gleaned from the literature for the project area.

4.2 PHYSICAL CHARACTERISTICS

4.2.1 Climate

The project area as compared to many other areas in Dar es Salaam city is influenced by coastal climatic conditions. The area experiences a modified type of equatorial climate.

- **Temperature, Sun hours and Radiation**

The region is generally hot and humid throughout the year with an average temperature of 29ºC. The hottest season is from October to March during which temperatures can raise up to 31ºC. It is relatively cool between July to September, with temperature around 20ºC. The maximum sun hours is 9 experienced from August to October, from November to January the sun hours

is 8 while in February to March and May to July is 7 hours and the minimum is 5 hours in April. That means from October to March the operation in the project site will probably need more electricity for the purposes of culling at the office, while during coolest monthlies which is from July to September the consumption might go down see figure 4.1

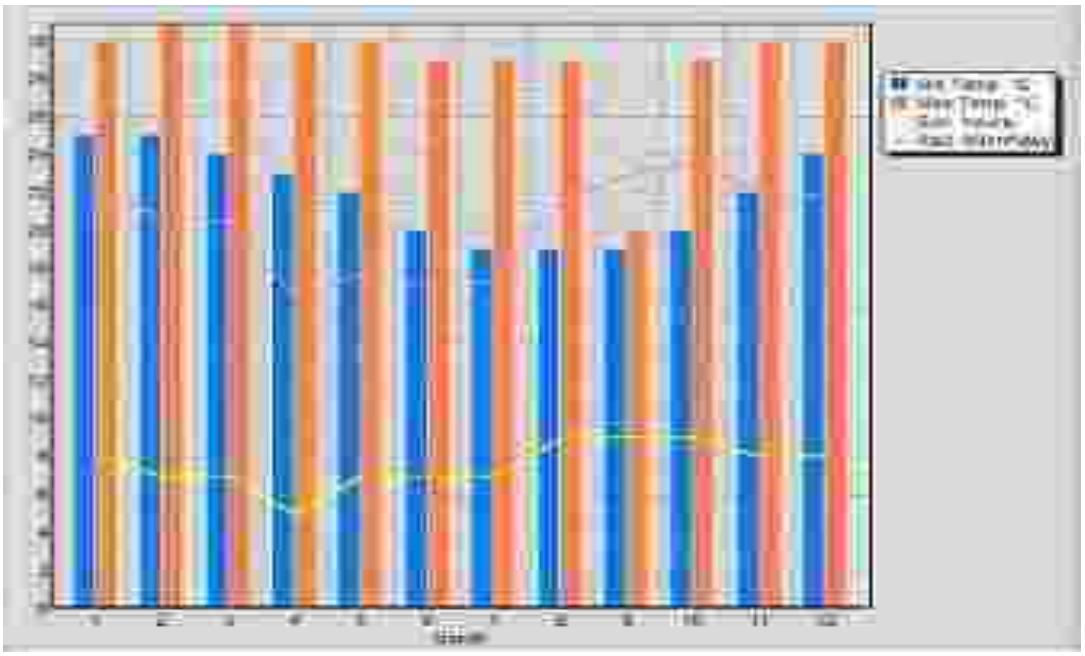


Figure 4.1: Annual temperature, sun hours and radiation of the site (Kigamboni Municipal Profile, 2019)

The average radiation of an area is 20.3 MJ/m^2/day, with 16.3 MJ/m^2/day being the minimum in April and 23.7 MJ/m^2/day maximum in October.

- **Wind Speed**

The region experiences the average wind speed of 5.74 m/s. The maximum wind speed is 7.63 m/s experienced in June which blows from the South South East (SSE) direction which means if the project site will produce and air pollutant all activities downstream of SSE direction will be prone to that pollution. The wind is calm around December to March. The climate is also influenced by the south-westerly monsoon winds from April to October and north-westerly monsoon winds between November and March.

- **Rainfall**

There are two main rain seasons; a short rain season from October to December and a long rain season between March and May. Figure 3.4 shows the effective rainfall received at Dar es Salaam region.

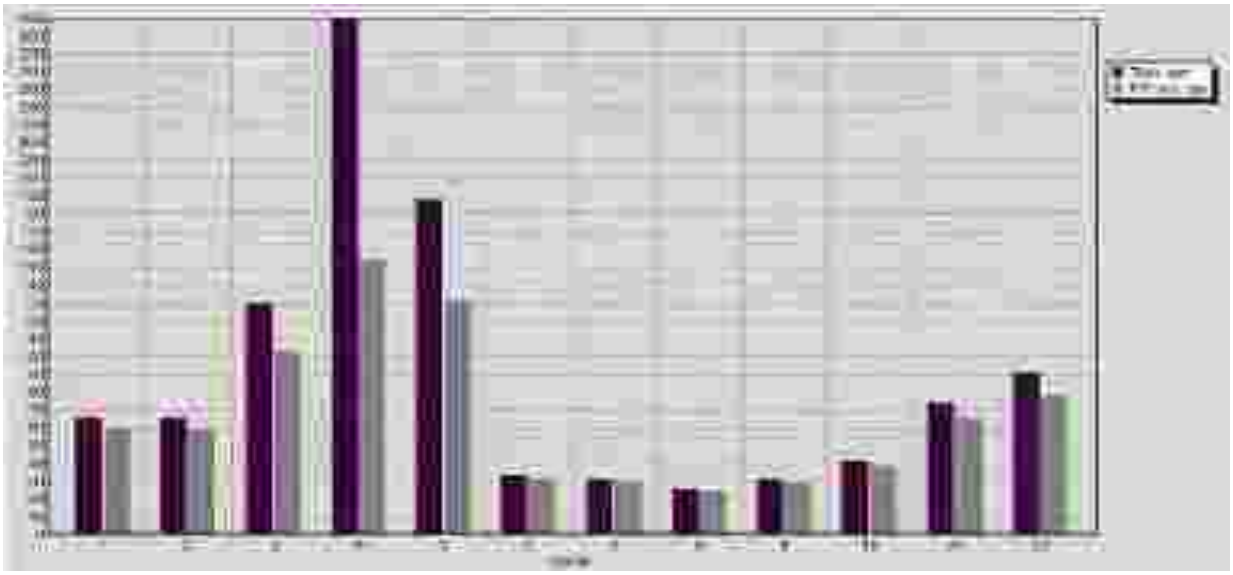


Figure 4.2: Average annual rainfall data for the site (Source Socio-Economic profile 2019)

4.2.2 Groundwater sources

Groundwater is abundant in almost the entire Dar es salaam City. This is because of the sea level rise. The major direct impacts of sea-level rise include inundation of low-lying areas, loss of coastal wetlands, increased rates of shoreline erosion, saltwater intrusion and increased salinity in estuaries and coastal aquifers, and higher water tables and higher extreme water levels leading to coastal flooding (Nicholls et al., 2007; Bicknell et al., 2009).

4.2.3 Topography

The landscape of the project site is highly manipulated to make the topography flat and suitable for storage activities. The highest contour elevation at the project site is 96.5m Above Mean Sea Level (AMSL) on the western side while the lowest contour elevation is94m AMSL at eastern part of the project site, that means the rainfall runoff at the project site are directed towards southern eastern side.

4.2.4 Air Quality and Noise Level

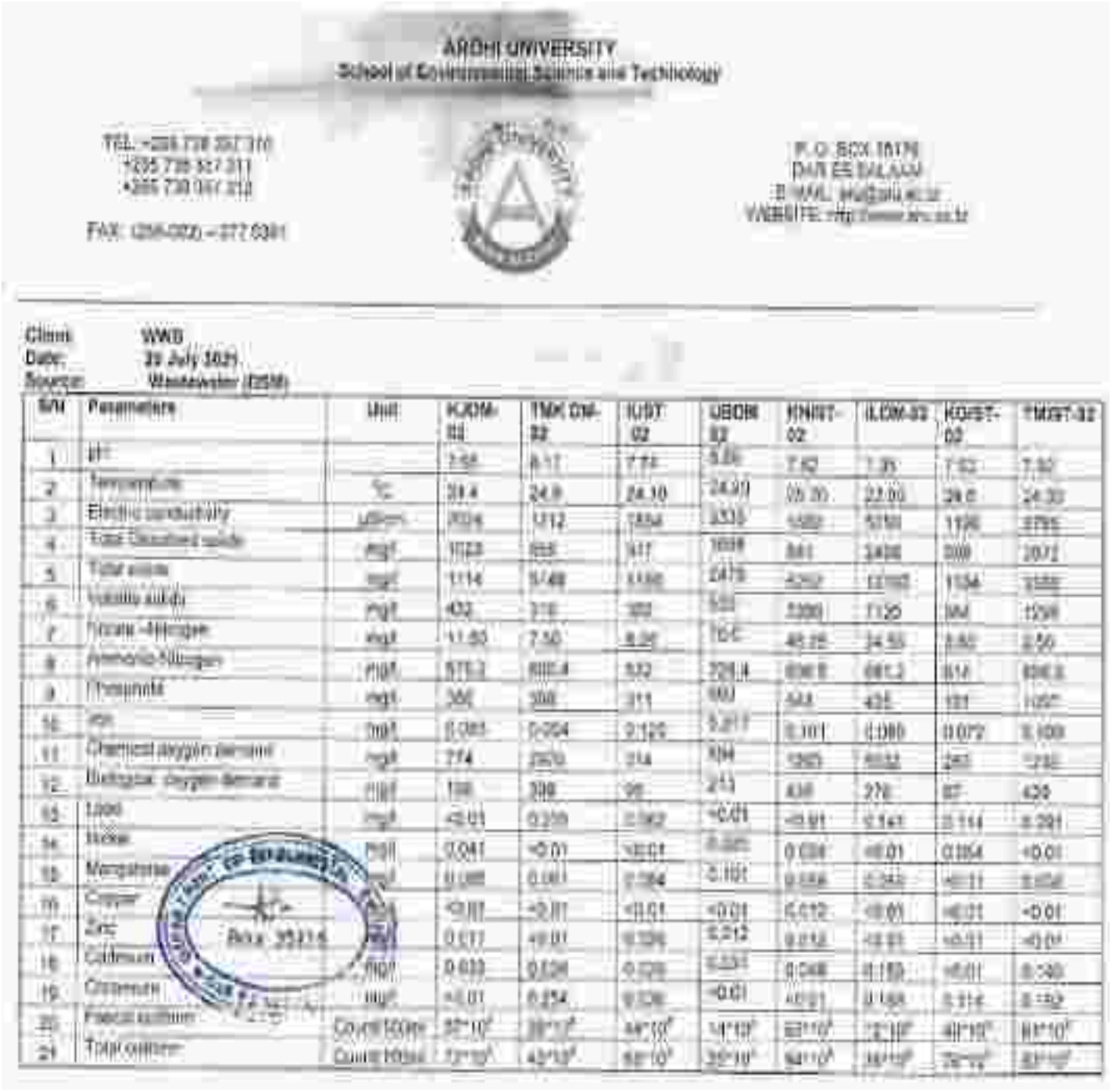
The ambient air quality at the project area was observed to be good because the area is for residential purposes only, just because of daily activities there will be particulate matter like dust.

4.2.5 Noise and Vibration

The noise and vibration levels at the project site are rated negligible as the only source of noise at the project site are motor vehicles using the street feeder road adjacent to the project area..During construction phase the constructor shall abide to national standars of 75dBA for an average noise level and 5mm/s PPV for ground vibration at all times.

4.4.8 Water Table and water quality analysis

Groundwater is abundant in almost the entire Dar es salaam City. While there is no permanent surface water sources in the vicinity of the proposed site for FSTP, groundwater resources is of concern. Groundwater is abundant in almost the entire city of Dar es Salaam. Data for Water quality from the project site were as presented in figure 4-1 and 4-1. However, the engineering design of the facility has taken on board all factors to ensure no contamination of groundwater is likely to occur.



ARDHI UNIVERSITY
School of Environmental Sciences and Technology

Client: WWB
Date: 29 July 2021
Source: Wastewater (DSM)

S/N	Parameters	Unit	KUKM-02	TMK DM-02	IUDT-02	UBDM-02	KINIT-02	ILDM-02	KDST-02	TMDT-02
1	pH		7.64	8.11	7.74	8.06	7.62	7.35	7.62	7.62
2	Temperature	°C	28.4	24.9	24.30	24.20	05:30	22.00	28.6	24.30
3	Electric conductivity	µS/cm	2004	1112	1854	2335	1480	5760	1936	3785
4	Total Dissolved solids	mg/l	1023	568	947	1068	841	2408	989	2071
5	Total solids	mg/l	1114	5748	1030	2478	4342	12705	1134	3355
6	Volatile solids	mg/l	402	218	382	503	5386	7125	364	1034
7	Nitrate-Nitrogen	mg/l	11.83	7.50	8.36	10.6	48.25	34.55	8.40	8.50
8	Ammonia-Nitrogen	mg/l	575.3	6002.4	532	728.4	696.8	6852.3	614	6062.5
9	Phosphate	mg/l	366	368	311	660	424	435	121	1057
10	Iron	mg/l	0.061	0.054	0.126	0.217	0.101	0.080	0.072	0.109
11	Chemical oxygen demand	mg/l	774	2570	714	894	1365	4032	241	2162
12	Biological oxygen demand	mg/l	198	398	95	213	438	276	87	429
13	Lead	mg/l	<0.01	0.316	0.362	<0.01	<0.01	0.141	0.114	0.291
14	Nickel	mg/l	0.041	<0.01	<0.01	0.020	0.034	<0.01	0.054	<0.01
15	Manganese	mg/l	0.088	0.061	0.364	0.101	0.156	0.345	<0.01	0.052
16	Copper	mg/l	<0.01	<0.01	<0.01	<0.01	0.012	<0.01	<0.01	<0.01
17	Zinc	mg/l	0.017	<0.01	0.026	0.012	0.012	<0.01	<0.01	<0.01
18	Cadmium	mg/l	0.033	0.026	0.026	0.031	0.048	0.150	<0.01	0.030
19	Chromium	mg/l	<0.01	0.054	0.036	<0.01	<0.01	0.164	0.014	0.052
20	Faecal coliform	Count/100ml	$3.5*10^3$	$3.8*10^3$	$4.4*10^3$	$1.1*10^3$	$8.2*10^3$	$2.3*10^4$	$4.8*10^3$	$8.8*10^3$
21	Total coliform	Count/100ml	$7.2*10^3$	$4.3*10^3$	$6.6*10^3$	$3.5*10^3$	$9.4*10^3$	$4.6*10^4$	$7.4*10^3$	$8.1*10^3$

Figure 4.1 Water quality test results (*Source Design Report 2021*)

UNIVERSITY OF DAR ES SALAAM
COLLEGE OF ENGINEERING AND TECHNOLOGY
DEPARTMENT OF WATER RESOURCES ENGINEERING
P.O. BOX 35131 - DAR ES SALAAM - TANZANIA

Our Ref.: WRE/WQL/08/2021

Date: 27th August, 2021

WASTE WATER QUALITY TEST RESULTS

PROJECT NAME: DAWASA OFF GRID SANITATION PROJECT IN DAR ES SALAAM

CLIENT: DOBWA ENGINEERING COMPANY LIMITED

Table 1: Summary of Physical, Chemical and Bacteriological Analyses of Waste Water samples tested.

S/N	PARAMETERS	UNITS	VALUE ATTAINED				
			KMST-01	UBDM-01	TMDM-01	IJST-01	ILDM-01
1	pH	-	7.1	7.3	7.5	7.5	6.9
2	Temperature	°C	28.7	29.3	31.5	29.7	30.2
3	E/Conductivity	uS/cm	5590	1380	4950	3430	2860
4	Total Dissolved Solids	mg/l	2800	700	2510	1720	1440
5	Total Suspended Solids (TSS)	mg/l	450	1770	2290	400	5990
6	Total Solids	mg/l	3810	3180	2502	1660	6750
7	Total Volatile Solids	% of TS	36	68	70	33	68
8	BOD_5	mg/l	700	3400	4700	800	4700
9	COD	mg/l	2800	11100	10700	3000	9020
10	Nitrate (NO_3-N)	mg/l	148	105	320	54	243
11	Ammonia (NH_3-N)	mg/l	115	70	117	39	455
12	Phosphate (PO_4-)	mg/l	88	233	220	263	180
13	Fecal coli form	No/100ml	1.0×10^5	3.0×10^7	2.0×10^5	1.4×10^6	2.0×10^6
14	Total Coli form	No/100ml	1.5×10^6	9.0×10^7	1.5×10^6	2.3×10^6	1.6×10^6
15	Lead (Pb)	mg/l	0.60	1.70	1.00	1.50	0.86
16	Cadmium (Cd)	mg/l	0.017	0.026	0.039	0.037	0.013
17	Chromium (Cr)	mg/l	3.60	1.73	0.88	2.54	7.95
18	Nickel (Ni)	mg/l	0.80	0.66	0.36	0.83	0.54

Signed by: ..... Date: 27th August 2021

F. Shagwa

Water Quality Laboratory

Figure 4.2 Water quality test results (*Source Design Report 2021*)

5.0 STAKEHOLDER VIEW ON THE PROPOSED PROJECT

During the conduction of this study, different stakeholders were consulted. Among these include the Kigamboni Municipal Council and the community at Golani (see Figure 5). Consultations were made through meetings.

Figure 5: Stakeholder's consultation meeting at Golani (Kimbiji Ward) and Kigamboni Municipal Council office (Source: Fieldwork August 24th 2022)

During the meeting, the consultant gave a brief explanation on the proposed Faecal sludge treatment Plant. The project description covered proposed location, type and design of the plant (a typical design was displayed). The stakeholders were given chance give their views on the project. Moreover, the consultant offered chance to clarify issues where stakeholders wanted to be given more explanations. The comments by stakeholders were analyzed and incorporated in the design of mitigation measures. Table 5 summarizes the issues raised. The names of the stakeholders consulted are given in Appendix II.

Table 5-1: Stakeholders issues and concerns

Institution	Name	Position	Issues/ concerns
Golani Street (Kimbiji Ward)	1. Tabitha Yohana Lindoya	MEO	○ Agreed with the project implementation and Insisted on timely implementation of the project rather than waiting for so long until the local government leadership is changed, then everything stacks with new leadership possibly unaware of the previous endeavours. ○ After cleaning the site, trees that will be cut should at least be distributed to residents. ○ During the implementation stage: Local Government leadership should closely be involved during the supervision ○ All stated mitigation measures should be implemented to avoid complaints from residents
Kigamboni Municipal Council – Environmental and Solid Waste Management Department	1. Juvenalis Mauna 2. Theresia C. Sikanyi 3. Tabu Abasi 4. Jenifa Kilegu 5. Amina Adamu 6. Hussein H. Mhoma 7. Jocelyne I. Tutindaga 8. Mathayo J. Mgimwa 9. Rehema A. John 10. Witness M. Mathayo 11. Shadrack G. Mushi 12. Mfuko Fatuma 13. Asha N. Magumbo 14. John M. Suleiman 15. Furaha A. Mchayungu	EMOs	○ Consultation to create awareness among residents of Golani should be done especially during this design stage. ○ During all consultations/meetings, minutes should be prepared accordingly ○ Before consultation of residents; representatives of Golani (Residents and Local leaders) should be facilitated to visit other pilot FSTPs located within the city for familiarization with the technology, then they'll become good ambassadors to the rest of the community. ○ Air quality data of the present condition before implementations should be acquired to establish a baseline and avoid complaints in future ○ During the Operational stage, there must be clear supervision of Cesspit emptiers, Because it is likely Industrial wastewater to be brought to the facility uncknowingly which will result in the malfunction of the facility.

6.0 POTENTIAL IMPACTS

6.1 Positive impacts

6.1.1 Improved living conditions and economic growth

The project will improve the living conditions in Kigamboni Municipal and Dar es Salaam at large, particularly Kimbiji residents whereby the project operation phase will do away with illegal fecal sludge dislodging especially during the rainy season or the night. The charged fee for emptying septic tanks and pit latrines will be such as affordable to the intended customer. Thus, there will be increased money circulation that results in increased income and consequently a better standard of living for people in the project area.

6.1.2 Employment opportunities

The Labour force for the project will be originated from Golani and the surrounding communities in the Kimbiji ward. Even though during construction the employment will be on a short-term basis, employees will have been benefiting from the project. Some will witness their incomes and livelihood improvement.

6.1.3 Increased Revenue to the nation through taxes, both direct and indirect

DAWASA is expected to increase government revenue collection at Municipal Council and the National level. This will be enhanced by time-to-time payment of all charges to dislodge septic tanks and pit latrines of the respective household. The revenue collected will contribute towards economic development within the municipal and the country at large.

6.1.4 Biogas production potential

Among other positive impacts, gas production for domestic uses is anticipated to serve the local communities and institutions. In this case, the residents which

are in proximity to the project site will be the immediate beneficiary of the produced biogas.

6.1.5 Minimized forest products harvesting

The Source of energy for cooking in most households originates from forest products. Charcoal and firewood are the most commonly used for domestic purposes. The biogas production from the plant will minimize the use of forest products as to why the gas will be availed to the local community. However, the quantity of the biogas produced depends on the quality of the influent on the facility.

6.1.6 Cost reduction for sewage management

The proposed facility will make it easier for the Institutions and households that at present incur unbearable costs for proper dislodging of the septic tanks when full. That simply means the households in the vicinity and the institutions will benefit through a direct connection to the treatment facility depending on the nature of the topography.

6.2 Negative impacts

6.2.1 Increased HIV/AIDS and other sexual-related diseases:

Local communities surrounding the project area have to be aware of the fact that HIV/AIDS is present in their areas but accede to it not being at an alarming rate. The communities were worried that with an influx of people into the project area the pace of spread will accelerate especially during the construction phase.

Mitigation Measures

- The contractor shall enforce a code of conduct in the project area to encourage respect for the local community and to maintain the self-cleanliness of the working area at all times.
- The contractor shall deploy locally available labor to reduce the risk of spreading communicable diseases (especially STDs).

- To prevent more HIV/AIDS infections, during the implementation phase, the project should include an information education and communication component (IEC) in its budget. This will help to raise more awareness of HIV/AIDS and means to suppress its incidence.

- A safety, health, and environment induction course shall be conducted for all workers, putting more emphasis on HIV/AIDS, which has become a national disaster.

6.2.2 Loss of biodiversity

Loss of biodiversity will be experienced during the site clearance for the construction activities to start. Huge biomass will be cleared that may include important and rare species. Among the species of trees that will be cleared at the site includes the *Eucalyptus* plant and *Trachycarpus fortune*.

Mitigation Measures

- Close supervision of earthworks shall be observed to confine land clearance within the area where the construction activities are to take place.

6.2.3 Land degradation and increased erosion

The establishment of a new facility within the project area might result in land degradation and promote soil erosion. The erosion will happen as a result of the removal of Aristida grasses, which are currently protecting the land against erosion.

Mitigation Measures

- Unnecessary ground clearance and sensitive re-alignments shall be avoided.

- Lined drainage channels at sensitive terrains shall be provided to control the speed and volumes of storm water.

- The contractor should plant grass or any other vegetation cover to minimize exposed soil surface.

- Directing flow to properly designated channels within the facility site.

6.2.4 Noise pollution

Noise pollution is likely to occur due to the application of construction equipment and generators at the site.

Mitigation Measure

- The proponent shall maintain equipment in good running conditions to ensure that ambient noise level and vibrations pollution into the environment is very minimum to comply with Tanzania standards

- The noisy construction activities will be scheduled at normal working hours. Regular inspection and maintenance of construction vehicles and equipment will be done to ensure that they have mufflers installed and worn parts are replaced

6.2.5 Air Pollution from dust emission

Air pollution is likely to occur due to the emission of suspended particulate matter (dust) into the atmosphere from construction activities.

Mitigation Measure

- Mixing equipment shall be sealed properly and vibrating equipment will be equipped with dust-removing devices.

- Also, all vehicles that generate excessive black smoke will not be used.

- Adequate training and use of personal protective equipment (PPE) such as eyeglasses and dust masks will be ensured to reduce risks associated with dust.

6.2.6 High Risk of Health associated with construction work

Construction activities expose the workers to a lot of risks for example risk of falling into the excavated pits more than 3 meters deep, the risk of injuries from falling objects or sharp pointed objects, etc.

Mitigation measure

- The project proponent shall ensure that all personnel is provided with appropriate protective gear.

- All works shall be planned and conducted following relevant OHS Guidelines. First Aid Kit as well as regular medical check-ups for the workers will be provided during the entire working hours.

- An adequate number of firefighting equipment/extinguishers will be provided every few distances to help put off fire in case of occurrence.

- Excavated pits should be protected by warning tape and guardrails to prevent workers from falling

6.2.7 Waste generation during construction

A lot of waste will be generated especially during the construction stage. For example, excavation of foundations will generate a lot of spoil materials that will need to be disposed of. The construction of walls and roof will both generate waste. Other wastes will be generated from cleaning construction equipment and containers like mixers and paint buckets.

Mitigation measures:

- Stick to the design specifications
- Provide waste containers
- Provide training to workers and orient them towards environmental protection values

7.0 ACTION PLAN FOR HEALTH AND SAFETY OF WORKERS AND COMMUNITY DURING THE IMPLEMENTATION STAGE

7.1 General

The project shall be implemented in compliance to labor laws in Tanzania, in particular, the Occupational Health and Safety Act (2003). Clauses to protect the health and safety of workers shall be included in the contract documents for implementation stage. All personnel are expected to comply fully with health and safety law and the associated approved codes of practice. Contractors are, in addition, to be aware of and pay due attention to guidance issued by the Health and Safety Executive as well as that issued by trade bodies and authorities, which constitute industry 'best practice'. Method and policy statements submitted for these works will be reviewed by the Site Project Manager and Safety Adviser to ensure that these standards are met. On such occasions that they fail to meet the standard they will be returned for amendment action.

7.2 Health and Safety Management System

7.2.1 Safety Training and Promotion

The aims of safety training programmers are:

- To update the safety awareness and technical skills of person in the field of application.
- To orient new employees to working environment.
- To identify and rectify hazards and convey the same to the workforce.
- To prepare the persons to select appropriate safety measure contain any unforeseen hazards/emergency situations.

To achieve the above aims, following types of training shall be conducted at the site level:

7.2.1.1 Health and Safety Induction Training

New or reassigned employees shall be given Health& Safety induction training pertaining to Health& Safety management and general safety rules and procedure, site specific Health& Safety rules and their responsibility and accountability in safety performance. Health& Safety induction shall be given to all categories of personnel at site by Health& Safety Manager. Health& Safety induction shall be recorded in the prescribed format. All employees shall acknowledge such training by signing relevant document.

7.2.1.2 On the Job Training

Based on the trade, individuals are given On the Job training. These trainings shall be focused on the safe ways of working in a particular trade including hazards involved. This shall be conducted by the foremen/supervisors in collaboration with Safety personnel and trainees' performance after the programme shall be assessed to evaluate the effectiveness of the training. All risk assessment and related knowledge shall be done by the Health & Safety Manager.

7.2.1.3 Refresher courses

Refresher courses shall be conducted to update the skill and safe methods of work for a particular job. This shall be conducted periodically for welding/cutting, plant and equipment operation, defensive driving and hazards in electrical installation.

7.2.1.4 Tool Box Talks

In addition to the formal training mentioned above, toolbox talks shall be conducted every day before the commencement of the job. The Faecal Sludge

Treatment Plant shall be designed to highlight relevant safety and individual health issue to the workforce to raise their level of awareness. Such meeting shall recall the risk assessment report and defects reported on previous performance. These shall be prepared and presented by the Supervisor/Foremen.

All trainings that are carried out shall be formally recorded on dated and signed by attendees and the copies shall be kept with the project safety focal point.

7.2.1.5 Safety Promotion

Safety Promotion schemes shall be developed and implemented at site to promote safety awareness amongst the workforce. Individuals with best safety performance shall be recognized and rewarded. A safety suggestion scheme shall be implemented at site to encourage the workforce to come up with good safety practices and suggestions for improving working condition. The best suggestion shall be selected and the person shall be rewarded.

Health& Safety posters and banners including HIV/AIDS shall be displayed around the worksite to raise the awareness among the workforce. The posters shall be prepared in English and Swahili languages.

7.2.2 Safety inspection and Follow up Actions

Contractor's Health& Safety Manager along with supervisory staff shall carry out frequent inspection with the focus on safety aspects at site and prepare reports of inspection. The frequency of inspection shall be determined by site activities and general conditions. However, the inspection shall be conducted at a minimum of once a week. Where high – risk activities are being carried out inspection shall be done at least once daily.

The inspection reports shall be discussed with the site managers and various sub – contractors (if any). In addition to these, the site staff will accompany the Engineer and other staff of Consultant for their site safety inspection.
Remedial action to rectify any deficiency identified or unsafe practices discovered during the safety inspection by developer shall be implemented immediately.

7.2.3 Reporting of Accidents, incidents & Investigation and Accident Statistics

Tanzania laws on incident reporting and investigation procedures shall be adhered. Such law requires reporting to the Chief inspector of Occupational Safety and Health Authority (OSHA) all lost time injuries (LTI) within twenty-four hours from the time of incident. Contractor will play this role to ensure that local requirements are followed. As per Contract Agreement the Contractor shall notify the Consultant and developer within 48 hours or as soon as reasonable possible after the occurrence of any accident which has resulted in damage or loss of property, disability or loss of human life, or which has or which could reasonably be foreseen to have a material impact on the environment and shall submit to the Consultant and developer no later than 28 days after the occurrence of such an event in the agreed format, a summary report thereof. All incidents including near misses shall be reported to the Consultant, regardless the potential of the incident.
All the incidents shall be investigated to find out the root causes and to prevent the recurrences of the same kind of incidents. If the consultant asks for the detailed investigation and the findings shall be submitting to the consultant. The methodology for the incident investigation shall be “Find out the facts, not the faults”.

Incident data, if properly collected and analyzed, indicates the trend and can show where and how problems arise. A monthly safety performance report of

the project shall be included in the Monthly Progress Report after the end of each month.

7.2.4 Hazard Identification and Risk Assessment

The purpose of the hazard identification and risk assessment is to identify all potential hazards and associated risks during construction. The contractor will take relevant measures to control all critical, high and moderate hazards. Low potential hazards will be totally eliminated. General risk assessment of this project has already been done and submitted to the relevant parts per Tanzania's Occupational Safety and Health Laws.

Depend on the severity of hazards we will be able to take necessary preventive and control measure to mitigate the hazards. Prior to the commencement of any activity, detailed hazard identification shall be done by the site supervisory staff with the assistance of Health& Safety Manager and the hazards shall be communicated to the whole team deemed to execute the task. The hazards analysis done shall be produced to Consultant for approval and mitigating measures shall be taken up to their satisfaction. Risk assessment shall be done per Occupational Safety and Health Act, number five of 2003.

7.2.5 Industrial Health and Hygiene

Hazards to health on a construction industry can arise from the use of a number of materials, substances and process if they are not properly controlled. Some of the more serious risks are caused by the inhalation of dust, toxic fumes, exposure to high temperature, noise, vibration, radioactive substances, ergonomic hazards etc.

DAWASA shall be responsible for maintaining health working conditions for all employees and sub – contractors. If it is not possible to remove the cause of

harm, then suitable and sufficient Personal Protective Equipment (PPE) shall be provide to those who could be affected.

7.2.6.1 Hazardous substances

Material Safety Data Sheet (MSDS) of all hazardous materials that are used on site (if any) shall be obtained. An inventory shall be kept of all such materials with the relevant MSDS and shall be available for the inspection of consultant. An assessment shall be conducted in relation to the intended usage of the hazardous substances on site and adequate precautionary and control measures shall be taken according to the assessment. Such MSDS shall be available for inspection from Tanzania Health and Safety law enforcer. An assessment shall be conducted in relation to the intended use of the hazardous substances on site and adequate precautionary and control measures shall be taken according to the assessment.

7.2.6.2 Heat

Illness due to heat comprises a wide range of problems from minor inconvenience to critical medical emergency and death. The functioning of the thermoregulatory system of the body gets upset, (balance between heart gain and heat loss), which results in the subsequent loss of salt and water. This takes the following forms like heat rashes; heat cramps; heat exhaustion and hear stroke. Following precautions shall be taken against heat stress.

- Wear light, airy clothes.
- Drink plenty of water even if you do not feel thirsty.
- Wear sunglass/balaclava while working outside.
- New employees shall give adequate time to acclimatize with the hot environment before deploying to the work site.

7.2.6.3 Dust

Dust control will be initiated prior to any activity in dusty condition. Such control will adopt but not limiting to de-dusting procedures. In case of unavoidable dust emissions, introduction of PPEs will be adopted. In any case no personnel shall be exposed directly to harmful airborne contaminants of Silica, Rust (ferrous oxide), Blasting grit, Asbestos, Glass wool & Paint solvent mist. Water sprinkling system shall be adopted to control the dust on all identification areas of the Project.

7.2.6.4 Noise

The Contractor shall comply with the applicable Tanzanian laws, orders and regulation concerning the prevention, control and abatement of excessive noise. Industrial deafness is cause by over exposure to high levels of noise from plant, machinery or construction processes. No employees shall be exposed to noise dose that exceeds 85 dB (A), unless they are wearing suitable hearing protectors, which effectively reduce the sound level at the user's level to or below 85 dB (A). Consideration shall be given first to reducing the noise level at source.

The precautionary measures for the exposure limits shall be as follows:

- 80 to 85 dB (A) – Provide hearing defends with proper training to use them.
- 85 dB (A) – Signposts shall be erected to inform all employees and public that usage of car defenders is mandatory in the area.
- 115dB (A) – No exposure to steady noise irrespective of hearing protection.
- 135 dB (A) – No exposure to impulse noise irrespective of duration of hearing protection.

7.2.6.5 Vibration

Vibration causes health hazards in two ways;

- Vibration of body parts due to hand held tools like concrete vibrator, plate compactor, jackhammer, hand drill, hand grinder etc.
- Vibration of the whole body experienced while traveling in vehicle and operating equipment like dozer, grader, roller etc.

Excess vibration will result in discomfort to the worker, which leads to a decrease in efficiency and finally causes damage to health. Vibrating equipment shall be equipped with proper handles to prevent causing any impact on the operator. Personnel shall be given intermittent rest or shall be changed and replaced frequently.

7.2.6.6 Sanitary Facilities

Adequate sanitary conveniences will be provided in strategic point of the workplace. Such conveniences are lavatories, showers, and washbasins. Such facilities shall be kept clean and in good working condition at all times. Domestic wastes shall be collected per environmental management plan and Environmental Guidelines.

7.2.6 Personal Protective Equipment (PPE)

PPE protects the employee from identified non-eliminated hazards at the site. Personal protective equipment safeguards the employee from the identified hazards so which he is exposed. PPE is the last line of defense for employee protection. PPE does not and cannot eliminate hazard, it can only prevent or reduce exposure to hazards and reduce the severity of the consequent injury.

All employees of the contractor shall be provided with necessary PPEs and ensure that the contractor and sub – contractor personnel are also properly

protected by appropriate PPE. Such provision will be free of charge. Employees shall be trained by line supervisors for the correct utilization of the PPE. Individuals shall not be allowed to work if they are not equipped with the appropriate PPE. Suitable signboards shall be kept in work area indicating the potential hazards (e.g. noise, radiation etc.) and PPE that is required to be worn in that area/for that activity, in applicable languages and visual signs. The signage will be in Kiswahili and English languages and posted in visible areas.

7.2.7 First Aid Facilities

All accidents, which involve personal injury, whether it is minor or major, shall be given medical treatment and report to concerned Supervisor. A first aid station shall be set up at the site office and a trained first aider will be in charge of the station. All injury cases, except minor injuries shall send to medical center for treatment. In case of an accident with personal injury doctors will attend such person in a prescribed hospital. Only ambulance will be allowed to transfer the casualties. Adequate number of first Aid boxes will be fixed in strategic points where employees will be notified the nearest location of the same, telephone number of Emergency control room will be also displayed. Adequate number of first Aid boxes shall be available site. There shall be one trained first aider in a group of 20 persons. First aid boxes shall be frequently inspected by the trained first aider and updated.

The Contractor shall comply with the Government medical or labour requirements at all times and provide, equipment and maintain base dressing stations where and at all times have trained first aider for attending minor injuries.

7.2.8 Fire Prevention and Fighting Facilities

Construction sites premises are very prone to fire hazards because of different kind of combustible material used in all the above places. The components of a fire are fuel (combustible substance), heat and oxygen. Unless all three are present fire will not occur. A fire hazard evaluation shall be conducted all the

project sites and camp to identify the fire risk at each location. Depend upon the risk factors fire prevention and fighting system shall be provided and maintained.

Following steps shall be taken to implement fire prevention system at our project premises.

- All the employees shall be education about the fire hazards, firefighting methods and precautionary measures specific to this project.
- Adequate number of portable fire extinguishers shall be placed at strategic locations.
- All employees shall be demonstrated the operation of portable fire extinguishers.
- Good housekeeping shall be maintained at all sites to reduce the fire risk.

7.2.9 Road safety management

This project as relies heavily on road transport. Analysis shows that road accidents contribute a major portion of total accidents in such construction projects. To avoid road accidents the following measures shall be adopted during the execution of project;

- A transport coordinator shall be appointed to control the movement of vehicles and equipment and he shall be responsible for safe and smooth deployment of fleet.
- All drivers and operators shall possess a valid Tanzania license for the types of vehicle being driven or machinery operated.
- All vehicles shall be kept in a plot with good conditions and preventive maintenance system shall be followed.
- An in-house training on defensive driving techniques and safe tipping operation shall be imparted to all drivers before allotting vehicles to them.
- The drivers shall follow all traffic rules and regulation of Tanzania.
- Over speeding shall not be allowed at any case and if observed do so disciplinary actions shall be taken against the defaulter.

- Drivers shall not allow working more than 8 hours shift period. The shift period includes loading, unloading, waiting and driving time.
- No vehicle shall be allowed to drive after consuming alcohol/drugs, some medicines, under fatigue or when sick or ill.
- Nobody is allowed to drive if under the influence of alcohol or drugs.
- Drivers shall wear necessary PPEs while driving.
- A driver forum shall be constituted and shall meet once in a month or immediately after an incident to discuss the general safety issues as well as specific leaning points from incidents.
- Only one person shall direct the driver/operator
- Beware signage shall be established on public institutions' entrances

7.2.10 Traffic management plan

This project involves movement of heavy traffic both at the site and outside the Site. All drivers are instructed to strictly follow the minimum speed of 20 KPH at the site. Adequate sign boards will be placed at the relevant location and flag man will be assigned whenever necessary. Anybody found violating the traffic rules will be punished.

7.2.11 Sub-Contractors

Subcontractors are treated as integral part of the contact and subject to the same standard of treatment as that of main contractor's employees in all matters pertaining to Health& Safety. List of subcontractors shall get approved by developer (DAWASA) prior to their deployment in the project.

On arrival of Subcontractor's employees, Health& Safety Manager shall conduct induction program. Sub-contractor employees shall participate in all Health& Safety activities along with Contractor's personnel working under the Contract.

7.2.12 General Safely Rules

All personnel working at site always shall strictly follow following Health& Safety rules:

- Never take their eyes off the job, pay attention to what you are doing.
- Shall be on the lookout for hazardous conditions that could lead to an accident.
- Shall pay attention to what you are doing.
- Shall be in a continuous observation of hazardous conditions that could lead to an accident.
- Shall report all first aid injuries, lost time accidents and near misses immediately to their supervisors.
- Shall wear proper uniforms and other personal protective equipment necessary for the job that they have to do.
- Shall ensure that they have the right tools and equipment for the job.
- Check the tools condition before using it.
- Shall always use provided personal protective equipment like overall, helmet, goggles, shoes and balaclavas etc.
- Shall know the location of the nearest fire extinguisher first aid box.
- Shall always keep work place clean and tidy.
- Shall not play with fire. Smoking in 'No Smoking' area only.
- Shall not interfere with overhead electrical supplies and appliances.
- Shall observe all warning signs, labels and hazard notices.
- Shall not overtake and over speed vehicles in high traffic areas. Shall observe all speed limits and traffic controls.
- Shall not use unstable material/platform for working, climbing and standing purpose.
- Shall not abuse toilets and welfare facilities provided for their use.
- Shall always take care when lifting load. Keep straight back and bent knees
- Shall not keep any material or obstacle in access ways or exit path.
- Shall not operate cranes over or in the close proximity of power lines.
- Shall take sufficient water and fluid regularly during hot and humid weather conditions.

- Safety is everybody's responsibility.

7.3 Safety in Various Construction Activities

7.3.1 Excavation

Excavation is one of the important phases of the construction activity. Any insufficient attention to the safety aspects may cause of accident, therefore we shall take utmost care in planning and executing all excavations. The following precautionary measures shall be followed:

- The area to be excavated shall be inspected thoroughly by a competent person for any underground services or structures.
- It shall be ensured that a person having good knowledge and experience supervises all excavations.
- All mechanical excavations shall be carried out only in the presence of an authorized banks man.
- The integrity of excavation and supports shall be inspected prior to the commencement of work on daily basis.
- No soil or other materials shall be stored close to the sides of the excavation and at least 1m clearance shall be provide for storage and dumping of excavated materials.
- Edges of excavations shall be barricaded to prevent falling of persons and materials.
- If vehicular traffic is allowed near to the excavation, contractor shall provide adequate lighting, warning signs and concrete blocks painted with reflective paints.
- Excavations exceeding 1m shall be demarcated with solid barricades plus warning tapes. The rest shall be barricaded with warning tapes.
- Where there is a possibility of ingress of water then pumping sumps shall be established with pumps being readily available for use and additional ladders placed for use in the event of emergency evacuation.

- Adequate means for entry and exit shall be provided for excavations over 1.5m and it shall be either ramp or ladder.
- All the personnel engaged shall be made aware about safe digging practices, hazards in the operation and emergency procedures.
- Adequate number of strong and stable temporary crossing with handrails shall be provided for personnel.

7.3.2 Reinforcement Steel Work

Reinforcement steel work is an essential part of any construction phase. The activity involves unloading, bar bending, cutting and fixing of bars in position and people's unsafe acts. The main hazards are handing hazards, working with machinery, using of electricity, falling of material on body and taken.

