Feasibility Study for the Lake Victoria Basin Integrated Water Resources Management Programme with High Priority Investments (BMZ-No. 2013 67 309)

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Feasibility Study

High Priority Investment Mwanza Wastewater Treatment Plant in Mkuyuni

Final

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Client:
Lake Victoria Basin Commission

JUMUIYA YA AFRIKA MASHARIKI

SWECO ALTERRA WAGENINGEN UR ECORYS

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Authors	:	Jan Spit, Nathan Mwema (Runji & Partners), Peter Vos (Ecorys) and Isabel Munandi (Runji & Partners)
E-mail	:	adsannen.id.as@gmail.com
Checked by	:	Ad Sannen
Signature checked	:	
Approved by	:	Alexander von Goertz
Signature approved	:	
Contact	:	Sweco GmbH Hanauer Landstr. 135-137 60314 Frankfurt am Main Phone: +49 69 95 921 0 www.sweco-gmbh.de

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Acronyms

AfD	French Development Aid
BH	Borehole
BOD	Biological Oxygen Demand
BoD	Board of Directors
BOQ	Bill of Quantities
DC	District Commissioner
DN	Nominal Diameter of pipes
EAC	East African Community
ECD	Early Childhood Development
EDF	European Development Fund
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EL	Elevation
EMP	Environmental Mitigation Plan
EU	European Union
EWURA	Energy and Water Utilities Regulatory Authority
FS	Feasibility Study
GIS	Geographical Information System
ha	Hectares
HPI	High Priority Investments
HV	High Voltage
IC	Individual Connection
IFI	International Financing Institutions
IRR	Internal Rate of Return
IWRM	Integrated Water Resources Management
KFW	German Development Bank
KM	Knowledge Management
km	Kilometre
l/c/d - lcd	Liters per capita per day
lps	Litres per second
LV	Low Voltage
LVBC	Lake Victoria Basin Commission
m	Metres
m^3/day	Cubic metres per day
m^3/hr	Cubic metres per hour
Maji	Water
MOU	Memorandum of Understanding
MoWI	Ministry of Water & Irrigation
MWAUWASA	Mwanza Water and Sanitation Company
NC	Non-individual Connection
NEMA	National Environmental Management Authority
NFP(O)	National Focal Point (Officers)
NGO	Non-Governmental Organization

O&M	Operation and Maintenance
PIA	Project Implementation Agency
PIU	Project Implementation Unit
PS	Prime Secretary
RGS	Rainfall Gauge Station
RPSC	Regional Policy Steering Committee
SEA	Strategic Environmental Assessment
SPA	Service Provision Agreement
SWOT	Strength Weakness Opportunity & Threats Analysis
TA	Technical Assistance
TAA	Tanzania Airports Authority
TANESCO	Tanzania Electric Supply Company Limited
TBS	Tanzania Bureau of Standards
TOR	Terms Of Reference
TWG	Technical Working Group
TZ	Tanzania
UFW	Unaccounted for Water
VIP	Ventilated Improve Pit
WA	Water Authority
WASREB	Water Service Regulatory Board
WATSAN	Water and Sanitation
WHO	World Health Organization
WIM	Water Intervention Module
WP	Working Package (1, 2 and 3)
WRM	Water Resources Module
WRMIS	Water resources Monitoring Information System
WSP	Water Service Provider
WUM	Water Utilization Module
WWTP	Wastewater Treatment Plant

Executive Summary

The rapidly deteriorating water quality in the Lake Victoria Basin (LVB) is the main reason to counteract against the pollution of the LVB. As a matter of fact, the Lake Victoria is the most important freshwater storage in East Africa, whereof 40 million people depending on its resources.

In this respect the East African Community (EAC) has established the regional cross-border institution, the Lake Victoria Basin Commission (LVBC) in order to coordinate sustainable development in the Basin among the Partner States of the EAC, Burundi, Kenya, Rwanda, Tanzania and Uganda. The main objective is to ensure the availability and quality of water resources through the trans-boundary and transparency IWRM Programme for the LVB through the implementation of regional IWRM investments and related measures. .

Although many programmes have been implemented over the last years, the planning, design and construction of water supply systems, wastewater treatment facilities and solid waste management do not keep up with population growth. Lack of sanitation facilities, open defecation and poor faecal sludge management lead to eutrophication and microbiological pollution of Lake Victoria and emphasis the focus on IWRM Programme.

For the short term a focus on the pressing and 'no-regret' issue of wastewater and sanitation has been chosen and has been translated in the concept of High Priority Investments. SWECO and partners were selected to execute the 'Feasibility Study for the Lake Victoria Basin Integrated Water Resources Management Programme with High Priority Investments' as a part of Work Package 2.

Four High Priority Investment (HPI) projects were selected in four riparian countries of Lake Victoria, based on a selection process guided by LVBC in close consultations with the stakeholders. The following HPIs were selected:

1. Wastewater treatment and sewerage in Mwanza, Tanzania;
2. Constructed Wetlands in Kampala, Uganda;
3. Faecal sludge treatment in Kigali, Rwanda;
4. Rehabilitation of the sewerage treatment network in Kisumu, Kenya.

For each of these HPIs a feasibility study is prepared.

The stakeholders endorsed the selection of the HPIs for further feasibility review during the Inception Meeting of the 3rd of March 2016 in Kisumu.

For Kisumu, the selected project area has changed after discussions with Lake Victoria South Water Board and the EIB/ AfD and now covers sanitation in informal settlements in Kisumu.

HPI Mwanza. The project area is Mwanza City, the second largest city in Tanzania. Mwanza is located in the north of Tanzania, directly along the shore of Lake Victoria.

The City of Mwanza wants to reduce the pollution load of Mwanza town currently discharged into the Lake Victoria. The rocky soils in Mwanza do not favour affordable on-site sanitation systems (mainly cess pits). The topography (hills) favours the 'illegal' emptying of full pits during the rains. Therefore, Mwanza has chosen off-site sanitation (sewerage) as the preferred wastewater management system in the future, expecting the town will grow to 1.9 million inhabitants in 2035.

Master Plan COWI. A Water Supply and Sanitation Master Plan[1] is being prepared for the expansion of water supply and sewerage. The Master Plan[2] (we had only access to the draft versions, in November 2016 the Final draft should be ready) foresees the operation of 3 Wastewater Treatment Plants in the short term: the existing one (WWTP Ilemela) in the north, the planned WWTP Igoma in the east (to be funded by EIB) and the new WWTP in the south, proposed at Mkuyuni, along the railway track. High-density neighbouring areas are to be connected to the sewerage system **by gravity** to the WWTP Mkuyuni, thus improving sanitary conditions immediately. Under the Master Plan a new water source in South Mwanza is to be developed.

EIB. The European Investment Bank (EIB) is the main funder of wastewater improvement in Mwanza, UN Habitat is the sanitation facilitation lead and several consultancy firms are providing services in Mwanza. It is recommended aligning with the EIB and UH Habitat and disseminating the findings of this study with the consultancy firms active in Mwanza.

Existing Sanitation Situation in South Mwanza. According to a recent survey, 84% of the people use water for anal washing, 1% uses toilet paper and 15% uses both[3]. Most households have *pour*-flush *toilets* connected to off-site, unlined and lined soak pits. As the soil is sandy (with rocks) these soak pits pollute the groundwater. Hence, shallow drinking water wells are contaminated with faecal coliforms where the distance between the well and soakpit is relatively short[4]. This (polluted) water is not only used for drinking but also for watering vegetable gardens.

At present Mwanza South does not have sewerage.

Existing WWTP: The existing wastewater treatment plant (WWTP), Ilemela, is located north of the city centre. It receives all wastewater collected in the existing sewerage system. More than 95% of the wastewater is pumped to the plant whereas the remaining is conveyed to the plant by gravity. The Ilemela WWTP consists of waste stabilisation ponds. It was redesigned and upgraded in 2010/11 with a new and extended hydraulic capacity of **5,750 m³/d.**

MWAUWASA's (the utility of Mwanza) monthly effluent samples show that the existing WWTP performance appears (negatively) impacted by sludge built-up in the ponds. The first-ever sludge removal maintenance (typically required on 1-2 year basis) will be conducted at the Ilemela ponds within the IIP-Immediate Investment Plan of this TZ-EIB-AFD investment program, scheduled within 2016-17[5]. The TZ-EIB-AFD investment program will also fund sewer connections to the existing sewer network[6], as the population cannot afford to finance the connections themselves. According to COWI, these new connections will result in overload of the existing WWTP.

The HPI aims at the implementation of the Mkuyuni Waste Water Stabilization Ponds to cater for the Mwanza South, which is currently not served with a sewerage network. In the original HPI we had foreseen to include faecal sludge treatment. However, we conclude that the market for faecal sludge management is relatively small, as households have found other means to empty the pits. Therefore, the design of the WWTP Mkuyuni does not need to take into account the treatment of faecal sludge.[7]

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[1] By COWI

[2] Master Plan & Short-Term Investment Plan, Strategy and Project Selection, Wastewater and Sanitation, COWI, 8 April 2016 (Water Supply and Sanitation for Mwanza Town and Satellites

[3] Chaggu et al., 2002

[4] Mushi et al., 2012

[5] Refer to COWI master plan report, 22 June 2016

[6] COWI clause 4.2 of the EIB MP TZ masterplan WW-WWTP ver 1

[7] Refer to Mwanza Sewerage Phase Ii Completion Report dated March 2012 by C. Lotti & Associati

In the past, very few households connected to the existing sewerage scheme with their own funds. But if donors finance them, such as in the Mwanza Sewerage Phase II works, completed in 2012, 98% of the population is willing to connect. At the start this percentage was lower, but as MAUWASA pointed out that they would only finance the connections during the construction phase, the percentage increased. Households that decided to connect after the construction period were charged a separate connection fee. Based on this experience, we conclude that when the connections are financed through the project, the overall majority of the people in the project area want to be connected.

During the KfW appraisal mission (24 June, 2016), the Prime Secretary (PS) Maji (Water) of the MoWI (Ministry of Water & Irrigation) stipulated that Mwanza will be the first town where a by-law will be adopted to enforce people to be connected that are living within a range of 30 meters of the sewer network. Hence, based on this experience in Mwanza, we can safely assume that 98% of the households in the service area can and will be connected. Both facts make us confident that 100% of the people near the sewer network will indeed be connected. This is an important fact as 100% connection rate is necessary to assure proper functioning of the system and recovery of costs to pay for operation and maintenance.

Operation and maintenance of sewerage is expensive; mainly due to high pumping costs (electricity) thus leading to high operational costs. Hence, it is recommended reducing O&M costs by focussing on the areas that can be served through gravity sewers. In total 7,400 households are to be connected. The capacity of the WWTP is 3,800 m^3/d.

Investment. The investment is composed of:

- Acquisition of 3 ha of land. This is valued at € 0.064 mln.;
- Pre-treatment works: screening and grit removal;
- Construct Waste Stabilization Ponds to treat the wastewater of 45,000 persons, capacity 3,800 m^3/d: Anaerobic ponds, Facultative ponds and Maturation ponds;
- City Council confirmed Reservation/ availability of an area that can host a WWTP for 400,000 capita, 34,000 m^3/day of 15-20 ha required for future expansion. This is valued at €0.3 mln.;
- Topographic and geotechnical survey to be undertaken for the sewer line and treatment area;
- In future phase, the existing Mwanza South sewer pump-house will be adapted to pump to the new works. This is in line with the COWI master-plan;
- The following areas can be connected by gravity: 3,000 households in Mando, 2,300 hh in Kanyerere, 1,000 hh in California and 1,100 hh in Password. Total 7,400 hh (around 45,000[8] persons);

Total costs: € 13.5 mln. The land already belongs to the government.

Table 1: *Summary Costs*

No	Description	Amount (Rounded) € Million
1	Total Direct Investment: WWSP + collector pipes	€ 11.8
2	Capacity building	€ 0.06
3	Construction Supervision	€ 0.4
4	Project Management Unit	€ 0.04
5	10% Contingencies	€ 1.2
6	**Sub Total at Project Completion by KfW**	**€ 13.5**
7	Land Value Contributed by Mwanza City Council (for entire future requirement of 15Ha)[9]	€ 0.3
8	**Total at Project Completion**	**€ 13.8**

[8]Connections are based on the current number of hh water connections only and not on the actual number of households in the area. Those without HH water connection not included.

[9] Source: https://kupatana.com/real-estate/land/plot-for-sale_i667309.

Environmental Impact and cost effectiveness. The implementation of this HPI is to result in an improvement of the waster quality: the Biochemical Oxygen Demand (BOD_5) will decrease from 413 mgBOD_5/l to 25[10] mg BOD_5/l for 3,800 m^3/day. Hence per day 1.47 ton BOD_5 is removed. So, the cost effectiveness is € 13.5 mln/1.47 tonnes BOD_5/day = € 9.2 mln /tonBOD_5 removed per day.

MWAUWASA is the implementing agency for the implementation of the HPI. MWAUWASA is capable of managing and implementing the project for the following reasons:

- MWAUWASA is financially sound; the cost-recovery level is currently over 100% and the collection ratio is also high, also in comparison with international standards: 98%;
- MWAUWASA has experience in operating and maintaining sewerage networks and WWTPs;
- MWAUWASA knows how to manage large projects that are financed by international financing institutions and development donors;
- There is staff that is capable of operating wastewater systems.

Key results financial calculations. The current surcharge is not sufficient to sustain the project. The level of surcharge will have to be increased from the current level of 50% to 75% to make the project feasible[11]. The following table presents the required sewerage charge and the corresponding change in key results.

Table 2: *Key Results Under the Current Tariff Regime (50%) and the Base Case (75%)*

Indicator	Value under 50% surcharge (current)	Value under 75% surcharge (base case)
Internal Rate of Return of operations – before finance	<0	<0
Net Present Value (10%) – after finance (EUR)	-569,288	56,420
Prime costs of treatment (0% discount rate, EUR/m^3)	0.516	0.516
Prime costs of treatment (5% discount rate, EUR/m^3)	0.382	0.382
Operating Cost Recovery ratio (revenue / O&M)	3.35	4.86
Full Cost Recovery ratio (sustainable => 1) (revenues / (O&M + depreciation))	0.71	1.03
Affordability (%) (water + sewerage bill / household income)	3.3%	3.7%
Impact Implementing Agent - net annual profit (EUR – full operations)	-277,428	7,529
Current annual profit operations Implementing Agency (EUR – 2015 operations)	-184,957	-184,957[12]

The Full Cost Recovery ratio under the current tariff regime shows that insufficient revenue is generated for future reinvestments. In order to operate sustainably, the sewerage surcharge needs to be raised from 50% to 75% (sewerage surcharges provide the majority of the revenue, as shown in Figure 1).

Table ***2*** shows that under this tariff regime, the Net Present Value after finance becomes positive.

MWAUWASA is required to receive approval from the regulator (the Energy and Water Utilities Regulatory Authority) for this increase in tariffs.

In addition, the company-wide operations of the MWAUWASA, which are currently at a slight loss, become positive under such a tariff. This is based on the additional revenue collected from

[10] At Design Stage connection as cost of increasing connection to ultimate 40,000 not considered.

[11] For project feasibility, the new surcharge is calculated over the new connections (7400)

[12] It is assumed that the new tariff will apply to all connections

households, which are already connected, to the existing sewerage network. Figure 1 provides the development of the revenue streams.

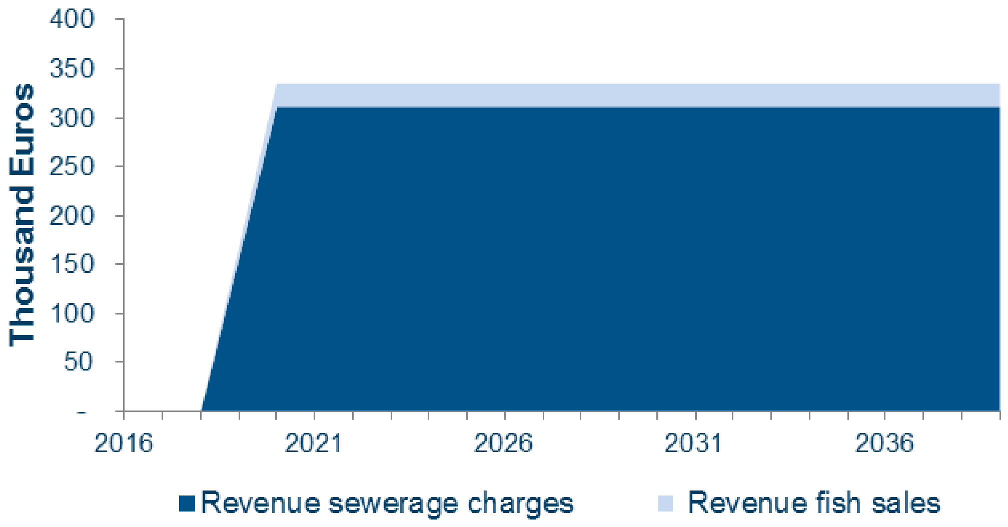

Figure 1: Breakdown of Revenue During Operations

The most significant revenue stream originates from the sewerage charges. There are some minor revenues from the sales of fish out of the fishponds. These are sold as fish-feed.

Figure 2 presents the year-on-year cash flow of the project under operations (before financing).

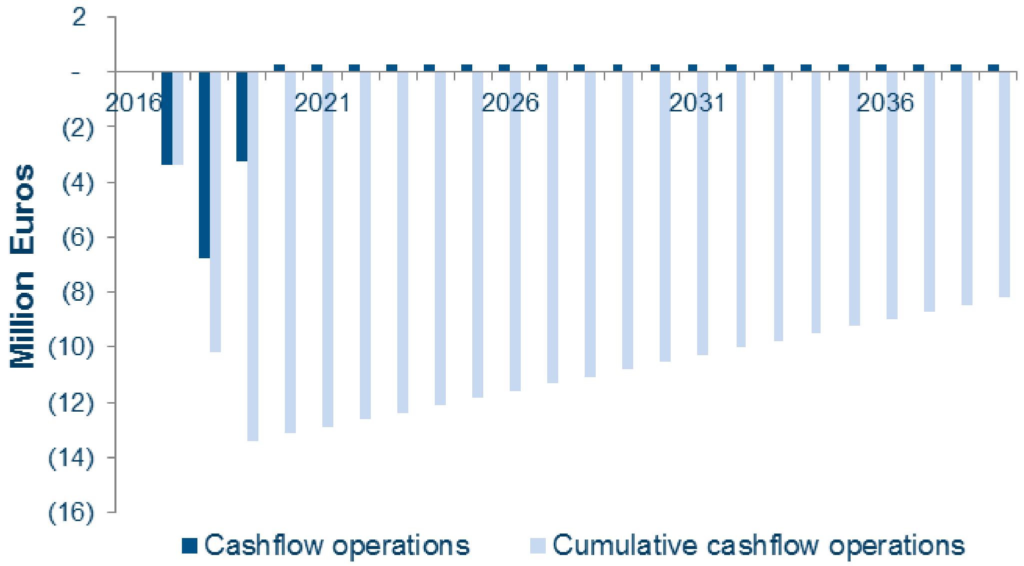

Figure 2: Cumulative and Year-on-year Cash Flow of Operations

To test the robustness of the financial operations of the project, a sensitivity analysis has been done. Table 3 shows the impact of various changes in parameters on the Full Cost Recovery ratio.

Table 3: *Sensitivity Analysis*

Parameter change	**Required sewerage surcharge**	**Affordability** Water and sewerage bill as % of household income
Base case	50%	3.3%
Financial sustainability	75%	3.7%
25% O&M cost increase	80%	3.8%
25% investment (and depreciation) cost increase	85%	3.9%
25% lower household connections	100%	4.2%
Maximum affordable surcharge increase	140%	5%

The results show that the maximum sewerage surcharge, which is still affordable by international benchmarks, is some 140%. Considering that a surcharge of 75% is needed for financial sustainability, the project can absorb some unexpected cost increases or revenue drawback. Obviously, this would require that both the target group and the regulator accept such a tariff increase, which may not necessarily be the case.

Updated Factsheet. The Fact Sheet that was prepared for the HPI selection has been updated and is presented as a reference of the following pages. This will allow easy comparison and ranking of the HPIs.

General	
Name of the project	Sewer connections, Sewer Lines and WWTP- Mkuyuni Area, South Mwanza
Country	Tanzania
Sector	Sewer collectors and Wastewater Treatment Ponds
Date	February, March, April and June, 2016
Project objective	In line with the Wastewater and Sanitation Master Plan that is being developed: Collect and treat wastewater in Mwanza South. Currently there is a wastewater treatment in the northern part of the city. In future the capacity of the wastewater that can be treated there is limited; mainly due to hydraulic limitation of the current sewerage system. The master plan that COWI started in 2014 envisages immediate rehabilitation of existing Ilemela ponds, construction of 2 new WWTP at Mkuyuni and Igoma plus 2 other WWTP for the north and south of the city to cater for the City by 2040, giving a total of 6 WWTP for the City of Mwanza. COWI is also responsible for implementation of the plan. There are EIB and AFD funds for Igoma WWTP, so KfW funds would make it possible to finance a Mkuyuni WWTP. The Mkuyuni WWTP is close to the Lake, targets a highly dense area hence resultantly, and has a high impact on the water quality. In contrary to the original project fact sheet, the option of treating faecal sludge from vacuum trucks that emptied septic tanks and cess-pits is abandoned as the present facilities are underutilized: the ‘market’ for pit and septic tank emptying in Mwanza is small and marketing is outside the scope of our project.
Technical features of the project	• Wastewater Stabilization Ponds have been recommended: Anaerobic Pre-treatment ponds, Facultative ponds and Maturation ponds; • Pre-treatment works will be screening and grit removal; • Expansion area for future works to be secured during this study; • Topographic survey undertaken for the sewer line and treatment area in the framework of this study; • Geotechnical survey has been undertaken for the sewer line and treatment area; • 150 m’ long access road to be constructed, see Figure 3 • Adaption of the existing Mwanza South sewer pump-house to pump to new works. This to be in the next phase of construction; • Existing Pumps have a capacity of 58 litres per sec; they can handle 3600m³/day; • In the existing situation there are three operational pumps complete with a stand-by generator; • The following areas can be connected by gravity: 3,000 households in Mando, 2,300 hh in Kanyerere, 1,000 hh in California and 1,100 hh in Password. Total 7,400 hh (around 45,000[13] persons); • Construct Waste Stabilization Ponds to treat the wastewater

[13]Connection based on current HH connection only not actual HH. Those without HH water connection not included.

	of 45,000 persons, capacity 3,800 m^3/d; • Reservation of an area that can host a WWTP for 400,000 capita, 34,000 m^3/day, around 15-20 ha; • Households with water connection in approved settlement to be considered under this design; • Waste water taken as 85% of water supplied; • Influent BOD for existing works was found to be on the low side, compared to experiences in the region and compared to the computed one; hence the later was assumed for design; • Main line to be designed to allow 50% increase in connection; • The sewer network will constitute 9.8km of 300mm diameter uPVC pipe, 6.6m of 250mm diameter uPVC pipe, 7.8km of 200mm diameter uPVC pipe and 13.2km of 160mm diameter uPVC pipe complete with 7,430pcs masonry connection chambers and 1,306 manholes. • Treatment Ponds to be for the projected connection considering current connection rates and plans; • Its assumed any future Industrial waste will be pre-treated before being discharged to the system in accordance with the law. In fact industrial wastewater is very limited as the area is surrounded by warehouses; • Wind flow assumed to be the average western direction; Average temperatures of 22ºc adapted for Permissible volumetric BOD loading computation;
Population served	• In July 2018, 40% of the target wastewater is collected and treated at the WWTP (1,600 m^3/day); • In 2020, 72% (2,700 m^3/day), in 2022 85% (3,200 m^3/day); In 2024 100% (3,800 m3/day) 44,800 persons (2016 population) i.e. 10% of projected 400,000 persons in 2040.
Implementing agency	MWAUWASA
Investment amount	- ~ € 3.5 million for WWTP to treat wastewater for 7,400 connections (~ € 471/connection); - ~ € 7.2 million (7,400 connections @ € 969/connection complete with conveyance to the plant; - ~ € 1.6 million for Preliminaries and Generals to construct the WWTP complete with connection network (@ € 215/connection); - 10% contingencies € 1.23 million; Total: ~ € 13.5 million (@ € 1,817/connection).
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Figure 3: Proposed WWTP Mkuyuni

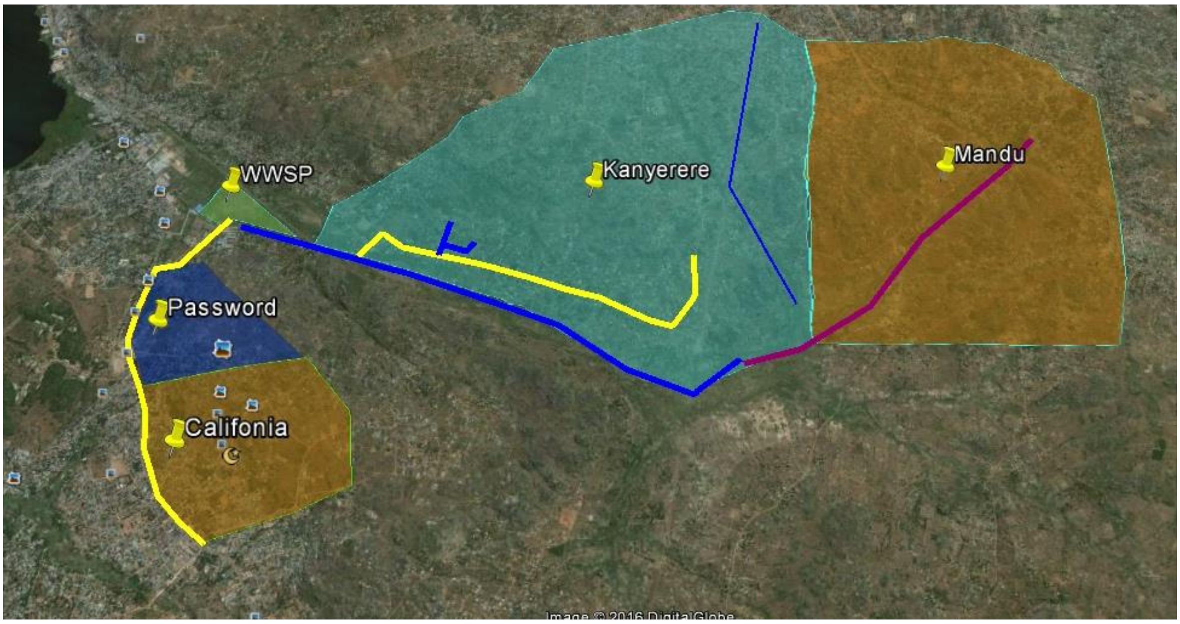


Figure 4: Location Map for the Proposed Mkuyuni WWTP and Collector System

Figure 5: Location WWTP Mkuyuni

Figure 6: Overview Project Location

<table>
<tr><th colspan="2">Project Issues and recommended solutions</th></tr>
<tr><td>Resettlement</td><td>No resettlement issues, terrain is already in hands of the city. Natural border by the rail way track</td></tr>
<tr><td>Consequences for poor</td><td>Positive, many live nearby in the hills and have water connection and can thus be connected immediately.</td></tr>
<tr><td>Design issues</td><td>Geotechnical survey for the WWTP and sewer line has been done as part of this FS.</td></tr>
<tr><td>Environmental impacts</td><td>Positive as currently untreated faecal sludge and wastewater of 45,000 persons is to be treated and disposed of in an environmentally sound way</td></tr>
<tr><td>Scope of the project (elements not covered)</td><td>Not included in the study are:
• Faecal sludge treatment because the existing Faecal Sludge Treatment Plant is hardly used as most on-site systems are emptied informally during the rains;
• The ‘reversing’ of the flow as foreseen in the COWI Master Plan where it is recommended to pump wastewater from Capri Point to the WWTP.</td></tr>
<tr><td>Sustainability</td><td>Mwanza city leads in the region in tariff collection and maintenance of works.</td></tr>
<tr><td>Financing aspects</td><td>Despite funding, households need to be willing and able to finance adjustments in the house and to pay water bills and surcharge.</td></tr>
<tr><td>Uncertainties</td><td>There are no clear plans or policy for settlements in the hilly areas, hindering availability of funds to extend water and sewer connections especially in the hilly terrains. Hence, we designed for actual number of connections and took into account the ‘natural’ growth rate in the area. In this way the project has immediate impact.</td></tr>
<tr><td>Others</td><td>There are several advantages of this location:
- MWAUWASA has an office near the site;
- A simplified sewerage system can be connected to the WWTP;
- Supply of water needs to be ensured to have sufficient water to flush the sewers;
- No resettlement issues.