- Loading and unloading of steel shall be done by proper lifting equipment lifting tackles and under proper supervision.
- All persons handling steel bars shall be provided with necessary PPE required for the job.
- The lengthy steel bars shall be stored in safe manner to avoid in tripping hazards and protruding hazards. Proper signage shall also be provided.
- Bar cutting machines and bending machines shall be in good working condition and provided with emergency stop switches and necessary guards. Both the machine shall be placed in such a way that the operation on it shall not create any danger to nearby workers.
- The electrical connections to the machine shall be done by electrician by providing appropriate circuit breakers and proper earthling after conducting risk assessment.
- Persons deployed for cutting and bending shall be trained and instructed about the job and its inherent hazards.
- The work area shall be kept clean and steel cut pieces will be kept separate.
- Adequate number of works shall be deployed to handle and fix the steel.

- The tools used for fixing the steel in place shall be inspected regularly and maintained properly.
- If the steel fixing work is at height or in an excavated pit/trench, safety measures shall be taken in accordance with the accordance with the particular procedure.

7.3.3 Concreting

This includes shuttering, formwork, de-shuttering and concreting. The main hazards are falling of objects; struck by object, falling of persons from height, crush injuries and impact injuries, ergonomic related, tripping and slipping. The following practices shall be adhered to ensure the safe operation in these activities.

- The persons deployed on work shall be given a safety induction related to the job. They shall participate in the risk assessment.
- The persons deployed on work shall have well experience and provided with all tools in good working condition.
- Handling, erection and dismantling of heavy shuttering shall be done with proper lifting equipment under close supervision.
- Required PPE shall be provided to all persons engaged in the job.
- The workers shall be informed about the hazards of the activity.
- The area shall be barricaded to prevent the entry of unauthorized persons and visitors.
- Hand tools shall be inspected on daily basis.
- There shall be effective communication between the crew members while erecting and dismantling the shuttering.
- Good housekeeping shall be maintained all over the area.
- Formwork for the concreting shall be inspected by a competent person, prior to the pouring.
- The concrete pump shall jack-up properly and park at firm and level ground.

- Two persons wearing reflective jackets shall be deployed to hold the concrete pouring pipe.
- Always look for overhead electrical cables while parking the concrete pump.
- Temporary platforms shall be provided on steel work for people to stand while working at the area.
- Tipping shall be away from overhead power lines

7.3.4 Material Handling

7.3.4.1 Mechanical Handling

Lifting equipment and lifting gears shall be inspected per Occupational Safety and Health Laws of this Country and should be used for handling of construction materials. All lifting equipment shall be checked and ensured that they are in good operating condition and free form defects. All lifting equipment and tackles shall have valid third party certificate. Inspection intervals shall be as per Tanzania laws and safety regulations. Inspection and certification shall be done from Tanzania's approved competent authority which is Occupational Safety and Health Authority (OSHA). Colour coding system for lifting equipment shall be followed. All lifting operations shall be done by experienced persons and supervised by competent persons. In case of tandem lifting only the Project Manager shall authorize such lifting. The following safe practices shall be adhered in all mechanical lifting operation. The following safe practices shall be adhered in all mechanical lifting operation.

- All lifting equipment and tackles shall be maintained in good operative condition.
- Every dangerous and rotating parts of lifting equipment shall be guarded.
- Care shall be taken to avoid the overloading lifting equipment and tackles.

- All lifting operation shall be performed under the supervision of an experienced and trained supervisor.
- Signalman with reflective jacket shall be deployed with the lifting equipment.
- Only one signalman shall direct the operator
- Proper communication shall be maintained between the operator and signalman during the operation.
- Wind speed shall be taken into consideration before lifting and if it exceeds the safe limit all lifting operation shall be ceased.
- Extreme care shall be taken while working near overhead power lines and safe distance shall be maintained.
- Toolbox talks shall be conducted before lifting operation for prevention of incidents.
- Only the project Manager shall authorize tandem lifting.

7.3.4.2 Manual Handling

Correct manual lifting and handling procedures can prevent back injuries and strains that account for a major portion of all industrial injuries. Before handling any material, its weight, size, shape and physical characteristics are to be seen and further action shall be taken accordingly. Following are the measures to prevent the incidents during manual handling.

- Load to be lifted shall be assessed for its weight, shape and size.
- Load shall be sized up ad assistance sought if necessary.
- Proper method and posture of lifting shall be adopted.
- Load being carried shall not obstruct the view in front.
- Do not change position of load while moving.
- Slipping and tripping hazards shall be taken care of.

7.3.5 Working at Height

7.3.6.1 Scaffolding

Proper scaffolding and working platform shall be provided to work at height. All scaffolds shall be designed by a competent person and shall be made of good and standard materials. Prior to use, all scaffolds shall be subjected to the inspection of Consultant and shall get approval. All persons involved in the erection and dismantling of scaffold shall be trained and experienced for the same. No persons other than the supervisor involved shall be permitted to be upon any part of an incomplete scaffold.

- All personnel shall be provided with necessary PPE.
- Persons with vertigo shall not be allowed to work at any height.
- All poles, planks and general materials used for scaffolding shall be kept in good condition and be inspected by a competent person on each occasion before being issued from stores.
- As long as the scaffold is in use, supervisor concerned shall inspect it daily before allowing persons to work on it and satisfy himself that the scaffold is complete and is fit for use.
- Subsequent to rain or heavy wind, the scaffolding supervisor shall inspect all scaffolds prior to restart the work.
- All working platforms shall be close boarded and all boards shall be lashed and secured.
- Handrail and toe board shall be provided for all scaffolds and the planks shall be tied to the ledgers properly.
- Scaffolds shall be supported adequately wherever possible
- Always ensure that no loose items and materials are left at height that may fall on person working or passing beneath.
- In case of mobile towers, the height shall never exceed three times the length of the shortest side and there shall be only one working platform on a mobile scaffold.

- The mobile tower shall only be moved by pulling or pushing the base and the working platform shall be clear of men and materials when the tower is being moved.
- The wheels of mobile tower shall be turned outwards and brakes shall be on and locked before use.
- Diagonal bracing shall be fitted on all lifts on all sides and cross bracing shall be fitted at the base and every alternative lifts of an independent tower scaffold.
- Adequate ladders shall be provided for the access to and egress form the scaffold.

7.3.6.2 Ladders

- All ladders shall be factory made and of sound construction.
- Wooden ladders shall not be used with the scaffold.
- If the work is being done in and around electrical equipment and/or cables only wooden (non-conductive) ladders shall be used.
- Ladders shall not be painted.
- Ladders shall be secured properly at top and base.
- Ladder shall be extended for at least on meter above the landing.
- Ladders shall not be used as working platform or part of load bearing component of a scaffold.
- The base to height ratio of ladder shall be maintained as 1:4 such that the angle is 750 from the horizontal can be maintained.

7.3.6 Heavy equipment and workshop

Faecal Sludge Treatment Plant construction project mostly depends on heavy equipment like Dozer, Excavator, Grader, Wheel Loader, Backhoe and Crane. So, the safe operation and maintenance of heavy equipment play a major role in accident prevention. A workshop facility shall be set up in the lay down area

to perform routine maintenance and repairs of equipment deployed for the project. Following measures shall be taken to ensure safe operation and maintenance of equipment and plant:

- Equipment shall be put into service after obtaining approval by a competent technical authority.
- All the operators shall have valid Tanzania license and thoroughly educated about the safe operation and maintenance of equipment.
- It shall be ensured that operators are performing daily checks before commencing the activity and report abnormalities, if any.
- All operators shall undergo frequent refresher training on safe operation and basic firefighting.
- No one shall be allowed to travel in the cabin along with the operator.
- Equipment shall be transported from one place to another only by low bed trailers and proper lashing shall be ensured while transporting through road.
- Adequate space shall be available in the workshop for free movement of vehicle / equipment and each activity shall be performed in a clearly defined area.
- Hazardous activities like painting, welding, cutting, grinding etc. shall segregate from other activities normally will do in dedicated booths.
- Storage of hazardous materials shall be in a secured and dedicated area as per Tanzania Policy standards.
- Emergency exit, fire alarm and firefighting equipment, first aid box, requirement to wear PPE and other necessary safety information shall be displayed at prominent locations with visible signs.
- Adequate lighting and ventilations shall be provided in all work places.
- Adequate provision shall be made for the collection, temporary storage and disposal of solid and liquid waste material from all workplace.
- Good housekeeping standards shall be maintained.
- Smoking and consumption of food shall be restricted to designate area.
- No horseplay or practical work jokes shall be allowed in work place.

7.3.7 Cable Laying, Termination and Jointing& Electrical Works:

Laying of high voltage and low voltage cable and other Electrical works are one of the activities in this project. The main hazards involved in these are struck by, falling of materials, fall of persons, and failure of lifting equipment and tackles, fire and burn injuries. Following precautionary measures shall be taken to avoid any incidents during this stage.

- Risk assessment shall be conducted prior to execution of such job.
- All electrical works shall be performed by qualified persons who shall be provided with adequate and necessary personal protective equipment.
- Prior to maintenance operations on any electrical equipment or appliances, the electrical current shall be disconnected, (lockout and tag out) with a lock or any other adequate means and tagged out to ensure the prevention of reenergizing of the equipment by any person during work.
- Employees working in electricity shall be instructed in using the proper fire extinguishers in electrical fires such as Dry Chemical and CO_2 extinguishers.
- Water or extinguishers containing water shall not be used in extinguishing electrical fires which occur in electrical equipment or conductors as water is a good conductor which causes electrical shocks for the person using the extinguisher.
- Metal ladders or non-insulated hand tools shall not be used while working in electrical installations. (Handles of all hand tools used shall be insulated and wooden ladders shall be used)
- When the fuse or circuit breaker disconnect the electrical circuit, electrical current shall not be re-connected before inspecting the cause of the fault and repair it and thus replace the fuse with other fuse of the same rating or the circuit breaker shall be returned to its first position by a qualified employee.
- Electrical circuit shall not be overloaded to prevent occurrence of fires.
- Electrical wires shall not be passed through doors or windows and shall be kept away from heating sources such as heaters and shall not be

hung from nails to prevent the damage or wearing of the insulating material.

- Defective or corroded electrical wires shall not be used and shall immediately replace.
- Cable drums shall be placed on level and firm ground and properly wedged to prevent rolling.
- Jacks and other accessories for cable laying shall be inspected by a competent person to make sure that if is free from defects.
- Rollers shall be placed properly to avoid the over exertion of force on cables while laying.
- The winch shall be fixed firmly on ground to prevent any unintended movement while pulling the cable.
- Experienced and trained persons shall be deployed for cable laying and winch operation.
- All cable jointing and terminations shall be done by certified and approved cable jointers.
- Adequate fire safety measures shall be taken care while termination and jointing the cable.
- The area shall be barricaded to prevent the entry of unauthorized persons during the operation.
- In case a person receives an electrical shock, this person shall not be touched, first, disconnect the power and remove the injured person away using a piece of wood or any other insulated material, and then, first aid shall be provided to the injured person such as Cardiac Pulmonary Resuscitation (CPR). The doctor shall be informed immediately or the injured person shall be taken to the nearest hospital.
- When recharging batteries, employees shall be instructed not touch the battery liquids, and shall be provided with adequate and suitable personal protective equipment when doing that (Face shield, rubber gloves, aprons) and when refilling batteries by acid, acid shall be added to water (and not water to acid), in case any burns by the effects of acids occurred, immediately flush the burn with big amount of water.

7.3.8 Portable Power and Hand Tools

The main causes of most injuries involving hand tools are the use of unsuitable tools, their incorrect use or their incorrect storage. Inspect the tool and ensure that it is in good condition. Unsafe tools include wrenches with cracked or worn jaws, screwdrivers with broken tips etc.

- Select the right tools for the job.
- Use all tools correctly.
- Keep tools in a safe place.
- We shall train the workers to select the right tools for each job, and ensure that the tools are available.
- Protect the edges of the sharp tools while carrying.
- Tools shall not be kept lying on floor, walkways or scaffolds,
- Tools shall not throw from one level to another. It shall be lifted and lowered by hand lines.
- All guards and covers shall be securely fitted and correctly adjusted.

7.3.9 Transportation

This section outlines the procedure and guideline for avoidance for motor vehicle accidents.

- Every person driving a motor vehicle or operating a machine must possess valid driving licenses appropriate to the class of vehicle being driven.
- All drivers should observe posted speed limits. Adverse weather conditions, traffic and light (visibility) require lower speeds than posted speed limit. Maximum speed limit must be limited 40 KPH in camps and 60 KPH on haul roads.
- All vehicles shall be parked uniformly and where provided, in designated parking areas. Parked vehicle shall not be obstructing other vehicle, roads, and access ways for fire hydrants.
- Vehicle shall be maintained in good condition and regular inspection carried out to check steering system, foot and parking breaks, tyres, seat

belts, horn, Head lights, tail lights, stop light and indicators, rear view mirrors, wind shield wipers and washer, crank case and radiator level.

- Drivers and passengers in all vehicles including buses should wear seat belts.
- Driver shall slowdown in inter section, blind corners and stop completely at all stop.

7.4 Emergency Preparedness and Response

DAWASA plan to construct a Faecal sludge treatment plant at Golani, Mtaa, Kimbiji Ward in Kigamboni Municipality. This DAWASA Emergency Response Plan (ERP) has been prepared to establish the procedures for responding to specific emergencies that may occur. Copies of these plans are maintained at the contractor office, DAWASA office and at each FSTP site. The Emergency Response Plan includes protocols to ensure close coordination with local area emergency response organizations, agencies and also with existing state and local Emergency Preparedness Plans. In the event there is a conflict within the standards or regulations or within pre-established site safety guidelines, the more stringent shall govern.

7.4.1 Review and responsibilities

- **DAWASA Management:** The management is committed to the principle of the safe working and desires that on no account, should any person ever put him to risk.
- **Contractor:** It is the responsibility of the site management to review and ensure awareness of emergency procedure among all the site personnel.
- **Contractor Employees:** It is also the responsibility of all employees to continually familiarize themselves with the assembly procedures for their relevant areas of work.

- **General:** Any information being relayed about an emergency shall be clear and precise giving the exact location, the nature of the emergency and the seriousness of the emergency and contact numbers and names.

8.0 ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

8.1 Environmental and Social Management Plan

The Environmental and Social Management Plan (ESMP) presents the implementation schedule of the proposed mitigation measures for both environmental and social impacts. The ESMP for the proposed Construction of the Faecal Sludge Treatment Plant (FSTP) in the Golani area is summarized in Table 4. The ESMP also indicates the environmental costs needed to implement the recommended mitigation measures. The Faecal Sludge site selection process and engineering designs have already included some of the mitigation measures recommended in this report. Additional recommendations are provided in the ESMP to enable the Faecal Sludge Treatment Plant to be constructed and operated in an environmentally friendly manner.

DAWASA in collaboration with Kigamboni Municipality shall be the main implementer of the ESMP through. The environmental measures incorporated in the detailed engineering design will be attached to the Bills of Quantities and Contract Documents. Moreover, there will be an Environmental, Social, Health and Safety (ESHS) Code of Conduct to be signed by the Contractor(s) to show their commitment to the implementation of the Environmental, Social, Health, and Safety. The implementation of the Code will be supervised by DAWASA or his consultant.

The ESHS Code is a set of Guidelines attached to the Bidding Document and Contract to be adopted by the Contractor during project implementation. It contains the commitment and obligations of the Contractor and its subsidiaries (i.e. Sub-Contractors and staff) to undertake construction activities following all applicable Laws, Rules, and Regulations. The Contractor and its subsidiaries shall comply with the Code of Conduct with high ethical standards. Failure to observe the Code will subject the firm to disciplinary action, including Contract termination. Violation of the Code is a violation of Law that may result in civil and/or criminal penalties to Contractors, Supervisors, or Firm.

Some of the issues to be included in the ESHS shall include;

- Site-specific **ESMP & HSMP**,
- Traffic Management Plan **(TMP), where applicable**
- HIV/AIDS Awareness Program
- Occupational Health and Safety Awareness Program
- Sexual Harassment Prevention Policy
- Child Labour Prevention Policy

The environmental and social mitigation and enhancement measures incorporated in the detailed engineering design will be attached to the Contract Documents. The Contractor shall take stock of the contents of the Project Brief.

Table 5: Environmental and Social Management Plan for the Proposed Construction of Feacal Sludge Treatment Plant at Golani area, Kimbiji ward, Kigamboni Municipal

Impact	Mitigation Measure	Responsible Institution	Estimated One Time Cost (TZS)	Estimated Annual cost (TZS)
Mobilization Phase				
Increased waste generation	○ Stick to the design specifications ○ Provide waste containers ○ Provide training to workers and orient them towards environmental protection values	DAWASA	To be included in the BOQ	
Noise pollution during construction	○ The proponent shall maintain equipment in good running conditions to ensure that ambient noise level and vibrations pollution into the environment is very minimum to comply with Tanzania standards ○ All construction works will be scheduled at normal working hours. ○ Proper inspection and maintenance of construction vehicles and equipment will be done to ensure that they have mufflers installed and worn parts are replaced	DAWASA	500,000.00	
Construction Phase				
Increased waste generation	○ Stick to the design specifications ○ Provide waste containers ○ Provide training to workers and orient them towards environmental protection values	DAWASA	To be included in the BOQ	

Impact	Mitigation Measure	Responsible Institution	Estimated One Time Cost (TZS)	Estimated Annual cost (TZS)
Increased HIV/AIDS and other STD	○ The contractor shall enforce a code of conduct in the project area to encourage respect for the local community and to maintain self-cleanliness of the working area at all times. ○ The contractor shall deploy locally available labor to reduce the risk of spreading communicable diseases (especially STDs). ○ To prevent more HIV/AIDS infections, during the implementation phase, the project should include an information education and communication component (IEC) in its budget. This will help to raise more awareness on HIV/AIDS and means to suppress its incidence. ○ A safety, health, and environment induction course shall be conducted for all workers, putting more emphasis on HIV/AIDS, which has become a national disaster.	DAWASA	5,000,000.00	
Land degradation and increased erosion	o The contractor should pave the walkways prone to erosion whose quantities are shown in the BoQ ○ To obtain the construction materials official negotiations should be performed with wards leaders to avoid conflict.	DAWASA	25,000,000	
Noise pollution during construction	○ The proponent shall maintain equipment in good running conditions to ensure that ambient	DAWASA	1,000,000.00	

Impact	Mitigation Measure	Responsible Institution	Estimated One Time Cost (TZS)	Estimated Annual cost (TZS)
	noise level and vibrations pollution into the environment is very minimum to comply with Tanzania standards ○ All construction works will be scheduled at normal working hours. ○ Proper inspection and maintenance of construction vehicles and equipment will be done to ensure that they have mufflers installed and worn parts are replaced			
Dust generation during construction	○ Mixing equipment shall be sealed properly and vibrating equipment will be equipped with dust-removing devices. ○ Also, all vehicles that generate excessive black smoke will not be used. ○ Adequate training and use of personal protective equipment (PPE) such as eyeglasses and dust masks will be ensured to reduce risks associated with dust.	DAWASA	3,000,000.00	
Health Risks associated with construction works	○ The project proponent shall ensure that all personnel is	DAWASA	33000,000.00	

Impact	Mitigation Measure	Responsible Institution	Estimated One Time Cost (TZS)	Estimated Annual cost (TZS)
	provided with appropriate protective gear. ○ All works shall be planned and conducted following relevant OHS Guidelines. First Aid Kit as well as regular medical check-ups for the workers will be provided during the entire working hours. ○ An adequate number of firefighting equipment/extinguishers will be provided every few distances to help to put off the fire in case of occurrence. ○ Excavated pits should be protected by warning tape and guardrails to prevent workers from falling Sensitization/Awareness of the beneficiary community on the importance of the Facility and the associated benefits			
Demobilization phase				
Noise pollution during construction	○ The proponent shall maintain equipment in good running conditions to ensure that ambient noise level and vibrations pollution into the environment is very minimum to comply with Tanzania standards	DAWASA	500,000.00	

Impact	Mitigation Measure	Responsible Institution	Estimated One Time Cost (TZS)	Estimated Annual cost (TZS)
	○ All construction works will be scheduled at normal working hours. ○ Proper inspection and maintenance of construction vehicles and equipment will be done to ensure that they have mufflers installed and worn parts are replaced			
Operational Phase				
Health Risks associated with Operation works	○ The project proponent shall ensure that all visitors and personnel are provided with appropriate protective gear. ○ An adequate number of firefighting equipment/extinguishers will be provided every few distances to help to put off the fire in case of occurrence. ○ Adhere to good maintenance ○ Sensitization/Awareness of the beneficiary community on the importance of the Facility and the associated benefits	DAWASA	Depend on the operational manual	
Total			**68,000,000.00**	**68,000,000.00**

9. 0 MONITORING PLAN

9.1 Environmental Monitoring

The national EIA guidelines require the developer to prepare and undertake a monitoring plan of implemented development projects. Monitoring is needed to check if and to what extent the impacts are mitigated, benefits enhanced and new problems addressed. Recommendations for monitoring have been included in Table 5. The monitoring plan also assigns responsibilities to different actors. Moreover, the ward and street environmental committees will shoulder the long-term monitoring of the project.

Table 6: Monitoring Plan for the Proposed Construction of Feacal Sludge Treatment Plant (FSTP) at Golani area, Kimbiji ward, Kigamboni Municipal-Dar es Salaam

Parameter	Monitoring Frequency	Sampling Area	Measurement Unit	Method	Target Level/Standard	Responsibility for monitoring	Estimated Annual (or once cost (TZS)
Mobilization Phase							
Dust (PM 2.5, PM 10)	Daily	Immediate working area	µg/Nm3	Physical-visual	Daily average of hourly values shall not exceed 0.10 µg/Nm3 and hourly values shall not exceed 0.20 µg/Nm3	DAWASA	None
Air Quality (SO_2, NO_2)	Daily	Around the Inspection chambers	ppm	Smelling (nasal)	0.2 ppm for 10 and 0.1 ppm for 8 hours of exposure respectively	DAWASA	2,500,000.00
Waste Generation	Weekly	At the working area	Amount of waste	Physical measurement or estimation	All waste contained	DAWASA	In BOQ
Health risks	Daily	At working area	Accidents	Counting	NO accident	DAWASA	In BOQ
HIV/AIDS	Monthly	Workers	Training	Numbers	One per month during construction phase only	DAWASA	5,000,000.00
Biodiversity	Once (at commence ment)	Working area	Destruction of habitat or removal of biodiversity	Area affected	Minimal disturbance to biodiversity	DAWASA	1,000,000.00
Construction phase							
Dust (PM 2.5, PM 10)	Weekly	Immediate working area	µg/Nm3	Physical-visual	Daily average of hourly values shall not exceed 0.10 µg/Nm3 and hourly values shall not exceed 0.20 µg/Nm3	DAWASA	None
Air Quality (SO_2, NO_2)	Weekly	Around the Inspection chambers	ppm	Smelling (nasal)	0.2 ppm for 10 and 0.1 ppm for 8 hours of exposure respectively	DAWASA	2,500,000.00

Parameter	Monitoring Frequency	Sampling Area	Measurement Unit	Method	Target Level/Standard	Responsibility for monitoring	Estimated Annual (or once cost (TZS)
Waste Generation	Weekly	At the working area	Amount of waste	Physical measurement or estimation	All waste contained	DAWASA	In BOQ
Health risks	Daily	At working area	Accidents	Counting	NO accident	DAWASA	In BOQ
HIV/AIDS	Monthly	Workers	Training	Numbers	One per month during construction phase only	DAWASA	5,000,000.00
Biodiversity	Once (at commence ment)	Working area	Destruction of habitat or removal of biodiversity	Area affected	Minimal disturbance to biodiversity	DAWASA	1,000,000.00
Demobilization Phase							
Dust (PM 2.5, PM 10)	Weekly	Immediate working area	µg/Nm3	Physical-visual	Daily average of hourly values shall not exceed 0.10 µg/Nm3 and hourly values shall not exceed 0.20 µg/Nm3	DAWASA	None
Air Quality (SO_2, NO_2)	Weekly	Around the Inspection chambers	ppm	Smelling (nasal)	0.2 ppm for 10 and 0.1 ppm for 8 hours of exposure respectively	DAWASA	500,000.00
Waste Generation	Weekly	At the working area	Amount of waste	Physical measurement or estimation	All waste contained	DAWASA	In BOQ
Health risks	Daily	At working area	Accidents	Counting	NO accident	DAWASA	In BOQ
HIV/AIDS	Monthly	Workers	Training	Numbers	One per month during construction phase only	DAWASA	5,000,000.00
Biodiversity	Once (at commence ment)	Working area	Destruction of habitat or removal of biodiversity	Area affected	Minimal disturbance to biodiversity	DAWASA	1,000,000.00
Operation phase							
Air Quality (SO_2, NO_2)	Monthly	Around the Inspection chambers	ppm	Smelling (nasal)	0.2 ppm for 10 and 0.1 ppm for 8 hours of exposure respectively	DAWASA	500,000.00

Parameter	Monitoring Frequency	Sampling Area	Measurement Unit	Method	Target Level/Standard	Responsibility for monitoring	Estimated Annual (or once cost (TZS)
Waste Generation	Monthly	At the working area	Amount of waste	Physical measurement or estimation	All waste contained	DAWASA	In operation manual
Health risks	Monthly	At working area	Accidents	Counting	NO accident	DAWASA	In operation manual
HIV/AIDS	Annually	Workers	Training	Numbers	One per month during construction phase only	DAWASA	In operation manual
						Total	**28,000,000.00**

10.0 COST BENEFIT ANALYSIS

10.1 JUSTIFICATION FOR RESOURCE EVALUATION

Regulation 18(1) of the Environmental Impact Assessment and Audit Regulations, 2005, requires that an Environmental Impact Statement should contain among others, a section discussion on the project's "resource evaluation or cost benefit analysis". The rule is that a Project should be undertaken if lifetime expected benefits exceeds all expected costs. The art of the analysis process comes in the measurement of these impacts, their adjustment for market failure, and for the effects of time, income distribution, incomplete information and potentially irreversible consequences. Although complexities arise when costs and benefits are being measured and corrected, CBA is a simple tool with numerous uses and applications, especially in the environmental assessment sphere. Its use increases accountability and consistency in decision-making.

10.2 ACTIVITIES COST

The project site will be developed and will include the construction of Feacal Sludge Treatment Plant FSTP, but will also be funded by World Bank

Activities conducted to date include:

- Topographical Survey for setting out purposes,
- Geo-technical Investigation for the areas allocated with the balancing tank and Anaerobic Baffled Reactor (ABR)
- Construction Materials' source Investigation,
- ESIA Study - Site visits were also conducted to obtain the physical environment properties (vegetation, fauna, water resources, topography) of the site and surrounding area. Consultation with relevant regulatory, surrounding communities and project stakeholders is also being undertaken during this phase for collecting social – economic information.

There will be cost for management of the potential impacts that mainly storm water management, sewage management, water resources protection and solid waste management.

DAWASA recognizes the significance of ensuring that the environmental impacts on site are minimized or eliminated. DAWASA will adopt the following hierarchy in environmental risks management;

- Eliminate the hazard altogether - get rid of the unacceptable technology in wastewater treatment.
- Substitute the hazard with a safer alternative – replace adopt the best available disposal technology.
- Isolate the hazard from anyone who could be harmed – ensure no interaction between unacceptable discharge/emission with environmental aspects.
- Use engineering controls to reduce the risk – incorporate environmental and safety issues in design stage.
- Use administrative controls to reduce the risk – training to users for appropriate operations.
- Use personal protective equipment (PPE) – additional protective gears to unavoidable risk which is always acceptable.

10.3 COST BENEFIT ANALYSIS CONCLUSIVE REMARKS

The direct benefits accrued by the communities through improved sanitation services, employment, to surrounding communities resulting in the stimulation of the local economy and environmental conservation make this Project a viable Project. Furthermore, environmental costs from impacts are to be mitigated and managed according to the proposed plan.

10.4 PROJECT BUDGET

The investment cost for the proposed Faecal Sludge Treatment Plant is estimated to be around Tshs. 0.7 billion that will be financed by The World Bank.

11.0 CHAPTER ELEVEN: CONCEPTUAL DECOMMISSIONING PLAN

No life span can be predicted and its potential impacts analyzed precisely for this project of an educational facility. Possibilities will be transfer of the ownership of the land, activities, rehabilitation/renovations, modification and additional infrastructures. The Environmental Management Act stipulates requirements that need to be adhered.

In event that no health activities or part of the facility or infrastructures change their intended use, the acceptable decommission plan for both NEMC and DAWASA will be developed. The plan should address how DAWASA will rehabilitate the disturbed area closer to its original state and will fund the whole closure process.

11.1 Conceptual closure plan

- The long-term preservation of water resources, wastewater treatment and Solid waste disposal facilities.
- The removal and or acceptable disposal of all internal road, structures, and equipment that will not be required after the end of the project life or by the next land user;
- The long-term stabilization of all exposed erodible materials;
- The natural integration of disturbed areas into the surrounding landscape, and the restoration of a natural appearance to the disturbed areas after camp ceases, to the best practical extent; and
- The establishment of a self-sustaining cover of vegetation that is consistent with existing biological environment;
- Reasonable notice for all affected stakeholders such as suppliers, employees and other indirect beneficiaries and
- Appropriate employment termination will be made as per work related governing laws.

12.0 CONCLUSION

The proposed project is of greater profit to the community and the country at large as it promotes and improve sanitation in the streets. When there is good and improved sanitation, then the outbreak of diseases like diarhoea and associated stomach and waterborne diseases are also reduced and prevented hence improved public health.

The impacts identified are preventable and of less negativity to the community, therefore the developer can be provided with the environmental clearance certificate in order to commence the implementation of the project.

It is, therefore, concluded that implementation of the proposed construction of the Faecal sludge treatment plant at Golani mtaa will entail no detrimental impacts provided that the recommended mitigation measures are adequately and timely put in place. The identified adverse impacts shall be managed through the proposed mitigation measures and implementation regime laid down in this EIS. DAWASA is committed to implementing all the recommendations given in the EIS and further carrying out the environmental auditing and monitoring schedules.

References

1. Bicknell, J.; Dodman, D., and Satterthwaite, D., (eds.), 2009. Adapting Cities to Climate Change: Understanding and Addressing the Development Challenges. London, UK: Earthscan, 397p.

2. Investment profile of Kigamboni District

3. Nicholls, R.J., Wong, P.P., Burkett, V.R., Codignotto, J.O., Hay, J.E., McLean, R.F., Ragoonaden, S. and Woodroffe, C.D. 2007. Coastal systems and low-lying areas. In: M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson, (Eds), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK, p. 315-356.

4. Population and Assets Exposure to Coastal Flooding in Dar es Salaam (Tanzania): Vulnerability to Climate Extremes

5. Kigamboni District Socio-economic profile 2010/2011

Appendix I: List of Stakeholders Consulted

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR THE PROPOSED CONSTRUCTION OF OFF-GRID SANITATION PROJECTS, DAR ES SALAAM

LIST OF CONSULTED STAKEHOLDERS

SN	DATE/TAREHE	NAME/JINA	INSTITUTION/TAASISI	POSITION/CHEO	PHONE NO./SIMU	SIGNATURE/SAINI
1	24/07/2018	[illegible]	[illegible]	AREO	0[illegible]	[illegible]
2	-11-	[illegible]	Kaole	DMO	0[illegible]	[illegible]
3	11	[illegible]	11	11	0[illegible]	[illegible]
4	11	[illegible]	11	11	0[illegible]	[illegible]
5	11	[illegible]	11	11	0[illegible]	[illegible]

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR THE PROPOSED CONSTRUCTION OF OFF-GRID SANITATION PROJECTS, DAR ES SALAAM

LIST OF CONSULTED STAKEHOLDERS

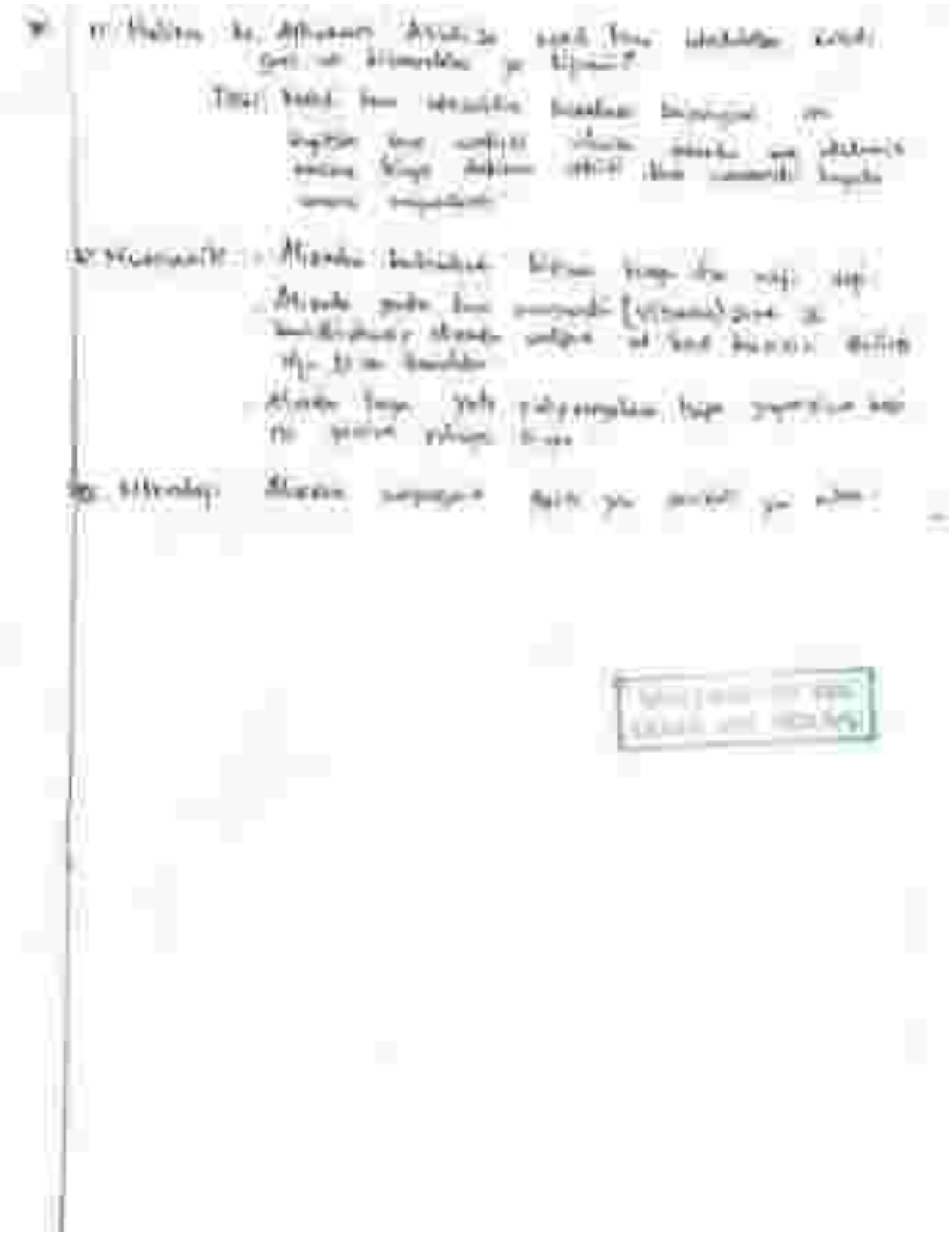
SN	DATE/TAREHE	NAME/JINA	INSTITUTION/TAASISI	POSITION/CHEO	PHONE NO./SIMU	SIGNATURE/SAINI
1		JUVENALIS TIAONGA	Kigamboni Mc	Environmental Officer	0762660617	
2	26-08/2021	Hussein H. Mtomba	—	—	0716 351 [illegible]	
3	"	JOCELYNE J. TUTINDAFIA	—	—	0654 200154	
4		MATHAYO J MGOMWA	"	"	0685 257025	
5	"	REHEMA A JOHN	"	"	06 210 8371	
6	—	[illegible]	—	—	[illegible]	

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT FOR THE PROPOSED CONSTRUCTION OF OFF-GRID SANITATION PROJECTS, DAR ES SALAAM

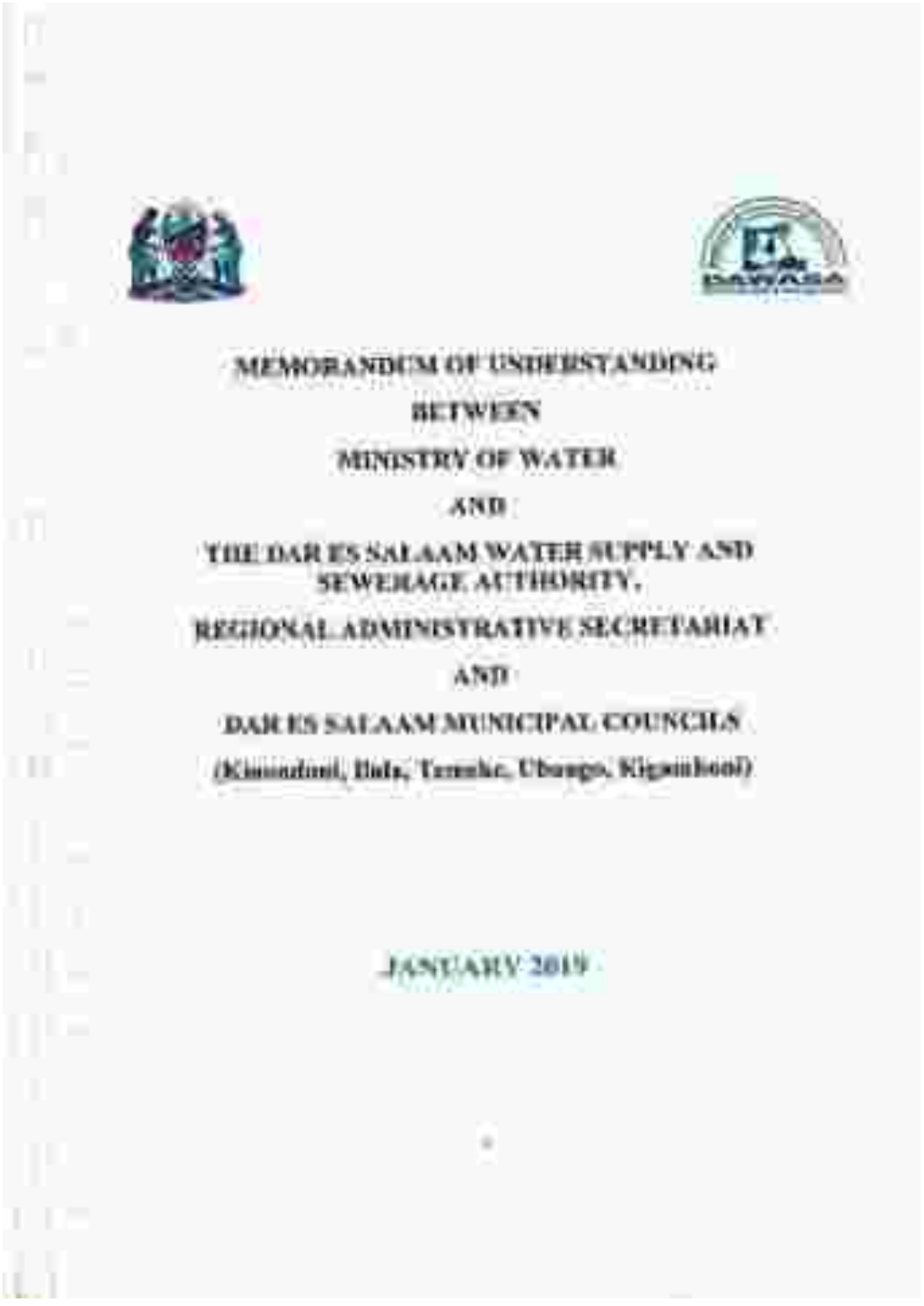
LIST OF CONSULTED STAKEHOLDERS

SN	DATE/TAREHE	NAME/JINA	INSTITUTION/TAASISI	POSITION/CHEO	PHONE NO./SIMU	SIGNATURE/SAINI
	25/03/2022	SIKUDHANI A. MLOKI	KINYAMWEZI MC	EMO	0712 210511	
	—11—	MARIKO FATIMA	—11—	EMO	0743 [illegible]	
		ASHA U. [illegible]	—11—	EMO	0655826714	
		JOHN M. SILEIMAN	—11—	EMO	0747-515 23	
		FUKANA A. NGHATUNGU	—11—	EMO	0672 [illegible]	

Appendix II: Minutes of Meetings with stakeholders



Appendix III: Memorandum of Understanding between DAWASA and Dar es Salaam Municipal Councils



MEMORANDUM OF UNDERSTANDING

BETWEEN

MINISTRY OF WATER

AND

THE DAR ES SALAAM WATER SUPPLY AND SEWERAGE AUTHORITY,

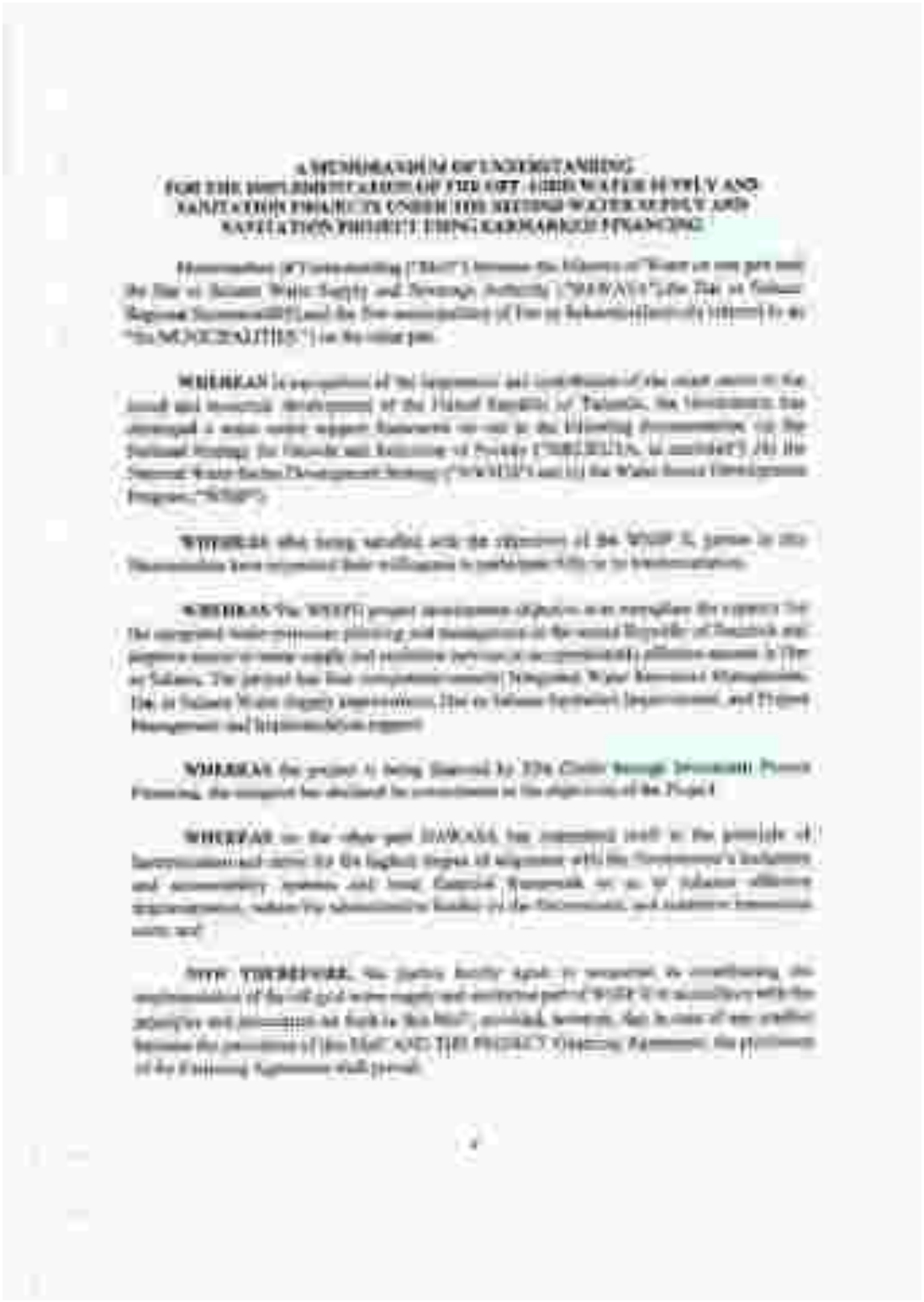
REGIONAL ADMINISTRATIVE SECRETARIAT

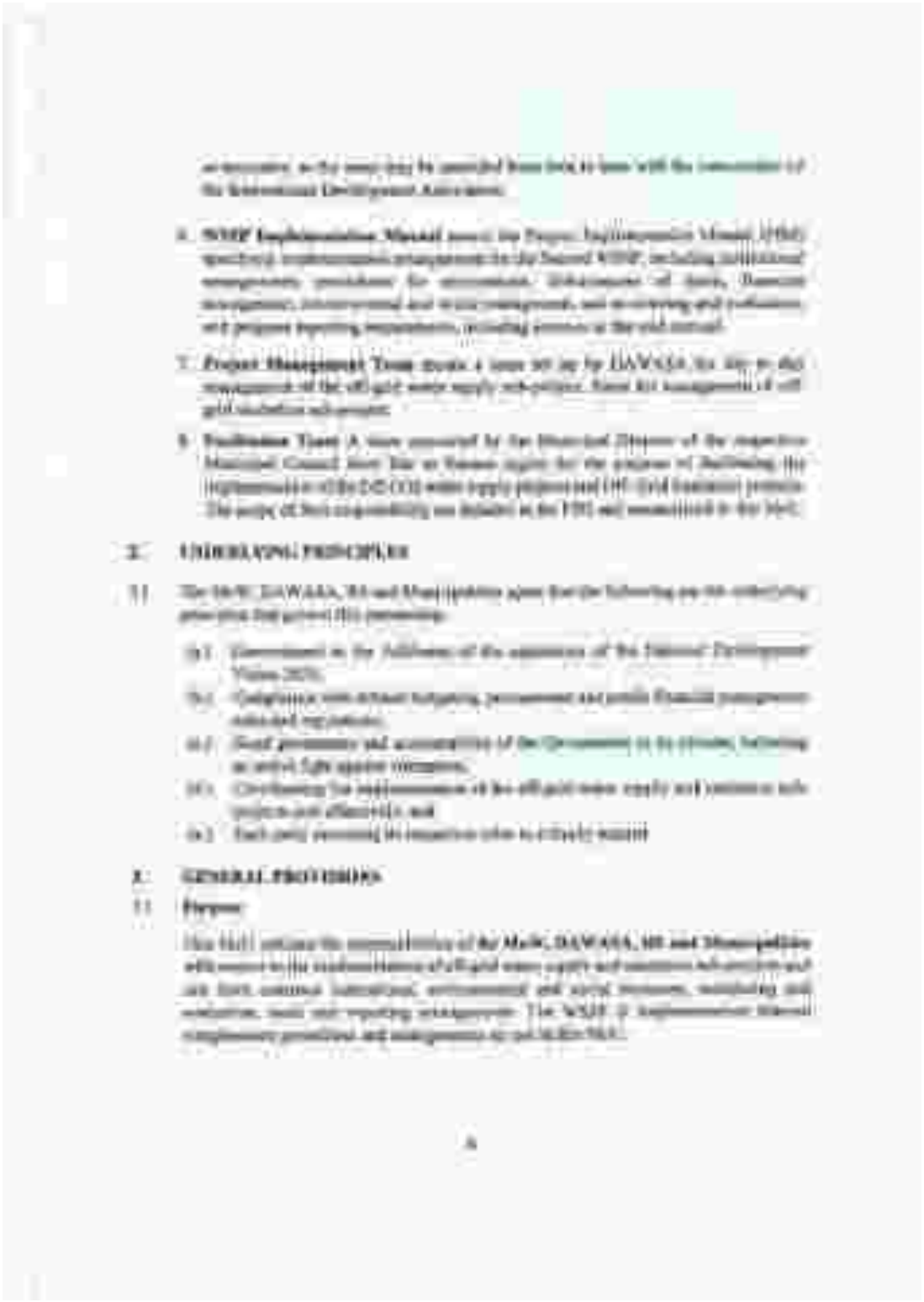
AND

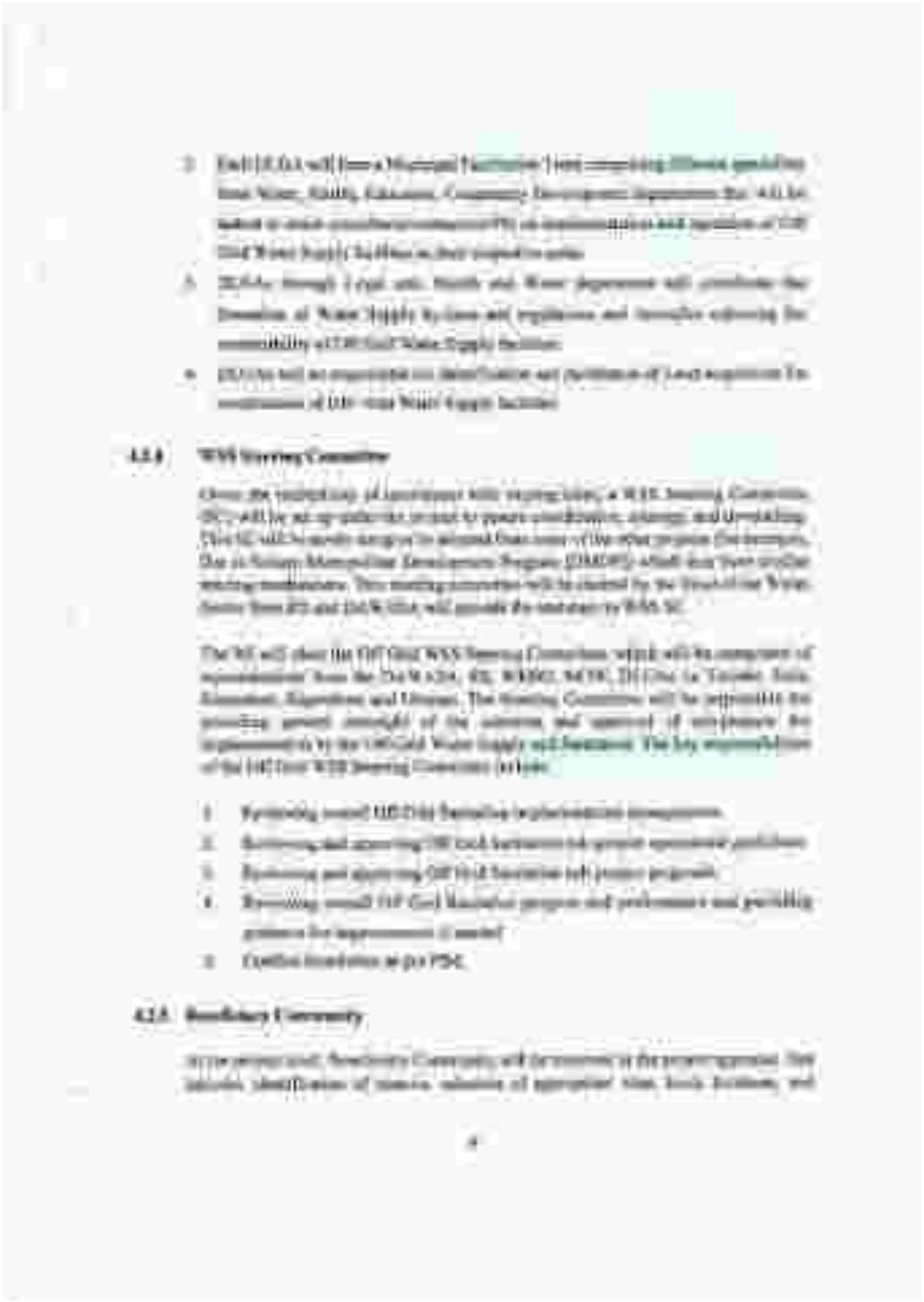
DAR ES SALAAM MUNICIPAL COUNCILS

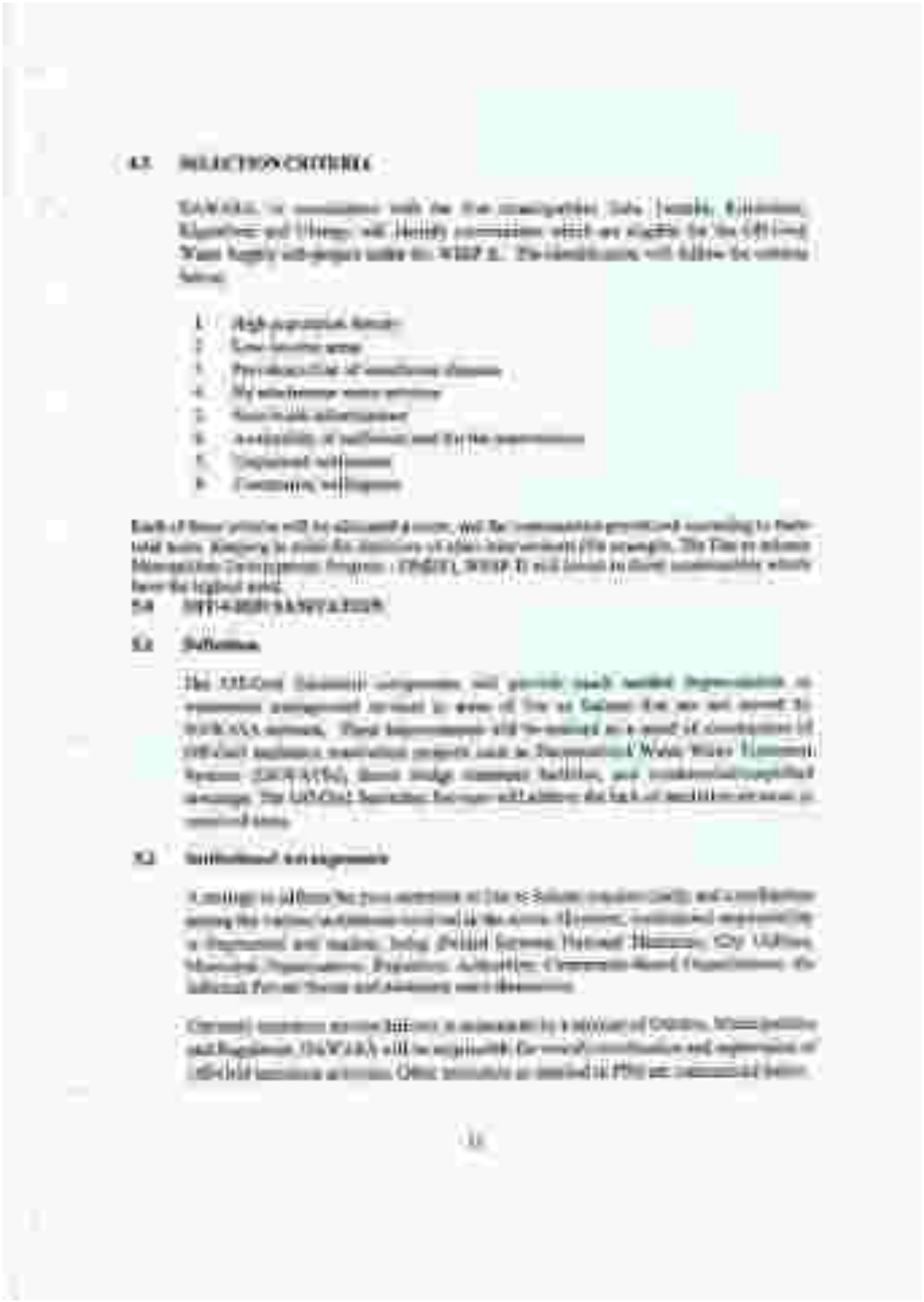
(Kinondoni, Ilala, Temeke, Ubungo, Kigamboni)

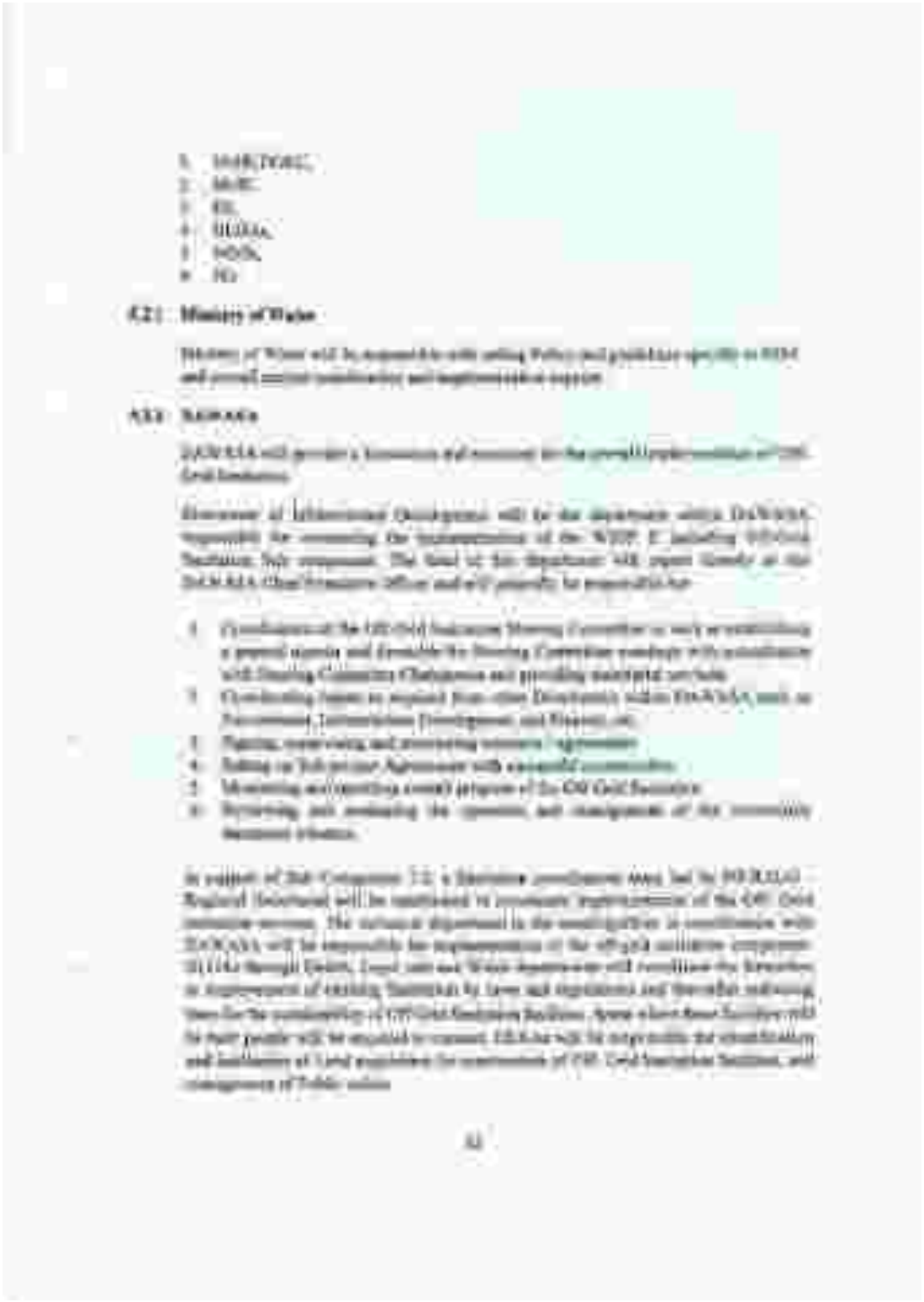
JANUARY 2019

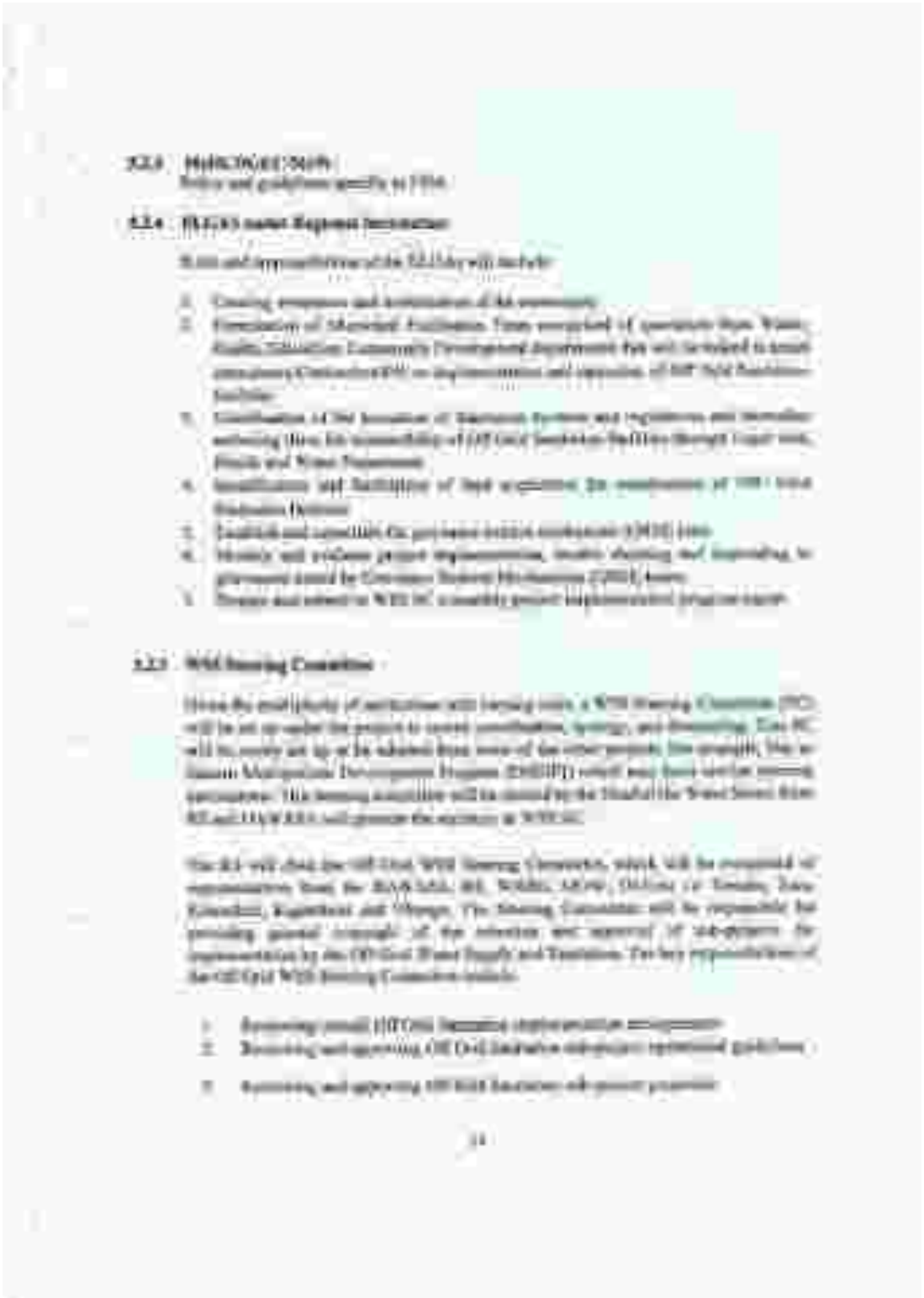


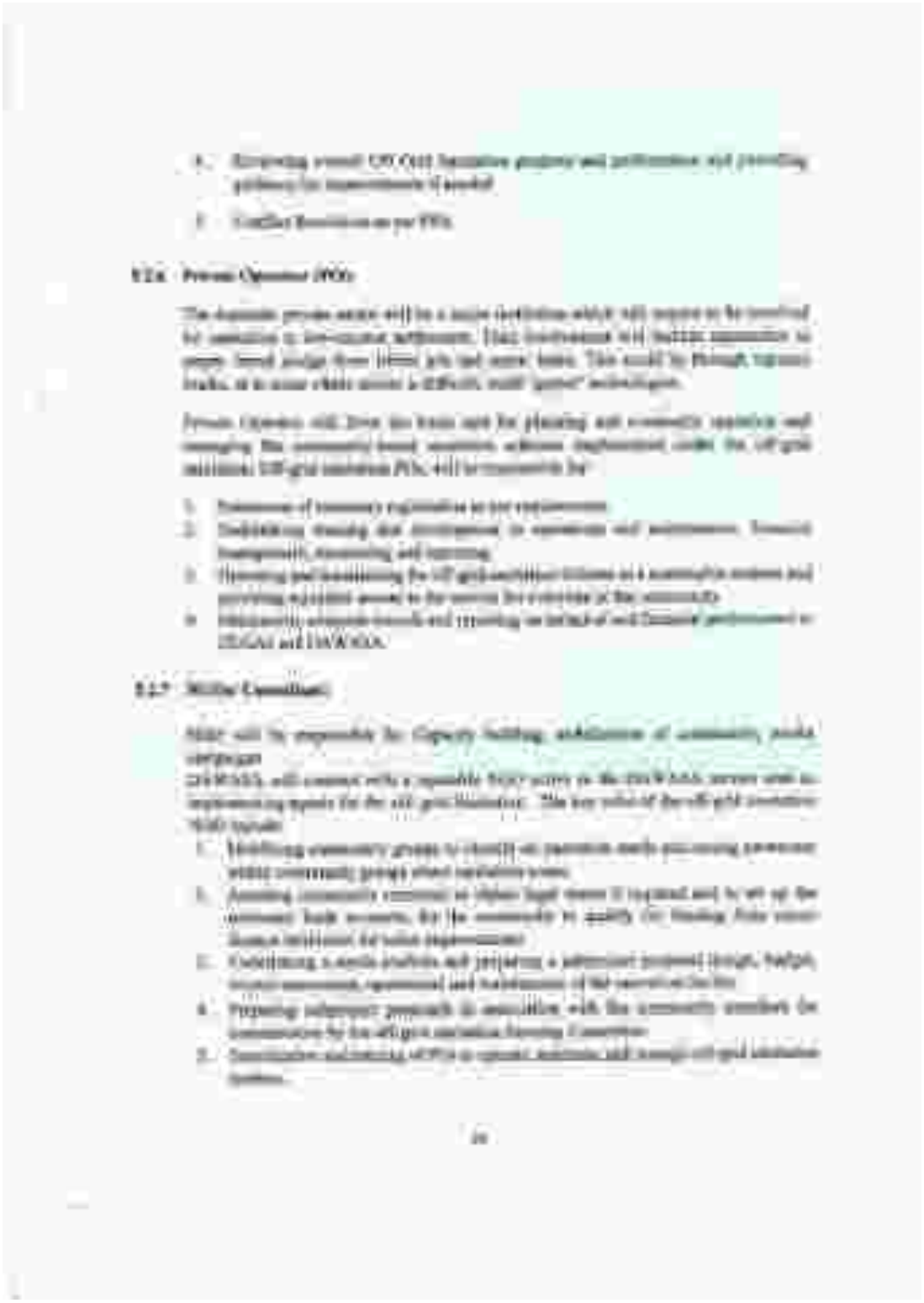


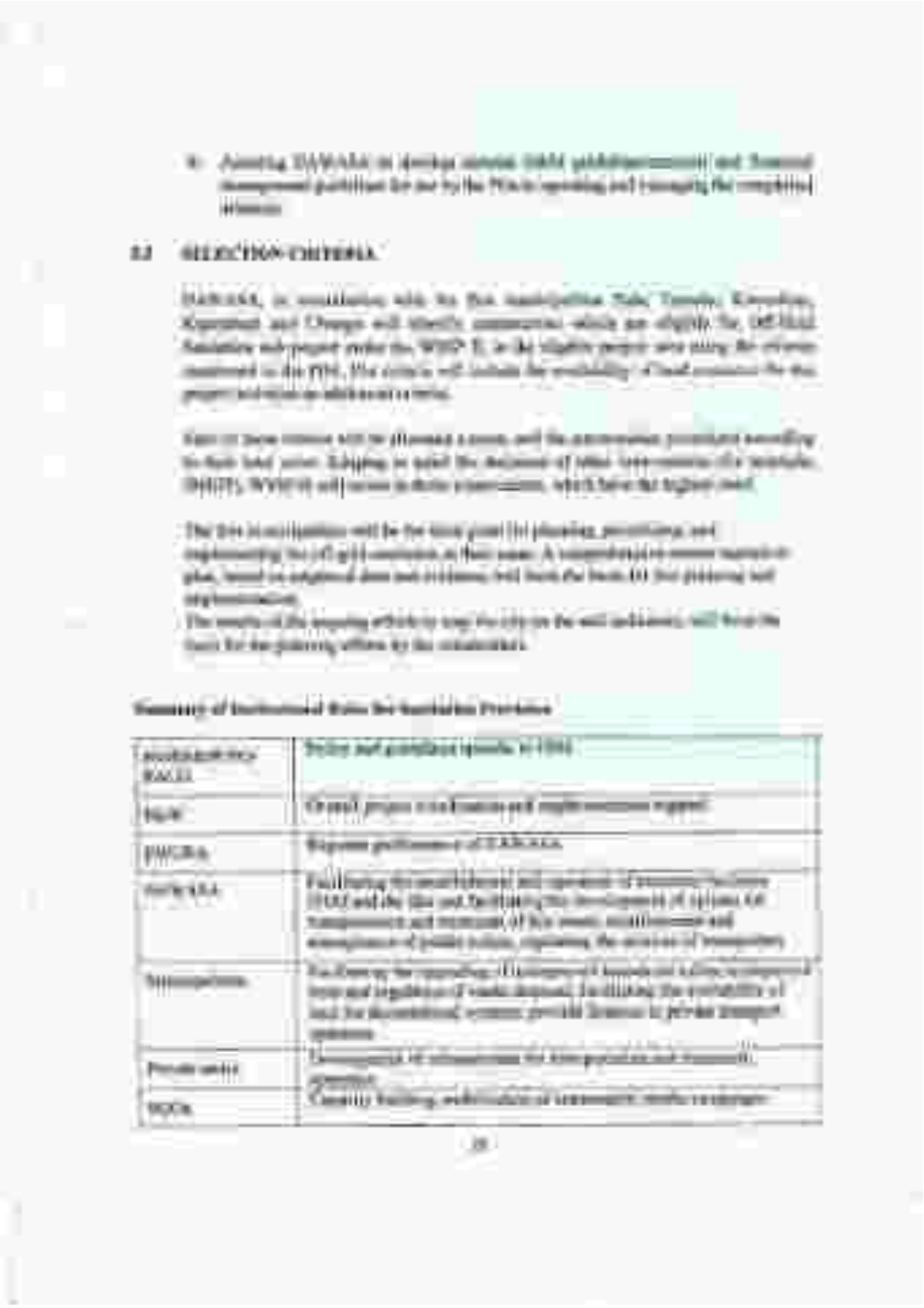


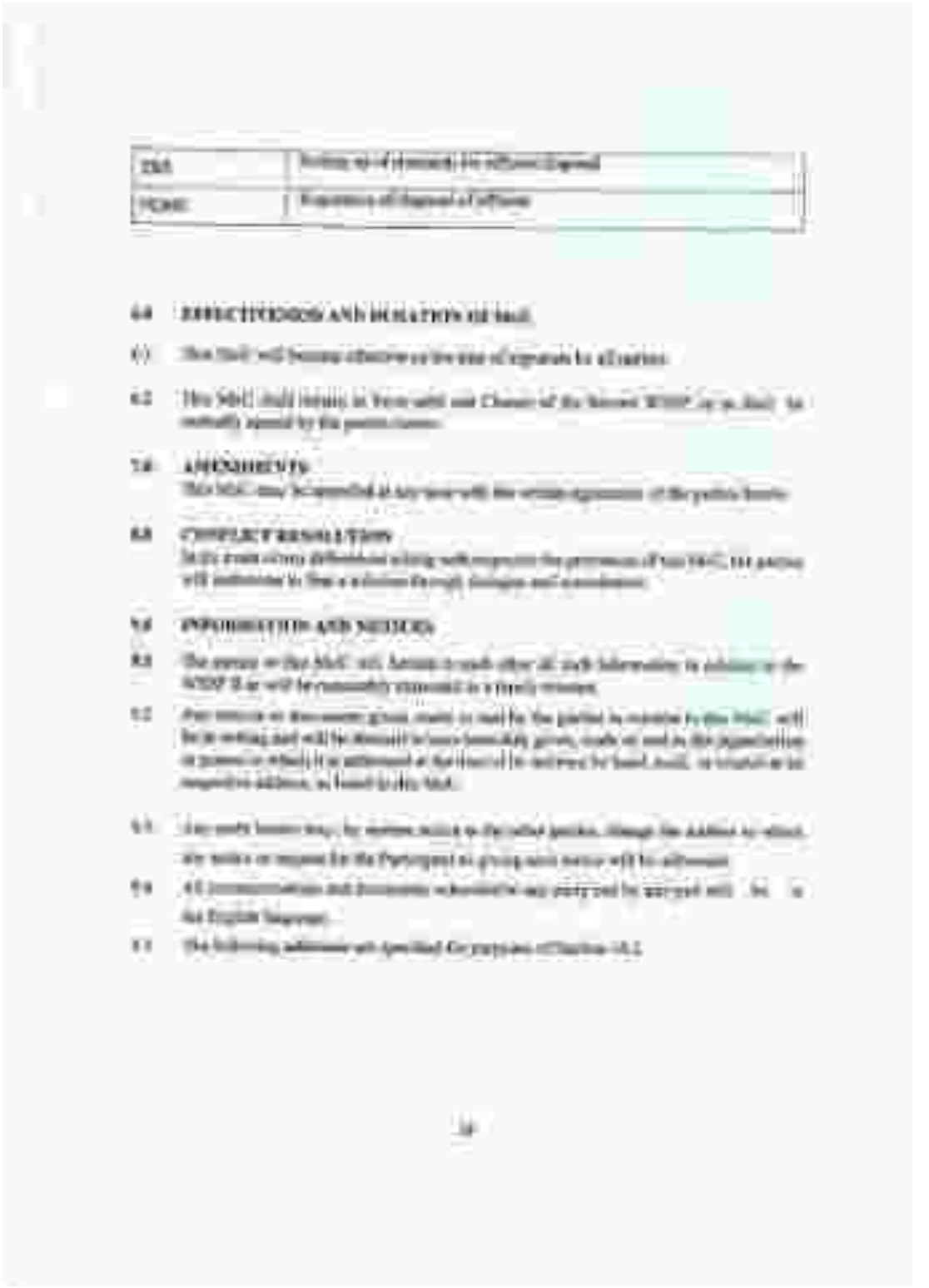












Appendix IV: Screening Letter from NEMC

THE UNITED REPUBLIC OF TANZANIA

VICE PRESIDENT'S OFFICE

NATIONAL ENVIRONMENT MANAGEMENT COUNCIL (NEMC)

In reply please quote:
Ref: EC/EIA/2022/2025 Date: 12th October, 2022

Chief Executive Officer,
Dar es Salaam Water & Sewerage Authority
P. O. Box 7273
Dar es Salaam

Re: SCREENING DECISION OF THE PROJECT BRIEF FOR THE PROPOSED FECAL SLUDGE TREATMENT PLANT (FSTP) TO BE BUILT AT GOLANI STREET, KIMBIJI WARD, KIGAMBONI DISTRICT, DAR ES SALAAM

Reference is made to the above mentioned subject.

2. The National Environment Management Council (NEMC) acknowledges receipt of your application attached with a project brief and paid the environmental impact assessment (EIA) application fees for the above project. The project has been registered on 12th September, 2022 and assigned with Application Reference Number (ARN) EC/EIA/2022/2025 in your future correspondences.

3. Following the review of the submitted documents, the Council has resolved to declare that your project will fall up to a Project Brief stage. Thus you are required to provide a Detailed Project Brief which will guide the Council to execute meeting. However, from the submitted project brief report, the following information must be included to enhance information in the project brief report:

i. Provide more current Baseline information of the project site including elevation, Water level, Soil and Air quality etc.

ii. Cover page:
   a. Update all email address of the Council
   b. Use "Mtaa" and do not mention any degree "Street" since description of "Mtaa" is as per Local Government Authority (LGA) Act and its respective Regulations.

iii. Information on the land ownership should be included in the project description.

iv. The report should discuss the management of hazardous waste generated in all phases.

v. Air and Noise more possible impacts and mitigation will form in project phases.

Appendix V: Permit to use the Land from the Local Government Authority

JAMHURI YA MUUNGANO WA TANZANIA
OFISI YA RAIS
TAWALA ZA MIKOA NA SERIKALI ZA MITAA
HALMASHAURI YA MANISPAA KIGAMBONI
(Barua zote zipelekwe kwa Mkurugenzi wa Manispaa Kigamboni)

S.L.P. (Box)
KIGAMBONI
DAR ES SALAAM
TANZANIA.

Simu: +255 22-2228499
Fax: +255 22-2228499
Barua pepe: info@kigamboni.go.tz
Tovuti: www.kigamboni.go.tz

Unapojibu tafadhali taja:

Kumbu. No. KDMC/HUM/13/5/08 Tarehe: 16 Desemba, 2021

Afisa Mtendaji Mkuu,
Mamlaka ya Usambazaji Maji na Usafi wa Mazingira,
S.L.P. 1573,
DAR ES SALAAM.

Kuh: TAHADHARI YA KUTUMIA ENEO WAZALA LILILOPO KIMBIJI KWA AJILI YA UJENGAJI WA SHUGHULI ZA UCHAKATAJI MAJITAKA

Tafadhali husika na andiko cha kichwa hapo juu.

2. Napenda kukuarifu kuwa tarehe 09/12/2021 ambayo Ujumbe wa kutoka kwenu ukiongozwa na Fatma Said ambaye ni Afisa Mazingira wa Halmashauri ya Manispaa ya Kigamboni ulifika katika eneo la ardhi lililotumika hapo awali kwa ajili ya kutupa taka ngumu za Manispaa ya Kigamboni lililopo Kata ya Kimbiji Kisarawe kwa lengo la kuangalia uwezekano wa kujenga mtambo wa kuchakata majitaka.

3. Kufuatia ziara hiyo Mheshimiwa Diwani wa Kata ya Kimbiji Mhe. **DAWASA** walitoa taarifa kuhusiana na mpango huo ambapo Mheshimiwa Diwani alikubaliana na mpango huo kwa kuwa eneo hilo halina shughuli yoyote ya kijamii inayofanyika kwa sasa.

4. Hivyo basi kwa barua hii napenda kukujulisha rasmi kwamba Halmashauri ya Manispaa ya Kigamboni haina pingamizi yoyote kuhusu eneo hilo kutumika kwa shughuli za uchakataji majitaka kwa kuzingatia sheria na taratibu za mazingira.

5. Aidha, Manispaa inaendelea na taratibu za kupima na kumilikisha eneo hilo kwa ajili ya matumizi yaliyokusudiwa.

Ahsante sana.

Erasto N. Kwale
MKURUGENZI WA MANISPAA
KIGAMBONI

c.c. Diwani wa Kata

Appendix VI: Architectural drawings

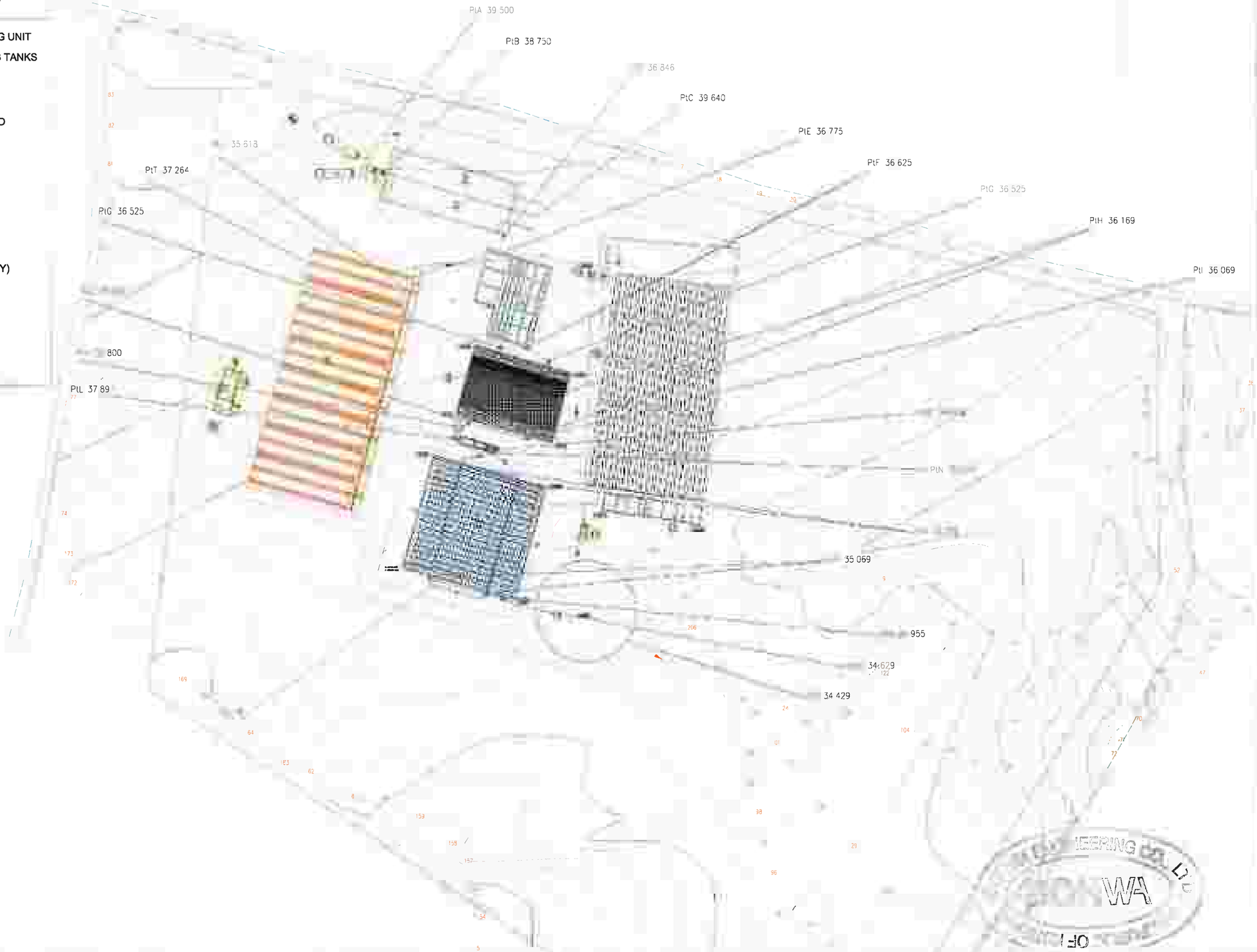
GOLANI FAECAL SLUDGE TREATMENT PLANT

1. FAECAL SLUDGE RECEIVING AND SCREENING UNIT
2. FAECAL SLUDGE SETTLING AND THICKENING TANKS
3. DRYING BEDS
4. INTEGRATED SETTLER, ABR & AF
5. HORIZONTAL FLOW CONSTRUCTED WETLAND
6. HYDROMECHANICAL SYPHON
7. VERTICAL FLOW CONSTRUCTED WETLAND
8. SERVICE BUILDING
9. POTABLE WATER TANK AND TOWER
10. TREATED EFFLUENT PUMP STATION
11. POLISHING POND
12. BY PRODUCTS RE-USE AREA (TREE NURSERY)
13. TREATED WATER OVERHEAD TANK

WASTWEATER/FS PIPE

EXISTING PATH/ROAD

FENCE



CLIENT: DAR ES SALAAM WATER SUPPLY & SANITATION AUTHORITY (DAWASA)	CONSULTANTS: DOHWA ENGINEERING CO., LTD — DOHWA Engineering Co., LTD IN ASSOCIATION WITH LUPTAN CONSULTS LTD AND WWS	CONTRACTOR: SHANXI CONSTRUCTION ENGINEERING CORPORATION AND MINERAL COMPANY

Project: CONSTRUCTION OF FAECAL SLUDGE TREATMENT PLANTS (FSTP) WORKS IN DAR ES SALAAM

REVISION

No:	Description	Made by	Date:

Drawing Title	SITE PLAN - Golani FSTP (120 m3/d)		Drawing No;
Designed by	SHANXI	Approved by	FSTP- 108 /SITE PLAN REV02
Drawn by	SHANXI	SHEET No.	
Checked by		Scale 1:1000	Date: September - 2024

APPENDIX VII: Geotechnical Report

SHANXI CONSTRUCTION ENGINEERING CORPORATION AND MINERAL COMPANY

GEOTECHNICAL REPORT

FOR

THE PROPOSED CONSTRUCTION OF FAECAL SLUDGE TREATMENT PLANTS (FSTP) WORKS IN DAR ES SALAAM

PREPARED FOR:

DAR ES SALAAM WATER SUPPLY & SANITATION AUTHORITY (DAWASA)

P.O. BOX 1573

DAR ES SALAAM

January 3, 2024

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1.0 EXECUTIVE SUMMARY

At the request of DAWASA, SHANXI CONSTRUCTION ENGINEERING CORPORATION AND MINERAL COMPANY recently completed a geotechnical survey that entailed the advancement of 7 No. sampled boreholes at the proposed site for construction of Faecal Sludge Treatment Plants (FSTP) Works at Golani in Dar Es Salaam.