It is expected that the project can be implemented effectively. Delays are not expected. The following actions are to assure this:

• The project should provide sufficient notice time to persons cultivating seasonal crops to harvest their products;
• During selection of local construction workforce, persons that were directly benefiting from utilizing the land should be given first priority;
• A public passageway could be designed at about the same location of the path currently used by the community to move between Butima and Mahina;
• Mwanza City Council confirmed that where people are eligible for land compensation, this should be taken up with the City Council, in line with Government of Tanzania guidelines;
• The experiences reported in the Mwanza Sewerage Phase II Completion in March 2012 show that house connections are best implemented by the project and not by MWAUWASA. From consultations with the Government agency responsible for water supply and sanitation services in Mwanza, this is manageable.

Literature:
• Master plan brainstorming and wastewater and sanitation, COWI, 21 October 2015
• Hand-out COWI, 8 April 2016
• Note on the Master Plan, COWI, 22 June 2016
• Mwanza Sewerage Phase Ii Completion Report dated March 2012 by C. Lotti & Associati.</td></tr>
</table>

Selection criterion	Findings
Effectiveness, removal BOD	BOD_5 decreases from 413 mgBOD_5/l to 25[14] mg BOD_5/l for 3800 m^3/day. Hence per day 1.47 ton BOD_5 is removed.
FIETS Sustainability	F = no regret investment I = bylaws stating that everybody needs to connect within 30m' of the lateral sewer is on its way and reported to be reinforced E = excellent T = no fail technology, sewer lines under gravity, no pumping required S = the land is owned by the local government but people use the area for food production. Hence, sufficient time should be given to harvest the crops
Water Quality Improvement	Expected to be high: from 413 to 25 mgBOD_5/l
Cost-effectiveness Euro/ton BOD removed	€ 13.5 mln/1.47 tonnes BOD_5/day. Hence, €9.2 mln /tonBOD_5 removed per day.
Leverage of funds / co-funding	EIB funds for the TZ-EIB-AFD investment program
Support stakeholders (Government, NGOs, local leaders)	There is strong commitment from the service provider MWAUWASA, Mwanza City Council, UN Habitant and the Local Leaders.
Synergy with other projects	EIB financing will be available for the Igoma WWTP in the east and rehabilitation of existing Ilemela WWTP.

Overall conclusion
It is a moderate good option as it is close to implementation and fits in existing plans. Has impact on water quality of Lake Victoria.

[14] At Design Stage connection as cost of increasing connection to ultimate 40,000 not considered.

1 Introduction

1.1 Background

Lake Victoria Basin Commission (LVBC) is intensifying its efforts on Integrated Water Resources Management (IWRM), in concordance with the sustainable development agenda of the East African Community (EAC). Cooperation in the international river basin of Lake Victoria is already strong; however, there is still an urgent need for regional coordination among the member states. Inter-sectoral and transboundary coordination of IWRM activities is still a challenge. Regulation and enforcement regarding water resources and ecosystems protection are partly ongoing but the process is very long.

Although many programmes have been implemented over the last years, the planning, design and construction of water supply systems, wastewater treatment facilities and solid waste management do not keep up with population growth. Lack of sanitation facilities, open defecation and poor faecal sludge management lead to eutrophication and microbiological pollution. One of the consequences of eutrophication has been high increases in growth of water hyacinths, which in turn leads to disruption of water transport, water intake and hydropower generation, blockage of fish landings and de-oxygenation of the lake. Microbiological pollution is an important cause for water borne diseases in the region.

The LVBC is committed to develop IWRM for the basin using a step-by-step approach. For the short term a focus on the pressing and 'no-regret' issue of wastewater and sanitation has been chosen. At the same time steps are taken to develop towards a regional water framework management plan and a related regional priority investment plan. The focus on pressing and 'no-regret' has been translated in the concept of High Priority Investments (HPI). During the Inception period this concept has been translated in three specific criteria that are presented in Figure 7.

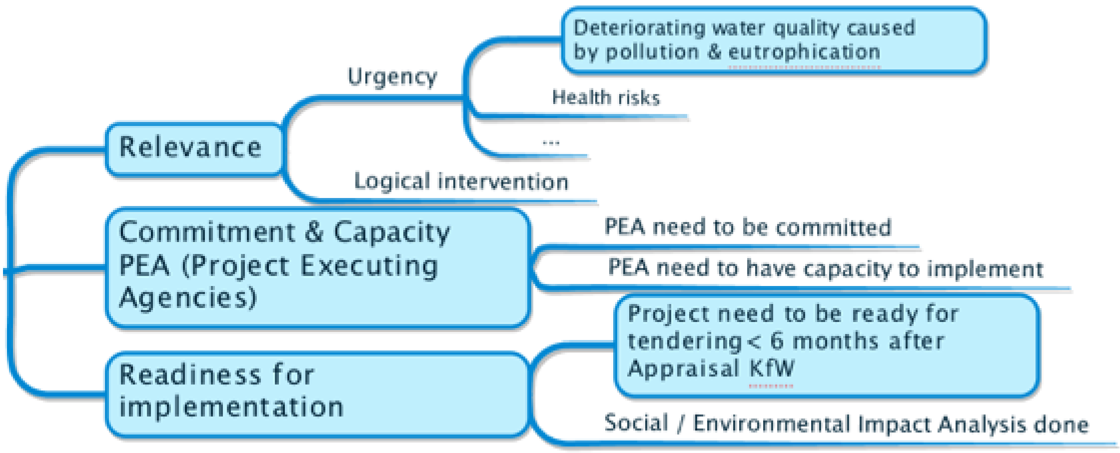


Figure 7: Criteria HPI Project

For the City of Mwanza, the HPI on wastewater treatment has been selected for further elaboration in a feasibility study.

1.2 Objective of this Feasibility Study

The selected HPI is to address urgent problems in wastewater and sanitation. Further investments in water and sanitation may follow: the ‘pipeline’ projects. In subsequent phases and in accordance with availability of further funding, investments in other areas of IWRM could be envisaged. In the long run, the program is to lead to the establishment of a regional water framework management plan and related regional priority investment plan.

The objective of this feasibility study is to provide all necessary information to the funders to execute the appraisal and at the same time setting a standard for pipeline projects. As KfW is the main potential funder, the feasibility study follows the *‘Appraisal Guidelines for Financial Cooperation Projects Wastewater / Sanitation (KfW, April 2013): Programme Proposal Part A (Priority Area Selection), Part B (Financial Cooperation Module)’*.

In Mwanza, the selected HPI is the Wastewater Treatment Plant (WWTP) planned in Mkuyuni. This extension of Mwanza Wastewater Sewerage will increase the number of people connected to adequate sanitation services. We assess the current situation and come up with recommendations, regarding adequate wastewater coverage to meet the current demands in terms of quality and quantity sanitation management system for Mwanza South. The study includes preliminary designs and cost estimates.

The specific scope of the study is:

- Identify areas within the Mwanza South, which are not served at the moment and make recommendations on the potential of the expansion/rehabilitation of the existing sewerage system and also to cover these areas adequately. Also make recommendations on the best wastewater disposal system that can be put in place to serve Mwanza South;
- To carry out a feasibility study for the expansion of sewerage system in the southern sewage district of Mwanza City;
- To identify potential Environmental Impacts of the proposed sewerage system and integrate appropriate mitigation measures in the design of the system;
- To conduct a topographical survey of the sewers collection and transmission system and ancillary works of the proposed system that can be integrated in the subsequent detailed design phase.

Planning Horizon. The time horizon to be applied in the Feasibility Study is for 22 years design period. Allowing for 2 years of project development, this implies that the proposed work should give effective service up to year 2040. This is in line with the horizon in the Master plan that is prepared by COWI.

1.3 Existing Reports

The following Reports were available to the Consultant and were consulted during the study:

- Mwanza Sewerage Completion Report (March 2012) by C. Lotti & Associati in association with Poyry;
- Master plan brainstorming and wastewater and sanitation, COWI, 21 October 2015;
- Hand-out COWI, 8 April 2016;
- Note on the Master Plan, COWI, 22 June 2016.

1.4 Objective of the Proposed High Priority Investment (HPI)

In line with the Water and Sanitation Master Plan that is currently being developed the objective of the HPI is to *‘Collect and treat wastewater in Mwanza South’*.

Currently there is a wastewater treatment in the northern part of the city. In future the capacity of the wastewater that can be treated there is limited; mainly due to hydraulic limitations of the current sewerage system.

The master plan that COWI started in 2014 envisages 6 WWTPs with 3 WWTP requiring immediate interventions. COWI is also responsible for implementation of the plan. There are EIB and AFD funds for one new WWTP (WWTP Igoma) and rehabilitation of the Existing Ilemela WWTP, so KfW funds would make it possible to finance the WWTP at Mkuyuni.
The relation with the COWI Master plan is presented in Figure 8

EIB: MWAUWASA INVESTMENT PROJECT

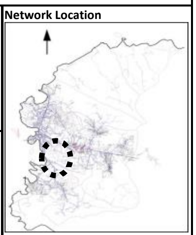
COWI

FACILITY SCOPING FORM

Facility option: **WWTP**	Facility name: **Mkuyuni-Bohari WWTP - Gravity**	Service Type (ws/ww): **Wastewater**	
Facility Type: **Sewer / wastewater treatment**	Service area: **Mwanza South**	Total CAPEX: Euro	**10.015.240**
		Total OPEX/2015: Euro	**95.901**

Design objective:
The aim is to etablish a WWTP at Mkuyuni serving the Mkuyuni industrial and residential areas. Improving the wastewater services in the area and reduce pollution of Lake Victoria and the environment in general.

Network Location



Note:
The sewerage system will cover an area south of the wastewater treatment plant including the prison area and the hills nearby. The treatment plant is considered to be a stabilisation pond type like the one in Ilemela to the north of Mwanza. It is required to establish a small pump station to convey the wastewater from the prison and area arround to the plant. Further it is required to establis an inlet pump station with a minor head loss as the inlet pipes will be located up to 2 m below ground level.
Design horizon for main sewers is 2040, whereas connections is bases on population in 2015.
22.000 people can be connected in 2015 resulting in 2.200 connections (two house holds á 5 persons per connection) - each connection is assessed at a length of 10m. Further connections will be established by Mwauwasa as population grows.
Establishing the WWTP will reduce the organic load on the environment and Lake Victoria in 2016 with approximately 330,000 kg BOD5/y - considering a BOD5 production of 50g/person per day and an reduction rate in the waste stabilisation ponds of 80-90% as may be seen from the existing WWTP at Ilemela. The reduction will increase to approximately 600.000 kg BOD5/y in 2025 with the projected population increase.

Locations Ward: Mkuyuni District: Nyamagana Land area:

	Latitude, Longitude: N	S	E	W	MASL			Total
WWTP: Wastewater Plant	-2.567841° ;	-2.564043°	33.920083° ;	33.925990°	1.146	WWTP	m²	100.000

Schematic Design

Population in service area	2040	2025	2015
Mkuyuni-Nyegezi	65.080	40.000	21.654
	65.080	40.000	21.654

Flow:			
2040	per hour:	m³/h	387
2040	per day:	m³/d	9.299
2025	per hour:	m³/h	238
2025	per day:	m³/d	5.715

Gravity side

Pipes	Material	Corrugated HDPE 225mm-500mm	
	Length, main	m	15.600
	Length, connections	m	20.000
	Lenght, total	m	35.600
CAPEX	Cost	Euro	5.812.940

WWTP

WWTP

New	100.000	m³
Drying beds	10.000	m³
Total	110.000	m³
CAPEX Cost Euro	3.580.000	

Pump stations - operation **2015**

1. Pump	Head	m		25
Power	Consumption	kWh/Year		25.000
Pipe	Material	-	HDPE 160mm	
	Length	m		300
OPEX, energy	Cost	Euro/year		1.563
tariff	150 Tshs/kWh			
2. Pump (inlet)	Head	m		10
Power	Consumption	kWh/Year		61.000
Pipe	Material	-	HDPE 250mm	
	Length	m		50
OPEX, energy	Cost	Euro/year		3.813
tariff	150 Tshs/kWh			
Total CAPEX	Cost	Euro		622.300

Figure 8: COWI Master Plan Mkuyuni Option, Mwanza City Tanzania

2 Review of Current Conditions

This chapter provides an overview of all relevant basic information on the country in general and the wastewater and sanitation sector specifically.

Figure 9: Location Tanzania

Figure 10: Project Location Map

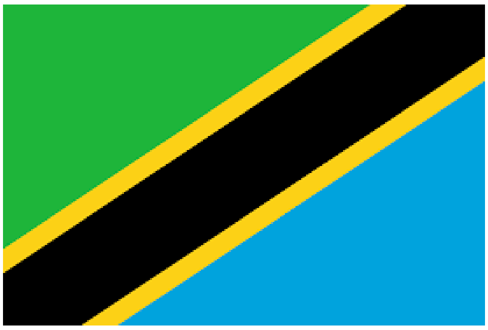


Figure 11: National Flag of Tanzania

2.1 Introduction

Tanzania, officially the United Republic of, is a country in East Africa within the African Great Lakes region. It is bordered by Kenya and Uganda to the north; Rwanda, Burundi, and the Democratic Republic of the Congo to the west; Zambia, Malawi, and Mozambique to the south; and by the Indian Ocean to the east. Kilimanjaro, Africa's highest mountain, is in north-eastern Tanzania. Tanzania's population of 51.82 million is diverse, composed of several ethnic, linguistic, and religious groups. Tanzania is a presidential constitutional republic, and since 1996, its official capital city has been Dodoma, where the President's Office, the National Assembly, and some government ministries are located. Dar es Salaam, the former capital, retains most government offices and is the country's largest city, principal port, and leading commercial Centre (Source: Wikipedia, 2016).

Economic overview[15]. The overall macroeconomic performance remains strong with a high rate of growth and a low rate of inflation. Real gross domestic product (GDP) growth is projected at 7% for 2015. From the supply side, the main drivers of growth recently have been several fast growing sectors, such as construction, transport and financial services. Inflation has gradually declined over the past 30 months due to tight monetary policy and falling international energy and food prices. While inflation has slightly increased recently largely driven by increase in domestic food prices and possible lagged effects of sharp depreciation of the local currency during the first half of 2015, the level remains relatively low at 5.6% in February 2016.
The external sector of the economy improved following a declining current account deficit that stood at 8.1% of GDP in 2015. Export growth driven by regional trade in manufactured goods and reduced imports bill from cheaper imported oil contributed to this decline.

Although revenue performance in 2015/16 has been better than in the past few years, shortfall has been experienced in the first quarter of the FY driven largely by weak implementation of the new 2015 VAT Act. The new government is committed to 4.2% of GDP fiscal deficit target for 2015/16. The government faces additional expenditure needs, equivalent to 0.7% of GDP, coming from expenditures carried over from last FY, payment of government arrears to TANESCO, and additional fiscal space needed for provision of free basic education and expansion of higher education students' loans program (new presidential initiatives).

Social Context. Approximately 28.2% of the population lived below the poverty line in 2012; a reduction from 34% in 2007. During the 2007/2012 period, there were improvements in living conditions, access to basic education, health and nutrition and, labour force participation in non-agriculture employment. Nevertheless, these benefits were not distributed equitably. Inequality has increased between urban and rural population and approximately 12 million Tanzanians are still living in poverty.

Development Challenges. Tanzania's main challenges include addressing infrastructure bottlenecks, improving the business environment, increasing agricultural productivity and value addition, improving service delivery to build a healthy and skilled workforce, and managing urbanization. The country also has a youthful labour force growing by approximately 800,000 every year and needs to increase the private sector's role in employment creation for them. The new administration has outlined among its priorities: increasing government revenues and reducing inefficiencies; investment in good health systems; raising education quality; increasing access to water and improving availability of electricity.

Health. At the country level, the top three causes of child mortality are: respiratory infections, birth asphyxia and prematurity. Malaria represents 10% of the causes and diarrhoea 7%. See Figure 12.

[15] Source: The World Bank Internet accessed 22 April 2016.

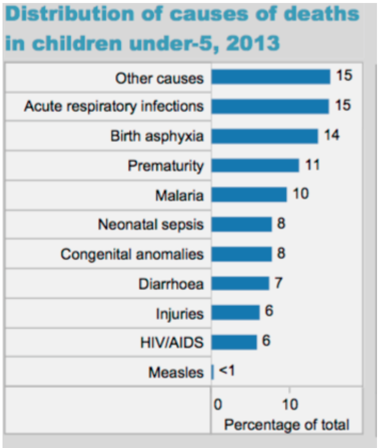


Figure 12: Causes of Child Deaths (WHO website, accessed 22 April 2016)

2.2 Facts and Figures Tanzania

Table 4: *Facts and Figures Tanzania*

Topic	Descriptions
Government type:	Republic
Political situation:	Political stability has provided a solid foundation for Tanzania's growth, and with its economic prospects, has raised Tanzania's profile in the region and the world. On October 25, 2015, Tanzania held its 5th general elections since it transitioned to a multiparty democracy in 1992. Dr. John Pombe Magufuli, the ruling Chama Cha Mapinduzi (CCM)'s candidate emerged winner with 58.46% of the vote, while Mr. Edward Lowassa, a former CCM stalwart, behind whom a formidable opposition coalition united, got 39.97% (the World Bank, accessed 22 April 2016)
Language:	English, Swahili
Population:	51.8 million (World Bank 2014 estimate)
Population growth:	3% (World Bank, 2013)
Economic growth (GDP growth in %):	7% (World Bank, 2015)
GDP (PPP):	USD 48 billion (2014, World Bank)
GDP (PPP) per capita:	USD 695 (2013, World Bank)
Unemployment rate (in %):	10.3% (2013, trading economics)
Inflation rate + forecast 2020 (in %):	5% (2016), 6% (2020)
Foreign direct investments (in % of GDP):	4% (2013, indexmundi)
ODA in % of GNI:	5.6% (2014, World Bank)
Doing business index:	139 out of 189 (2015, trading economics)
WEF Global competitive index:	120 out of 140 (World Economic Forum, 2015-2016)

2.3 Facts and Figures Mwanza

The project area is Mwanza City, the second largest city in Tanzania. Mwanza is located in the north of Tanzania along the shore of Lake Victoria. It is the Regional Headquarters for Mwanza Region. Mwanza Region lies between 2°15" – 2°45" (S) latitude and 32°45" – 33°00" (E) longitude. The region is at an elevation of between 1,100 and 1,300 m' above mean sea level. The terrain is hilly with rock outcrops.

Population. Based on the 2012 national census, Mwanza City has a population of 700,000 people. COWI and the Urban Planner Surbana use different growth rates but expect Mwanza to grow to 1.9 million people in 2040 (COWI) or 2.4 million people in 2035 (Surbana)[16].

[16] Personal communication Ms Robba Gabriella Urbana, Mwanza, 18 March 2016.

Figure 13 provides the population distribution in the districts for 2035.