Each of the boreholes was advanced to 10 m below existing ground level. The boreholes encountered alternating layers of clay and sand.

Based on the data obtained from our subsurface exploration, the prevalent soil type is sand. The sand is considered suitable for the support of shallow foundations.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that full details are not provided in this section, and the report must be read in its entirety for a comprehensive understanding of the items highlighted herein.

2.0 INTRODUCTION

2.1 Antecedents

This report presents the findings of the recently completed geotechnical investigation in support of the proposed construction of a Faecal Sludge Treatment Plants (FSTP) in Dar Es Salaam. The work was commissioned by The Dar Es Salaam Water Supply & Sanitation Authority (DAWASA) and executed by Shanxi Construction Engineering Corporation and Mineral Company.

The purpose of the investigation was to determine the subsoil stratification at the proposed plant site and assess the suitability of existing subsoil materials for foundation support.

The geotechnical investigation, which was completed in September 2023, mainly entailed the rotary drilling of 7 No. geotechnical boreholes (each to a maximum depth of 10 m below existing ground level) at the proposed site, sample collection and laboratory testing of the recovered samples.

This report encompasses the results of the geotechnical investigation and based on this information, it provides geotechnical recommendations relating to the general design of the

proposed foundations. This document also contains brief descriptions of the investigation methods used to acquire the factual data reported herein.

This report should be read in conjunction with "Limitations of the Report" which is appended following the text of the report. The reader's attention is specifically drawn to this information, as it is essential that it is followed for the proper use and interpretation of this report.

2.2 Objectives

The following were the main objectives of the geotechnical survey:

a) Determine the subsurface stratigraphy to the full depths of the boreholes.
b) Provide lithological descriptions of the stratigraphic units encountered in the boreholes.
c) Evaluate the engineering characteristics of the subsurface materials through in situ and laboratory tests.
d) Provide an interpretative geotechnical report for the site.

2.3 Scope

To fulfil the abovementioned objectives, the completed scope of the survey is as follows:

a) Rotary drilling, sampling and logging of 7 No. geotechnical boreholes, each to a depth of 10 m below ground level (bgl).
b) Execution of Standard Penetration Tests (SPT) on soils and unconsolidated deposits encountered in the boreholes.
c) Laboratory testing of representative soil samples.
d) Preparation of this engineering report that outlines field methodologies, documents findings and provides clear geotechnical recommendations based on engineering analysis of the data, our experience and acceptable engineering practice.

2.4 Site and Project Description

2.4.1 Site Location and Description

The proposed plant site is located along an access road in Kimbiji administrative ward of the Dar es Salaam Region of Tanzania.

The ground elevation at the site was measured and found to range between 33.46 m and 40.16 m above mean sea level.

Figure 1 below presents a satellite map of the project site, indicating the geographic locations of the 7 No. drill points.

Figure 1 - Satellite image of the project site indicating the locations of the boreholes

2.4.2 General Project Description

The FSTP project will include construction of the following structures:

- Receiving & screening unit
- Settling-thickening tanks
- Drying beds
- Integrated settler
- Horizontal & vertical flow constructed wetland,
- hydro-mechanical siphon
- Potable water & treated wastewater tank and tower,
- Pump station,
- Service building, and,

- Polishing pond.

3.0 FIELDWORK

3.1 General

The geotechnical field investigation was executed in the period between 9th and 19th September, 2023 and consisted of 7 No. boreholes. The field work was conducted under the supervision of competent personnel, who maintained detailed field records of the various soil strata and groundwater conditions encountered.

3.2 Code of Practice

The requirements given in British Standard BS 5930:2015 (Code of Practice for Site Investigations) were used as a general guide for carrying out the survey.

3.3 Methodology

3.2.1 Geodetic Coordinates of the Sampling Points

The placed geodetic coordinates at the drill points are tabulated below:

Hole ID	Investigated Depth (m)	Placed Coordinates (WGS84, Zone 37 S)		Elevation (masl)
		Easting	Northing	
PtB (or BH1)	10	557138.83	9225884.84	38.11
PtC (or BH2)	10	557287.90	9225836.81	33.46
PtD (or BH3)	10	557215.72	9225813.90	34.40
PtG (or BH4)	10	557210.92	9225708.41	35.20
PtF (or BH5)	10	557150.84	9225765.97	35.00
PtE (or BH6)	10	557054.06	9225815.93	36.97
PtA (or BH7)	10	557069.42	9225905.88	40.16

Table 1 - Geodetic coordinates at the drill points

3.2.2 Drilling

3.2.2.1 Equipment

The boreholes were advanced using a XY-1 rotary drilling rig equipped with augers, core barrels and standard SPT equipment. The drilling equipment also included a mud pump which was used to impel drilling water into the borehole to cool the diamond bit as it advanced through hard strata as well as flush out cuttings from the bottom of the borehole.

3.2.2.2 Standard Penetration Test

Standard Penetration Tests (SPT) were performed in the soil and unconsolidated strata encountered in the boreholes. The dynamic test entailed the driving of a split spoon sampler into the soil layer at the bottom of the borehole by dropping a standard weight (63.5 kg), automatic trip hammer through a standard distance (760 mm). This was followed by recording of the number of blows (N) required to achieve 300 mm penetration (in 150 mm increments) after an initial seating drive of 150 mm or 25 blows, whichever was achieved first. The standard test termination criteria for SPT testing was as follows:

- When the full test drive (300 mm) was achieved, or;
- When a limiting blow count of 50 (N=50), also referred to as penetration 'refusal', was reached. The test was also concluded as refusal when no penetration was achieved after several impacts of the hammer.

Based on data summarized by Skempton (1986), the generalized energy ratio (E_r) for our auto-trip hammer is 80%. The equation below can be used to acquire corrected N-values which is dependent on rod length ($C_r = 0.75$), sampler type ($C_s = 1.0$) and hole diameter ($C_d = 1.0$). These correction factors have been adapted from BS (2011).

$$\boldsymbol{N_{corr} = N\frac{E_r}{60} \times 0.75}$$

Note that in this case the corrected N-values are equivalent to the raw field N-values. A tabulated summary of the SPT test results is provided in subsection 5.1.1 of this report.

Figure 2 – SPT Testing at borehole PtE

3.2.2.3 Borehole Sampling

i. Core Sampling

The boreholes were generally advanced using the coring technique. After being carefully extracted from the core barrels, soil and rock cores were placed into grooved, wooden core boxes ensuring that the original depth orientation of each sample was maintained. The typical core box was divided into five grooves, each groove with adequate dimensions for containing one metre of the core section at full recovery. Each core box was labelled to indicate the site name, borehole number, core runs and date of sampling. Colour photographs of the core boxes populated with samples are provided in Appendix II.

ii. Undisturbed Sampling

Relatively undisturbed soil samples were acquired from the SPT sampler.

3.2.3 Geological Logging of Soils and Rocks

Field logging was performed by a qualified engineer who was stationed at the site for the entire duration of the works. Soil samples were subjected to visual-manual inspection to develop material descriptions conforming to BS 5930.

4.0 GEOLOGY AND SITE SUBSURFACE CONDITIONS

4.1 Geology of Tanzania

Numerous studies on tectonics of the region have shown that the many mechanisms for rifting and the tectonic history of rifting is quite complex (Dawson, 2008). On regional scales four major tectonic provinces have been recognized: the western system (Ubendian system), central system (Tanzanian craton partial covered by Dodoma system), mobile Usagaran system and eastern continental and marine sedimentary rocks of Lower Jurassic to Quaternary (Figure 4). The stable Tanzania craton consist of Archean rocks which are granitic complexes, Dodoma system and greenstone belt. The eastern extension of this underlies Mozambique belt contained deformed metasedimentary rocks and intrusions.

The area is characterized by folds and thrusts verging eastward from the orogenic belt. The same characteristic is perceived in the Ubendian system. The Ubendian system comprises of high grade metamorphic rocks of sedimentary and igneous origin. The rocks include granulite, amphibolite, migmatite, gneiss, schist, quartzites and marble. The metamorphic grade of Ubendian system is mainly amphibolite or granulite facies. The usagaran system contains rocks of Paleoproterozic age that were deposited in geosynclinals troughs. The usagaran system comprises sedimentary rocks and volcanic rocks. In the coast regions and in the parts of the rift, the Mesozoic rocks occur. The Mesozoic sedimentary rocks are alternating transgressive and regressive sequence. The rocks comprise of sandstones, siltstones, mudstone, coral limestones and silty shales. The Cenozoic period consist of sediments and volcanic eruption occurred in several parts of Tanzania. The Neogene volcanic which most occur within East African rift valley overlie Precambrian rocks in the southwest and north eastern part of the

country. The quaternary period is characterized by deposition and erosion cycles related to mainly sea level, climate changes and tectonics.

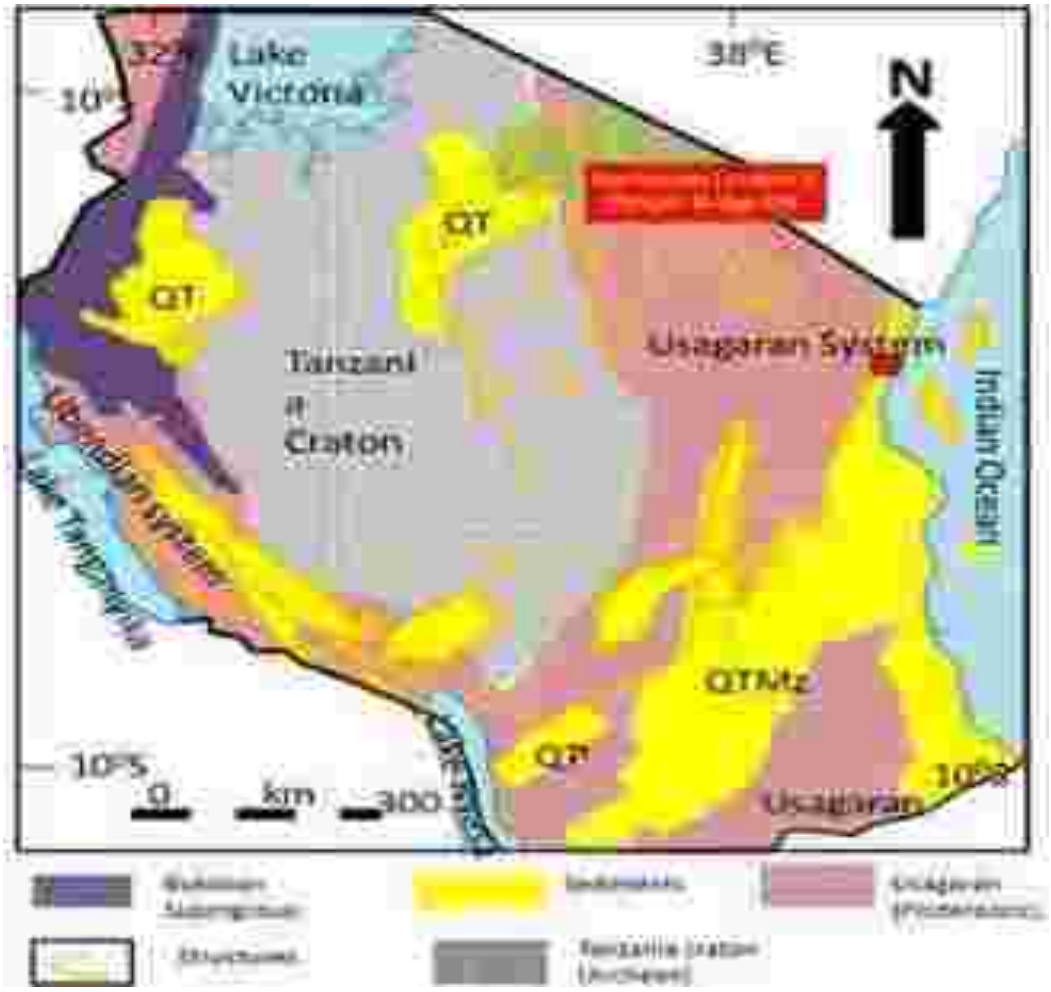


Figure 3 - Simplified geological map of Tanzania (Modified from Hester, 1998)

4.2 Local Subsurface Conditions

The details of the subsurface conditions encountered during our investigation are presented on the borehole logs and cross section provided in Appendix I. The generalized subsurface profile at the drilling points, as inferred from the subsurface exploration data, is summarized below.

4.2.1 Summary of Stratigraphy

The boreholes encountered soil material from ground level to the maximum depth of investigation of 10 m bgl. The subsoil comprises of alternating layers of very stiff to hard CLAY and medium dense to dense SAND. The predominant soil material at the site is sand.

4.2.2 Ground Water

The table below presents a record of the final water levels measured in the boreholes. Due to the influence of drilling water, these levels do not represent the full equilibrium condition. Different water levels should be expected during construction.

Hole ID	Water Level (m)
BH1	2.2
BH2	1.0
BH3	2.2
BH4	2.0
BH5	1.7
BH6	0.0
BH7	0.5

Table 2 – Borehole water levels at completion of drilling

5.0 ANALYSIS AND DISCUSSION OF TEST RESULTS

5.1 Field Tests

5.1.1 Standard Penetration Test

The table below provides a summary and interpretation of the N-values from the SPT test. It should be noted that since the efficiency of the SPT hammer is 80%, the overall correction factor calculates to 1, i.e. field values are equivalent to corrected values.

Hole ID	Depth (m)		N-value	N_{corr}
	From	To		
BH1	1.5	1.95	14	14
BH1	3	3.45	29	29
BH1	4.5	4.95	31	31
BH1	6	6.45	41	41
BH1	7.5	7.95	42	42

BH1	10	10.45	42	42
BH2	1.5	1.95	14	14
BH2	3	3.45	23	23
BH2	4.5	4.95	27	27
BH2	6	6.45	29	29
BH2	7.5	7.95	32	32
BH2	10	10.45	32	32
BH3	1.5	1.95	24	24
BH3	3	3.45	22	22
BH3	4.5	4.95	38	38
BH3	6	6.45	40	40
BH3	7.5	7.95	41	41
BH3	10	10.45	30	30
BH2	1.5	1.95	22	22
BH2	3	3.45	15	15
BH2	4.5	4.95	20	20
BH2	6	6.45	20	20
BH2	7.5	7.95	30	30
BH2	10	10.45	32	32
BH5	1.5	1.95	18	18
BH5	3	3.45	26	26
BH5	4.5	4.95	23	23
BH5	6	6.45	19	19
BH5	7.5	7.95	24	24
BH5	10	10.45	20	20
BH6	1.5	1.95	21	21
BH6	3	3.45	18	18
BH6	4.5	4.95	22	22
BH6	6	6.45	22	22

BH6	7.5	7.95	29	29
BH6	10	10.45	32	32
BH7	1.5	1.95	16	16
BH7	3	3.45	28	28
BH7	4.5	4.95	31	31
BH7	6	6.45	30	30
BH7	7.5	7.95	35	35
BH7	10	10.45	31	31

Table 3 - Summary and interpretation of SPT N-values

Bowles (1997) recommended the following equations [adopted from Terzaghi and Peck (1967) and Meyerhof (1956, 1974)] to compute the bearing capacity of soils:

$$\boldsymbol{q_a} = \frac{\boldsymbol{N_{corr}}}{\boldsymbol{F_1}} \times \boldsymbol{K_d} \qquad \text{for } B \leq F_4$$

$$\boldsymbol{q_a} = \frac{\boldsymbol{N_{corr}}}{\boldsymbol{F_2}} \left(\frac{\boldsymbol{B+F_3}}{\boldsymbol{B}}\right)^{\boldsymbol{2}} \times \boldsymbol{K_d} \qquad \text{for } B > F_4$$

Where,

$\boldsymbol{q_a}$ = Allowable bearing capacity for 25 mm settlement,

$\boldsymbol{N_{corr}}$ = Statistical average of corrected N-value between $0.5B$ above foundation and $2B$ below foundation,

$\boldsymbol{B}$ = Foundation width,

$\boldsymbol{D}$ = Foundation depth,

$\boldsymbol{K_d} = 1 + 0.33\frac{D}{B} \leq 1.33$

$\boldsymbol{F_1}, \boldsymbol{F_2}, \boldsymbol{F_3}, \boldsymbol{F_4}$ = Factors for 80% efficiency hammer (N_{80}) which are 0.033, 0.046, 0.3 and 1.2 respectively. It should be noted that factors F_1 and F_2 have been linearly extrapolated from existing N_{55} and N_{70} factors documented by Bowles while factors F_3 and F_4 remain the same.

The equations above assume 25 mm settlement. In general, the allowable pressure ($q_a{}'$) for any settlement (ΔH) can be computed as:

$$\boldsymbol{q_a'} = \frac{\boldsymbol{\Delta H}}{\boldsymbol{25}} \times \boldsymbol{q_a}$$

The table below presents a summary of the allowable bearing pressures for footings of various widths founded on the in situ soil at 1.5 m, 2 m, 2.5 m and 3 m bgl.

Foundation Details		K_d	q_a (kN/m^2)	q_r (kN/m^2)
D (m)	B (m)			
1.0	1.0	1.33	742	371
	1.5	1.22	802	401
	2.0	1.17	770	385
	2.5	1.13	710	355
	3.0	1.11	701	350
1.5	1.0	1.33	846	423
	1.5	1.33	874	437
	2.0	1.25	825	412
	2.5	1.20	784	392
	3.0	1.17	735	368
2.0	1.0	1.33	846	423
	1.5	1.33	958	479
	2.0	1.33	879	440
	2.5	1.26	827	414
	3.0	1.22	834	417
2.5	1.0	1.33	927	463
	1.5	1.33	958	479
	2.0	1.33	918	459
	2.5	1.33	870	435
	3.0	1.28	872	436
3.0	1.0	1.33	1008	504
	1.5	1.33	1041	520
	2.0	1.33	994	497
	2.5	1.33	943	471
	3.0	1.33	910	455
N-value taken as statistical average between 0.5B above footing of width B, to 2B below the footing				

Table 4 - Bearing capacity of soil as computed from corrected N-values

In view of the fact that Bowles' method scales up Terzaghi's values by about 50%, we have applied a safety factor of 2 to the computed values of q_a to acquire the recommended design value, q_r, listed above.

5.2 Laboratory Tests

Select soil samples recovered from the boreholes were subjected to a program of laboratory tests based on review of sample composition, sample size and to fulfill the general requirements of the contract.

The following subsections present a summary of the parameters directly acquired and/or inferred from the test results. Comprehensive backup sheets of the tests are provided in Appendices and should be concurrently referred to when reading this section.

The table below presents a list of the completed laboratory tests.

Material	Test	No. of Tests
Soils	Atterberg Limits	5
	Sieve Analysis	9
	Bulk Density and Natural Moisture Content	13
	Direct Shear Test	7
	Unconsolidated Undrained Triaxial Shear	6
	One-Dimensional Consolidation	8

Table 5 - Laboratory tests performed on soil samples

5.2.1 Atterberg Limits

The Atterberg tests were performed to investigate whether the soils at the site exhibit the proper consistency to support the proposed structures even as their moisture levels change. Atterberg limit tests are classification tests that determine the liquid limit (LL) and plastic limit (PL) of the soil fraction finer than the No. 40 (0.425 mm) sieve.

Liquid limit is the moisture content at which a soil passes from the liquid to the plastic state and is directly proportional to the compressibility of soil. A cone penetrometer, which

correlates liquid limit to the penetration of a freely falling calibrated cone, was used to determine the liquid limits of the soil specimens.

Plastic limit, defined the moisture content at which a fine-grained soil can no longer be remolded without cracking, was determined by measuring the water content when threads of soil (3 mm in diameter) began to crumble.

Plasticity index (PI), which is essentially the difference between the liquid and plastic limits, indicates the degree of plasticity or the magnitude of the water content over which the soil remains plastic. Since plasticity is attributed to clay, cohesionless soils have no plasticity phase, and therefore their PI is zero.

5.2.1.1 Plasticity Index

The plasticity indices of the test samples were found to range from 22% to 37%, implying highly plastic soil. The plasticity description is based on the qualitative plasticity classification proposed by Burmister (1949).

5.2.1.2 Plastic Limit

The data indicates a range of plastic limits between 15% and 17%.

5.2.1.3 Liquid Limit

The liquid limits of the test samples were determined to vary between 39% to 56%. The table below presents the relationship between liquid limit and degree of compressibility as proposed by Mills *et al.* (1980).

Rating	Liquid Limit (%)	Degree of Compressibility
Low	< 45	Low
Medium	45 – 55	Medium
High	55 – 75	High
Very High	> 75	Very High

Table 6 - Ratings for compressibility based on liquid limit (Mills et al. 1980)

Based on the average liquid limit of 46%, the soil at the site is interpreted to have a medium degree of compressibility.

The following is a tabulated summary of the Atterberg limits test results discussed above.

Hole ID	Depth (m)		Liquid Limit	Plastic Limit	Plastic Index
	From	To			
BH1	3.00	3.45	41	15	26
BH6	1.50	1.95	56	17	39
BH7	6.00	9.00	54	17	37
BH7	4.50	4.95	40	17	23
BH7	1.50	1.95	39	17	22

Table 7 – Atterberg parameters

5.2.2 Particle Size Distribution

Particle size distribution analysis evaluates the relative portions of different sizes of soil particles. From this, it is possible to determine whether the soil consists of predominantly gravel, sand, silt or clay sizes and, to a limited extent, which of these size ranges is likely to control the engineering properties of the soil.

Representative soil specimens were analyzed for particle size distribution through wet sieving. The grading test results concur with the borehole logs by indicating prevalence of granular soil at the project site. As indicated on the table below, the recorded fines (< 0.063 mm) from the sieve test range from 3% to 44% averaging at 20%.

Hole ID	Depth (m)		Fines (%) (< 0.063mm)	Sand (%) (0.063 – 2 mm)	Gravel (%) (2mm – 60 mm)
	From	To			
BH1	3.0	6.0	3	97	0
BH2	0.0	3.0	34	66	0
BH2	3.0	6.0	27	71	2
BH2	6.0	9.0	21	77	2
BH3	6.0	9.0	7	93	0
BH4	3.0	6.0	5	93	2
BH4	6.0	9.0	35	63	2
BH5	6.0	9.0	44	56	0
BH6	6.0	9.0	7	93	0

Table 8 – Sieve analysis results

5.2.3 Bulk Density and Moisture Content

The bulk densities (ρ) of the SPT soil samples were determined through direct measurements. The samples were then examined for natural moisture content (w) by oven-drying at 110 °C and expressing the mass lost after drying as a percentage of the resulting dry soil mass. Finally, the dry density (ρ_d) of the samples were calculated from their bulk densities and moisture contents using the equation below:

$$\boldsymbol{\rho_d = \frac{\rho}{1 + w}}$$

The density test results are tabulated below:

Hole ID	Depth (m)		Bulk Density (kg/m^3)	Bulk Unit Weight (kN/m^3)	Dry Density (kg/m^3)	Dry Unit Weight (kN/m^3)	Moisture Content (%)
	From	To					
BH1	0.0	3.0	1987	19.49	1965	19.28	1.1
BH2	1.5	1.95	1980	19.42	1675	16.43	18.2
BH2	-	-	1962	19.25	1736	17.03	13.0
BH2	10.0	10.45	1937	19.00	1616	15.85	19.9
BH3	4.5	4.95	1909	18.73	1716	16.83	11.2
BH3	10.0	10.45	1966	19.29	1873	18.37	5.0
BH4	1.5	1.95	2072	20.33	1794	17.60	15.5
BH4	10.0	10.45	1970	19.33	1276	12.52	54.4
BH5	4.5	4.95	2037	19.98	1637	16.06	24.4
BH6	1.5	1.95	1979	19.41	1736	17.03	14.0
BH6	4.5	4.95	1983	19.45	1753	17.20	13.1
BH7	1.5	1.95	2031	19.92	1815	17.81	11.9
BH7	4.5	4.95	2073	20.34	1745	17.12	18.8

Table 9 - Summary of soil densities

5.2.4 Direct Shear Parameters

The shear strength of a soil is controlled by the effective stress that acts upon it. Disturbed soil samples were remolded and tested for the drained (effective) shear parameters: cohesion (c') and the angle of internal friction (φ').

The typical test specimen was placed in a shear box apparatus and subjected to a constant vertical pressure while a horizontal force was applied to the setup such that the specimen sheared in half along a failure plane guided by the two halves of the shear box and failure occurred within about 5 minutes (rate of about 0.01 mm/min). A summary of the direct shear tests is provided below:

Hole ID	Depth (m)		Shear Parameters	
	From	To	∅ (°)	*c* (kN/m^2)
BH1	0.0	3.0	33.7	18.47
BH2	0.0	3.0	33.7	28.79
BH3	0.0	3.0	32.2	25.04
BH3	3.0	6.0	32.7	29.08
BH6	0.0	3.0	30.0	35.26
BH4	2.8	3.0	30.1	21.21
BH4	3.0	6.0	27.8	29.83

Table 10 - Summary of direct shear parameters

5.2.5 Unconsolidated Undrained Triaxial Test

In triaxial tests, a cylindrical soil specimen with a height approximately equal to twice its diameter is placed in a triaxial cell and subjected to three stresses at right angles to each other. The test consists of two phases, the consolidation phase and the shear phase.

The UU (Q) triaxial test was performed on undisturbed soil samples. In the test, each specimen (assumed saturated) was first subjected to a confining pressure and then the principal stress difference applied immediately without permitting drainage (i.e. no consolidation) at any phase of the test. In this case, the applied confining pressure was not entirely carried by the soil skeleton but rather also resulted in an increase in pore water pressure. Since the pore and back

pressures are not measured in the UU test, the results have been interpreted in terms of total stress over a confinement pressure. The UU test was repeated for three different confining pressures and the results are summarized below:

Hole ID	Depth (m)		Undrained Shear Parameters	
	From	To	Angle of Shear Resistance, φ_u (°)	Cohesion, c_u (kN/m^2)
BH1	3.0	6.0	11.8	10.9
BH2	9.0	9.45	21.0	25.7
BH3	0.0	3.0	22.8	12.36
BH4	3.0	6.0	20.6	18.8
BH5	0.0	3.0	22.8	12.38
BH6	0.0	3.0	21.0	18.4

Table 11 - Undrained shear parameters

5.2.6 One Dimensional Consolidation

The objective of the consolidation test was to determine the compressibility characteristics of the soil found at the site. The test entailed determination of the magnitude and rate of the consolidation of a saturated or near-saturated specimen of soil in the form of a disc confined laterally, subjected to vertical axial pressure, and allowed to drain freely from the top and bottom surfaces. The consolidation test was performed on undisturbed soil specimens.

Each test sample was loaded axially in increments, whereby each stress increment was held constant until the primary consolidation was complete. The following table provides the results of the consolidation testing including the inferred settlement parameters. The settlement parameters listed in the table are defined below:

$\boldsymbol{\sigma}$ = Pressure increment (kN/m^2)

$\boldsymbol{M_v}$ = Coefficient of volume compressibility (m^2/MN)

$\boldsymbol{e}$ = Voids ratio

$\boldsymbol{E_{oed}}$ = Oedometric Modulus (kN/m^2)

Hole ID	Depth (m)		σ	M_v	Description	E_{oed}	e
	From	To					

BH1	0.0	3.0	0	-	-	-	0.32
			25	0.54	High	1.9	0.30
			25	0.59	High	1.7	0.28
			50	0.37	High	2.7	0.26
			100	0.17	Medium	5.9	0.24
			200	0.10	Low	10.0	0.22
			400	-	-	-	0.19
BH2	0.0	3.0	0	-	-	-	0.48
			25	0.56	High	1.8	0.45
			25	0.59	High	1.7	0.43
			50	0.37	High	2.7	0.41
			100	0.18	Medium	5.6	0.38
			200	0.10	Low	10.0	0.36
			400	-	-	-	0.33
BH2	3.0	6.0	0	-	-	-	0.34
			25	0.40	High	2.5	0.31
			25	0.49	High	2.0	0.30
			50	0.28	Medium	3.6	0.28
			100	0.16	Medium	6.3	0.26
			200	0.09	Low	11.1	0.24
			400	-	-	-	0.22
BH3	0.0	3.0	0	-	-	-	0.44
			25	0.52	High	1.9	0.41
			25	0.80	High	1.3	0.39
			50	0.44	High	2.3	0.37
			100	0.23	Medium	4.3	0.34
			200	0.12	Medium	8.3	0.31
			400	-	-	-	0.27
BH3	3.0	6.0	0	-	-	-	0.61
			25	0.55	High	1.8	0.58
			25	0.85	High	1.2	0.56

			50	0.44	High	2.3	0.53
			100	0.31	High	3.2	0.49
			200	0.18	Medium	5.6	0.45
			400	-	-	-	0.39
BH4	0.0	3.0	0	-	-	-	0.63
			25	1.00	High	1.0	0.56
			25	1.23	High	0.8	0.52
			50	0.60	High	1.7	0.47
			100	0.32	High	3.1	0.43
			200	0.16	Medium	6.3	0.39
			400	-	-	-	0.34
BH5	3.0	6.0	0	-	-	-	0.63
			25	0.38	High	2.6	0.61
			25	0.60	High	1.7	0.60
			50	0.43	High	2.3	0.57
			100	0.30	Medium	3.3	0.54
			200	0.15	Medium	6.7	0.49
			400	-	-	-	0.45
BH6	0.0	3.0	0	-	-	-	0.43
			25	0.41	High	2.4	0.41
			25	0.66	High	1.5	0.40
			50	0.38	High	2.6	0.38
			100	0.29	Medium	3.4	0.35
			200	0.13	Medium	7.7	0.31
			400	-	-	-	0.28

Table 12 - Summary of consolidation parameters

6.0 RECOMMENDATIONS

6.1 General

The recommendations and conclusions provided herein are based on the following:

- General observations made during field exploration,
- Field and laboratory test results,
- Experience with similar conditions at other sites, and
- Research of generally accepted geotechnical engineering principles and practices.

It should be noted that all interpretations of geotechnical data involve a degree of uncertainty because of the differing origins, inherent variability, and innumerable complexities associated with natural materials. If the encountered subsurface conditions differ from those forming the basis of our recommendations, we should be informed in order to assess the need for amendments.

6.2 Geotechnical Model

Field logs and laboratory sieve analysis confirm that the prevalent soil type at the site is sand soil.

6.3 Bearing Capacity for Shallow Foundations

Typical size (1 m to 3.0 m) spread and strip foundations, both embedded to typical depths between 1.2 m and 3 m below ground level, were considered for bearing capacity analysis using the equations below based on the classic theories by Terzaghi (1943) and the average soil parameters as obtained from laboratory tests.

Strip footings: $$q_u = cN_c + \gamma D_f N_q + 0.5\gamma B N_\gamma$$

Square foundations: $$q_u = 1.3cN_c + \gamma D_f N_q + 0.4\gamma B N_\gamma$$

Rectangular foundations: $$q_u = cN_c\left(1 + 0.3\frac{B}{L}\right) + \gamma D_f N_q + 0.5\gamma B N_\gamma\left(1 - 0.2\frac{B}{L}\right)$$

Where,

q_u = Ultimate bearing capacity

c = Soil cohesion

$\emptyset$ = Angle of internal friction

γ = Effective unit weight of soil

B = Width of the foundation

L = Length of the foundation

$\boldsymbol{D_f}$ = Foundation depth

$\boldsymbol{N_c, N_q, N_\gamma}$ = Terzaghi's bearing capacity factors for general shear failure (see Figure 4)

A factor of safety (F.O.S) of 6 was used to compute the allowable bearing capacity ($\boldsymbol{q_a}$) from the ultimate capacity. The calculation results are tabulated below:

Foundation Details				$\boldsymbol{q_a}$ **(kN/m^2)**
Type	$\boldsymbol{D_f}$ **(m)**	**B (m)**	**L (m)**	
Strip	1.2	1.2	>>1.2	333
		1.5	>>1.5	353
		2.0	>>2.0	373
		2.5	>>2.5	393
		3.0	>>3.0	413
	1.5	1.2	>>1.2	359
		1.5	>>1.5	379
		2.0	>>2.0	399
		2.5	>>2.5	419
		3.0	>>3.0	440
	2.0	1.2	>>1.2	402
		1.5	>>1.5	422
		2.0	>>2.0	443
		2.5	>>2.5	463
		3.0	>>3.0	483
	2.5	1.2	>>1.2	446
		1.5	>>1.5	466
		2.0	>>2.0	486
		2.5	>>2.5	506
		3.0	>>3.0	526
	3.0	1.2	>>1.2	489
		1.5	>>1.5	509
		2.0	>>2.0	530

		2.5	>>2.5	550
		3.0	>>3.0	570
Spread	1.2	1.2	1.2	381
		1.5	1.5	397
		2.0	2.0	413
		2.5	2.5	429
		3.0	3.0	446
	1.5	1.2	1.2	407
		1.5	1.5	423
		2.0	2.0	439
		2.5	2.5	455
		3.0	3.0	472
	2.0	1.2	1.2	450
		1.5	1.5	467
		2.0	2.0	483
		2.5	2.5	499
		3.0	3.0	515
	2.5	1.2	1.2	494
		1.5	1.5	510
		2.0	2.0	526
		2.5	2.5	542
		3.0	3.0	559
	3.0	1.2	1.2	537
		1.5	1.5	554
		2.0	2.0	570
		2.5	2.5	586
		3.0	3.0	602
Parameters used:				

$c = 26.81$ (kN/m^2)	*- Average of cohesion from direct shear tests*
$\emptyset = 31.45°$	*- Average of friction angle from direct shear tests*
$\gamma = 19.53$ (kN/m^3)	*- Average of bulk unit weight*
$N_c = 42.05$	*- Acquired from chart of bearing capacity factors*
$N_q = 26.72$	*- Acquired from chart of bearing capacity factors*
$N_\gamma = 24.82$	*- Acquired from chart of bearing capacity factors*

Table 13 - Bearing capacity calculation results

The bearing capacities of strip and square foundations of intermediate dimensions and/or founded at intermediate depths can be acquired from linear interpolation of the respective values above.

Due to the many possible combinations of length (L) width (B) and depth (D_f) for rectangular foundations, our analysis does not provide bearing capacities for the same. However, the designer can incorporate our soil parameters into the provided equation for rectangular foundations and compute the bearing capacity of the desired configuration of the rectangular foundation. Generally, the bearing capacity of rectangular foundations computed using the classic equations lies between that for similar width strip and spread footings.

The table below presents our recommended design bearing pressures for strip and spread foundations of widths not exceeding 3 m.

Depth (m)	**Design Bearing Capacity (kN/m^2)**
1.2	330
1.5	355
2.0	420
2.5	445
3.0	485

Table 14 – Recommended design pressures

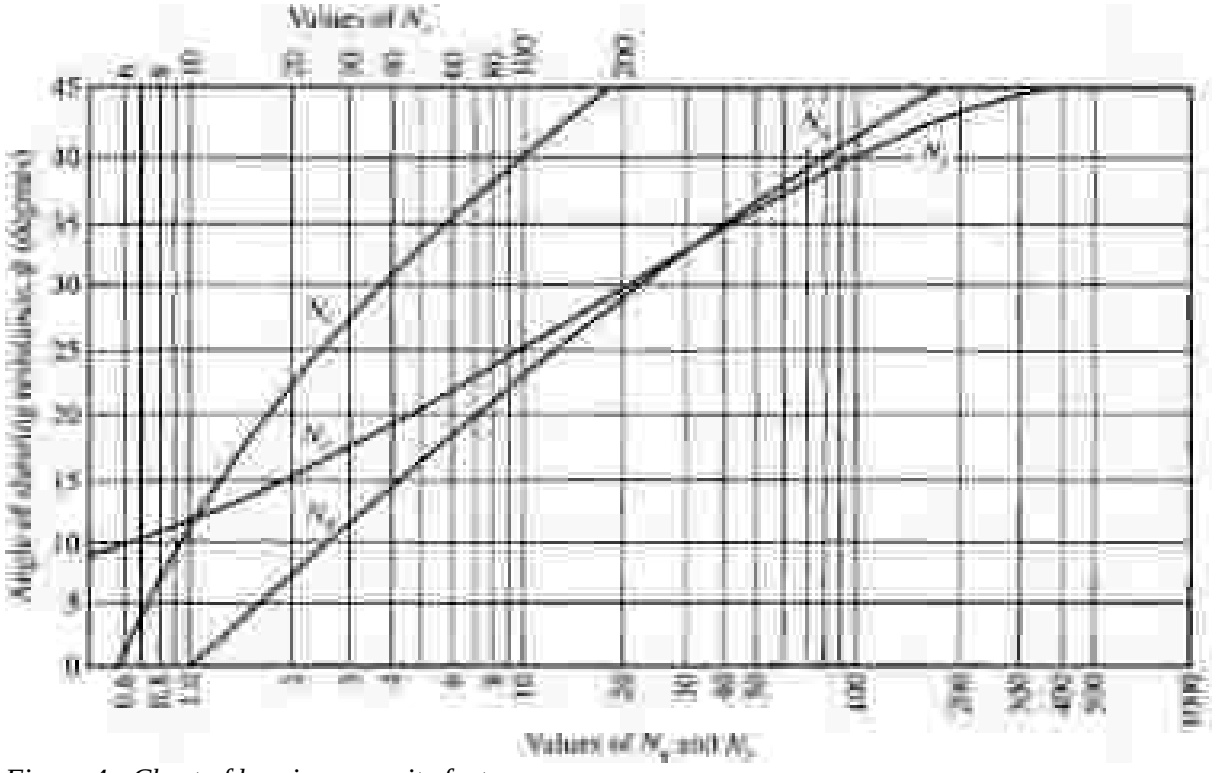


Figure 4 - Chart of bearing capacity factors

6.4 Excavation

The silty soil at the site can be categorized as Type B to Type C soil according to OHSA (Occupational Safety and Health Administration, USA). Therefore, battered slopes of 1.5H:1V are considered safe when excavating the in situ soil to depths not exceeding 6 m (and above water table). Shoring systems will be required to support excavations extending below the static ground water level.

6.5 Backfill and Reuse of Excavated Spoil

It has been established that the soil at the site consists of both fine and coarse soil, with the latter being predominant. The 'mixed' soil is therefore not recommended for reuse as engineering/structural fill.

Instead, granular and non-expansive soil (preferably SC soil) of consistent soil structure can be imported for use as structural backfill. The engineering fill should be placed in 150 mm lifts and compacted to at least 95% of its Standard Proctor maximum dry density. Alternatively, the excavated areas can also be backfilled with selected approved hard-core.

7.0 CONCLUSION

The subsoil condition at the site is primarily granular and suitable for the support of shallow foundations.

8.0 LIMITATIONS

This report was prepared by SHANXI CONSTRUCTION ENGINEERING CORPORATION AND MINERAL COMPANY for the exclusive use of DAWASA. The intent of the report was to provide geotechnical engineering information on the subsurface to support the design and construction of the proposed faecal sludge treatment plat, and not for other purposes. The report is site specific and not applicable to any other property.

This assessment has been carried out using engineering analysis methods consistent with those ordinarily exercised by SHANXI CONSTRUCTION ENGINEERING CORPORATION AND MINERAL COMPANY and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. It must be recognized that there are risks whenever engineering or related disciplines are applied to identify subsurface conditions. A comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions.

It must also be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Therefore, the findings of this geotechnical investigation are valid for the design of the proposed plant assuming no significant time gap between the investigation and actual construction.

Professional judgement was exercised in gathering and analyzing the information reported in this document. The conclusions presented in this report are the product of professional care and competence, but **cannot** be construed as an absolute guarantee. We iterate that if the encountered subsurface conditions differ from those forming the basis of our recommendations, we should be informed in order to assess the need for amendments.

We trust the foregoing information is sufficient for your present requirements in the design and construction of the plant.

APPENDIX I – Logs and Cross Section

Borehole Logs

ABBREVIATIONS AND BASIS OF DESCRIPTIONS

Weathering Grades

I: Fresh & Hard
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil

Recovery Properties

TCR: Total Core Recovery
RQD: Rock Quality Designation

Sample Type

DS: Disturb Sample
CS: Core Sample

Fracture Properties

CF: Clean & Hard
SF: Shattered
R: Rough and Irregular

Fracture Index

Fr: Fracture Material

DYNAMIC CONE PENETRATION TEST

Dynamic Cone Penetration Test (DCPT) involves driving a 60° steel cone into the ground using an 8 kg sliding hammer over a 575 mm drop height and recording the penetration for every blow.

STANDARD PENETRATION TEST

Standard Penetration Test (SPT) is an in-situ dynamic penetration test that entails the driving of a split spoon sampler into soil at the bottom of the open borehole by dropping a standard weight (63.5 kg) hammer through a standard fall (760 mm) and recording the number of blows (N) required to achieve 300 mm penetration after an initial seating drive of 150 mm or 25 blows, whichever is achieved first (BS EN ISO 22476-3). Blow counts in excess of 50 in the 300 mm test phase are recorded as "refusal" to penetration and abbreviated 'Ref' in the logs. Below are typical consistency descriptions of soils based on N - values. Note that SPT is not normally carried out in soft cohesive soils (as the sampler tends to deform) so the standard method does not apply.

Cohesionless Soils

Relative Density	N - Value
Very Loose	< 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	> 50

Source: BS 5930:2015

Cohesive Soils

Consistency	Undrained Shear Strength, kPa	N - Value
Very Soft	< 12	< 2
Soft	12 - 25	2 - 4
Firm	25 - 50	4 - 8
Stiff	50 - 100	8 - 15
Very Stiff	100 - 200	15 - 30
Hard	> 200	> 30

Source: Canadian Foundation Engineering Manual (as cited in Terzaghi and Peck 1967)

SPT Correction Factors

Hammer Energy Ratio, E_r = 90%

C_b = 0.75 (pad length 3 - 4 m)

C_s = 1.0 (side diameter 65 - 115 mm)

C_r = 1 (standard sampler)

$\therefore N_{60} = 1 \times N_m$

Source: BS EN ISO 22476-3

FIELD MOISTURE DESCRIPTIONS

Dry – refers to a soil sample with a moisture content well below optimum ($w < w_{opt}$), absence of moisture, dusty, dry to the touch.