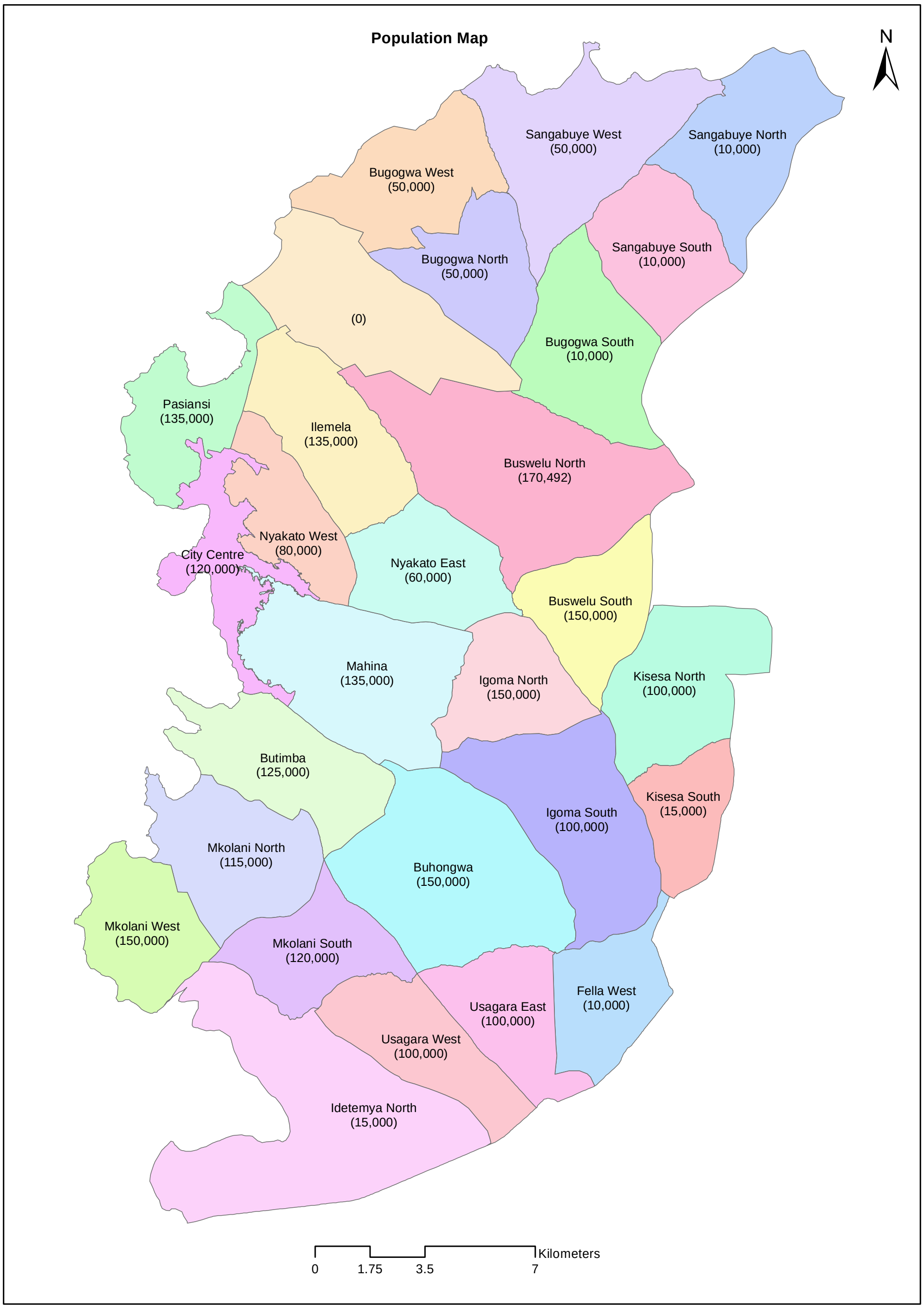


Figure 13: Population Map 2035 (Surbana, 2015)

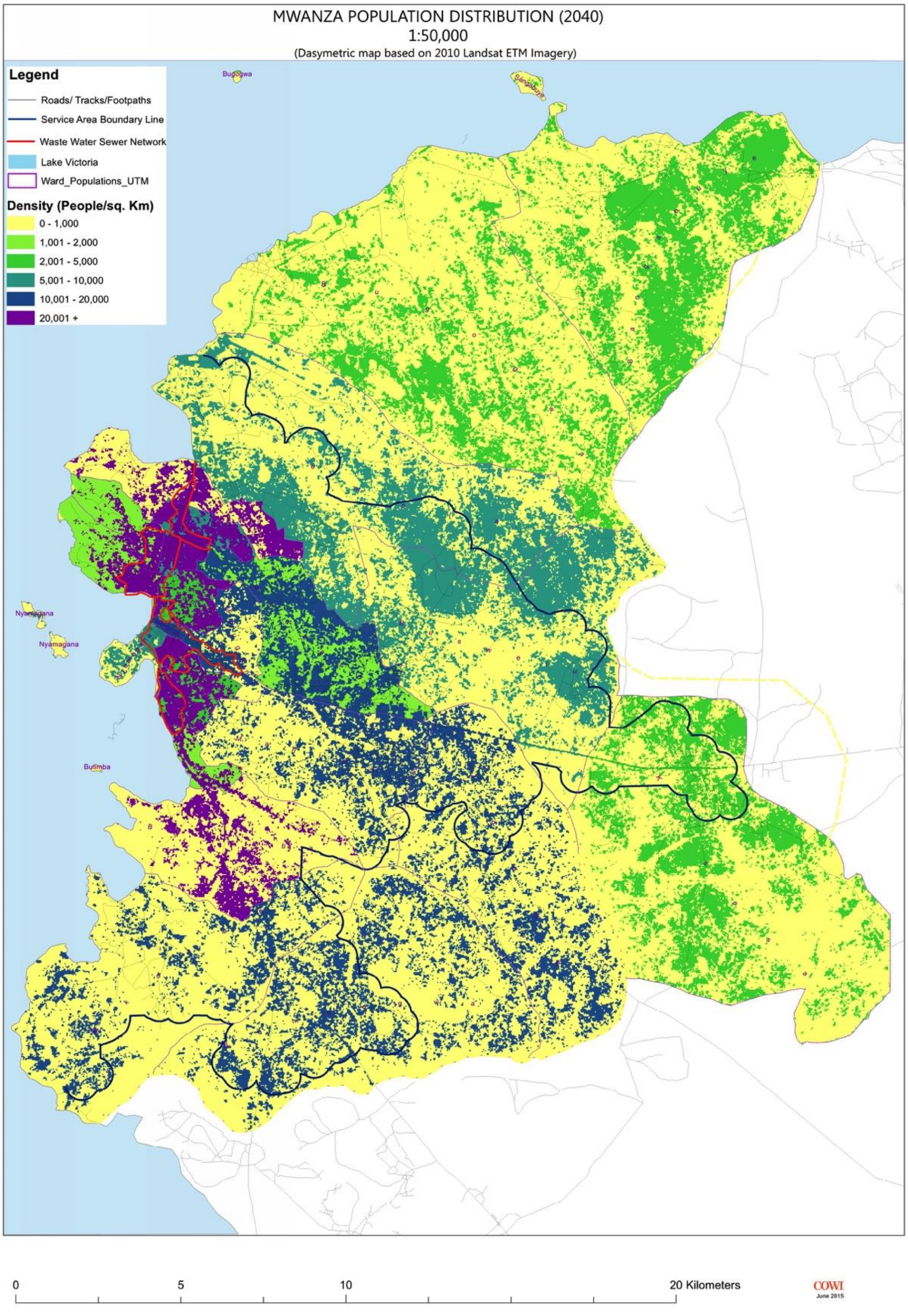


Figure 14: Population Density 2040 (COWI, 2040)

2.4 Population in the Project Area

Mwanza is an administrative region, and located northwest in the mainland Tanzania, along the southern shores of Lake Victoria. Mwanza Region is composed of seven districts, namely: Ilemela, Kwimba, Magu, Misungwi, Nyamagana, Sengerema, and Ukerewe; and, it is close located to Mwanza City, which is one of thirteen big urban centres of Tanzania. Mwanza City consists of two of the seven districts that make up Mwanza Region, namely Nyamagana and Ilemela. The Project Area is in Nyamagana, Mwanza City.

Figure 15: Districts of Mwanza Region (Source : http://mwanza.go.tz/kurasa/muundo/index.php)

Population Distribution of Mwanza

As per the 2012 census results, Mwanza Region had an estimated population of 2,772,509 individuals, up from 2,058,866 in 2002 census. The 2012 census results also informs that, as Figure 14 illustrates, the population distribution of this region, at 293 person/ km^2, was among the highest in Tanzania. A third of the population of Mwanza Region is urbanised.

Narrowing to the District where the Project Area is located, the 2012 census results show that it has the highest population density of the districts that comprise Mwanza Region.

Table 5: *Districts of Mwanza*

Region	**Status**	**Population by Census Results**			**Estimated Land Size (Km^2)**	**Density (by 2012 Census)**
		1988	2002	2012		
Ilemela	Municipality	-	-	343,001	895	383.24
Kwimba	District	236,443	314,925	406,509	3,599	112.95
Magu	District	-	-	299,759	4,800	62.45
Misungwi	District	191,283	256,133	351,607	1,947	180.59
Nyamagana	Municipality	109,985	209,806	363,452	183	1986.08
Sengerema	District	303,897	498,993	663,034	8,817	75.20
Ukerewe	District	172,946	260,831	345,147	530	651.22
Total			2,058,866	2,772,509	*20,771	
Ilemela and Nyamagana Districts				**706,453**	***1,078**	

*Key: *Computed for both dry land area and water area.*
http://lakezoneinvestmentforum.go.tz/sites/default/files/Mwanza%20Investment%20Profile%20Consolidated_1.pdf ; http://www.tzonline.org/pdf/Mwanza.pdf

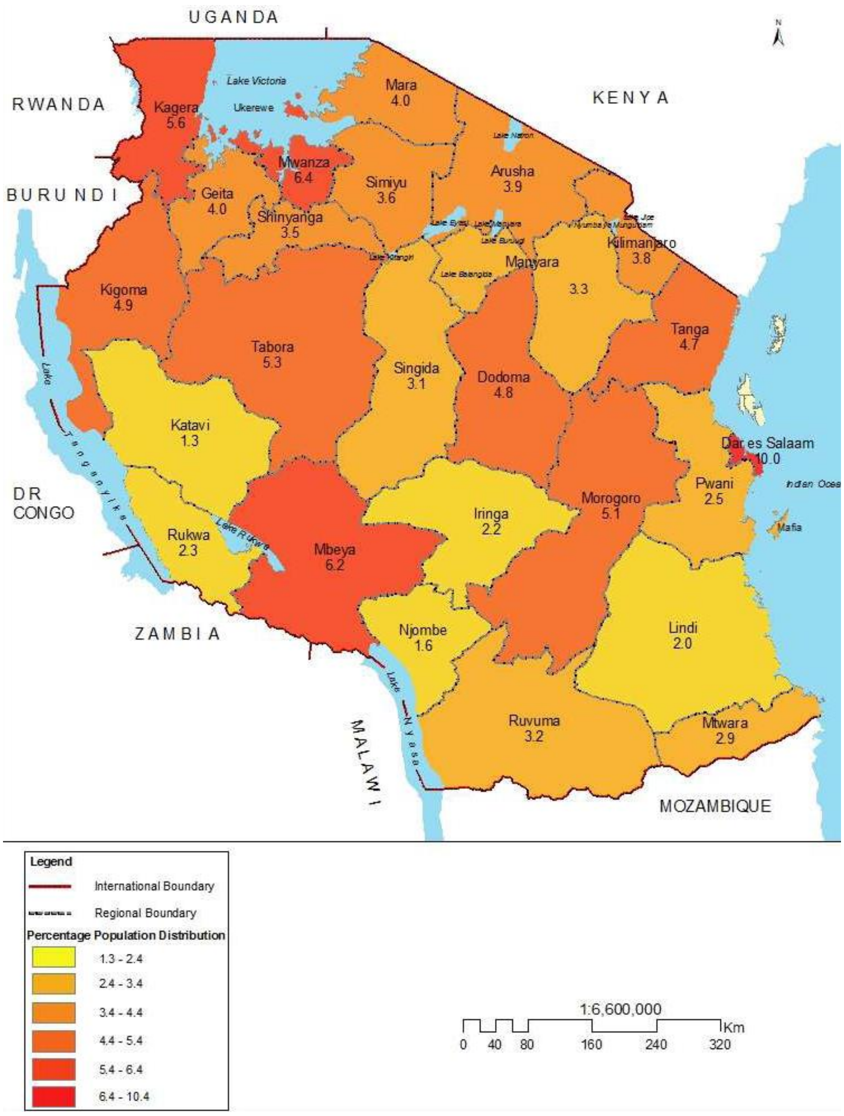


Figure 16: Percentage Population Distribution by Region, Tanzania Mainland – 2012 Census
(Source: http://nbs.go.tz/nbs/sensa/PDF/2012%20PHC%20POPULAR%20VERSION.pdf)

2.5 Geology of Mkuyuni WWTP location, Mwanza Region

The geology of the proposed site for Mkuyuni WWTP is predominantly of alluvial brownish heavy clayed soils, silt clayed sandy soil, coarse sandy soils under-laying a variable thickness of brownish Hard Pan Basalt at depths ranging from 1.5 m to 6.0 m of the surface level.

For any structure, a stable foundation is within the same range with a bearing capacity greater than 75kN/m^2 according to Terzaghi-Peck (1967).

A detailed report is presented in APPENDIX 5: GEO-TECHNICAL INVESTIGATION.

2.6 Topographic Survey of Mkuyuni WWTP location, Mwanza Region

A topographical survey was carried out to map out the allocated area. During the survey work, rice and grasses covered the pond area. The activity started by establishing control points (benchmarks) around the project area by using RTK GPS (Real Time Kinematics) technique. Topographical survey prepared a base line of five hundred meters and twenty grid lines of twenty five by twenty five meters interval for a detailed survey of the area. In addition cross-sections at fifty-meter intervals with a span of ten meters for the proposed pipe lines of thirty kilometres was prepared.

A detailed report is presented in APPENDIX 6: TOPOGRAPHIC SURVEY REPORT FOR MKUYUNI WWTP.

2.7 Access to Water and Main Mode of Human Waste Disposal in Mwanza Region

By the 2012 census results, slightly less than a third of the households in Mwanza had access to reticulated water supply, i.e. piped water into dwelling and piped water to yard/plot or public tap/standpipe. Regarding the main mode of human waste disposal, the majority of the households (≈98%) have on-site systems. Of these, 5% have a septic tank as their on-site facility, the others cesspits and pit latrines. As Table 5 indicates, Mwanza City is growing. It therefore needs modern ways of water supply as well as wastewater, sanitation and solid waste management.

2.8 Sewerage

In Mwanza City, a government agency is responsible for reticulated water supply and sewerage services. This agency is Mwanza Urban Water Supply and Sanitation Authority (MWAUWASA). The water it supplies is abstracted from Lake Victoria. According to MWAUWASA, the water production capacity is 108,000 m^3 per day against a demand of 85,000 m^3 per day. Regarding centralised sewerage services, MWAUWASA has sewerage network of 85 km, servicing about 15% of Mwanza City population mainly the Central Business District and some surrounding area such as Kirumba, Nyamanoro, Kilimahewa, Pasianisi and Igogo. The number of household connections is 3,500. This sewer network is a combination of gravity and pumping.

Two main limiting aspects the authority has with expansion of the reticulated water supply and sewerage network to unserved regions of Mwanza City are funds and terrain. Mwanza has lot of natural rock outcrop hills. Some rocks even protrude from Lake Victoria water. Due to this, the City is nicknamed *the Rock City*. This natural rock outcrop hills make supply of water to regions at higher elevations than the distribution reservoirs a challenge.

Mwanza City is divided into four sub-areas for the purposes of planning and analysis of the sewerage facilities. There is one existing sewage treatment work facility Ilemela Conventional Sewage Treatment Works (STW) - currently serving the Central Wastewater Treatment Zone. See Figure 17. The design capacity for Ilemela Conventional treatment works is 5,600m^3/ day[17]. The sewer reticulation system is served by three pumping stations (PS): Mwanza South PS, Kirumba PS, and Central PS. The sewerage system in Mwanza City falls into four zones wastewater treatment areas. Currently, COWI prepares a master plan on the sewerage systems and the treatment plants in the City of Mwanza. See Figure 18.

[17] Computed from 7000 connections with each having an average of 10 persons generating 80lt of waste in a day.

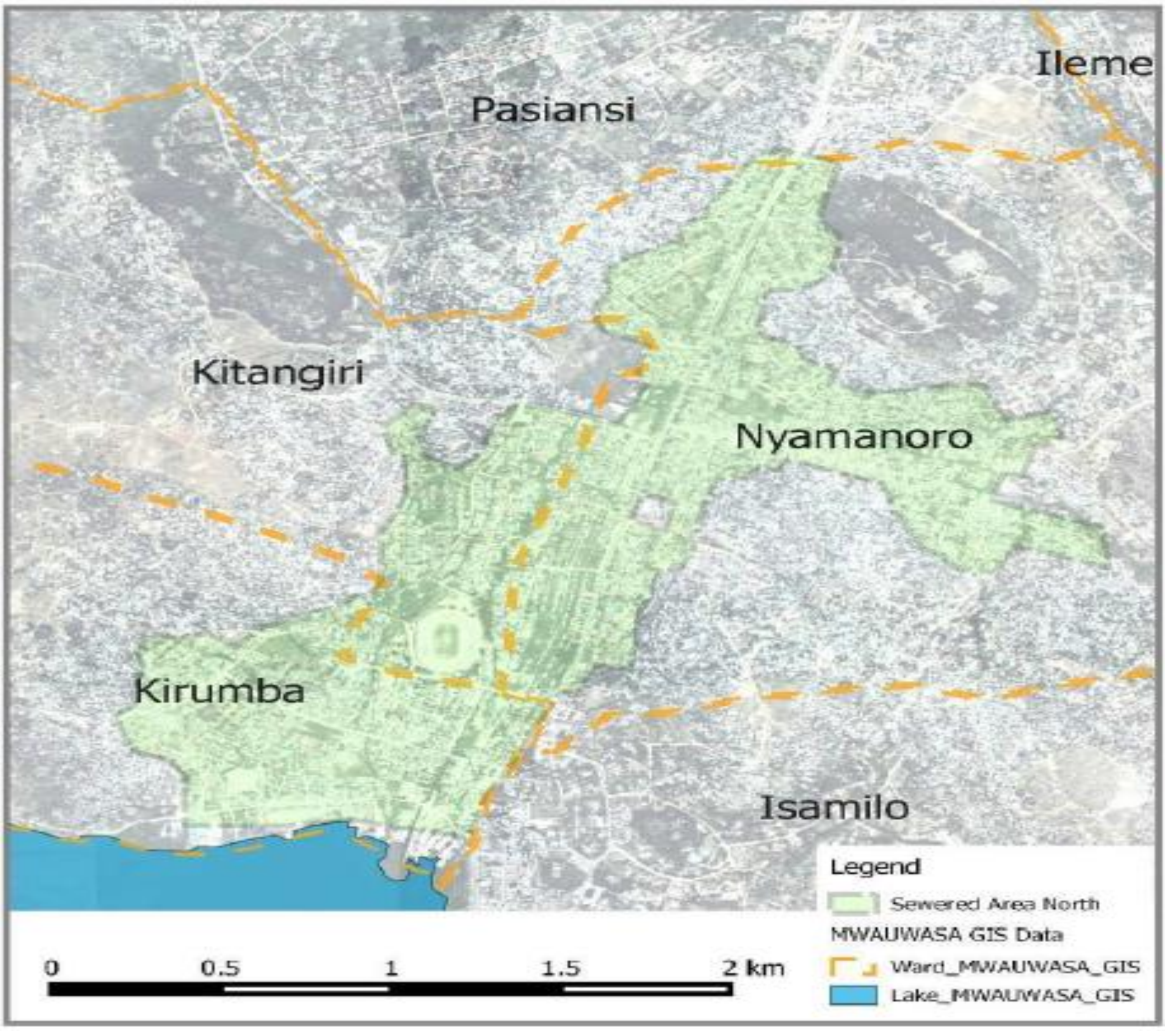


Figure 17: Area Currently Covered by Sewerage

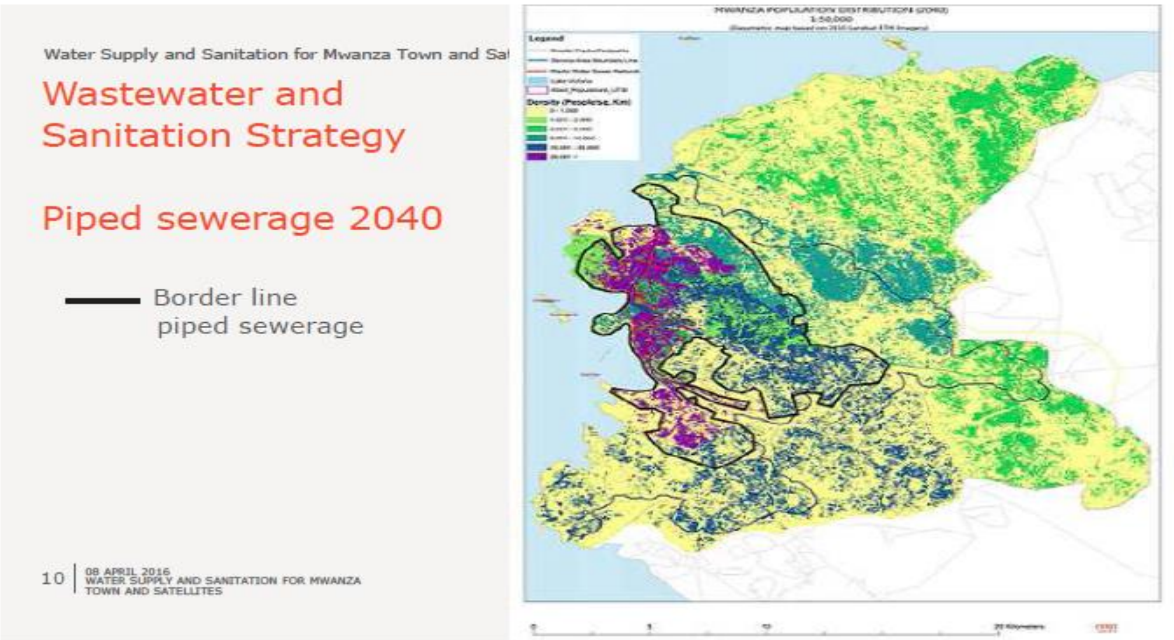


Figure 18: Sewerage Service Area 2040 (COWI, 2016)

The Mwanza Sewerage Completion Report (March 2012) by C. Lotti & Associati in association with Poyry clearly highlights the challenges the service provider faced in the installation of additional chambers and lines of the secondary network. This is a major cause of very slow progress in increasing the number of connections. The ones connected come at irregular interval and are scattered as the area is unplanned and unorganized, which makes the secondary network expensive.

In the Draft Final Master Plan, a site for the wastewater treatment works for the Southern Wastewater Treatment Zone is proposed at Mkuyuni.

2.9 Operation and Maintenance Arrangements

MWAUWASA has been licensed for the provision of water and sanitation services within Mwanza City. MWAUWASA has its offices in Mwanza City next to the central pumping station. There is also a utility building at the Ilemela Wastewater Treatment Works and a laboratory. An inventory of all existing water supply and sewerage systems infrastructure is annually undertaken. This has facilitated maximizing equipment lifespan and operating efficiency, MWAUWASA has preventative maintenance plans for existing facilities, follows the plans closely, and has been recording maintenance histories for equipment. MWAUWASA has qualified staffs for O&M. This has been done through hiring of sufficiently trained staff and also conducting on the job training for the present staff. All records and billing are computerized.

Laboratory facilities are required for quality assurance in the operations of the water supplies and sewerage services. Existing laboratories are fully equipped.

2.10 Problem Analysis

In Figure 19 we present the 'problem tree' associated with malfunctioning sanitation. The poorly designed, constructed and operated systems are emptied during the rains leading to pollution downstream. Main cause is that the rocky soils make on-site systems expensive. The narrow and steep hills make emptying difficult.

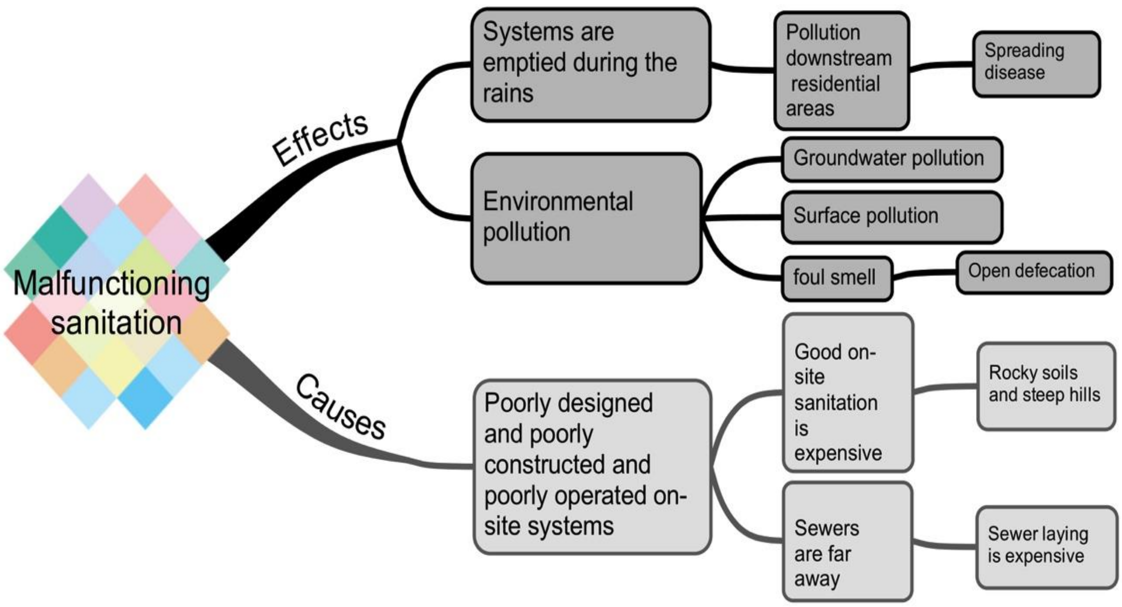


Figure 19: Problem Tree Malfunctioning On-site Systems

It is expected that the High Priority Investment project on wastewater treatment in Mwanza will remove the underlying causes of the present problems. Further details on this topic are explained in Table 6.

Table 6: *Problems Associated with Malfunctioning Sanitation in Mwanza and Solutions*

Underlying cause for problems associated with malfunctioning sanitation: poorly designed and poorly constructed and operated on-site systems	**Solution: connection to sewers and WWTP**
Rocky soils, narrow roads and steep hills	Shallow / neighbourhood sewers
Sewer laying is expensive	Detailed site surveys so that sewer lines follow contours and minimize pumping requirements.

2.11 Other Development Partner Involvement and Coordination

The main funder in Mwanza is the European Investment Bank and the AFD. While the coordination of the consultants is quite complex, the main Development Partner are:

- UN Habitat: sanitation facilitation lead;
- Mott McDonald: Project Management Support Consultants;
- MWH: consultant acting on behalf of lenders.

3 Description of the Proposed HPI

3.1 Description Proposed HPI

The proposed HPI is largely a standalone project namely Mkuyuni Waste Water collection and Treatment works. This targets Southern Mwanza City.

The works entails:

- Wastewater Stabilization Ponds i.e.: Anaerobic Pre-treatment ponds, Facultative ponds and Maturation ponds;
- Pre-treatment works: screening and grit removal;
- Topographic and geotechnical survey to be undertaken for the sewer line and treatment area;
- Southern Gravity flow to include Nyengesi area: Password and California area;
- Northern gravity system connecting Mandu area of Nyakato, Kanyerere and Mkuyuni area;
- Adaption of the existing Mwanza South sewer pump-house to pump Butimba and Mahina area to new WWSP;
- Households with water connections in approved settlements to be considered under this study;
- Waste water taken as 85% of water supplied;
- Either the influent BOD5 for existing works assumed for design or a theoretical value; whatever is the highest;
- Main line to be designed to allow 50% increase in connection;
- Treatment Ponds to be for the projected connection considering current connection rates and plans;
- Industrial waste assumed to be pre-treated before being discharged into the system;
- Wind flow assumed to be the average western direction;

Average temperatures of 22^{o}C adapted for Permissible volumetric BOD loading computation.