Moist – refers to a soil sample with a moisture content at or near optimum ($w \approx w_{opt}$), no visible pore water.

Wet – refers to a soil sample with a moisture content well above optimum ($w > w_{opt}$), has visible pore water.

ROCK DESCRIPTIONS

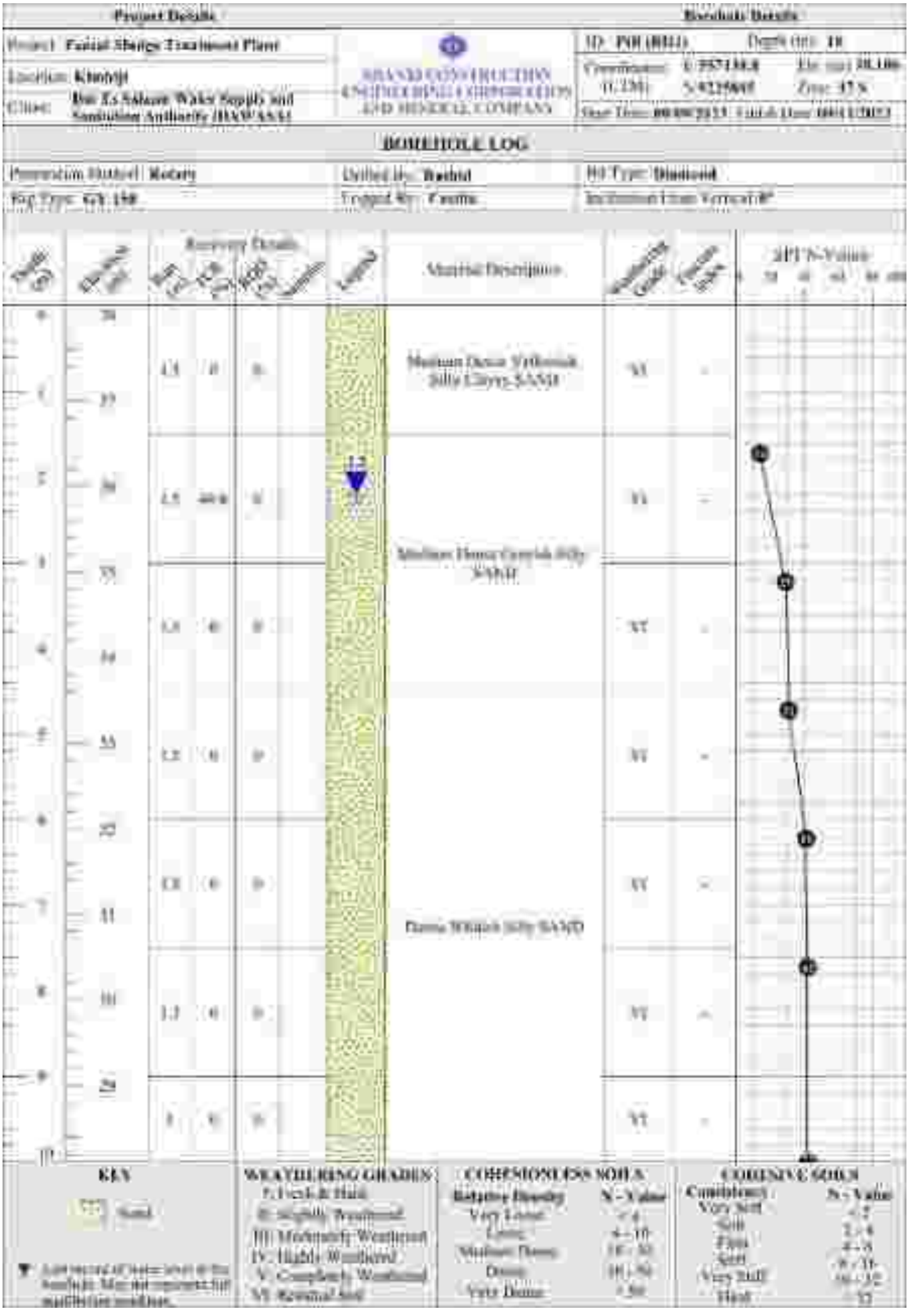
RQD (%)	Rock Mass Quality
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

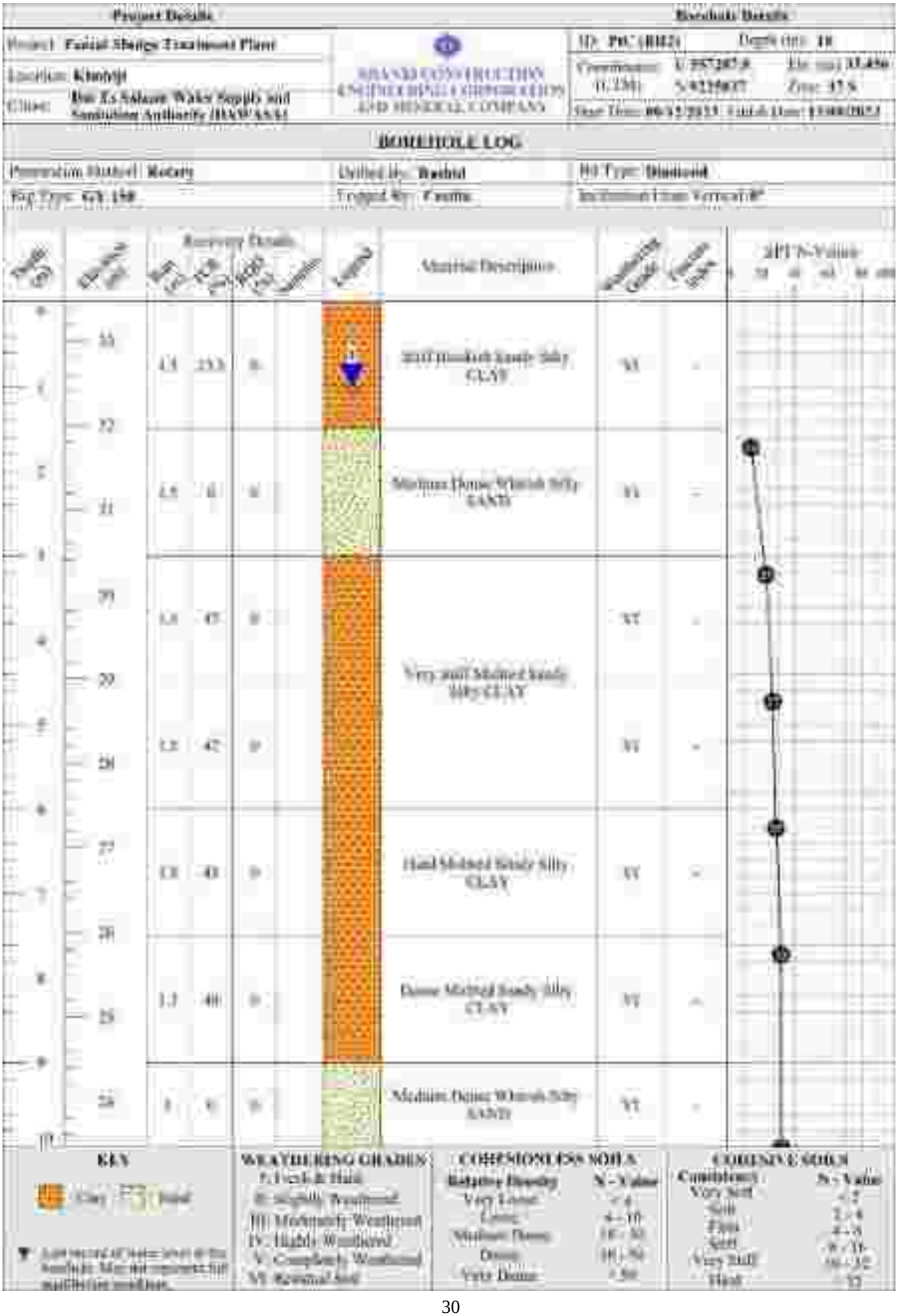
Compressive Strength (MPa)	Strength Classification
< 1	Extremely Weak
1 - 5	Very Weak
5 - 25	Weak
25 - 50	Medium Strong
50 - 100	Strong
100 - 150	Very Strong
> 250	Extremely Strong

Source: Rock Mass Rating (RMR) system by Bieniawski (1989)

SYMBOLS

▼ Last record of water level in the borehole. May not represent full equilibrium condition.


Project Details
Borehole Details
Project: Eastern Sludge Treatment Plant
Location: Kisumu
Client: Kisumu Water Supply and Sanitation Authority (KIWASAS)
BRANCO CONSTRUCTION
CONSTRUCTION CONTRACTORS
AND SERVICE COMPANY
ID: PH (BH1)
Depth (m): 18
Coordinates (UTM): E 0357183.8 N 9925869
Elevation: 1138.186
Zone: 37 S
Start Time: 08/08/2019 End Time: 09/08/2019
BOREHOLE LOG
Penetration Method: Rotary
Drilled By: Bashid
Rig Type: Diamond
Rig Type: GX-150
Logged By: Fredrick
Inclination from Vertical: 0°
Recovery Details
Material Description
SPT N-Value
Medium Dense Yellowish Silty Clayey SAND
Medium Dense Greyish Silty SAND
Dense Whitish Silty SAND
KEY
WEATHERING GRADES
I: Fresh Rock
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil
COHESIONLESS SOILS
Relative Density
N - Value
Very Loose
< 4
Loose
4 – 10
Medium Dense
10 – 30
Dense
30 – 50
Very Dense
> 50
COHESIVE SOILS
Consistency
N - Value
Very Stiff
8 – 15
Stiff
15 – 30
Hard
> 30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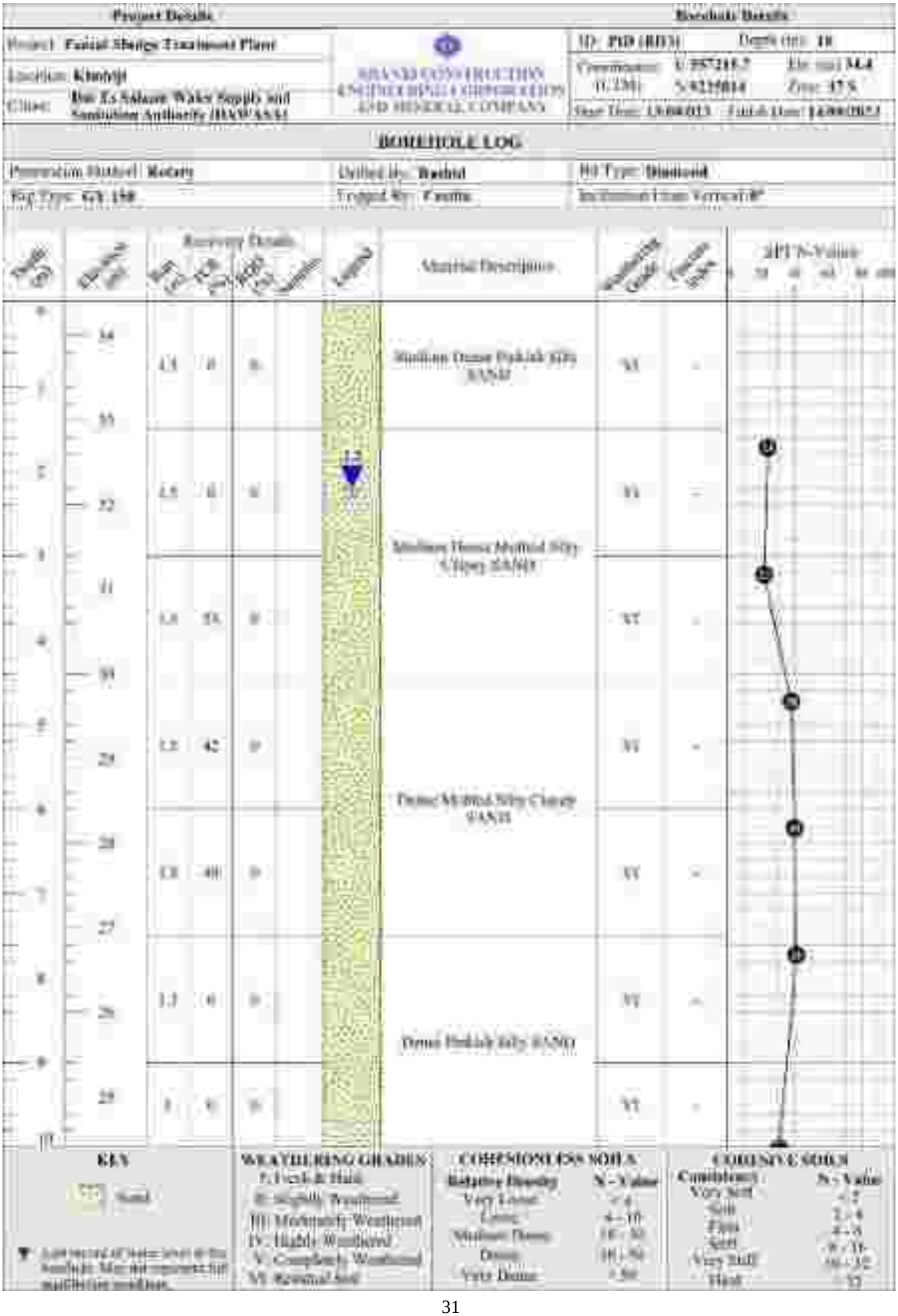
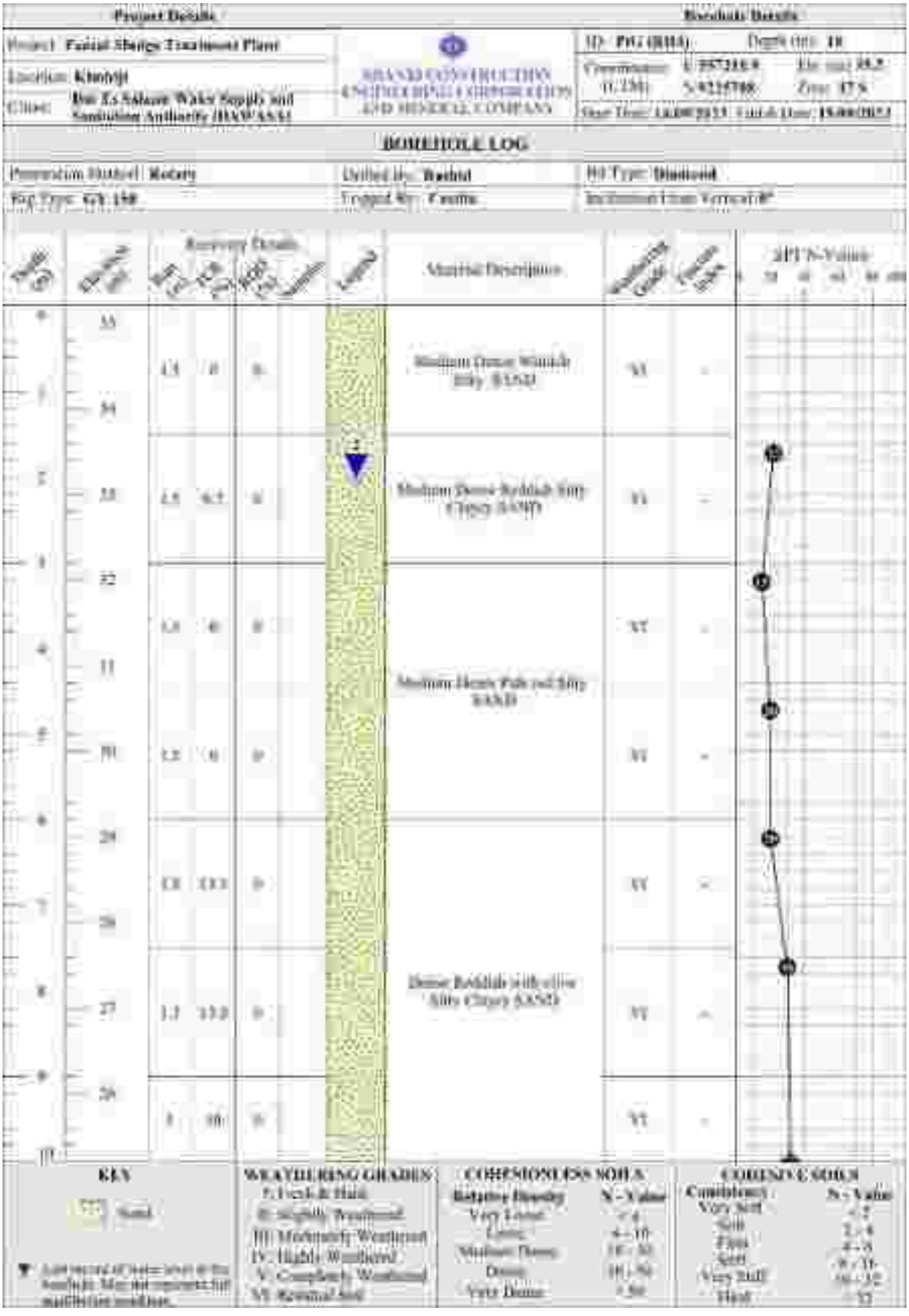
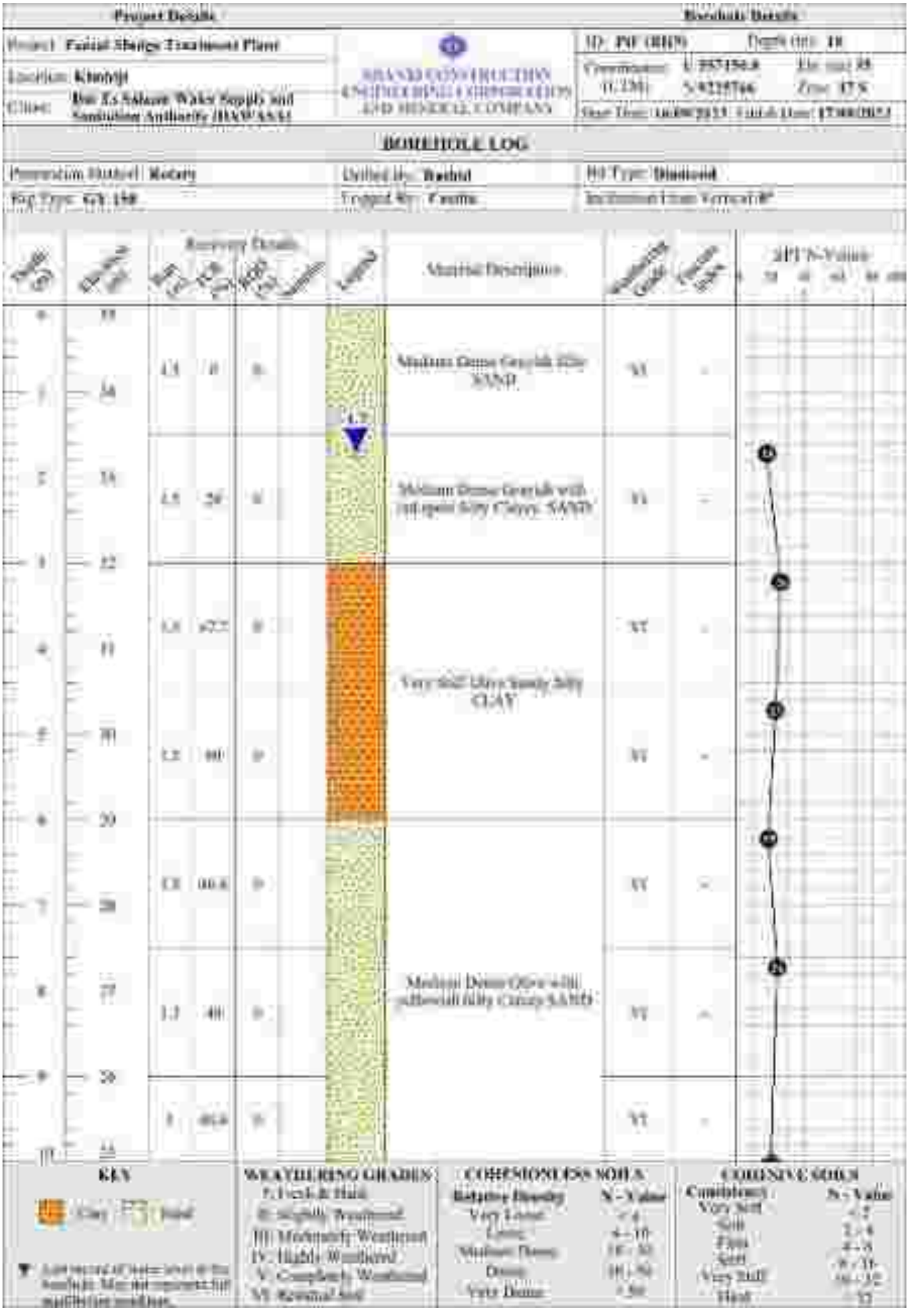
Borehole Details
Project: Eastern Sludge Treatment Plant
Location: Kisumu
Client: Kisumu Water Supply and Sanitation Authority (KIWASAS)
BRANDCO CONSTRUCTION ENGINEERING CORPORATION AND BRANDCO COMPANY
ID: PH7 (BH2)
Depth (m): 10
Coordinates (UTM): E 357207.9 N 9925837
Elevation: 1134.456
Zone: 37 S
Start Time: 08/12/2019
Finish Time: 13/08/2019
BOREHOLE LOG
Penetration Method: Rotary
Drilled By: Brabut
Rig Type: GX 150
Logged By: Fredrik
Bit Type: Diamond
Inclination from Vertical: 0°
Recovery Details
Material Description
SPT N-Value
Very soft Mottled Sandy Silty CLAY
Medium Dense Mottled Silty SAND
Very soft Mottled Sandy Silty CLAY
Very soft Mottled Sandy Silty CLAY
Hard Mottled Sandy Silty CLAY
Dense Mottled Sandy Silty CLAY
Medium Dense Mottled Silty SAND
KEY
Clay
Silt
WEATHERING GRADES
I: Fresh Rock
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil
COHESIONLESS SOILS
Relative Density
N - Value
Very Loose
< 4
Loose
4 – 10
Medium Dense
10 – 30
Dense
30 – 50
Very Dense
> 50
COHESIVE SOILS
Consistency
N - Value
Very Soft
< 2
Soft
2 – 4
Firm
4 – 8
Stiff
8 – 15
Very Stiff
15 – 30
Hard
> 30


Project Details
Borehole Details
Project: Fadiel Sludge Treatment Plant
Location: Khayelitsha
Client: Bulk Bulk Sewer Water Supply and Sanitation Authority (BWSSA)
BRANDCO CONSTRUCTION
ENGINEERING CONSTRUCTION
AND MINERAL COMPANY
ID: PID (BD3)
Depth (m): 10
Coordinates (UTM): E 0357215.7 N 6225814
Elevation: 34.4
Zone: 33 S
Start Time: 13:00:03
Finish Time: 14:00:00
BOREHOLE LOG
Penetration Method: Rotary
Drilled By: Bashid
BH Type: Diamond
Rig Type: GX 150
Logged By: Fumba
Inclination from Vertical: 0°
Recovery Details
Material Description
SPT N-Value
Medium Dense Pinkish Silty SAND
Medium Dense Mottled Silty Clayey SAND
Dense Mottled Silty Clayey SAND
Dense Pinkish Silty SAND
KEY
Sand
WEATHERING GRADES
I: Fresh & Hard
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil
COHESIONLESS SOILS
Relative Density
N - Value
Very Loose
< 4
Loose
4 - 10
Medium Dense
10 - 30
Dense
30 - 50
Very Dense
> 50
COHESIVE SOILS
Consistency
N - Value
Very Soft
< 2
Soft
2 - 4
Firm
4 - 8
Stiff
8 - 15
Very Stiff
15 - 30
Hard
> 30


Project Details
Borehole Details
Project: Eastern Sludge Treatment Plant
Location: Kinoiji
Client: Nairobi Metropolitan Water Supply and Sanitation Authority (NAIWASS)
BRAND CONSTRUCTION ENGINEERING CONTRACTORS AND SERVICE COMPANY
ID: BH1 (BH4)
Depth (m): 10
Coordinates (UTM): E 257318.9 N 9215788
Elevation: 28.9
Zone: 37S
Start Time: 14:00:23/13 Finish Time: 15:00:00/13
BOREHOLE LOG
Penetration Method: Rotary
Drilled By: Rashid
Bit Type: Diamond
Rig Type: KX 150
Logged By: Faraja
Inclination from Vertical: 0°
Recovery Details
Material Description
SPT N-Value
55
54
53
52
51
50
49
48
47
46
4.5
6.5
11.0
13.0
KEY
WEATHERING GRADES
I: Fresh Rock
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil
COHESIONLESS SOILS
Relative Density
N - Value
Very Loose
< 4
Loose
4 – 10
Medium Dense
10 – 30
Dense
30 – 50
Very Dense
> 50
COHESIVE SOILS
Consistency
N - Value
Very Stiff
11 – 19
Hard
> 19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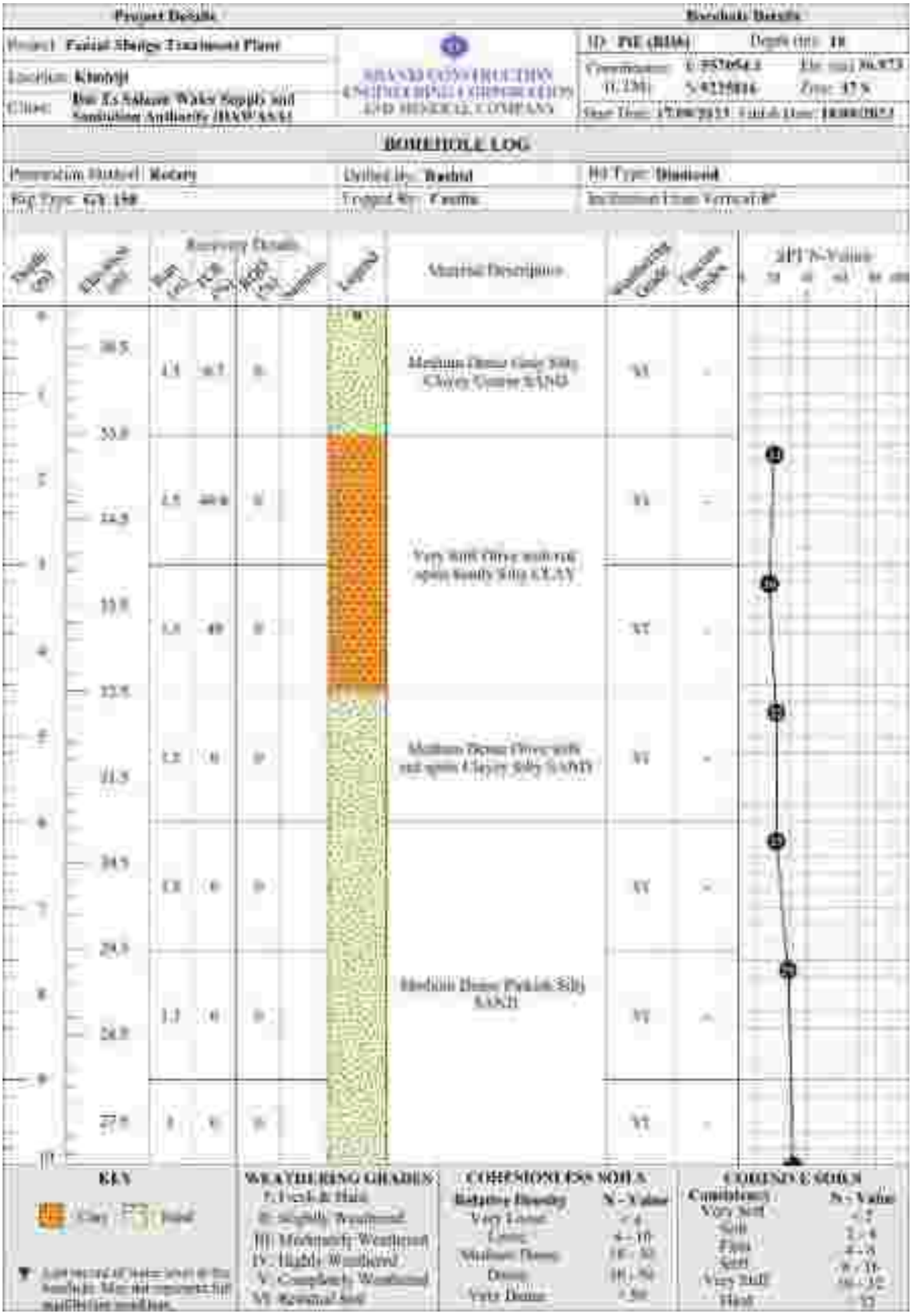
Borehole Details
Project: Eastern Sludge Treatment Plant
Location: Kinoyiti
Client: Nairobi Metropolitan Water Supply and Sanitation Authority (NAIWASS)
BRAND GOVINDJEE
GEOTECHNICAL CONSULTANTS
AND MINERAL COMPANY
ID: PH (BH9)
Depth (m): 10
Coordinates (UTM): E 357150.8 N 9225746
Elevation: 28
Zone: 37S
Start Time: 10/08/2015
Finish Time: 17/08/2015
BOREHOLE LOG
Penetration Method: Rotary
Drilled By: Bashid
Rig Type: Diamond
Rig Type: GX 150
Logged By: Fredrick
Inclination from Vertical: 0°
Recovery Details
Material Description
SPT N-Value
Medium Dense Greyish Silty SAND
Medium Dense Greyish with reddish Silty Clayey SAND
Very Stiff Grey Sandy Silty CLAY
Medium Dense Grey with yellowish Silty Clayey SAND
KEY
Clay
Silt
Sand
WEATHERING GRADES
I: Fresh Rock
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil
COHESIONLESS SOILS
Relative Density
N - Value
Very Loose
< 4
Loose
4 – 10
Medium Dense
10 – 30
Dense
30 – 50
Very Dense
> 50
COHESIVE SOILS
Consistency
N - Value
Very Stiff
8 – 15
Hard
> 15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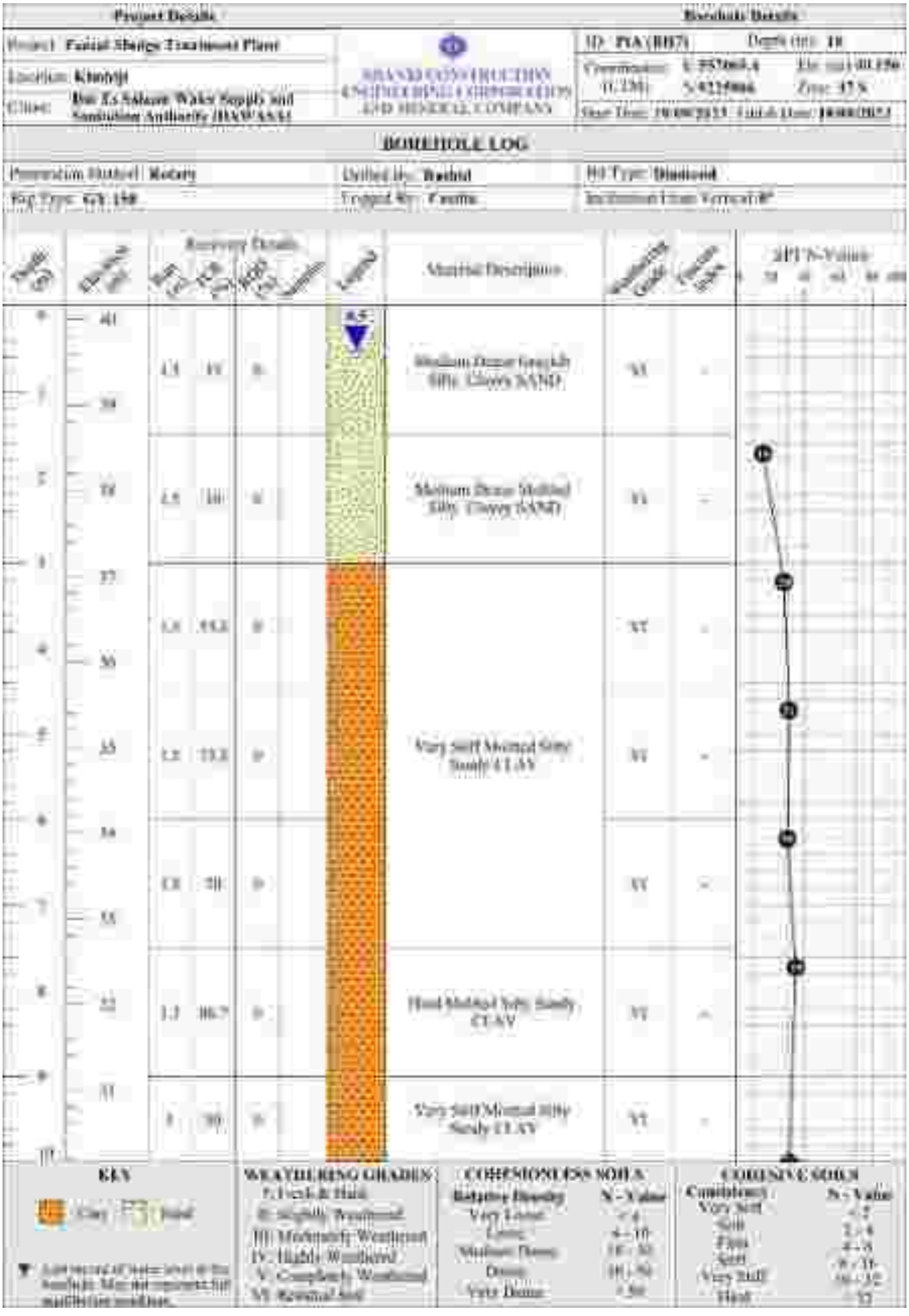
Location: Kinoyki
Client: Nairobi Metropolitan Water Supply and Sanitation Authority (NAIWASS)
BRAND CONSTRUCTION ENGINEERING CORPORATION AND HOUSE LIMITED
ID: PH (BH6)
Depth (m): 18
Coordinates (UTM): E 253654.2 N 9225816
Elevation: 36.973
Zone: 37 S
Start Time: 17/08/2023
Finish Time: 18/08/2023
BOREHOLE LOG
Penetration Method: Rotary
Drilled By: Bashid
Rig Type: Diamond
Rig Type: KX-150
Logged By: Fredrick
Inclination from Vertical: 0°
Recovery Details
Material Description
SPT N-Value
36.5
33.0
14.5
19.5
17.5
22.5
24.5
26.5
27.5
Medium Dense Grey Silty Clayey Coarse SAND
Very Soft Olive mottled light Sandy Silty CLAY
Medium Dense Olive with red spots Clayey Silty SAND
Medium Dense Pinkish Silty SAND
KEY
Clay
Sand
WEATHERING GRADES
I: Fresh Rock
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil
COHESIONLESS SOILS
Relative Density
N - Value
Very Loose
< 4
Loose
4 – 10
Medium Dense
10 – 30
Dense
30 – 50
Very Dense
> 50
COHESIVE SOILS
Consistency
N - Value
Very Soft
< 2
Soft
2 – 4
Firm
4 – 8
Stiff
8 – 15
Very Stiff
15 – 30
Hard
> 30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Project: Eastern Sludge Treatment Plant
Location: Kisumu
Client: Kisumu Water Supply and Sanitation Authority (KIWASAS)
BRAND GOVINDJI ENGINEERING CONSULTANTS AND BUILDING CONTRACTORS
ID: PSA(BH7)
Depth (m): 18
Coordinates (UTM): E 553663.4 N 9225986
Elevation: 1130
Zone: 37S
Start Date: 10/08/2023
Finish Date: 10/08/2023
BOREHOLE LOG
Penetration Method: Rotary
Drilled By: Bashid
Rig Type: Diamond
Rig Type: GX-150
Logged By: Fatma
Inclination from Vertical: 0°
Recovery Details
Material Description
SPT N-Value
REV
WEATHERING GRADES
I: Fresh Rock
II: Slightly Weathered
III: Moderately Weathered
IV: Highly Weathered
V: Completely Weathered
VI: Residual Soil
COHESIONLESS SOILS
Relative Density
N - Value
Very Loose
< 4
Loose
4 – 10
Medium Dense
10 – 30
Dense
30 – 50
Very Dense
> 50
COHESIVE SOILS
Consistency
N - Value
Very Stiff
8 – 15
Hard
> 15

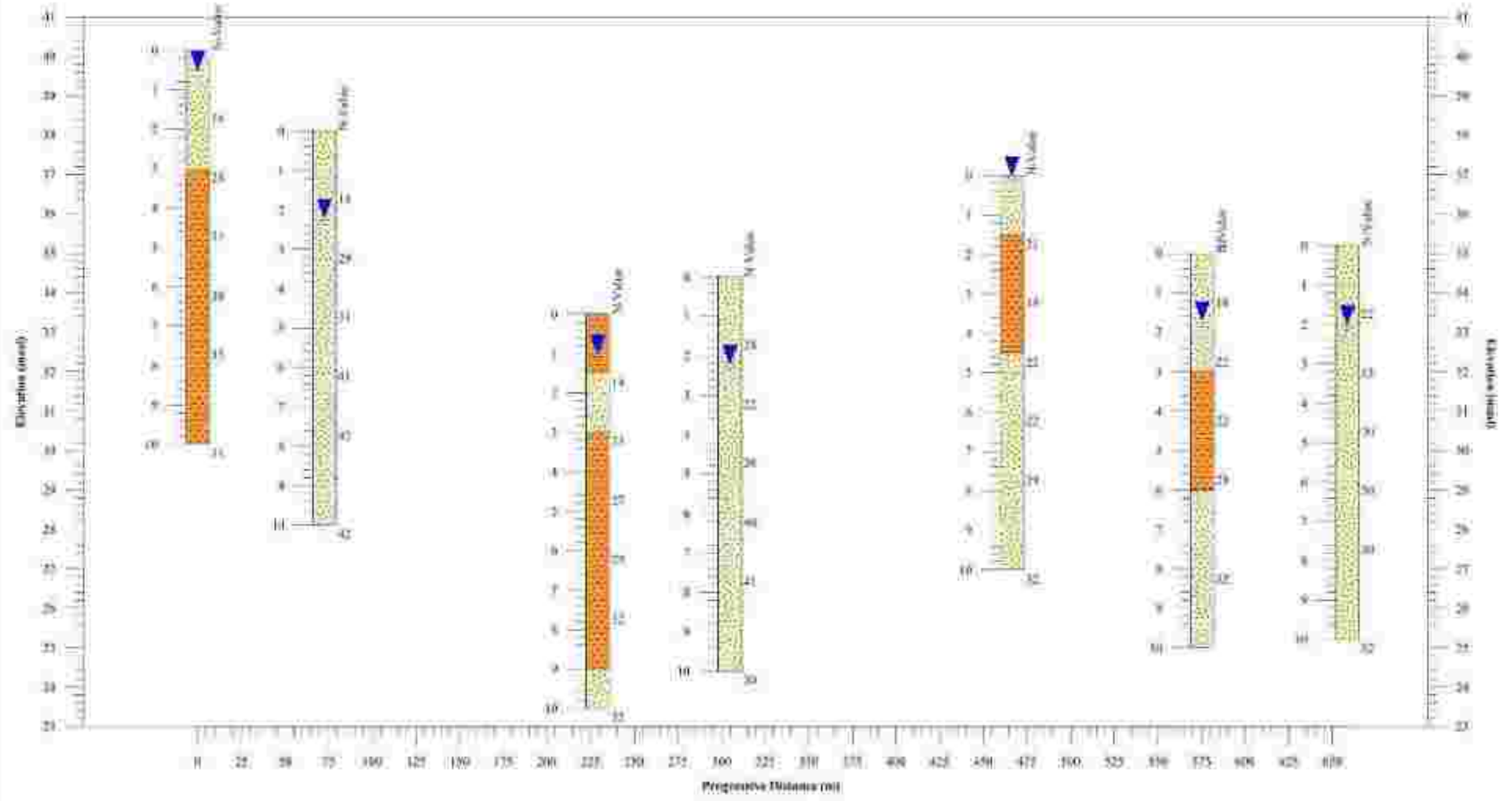
Project: Kinyerezi Sludge Treatment Plant

Location: Kinyerezi

Client: Dar Es Salaam Water Supply and Sanitation Authority

SHANXI CONSTRUCTION ENGINEERING CORPORATION AND MINERAL COMPANY

INFERRED GEOTECHNICAL CROSS SECTION



Key: Clay; Sand

APPENDIX II – Sample Photographs

BH1 (Pitfall): Box 1/2

BH1 (Pitfall): Box 2/2

BH2 (PtC): Box 1/2

BH2 (PtC): Box 2/2

BH3 (PtD): Box 1/2

BH3 (PtD): Box 2/2

BH4 (PtG): Box 1/2

BH4 (PtG): Box 2/2

BH5 (PtF): Box 1/2

BH5 (PtF): Box 2/2

BH6 (PtE): Box 1/2

BH6 (PtE): Box 2/2

BH7 (PtA): Box 1/2

BH7 (PtA): Box 2/2

APPENDIX III – References

References

1. British Standards Institution (2006) *BS 1377-2016, Method of Test for Soils for Civil Engineering Purposes.* London: British Standard Institution.
2. British Standards Institution (1999) *BS 5930-1999, Code of Practice for Site Investigations.* London: British Standard Institution.
3. Keneth L. (2013). International Journal of Research in Engineering and Science - *A Review of Engineering Geology in Tanzania.*
4. Murthy V.N.S (2007). *Advanced Foundation Engineering.* CBS Publishers and Distributors.
5. Robert W.D. (2010). *Foundation Engineering Handbook 2nd Ed*. Mc Graw Hill, New York.

APPENDIX IV – Laboratory Test Reports

Dar es Salaam Institute of Technology.
Civil & Building Engineering Department.
Materials Testing Laboratory.

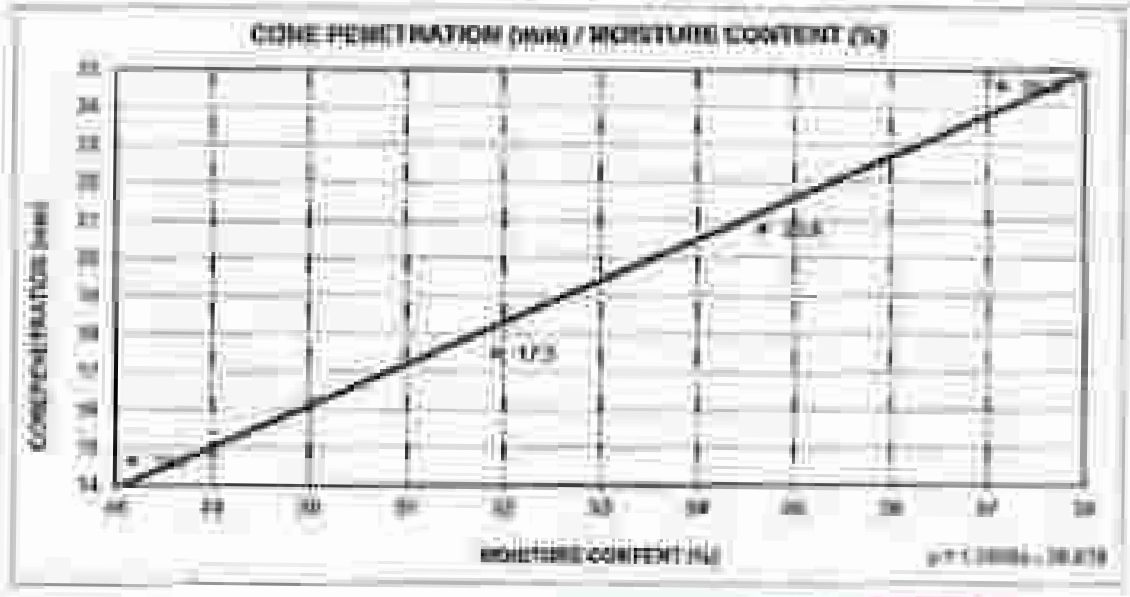
TZS 82:1987 | Part 116 : 1985

ATTERBERGS' LIMITS TEST

CLIENT : SHAKTI CONSTRUCTION COMPANY
LOCATION : KIMARA, DSM
OPERATOR : JAMES
DATE : 12.12.2023

BH No. 7
Sample No. SD
Depth(m): 4.00-4.50

Test No.		1		2		3		4			
TYPE OF TEST		LL		LL		LL		LL		PL	PL
Initial dial gauge reading	mm	1.5	1.7	1.5	1.6	1.5	1.5	1.5	1.6		
Final gauge reading	mm	16.5	16.7	19.0	19.6	23.4	23.5	26.5	26.1		
Cone penetration	mm	14.7		17.5		20.9		24.6			
Container No.		T10		T6		T7		T12		T17	T18
Mass of wet soil + container	gm	46.80		46.40		51.80		50.09		23.40	23.20
Mass of dry soil + container	gm	40.50		40.30		45.20		42.80		21.30	20.90
Mass of container	gm	32.30		32.10		36.20		33.10		5.10	5.00
Mass of moisture	gm	6.30		6.10		6.60		7.29		2.10	2.30
Mass of dry soil	gm	13.70		13.80		15.00		13.70		16.20	15.90
Moisture content (w)	%	45.98		44.20		44.00		97.14		12.97	14.47
Cone penetration	mm	14.7		17.5		20.8		24.6		17	



Liquid limit : 54
Plastic limit (PL) 17
Plasticity index (PI) 37

Dar es Salaam Institute of Technology.
Civil & Building Engineering Department.
Materials Testing Laboratory.

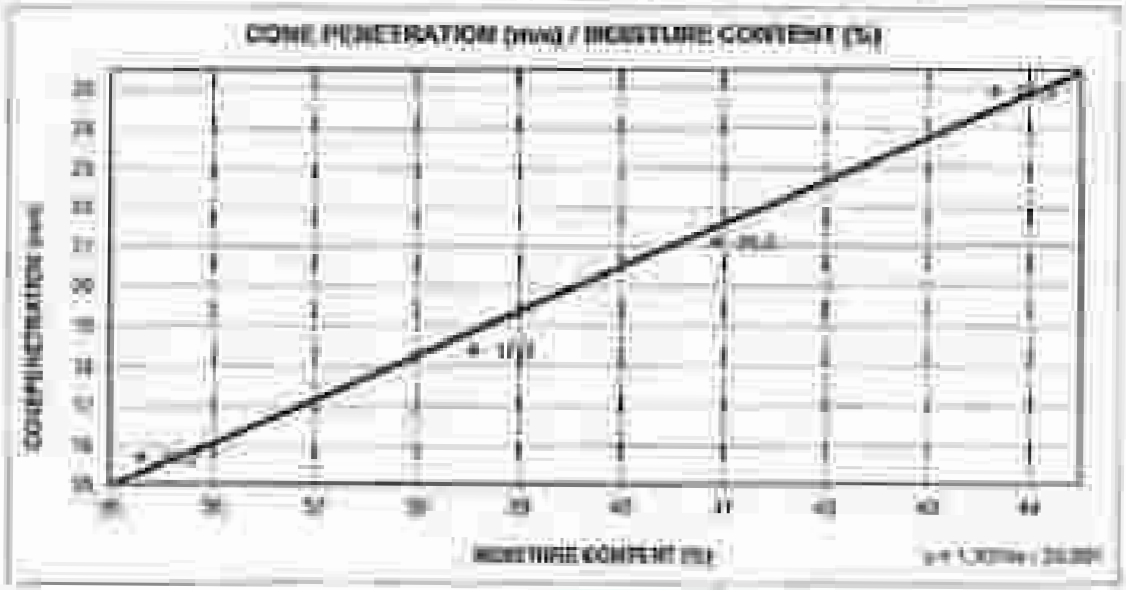
TO BS 1661 : Part 196 : 1985

ATTERBERGS' LIMITS TEST

CLIENT : SHANKI CONSTRUCTION COMPANY
LOCATION : KINSHA, DSM
OPERATOR : JAMES
DATE : 12.12.2023

BH No. 7
Sample No. DPT
Depth(m) 4.50-4.95

Trial No.		1		2		3		4			
TYPE OF TEST		LL		LL		LL		LL		PL	PL
No of full blow making	nos	16	17	15	13	15	16	15	14		
Final cone reading	mm	35.2	36.7	19.2	20.0	22.1	23.1	29.3	30.7		
Cone penetration	mm	15.2		17.2		22.6		34.5			
Container No.		T10		T6		T7		T12		T17	T18
Mass of wet soil + container	gm	47.50		53.40		50.60		47.80		27.10	25.80
Mass of dry soil + container	gm	41.80		47.80		43.80		41.60		24.90	23.10
Mass of container	gm	28.30		30.40		28.40		27.40		9.40	9.00
Mass of moisture	gm	5.70		5.60		6.80		6.20		2.20	2.70
Mass of dry soil	gm	13.50		17.40		15.40		14.20		15.50	13.50
Moisture content (w)	%	42.22		32.18		44.16		43.66		14.19	20.00
Cone penetration	mm	15.2		17.2		22.6		34.5		PI	



Liquid limit : 43
Plastic limit (PL) 17
Plasticity index (PI) 23

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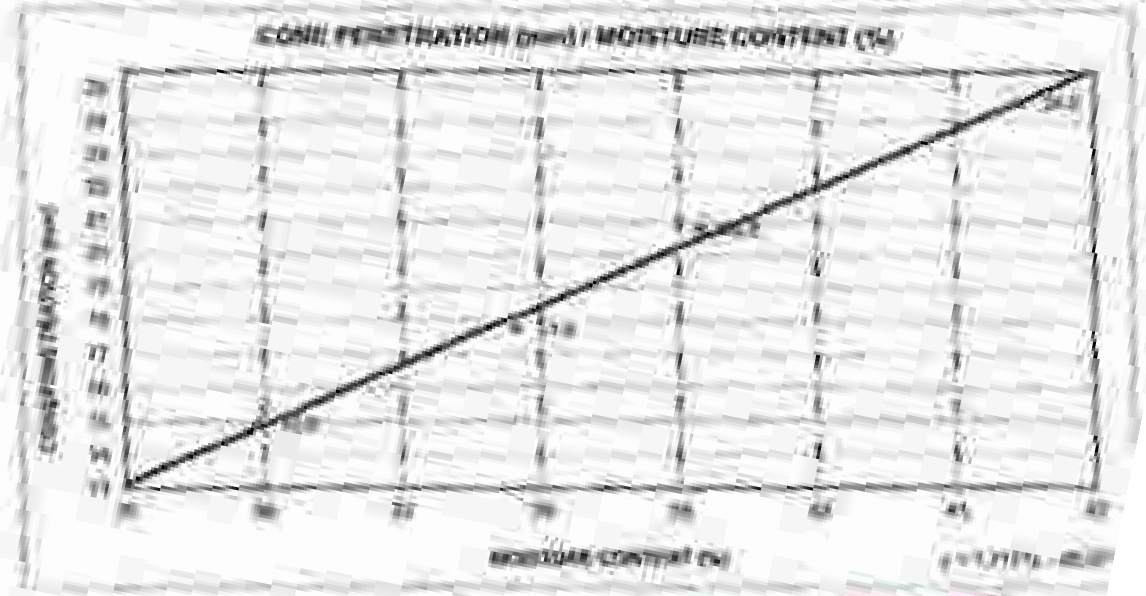
Civil & Building Engineering Department.
Materials Testing Laboratory.

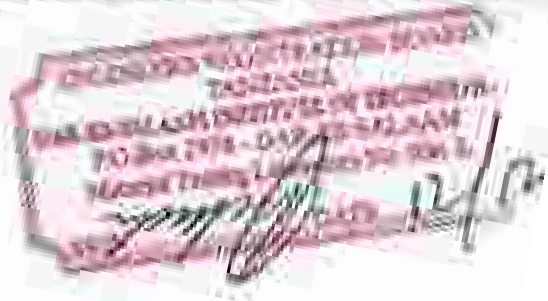
ATTERBERGS' LIMITS TEST

CLIENT :	SAMARI CONSTRUCTION COMPANY	BH No.	2
LOCATION :	KIMARA, DSM	Sample No.	SPT
OPERATOR :	JAMES	Depth(m)	1.50-1.95
DATE :	12.12.2021		

Test No.		1	2	3	4	PL	PL
NO. OF BLOW		42	34	28	21		
Mass of can + wet soil	gm	17.5	17.5	17.5	17.5	17.5	17.5
Mass of can + dry soil	gm	15.0	15.1	15.2	15.3	15.4	15.4
Mass of moisture	gm	2.5	2.4	2.3	2.2	2.1	2.1
Mass of can	gm	10.0	10.0	10.0	10.0		
Mass of dry soil	gm	5.0	5.1	5.2	5.3		
Moisture content	%	50.0	47.1	44.2	41.5		
Container No.		T08	T5	T7	T12	T10	T16
Mass of can + wet soil + Cup/Lever	gm	43.50	42.30	51.40	53.10	30.50	31.50
Mass of can + dry soil + Cup/Lever	gm	41.30	40.40	49.10	50.30	30.20	31.10
Mass of moisture	gm	2.20	1.90	2.30	2.80	0.30	0.40
Mass of Cup/Lever	gm	33.80	32.80	39.80	41.00	29.70	30.60
Mass of dry soil	gm	7.50	7.60	9.30	9.30	0.50	0.50
Mass of water	gm	4.50	4.20	5.20	5.60	3.70	3.80
Liquid limit	%	60.00	55.30	55.90	60.20	74.00	76.00
Flow index (Fi)	%	5.00	4.20	5.20	5.60	3.70	3.80



Liquid limit :	76
Plastic limit (PL)	17
Plasticity index (PI)	61



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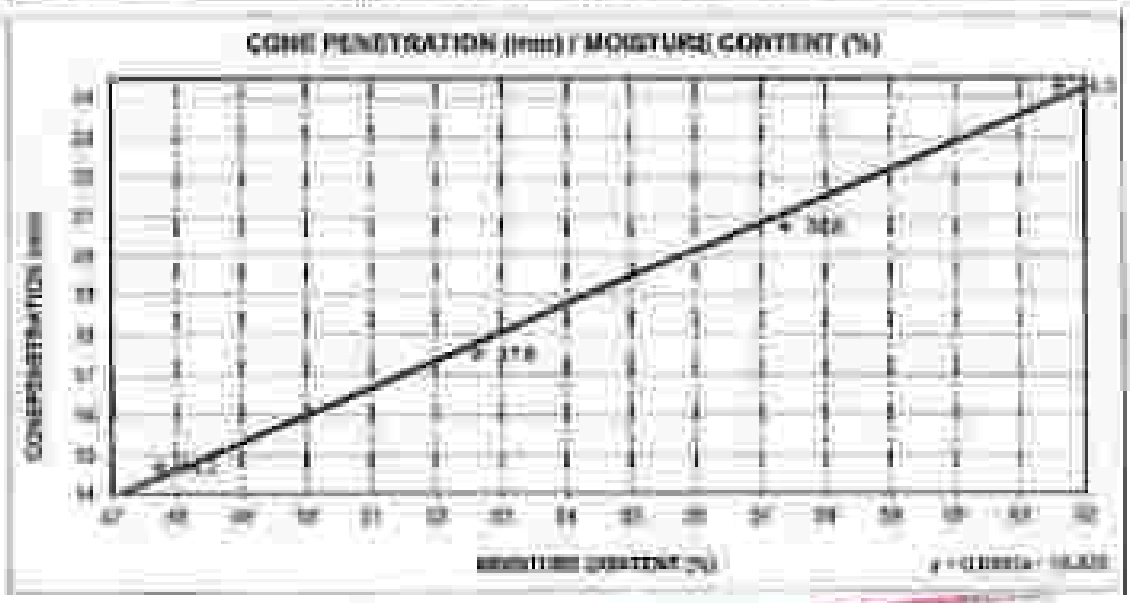
TO BS 1881 | Part 116 : 1983

ATTERBERGS LIMITS TEST

CLIENT : SINANO CONSTRUCTION COMPANY
LOCATION : KIMARA, DSM
OPERATOR : JAMES
DATE : 12.12.2023

BH No. 6
Sample No. SP1
Depth(m) 1.50-1.95

Test No.		1		2		3		4			
TYPE OF TEST		LL		LL		LL		LL		PL	PL
Initial dial gauge reading	mm	1.5	1.6	1.5	1.6	1.5	1.5	1.6	1.6		
Final gauge reading	mm	16.1	16.3	18.2	18.1	22.1	22.1	25.6	25.7		
Cone penetration	mm	14.7		17.6		20.6		24.0			
Container No.		T18		T8		T7		T12		T17	T16
Mass of wet soil + container	gm	45.80		45.40		47.80		46.70		30.10	24.50
Mass of dry soil + container	gm	33.30		33.40		40.80		40.20		29.70	23.90
Mass of container	gm	22.70		22.70		22.70		22.40		8.40	8.50
Mass of moisture	gm	4.20		7.00		7.00		6.50		0.40	0.60
Mass of dry soil	gm	10.60		10.60		18.00		17.80		21.30	15.40
Moisture content (w)	%	47.17		66.04		47.06		41.00		18.78	18.18
Cone penetration	mm	14.7		17.6		20.6		24.0		17	



Liquid limit : 35
Plastic limit (PL) : 17
Plasticity index (PI) : 18

Dar es Salaam Institute of Technology.
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Materials Testing Laboratory.

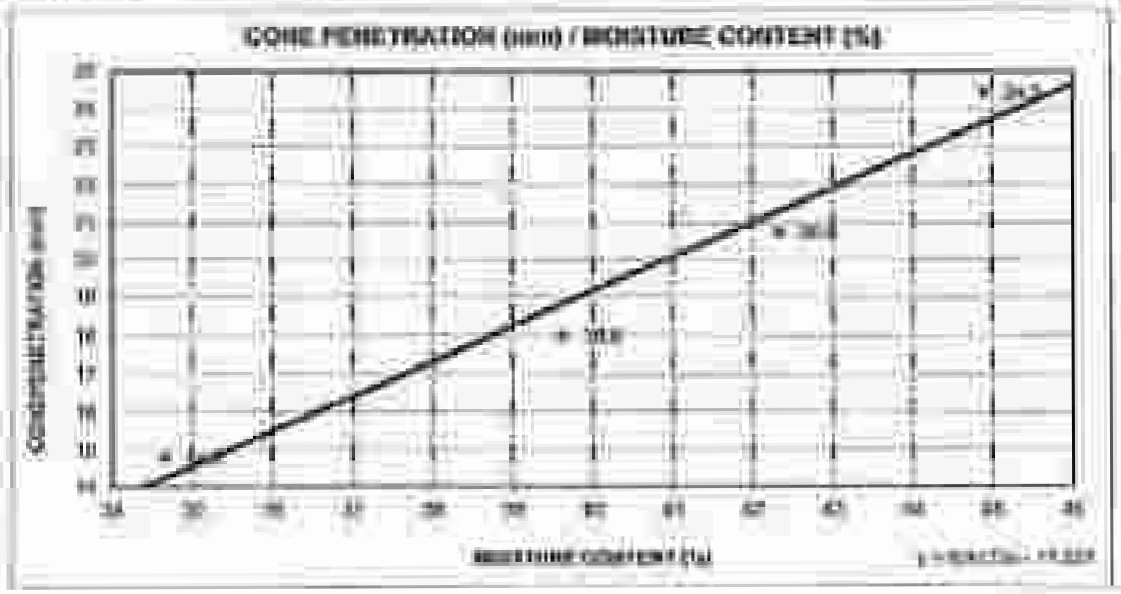
BS 1377 : Part 2 : 1990

ATTERBERGS' LIMITS TEST

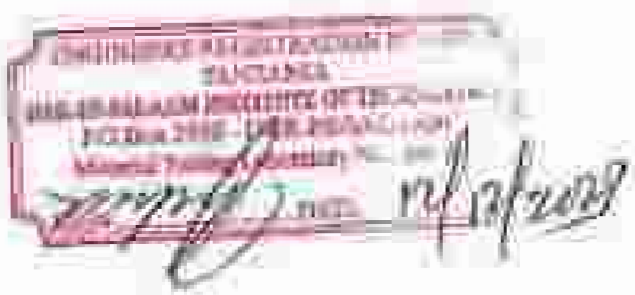
CLIENT : SUAKIS CONSTRUCTION COMPANY
LOCATION : KIMARA, DSM
OPERATOR : JAMES
DATE : 12.12.2023

BH No. 1
Sample No. SPT
Depth(m) 3.50-3.65

Test No.		1		2		3		4			
TYPE OF TEST		LL		LL		LL		LL		PL	PL
Initial dial gauge reading	mm	13	15	13	18	15	18	15	15		
Final gauge reading	mm	16.3	17.2	19.7	19.3	22.1	22.5	25.1	22.4		
Cone penetration	mm	14.5		16.0		20.8		24.5			
Container No.		T16		T6		T7		T12		T17	T19
Mass of wet soil + container	gm	47.80		51.30		52.10		55.50		23.40	23.50
Mass of dry soil + container	gm	41.70		45.20		45.20		47.60		21.20	21.30
Mass of container	gm	26.40		23.16		23.30		30.00		8.40	8.30
Mass of moisture	gm	6.10		6.10		6.90		7.90		2.20	2.20
Mass of dry soil	gm	15.30		15.04		15.09		17.60		12.80	13.00
Moisture content (W)	%	39.84		39.62		42.33		44.89		16.56	16.92
Cone penetration	mm	14.5		16.0		20.8		24.5		16	



Liquid limit : 41
Plastic limit (PL) 16
Plasticity index (PI) 25



Dar es Salaam Institute of Technology

Civil & Building Engineering Department

Materials Testing Laboratory

CLIENT: [illegible] CONSTRUCTION COMPANY

PROJECT: PROPOSED HOME SEWAGE TREATMENT PLANT

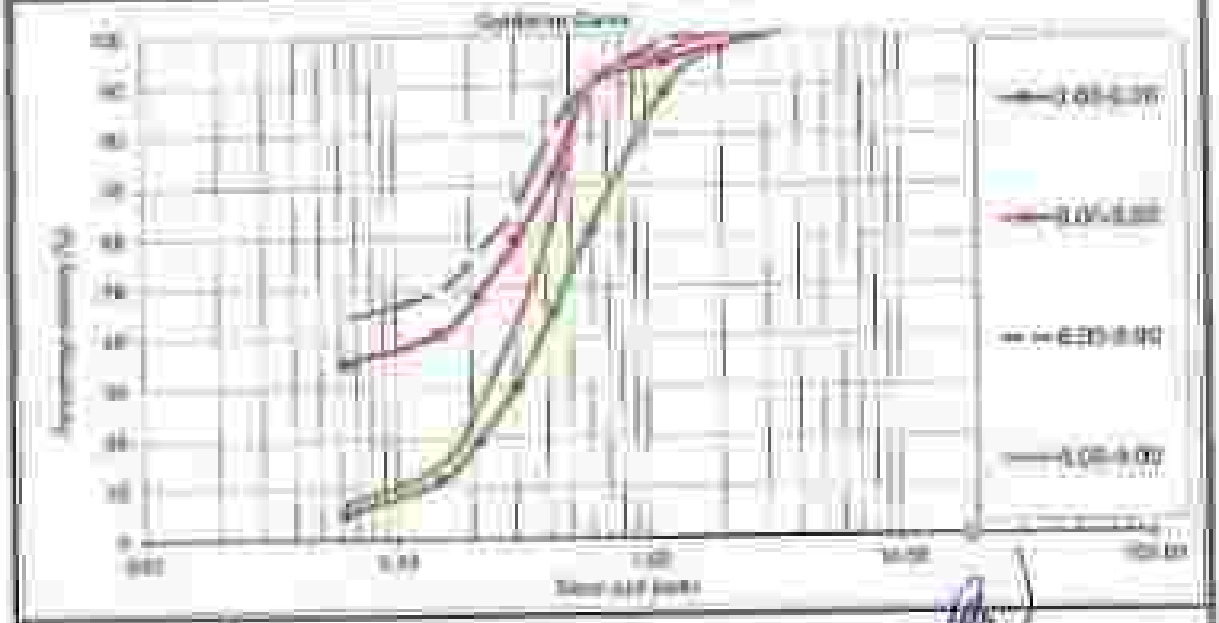
DATE: 14.12.2021

GRAIN SIZE DISTRIBUTION

SAMPLE TYPE	GS	BS	BC	SC
BOREHOLE No.	4	4	3	4
DEPTH	1.00-2.00	0.50-1.00	0.50-1.00	0.50-1.00
Sieve Size (mm)	Percentage passing			
75.0				
37.50				
19.00				
9.50				
4.75				
2.36	100	100	100	100
2.00	98	94	100	100
1.18	96	92	99	96
0.850	91	91	98	93
0.425	85	77	91	88
0.300	74	56	85	72
0.212	52	43	67	48
0.150	32	41	48	14
0.063	5	35	33	7

CLASSIFICATION

BSCS	SC	SC - Medium to High Plasticity	SC - High Plasticity	SC - High Plasticity
% Gravels	2	2	2	2
% Sand	93	63	98	93
% Fines	5	35	44	7
LL (%)		47	52	50
PL (%)		17	28	27
PI (%)		30	24	23



TESTED BY: CHARLES JOSEPH

APPROVED BY: Eng. JULIUS G.MSHA

HEAD OF DEPARTMENT/CHIEF ENGINEERING SECTION/LABORATORY SUPERVISOR

DAR ES SALAAM INSTITUTE OF TECHNOLOGY

14/12/2021

Dar es Salaam Institute of Technology.
Civil & Building Engineering Department.
Materials Testing Laboratory.

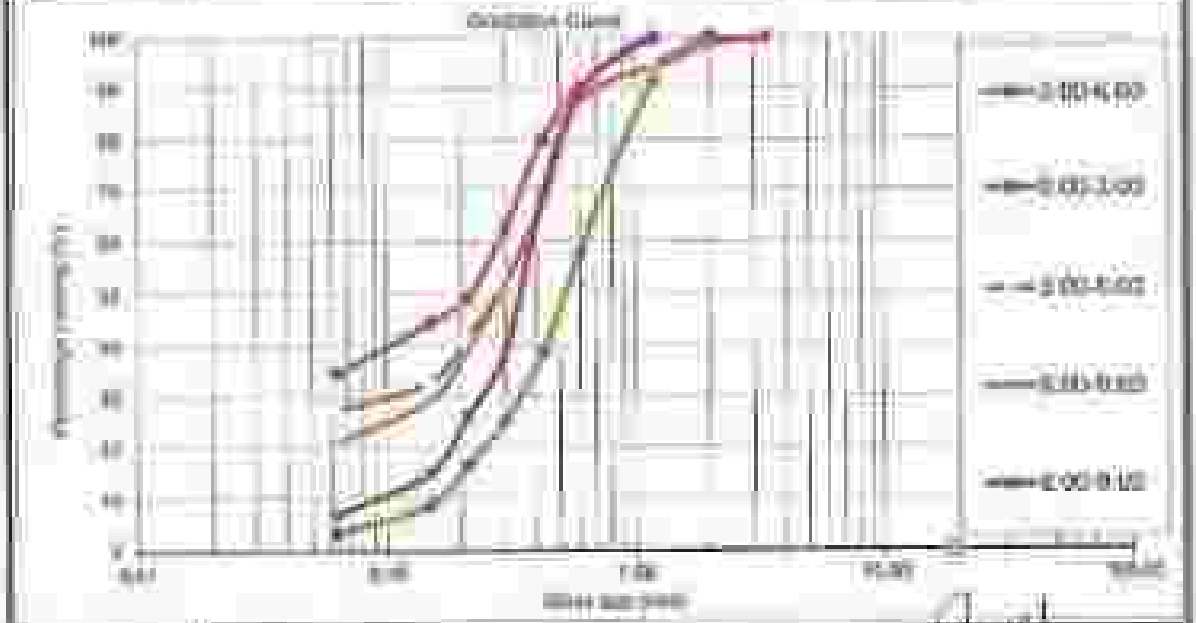
CLIENT:	SHIVAJI CONSTRUCTION COMPANY
PROJECT:	PROPOSED FAECAL SLUDGE TREATMENT PLANT
DATE:	14.12.2023

GRAIN SIZE DISTRIBUTION

SAMPLE TYPE:	DS	DS	DS	DS	DS
BOREHOLE No.	1	3	3	4	5
DEPTH (m)	3.45-5.00	0.00-1.00	1.00-2.00	3.00-5.00	5.00-6.00
Sieve Diameter,	Percentage passing				
19.0					
12.50					
10.00					
6.30					
4.75					
3.35	100	100	100	100	100
2.36	99	100	99	98	100
1.18	97	100	97	97	100
0.600	92	99	97	95	99
0.425	88	97	96	93	98
0.300	83	93	95	90	96
0.212	76	87	93	86	92
0.150	67	78	89	78	85
0.063	51	64	82	58	72
0.038	39	54	77	47	61

CLASSIFICATION

USCS	SC	SC	SC	SC - Medium to High Plasticity	SC
% Gravels	0	0	0	2	0
% Sand	61	46	23	51	28
% Fines	39	54	77	47	72
D60				0.41	
D30				0.17	
D10				0.06	



TESTED BY: CHARLES JAMES

APPROVED BY: C.Eng. JAMES GWEVA

HEAD OF MECHANICAL ENGINEERING AND CIVIL & BUILDING ENGINEERING DEPARTMENT

DAR ES SALAAM INSTITUTE OF TECHNOLOGY
P.O. Box 2958 - DAR ES SALAAM
Materials Testing Laboratory No. 006
14/12/2023

Dar es Salaam Institute of Technology.
Civil Engineering Department.
Materials Testing Laboratory.

BULK DENSITY/MATURAL MOISTURE CONTENT DETERMINATION

DO-LAB TEST RESULT.

CLIENT: SHANU CONSTRUCTION COMPANY. SITE: KIMARA, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: SH #3 DEPTH(m): 0.60-1.90

Test No.		1
Mass of tin + Sample	g	1872.7
Mass of tin	g	-
Mass of soil/m	g	1872.7
Length of sample	mm	150.0
Diameter of sample	mm	100.0
Volume of sample	mm^3	1178
Bulk Density	kg/m^3	1587
Dry Density	kg/m^3	1365

Test No.		1
Mass of wet soil + tin	g	384.6
Mass of dry soil + tin	g	348.5
Moisture content (w) %		10
Mass of tin	g	36.0
Natural moisture content	%	11.7

CLIENT: SHANU CONSTRUCTION COMPANY SITE: KIMARA, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: SH #2 DEPTH(m): 1.20-1.90

Test No.		1
Mass of tin + Sample	g	371.4
Mass of tin	g	0
Mass of sample	g	371.4
Length of sample	mm	300.0
Diameter of sample	mm	150.0
Volume of sample	mm^3	2650.8
Bulk Density	kg/m^3	1948
Dry Density	kg/m^3	1875

Test No.		1
Mass of wet soil + tin	g	253.7
Mass of dry soil + tin	g	231.7
Moisture content (w) %		14
Mass of tin	g	36.0
Natural moisture content	%	14.5

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Dar es Salaam Institute of Technology,
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Materials Testing Laboratory.

BULK DENSITY/NATURAL MOISTURE CONTENT DETERMINATION

ON-LAB TEST RESULT.

CLIENT: SHANG CONSTRUCTION COMPANY SITE: KIBIGIJI, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: BH 02 DEPTH(m):

Test No.		1
Mass of tube + Sample	g	500.3
Mass of tube	g	0
Mass of sample	g	500.3
Length of sample	mm	100.0
Diameter of sample	mm	70.0
Volume of sample	mm^3	384634
Bulk Density	kg/m^3	1562
Dry Density	kg/m^3	1126

Test No.		1
Mass of wet soil + tin	g	150.3
Mass of dry soil + tin	g	123.9
Moisture content (w)		21%
Mass of tin	g	43.0
Natural moisture content	(%)	13.0

CLIENT: SHANG CONSTRUCTION COMPANY SITE: KIBIGIJI, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: BH 02 DEPTH(m) 10.00-10.45

Test No.		1
Mass of tube + Sample	g	550.3
Mass of tube	g	0
Mass of sample	g	550.3
Length of sample	mm	100.0
Diameter of sample	mm	70.0
Volume of sample	mm^3	384634
Bulk Density	kg/m^3	1847
Dry Density	kg/m^3	1516

Test No.		1
Mass of wet soil + tin	g	220.3
Mass of dry soil + tin	g	203.9
Moisture content (w)		8%
Mass of tin	g	43.0
Natural moisture content	(%)	18.0

ENGINEERS REGISTRATION BOARD
ENGINEER
DAR ES SALAAM INSTITUTE OF TECHNOLOGY
P.O. Box 2958 - DAR ES SALAAM
Material Testing Laboratory No. 006 A
Date: 24/11/2023

Dar es Salaam Institute of Technology.
Civil Engineering Department.
Materials Testing Laboratory.

BULK DENSITY/NATURAL MOISTURE CONTENT DETERMINATION

OFF-LAB TEST RESULT.

CLIENT: SHUMSI CONSTRUCTION COMPANY SITE: KIMBILI, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2022

SOURCE: BH ID: DEPTH (m): 4.50-4.95

Test No.		1
Mass of tube + Sample	g	991.0
Mass of tube	g	0
Mass of sample	g	561.0
Length of sample	mm	130.0
Diameter of sample	mm	55.0
Volume of sample	mm^3	308624
Bulk Density	kg/m^3	1818
Dry Density	kg/m^3	1731

Test No.		1
Mass of wet soil + tin	g	206.0
Mass of dry soil + tin	g	187.0
Moisture content (w)	%	10.16
Mass of tin	g	35.45
Natural moisture content	(%)	11.2

CLIENT: SHUMSI CONSTRUCTION COMPANY SITE: KIMBILI, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2022

SOURCE: BH ID: DEPTH (m): 10.00-10.46

Test No.		1
Mass of tube + Sample	g	340.5
Mass of tube	g	0
Mass of sample	g	340.5
Length of sample	mm	130.0
Diameter of sample	mm	55.0
Volume of sample	mm^3	308624
Bulk Density	kg/m^3	1868
Dry Density	kg/m^3	1813

Test No.		1
Mass of wet soil + tin	g	193.5
Mass of dry soil + tin	g	185.5
Moisture content (w)	%	5.10
Mass of tin	g	41.45
Natural moisture content	(%)	5.0

Dar es Salaam Institute of Technology,
Civil Engineering Department,
Materials Testing Laboratory.

BULK DENSITY/NATURAL MOISTURE CONTENT DETERMINATION

DT-LAB TEST RESULT

CLIENT: SHANDI CONSTRUCTION COMPANY SITE: KIMARA, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: [illegible] DEPTH(m): 1.50-1.95

Test No.		1
Mass of tare + Sample	g	[illegible]
Mass of tare	g	[illegible]
Mass of sample	g	[illegible]
Length of sample	mm	100.0
Diameter of sample	mm	35.5
Volume of sample	mm^3	[illegible]
Bulk Density	kg/m^3	[illegible]
Dry Density	kg/m^3	[illegible]

Test No.		1
Mass of wet soil + tin	g	[illegible]
Mass of dry soil + tin	g	[illegible]
Moisture content in %%		[illegible]
Mass of tin	g	[illegible]
Natural moisture content	(%)	[illegible]

CLIENT: SHANDI CONSTRUCTION COMPANY SITE: KIMARA, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: [illegible] DEPTH(m): 10.00-10.40

Test No.		1
Mass of tare + Sample	g	[illegible]
Mass of tare	g	[illegible]
Mass of sample	g	[illegible]
Length of sample	mm	[illegible]
Diameter of sample	mm	35.5
Volume of sample	mm^3	[illegible]
Bulk Density	kg/m^3	[illegible]
Dry Density	kg/m^3	[illegible]

Test No.		1
Mass of wet soil + tin	g	[illegible]
Mass of dry soil + tin	g	[illegible]
Moisture content in %%		[illegible]
Mass of tin	g	[illegible]
Natural moisture content	(%)	[illegible]

Dar es Salaam Institute of Technology.
Civil Engineering Department.
Materials Testing Laboratory.

BULK DENSITY/NATURAL MOISTURE CONTENT DETERMINATION

OFFLAB TEST RESULT.

CLIENT: SHANG CONSTRUCTION COMPANY
SITE: KIMARA, DAR ES SALAAM
PROJECT: PROPOSED TREATMENT PLANT
DATE: 24.11.2023
SOURCE: BH 05
DEPTH: 4.50-4.95

Test No.		1
Mass of tube + Sample	g	1180.0
Mass of tube	g	0
Mass of sample	g	1180.0
Length of sample	mm	200.0
Diameter of sample	mm	95.0
Volume of sample	mm^3	2836CH
Bulk Density	kg/m^3	3031
Dry Density	kg/m^3	1827

Test No.		1
Mass of wet soil + tin	g	223.7
Mass of dry soil + tin	g	194.3
Moisture content (w)		00
Mass of tin	g	35.5
Mass of moisture content	(%)	34.4

CLIENT: SHANG CONSTRUCTION COMPANY
SITE: KIMARA, DAR ES SALAAM
PROJECT: PROPOSED TREATMENT PLANT
DATE: 24.11.2023
SOURCE: BH 06
DEPTH: 1.50-1.95

Test No.		1
Mass of tube + Sample	g	1177.0
Mass of tube	g	0
Mass of sample	g	1177.0
Length of sample	mm	200.0
Diameter of sample	mm	95.0
Volume of sample	mm^3	2836CH
Bulk Density	kg/m^3	1978
Dry Density	kg/m^3	1736

Test No.		1
Mass of wet soil + tin	g	209.0
Mass of dry soil + tin	g	190.0
Moisture content (w)		00
Mass of tin	g	35.5
Mass of moisture content	(%)	14.0

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Materials Testing Laboratory.

BULK DENSITY/NATURAL MOISTURE CONTENT DETERMINATION

DIT-LAB TEST RESULT.

CLIENT: SHUNDI CONSTRUCTION COMPANY SITE: KIMARA, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: BH 05 DEPTH(m): 4.50-4.95

Test No.		1
Mass of tube + Sample	g	572.3
Mass of tube	g	0
Mass of sample	g	572.3
Length of sample	mm	300.0
Diameter of sample	mm	95.0
Volume of sample	mm^3	2128634
Bulk Density	kg/m^3	1963
Dry Density	kg/m^3	1763

Test No.		1
Mass of wet soil + tin	g	268.3
Mass of dry soil + tin	g	232.2
Moisture content (w)	%	15.5
Mass of tin	g	34.5
Mass of moisture content	(%)	15.5

CLIENT: SHUNDI CONSTRUCTION COMPANY SITE: KIMARA, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: BH 07 DEPTH(m): 4.00-4.50

Test No.		1
Mass of tube + Sample	g	566.1
Mass of tube	g	0
Mass of sample	g	566.1
Length of sample	mm	300.0
Diameter of sample	mm	95.0
Volume of sample	mm^3	2128634
Bulk Density	kg/m^3	1931
Dry Density	kg/m^3	1815

Test No.		1
Mass of wet soil + tin	g	190.0
Mass of dry soil + tin	g	73.2
Moisture content (w)	%	05
Mass of tin	g	34.5
Mass of moisture content	(%)	4.6

Dar es Salaam Institute of Technology,
Civil Engineering Department,
Materials Testing Laboratory.

BULK DENSITY/NATURAL MOISTURE CONTENT DETERMINATION

DIT-LAB TEST RESULT.