The existing Mwanza south pump station has:

- 3 operational Pumps;
- Each Pump has a capacity of 58 litres per sec. Hence, it can handle 3600 m^3 per day;
- A stand-by generator.

Figure 20: Location Proposed WWTP

Figure 21: Location WWTP Mkuyuni

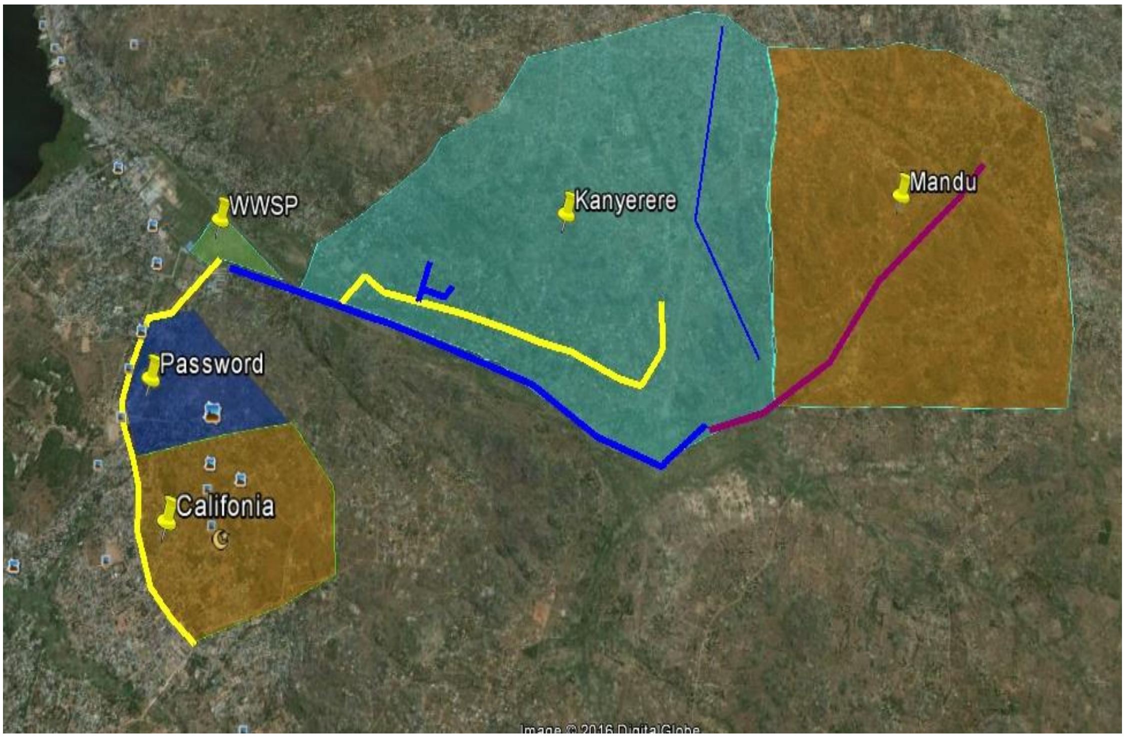


Figure 22: Location Areas to Be Served and the WWTP Mkuyuni

3.2 HPI Objective and Indicators

In line with the Wastewater and Sanitation Master Plan that is currently being developed the objective of the HPI is to 'Collect and treat wastewater in Mwanza South'.

The overarching objective is that off-site systems in Mwanza will fulfil the Sustainable Development Goals on sanitation (Goal 6): "By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally".

The indicators and assumptions that relate the HPI to this objective are presented in Table 7.

Table 7: *Indicators and Assumptions for the HPI*

Indicator	Assumption
In July 2018 the Mkuyuni WWTP can treat the wastewater of 45,000 capita (capacity: 3,800 m^3 /day). Land has been acquired for a WWTP that can treat up to 34,000 m^3/day	• Land acquisition is done in time; • Tendering for Design, Construct and Operate is successful; • Funds for implementation released.
• In July 2018, 40% of the target wastewater is collected and treated at the WWTP (1,600 m^3/day); • In 2020, 72% (2,700 m^3/day), in 2022 85% (3,200 m^3/day); • In 2024 100% (3,800 m^3/day) 45,000 persons (2016 population) i.e. 10% of projected 400,000 persons in 2040.	• Targeted households are connected to drinking water supply system and willing and able to pay for at least 100 lcd; • Lateral and collector sewers can convey the wastewater under gravity conditions, no pumping required; • Households are willing and able to connect to the simplified sewerage systems; • Permission can be obtained to construct the sewer lines and manholes; • Permission can be obtained to cross the railway line (siphon); • The relevant (government) authorities have to put adequate laws and regulations into practice to

Indicator	Assumption
	persuade households not willing[18] to connect to the lines and are actively enforcing.
100% of the collected wastewater is treated in an environmentally sound way: • Effluent fulfils national discharge standards; • Any produced sludge (co-compost) fulfils environmental standards.	• The operator is checking the quality; • Qualified labs available that can do the testing; • The relevant (government) authorities have put adequate control mechanisms into practice and are actively enforcing; • The operator is certified for producing sludge / co-compost, if relevant

The specific scope of the study is to include the following:

- Identify areas within the Mwanza South, which are not currently served and make recommendations on the potential of the expansion/rehabilitation of the existing sewerage system and also to cover these areas adequately. Also make recommendations on the best wastewater disposal system that can be put in place to serve Mwanza South;
- To carry out Feasibility study for the expansion of sewerage system in the southern sewage district of Mwanza City;
- To identify potential Environmental Impacts of the proposed sewerage system and integrate appropriate mitigation measures in the design of the system;
- To conduct Topographical Survey of Sewers collection and transmission System and ancillary works of the proposed system that will facilitate Detailed Engineering Design in the near future.

Planning Horizon. The time horizon to be applied in the Feasibility Study is for 22 years design period. Allowing for 2 years of project development, this implies that the proposed work should give effective service up to year 2040. This is in line with the horizon in the Master plan that is prepared by COWI.

3.3 Target Group and Stakeholders in the Priority Area / Sub-sector

The Mkuyuni WWTP system is to serve Mwanza South, an area south of the wastewater treatment plant. That is, to serve Mkuyuni industrial and residential areas. Few of the connections will be for industries. Majority of the connections will be for households. At present, nearly 10,000 households from the residential area to be served are connected to reticulated water supply network. These households are a mix of low and middle-income earners. Majority are middle-income earners. See the map in Figure 22.

Table 8: *Households in Mkuyuni Area that are at Present Connected to Water Supply Network Managed by MWAUWASA*

Area	Number of Connections
Mkuyuni, Kanyerere	2,212
Nyakato around Mandu	3,044
Nyegezi, Password, California	2,073
Total	**7,349**

3.4 HPI Cost

The specific investment for this particular investment is composed of:

- Acquisition of 3 ha of land for the HPI;
- Pre-treatment works: screening and grit removal;
- Construct Waste Stabilization Ponds to treat the wastewater of about 45,000 persons, capacity 3,800 m^3/d: Anaerobic ponds, Facultative ponds and Maturation ponds;

[18] Noted as 2% in the Mwanza water and Phase II.

- Reservation of an area that can host a WWTP for 400,000 capita, 34,000 m^3/day, around 15-20 ha;
- Topographic survey to be undertaken for the sewer line and treatment area;
- The following areas can be connected by gravity: 3,000 households in Mando, 2,300 hh in Kanyerere, 1,000 hh in California and 1100 hh in Password. Total 7,400 hh (around 45,000[19] persons);
- Ancillary works like a 150m long access road, power extension to the area, etc. which are factored in the preliminaries and general;

Total costs: € 13.8 million, see

- Table 9. As the land already belongs to the government, the value of the land is estimated to be € 0.30 mln.;
- NOTE: cost of land is 'in kind' as the land is already owned by the City Council.

Table 9: *Summary Costs*

No	Description	Amount (Rounded) € Million
1	Total Direct Investment: WWSP + collector pipes	€ 11.8
2	Capacity building	€ 0.06
3	Construction Supervision	€ 0.40
4	Project Management Unit	€ 0.04
5	Contingencies	€ 1.20
6	**Sub Total at Project Completion KfW**	**€ 13.5**
7	Land Value Contributed by Mwanza City Council (for entire future requirement of 15Ha)[20]	€ 0.30
8	**Total at Project Completion**	**€ 13.80**
9	**Cost per connection**	**€ 1,865 $*10^{-6}$**

3.5 HPI Phasing

We have analysed whether phasing of the project to a smaller scale would be possible. We analysed connections of California and Password areas. This would make the cost per connection very high; see Table 10 and financially and economically not feasible as this would not be affordable for the people connected. If it would be decided to incorporate phasing of the project, alternative options would become more attractive. Decentralized treatment, for instance in anaerobic baffled reactors would be much cheaper. This option would, however, conflict with the Master Plan.

Table 10: *Summary Costs of a First Phase*

No	Description	Amount (Rounded) € Million
1	Total Direct Investment: WWSP + collector pipes	€ 3.98
2	Capacity building	€ 0.06
3	Construction Supervision	€ 0.30
4	Project Management Unit	€ 0.03
5	Contingencies	€ 0.44
6	**Sub Total at Project Completion KfW**	**€ 4.81**
7	Land Value Contributed by Mwanza City Council (for entire future requirement of 15Ha)[21]	€ 0.3
8	**Total at Project Completion**	**€ 5.11**
9	**Cost per connection**	**€ 4,700 $*10^{-6}$**

[19]Connection based on current House Hold (HH) connection only not actual HH. Those without HH water connection not considered.

[20] https://kupatana.com/real-estate/land/plot-for-sale_i667309.

[21] https://kupatana.com/real-estate/land/plot-for-sale_i667309.

3.6 HPI Financing Plan

It is assumed that for the HPIs, the investment costs will be covered by the development partners through a contribution. These investment costs comprise the hardware for the equipment, facilities, pipes and electrical-mechanical installations (if any). Also included in the investment costs are the preparatory costs, tender & detailed design costs and training costs that are needed to train staff to run the facilities. Access roads of 150m length and electricity are included in the investment costs. However other public services aren't included in the investment costs these are to be provided by the government. It has been assumed that the financing will be grant financing, because KfW and EU are the initiators of the feasibility studies that are presently executed. However, if other financiers will step in or will co-finance, other financing modalities can be incorporated. If grant funding is to be replaced by loan financing or equity financing, the financial viability of the HPI projects will be lower as financing costs have to be included in the calculations.

Any follow-up financing of investments later on in the project will have to be financed through non-project sources. This could be internally generated funds of the implementing agency, contributions by the government, commercial financing (if possible) or other sources.

Depreciation is included in the calculations to ensure that at the end of the economic lifetime of the project, sufficient sources will be available to do new investments.

As to the O&M costs, these have to be covered by the project, through the revenues generated by the project. The full-cost recovery ratio (FCR) should therefore be positive; the revenues divided by the operational costs and depreciation costs should be larger than 1.

3.7 Relation with the National Strategy

The Ministry of Water has upgraded the organization of the Water Sector in Tanzania in 1996. In a governmental act, a revision divided the responsibilities and activities such as to have the urban water and sewerage issues specialized and separated for each urban centre in the country as a parastatal urban – authority, fully autonomous and responsible for all urban water and sewerage issues including tariffs. There are 20 such "URBAN WATER AND SEWERAGE AUTHORITIES" (abbrev. UWSA) in the country, being autonomous, but with the obligation of regular reporting to the Ministry. For Mwanza City, Mwanza Urban Water and Sewerage Authority (MWAUWASA) owns the sewerage infrastructure.

The actual situation is organized by the Ministry of Water (MoW) with monthly reports, produced by each UWSA, depicting the extended situation on the sector, including the individual financial situation of each established UWSA. Under some special circumstances, the Ministry provides grants to specially identified UWSA‟s for specified tasks.

3.8 Relation with the City Plan

At present, Surbana is preparing the City Master Plan. Surbana was only able to provide us with verbal information. Surbana wants to 'turn the town towards the lake' and follows the outline for the sewerage system being developed by COWI.

4 Comparative Analysis

4.1 Design Proposed HPI

The design parameters are presented in Appendix 1. The population to be served is presented in Table 11. In 2040, the WWTP will also receive water from the centre of the town, in line with the Master Plan.

Table 11: *Water Connected for Mkuyuni WWSP Catchment, Mwanza City*

AREA	ROUTES	NUMBER OF CONNECTIONS
Mkuyuni, Kanyerere	F4	1,145
	F11	1,067
Nyakato around Mandu	G9	949
	G22	1,078
	G26	1,017
Nyegezi: Password, California	F15	1,083
	F16	990
TOTAL		**7,329**

In line with the knowledge and skills available in Mwanza, Waste Stabilization Ponds are proposed. Waste or Wastewater Stabilisation Ponds (WSPs) are artificial man-made lagoons in which black water, grey water or faecal sludge are treated by natural occurring processes and the influence of solar light, wind, microorganisms and algae. The ponds can be used individually or in series of an anaerobic, facultative and aerobic (maturation) pond. WSPs are low-cost for O & M and BOD and pathogen removal is high. However, large surface areas and expert design are required. The effluent still contains nutrients (e.g. N and P) and is therefore appropriate for the reuse in agriculture (irrigation) or aquaculture (e.g. fish- or Macrophyte ponds) but not for direct recharge in surface waters. See Figure 23 for a typical scheme.

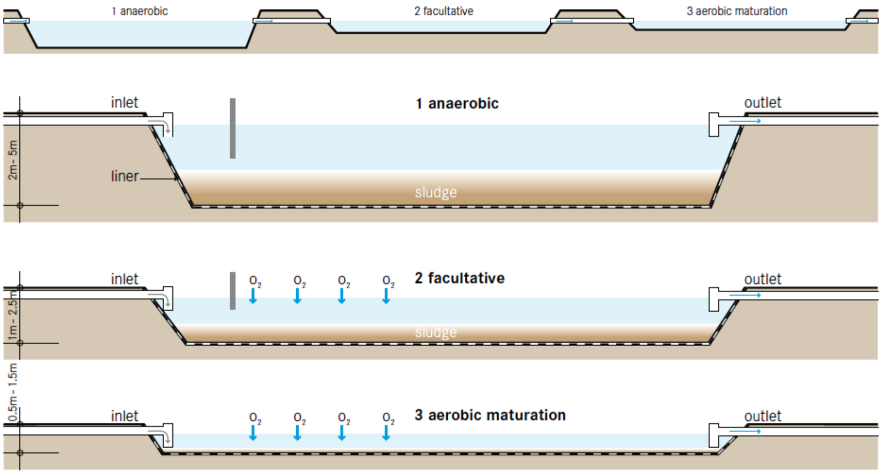


Figure 23: Typical Scheme of a Waste Stabilization System: An Anaerobic, Facultative and Maturation Pond in Series. Source: TILLEY et al. (2008)

Design. Assuming a per capita BOD_5 contribution of 35g BOD/capita, a water consumption of 100 litres/capita per day and a return rate of 85%, the design flows are presented in Table 12.

Table 12: *Design Parameters WWTP Mkuyuni*

		Password California	Mando	Kanyerere Mando	California Kanyerere Mando	Password California Kanyerere Mando
Description	**Unit**	**C&P**	**M**	**M&K**	**M&K&C**	**M&K&C&P**
Properties	[nrs.]	1 090	3 050	5 350	6 340	7 430
Household size	[cap/hh]	6	6	6	6	6
Persons served	[cap]	6,540	18,300	32,100	38,040	44,580
Wastewater production	[lcd]	85	85	85	85	85
Daily Capacity	[m3/day]	556	1,556	2,729	3,233	3,789
BOD per capita	[gBOD/day]	35	35	35	35	35
Avg. sewage strength	[mgBOD/l]	412	412	412	412	412

Anaerobic ponds. Anaerobic Treatment Ponds are deep ponds (2 to 5 m) devoid of dissolved oxygen, *where sludge is deposited on the* bottom and anaerobic bacteria break down the organic matter by anaerobic digestion, releasing methane and carbon dioxide. Viruses, bacteria, Helminth, Ascaris eggs and other pathogens can also be inactivated by sedimentation when associated with solids. N, P and K can also be reduced by sludge formation and the release of ammonia into the air. However, the main function of anaerobic ponds is BOD removal, which can be reduced 40 to 85 % (WSP 2007). As a complete process, the anaerobic pond serves to: Settle undigested material and non-degradable solids as bottom sludge, dissolve organic material and break down biodegradable organic material. The design of the Mkuyuni Anaerobic ponds are presented in Table 13.

Table 13: *Anaerobic Ponds*

Description	Unit	C&P	M	M&K	M&K&C	M&K&C&P
ANAEROBIC PONDS						
Retention time	[days]	1.00	2.44	1.39	1.17	1.00
Volume	[m3]	556	3 789	3 789	3 789	3 789
Depth	[m']	2.5	2.5	2.5	2.5	2.5
Surface area	[m2]	222	1 516	1 516	1 516	1 516
Desludging interval	[years]	1	2.44	1.39	1.17	1
Per person sludge production	[liters/year]	25	25	25	25	25
Sludge	[m3]	164	1 115	1 115	1 115	1 115
Extra depth	[m']	0.74	0.74	0.74	0.74	0.74
Total depth	[m']	3.24	3.24	3.24	3.24	3.24
Organic loading	gBOD/m3/d	412	169	296	351	412
BOD removal lower layers	[%]	30%	30%	30%	30%	30%
Remaining BOD	[mgBOD/l]	288	288	288	288	288
BOD effluent	[mgBOD/l]	204	143	183	194	204
BQ effluent	[E-coli/l]	2E+07	1E+07	2E+07	2E+07	2E+07
Efficiency BOD removal	[%]	51%	65%	56%	53%	51%
Efficiency E-coli removal	[%]	79%	90%	84%	81%	79%

Facultative Treatment Ponds are the simplest of all WSPs and consist of large shallow ponds (depth of 1 to 2m) with an aerobic zone close to the surface and a deeper, anaerobic zone. There are two types of facultative ponds: primary facultative ponds that receive raw wastewater (after grit removal), and secondary facultative ponds receiving settled wastewater usually from the anaerobic pond. In primary facultative ponds, the functions of anaerobic and secondary facultative ponds are combined. This type of pond is designed generally for the treatment of only slightly polluted wastewater and in sensitive locations where anaerobic ponds' odour would be unacceptable. The design for the secondary facultative pond at Mkuyuni is presented in Table 14.

Table 14: *Facultative Ponds*

Description	Unit	C&P	M	M&K	M&K&C	M&K&C&P
FACULTATIVE PONDS						
Retention time	[days]	3.00	7.31	4.17	3.52	3.00
Volume	[m3]	1 668	11 368	11 368	11 368	11 368
Effective depth	[m']	1.50	1.50	1.50	1.50	1.50
Surface area	[m2]	1 112	7 579	7 579	7 579	7 579
BOD effluent	[mg/l]	0%	0%	0%	0%	0%
BQ effluent	[E-coli/l]	204	143	183	194	204
Efficiency BOD removal	[%]	91	35	67	79	91
Efficiency E-coli removal	[%]	2E+06	4E+05	1E+06	1E+06	2E+06

Maturation ponds. Whereas anaerobic and facultative ponds are designed for BOD removal, maturation or polishing ponds are essentially designed for pathogen removal and retaining suspended stabilised solids. The size and number of maturation ponds depends on the required bacteriological quality of the final effluent. The design for the maturation ponds at Mkuyuni is presented in **Table 15**.

Table 15: *Maturation Ponds*

Description	Unit	C&P	M	M&K	M&K&C	M&K&C&P
Retention time	[days]	7	16	9	8	7
Volume	[m3]	3 613	24 630	24 630	24 630	24 630
Effective depth	[m']	1.50	1.50	1.50	1.50	1.50
Surface area	[m2]	2 409	16 420	16 420	16 420	16 420
BOD effluent	[mg/l]	24.5	4.7	14.1	18.9	24.5
BQ effluent	[E-coli/l]	7E+04	6E+03	3E+04	5E+04	7E+04
Efficiency BOD removal	[%]	73%	87%	79%	76%	73%
Efficiency E-coli removal	[%]	96%	98%	97%	97%	96%
Fish production	[kg/month]	2 168	14 778	14 778	14 778	14 778
Sludge drying	[ha]	0.03	0.2	0.2	0.2	0.2

Table 16: *Summary design WWTP*

Description	Unit	C&P	M	M&K	M&K&C	M&K&C&P
Net Land requirement	[ha]	0.40	2.80	2.80	2.80	2.80
Gross/Net		1.25	1.25	1.25	1.25	1.25
Gross Land requirement	**[ha]**	**0.5**	**3.5**	**3.5**	**3.5**	**3.5**
Total retention time	***[days]***	***11***	***26***	***15***	***12***	***11***

Ponds construction considerations. According to the geo technical investigations, the water table at the proposed anaerobic facilities is at 1.0 m to 1. 5 m below the surface. Hence, the anaerobic ponds will have an average excavation of 1.0 m and a fill of 2.9 m while considering a 0.5 m freeboard.

The water table at the proposed Facultative ponds is at 0.9 m to 0.8 m depth. Hence, the Facultative ponds have been designed an average excavation of 0.8 m and a fill of 1.2 m while considering a 0.5 m freeboard.

The water table at the proposed maturation ponds is at 0.6 m dept. Hence, the maturation ponds have been designed an average excavation of 0.6 m and a fill of 1.4 m while considering a 0.5 m freeboard.

Refer to APPENDIX 5: GEO-TECHNICAL INVESTIGATION for the geotechnical report.

4.2 Alternative Scenarios

4.2.1 Alternative Sanitation Systems for Mkuyuni Catchment

4.2.1.1 General

The sanitation options available for Mwanza City have been considered under this chapter. The options range from use of 100% on-site sanitation to a sewerage network in combination with on-site sanitation.

4.2.1.2 Sanitation Development Strategy

The Mkuyuni sewage catchment area has been analysed considering the expected sewage flows, population densities, and feasibility of the sewerage system and presence of large sewage generation facilities in a particular area.

4.2.1.3 On-site Sanitation Option

In this option consideration is given to the development of onsite sanitation such as the construction of septic tanks and Ventilated Improve Pit (VIP) latrines to serve the Informal settlements and areas where the sewer lines cannot reach. It is noted that public toilets connected to septic tanks or sewer systems can be employed in certain key locations such as bus parks and market centres. In areas with low population density such as some areas in the outskirts of the town, the residents can be encouraged to construct their own septic tanks. The adoption of this option will require purchase of de-sludging trucks and construction of faecal sludge treatment units such as sludge drying beds and treatment facility for the leachate.

4.2.1.4 Sewerage Reticulation System

The Mkuyuni sewer layout plan and profiles for this preliminary study have been developed from Topo Survey undertaken during the course of the study. This majored mainly on the treatment area, primary sewer lines and the secondary.

Tertiary sewer lines are developed from map sheets from Survey of Tanzania and sewer master plan for Mwanza City Digital Terrain Modelling developed by COWI using AutoCAD Civil 3D Software.

4.2.1.5 Wastewater Treatment Options

The following available technologies for wastewater treatment have been considered for the Mkuyuni Wastewater Treatment District:

- Trickling filters (Conventional Wastewater Treatment System);
- Activated sludge system;
- Facultative aerated lagoons;
- Waste stabilization ponds.

1) <u>Trickling filters</u>

This wastewater treatment technology has been in use for a long time. The technology is very efficient in the reduction of BOD but has little effect on the Faecal Coliform except with the incorporation of disinfection system.

The system has the disadvantage that a lot of pumping systems will be required for sludge management such as pumping into the digester and also to the sludge drying bed.

As Major challenge facing the City is the cost[22] of pumping sewer, adding power-consuming equipment will increase the current problems the service provider is having.

2) Activated Sludge System

An activated sludge process refers to a multi-chamber reactor unit that makes use of highly concentrated microorganisms to degrade organics and remove nutrients from wastewater to produce a high-quality effluent. To maintain aerobic conditions and to keep the activated sludge suspended, a continuous and well-timed supply of oxygen is required.

Different configurations of the activated sludge process can be employed to ensure that the wastewater is mixed and aerated in an aeration tank. Aeration and mixing can be provided by pumping air or oxygen into the tank or by using surface aerators. The microorganisms oxidize the organic carbon in the wastewater to produce new cells, carbon dioxide and water. Although aerobic bacteria are the most common organisms, facultative bacteria along with higher organisms can be present.

The exact composition depends on the reactor design, environment, and wastewater characteristics. The flocs (agglomerations of sludge particles), which form in the aerated tank, can be removed in the secondary clarifier by gravity settling. Some of this sludge is recycled from the clarifier back to the reactor. The effluent can be discharged or treated in a tertiary treatment facility if necessary for further use.

Highly trained staff is required for maintenance and troubleshooting. The mechanical equipment (mixers, aerators and pumps) must be constantly maintained. As well, the influent and effluent must be constantly monitored and the control parameters adjusted, if necessary, to avoid abnormalities that could kill the active biomass and the development of detrimental organisms which could impair the process (e.g., filamentous bacteria).

Conclusion

This is a highly mechanized system with aeration and requires sophisticated process control. Due to this the treatment technology is not considered feasible for the present technological development in the country.