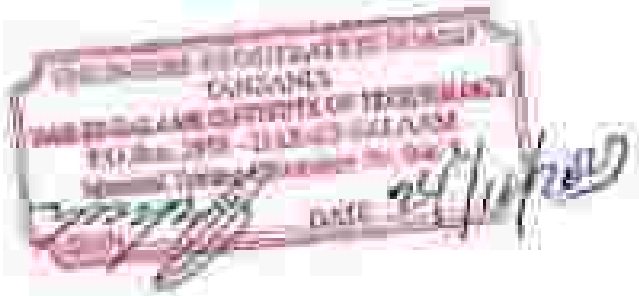
CLIENT: SHANDI CONSTRUCTION COMPANY SITE: KIMBILIO, DAR ES SALAAM

PROJECT: PROPOSED TREATMENT PLANT DATE: 24.11.2023

SOURCE: BH 07 Depth 4.50-5.00

Test No.		1
Mass of tube + Sample	g	590.4
Mass of tube	g	0
Mass of sample	g	590.4
Length of sample	mm	300.5
Diameter of sample	mm	50.0
Volume of sample	mm^3	589604
Bulk Density	kgm^3	2323
Dry Density	kgm^3	1748

Test No.		1
Mass of wet soil + tin	g	190.1
Mass of dry soil + tin	g	162.4
Moisture content in tin		0
Mass of tin	g	24.5
Moisture content	%	16.6



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Civil Engineering Department
Materials Testing Laboratory

PROJECT:	PROPOSED 7 MGD WATER TREATMENT PLANT
DATE:	13.12.2022
SECTION:	1.00-1.50
SAMPLE:	Dry & Clean
NO:	1
CLIENT:	DRIDA DISTRIBUTION COMPANY

OPERATOR: JAMES CHARLES

DIRECT SHEAR TEST

Normal load (kg)	Ring Reading (div)	Vertical stress (kN/m²)	Shear stress (kN/m²)	Normal load (kg)	Ring Reading (div)	Vertical stress (kN/m²)	Shear stress (kN/m²)	Normal load (kg)	Ring Reading (div)	Vertical stress (kN/m²)	Shear stress (kN/m²)
0.5	0	100	0	0.5	0	110	0	0.5	0	120	0
0.5	3	100	7	0.5	5	110	12	0.5	10	120	24
0.5	7	100	17	0.5	7	110	17	0.5	14	120	34
0.5	9	100	21	0.5	14	110	33	0.5	19	120	46
0.5	12	100	29	0.5	18	110	43	0.5	23	120	55
0.5	14	100	33	0.5	19	110	46	0.5	26	120	63
0.5	16	100	38	0.5	21	110	51	0.5	28	120	67
0.5	18	100	42	0.5	26	110	62	0.5	31	120	74
0.5	20	100	47	0.5	28	110	67	0.5	34	120	81
0.5	22	100	52	0.5	29	110	69	0.5	36	120	86
0.5	23	100	55	0.5	31	110	74	0.5	38	120	91

Normal stress (kN/m²)	100	110	120
Shear stress (kN/m²)	55	74	91

MOISTURE CONTENT (%)	
	1
	1000.1
	1000.5
	20
	20.0
	0.5

PREPARED BY:

APPROVED BY:

Ge'ez Selam Institute of Technology
Civil Engineering Department
Materials Testing Laboratory

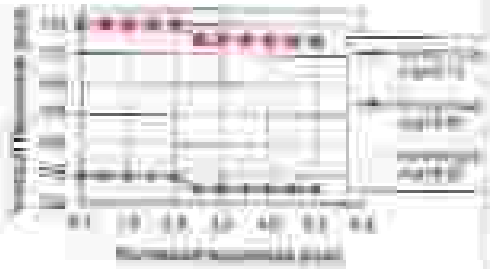
PROJECT:	[illegible]
DATE:	[illegible]
SAMPLE:	[illegible]
TEST NO:	[illegible]
CLIENT:	[illegible]

DIRECT SHEAR TEST

Normal load Ring				Proving ring constant (kg/div)	Shear load Ring				Normal load (kg/cm²)				Moisture content (%)	
Horizontal reference (mm)	Ring Reading (Div)	Vertical Normal (Kg)	Shear stress (kg/cm²)		Horizontal reference (mm)	Ring Reading (Div)	Vertical Normal (kg)	Shear stress (kg/cm²)	Horizontal reference (mm)	Ring Reading (Div)	Vertical Normal (kg)	Shear stress (kg/cm²)		
0.0	0	124	0	4.000	0.0	0	120	0	0.0	0	115	0		
0.5	2	124	8	500	0.5	5	120	12	0.5	2	115	20		
1.0	7	125	7	501	1.0	7	120	17	1.0	14	115	33		
1.5	8	124	14	504	1.5	9	120	21	1.5	18	115	43		
2.0	9	124	21		2.0	12	120	29	2.0	22	115	55		
2.5	11	125	28		2.5	14	120	34	2.5	24	115	63		
3.0	14	125	33		3.0	17	120	42	3.0	24	115	63		
3.5	14	125	33		3.5	17	120	42	3.5	24	115	63		
4.0	17	126	40		4.0	20	120	49	4.0	28	115	77		
4.5	19	126	45		4.5	23	120	55	4.5	33	115	120		
5.0	20	126	47		5.0	24	120	58	5.0	31	115	113		
									5.5	32	115	142		

Device Constant			
Normal Stress (kN/m²)	120	294	196
Shear stress (kN/m²)	97	83	144

Dry sample



Soaked

Mud Strength

Tested BY:

Checked BY:

Approved BY:

Dar es Salaam Institute of Technology
Civil Engineering Department
Materials Testing Laboratory

OPERATOR:	[illegible]	[illegible]	[illegible]

PROJECT:	[illegible]
DATE:	[illegible]
DEPTH (m):	[illegible]
SAMPLE:	[illegible]
BH NO:	[illegible]
CLIENT:	[illegible]

DIRECT SHEAR TEST

Normal load (kg) [illegible]			
Horizontal (displacement) (mm)	PR Reading (divs)	Vertical movement (divs)	Shear stress (kN/m²)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

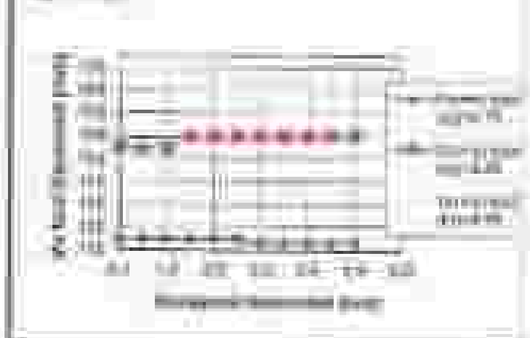
Normal load (kg) [illegible]			
Horizontal (displacement) (mm)	PR Reading (divs)	Vertical movement (divs)	Shear stress (kN/m²)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Normal load (kg) [illegible]			
Horizontal (displacement) (mm)	PR Reading (divs)	Vertical movement (divs)	Shear stress (kN/m²)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

MOISTURE CONTENT (%)	
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Shear Strength			
Normal stress (kN/m²)	[illegible]	[illegible]	[illegible]
Shear stress (kN/m²)	[illegible]	[illegible]	[illegible]

Dry Loads



TESTED BY:
[illegible]

APPROVED BY: [illegible]
HEAD OF DEPARTMENT [illegible] MATERIALS TESTING LABORATORY

Dar es Salaam Institute of Technology
Civil Engineering Department
Materials Testing Laboratory

PROJECT:	[illegible]
DATE:	[illegible]
DEPTH (m):	[illegible]
SAMPLE:	[illegible]
BH NO:	[illegible]
CLIENT:	[illegible]

OPERATOR: [illegible]

DIRECT SHEAR TEST

Normal load (kg) = [illegible]

Horizontal displacement (mm)	PR Reading (div)	Vertical movement (div)	Shear stress (kN/m²)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Normal load (kg) = [illegible]

Horizontal displacement (mm)	PR Reading (div)	Vertical movement (div)	Shear stress (kN/m²)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Normal load (kg) = [illegible]

Horizontal displacement (mm)	PR Reading (div)	Vertical movement (div)	Shear stress (kN/m²)
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

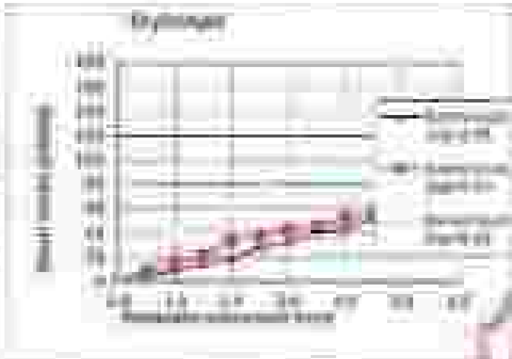
MOISTURE CONTENT (%)

[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]

Stress Results

Normal stress (kN/m2)	[illegible]	[illegible]	[illegible]
Shear stress (kN/m2)	[illegible]	[illegible]	[illegible]

Dry sample



TESTED BY:
[illegible]

APPROVED BY:
[illegible]

Co-op Sokoine Institute of Technology
Civil Engineering Department
Materials Testing Laboratory

PROJECT:	PROPOSED FARMS BLOCK TREATMENT PLANT
DATE:	11.11.2021
SAMPLE:	Dry & Sieve
BH NO:	1
CLIENT:	SHIRAZ CONSTRUCTION COMPANY

OPERATION: | SIEVE ANALYSIS | PHASE | LABORATORY

DIRECT SHEAR TEST

Normal load 50kPa

Horizontal movement (mm)	PR Reading (div)	Vertical movement (div)	Shear stress (kN/m²)
0.0	0	100	0
0.5	5	102	5
1.0	7	103	7
1.5	9	105	9
2.0	11	107	11
2.5	12	108	12
3.0	13	109	13
3.5	14	110	14
4.0	15	111	15
4.5	16	112	16
5.0	17	113	17

Normal load 100kPa

Horizontal movement (mm)	PR Reading (div)	Vertical movement (div)	Shear stress (kN/m²)
0.0	0	100	0
0.5	6	102	6
1.0	8	103	8
1.5	10	105	10
2.0	12	107	12
2.5	13	108	13
3.0	14	109	14
3.5	15	110	15
4.0	16	111	16
4.5	17	112	17
5.0	18	113	18

Normal load 150kPa

Horizontal movement (mm)	PR Reading (div)	Vertical movement (div)	Shear stress (kN/m²)
0.0	0	100	0
0.5	7	102	7
1.0	9	103	9
1.5	11	105	11
2.0	13	107	13
2.5	14	108	14
3.0	15	109	15
3.5	16	110	16
4.0	17	111	17
4.5	18	112	18
5.0	19	113	19

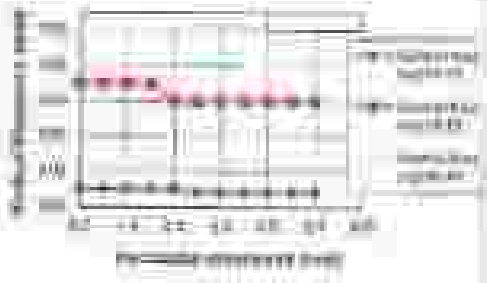
MOISTURE CONTENT (%)

			1
			16.8
			17.6
			0.23
			20.3
			3.2

Shear Results

Normal stress σ(kN/m²)	150	200	300
Shear stress τ(kN/m²)	40	60	100

Dry sample



Hysteresis

Shear strength

Checked by:

Approved by:

Head of Materials Testing Laboratory

[illegible] Institute of Technology
Civil Engineering Department
Material Testing Laboratory

PROJECT:	[illegible]
DATE:	[illegible]
DEPTH (m):	[illegible]
SAMPLE:	[illegible]
BH NO:	[illegible]
CLIENT:	[illegible] CONSTRUCTION COMPANY

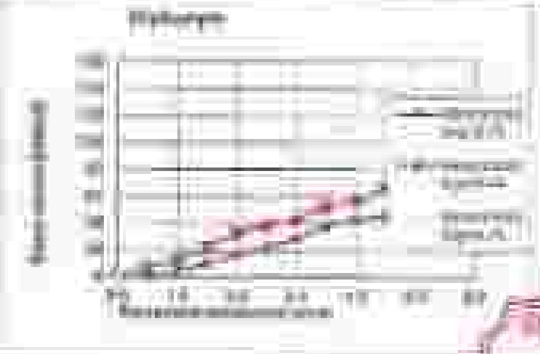
DIRECT SHEAR TEST

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

MOISTURE CONTENT (%)

[illegible]	[illegible]

Normal stress (kN/m2)	100	200	300
Shear stress (kN/m2)	[illegible]	[illegible]	[illegible]



TESTED BY:
[illegible]

APPROVED BY:
[illegible]

Dar es Salaam Institute of Technology Civil Engineering Department Materials Testing Laboratory	PROJECT: PROPOSED NATIONAL SLUDGE TREATMENT PLANT
OPERATOR: [illegible]	DATE: [illegible]
	DEPTH (m): [illegible]
	SAMPLE: [illegible]
	BH NO: [illegible]
	CLIENT: [illegible] CONSTRUCTION COMPANY

DIRECT SHEAR TEST

Normal load (kg) [illegible]					Normal load (kg) [illegible]					Normal load (kg) [illegible]				MOISTURE CONTENT (%)	
Horizontal displacement (mm)	PR Reading (Divs)	Vertical displacement (Divs)	Shear stress (kN/m²)		Horizontal displacement (mm)	PR Reading (Divs)	Vertical displacement (Divs)	Shear stress (kN/m²)		Horizontal displacement (mm)	PR Reading (Divs)	Vertical displacement (Divs)	Shear stress (kN/m²)		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
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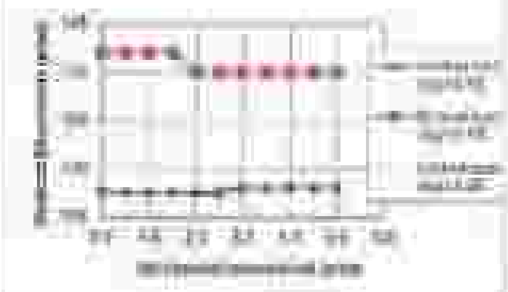
Testing Results			
Normal stress (kN/m²)	[illegible]	[illegible]	[illegible]
Shear stress (kN/m²)	[illegible]	[illegible]	[illegible]

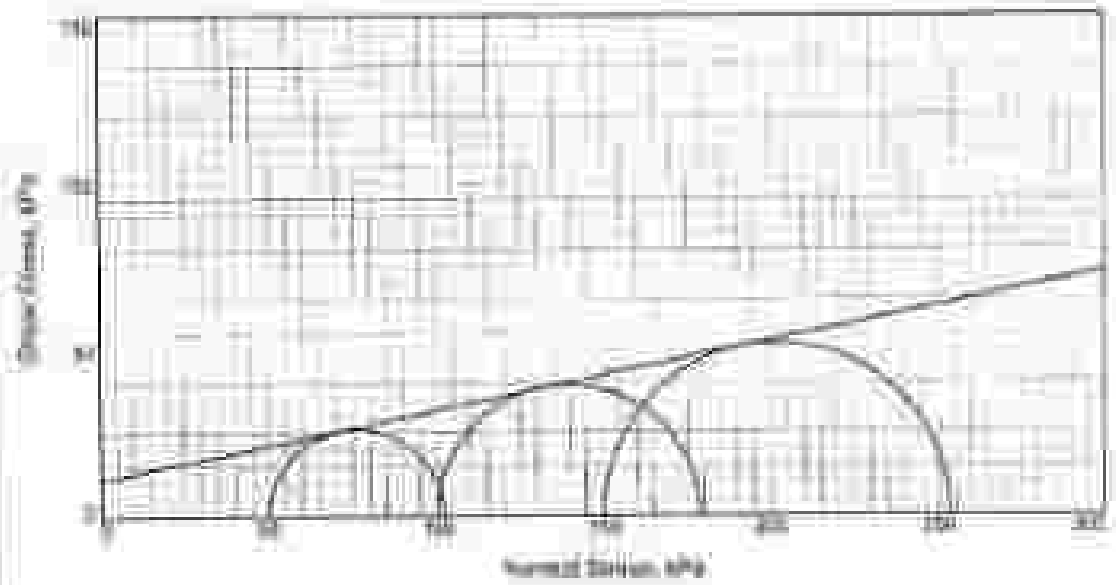
Dry sample



TESTED BY:
[illegible]

APPROVED BY:
[illegible]
HEAD OF [illegible] LABORATORY

TRIAXIAL SHEAR TEST REPORT



Type of Test: Unconsolidated Undrained **Sample Type:** UNSATURATED

No.	Cell	Back	Ev/Axial	Strain, %	Deviator	Strain, %		
1	50.0	0.0	52.3	4.4			100.3	50.0
2	100.0	0.0	106.9	4.5			179.4	100.6
3	200.0	0.0	185.5	5.8			287.3	170.0

Sample Parameters:

No.	% Water Content	Dry Dens. kg/m3	Saturation	Void Ratio	Diameter mm	Height mm	Strain Rate mm/m
1	13.2	1964	100.0%	0.3493	38.0	248.0	1.4
2	13.2	1964	100.0%	0.3493	37.9	133.4	1.4
3	13.2	1964	100.0%	0.3493	77.4	127.3	1.4

Mohr-Coulomb Strength Parameters	Material Description
Total Strength intercept, c= 10.9 kPa Friction angle, ϕ= 11.8 deg Tan(ϕ), k= 0.21	

Client: SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Location: KIMBIJI -DSM

Sample Number: Dep0: 3.00-3.00m

Date Sampled: 12.12.2023

File: KIMBIJI

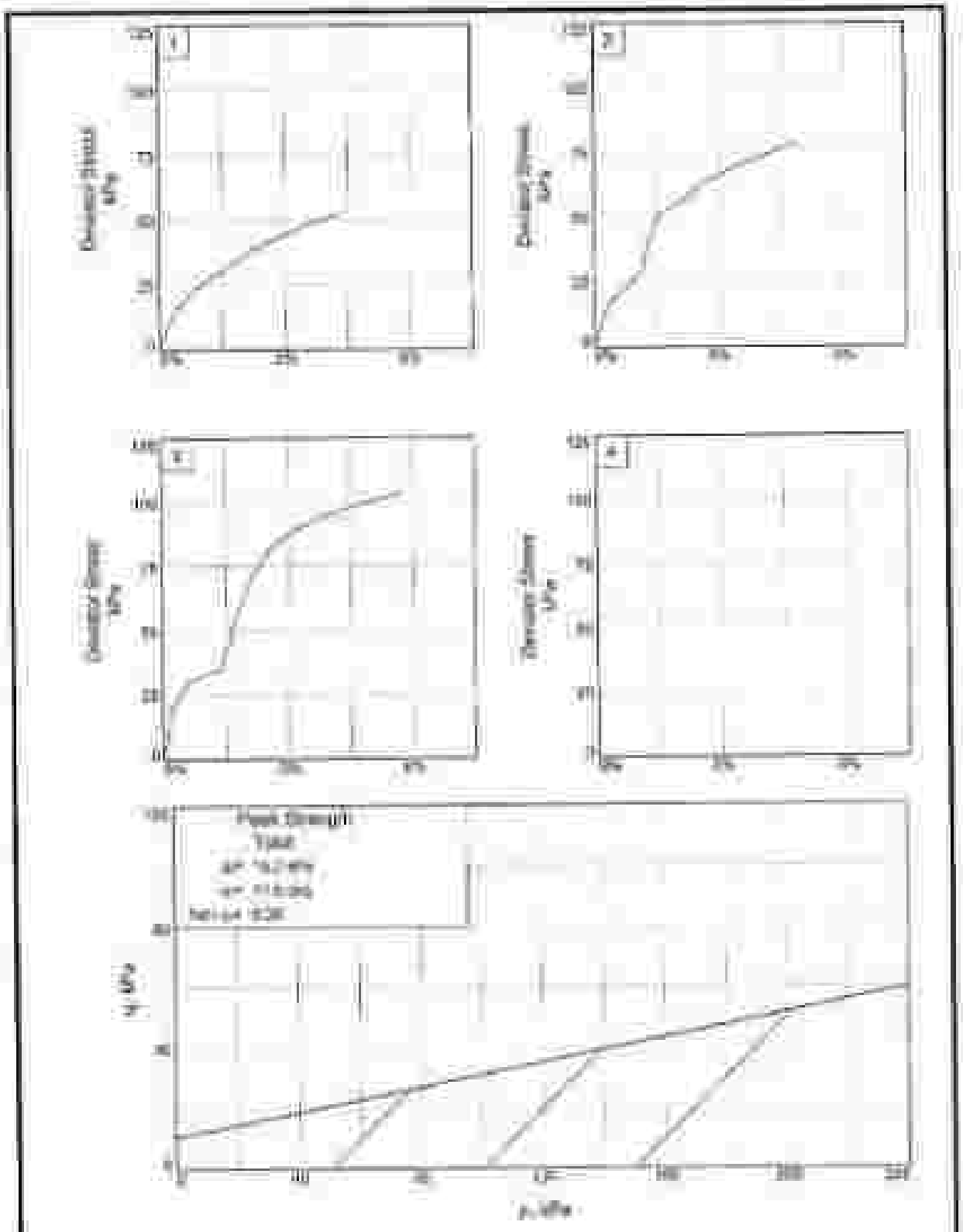
Remarks:

TRIAXIAL SHEAR TEST REPORT

Figure:

Tested & Prepared By: CHARLES JAMES

19/12/2023



Client: SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Loc.: KIMBIJI -DSM Borehole Depth: 3.50-5.00m Sample

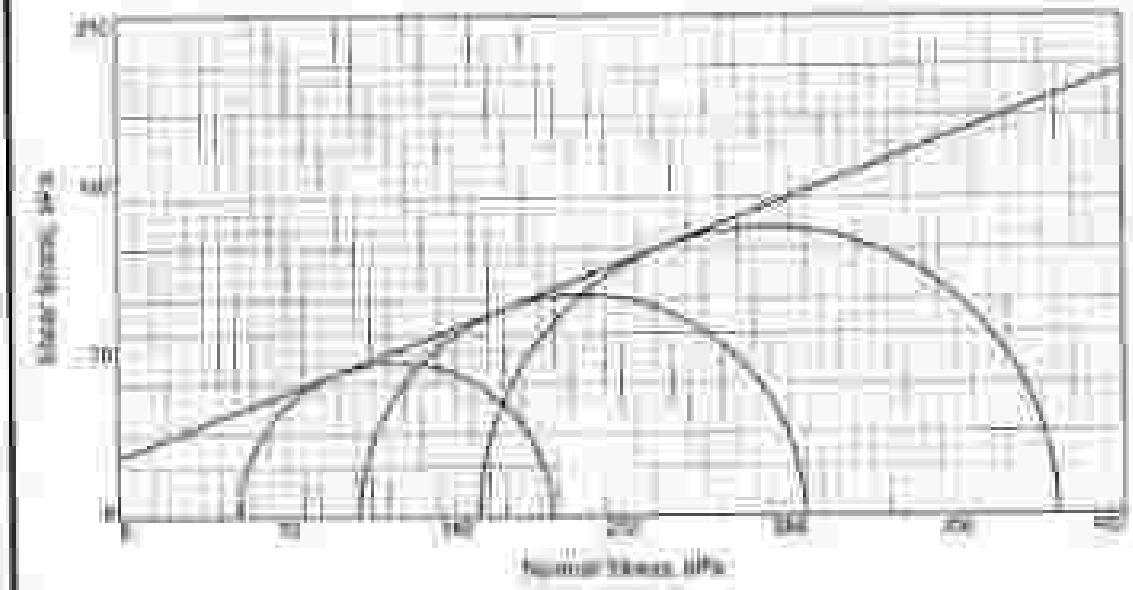
No.: (1) Project No.: BH NO.1

Figure 1

Tested & Prepared By: CHARLES JAMES

12/12/2023

TRIAXIAL SHEAR TEST REPORT



Type of Test: [illegible] **Sample Type:** [illegible]

No.	Fluid Press. kPa		Eff. Stress, kPa		Ult. Stress, kPa		Failure	
	Cell	Back	Deviator	Strain, %	Deviator	Strain, %	σ1	σ3
1	70.0	0.0	139.5	4.4			140.5	39.8
2	100.0	0.0	194.8	4.7			294.8	100.0
3	150.0	0.0	342.2	5.2			492.2	150.0

No.	Strength Parameters						
	% Water Content	Dry Dens. kg/m³	Saturation	Void Ratio	Diameter mm	Height mm	Strain Rate mm/min
1	16.1	2091	100.0%	0.3679	70.0	140.0	1.4
2	16.1	2091	100.0%	0.3679	71.6	133.9	1.4
3	16.1	2091	100.0%	0.3679	73.3	127.7	1.4

Mohr-Coulomb Strength Parameters		Material Description
	Total	
Strength intercept, c =	15.7 kPa	
Friction angle, ϕ =	21.6 deg	
Tangent, ϕ =	0.39	

Client: SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Location: KIMBIJI -DSM

Hole No.: [illegible] **Number:** 1/6

Date Sampled: 12.12.2023

File: KIMBIJI -DSM

Remarks: [illegible]

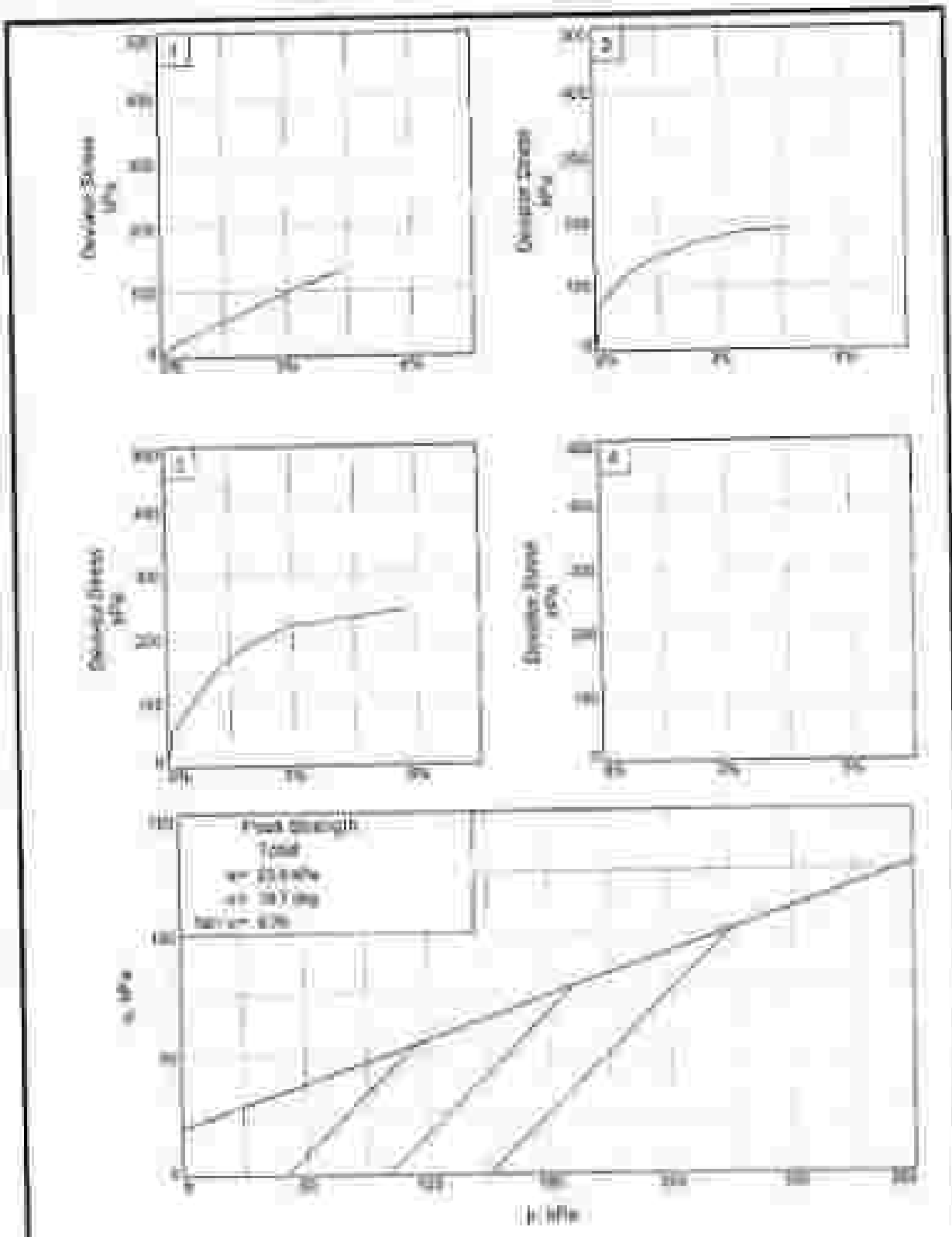
Depth: [illegible]

TRIAXIAL SHEAR TEST REPORT

Figure 1

Tested & Prepared By: CHARLES [illegible]

13/12/2023

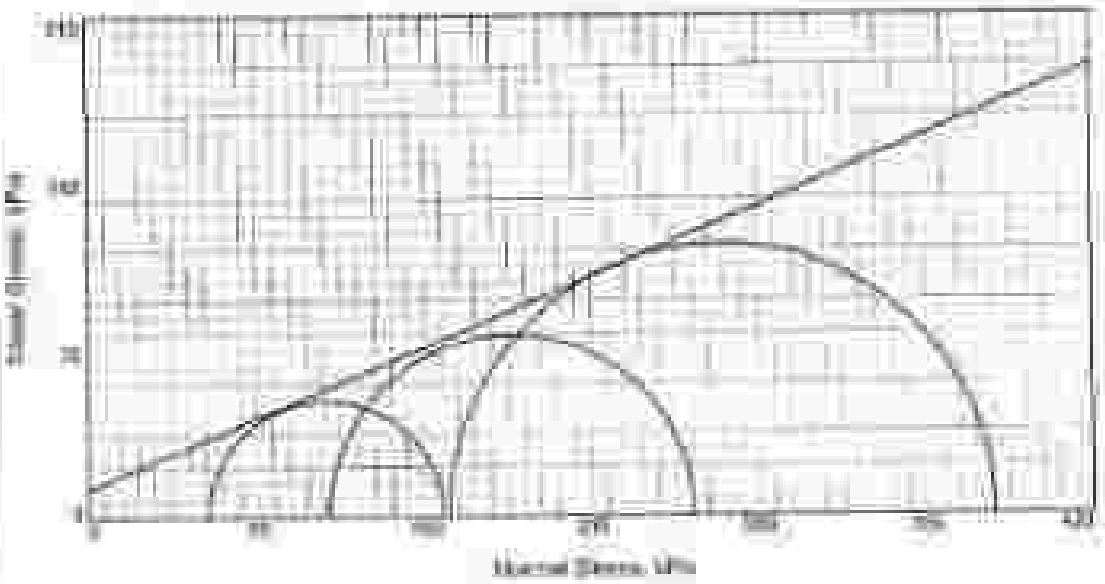


Client: SHANXI CONSTRUCTION COMPANY
Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT
Location: KIMBIJI -DSM

Figure 2

BH 2 Depth: 8.00-8.45m Sample No.: M4

TRIAXIAL SHEAR TEST REPORT



Type of Test: Unconsolidated Undrained **Sample Type:** UNSATURATED

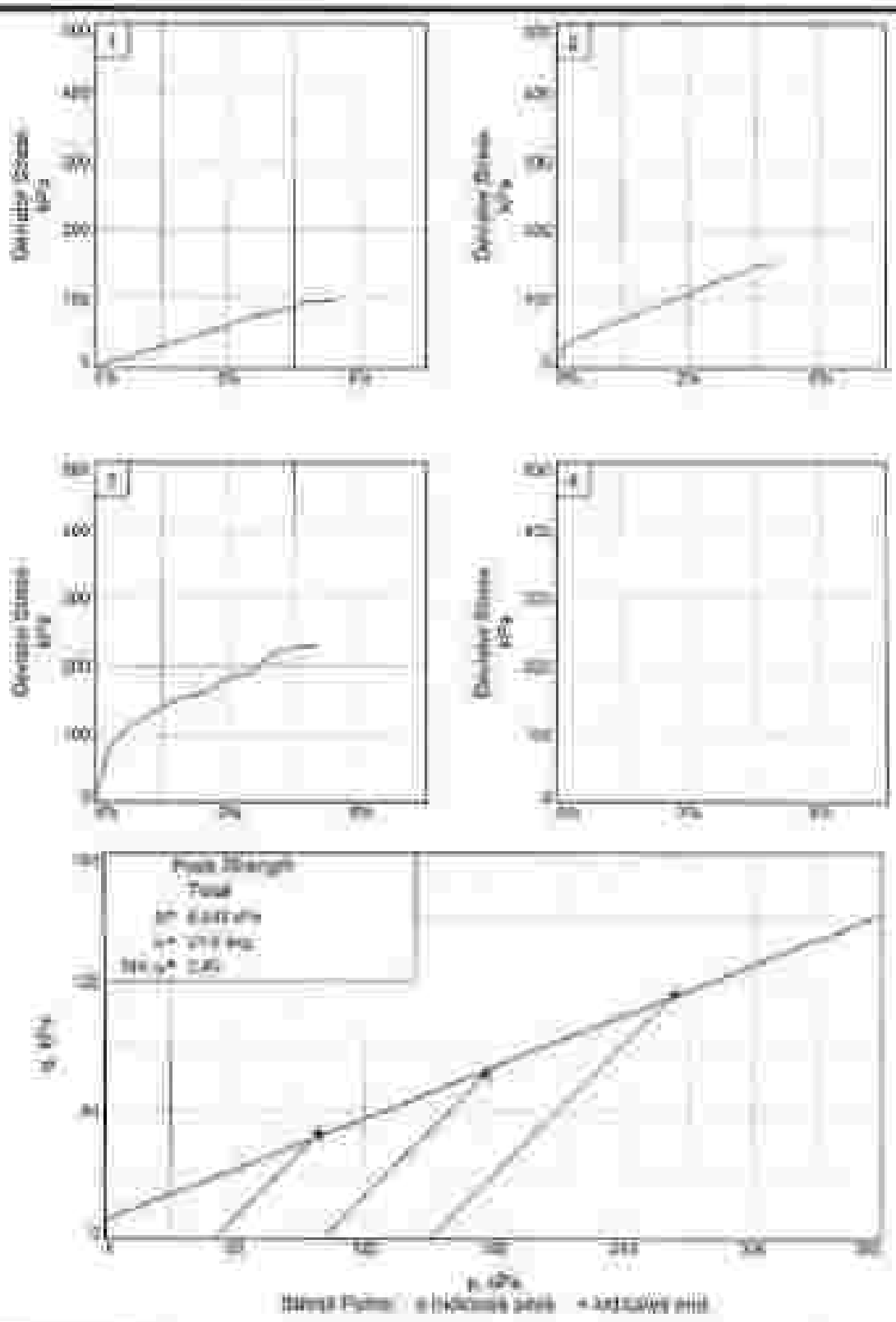
No	Fluid Press. kPa: Cell	Back	Rad. Stress, kPa: Deviator	Strain, %	Ult. Stress, kPa: Deviator	Strain, %	Wn	Sr
1	200.00	0.00	97.67	5.0			147.97	59.0%
2	400.00	0.00	157.81	5.0			222.42	100.0%
3	700.00	0.00	339.63	5.0			276.63	100.0%

Sample Parameters

No	% Water Content	Dry Dens. kg/m3	Satu-ration	Void Ratio	Diameter mm	Height mm	Shear Rate in/min.
1	13.1	1949	100.0%	0.3461	39.04	148.00	1.46
2	13.1	1868	100.0%	0.3861	39.01	145.00	1.46
3	13.1	1869	100.0%	0.3461	39.00	148.00	1.46

Mohr-Coloumb Strength Parameters	Material Description
Total Strength intercept, c= 82.36 kPa Friction angle, ϕ = 33.8 deg Tangent, a = 0.41	
Client: SHANXI CONSTRUCTION COMPANY **Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT** **Sample Number:** [illegible] **Depth: 0.0-3.0m**	**Date Sampled: 12.12.2023** **File: KUMASI -BSM** **Remarks:** BOREHOLE NO 3 DEPTH 0.0-3.0pm
TRIAXIAL SHEAR TEST REPORT	

Tested & Prepared By: CHARLES JAMES



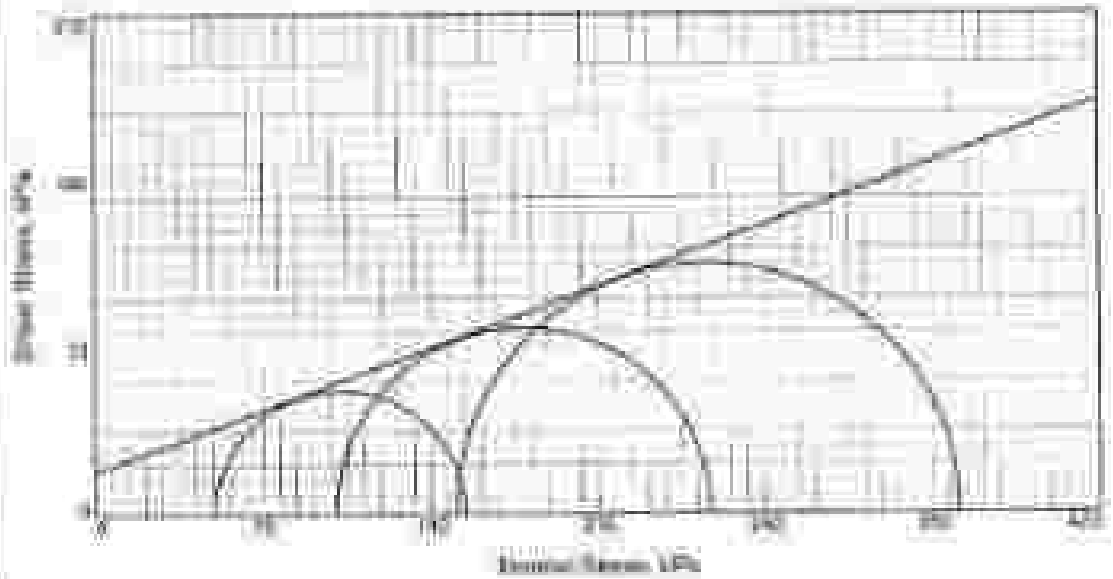
Client: SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Loc.: KIBUBA-OSIR Figure 1 Depth: 0.0-2.0m Sample No.: 04

Tested & Prepared By: CHARLES JAMES

TRIAXIAL SHEAR TEST REPORT



Type of Test: [illegible] **Sample Type:** UNSATURATED

No.	Fluid Press. kPa		Eff. Stress kPa		Dif. Stress kPa		"200:500"	
	Cell	Back	Deviator	Strain, %	Deviator	Strain, %	%	%
1	50.0	0.0	184.9	4.7			154.8	30.0
2	100.0	0.0	187.9	3.2			257.8	58.0
3	150.0	0.0	211.1	5.0			361.3	150.0

No.	Sample Parameters						
	% Water Content	Dry Density kg/m3	Saturation	Void Ratio	Diameter mm	Height mm	Shear Rate mm/min
1	61.3	1808	100.0%	1.6000	70.0	140.0	1.4
2	61.3	1808	100.0%	1.6000	70.0	140.0	1.4
3	61.3	1808	100.0%	1.6000	70.0	140.0	1.4

Mohr-Coulomb Strength Parameters		Material Description
	Total	
Strength intercept, c =	16.8 kPa	
Friction angle, ϕ =	28.8 deg.	
Tangent, a =	0.37	

Client: SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Sample Number: [illegible] **Depth:** 3.00-6.0m

TRIAXIAL SHEAR TEST REPORT

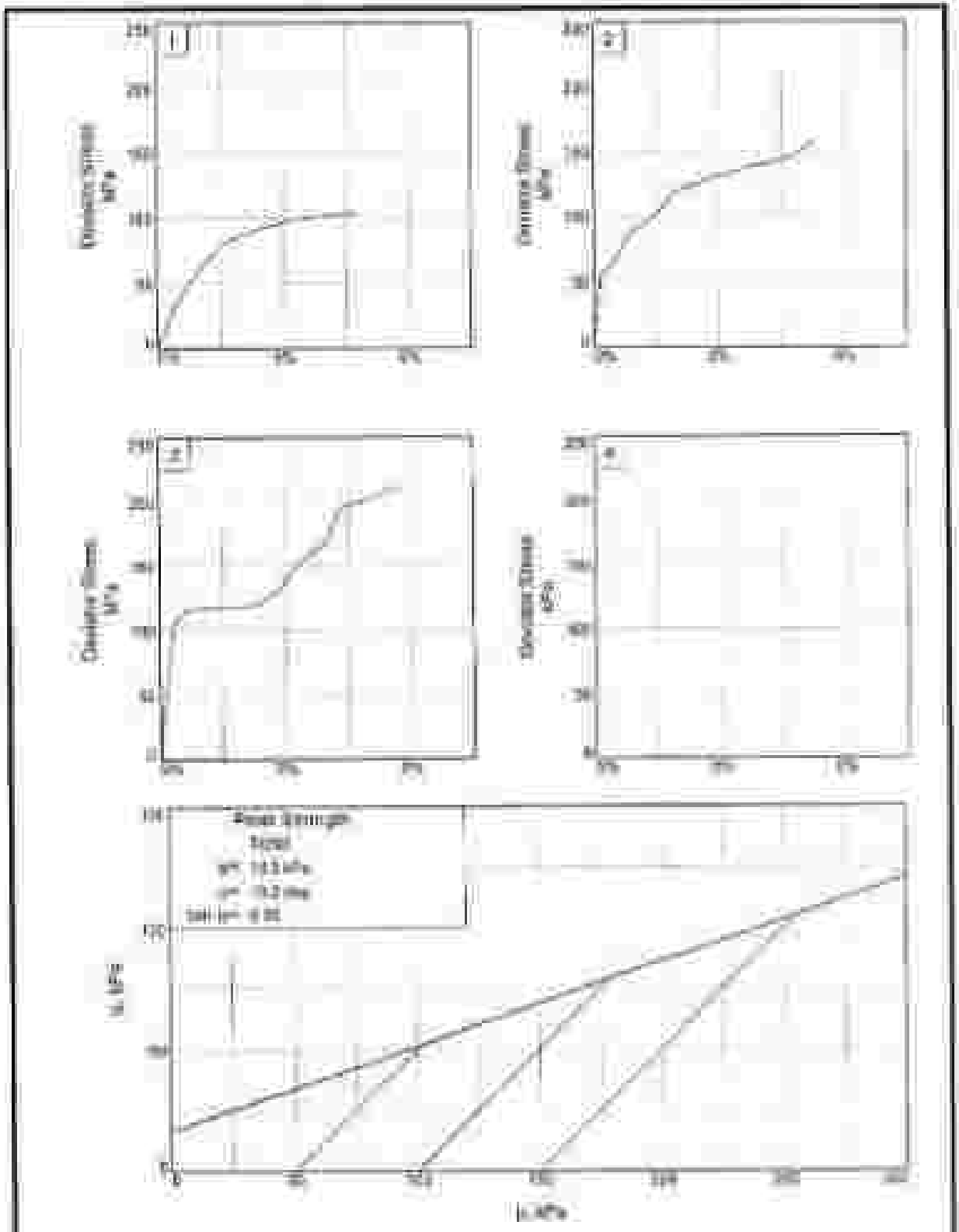
Date Sampled:

12.12.2023

File: FINANCE

Remarks:

Tested & Prepared By: CHARLES JAMES



Client: BHANJI CONSTRUCTION COMPANY

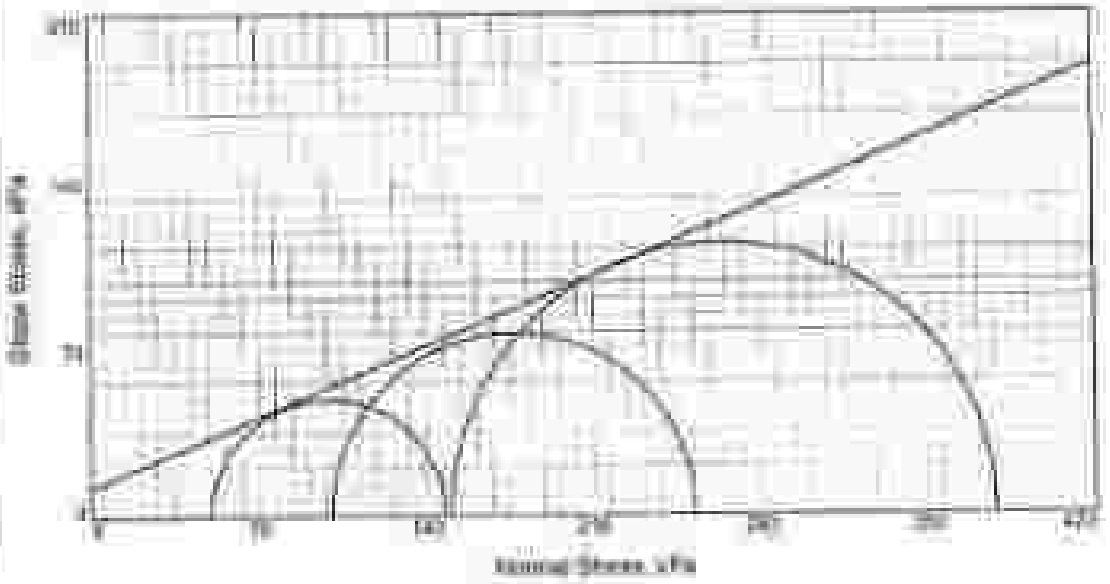
Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Depth:

2.00-6.0mm BH 4

Tested & Prepared By: CHARLES JAMES

TRIAXIAL SHEAR TEST REPORT



Type of Test: Unconsolidated Undrained **Sample Type:** UNSATURATED

No	Fluid Press, kPa		Pdf. Stress, kPa		Ult. Stress, kPa		Moisture Content	
	Cell	Back	Deviator	Strain, %	Deviator	Strain, %	%	%
1	50.00	0.00	97.63	7.4			141.01	50.09
2	100.00	0.00	192.87	5.0			282.45	104.90
3	150.00	0.00	259.63	5.0			379.45	135.60

No	Sample Parameters						
	% Water Content	Dry Density kg/m3	Saturation	Void Ratio	Diameter mm	Height mm	Strain Rate mm/min
1	63.1	1409	100.0%	0.9401	70.00	140.00	1.40
2	63.1	1409	100.0%	0.9401	70.00	140.00	1.40
3	63.1	1409	100.0%	0.9401	70.00	140.00	1.40

Mohr-Coulomb Strength Parameters	Total
Strength intercept, c=	43.14 kPa
Friction angle, ϕ =	23.8 deg.
Tangent, ϕ =	0.44

Material Description

Client:SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Location: KIMARA -DSM

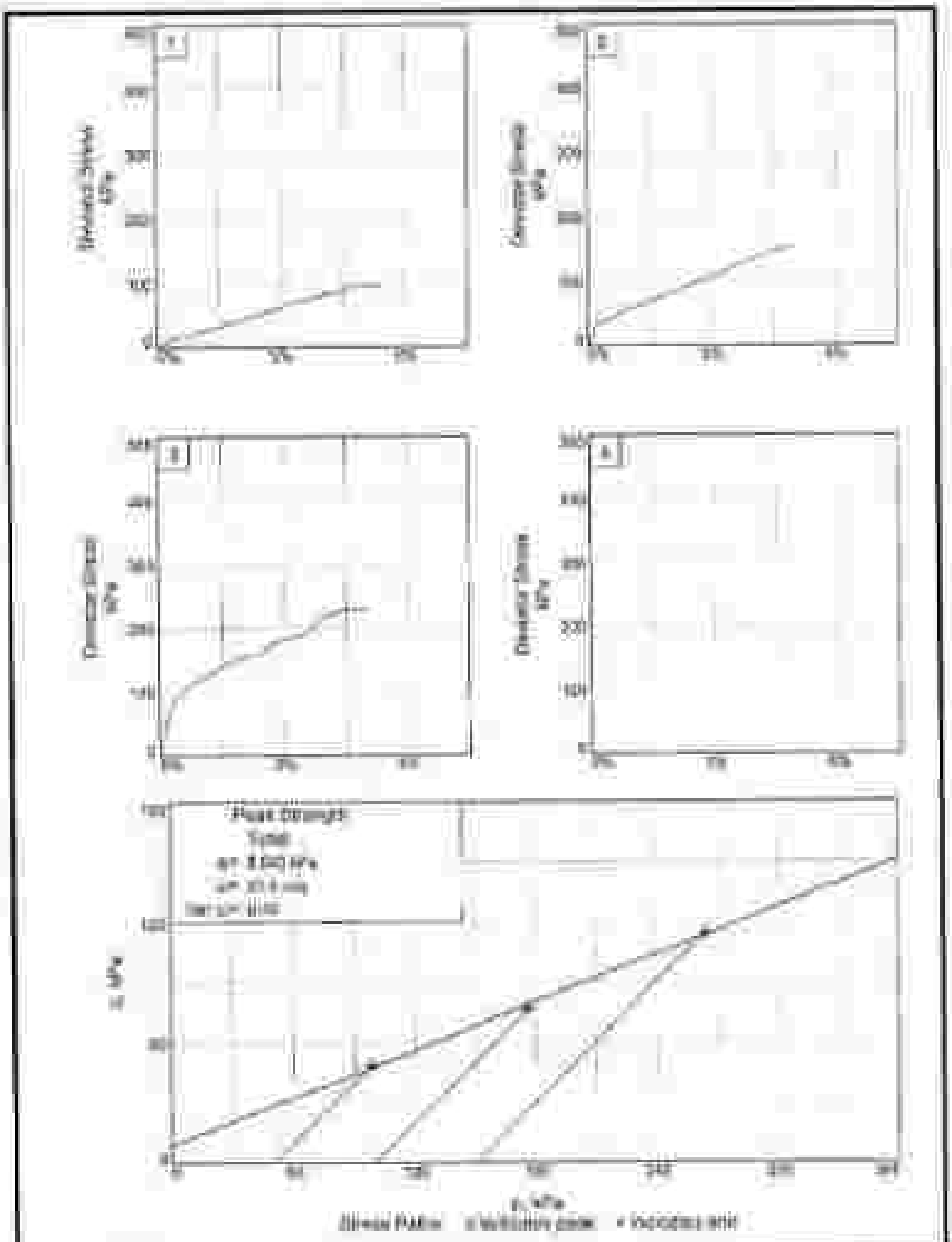
Depth: 0.0-3.0m BH NO.1

Date Sampled: 12.12.2023

TRIAXIAL SHEAR TEST REPORT

Dar Es Salaam, Tanzania

Tested & Prepared By: CHARLES JAMES



Client: SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

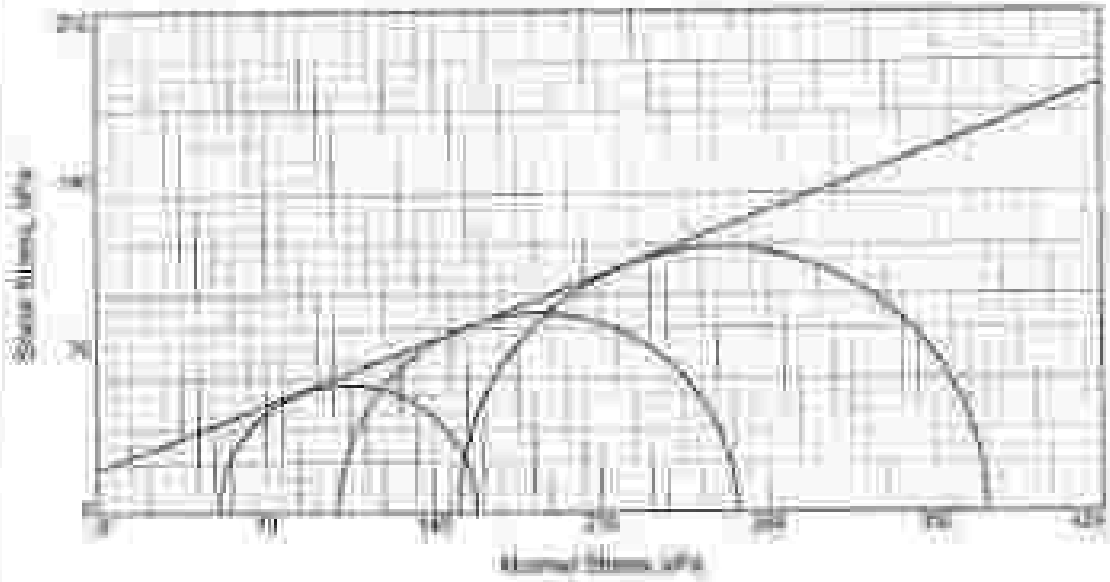
Depth: 0.0-3.0m Sample No.: BH No.:

Figure 1

Tested & Prepared By: CHARLES JAMES

12/12/2022

TRIAXIAL SHEAR TEST REPORT



Type of Test: Consolidated Undrained

Sample Type: UNDISTURBED

No.	Cell Pressure, kPa	Back	Axial Stress, kPa Deviator	Strain, %	Max. Shear Stress, kPa Deviator	Strain, %	Pore Pressure kPa	%
1	50.0	0.0	197.7	4.7			137.7	69.6
2	100.0	0.0	197.8	4.4			216	100.0
3	150.0	0.0	211.4	4.0			174.6	100.0

No.	Sample Parameters % Water Content	Dry Density kg/m³	Saturation %	Void Ratio	Diameter mm	Height mm	Strain Rate mm/min
1	25.8	1237	100.0%	1.0509	70.0	140.0	1.4
2	25.8	1237	100.0%	1.0509	70.0	140.0	1.4
3	25.8	1237	100.0%	1.0509	70.0	140.0	1.4

Mohr-Coulomb Strength Parameters	Test
Strength Intercept, c =	0.4 kPa
Friction angle, ϕ =	21.6 deg
Tangent, c =	0.40

Material Description

Client: SHANXI CONSTRUCTION COMPANY

Project: PROPOSED FAECAL SLUDGE TREATMENT PLANT

Location: KINSHASA - DRC

Depth: 0.00-3.0m

TRIAXIAL SHEAR TEST REPORT

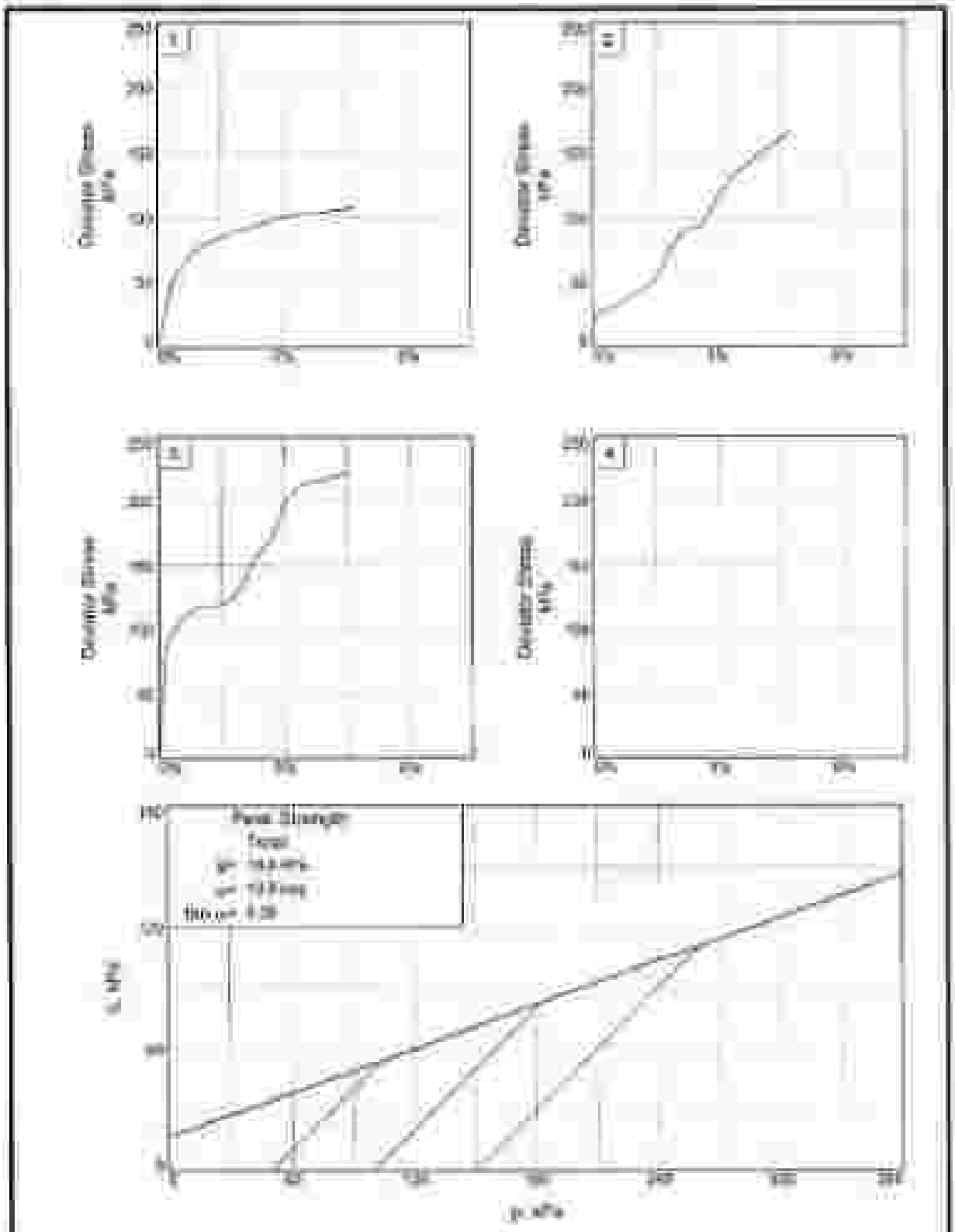
Date Sampled: 12.12.2023

Filer Remarks: BOREHOLE 05 DEPTH 0.5-3.0m

Figure

Tested & Prepared By: CHARLES JAMES

12/12/2023



Client: SHANXI CONSTRUCTION COMPANY

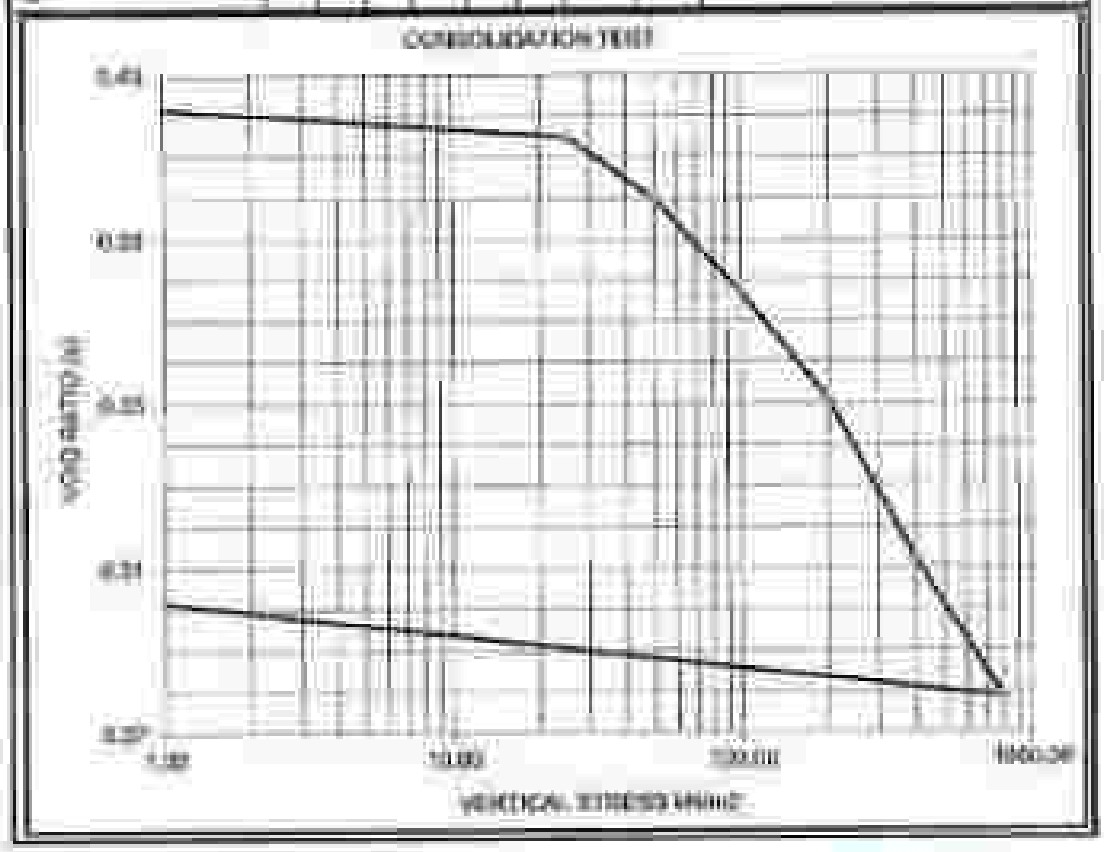
Project:PROPOSED FAECAL SLUDGE TREATMENT PLANT

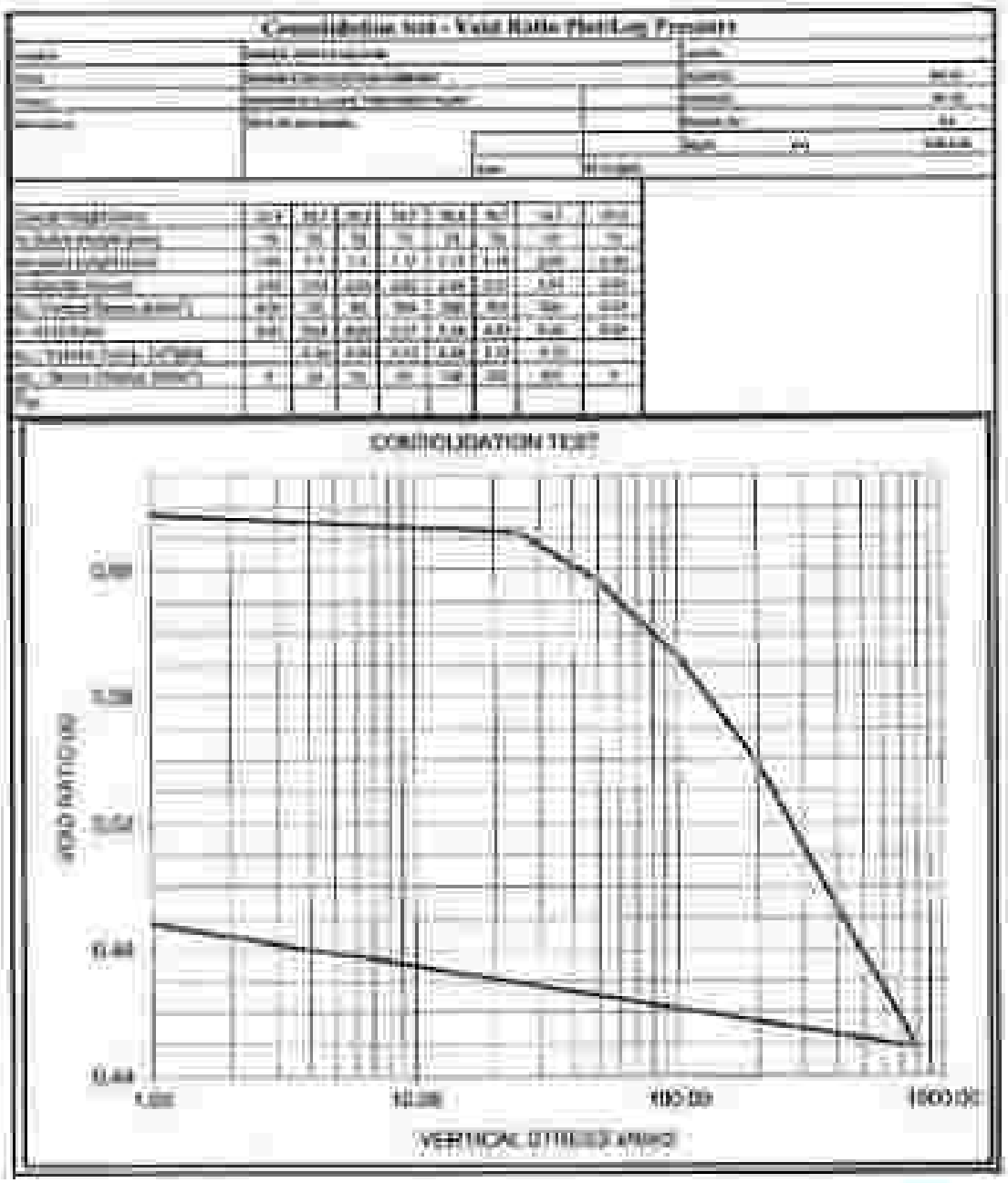
Depth: 0.00-3.0m Project No.: (illegible)

Figure

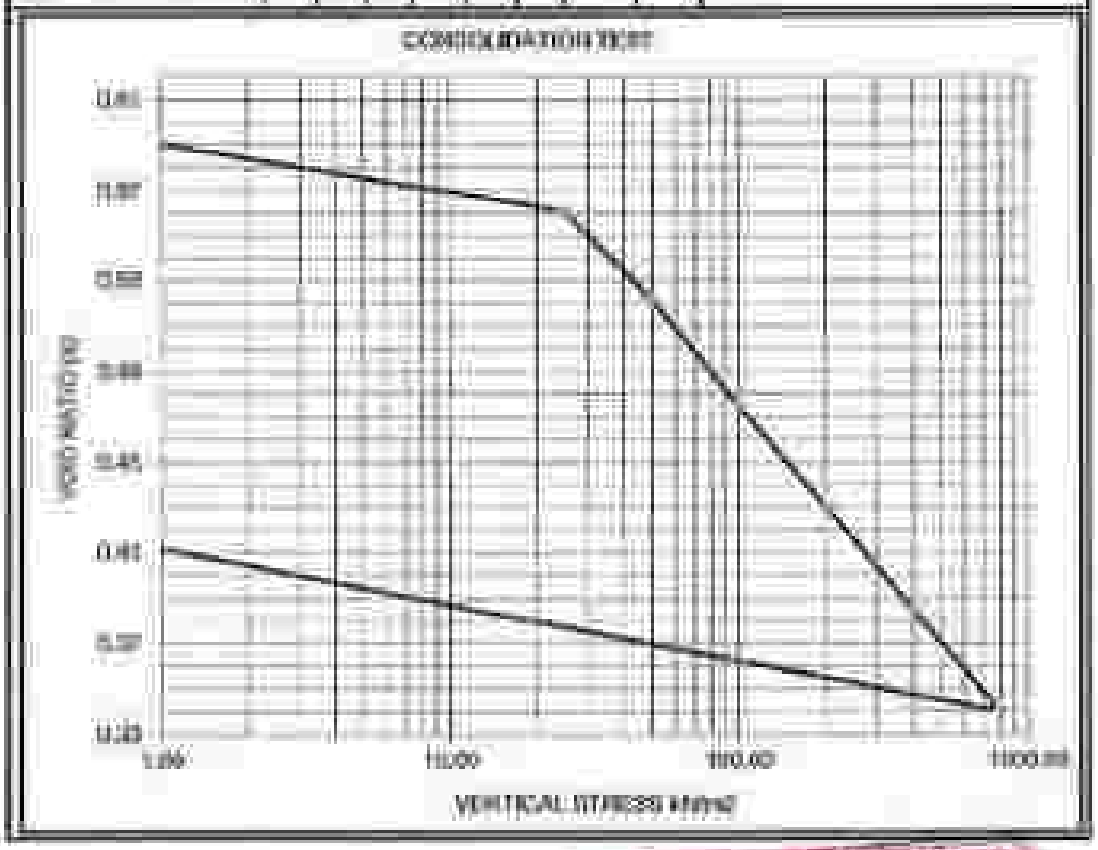
Tested & Prepared By: CHARLES JAMES

Consolidation test - Void Ratio Plotting Pressure

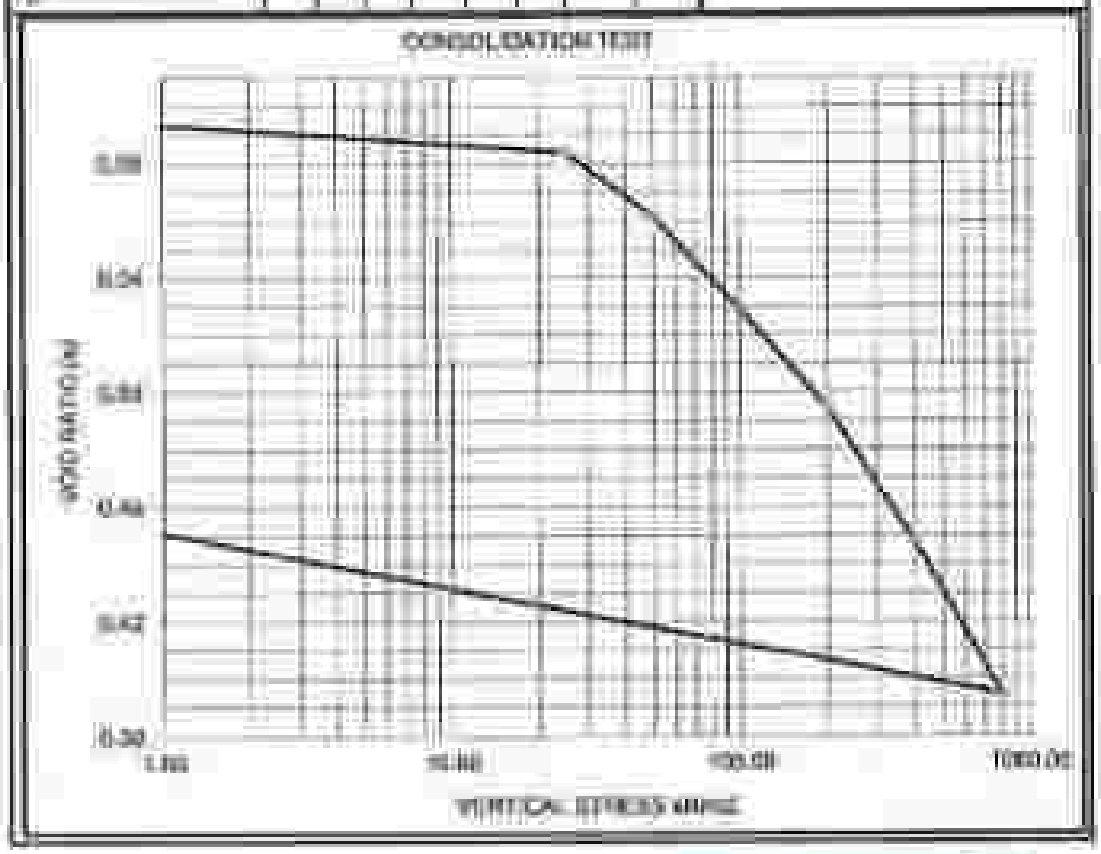


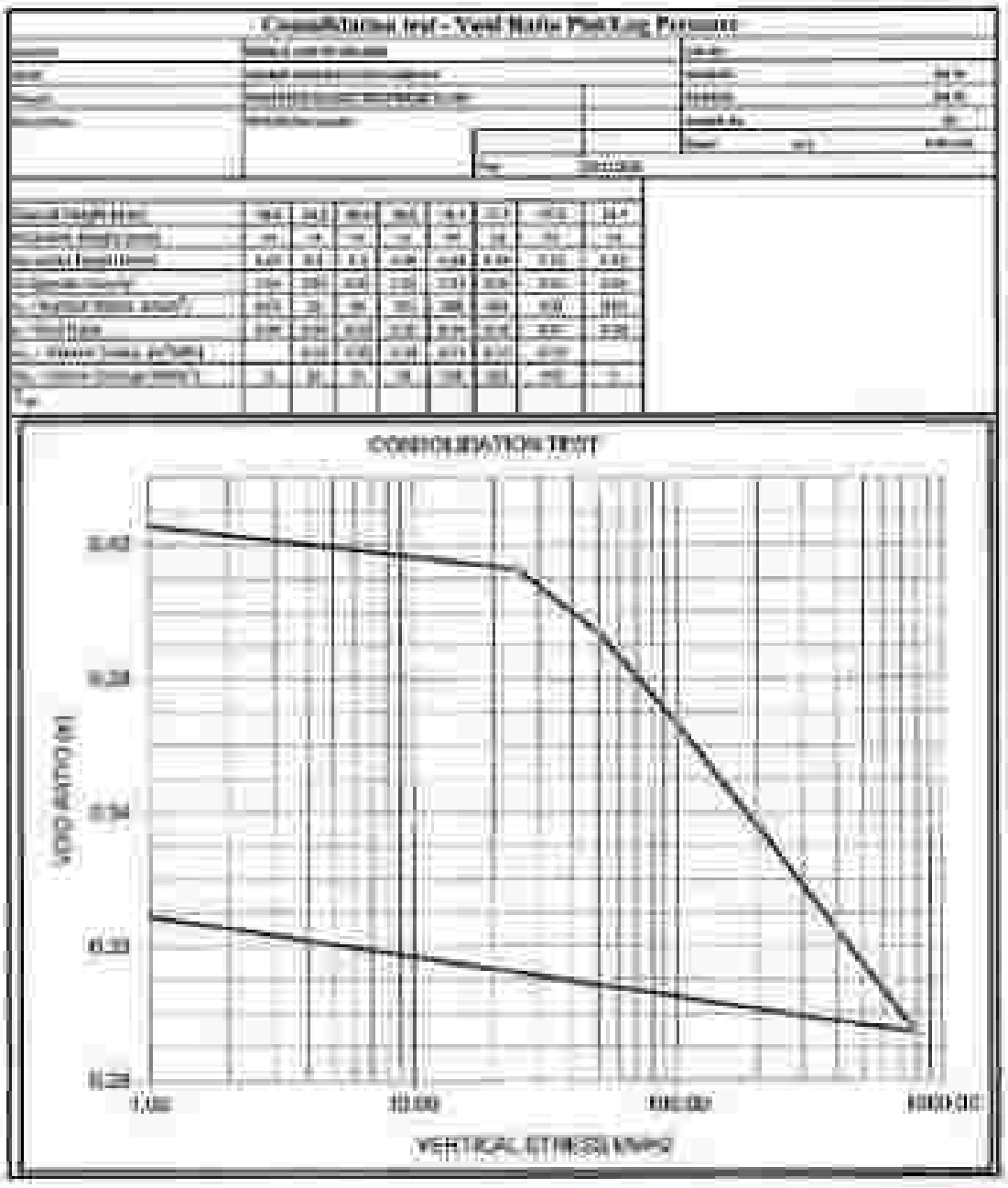

CONSOLIDATION TEST

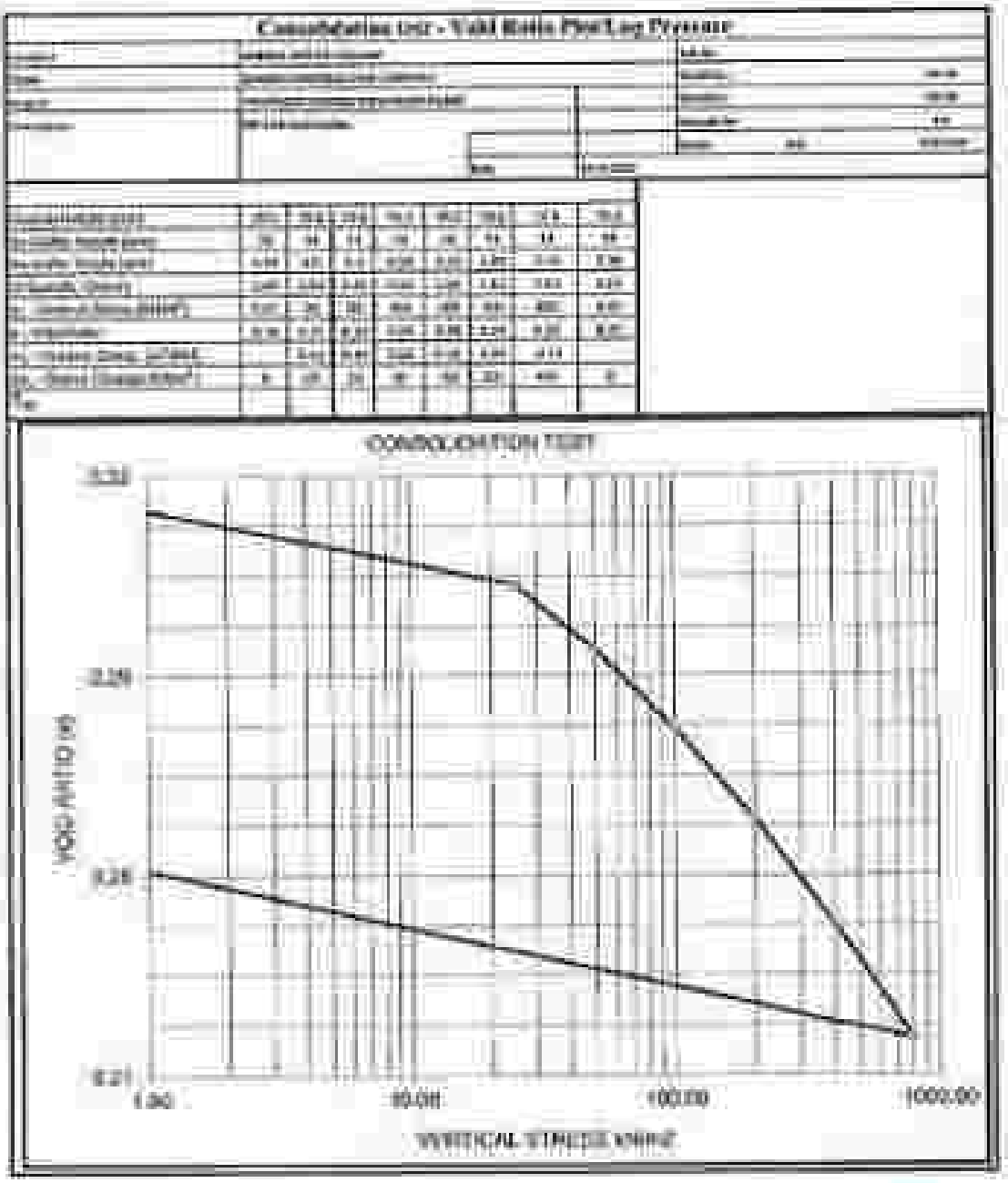
Consolidation test - Void Ratio Plotting Pressure



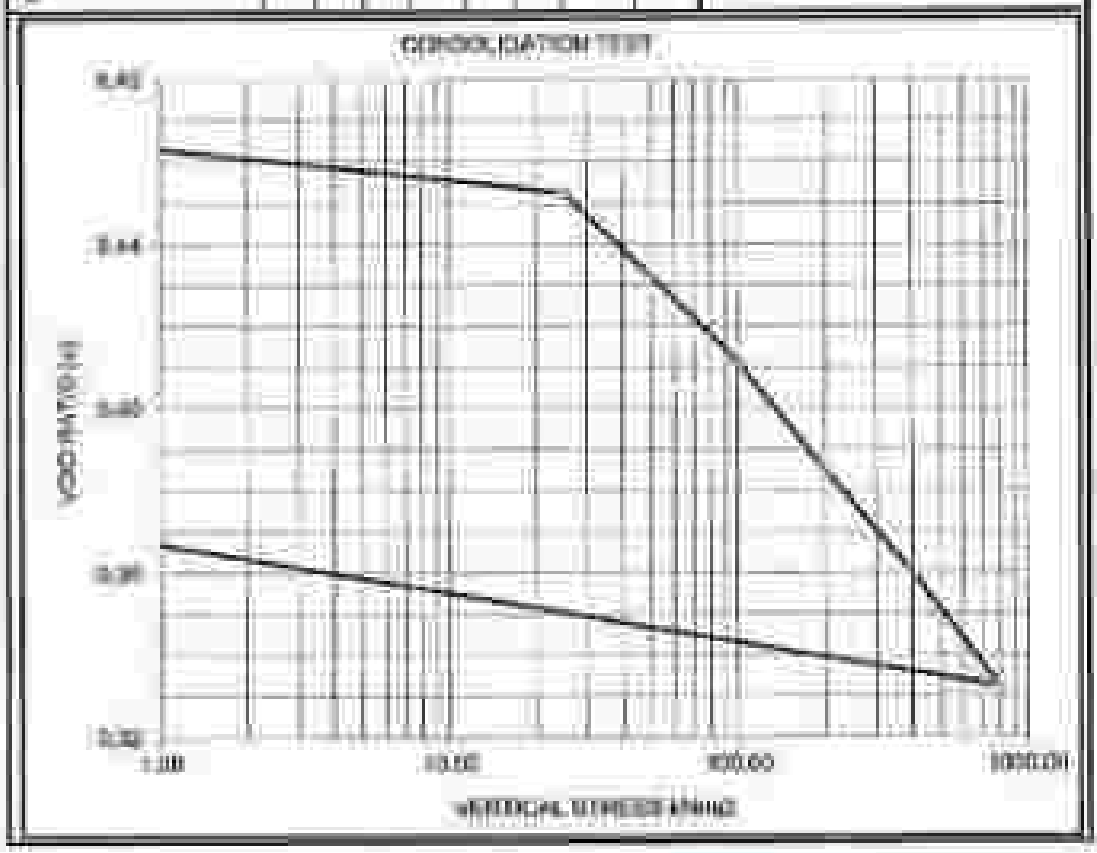
Consolidation test - Void Ratio Plotting Pressure

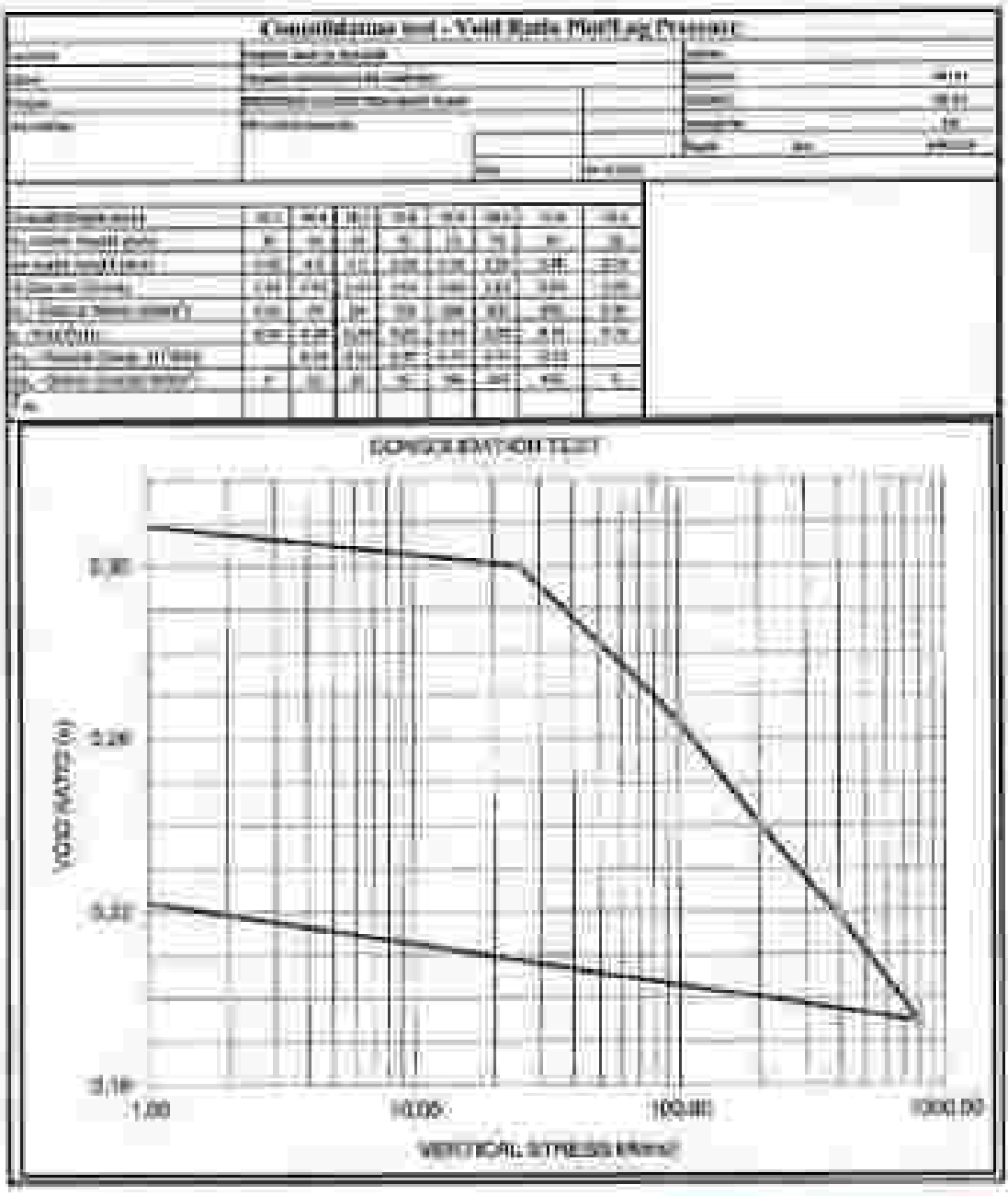


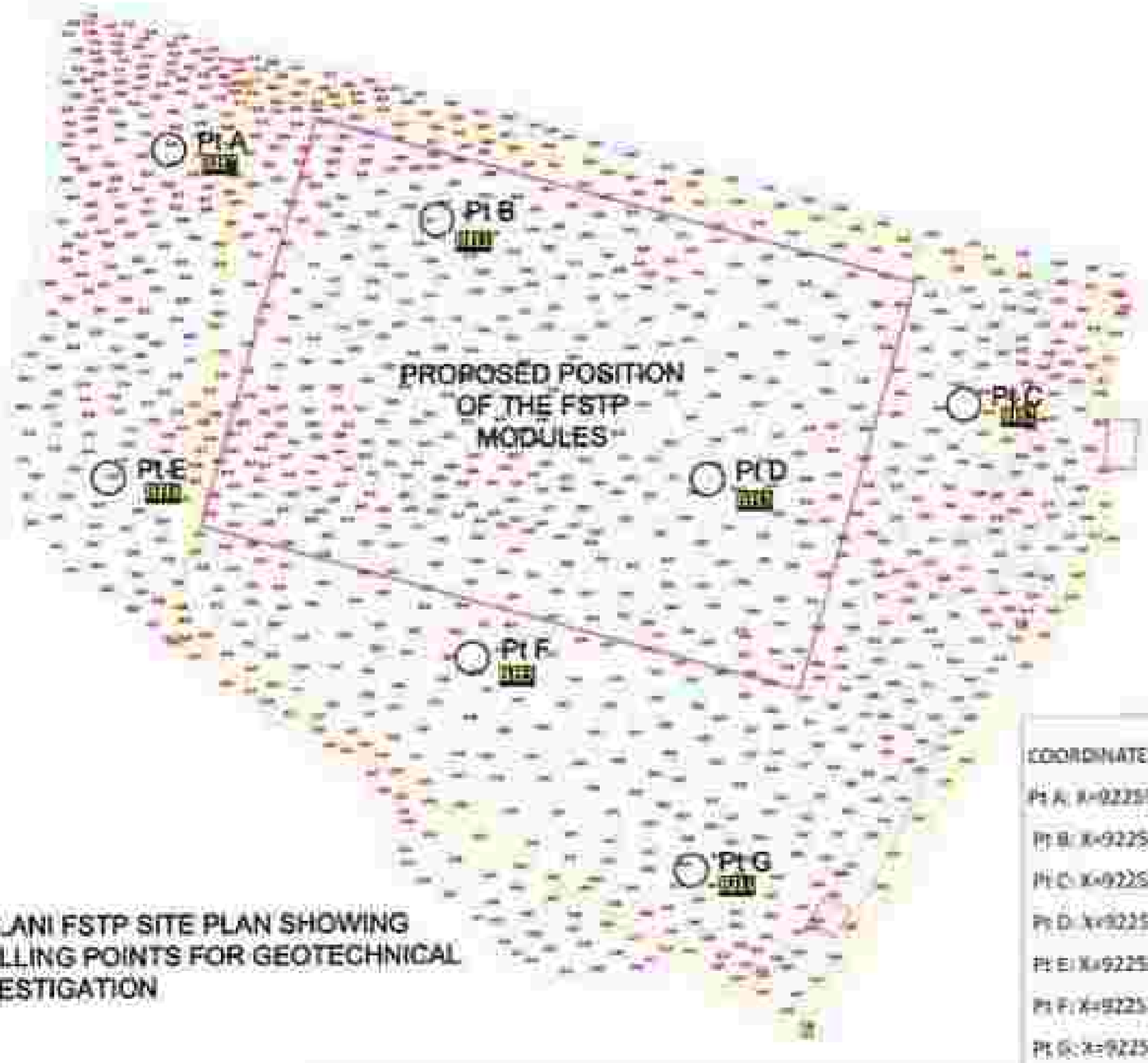

CONSOLIDATION TEST
VOID RATIO (e)
VERTICAL STRESS (kg/cm²)


CONSOLIDATION TEST
VOID RATIO (e)
VERTICAL STRESS kN/m²
0.30
10.00
100.00
1000.00

Consolidation test : Void Ratio Plot Log Pressure




CONSOLIDATION TEST
VOID RATIO (e)
VERTICAL STRESS (kPa)
1.00
10.00
100.00
1000.00



GOLANI FSTP SITE PLAN SHOWING DRILLING POINTS FOR GEOTECHNICAL INVESTIGATION

COORDINATES OF THE PROPOSED GEOTECHNICAL SURVEY POINTS

Pt A:	X=9225805.879	Y=557069.421	Z=40.156
Pt B:	X=9225884.842	Y=557138.834	Z=38.109
Pt C:	X=9225836.813	Y=557287.895	Z=33.466
Pt D:	X=9225813.901	Y=557215.719	Z=34.000
Pt E:	X=9225815.932	Y=557054.059	Z=36.973
Pt F:	X=9225765.970	Y=557150.838	Z=35.000
Pt G:	X=9225706.414	Y=557210.920	Z=35.200