3) Facultative aerated lagoons

The design of an aerated facultative pond is very similar to that of a facultative pond, with an aerobic zone close to the surface and a deeper, anaerobic zone. But there are no requirements in term of surface area as the process is independent of photosynthesis. The two main design criteria are HRT (*the average amount of time that liquid and soluble compounds stay in a tank*) and depth.

This technology requires the use of mechanical aerators for the facultative ponds. This technology will pose a challenge to maintenance of the systems and generally expensive to operate.

4) Waste Stabilization ponds.

This option considers the use of waste stabilization ponds consisting of screening and grit removal, Anaerobic, Facultative and Maturation ponds in series. The technology has numerous advantages among them being:

- Low maintenance costs as there is minimum power requirement;
- Ease of operation and requires low level skills;
- Ability to absorb sock loads etc.

[22] Refer to MWAUWASA website April 2016 on challenges faced by the service provider.

Advantages: They have the additional advantage that, where treatment includes maturation ponds, they offer greater efficiency in removing both bacteria and parasitic worm eggs than can be expected from almost all other waste treatment processes. Waste stabilization ponds are simple, robust and can deal with fluctuations in wastewater flows.

The major disadvantage of waste stabilization ponds is their large land requirement. Their large land requirement means that they are unlikely to be a viable option where land is either expensive or in short supply.

- The option requires adequate land for wetlands of which have been secured earlier by the City Council;

We recommend waste stabilisation ponds system based on strength analysis in Table 17.

Table 17: *Waste Management Option Appraisal Scores*

CRITERION	Trickling Filters SCENARIO I	Score	Activated Sludge SCENARIO II	Score	Facultative aerated lagoons SCENARIO II	Score	Waste Stabilisation Ponds SCENARIO III	Score
Cost	Very expensive due to equipment's cost	0	Expensive due to equipment's cost	+	Fair cost of construction	++	Low construction cost	+++
Land requirement	Low	+++	Fair	+	Fair	+	High	0
Process Control	Recirculation of wastewater flow	++	Aeration Levels and effluent observation	++	Regular monitoring of plant loading quantity	+	Regular monitoring of plant loading quantity	+
Aesthetics	Imitating nature, quite okay	++	Excessive frothing create aesthetic or nuisance problems	+	Grey algae create poor aesthetic	0	Grey algae create poor aesthetic	0
Maintenance	Skilled labour required and equipment	0	Skilled labour required, Pump and Sediment	0	Aerators, Sludge weir and floating matter	+	Cutting plants and Entrance clearance	++
Ease of Operation	Needs instruction and supervision	0	Needs instruction and supervision	0	Business as Usual	++	Very easy	+++
Socio-economic	Chased away for unskilled labour	0	Chased away for unskilled labour	0	Semi-skilled Labour, Harvest, Incomes	+	Unskilled Labour, Harvest, Incomes	++
Water Quality - BOD, N, P	Good	++	Good	++	Okay	+	Excellent	+++
Energy	High	0	Medium	+	Low	++	Zero	+++
Possibility for Upgrading/ Expansion	Not Possible for other Areas	0	Not Possible for other Areas	0	Just add	++	Okay	+++
Malaria	Good	++	Good	++	Bad	0	Bad	0
Innovatively	Good	++	Good	++	Okay	+	Okay	+
Safety	Fair	+	Fair	+	Okay	+	Okay	+
	TOTAL	**14+**	**TOTAL**	**13+**	**TOTAL**	**15+**	**TOTAL**	**22+**

4.2.2 Sewer Lines

The following self-cleansing flows have been considered in the sizing of the sewer pipes for the Mkuyuni Wastewater Treatment.

From the connection of the households, this general sizing has been developed as in Table 18.

Table 18: *General Sizing for Varying Connections*

NO	HOUSEHOLD	SEWER CUM	PIPE DIA mm	MIN SLOPE[23]
1	234	0.0021	160	0.008
2	1,170	0.0105	160	0.008
3	1,170	0.0105	225	0.004
4	2,039	0.0183	225	0.004
5	2,039	0.0183	300	0.004
6	4,435	0.0398	300	0.004
7	4,435	0.0398	450	0.004
8	13,059	0.1172	450	0.004
9	13,059	0.1172	600	0.004

From the table, the connected area main pipes have been sized as in Table 19.

Table 19: *General Sizing for Mwanza South Connections*

AREA	ROUTES	CONNECTION	CUMM. PER LINE	PIPE DIA mm
		No	**No**	mm
Mkuyuni, Kanyerere	F4	1,145		225
	F11	1,067	2212	300
Nyakato around Mandu	G9	949		160
	G22	1,078		225
	G26	1,017	3044	300
Nyegezi: Password, California	F15	1,083		160
	329	990	2073	225
TOTAL		**7,329**		

[23] For flow analysis, refer to Appendix 4.

4.3 Cost Estimates of the Works

Table 20: *Preliminary Cost Estimate for the Works*

Bill No	Bill of Quantities					
	Description		**Qty**	**Unit**	**Rate €**	**Amount €**
1.00	**Waste stabilization Pond**					
1.01	Excavation in soft material complete with bush clearing		38,404	Cu m	11	€ 400,000
1.02	Ditto but in Rock[24]		7,681	Cu m	43	€ 330,000
1.03	Fill		23,024	Cu m	26	€ 600,000
1.04	Lining					€ 840,000
	Accessories: concrete conveyance canals, gates, etc.					€ 1,030,000
1.05	**Sub-total**					**€ 3,200,000**
1.06	**Screening**		**1%**		**3,221,561**	€ 32,000
1.07	**Grit removal**		**1%**		**3,221,561**	€ 32,000
1.08	**Pumps, pipes, etc.**		**7%**		**3,221,561**	€ 225,000
1.09	**Sub-total: Waste Stabilization Ponds (rounded)**					**€ 3,500,000**
2.00	**Sewer Works**					
			Qty	**Unit**	**Rate €**	**Amount €**
2.01	300mm Diameter uPVC pipe Supply and Fit	300	9,800.00	m	56.52	€ 1,500,000
2.02	250mm Diameter uPVC pipe Supply and Fit	250	6,600.00	m	113.04	€ 750,000
2.03	200mm Diameter uPVC pipe Supply and Fit		7,821.00	m	69.57	€ 540,000
2.04	160mm Diameter uPVC pipe Supply and Fit		13,211.00	m	43.48	€ 570,000
2.05	**Sub-total: Sewer Works**					**€ 3,360,000**
3.00	**Manholes for average depths**	**Depth Av**	**Qty**	**Unit**	**Rate**	**Amount**
3.01	1200mm Diameter RCC	3	350	nr	€ 2,234.78	€ 780,000
3.02	900mm Diameter RCC	2	956	nr	€ 1,191.30	€ 1,140,000
3.03	600mm Square Masonry	1.5	7,430	nr	€ 217.39	€ 1,900,000
3.04	**Sub-total: Sewer Works**					**€ 3,820,000**
4.00	**Preliminaries and General**					**€ 1,120,000**
5.00	**Total Direct Investment (rounded)**					**€ 11,800,000**
6.00	Capacity building					**€ 60,000**
7.00	Construction Supervision					**€ 400,000**
8.00	Project Management Unit					**€ 40,000**
9.00	Contingencies					€ 1,200,000

[24] Quantities assumed. Upon completion of Geotechnical Survey, they will be reviewed.

10.00	**Total at Project Completion**		**€13,500,000**
11.00	**Indirect cost: Land securing**		**€300,000**

4.4 Social and Community Development Aspects Proposed HPI and Social and Community Development Aspects Alternative Scenario

Displacement of Households. The proposed site to locate the treatment plant is public land that is to be found at the boundary of Butima and Mahina areas of Mwanza. Additionally, from the design, as much as possible, the sewer (gravity) lines will be located within the road reserves, parallel to a carriageway. This is to minimise cutting of paved road. From this design consideration, anticipated is minimal disruptions. Compulsory acquisition of land is likely not to occur, and so is involuntary displacement of households. However, should it later be determined that compulsory acquisition of land is necessary, this should be taken up with the Government of Tanzania. From consultations with the Government agency responsible for water supply and sanitation services in Mwanza, this is manageable.

Potential Disruption: Loss of Seasonal Crop. The site to locate the proposed WWTP is a wetland utilised by the local community to cultivate seasonal crops. The main crop cultivated is rice. Others, but in small quantity, are maize and beans. The proposed mitigation measure is to give the squatters a notice to vacate the site. The notice should be sufficient to allow them to harvest their crop. Also, during selection of local construction workforce, persons that were directly benefiting from utilising the land should be given first priority.

Potential Disruption: Loss of Temporary Structure. At the site to locate the proposed WWTP is one temporary structure for housing, which belongs to a squatter that has not made it his/her permanent quarters, but resting point when farming. This structure would have to be removed toward effective implementation of the proposed WWTP. The proposed mitigation measure is to give the squatter a notice to vacate the site. The notice can be of the same period as under “2” above.

Potential Disruption: Loss of a Path. Other observation made at the proposed site to locate the facility, is a path created by the locals, which they use to cross from one region to the other. Thus, in the absence of mitigation, easy movement between Butima and Mahina areas is likely to be negatively affected on implementation of the treatment plant at the site. The proposed mitigation measure is for the design to consider construction of a public passageway across the facility.

Figure 24: Indication of the Proposed Site to Locate the Mkuyuni WWTP

4.5 Comparison of Proposed HPI with Alternative Scenarios

The following available technologies for wastewater collection have been considered for the Mkuyuni Wastewater Treatment District:

- Communal Septic Tanks.
- Collector pipes with conveyance lines.

The cost to build a septic tank system varies widely, depending on your location. Considering a communal system for an average 100 households, the cost is as in Table 21.

Table 21: *Preliminary Cost Estimate for the Communal Septic Tanks Works*

No	Description	Amount
1	Preliminaries and General	**€ 41,780**
2	Sewer Works	**€278,754**
3	Septic Tank	**€ 58,056**
4	Accessories: manholes etc	**€ 79,826**
5	Contingencies	**€45,958**
6	Sub Total for 100 HH	**€505,536**
7	Total for 140 units for 100HH	**€70,775,040**

Table 21 clearly shows that communal septic tanks are far more expensive than the option chosen: around **€ 70 mln.**

The following available technologies for wastewater treatment have been considered for the Mkuyuni Wastewater Treatment District with respective attribute highlighted in

Table ***22***:

- Trickling filters (Conventional Wastewater Treatment System)
- Activated sludge System
- Facultative aerated lagoons
- Full Waste Stabilization ponds.

Table 22: *Advantages and Disadvantages of Various Treatment Options*

No	Option	Attributes
1	Trickling filters	***Advantages of Trickling filtration plant*** • Simple and reliable process that is suitable in areas where large tracts of land are not available for a WSP treatment system • Effective in treating high concentrations of organic material depending on the type of media used • Very efficient in removal of ammonia from wastewater • Appropriate for small- to medium-sized communities With the introduction of plastic filter media to replace the rock media, speed control, and more reliable rotary distributor mechanisms, the performance of trickling filters has been greatly enhanced. • Ability to handle and recover from shock loads • Relatively low power requirements; they require power for pumping only and do not need large power-hungry aeration blowers. From motor-driven rotary distributors are powered by fractional horsepower electric motors. • They produce less sludge than suspended-growth systems. The sludge tends to settle well because it is compact and heavy. • Level of skill and technical expertise needed to manage and operate the system is moderate • The cost to operate a trickling filter is very low. ***Disadvantages of Trickling filtration plant*** • Additional treatment may be needed for the effluent to meet strict discharge standards;

No	Option	Attributes
		• Generates sludge that must be treated and disposed of; • Regular operators attention is needed; • Relatively high incidence of clogging; • Relatively low loadings required depending on the media; • Limited flexibility and control in comparison with activated sludge processes. They require high maintenance costs of rotary distributor centre mechanisms. Any maintenance service for the rotary distribution mechanism would require a crane and complete removal of the rotary distributor mechanism, guy rods, and arms. • Potential for vector and odour problems
2	Activated sludge system	***Advantages of Activated Sludge System*** • Resistant to organic and hydraulic shock loads • Can be operated at a range of organic and hydraulic loading rates • High reduction of BOD and pathogens (up to 99%) • High nutrient removal possible • Can be modified to meet specific discharge limits ***Disadvantages of Activated Sludge System*** • High energy consumption, a constant source of electricity is required • High capital and operating costs • Requires operation and maintenance by skilled personnel • Prone to complicated chemical and microbiological problems • Not all parts and materials may be locally available • Requires expert design and construction • Sludge and possibly effluent require further treatment and/or appropriate discharge
3	Facultative aerated lagoons	***Advantages of Facultative Aerated Lagoons*** • Resistant to organic and hydraulic shock loads • High reduction of BOD and pathogens • No real problems with insects or odours if designed and maintained correctly • Can treat high loads • Less land required than for simple pond systems (e.g. WSP) • The treated water can be reused or discharged if a secondary maturation/settling pond follows the aerated lagoon/completely mixed aerated pond ***Disadvantages of Facultative Aerated Lagoons*** • Requires a large land area • High energy consumption, a constant source of electricity is required • High capital and operating costs depending on the price of land and of electricity • Requires operation and maintenance by skilled personnel • Not all parts and materials may be locally available • Requires expert design and construction supervision • Sludge and possibly effluent require further treatment and/or appropriate discharge
4	Full waste stabilization ponds	***Advantages of Waste Stabilization Ponds*** • Waste stabilization ponds are simple, robust and can deal with fluctuations in wastewater flows. • Have a good reduction in pathogen levels to safe levels. •

No	Option	Attributes
		Disadvantages of Waste Stabilization Ponds • The major disadvantage of waste stabilization ponds is their large land requirement. • Their large land requirement means that they are unlikely to be a viable option where land is either expensive or in short supply

4.6 Conclusion of the Analysis

We recommend the implementation of the wastewater stabilization ponds as:

- They are relatively cheap to construct and maintain;
- Skills and equipment for construction of the work is available in Mwanza;
- MWAUWASA has experience in maintaining a similar development;
- Targeted users have a history of paying their bills. Hence, operation costs can be met.

5 Project implementation and Capacity Building

5.1 Project Implementation

It is envisaged that the implementation programme for the project will take approximately 4 years. Detailed design for the project will take 1 year with the construction and defect liability period taking 3 years.

Program of the Selected Project Development

Implementation Program

The construction implementation program envisaged is as follows:

1. Request for prequalification
2. Tendering and selection of contractors
3. Contract award
4. Construction
5. Defects liability period

The implementation works will require a consultancy supervision and program of the consultancy services will consist of:

1. Request for proposal
2. Selection of consultant
3. Award and Signature
4. Construction supervision
5. Defects liability period.

Table 23: *Implementation Schedule for Consultancy Supervision and Construction*

	Year 1											
Acitivity	1	2	3	4	5	6	7	8	9	10	11	12
Request for prequalification	X											
Tendering and selection		X	X									
Request for proposal				X								
selection of the consultant					X	X	X					
Award and Signature for the consultant								X				
Contract Award for the contractor								X				
Construction and construction supervision										X	X	X
Defect Liablity period												

Table 24: *Construction Supervision Continued*

	Year 2											
Acitivity	13	14	15	16	17	18	19	20	21	22	23	24
Construction and construction supervision	X	X	X	X	X	X	X	X	X	X	X	X
Defect Liablity period												

Table 25: *Construction Supervision Continued*

	Year 3											
Acitivity	25	26	27	28	29	30	31	32	33	34	35	36
Construction and construction supervision	X	X	X	X	X	X	X	X	X	X		
Defect Liablity period											X	X

Table 26: *Defects Liability Period*

	Year 4										
Acitivity	37	38	39	40	41	42	43	44	45	46	47
Construction and construction supervision											
Defect Liablity period	X	X	X	X	X	X	X	X	X	X	X

5.2 Capacity Building

General

As noted during the study, MWAUWASA has a number of operational challenges. These should be tackled urgently through capacity building to enable the proposed project to have its intended impact.

Proposed capacity building measures:

Operation and Maintenance of the Facilities

The Operation and Maintenance set up for the existing Scheme and the proposed expansion will be improved and rationalized in order to ensure continuity of wastewater system coverage to whole Project Area.

The Operation and Maintenance teams will ensure the following:

i. Maintain a reliable water supply and sewerage system
ii. Ensure equitable distribution of water supply and sewerage collection system to consumers
iii. Provide an efficient service to all the consumers by prompt attendance to complainants
iv. Ensure a sound revenue base
v. Regularly maintain various components of the Scheme in order to avoid continuous deterioration and subsequent high rehabilitation costs

For the above Operation and Maintenance goals to be satisfactorily met, the following improvements will be carried out:

a) Operation and Maintenance bases will be established
b) Provision of adequate and reliable transport to the maintenance staffs
c) Provision of proper tools and equipment's for maintenance purposes
d) Provision of adequate and experienced staff to carry out the Operation and Maintenance duties

Improvement in Operation and Maintenance

This section describes the improvements in current operational measures and maintenance procedures that will be required if the new and improved facilities are to operate effectively and at full capacity throughout their lifetimes.

Develop system inventory and asset management plans utilizing toolkit proposed to be created by kfW. The inventory should include major equipment, piping and treatment systems. Available data such as age, expected useful life, condition, service history, and nameplate data should be included. Financial value of assets and list of depreciated assets should be included. Develop or use available standard forms, or purchase and customize available software (recommended) to create inventories and convert to an asset management plan by prioritizing assets and estimating future needs and costs. Priority should be given to critical infrastructure at or past the end of its useful life.
Develop a preventative maintenance plan and maintenance tracking system, including all inventory components.

Prepare O&M manuals for all facilities including layout drawings and regular maintenance requirements. Obtain manufacturer's manuals for all existing equipment, incorporate recommended maintenance into preventative maintenance plan.
Review water and wastewater staffing levels and conduct staff rationalization study by an external Human Resources consultant. Include consideration for organizational chart development, task analysis, determination of staffing requirements, creation of job descriptions, and implementation plan for staffing changes.

Provision of Operation and Maintenance Tools and Facilities
In order to provide efficient and effective operation and maintenance of the wastewater facilities, the following basic tools and equipment will need to be provided by MWAUWASA:

- Provision of vehicles: 1no. Pick up (double cabins) 4WD and 2 no. Pick up 2WD;
- One Lorry for transporting repair materials and the chemicals;
- Provision of Motor bikes: 1 No;
- Provision of Tools and equipment for operation and maintenance work, 4 no. sets;
- Provision of Blockage detection equipment for assessment and detection of blockages along the sewer lines;
- A JCB Excavator for necessary extensions and repairs. – 1 No.;
- Provision of 1 No. Division Office including IT and communication equipment such as radio call and furniture and well manned by competent staff;
- Provision of one exhauster;
- Establishing transport department that will manage the proposed tools and facilities.

The consultant strongly proposes that the management of MWAUWASA creates the one Division for operation and maintenance of the wastewater facilities to cover the whole of the Southern Wastewater Treatment District.

Because MWAUWASA understands their difficulties in their daily operations, the above Divisional Office can be modified to suit the ground conditions. The office may be established or be rented as an initial temporal measure as a permanent building is being established.

Training of O&M Staff
Establish a regular staff training program, including training of staff on performance indicators and technical, financial, and managerial skills for both WSP and WSB staff. Further organize for on-the-job training of the operators on the best practices on plant process control. Training of WSP and WSBs staff on preventive maintenance will also be conducted. Exchange programmes with other local WSBs/WSPs and international organizations in the water and sewerage sector to expose staff to sector best practices have also been contemplated
Training and capacity building is recommended, including specific training courses, targeted workshops, and study tours for the Board of Directors, Senior Management and staff of MWAUWASA.

Cost estimate for Capacity building proposals
It is estimated that the capacity building proposals will cost **€ 60,000.**

6 Legal and Institutional Analysis

6.1 General

MWAUWASA was established as water authority in 1997 as a semi-autonomous body, under the Water Works Ordinance of 1998. In 1998 the Water Authority (WA) was converted into a 'Body Corporate' as a fully autonomous body, being financially, technically and institutionally independent from government.

6.2 Legal Setting

MWAUWASA operates under the Water Supply and Sanitation Act which was put in force on May, the 12th 2009. The Act is to provide for sustainable management and adequate operation and transparent regulation of water supply and sanitation services with a view to give effect to the National Water Policy (2002). The Act is also to provide for the establishment of water supply and sanitation authorities as well as community owned water supply organizations and to provide for appoint for service providers. The Act is a modernization of the original Water Ordinance of 1998. Main features of the Water Supply and Sanitation Act are described here.

The **Ministry of Water and Irrigation** shall be responsible for formulation of National Policy and Strategy and for ensuring the execution by authorities under the control of the Minister of their functions connected with the implementation of the Act. The Minister shall (Part III, art 5) i.a.:

- Coordinate and provide technical and financial support for the construction of water supply and sanitation schemes and expansion or rehabilitation of existing schemes of national importance
- Secure capital finance for schemes of national importance
- Coordinate and monitor water authority strategies and plans
- Monitor performance of and regulate community owned water supply organizations
- As to the Water Authorities, the Minister may establish water authority and cluster water authorities in order to achieve commercial viability (Part IV, art 9)

The declared commercial water authorities shall be financially autonomous depending on the commercial viability of providing water and sewerage services (Part IV, art 9)

The **water authority** shall be a corporate body with perpetual succession and a common seal and shall have power to sue and be sued and in the execution and performance of its powers and functions to do and permit all such things as may lawfully be done or permitted by a body corporate (Part IV, art 9)

The water authority shall act as a licensee, be responsible for the efficient and economical provision of water supply and sanitation services authorized by the license (Part IV, art 15)
There shall be a Board of Directors for each water authority, appointed by the Minister, responsible for carrying out the functions and managing the business and affairs of the water authority (Part IV, art 9). The Board shall not delegate its function, power, authority or duty in relation to (Part IV, art 12):

- Approval of plan and budget'
- Approval of annual report or audited accounts
- Borrow sums of money as may be necessary for the water authority

The ownership of the water works, plant, equipment and other assets used by the Government or local government authorities in connection with water and sanitation services shall, without any compensation or costs incurred, be transferred to the water authority upon establishment together with any associated liabilities (Part IV, art 16)

There shall be a Managing Director of the water authority who shall be appointed by the Minister on recommendation of the Board (Part IV, art 17)
The functions of the water authority shall be (Part IV, art 20):

- Provide water supply for uses as required by this Act
- Secure continued supply of water by treating the water and monitoring the quality of water supplied as described in the water quality standards
- Protect and maintain water sources
- Develop and maintain waterworks and sanitation works
- Plan and execute new projects for the supply of water and provision of sanitation
- Liaise with local government authorities on matters related to water supply and sanitation
- Collect fees and levies including any regulatory levy for water supply and sanitation services supplied to consumers by the water authority
- Propose water supply and sanitation tariffs

The duties of the water authority are (Part IV, art 21), i.a.:

- Keep custody, acquire, including through compulsory purchase, construct and operate water works and sanitation works
- Install water meters for the purpose of measuring the amount of water supplied to a consumer
- Enter into an agreement with the owner or occupier of land for more effectively collecting, conveying or preserving the purity of water
- Charge fees for services rendered
- Enter premises for any purpose related to the provision of water supply and sanitation services to consumers
- Prohibit discharge of certain wastes into a sewerage system
- Promulgate By-laws for the better performance of functions under this Act

The water authority shall take into account the existence and needs of the economically disadvantaged persons, in: supplying water, setting tariffs and other charges.
The funds and resources of a water authority shall consist of (Part V, art 23), i.a.:

- The sums as my be appropriated by parliament for the purpose of the water authority
- Any sums which the water authority may receive as fees, rates or charges for water supplied and services rendered.
- The sums that may be borrowed by the water authority from any source

The water authority shall in the performance of its functions be subject to regulation by the **Energy and Water Utilities Regulatory Authority** (EWURA) in accordance with the Energy and Water Utilities Regulatory Act (Part VI, art 27)
The functions conferred on EWURA in relation to water supply and sanitation are, i.a.:

- Licensing and regulatory functions
- Establish standards relating to equipment
- Establish guidelines on tariffs chargeable for the provision of water supply and sanitation services
- Approve tariffs the provision of water supply and sanitation services
- Monitor water quality and standards of performance for the provision of water supply and sanitation services

There is a fund, which shall be known as the **National Water Investment Fund** (part XIII, art 44). The objectives if the Fund shall be to provide investment support for water services provision and management of the catchment areas serving water supply abstractions. The sources of funding shall consist of:

- Money as may be appropriated by Parliament
- Donations and grants to the Fund
- Other charges payable to the Fund

The Minister shall make regulations prescribing the procedures and the performance of the functions and the use of the funds for the operations of the Fund. The funds of the Fund shall vest in the Board of Trustees and be administered as such. The Minister shall appoint the Board.

6.3 Institutional Setting

In the figure below, the current organizational structure is given. It was approved 28th of November 2014. The WA is an independent entity under public law and formally falls under the Ministry of Water and Irrigation. The ministry sets the strategic directions and policies for the water sector in Uganda. The highest authority within the WA is the Board of Directors (BoD), which is appointed by the Minister. The BoD consists 10 members: the MD as secretary, a representative of the ministry and further 8 representatives of the stakeholders (local authority, women, institutions, consumers etc.).

There are 4 Managers under the MD: a technical, a commercial, a financial and an admin & HR Manager. Sanitation operations fall within the technical department. The Mwanza area is divided into three zones. The zones fall under the Commercial Manager, which indicates the importance, the organization attaches to billing and collection and revenue generation. In the next section, it can be seen that the high priority attached to the revenue side, is reflected in the financial results.

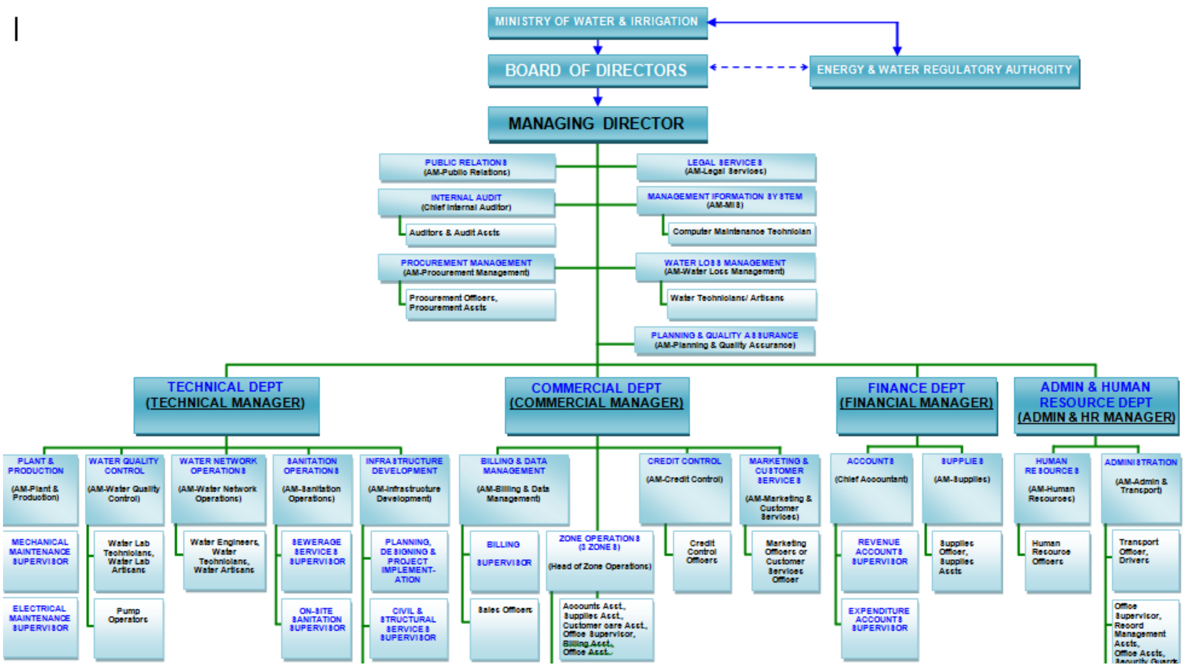


Figure 25: MWAUWASA Organizational Setting

Currently, MWAUWASA holds 290 staff and according to the Assistant HR Manager, Renatus Fulla, they will grow to 300 in the coming months. He sees the following challenges for the sanitation department: to build up experience in sanitation. Currently they have 5 sanitation staff (2 engineers, 3 technical staff) and some 20 causal laborers, but more staff is needed when they increase the sanitation activities. The other challenge is to replace the technical staff that will retire shortly.

They have a PMU, consisting of 1 head and 4 assistants, for managing projects. We think that the PMU role should be strengthened further.

We heard that there was some kind of performance-based salary system to give incentives to staff to improve performance, but that was denied by the assistant HR Manager. Salaries are fixed. Hence they would like to implement such a kind of system but they need support for that.

6.4 Financial Performance

There is a MoU between the Authority, the ministry and EWURA setting performance targets for the Authority. It covers technical, financial, commercial performance and performance on customer relations. In the next table the performance targets are given.

Table 27: *Performance targets MWAUWASA (Source: financial statements of MWAUWASA 30th June 2015)*

PT No	Performance indicator	Unit	Performance Target (July 2014 – June 2017		
			Target 2014/15	Actual 2014/15	Provisional Target 2015/16
Protection of user interest					
User service accessibility					
PT 1	Proportion of population living within the area with water network	**%**	94	95.9	95
PT 2	Proportion of population with direct access to water supply	**%**	61	81	62
PT 3	Number of households with connections to water supply	**No**	166,790	103,036	171,460
PT 4	Proportion of population connected with sewerage network	**%**	15	23.7	20
PT 5	Number of households with connection to sewerage	**No**	7500	6798	8000
PT 6	Number of public water kiosks	**No**	135	151	135
PT 7	Average hours of supply	**Hours**	22	22	22
Sustainability of the operator					
Operators financial and economic sustainability					
PT 9	Metering ratio	**%**	100	100	100
PT 10	Non-Revenue water or NRW	**%**	37	41.8	35
PT 11	Revenue collection efficiency	**%**	100	102.36	100
PT 12	Working ratio		0.5	0.98	0.5
PT 13	Operating ratio		0.63	1.1	0.62
PT 14	Personnel expenditures as % of collection from water, sewerage bills	**%**	30	31.31	30

PT No	Performance indicator	Unit	Performance Target (July 2014 – June 2017		
	and related services				
Operators human resource efficiency					
PT 15	Personnel/1000 (W&S)connections		7	5	6

Remarkable features:

- Percentage of population with water supply and sewerage (PT2 and 4) are higher than the targeted percentage, while the number of households with connections are lower. For PT 2 it could imply that people are having water from standpipes etc, but for sewerage PT 4 it reads the proportion of people connected to sewerage network. It is hard to understand how come that the number of people connected is higher while the number of connections is lower than target. This could only imply that the figure of the number of people per connection (which is not a target) is not correct.
- The NRW is considerably higher than target and should receive high attention from management
- The revenue collection is very high, even compared to international standards.
- 100% of the connections is metered which is high also to international standards.
- Operational costs coverage was above 100%, implying that all operational costs were covered by revenues. Also depreciation costs were included.
- The number of people per 1000 connections is reasonable and there seems to be no major overstaffing, which implies that the Authority is business-run.
- There are no performance criteria on customer satisfaction such as number of complaints or satisfaction grades.

Being independent implies that the Water Authority bears all operational costs for operating and maintaining the water and sanitation networks and installations. Hence, there are no government subsidies for the WA, also not for investments in facilities and networks. Since the WA cannot cover the investments from its operational budgets, these funds have to mainly come from development partners.

MWAUWASA is allowed to gain profit. In FY14/15 the Authority made a profit of 458 million TZS (4.5 million USD), against a loss of 746 million TZS in the year before. The improvement was due to higher sales (15 million TZS in FY14/15 against 14 million TZS in FY13/14) and lower costs of operation, especially savings on energy costs.

In FY14/15, the Authority spent 647 million TZS of internally generated funds for investment projects, which was 4% of total operating revenues.

One of the main worries for MWAUWASA is the issue of the outstanding debts. Recently, there was an article in the local newspaper that the amount outstanding is some 1.6 billion TZS (16 million USD, or 4 times the annual profit), mainly public and private institutions. The outstanding arrears seriously hampers its cash-flow position and could lead to disruption of operations. Settlement of those arrears is therefore urgently needed.

6.5 Assessment on Sustainability MWAUWASA

We consider MWAUWASA capable of managing the project and doing the project implementation for the following reasons:

- They are financially sound; their cost-recovery level is currently over 100% and their collection ratio is also high, also in comparison with international standards: 98%
- They have experience in operating and maintaining sewerage networks and WWTPs

- They know how to manage large projects that are financed by international financing institutions and development donors
- They have capable staff operating WW systems

7 Financial and Economic Analysis

7.1 Assumptions

Table 28 presents the assumptions applied for the financial analysis.

Table 28: *Assumptions for the Financial Analysis*

Variable	Value	Unit	Source / rationale
Generic			
Exchange rate x TZS to 1 EUR	2,481	TZS per euro	www.xe.com (April 2016)
Price index (2012)	78	Index	www.tradingeconomics.com
Price index (2016)	100	Index	www.tradingeconomics.com
Construction period	2	Years	Assumption
Project duration	20	Years	Assumption
Period of operations	Q3 2019 – Q2 2039		Assumption
Operational days per year	365	days	Assumption
Domestic water use			
People per household connection	6	people / connection	Expert judgement project team and the Household Budget Survey Main Report 2012, page xxi
Household connection rate	0.98	%, 0 - 1	Experience from works on Mwanza Sewerage Phase II
Wastewater as a percentage of water use	0.85	%, 0 – 1	Expert judgement project team
Average domestic water use	100	litres / person / day	Expert judgement project team
Change in domestic water use	0%	% increase / year	Assumption (a flat rate is used – the 100 litres already contains a slight growth)
Revenues			
Domestic drinking water tariff, <10m3	700	TZS / m3 of drinking water	Energy and Water Utilities Regulatory Authority, in a matter of Application by the Mwanza Water Supply and Sanitation Authority for a Multi-Year Tariff Adjustment
Domestic drinking water tariff, 11-25m3	865	TZS / m3 of drinking water	
Domestic drinking water tariff, 25>m3	900	TZS / m3 of drinking water	
Domestic sewerage tariff, <10m3 / year	305	TZS / m3 of drinking water	
Domestic sewerage tariff, 11-25m3 / year	330	TZS / m3 of drinking water	
Domestic sewerage tariff, 25>m3 / year	390	TZS / m3 of drinking water	

Variable	Value	Unit	Source / rationale
Fee collection rate	100	%	p12 of the Audit report[25]
Fish production	11,368	Kg / month	Expert judgement
Fish price	0.18	EUR / kg	3 to 4 EUR/kg for fresh high quality fish. Assumed 5% of this price for the low quality sewerage pond fish (used e.g. for fishmeal)
Household income / affordability			
Mean household expenditures 'other urban areas' Tanzania (excl Dar es Salaam)	380,437	TZS (corrected to 2016 values) / household / month	Household Budget Survey Main Report 2012, p85, http://www.nbs.go.tz /tnada/index.php/catalog/36
Median household expenditures 'other urban areas' Tanzania (excl Dar es Salaam)	290,415	TZS (corrected to 2016 values) / household / month	Household Budget Survey Main Report 2012, p85, http://www.nbs.go.tz /tnada/index.php/catalog/36
Low income households in the area	100,000	TZS / household / month	Expert judgement project team and municipality of Mwanza
Middle income households in the area (= assumed as the target group)	500,000	TZS / household / month	Expert judgement project team and municipality of Mwanza
Real income per capita increase per year	1,5	% per year	Assumption
Benchmark affordability of water and sewerage expenditures	5	% of total income	P14 of Guy Hutton (2012) Monitoring "affordability" of water and sanitation services after 2015: Review of global indicator options. Original source: Smets, H. Quantifying the affordability standard, in The Human Right to Water: Theory, Practice and Prospects. 2012. Cambridge University Press.
Cost estimates			
See clause 3.4 for the cost estimates			
Depreciation rate excavation works	0	% per year	Expert judgement
Depreciation rate Sewerage network structure	2	% per year	P37 of the Audit report (see full reference above)
Depreciation rate pumps	10	% per year	Expert judgement

We have assumed constant real prices and tariffs based on 2016 price levels.

[25] National Audit Office (2015), Report of the controller and auditor general on the audit of financial statements of Mwanza urban water supply and sanitation authority (MWAUWASA) for the year ended 20th June 2015

7.2 Results

The figure below presents the year-on-year cash flow of the project under operations (before financing).

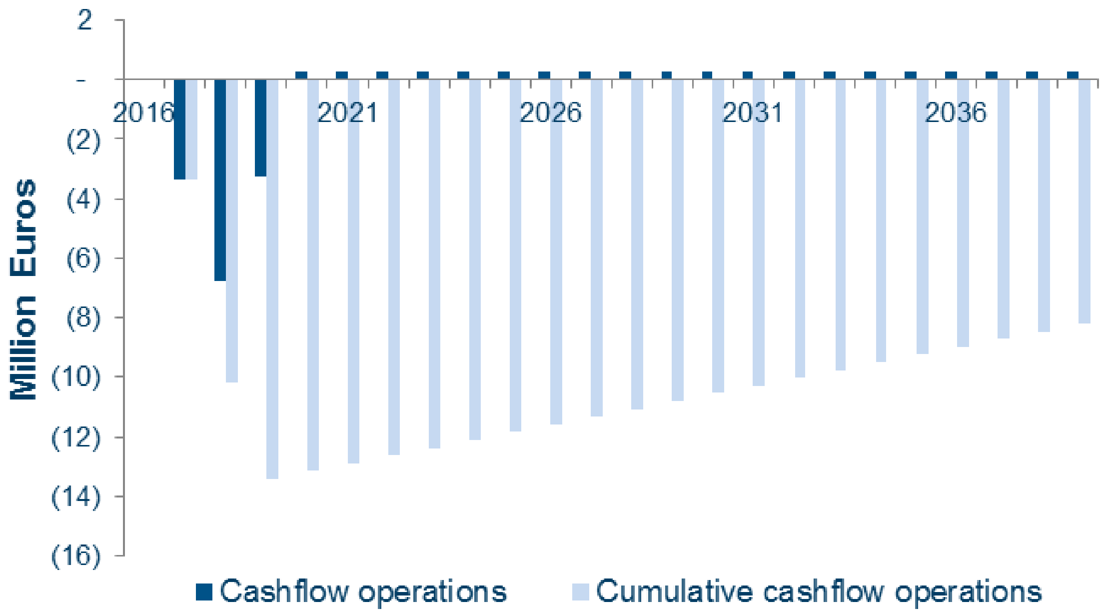


Figure 26: Cumulative and Year-on-year Cash Flow of Operations

It can be observed that the project generates sufficient revenue to cover operation and maintenance costs, which is shown by the positive cash flow from 2020 onwards. However, the project does not provide a positive return on investment (negative cumulative cash flow).

An assessment was done to what level the sewerage surcharge needs to be raised in order to achieve financial sustainability of the project. The following table presents both the current and required sewerage charge and the corresponding key results.

Table 29: *Key Results Under the Current Tariff Regime (50%) and the Base Case (75%)*

Indicator	Value under 50% surcharge (current)	Value under 75% surcharge (base case)
Internal Rate of Return of operations – before finance	<0	<0
Net Present Value (10%) – after finance (EUR)	-569,288	56,420
Prime costs of treatment (0% discount rate, EUR/m^3)	0.516	0.516
Prime costs of treatment (5% discount rate, EUR/m^3)	0.382	0.382
Operating Cost Recovery ratio (revenue / O&M)	3.35	4.86
Full Cost Recovery ratio (sustainable => 1) (revenues / (O&M + depreciation))	0.71	1.03
Affordability (%) (water + sewerage bill / household income)	3.3%	3.7%
Impact Implementing Agent - net annual profit (EUR – full operations)	-277,428	7,529
Current annual profit operations Implementing Agency (EUR – 2015 operations)	-184,957	-184,957

The Full Cost Recovery ratio under the current tariff regime shows that insufficient revenue is generated for future reinvestments. In order to operate sustainably, the sewerage surcharge needs to be raised from 50% to 75% (sewerage surcharges provide the majority of the revenue, as shown in the figure below). The table shows that under this tariff regime, the Net Present Value after finance becomes positive.

In addition, the company-wide operations of the Implementing Agent, which are currently at a slight loss, become positive under such a tariff. This is based on the additional revenue collected from households which are already connected to the existing sewerage network.

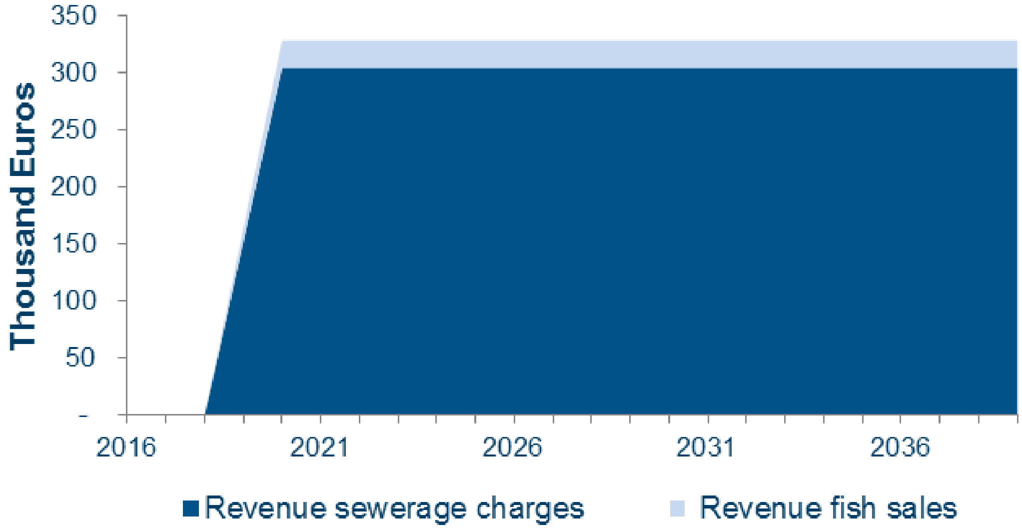


Figure 27: Breakdown of Revenue during Operations

Considering that an increase in sewerage tariffs is required for Full Cost Recovery, it is crucial to what extent this increase is realistic. This depends on two important conditions:

- Affordability of the water and sewerage bill for households.
  Under the assumptions we present an international affordability benchmark of affordability. When the water and sewerage bill exceeds this 5% of household income, we consider it to be not unaffordable. The table above shows that this value is not exceeded, implying that an increase in tariffs should be feasible from this perspective.
- Approval of the regulator.
  MWAUWASA is required to receive approval from the regulator (the Energy and Water Utilities Regulatory Authority) for any increase in tariffs.

The following considerations are also relevant. In our experience, a sewerage surcharge of 75% of the water bill is realistic in Eastern Africa. From a social justification perspective, it is important to note that the proposed tariff increase only affects beneficiaries of sewerage service. Moreover, these households will also get a cost reduction, considering that sewerage reduces the costs of alternative on-site sanitation. Finally, the increase in sewerage tariff will also affect currently existing sewerage connections, which would provide sufficient revenue for the MWAUWASA to go from a net loss to a slight profit of their total operations. This would be beneficial from a financial sustainability perspective.

From the table it can be seen that the expenses for water and sewerage, also with a surcharge of 75%, remain within the boundary conditions used by the World Bank (maximum 4 – 5 % of household income).

All in all, we consider that an increase in sewerage tariff is reasonable, under the condition of regulatory approval.

The observation that an increase in sewerage surcharges is required shows that the financial sustainability of the project is challenging. To further test the robustness of the financial operations of the project, we have conducted a sensitivity analysis.

We have approached this by analysing to what extent the sewerage surcharge can be raised to cover lower household connections or unexpected cost increases, without compromising the affordability of the water and sewerage bill of households. The table below presents the results.

Table 30: *Sensitivity Analysis*

Parameter change	Required sewerage surcharge	**Affordability** Water and sewerage bill as % of household income
Base case	50%	3.3%
Financial sustainability	75%	3.7%
25% O&M cost increase	80%	3.8%
25% investment (and depreciation) cost increase	85%	3.9%
25% lower household connections	100%	4.2%
Maximum affordable surcharge increase	140%	5%

The results show that the maximum sewerage surcharge which is still affordable by international benchmarks is some 140%. Considering that a surcharge of 75% is needed for financial sustainability, the project can absorb some unexpected cost increases or revenue drawback. Obviously, this would require that such a tariff increase is accepted by both the target group and the regulator, which may not necessarily be the case.

7.3 Conclusions

Under the current tariff regime, the project is not financially sustainable under – the Full Cost Recovery ratio would stand at 0.72. In order to reach financial sustainability, the sewerage surcharge needs to be raised to 75% instead of the current 50% surcharge on the water bill.

Such a sewerage surcharge is affordable based on international benchmarks. Moreover, we consider it to be justifiable. However, the approval of the regulator is conditional for the financial feasibility of the project.

The project is vulnerable for unexpected cost increases and revenue drawbacks. This can in theory be absorbed by increasing tariffs, although not beyond a sewerage surcharge of 140%. Importantly, the project would then also have to deal with regulatory approval and public acceptance of tariff increases.

8 Project Risk Analysis

Although the collection efficiency in Mwanza is quite high, the sewer connection rate is still very low. The Water Utility is still not in a position to convince customers to connect. Only 50 connections per year are constructed (Mwanza is the second largest town in Tanzania). The bylaw requesting that customers living in a range of 30 m from sewer line have to be connected is not consequently applied. As a result the existing and KfW-co-financed WWTP works at around 30 % of its capacity.

Considering this background it seems questionable whether the construction of a new WWTP (or even two) will improve the wastewater situation in Mwanza as long as customers are not forced to be connected. Hence, financing of house connections is the only workable solution.

Sewer networks in Mwanza hilly areas, especially when it comes to simplified sewer systems, require a high level of acceptance and participation. Accompanying measures have to be included in the project concept in order to ensure the sustainability of the investment. UN Habitat has suggested the following measures:

- A baseline study to comprehensively identify the number, type and capacity of the customers, including the knowledge and attitude about the sewerage service;
- High levels of stakeholder mobilization. This is about bringing in the government at all levels leave alone other players like institutions;
- Enforcement of bye laws and this is done under participatory process which is quite tedious and time consuming;
- Preparation of a promotional tool kit, flyers, brochures and;
- Conducting awareness raising interventions at various intervals during the project implementation phase. This task can go beyond the completion of the physical infrastructure to monitor the practical response of the households and the actual action taken by them in connecting to the sewerage system.

UN Habitats estimates 18 months time over 4 years period and a budget of say € 12,000 per month, which is about € 200,000. It is suggested to include this in the overall budget[26]

Sludge transport by vacuum tanker and sludge treatment is not really promoted by the Water Utility. Two years after completion of sludge drying beds at WWTP none has ever been used. The project needs to have component on “sludge promotion”.

Alternative solution, which could be considered: Construction of communal septic tanks, which will be emptied by tankers and sludge will be treated at existing WWTP (increasing of used capacity). Communal septic tanks could be designed in a way allowing connecting to a future sewer system in the southern part of Mwanza. However, Table 21 clearly shows the capital cost is quite high to implement the proposal, running the facility will also require high investment in vacuum trucks and faecal sludge treatment facilities.

Failure to intervene implies the ongoing contamination of Lake Victoria will continue as history clearly shows expansion of the facilities have quite been a challenge.

MWAWASA thus requires intervention not only in establishment of the Waste Water Treatment Plants but also in connecting the households to the network. Operational cost will be collected with the surcharge, as is the current case.

[26] UN Habitat e-mail received on 28 July 2016.

9 Environmental and Social Impact and Mitigation Measures

9.1 Introduction

This section presents the Environmental and Social Impact. It includes recommendations and mitigation and enhancement measures, if and when required. These measures aim to reduce potentially significant adverse impacts to acceptable levels, including traffic, dust, odour, waste, flooding risks, and compensate residual effects. The plan includes prevention or minimization of any potential adverse environmental and social impacts of the Project that have not already been identified, e.g. actions for labour management, contractor management and performance in accordance with good international construction practices. This chapter aims to define certain aspects of the Tender Documents to be prepared for realization of the Mkuyuni WWTP.

This chapter includes a monitoring program to provide information on the environmental and socio-economic impacts of the project during implementation and on the effectiveness of mitigation and enhancement measures. The latter intended to allow corrective responses where results are insufficient.

In this chapter we describe the positive and negative environmental and social impact of the proposed HPI, the WWTP Mkuyuni. We distinguish between:
- Pre-construction phase;
- Construction phase;
- Post-construction phase;
- Operation and Maintenance phase.

As far as the environmental impact is concerned we describe any positive and negative effects. As far as the negative effects are concerned we describe the mitigating measures that need to bed done.

9.2 Pre-construction Mitigation Measures

The following table describes the mitigation measures during the pre-construction phase.

***Table 31**: Pre-construction Mitigation Measures*

Impact	Mitigation Measures
Design review WWTP	Confirm size and type: screening, grit channel, anaerobic pond, facultative pond, maturation pond, sludge drying, etc.
Design review Maturation Ponds	Confirm that designed maturation ponds reach effluent standard of < 50 $mgBOD_5/l$
Prevention of Bypassing influent	Confirm that WWTP design and related pumping stations are robust enough to maintain influent treatment during periods of high water/flooding
Sewer connections arranged	Ensure connection of all households in the service areas. Ensure all households have drinking water supply and (pour-) flush toilets to sewer system, as part of the sewerage packages. Provide adequate sanitation services to Project Affected People along trunk main and around WWTP
Routing and design Trunk Main	Ensure that coordination with City of Mwanza, MWAUWASA, Railways and Transport Authorities is performed.
Effluent Discharge	Design effluent discharge below river surface level and optimize dilution with river water flow

Impact	Mitigation Measures
Buffer Zone and Visual Impacts	Confirm that buffer zone (and trees) are included in final design of WWTP; To prevent an increase in population density around the WWTP and maturation ponds a spatial planning order of the City of Mwanza could be developed limiting new developments of housing in the area of influence around the WWTP
Flooding Risks	Confirm that adequate flood protection measures are included in the design of the WWTP if needed
Malaria Risks (Design)	Include biological prevention measures into the design of the maturation ponds, to prevent malaria
Odour emissions (design)	Prepare for Odour Mitigation Measures during design phase: (1) anaerobic ponds, (2) prepare design for a basic weather station for recording wind speed, direction, humidity and rainfall at the WWTP.
GHG emissions (design)	Apply reusable building materials where possible
Resettlement Action Plan for WWTP and maturation ponds	Implement land acquisition and RAP for WWTP
Implement Stakeholder Engagement Plan	Implement SEP during pre-construction phase
Water Quality Monitoring	Design a chemical and biological laboratory on the site of the WWTP for weekly analysis of influent, effluent and ambient water quality (COD, TSS, total Nitrate, Phosphate and pH)
Electricity	(1) Confirm capacity of central electricity net, to supply sufficient energy to WWTP, pumping stations and to other consumers of the electricity net; (2) confirm sufficient stand-alone back up energy capacity for WWTP and pumping station

9.3 Construction Mitigation Measures

The mitigation measures during construction are presented in the following table.

Table 32: *Construction Mitigation Measures*

Impact	Source / Subject	Mitigation Measures
Disturbance to local residents during construction works	Location of construction works close to neighbouring living areas	Contractor shall submit construction yard logistics to Client, including means of separation from living areas
Traffic Management Plan	Construction Vehicles and traffic management	The Contractor shall elaborate a Traffic Management Plan, which shall be coordinated with the City of Mwanza and the relevant traffic authorities and the police. This plan shall be approved prior to the start of the construction works, and will include: • Traffic routes for construction equipment and building materials, including foreseen timing and frequency of traffic movements; • Identify critical traffic safety and accident risk locations along the route, and propose related mitigation measures, including speed control and road signs; • Timing and access of construction material delivery vehicles to site should be strictly controlled to avoid the disturbances to the local community; • Timing of construction of sewer network and trunk main to limit risks of traffic accidents, traffic jams and nuisance; • Appropriate traffic signage must be erected on site by the Contractor to alert other road users to construction activities; • The Contractor should strategically position the site entry and exit points to ensure that there is minimum impact to the traffic flow on neighbouring areas; • A low speed limit shall be adhered to on site; • Construction vehicles must utilise existing main road and

Impact	Source / Subject	Mitigation Measures
		access roads and not create new unauthorised access roads; • The Contractor must ensure that local access roads are not damaged by construction vehicles. If damage does occur, it needs to be attended to immediately to avoid long term problems; • Lighting used to facilitate construction at night should not disturb neighbouring residents. Down lighting should be employed where practicable; • Accessibility of public buildings (among others offices, hospitals, schools, universities, businesses and culturally important sites) needs to be guaranteed during normal working hours. Specific attention shall be given to accessibility for people with disabilities
Storm water discharge to neighbouring residents	Storm water and drainage at construction site	Contractor shall attend storm water drainage on construction site, to prevent soil erosion and flooding
Unauthorized access to site camp	Access points	The site yard must be secure at all times to prevent unauthorised access at the construction site. The Contractor must ensure that construction trenches and material storage areas are sealed off with barrier tape/fences. There must be security at the entrance gate controlling access to the site.
Site contamination	Storage and use of equipment and hazardous substances	Hazardous substances need to be kept in a secured storage area, which is funded and/or has an impermeable floor layer that is able to contain spillages. The hazardous substance storage area needs to be locked at all times. Spill kits must be kept at the hazardous substance storage facility to treat and manage any spills immediately. All contaminated soil/clothing/material must be disposed of at a licensed or approved hazardous landfill site. The hazardous material storage facility should be sited away from storm water drainage lines. Clear warning signage must be placed at all storage areas containing hazardous substances / materials. Staff dealing with these materials / substances must be aware of their potential hazard and follow the appropriate safety measures.
Site contamination	Solid waste handling	Sufficient waste bins shall be provided on site to encourage waste separation and for recycling purposes, if such systems are available. Refuse bins shall be placed at strategic positions to ensure that litter does not accumulate on site. Construction workers need to be encouraged to use the waste bins provided at all times, and littering should be prohibited. The Contractor must engage with the local authorities or a private waste service provider regarding to the provision of waste containers. Waste containers should be kept on site to dispose of construction rubble. Containers must be removed when they fill up to maintain a clean site. Waste must be disposed of at the official landfill, approved by the authorities. If the waste disposal facility does not issue a record of the waste disposed, it is recommended that the Contractor keep a record at the construction site of the volumes of waste taken to the facility. Burning of waste on site or in waste containers is prohibited. Hazardous waste may not be stored on site in excess of a 90 calendar day period.
Site contamination	Sanitation	The Contractor shall install toilets on the site and place them in a designated area. The Contractor needs to establish hand washing facilities and soap to maintain good hygiene on site.

Impact	Source / Subject	Mitigation Measures
		Staff shall be sensitised to use these facilities at all times. Ablution facilities shall be within 100m from workplaces. The Contractor should arrange that the service provider services the toilets regularly.
Air and soil pollution	Handling of cement, asphalt, fuel, paints and other chemicals	Cement or asphalt mixing must take place on impermeable/-protected surfaces. Use of ready mixed cement/asphalt will require the establishment by the Contractor of proper truck and equipment wash bays with an impermeable floor layer. Used paint tins/brushes must be disposed of as hazardous waste and paint washings collected in receptacles for later safe disposal. Paint must not be washed into stormwater drains on site.
GHG Emissions	Air emissions	Purchase reusable building materials where possible; minimize construction transport distances and related transport air pollution
Noise	Construction noise	Construction works related noise levels must be kept within acceptable limits. The noise and sound generated shall adhere to the Tanzanian noise standard specifications and take account of nearby residents when work is performed at night. No sirens and hooters may be utilized except where required or in emergencies. The playing of loud music at the construction yard is prohibited. The Contractor should keep the local community informed of unavoidable noisy activities and their duration.
Dust generation	Dust from excavations, cement and construction materials	Excavations and other site clearing activities shall only be undertaken during agreed working times to avoid the spreading of sand and dust into neighbouring areas. The Contractor shall be responsible for dust control (water spraying) on site to ensure no nuisance is caused to the neighbouring landowners and the local community. A speed of 20 km/h shall not be exceeded on site. The Contractor must attend to complaints resulting from dust generation immediately. The Contractor should commence with rehabilitation of exposed soil surfaces as soon as practically possible after completion of earthworks. All material resulting from excavation must be put in a location protected from wind and regularly sprinkled with water until reused for fill Dust suppression measures must be implemented where required.
Fire risks	Potential fires	The Contractor shall have operational fire-fighting equipment available on site at all times. The level and capacities shall be sufficient to address any major fire outbreak. Open fires shall be prohibited on the site
Surface Water pollution	Chemical and hazardous materials	All hazardous materials shall be placed in containment areas on sealed floor surfaces and 100m away from any water bodies. The Contractor must remove contaminated wastewater resulting from construction activities and dispose of it at a licensed commercial wastewater treatment facility. Temporary cut-off drains and berms must be erected in order to capture surplus storm water and promote infiltration. Used oil on site must either be collected by a registered waste oil collector or disposed of to a registered processing or disposal facility. Manual cement/asphalt mixing activities must take place in a lined are a to prevent runoff from the area entering the storm water drainage system. It is recommended that ready mixed cement/asphalt be utilised to prevent onsite water pollution and impacts on surrounding areas, where possible. A designated, properly designed impermeable washing area for vehicle and the Contractor must establish construction

Impact	Source / Subject	Mitigation Measures
		equipment if this cannot be undertaken off-site. Any accidental spillages that occur on site must be contained and remediated as soon as possible. On site ablution facilities need to be serviced regularly and placed in a special area. Storm water needs to be managed especially during the wet season. It should not be allowed to drain into trenches nor should it be allowed to flood areas where construction materials or equipment are stored. A storm water management plan must be prepared by the Contractor and approved by the ESO, ECO and /or the Independent Engineer. Water pumped from any excavations/trenches must be safely disposed of and be free from silt and sediments.
Safe water use	Leakage and wasting	The contractor needs to provide safe drinking water to its employees, meanwhile avoiding wastage and timely repair of leakages
Disturbance of wetland ecology	During construction maturation ponds	Construction work site shall be physically separated from surrounding wetlands/ paddy fields. Nuisance and pollution of the surrounding wetlands shall be fully prevented, including dust, noise, wastewater emissions, and particularly waste generation and disposal. The contractor shall prevent that animals, fishes and other fauna will be disturbed, trapped, hunted or killed by the workers and staff involved in the construction works. In case of emergencies accidents with impacts on the wetland ecology beyond the boundaries of the construction site, the relevant authorities shall be informed immediately, and related mitigation measures shall be prepared and implemented as soon as possible
Occupational Health and Safety Impacts	Workers and community safety	A health and safety plan shall be drawn up by the Contractor to ensure the safety of workers. Contractors shall ensure that all equipment is maintained in a safe operating condition. A record of health and safety incidents shall be kept on site. Any health and safety incidents shall be reported to the Employer immediately. First aid facilities shall be available on site at all times. Workers have the right to refuse work in unsafe conditions. Material stockpiles or stacks shall be stable and well secured to avoid collapse and possible injury to site workers.
Occupational Health and Safety Impacts	Use of Protective gear	Personal Protective Equipment (PPE) shall be made available to all workers and use of PPE shall be made compulsory. The minimum PPE includes: • Hard hat; • Safety shoes • Overalls; • Gloves; • Reflector vests; Certain operations may require additional PPE such as: • Ear plugs; • Eye protection glasses; • Face masks; No person is to enter the construction site without the necessary PPE.
Occupational Health and Safety Impacts	Site safety issues	The WWTP construction yard shall remain fenced at all times. Potentially hazardous areas such as trenches are to be demarcated and clearly marked. Adequate warning signs of hazardous working areas shall be erected in suitable locations. Emergency numbers for the local police, clinic/hospital and fire department shall be placed in a

Impact	Source / Subject	Mitigation Measures
		prominent area. Fire fighting equipment shall be placed in prominent positions across the site where it is easily accessible. This includes fire extinguishers, a fire blanket as well as a water tank. Workers need to be trained on how to operate the fire fighting equipment. All flammable substances shall be stored in safe areas which do not pose an ignition risk. Smoking may only be conducted in demarcated areas as agreed upon by the SHE officer and the Contractor. A speed limit of 20km/h shall be adhered to by all construction vehicles and machinery. The works that take place in the public space, especially the construction of the sewer network and the trunk main, need specific health & safety planning, traffic safety planning, and training of the construction workers to limit public the safety risks, such as falling into holes, pools or ditches or collisions with construction equipment.
Stakeholder Engagement Planning	Stakeholders	Stakeholder engagement should continue into the construction phase. Specific attention should be given to communication about public health & safety risks and measures to mitigate these. The project council with representatives of the local residents should be in regular contact with the City of Mwanza and MWAUWASA. A grievance mechanism should be established and managed.
Neighbouring Community	Community relations	The Contractor must be courteous at all times when dealing with the neighbouring community and their rights need to be respected at all times. A complaints register should be kept on site and the Contractor must attend to any public complaints as soon as possible. No interruptions other than those negotiated shall be allowed to any essential services, including access to water sources and local infrastructure. Damage to local infrastructure shall not be tolerated and any damage shall be rectified immediately by the Contractor. A record of all damages and remedial actions shall be kept on site. Where possible, unskilled job opportunities should be afforded to local community members in order to transfer employment skills. The Contractor will need to engage with the municipal local Councillors or other community leaders to assist with the recruitment of the local unskilled labour when required.
Neighbouring Community Impacts	Infection risks from HIV / AIDS. Ebola and other diseases	The Contractor must coordinate and implement an awareness campaign on HIV/Aids, Malaria and other potential sicknesses within Mwanza. The campaign must aim at sensitizing the employees and neighbouring communities to potential health risks and regulating behaviour.
Neighbouring Community Impacts	Alcohol and drug abuse	The consumption of alcohol and drugs by employees must be prohibited on and surrounding the construction area
Employment opportunities	Labour recruitment	Where possible local residents, including women, shall be given the opportunity to apply for construction jobs and to supply materials, food and beverage.

9.4 Post-construction Mitigation Measures

Following the completion of the construction works, the following post-construction actions need to be implemented by the Contractor:

- The construction yard is to be checked for spills of substances such as oil, paint, chemicals, other types of waste, and these shall be cleaned up;
- The Contractor must arrange for the cancellation of all temporary services, e.g. toilets;

- All areas where temporary services were installed are to be rehabilitated to the satisfaction of the local authorities and the Independent Engineer, if assigned;
- Surfaces are to be checked for waste products from activities such as concreting/asphalting and cleared accordingly;
- All surfaces hardened due to construction activities are to be ripped and concrete/asphalt material removed;
- Topsoil must be replaced back to disturbed surfaces and used to re- vegetate disturbed areas;
- The use of a geotextile cover is particularly important where there is a slope, or where the soils are likely to remain exposed for any period of time while the new vegetation establishes itself;
- All construction waste and rubble is to be removed from the site and disposed of to the municipal or recognized/approved landfill site;
- The site is to be cleared of all litter and temporary cabins and structures should be dismantled;
- Fences, barriers and demarcations associated with the construction footprint are to be removed from the site;
- All residual stockpiles must be removed from the site;
- The Contractor must repair any damage that the construction works has caused to neighbouring properties;
- Quarries used for sourcing construction material must be rehabilitated accordingly.

Public Information to prepare for Construction Works

The Project Affected People and general public shall be informed through the City of Mwanza about the type and duration of the upcoming construction works, as well as during these works. This shall include information on the timing and planning of the construction works, the impacts on roads and traffic such as road closures and rerouting of vehicle and pedestrian traffic, potential temporary environmental nuisance and temporary traffic signs and warnings.

9.5 Mitigation Measures during Operation and Maintenance

The mitigation measures during operation and maintenance are presented in the following table.

Table 33: *Post Construction Mitigation Measures*

Impact	Mitigation Measures
Effluent water quality	Establish effluent monitoring program in line with RS 109 2009 Water Quality, and optionally with EU Directive 91/271/EEC and amendment 98/15/EEC, particularly for BOD, Ammonia and SS and occasionally for non-typical components
Monitoring and reporting	The operator should maintain records of air emissions, effluents, and hazardous wastes sent off site, as well as significant environmental events such as spills, fires, and other emergencies that may have an impact on the environment. The information should be reviewed and evaluated to improve the effectiveness of the monitoring. It should further include procedures for handling of accidents and disaster preparedness.
Occupational Health and Safety during operations (management system)	Establish an OH&S management system. Supervisors must first have the proper attitude and interest in OH&S, and shall gain a full working knowledge and understanding of the many ways in which they can prevent accidents and occupational illness.
Occupational Health and Safety during operations (chemical handling)	Many of the materials and chemicals used in the wastewater treatment are corrosive, poisonous, explosive, or flammable. Handling of these materials requires proper precautions.
Occupational Health and Safety during operations (ventilation)	Wastewater treatment plants require careful analysis of and provision for ventilation needs, because plant ventilation prevents dangerous gas mixtures, and helps to maintain safe working conditions.
Occupational Health and Safety during operations	All equipment, buildings and fire alarm systems should comply with local, state, and national fire codes and standards.

Impact	Mitigation Measures
(fire prevention)	
Occupational Health and Safety during operations (electrical hazards)	Most of the equipment in the WWTP uses electricity as the primary power source. Maintenance of the equipment requires strict safety measures against exposure to electrical hazards that may result in shock or death.
Noise	Confirm that WWTP operations with meet the ambient noise standards
Air Quality	Confirm that WWTP operations with meet the air quality standards.
Influent Water Quality	Establish influent monitoring to confirm that the influent is not mixed with industrial produced wastewater
Prevention of Bypassing influent (operations)	Confirm that Operations of WWTP and treatment of influent continues during periods of high water / flooding
Sludge Quality	Analysis of Final Sludge Quality, and evaluate against WHO / Tanzania limit values for reuse in agriculture
Sludge Reuse	Provision of training and support to agricultural sector, if sludge reuse standards are met and sludge is provided to agricultural sector
Sludge final disposal	Sanitary disposal of sludge, if sludge reuse standards are not met
Wastewater Reuse	Study options for wastewater reuse near WWTP, based on total flow, effluent quality, and local (agricultural) market options.
Wastewater Treatment Fees	Ensure financial sustainable operations, including effective and adequate fee collection system and adequate pro-poor provisions
Buffer Zone and Visual Impacts	Maintain buffer zone and trees in this zone, including water supply, and maintain spatial plan around the project area. Enforcement of spatial planning around the WWTP and maturation ponds limiting new developments of housing in the area of influence around the WWTP
Flooding Risks	Main flood protection measures (dam and surface water drainage) and operate them during periods of high water level and floods for the western part of WWTP
Water Quality Monitoring	Establish WWTP WQ monitoring program, upstream + downstream of WWTP effluent point, particularly for BOD, coliform, Ammonia and SS and occasionally for non-typical components.
Water Quality Analysis	Operate the chemical and biological laboratory on the site of the WWTP on a weekly basis for analysis of influent, effluent and ambient water quality (COD, TSS, total Nitrate, Phosphate and pH)
Malaria Risks (Operations)	(1) Operate and maintain biological malaria prevention measures during operations of maturation ponds, (2) ensure regular distribution of malaria nets to inhabitants; (3) monitoring malaria occurrence in surroundings of maturation ponds in co-operation with Health Centres
Odor emissions (monitoring)	(1) Set up effective odour monitoring program with participation from neighbouring population; (2) operate the basic weather station for recording wind speed, direction, humidity and rainfall at the WWTP.
Odour emissions (operations)	Implement odour reduction measures (covering up and air filtering) if monitoring program measure structural odour nuisance
GHG emissions (Operations)	Implement gas emission reuse for power generation once this is possible financially and market / demand wise.
Implement Stakeholder Engagement Plan	Implement SEP during operational phase
Inequality Compensation	Provide piped water supply and sanitation services for project affected people
Electricity Supply	(1) Confirm capacity of central electricity net, to supply sufficient energy to WWTP, pumping stations throughout operations and (2) operate and maintain stand alone back up energy capacity for WWTP.
Labour Opportunities	Assess operational job opportunities for local residents

10 Conclusions and Recommendations

Conclusions	Recommendations
From the Feasibility Study we conclude that the rocky soils in Mwanza do not favour affordable on-site sanitation systems (mainly cess pits). The topography (hills) favours the ‘illegal’ emptying of full pits during the rains. Mwanza has chosen off-site sanitation (sewerage) as the preferred wastewater management system in the future, expecting the town will grow to 3 million inhabitants in 2040. International consultancy firms prepare plans and tender document for expansion of the sewerage. In the south of Mwanza the master plans that are currently being developed designate a Wastewater Treatment Plant in the south. At Mkuyuni, along the railway track a suitable area is available where a WWTP can be constructed. Mwanza has already a WWTP where the wastewater is treated in Waste Stabilization Ponds. The water utility MWAUWASA knows this technology and is capable to operate and maintain it satisfactorily.	In line with the Wastewater Master Plan currently under development, to construct a WWTP at Mkuyuni. High-density neighbouring areas are to be connected to the sewerage system connected to the WWTP Mkuyuni, thus improving sanitary conditions immediately. To assure that in future all wastewater of Mwanza can be treated: reserve an area to treat the wastewater of 400,000 persons using Waste Stabilization Ponds: around 15-20 ha.
Operation and maintenance of sewerage is expensive mainly due to high pumping costs (electricity) thus leading to high operational costs.	Reducing O&M costs by focussing on the areas that can be served through gravity sewers. At Mkuyuni, these areas are: 3,000 households in Mando, 2300 hh in Mayorere, 1,000 hh in California and 1100 hh in Password. Total 7,400 hh (around 45,000 persons). Construct Waste Stabilization Ponds to treat the wastewater of 45,000 persons, capacity 3,800 m^3/d.
In the original HPI we had foreseen to include sludge treatment. However we conclude that the market for faecal sludge management is relatively small, as households have found other means to empty the pits.	The design of the WWTP Mkuyuni does not need to take into account the treatment of faecal sludge.
The European Investment Bank (EIB) is the main funder, UN Habitat is the sanitation facilitation lead and several consultancy firms are providing services in Mwanza.	Align with the EIB and UH Habitat and disseminate the findings of this study with the consultancy firms active in Mwanza.

APPENDIX 1: References

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APPENDIX 2: Design Criteria

Design criteria for the sewerage and WWTP
This sub-section describes the criteria to which the assignment has been designed.

Sewerage network
A water-borne sewage disposal system is justified from technical and economic point of view when the population density of the place is above 150 persons per ha which is way less than the 1046 persons per km^2 (census 2009) and that the resulting flows would reach the self-cleansing velocities.

The design criteria adopted for this preliminary design conforms to the following:

- Report No. 9 – Selection and design criteria for Sewerage Projects: WHO 1973;
- Wastewater Engineering, Treatment Works, Disposal and Reuse; Metcalf and Eddy Inc. 3rd 1992;
- Sewerage Treatment in hot Climates, D. Mara;
- Waste Stabilization Ponds- A design Manual for East Africa, D. Mara et all;
- MOPW&H Manual for Civil Works detail;
- Design calculation in wastewater treatment, F.Wilson;
- Design manual for waste stabilization ponds in India.

Type of sewerage systems
In sewerage, three types of systems are normally recognized:

- Separate system - which takes no storm water;
- Combined – which disposes of all the storm water drained from the sewered area;
- Partially separate system – which takes a predetermined quantity of storm water.

A separate sewerage system has been proposed for the project area. This is inevitable given the existing legal framework for the water sector where the Ministry of Water is in charge of Water and Sewerage services whereas the Local Authorities are in charge of road drainage and maintenance. It is also obvious that separate sanitary sewers are less costly to construct and operate.

Prediction of foul sewage flows for the project
The estimation of the sewer flows has been done according to the MWAUWASA and the World Bank guidelines on the wastewater flows:
The formula adopted for calculation of total sewerage flows is therefore:

$$DWF = \frac{P*G}{86400} * \left(1 + \frac{S_A}{100}\right) + \frac{E*A_E}{86.4} + I\left(A_E + A_P\right)$$

and
$QR = FR(DWF - 1) + 1$ in litres/sec

Where QR = Peak flow rate litres/sec

FR	= Peak flow factor	litres/sec
DWF	= Dry weather flow	litres/sec
P	= Population	No. of persons
G	= Water consumption	litres/person/day
SA	= Splash area as	
	= Percentage of P x G (normally taken as 15%)	
E	= Commercial and Institutional Waste water flow (m^3/ha/day)	
AE	= Commercial & Institutional Area (Hectares)	
I	= Infiltration water flow rate (litres/sec)	

Peak flows have been taken as follows:

DWF (litres/second)	Peak factor (FR)
Less than 6.0	7.5
12	6.6
60	5.5
120.0	5.0

Infiltration

- The amounts of groundwater that can be expected to infiltrate into the sewers depend on the following factors:
-
    - Number of joints
    - Type of pipe
    - Type of joints
    - Ground water conditions
    - Workmanship

Ground water infiltration rate of 0.025 litres/sec/ha has been adopted for the sewer designs. The infiltration rate is taken as constant for the whole of drainage area and throughout the design life of the project.

Rising mains

For calculations for rising mains, the Hazen-Williams equation is utilized with a C-value of 110.

Eqn. 2 $v = k\,C\,R^{0.63}\,S^{0.54}$

Where v = velocity (m/s)

K = unit conversion factor = 0.85

C = Friction loss coefficient

R = Hydraulic Radius (m)

S = slope (m/m)

To ensure that self-cleansing is achieved, the sewers will be designed to have a gradient that attains self-cleansing velocity at least once a day. A minimum velocity of 0.75 m/s has been used in design, in order to reduce the build-up of hydrogen sulphide in the sewers and to attain the higher velocities required for self-cleansing during the minimum night flows.

To avoid abrasion caused by grit in the sewage, maximum design velocities in the sewers have been kept to <3.0 m/s. Where the gradient is steep and the flow velocity is expected to exceed 3.0 m/s, drop manholes will be introduced to decrease the velocity.

The minimum and maximum gradients for sewers resulting from the above considerations have been kept within the limits given in Table 34 below. Where self-cleansing velocity may not be attained due to the flat gradients, flushing tanks will be designed along the mains at the affected sections.

Table 34: *Sewer Pipe Gradients*

		Pipe Gradients (%)	
Diameter of Pipe, mm	**Min.**	**Max.**	**Average**
House Connections	10	100	20
200 – 300	5	66	10
300 – 600	3.5	50	5.0
600 – 1000	1.5	33	3.5
1000 – 2000	0.3	20	1.5

Calculation of sewer sizes

Colebrook-White Equation for Transitional Flow has been adopted for use in the sizing of the sewers. The equation is as follows:

$$\frac{1}{\sqrt{\lambda}} = -2log\left[\frac{k}{3.7D} + \frac{2.51}{Re\sqrt{\lambda}}\right]$$

Where: λ = The Darcy-Weisback friction factor= $\frac{2gDI}{v^2}$
Re= Reynold's number
D= Diameter of pipe
k= Absolute roughness of the pipe wall
I= Hydraulic gradient

Charts prepared from Colebrook-White equation are available for use in sizing the sewer reticulation.

Based on the derived wastewater peak flow rates, the sewer sizes have been calculated on the basis of Colebrook-White equation with k value for concrete pipe being taken as 1.5mm.

The minimum size of main sewers to be adopted is 225mm diameter. Property/house connections will be designed with a minimum diameter of 100 mm. The sewers are assumed full when flowing half full.

Location of foul Sewer lines
In order to avoid inaccessibility of sewers during maintenance, sewers have been proposed along road reserves and drainage river valleys. Sewers will also be laid outside the road pavements to avoid expensive concrete protection of sewers and also to avoid interruption in traffic during maintenance.

Gradient of Foul sewer lines
Minimum gradients in sewers adopted are to ensure that velocity of flow is not less than 0.6m/sec at least once a day. Preferably the sewer slopes are to be such that that self-cleaning velocity of 0.75m/sec will be ensured.

In the preliminary design, a minimum slope of 0.5% has been adopted. At the detailed design stage, it is expected that a proper analysis will be undertaken to base the design on tractive force required to ensure self-cleansing rather on minimum velocities.

Spacing of manholes
Manholes permit the inspection, cleaning and maintenance of sewers for the removal of blockages. As such manholes would be provided at changes in horizontal alignment, vertical grade and at spacing not exceeding 60 metre centres for the branch main. The Trunk Sewer lines along the river will to be spaced at 90m interval.

Precast manhole rings are recommended for use in the construction of manholes in this project.

In public roads, the manhole covers are recommended to be made of heavy cast iron frame and cover with holes for ventilation.

Manholes would be sited in areas so as to ensure that flood waters do not drain into the sanitary sewers.

Material for foul sewer pipes

Three types of pipes are generally used in Tanzania namely uPVC flexible (i.e. with rubber rings) sewer pipes, rigid jointed concrete pipes and flexible jointed (i.e. with rubber ring) concrete pipes.

Concrete pipes are structurally more stable and durable and would require lower protection backfill covers. However, there is risk of chemical attacks on concrete, which is likely to reduce the span of concrete in situations where harsh industrial wastes are released. The pipes have higher frictional resistance values and therefore in flat areas where the ground gradients are a limiting factor, they would cause higher excavations and therefore higher construction costs. Due to their higher porosity they are bound to allow higher ingress of groundwater. They are generally heavy to transport over long distances with the resultant higher costs and breakages.

The uPVC pipes on the other hand have smaller frictional resistance and allow little ingress of groundwater. The pipes are light to transport and therefore would incur lesser costs in transportation over longer distances. The pipes are flexible and the incidences of breakages during transportation are minimal. The pipes can easily be sourced from within the country. Due to their resistance to chemical attacks, they can be used in special circumstances such as in marshy areas or where the pH of the soils is likely to be high.

Of the above three types of pipes the most commonly used pipes are rigid jointed concrete pipes. These have the disadvantage of requiring expensive concrete bed and haunches.

On the other hand, flexible jointed concrete pipes require a granular bedding only but incorporates an expensive socket and spigot joint with a rubber ring.

In view of the above arguments, and to mainly to contain cost, uPVC pipes were chosen for this project.

Standard, Workmanship and Testing

Sewers will be constructed to connect such that their soffits are at level and their depths to be sufficient to take the gravity flows of sewage from the adjacent developments being served. The sewer depths deeper than 6.0m will be avoided and a minimum depth should be 0.6m deep.

All pipes with a cover less than 1.25m and are in areas prone to vehicular traffic are to have Reinforced Concrete surround protection.

On completion of construction, all sewers would be tested for water tightness and infiltration. Concrete works to be closely supervised. Water tests shall be taken by applying minimum head of 1.0 m to every section of sewer length.

Design criteria for sewage treatment works

Prediction of stabilization design flows

The wastewater flows adopted for the design of the wastewater treatment works would be based on the average water consumption. 85% of the average water consumption is assumed to end up as wastewater for collection and final treatment.

Wastewater characteristics

As Mwanza City has a waterborne wastewater system, it was possible to obtain the wastewater characteristics for the preliminary design to be based on actual measured wastewater characteristics.

The average characteristic of the wastewater for the design as obtained from MWAUWASA is given below.

- Influent BOD_5 - 140- 380mg/l (Ilemela Stabilization Ponds)
- Influent FC - $5*10^7$ FC/100ml

The measured values are far lower than the figures recommended by design standards, hence the computed BOD of 412mg/l is adopted for design because it is the highest.

Effluent discharge standards
The effluent standards adopted for the design are as follows:

- Effluent BOD concentration - 50 mg/l
- Suspended solids - 30mg/l
- Effluent FC concentration - 5000 FC/100ml

These are the standards recommended by NEMA and Ministry of Water & Irrigation. These are adopted so as to ensure the effluent can also be used for irrigation downstream.

Sizing of Waste Stabilization Ponds

It is recommended that the proposed sewerage treatment works for the project area be a combined system of waste stabilization ponds and conventional wastewater treatment system. The treatment works will provide preliminary treatment, anaerobic treatment, facultative treatment and polishing in the maturation ponds.

Preliminary Treatment
Preliminary treatment is carried out at the inlet works by providing screening for removal of large inorganic solids and grit channels for removal of small inorganic solids.

- Flow velocity through screen bars at peak flow – 0.9m/s
- Flow velocity in grit chamber – 0.25 – 0.4m/s

Anaerobic Ponds
Anaerobic ponds will be proposed immediately after the preliminary treatment. The design will be based on the following:-

- Mean Hydraulic retention time – 1 day
- Surface loading rate - 3,500 kg BOD/ha/day.
- Volumetric loading rate - 0.22 kg BOD/m^3/day
- Effective liquid depth (range) - 2-4m

Facultative pond
The design is based on 22^{0}C rates as follows:-

- Surface loading rate - 345kgBOD/ha/day
- Minimum hydraulic retention time - 3days
- Effective liquid depth (range) - 1-2m

Maturation Ponds
Maturation ponds provide polishing the effluent prior to discharge to reduce the faecal coliform and BOD concentrations.

The design is based on the following:-

- Effluent FC concentration - 1000 FC/100ml
- Mean hydraulic retention time per pond - 5 days
- Effective depth - 1-1.5m

Design criteria for sewage pumping stations

The use of pumping stations will be avoided as much as possible due to operational and maintenance problems associated with their operations. However, where their installation cannot be avoided, the following design criteria will be applied.

Pump sump (wet wells)

In the design of the wet wells, the maximum number of starts per hour has been limited in accordance with the following values;

i. Motor capacity < 10kW - 10/hr

ii. Motor capacity > 10kW - 8/hr

The volume between START and STOP levels will be calculated according to the following equation:

$V_{min}. = 0.9*Q /z$

Where V_{min} = Minimum permissible volume between START and STOP levels in m3

Q = Pump capacity in l/s

z = Permissible number of starts per hour

Pumping head

Static head

The static head has been calculated as the difference between the minimum level at suction point (entry into the pump suction side) and the delivery level.

Friction Head

Friction head has been calculated as the sum of the continuous losses in the pressure main and the fittings losses (using the D'arcy –Weisbach equation) and the fittings losses.

Eqn.4

$$h_f = \lambda \times \frac{L}{D} \times \frac{v^2}{g}$$

Where: h_f = head losses due to friction (m)

λ = friction factor (unit less)

$\frac{L}{D}$ = ration of length (m/m)

v = flow velocity (m/s)

g = 9.81 (m/s^2)

Pump Room (Dry Well)

This is placed in a convenient place and pumps are installed inside it. Its location should be such that the pumping sets function easily. It is a RC and masonry room rectangular shape in plan. The sewerage pumping set, it's driving units, control valves and necessary pipes with the fittings are installed in it. Its sizing depends only on the required space for the operator to move during installation, operation, maintenance and repairs. It is proposed that the pumping set be installed on the dry well as opposed to the submerged position, because of maintenance problems associated with the submerged option.

Pipes, Valves Fittings etc. in the pumping station

The cast iron pipes with flanged joints should be provided in all the installation works at the pumping station. The flanged joints provide easiness in dismantling and repair of the pumping station equipment. To reduce the loss in head, the number of valves, bends, junctions etc, should be kept at a minimum.

A gate valve should be provided on the sewer line just before the wet well and on the suction and discharge pipes to close the flow of the sewage during maintenance, inspection and repair of the pumps.

Control Devices and their Location
Since it is common practice to install pumps of a higher capacity, automatic control devices need to be provided to cope with the continuously varying sewage flow rates. The operator should ensure that the time between switching off a pump and switching on another should not be more than 5 minutes.

The location of the driving units should:

- Be as close as possible to the pumps they have to drive
- The moving motor should be away from the damp or hot surroundings.

The connection rate for MWAUWASA has been 1.5%, hence adapted for population projection.

Water Demand
The water demand within the project area is divided into the following four main categories depending upon nature of use.

(i) Domestic Demand - individual connections, yard tap connections and communal water points/kiosks

(ii) Institutional demand

(iii) Commercial and industrial demand

(iv) Water demand for livestock.

1. Domestic Demand

Domestic water demand consists of three components as follows.

- Individual connection: 100lcpd
- Yard Tap Connection : 75lcpd
- Communal water point/kiosks: 50Icpd

2. Individual connections in Mwanza City

This normally accounts for the largest proportion of domestic demand and approximately 35% of all the water consumed in the domestic sector and it is expected to be provided this way. These connections are expected to form large proportion of all the revenue collected from the supply of water to the domestic sector at a consumption rate of 100l/c/d.

3. Yard Tap Connections in Mwanza City

Yard tap connections account for the largest proportion of domestic demand and it is expected that approximately 55% of water consumed in the domestic sector will be supplied in this way. For Mwanza town a consumption rate of 75l/c/d is adopted.

4. Communal Water Points in Mwanza City

Consumers who do not have access to or the means to acquire either individual connections or yard taps will be served from communal water points. This category of consumers is estimated to be 10% of the total population and they consume approximately 50l/c/d.

5. Consumption for People without connections in the rural areas

The rural areas are composed of Medium Potential to Low Potential consumers. On average 25l/c/d is adopted. Design manual gives a figure ranging from 15-10l/c/d and for the purpose of this assignment; we consider this to be low.

6. Institutional Demand for the project area

The institutions are mainly primary, secondary schools and tertiary colleges (Teachers' Training College)

- Secondary schools - students 50l/c/d, teachers 100l/c/d
- Primary schools - 25l/c/d on average
- Tertiary colleges – students 60l/c/d, teachers 150l/c/d
- District Hospitals – 5000l/d
- Dispensaries – 5000l/d

•

7. Industrial and Commercial Demand

We estimate that 10% of the Domestic water demand will be consumed by the industries and commercial set –up.

Seasonal variation factor
A seasonal variation factor of 1.5 will be adopted.

Water Demand Computation for this Project

Based on the current connection records, the projected demand is as shown in the Table 12

Wastewater flow estimation
To estimate the wastewater flows, the consultant has estimated the sewerage coverage at the ultimate stage for the project area to be within the areas currently with water connection. The estimation is done for the expected sewerage coverage for the Initial, Intermediate and Ultimate duration based on the population data, water consumption rates and the assumed sewerage coverage, the expected wastewater flows that would require collection and treatment is as given in **Table** 12.

APPENDIX 3: Population Figures

Region	Population									Inter-censal Average Annual Growth Rate	Population Density	Average Household Size
	Urban			Rural			Total					
	Male	Female	Total	Male	Female	Total	Male	Female	Total			
Mwanza	445,535	478,686	924,221	914,846	933,442	1,848,288	1,360,381	1,412.128	2,772,509	3.0	293	5.7
Tanzania Mainland	12,701,238	6,120,277	6,580,961	15,119,036	15,805,080	30,924,116	21,239,313	22,386,041	43,625,354	2.7	49	4.8
Tanzania	6,407,396	6,897,608	13,305,004	15,462,594	16,161,325	31,623,919	21,869,990	23,058,933	44,928,923	2.7	51	4.8

Table 35: Number of Individuals by Region, Sex and Status

(Source: http://nbs.go.tz/nbs/sensa/PDF/2012%20PHC%20POPULAR%20VERSION.pdf; and, http://ihi.eprints.org/2169/1/Age_Sex_Distribution.pdf)

Table 36: Number of Households in Mwanza Region by Main Source of Drinking Water; Tanzania, 2012 Census

(Source: http://www.nbs.go.tz/)

Main Source of Drinking Water	**Piped Water into Dwelling**	**Piped Water to Yard/ Plot**	**Public tap/ Standpipe**	**Tube well/ Borehole**	**Protected Dug Well**	**Unprotected Dug Well**	**Protected Spring**	**Unprotected Spring**	**Rain Water Collection**	**Bottled Water**	**Cart with Small Tank/ Drum**	**Tanker Truck**	**Surface Water (River, Dam, Lake etc.)**	**Total**
Count	50,987	46,430	58,511	55,652	50,941	109,478	8,844	47,075	1,270	936	4,710	559	45,714	481,107
%	10.60	9.65	12.16	11.57	10.59	22.76	1.84	9.78	0.26	0.19	0.98	0.12	9.50	100.00

Type of Toilet Facility	Flush/ Pour to Piped Sewer System	Flush/ Pour to Septic Tank	Flush/ Pour to Covered Pit	Flush/Pour to Somewhere Else	Ventilated Improved Pit Latrine	Pit Latrine with Washable Slab with Lid	Pit Latrine with Washable Slab without Lid	Pit Latrine without Washable/ Soil Slab	Pit Latrine without Slab/Open Pit	Composting/ Ecoson Latrine	Bucket	No Facility(Bush/ Field/ Beach)	Total
Count	9,227	23,761	51,847	7,327	10,299	20,375	34,714	116,024	163,655	1,374	111	42,394	481,107
%	1.92	4.94	10.78	1.52	2.14	4.24	7.22	24.12	34.02	0.29	0.02	8.81	100.00

Table 37: Number of Households in Mwanza Region by Type of Toilet Facility; Tanzania, 2012 Census

Source: http://www.nbs.go.tz/

Region	Population	Households with piped water (%)	Households with no toilet facility (%)	Population living in urban areas (%)
Mwanza	2,772,509	32.4	8.8	33.3
Tanzania Mainland	43,625,354	35.8	7.5	29.1
Tanzania	44,928,923	36.8	7.8	29.6

Table 38: Number of Households in Mwanza with Piped Water and No Toilet Facility Relative to Tanzania

Source: http://ihi.eprints.org/2169/1/Age_Sex_Distribution.pdf

APPENDIX 4: PIPE FLOW ANALYSIS WITH FLOW MASTER

Table 39: Minimum pipe sizing

Worksheet	MAIN PIPE1	MAIN PIPE3	SECONDARY PIPE1	SECONDARY PIPE3	COLLECTOR PIPE1	
Flow Element	Circular Channel	Circular Channel	Circular Channel	Circular Channel	Circular Channel	
Method	Manning's Formula	Manning's Formula	Manning's Formula	Manning's Formula	Manning's Formula	
Solve For	Channel Depth	Channel Depth	Channel Depth	Channel Depth	Channel Depth	
Input Data						
Mannings Coefficient	0.01	0.01	0.01	0.01	0.01	
Slope	0.004	0.004	0.004	0.004	0.008	m/m
Diameter	450	600	225	300	160	mm
Discharge	0.0398	0.1172	0.0105	0.0183	0.0021	m³/s
Results						
Depth	0.13	0.2	0.08	0.1	0.03	m
Flow Area	3.60E-02	0.1	1.30E-02	2.00E-02	3.10E-03	m²
Wetted Perimeter	0.5	0.73	0.29	0.36	0.15	m
Top Width	0.4	0.56	0.22	0.28	0.13	m
Critical Depth	0.14	0.22	0.08	0.1	0.04	m
Percent Full	27.9	32.8	36.5	32.6	21.3	%
Critical Slope	0.002922	0.002677	0.003719	0.003355	0.004142	m/m
Velocity	1.1	1.45	0.8	0.91	0.67	m/s
Velocity Head	0.06	0.11	0.03	0.04	0.02	m
Specific Energy	0.19	0.3	0.11	0.14	0.06	m
Froude Number	1.17	1.23	1.04	1.09	1.38	
Maximum Discharge	0.2522	0.5431	0.0397	0.0855	0.0226	m³/s
Discharge Full	0.2344	0.5048	0.0369	0.0795	0.021	m³/s
Slope Full	0.000115	0.000216	0.000324	0.000212	0.00008	m/m
Flow Type	Supercritical	Supercritical	Supercritical	Supercritical	Supercritical	

Table 40: Pipe flow optimization

Worksheet	MAIN PIPE2	MAIN PIPE4	SECONDARY PIPE2	SECONDARY PIPE4	COLLECTOR PIPE2	
Flow Element	Circular Channel	Circular Channel	Circular Channel	Circular Channel	Circular Channel	
Method	Manning's Formula	Manning's Formula	Manning's Formula	Manning's Formula	Manning's Formula	
Solve For	Discharge	Discharge	Discharge	Discharge	Discharge	
Input Data						
Mannings Coefficient	0.01	0.01	0.01	0.01	0.01	
Slope	0.004	0.004	0.004	0.004	0.008	m/m
Depth	0.23	0.3	0.11	0.15	0.08	m
Diameter	450	600	225	300	160	mm
Results						
Discharge	0.1172	0.2524	0.0183	0.0398	0.0105	m³/s
Flow Area	0.1	0.1	2.00E-02	3.50E-02	1.00E-02	m²
Wetted Perimeter	0.71	0.94	0.35	0.47	0.25	m
Top Width	0.45	0.6	0.22	0.3	0.16	m
Critical Depth	0.24	0.33	0.11	0.15	0.09	m
Percent Full	50	50	49.8	50	50	%
Critical Slope	0.00328	0.003022	0.004009	0.003691	0.004893	m/m
Velocity	1.47	1.79	0.93	1.12	1.05	m/s
Velocity Head	0.11	0.16	0.04	0.06	0.06	m
Specific Energy	0.34	0.46	0.16	0.21	0.14	m
Froude Number	1.12	1.17	1	1.05	1.33	
Maximum Discharge	0.2522	0.5431	0.0397	0.0855	0.0226	m³/s
Discharge Full	0.2344	0.5048	0.0369	0.0795	0.021	m³/s
Slope Full	0.001	0.001	0.000985	0.001	0.002	m/m
Flow Type	Supercritical	Supercritical	Subcritical	Supercritical	Supercritical	

APPENDIX 5: GEO-TECHNICAL INVESTIGATION

A) TRIAL PITS ANALYSIS WITHIN MUKUYUNI WWTP-IWRM-HP 1

PROFILE (mm)	SOILS DESCRIPTIONS	SOILS CLASSIFICATIONS	INSITU BULK DENSITY(kg/m^3)	NMC (%)	CBR (%)	DRY DENSITY (kg/m3)	OMC(%)	LL(%)	PL(%)	PI(%)	BEARING (Kpa)	PERCOLATIONS
TP 1	SOUTH-WEST(SW)											
0-700	Silt Clayey Sandy Soils	SC	1535	17	5	1515	19	45	26	19	100	Fair
700-1500	Coarse Sandy Soils	GC	2047	7.1	NP	NP	NP	NP	NP	NP	100	Good
1500-3000	Basalt	NP	NP	NP	NP	NP	NP	NP	NP	NP	>500	Poor
1000	**Underground Gravitational water flowing**											

TP 2	SOUTH-WEST(SW)											
0.0- 1000	Silt Clayey Sandy Soils	SC	1565	18.3	5	1505	19.8	45.7	25.7	20	100	Fair
1000-1800	Sandy Soils	SW	1937	7.3	NP	NP	NP	NP	NP	NP	100	Good
1800-3000	Heavy Clayey Soils	CH	1417	22	3	1425	23	55.5	31.5	24	75	Bad
1000	**Underground Gravitational water flowing**											
TP 3	SOUTH-WEST(SW)											
0-1100	Silt Clayey Sandy Soils	SC	1527	19.4	5	1520	19	45	26.1	19	100	Fair
1100-2000	Coarse Sandy Soils	SW	2030	7.3	NP	NP	NP	NP	NP	NP	150	Good
2000-3000	Heavy Clayey Soils	CH	1395	24	3	1410	23	57.5	33.8	24	75	Bad
1500	**Underground Gravitational water flowing**											
TP 4	NORTH-EAST (NE)											
0-500	Silt Clayey Sandy Soils	SC	1541	18.2	5	1530	19	46.5	26.6	20	100	Fair
500-4100	Sandy Soils	SW	1923	7.2	NP	NP	NP	NP	NP	NP	150	Good
4100-5200	Heavy Clayey Soils	CH	1396	23.4	3	1400	23.8	56.5	33.1	23	75	Bad
5200-6000	Basalt	NP	NP	NP	NP	NP	NP	NP	NP	NP	>500	Poor

800	**Underground Gravitational water flowing**											
TP 5	NORTH-EAST (NE)											
0- 700	Silt Clayey Sandy Soils	SC	1487	20.1	4	1500	19.8	45.5	25.8	20	100	Fair
700-4000	Sandy Soils	SW	1983	7.1	NP	NP	NP	NP	NP	NP	150	Good
4000-5000	Heavy Clayey Soils	CH	1381	23.8	3	1400	24	58	33.2	25	75	Bad
5000-6000	Basalt	NP	NP	NP	NP	NP	NP	NP	NP	NP	>500	Poor
900	**Underground Gravitational water flowing**											
TP 6	NORTH-EAST (NE)											
0- 700	Silt Clayey Sandy Soils	SC	1479	20.1	4	1505	19.8	45.7	25.6	20	100	Fair
700-4200	Sandy Soils	SW	1898	7	NP	NP	NP	NP	NP	NP	150	Good
4200-5200	Heavy Clayey Soils	CH	1393	23.3	4	1415	23.4	58.3	34.5	24	75	Bad
5200-6000	Basalt	NP	NP	NP	NP	NP	NP	NP	NP	NP	>500	Poor
800	**Underground Gravitational water flowing**											

TP7	NORTH-EAST (NE)											
0- 500	Silt Clayey Sandy Soils	SC	1484	20	5	1510	19.8	47	27	20	100	Fair
500-4000	Sandy Soils	SW	1969	7	NP	NP	NP	NP	NP	NP	150	Good
4000-5200	Heavy Clayey Soils	CH	1388	23	3	1405	23.8	57	33.5	24	75	Bad
5200-6000	Basalt	NP	NP	NP	NP	NP	NP	NP	NP	NP	>500	Poor
600	**Underground Gravitational water flowing**											
C) GROUND LAYERS PERCOLATIONS												
	25mm in 5min - Good											
	25mm in 15min - Fair											
	25mm in 30min - Poor											
	25mm in >60min - Bad											
D) SOIL PERMEABILITY												
	Group	**Description**	**MDD(kg/m^3)**	**OMC (%)**							**k-values (m/sec)**	**Drainage**

	SC	Silt Clayey Sandy Soils	1530	19.8							$3X10^{-3}$ - $8X10^{-4}$	Fair
	SW	Sandy Soils	NP	NP							$4X10^{-3}$ - $5X10^{-4}$	Good
	CH	Heavy Clayey Soils	1425	24							$2X10^{-7}$ - $1X10^{-10}$	Bad
E) SOILS SUITABLE FOR EMBANKMENT CONSTRUCTION												
	SC	Silt Clayey Sandy Soils										
	CH	Heavy Clayey Soils										
NOTE:	Embankment Fill compacted to minimum 98% MDD at OMC											
	Percolation 25mm in >min- poor to bad											
	Permeability - practically impervious											
COMMENT:	It is recommended to use soils with **fair to bad drainage** during embankment construction in order to obtain adequate density before applying water proof cement structure at depth range of 1800mm to3000mm -SW and 4500mm to 5200mm with presumptive bearing capacity of 75Kpa.											

APPENDIX 6: TOPOGRAPHIC SURVEY REPORT FOR MKUYUNI WWTP

INTRODUCTION:

The proposed Mkuyuni WWTP is located in Mwanza region, Nyamagana district, Mkolani ward in Mkolani Division, which lies at an altitude about 1185m above sea level.

Area

The proposed sludge facilitating ponds covers 30ha.

Topography

The area is gently sloping westwards and northwards towards Mkuyuni valley.

METHOD USED

Topographical survey was carried out from second day of April up to 24th day of April 2016. Where two surveyors, one technician and six unskilled laborers were involved. During the survey work, the pond area was covered by rice and grasses. The activity stated by establishing control points (benchmarks) around the project area by using RTK GPS (Real Time Kinematics) technique. Topographical survey stated at sludge facilitating ponds by establishing base line of five hundred meters and twenty grid lines of twenty five by twenty five meters interval for detail survey of that area .After completion of topographical survey of sludge facilitating ponds. We started to take cross sections of fifty meter interval with a span of ten meters for the proposed pipe lines of thirty kilometers.

OUT PUT

Data for topographical survey of sludge facilitating ponds which covering twenty four hectors limited by the railway line at northern part of the selected project area, longitudinal profile of thirty kilometers covering Nyegezi line, Butimba line, Mhandu line via kanyelele area .

ACCURACY

According to the method and instrument used (RTK) the accuracy attained was within the limits of tolerable era (plus or minus 0.002cm).

CONCLUSION

The survey work was well conducted, where 24ha were surveyed for the project site. Twenty seven bench marks were constructed at strategic positions with regard of inter-visibility of the area.

COORDINATE LIST

N	E	Z	D
9716254	491444.4	1134.846	CONTROL 1
9716313	491350.7	1132.076	CONTROL2
9716237	492014.7	1133.885	CONTROL3
9715787	491003	1154.153	CONTROL MUWASA1
9715639	490925.9	1163.586	CONTROL MUWASA2
9715022	490905.6	1186.348	BWALO
9714171	491183.7	1189.497	NYEGEZI
9713632	491596.2	1190.521	NYEGEZI STAND
9713657	491857	1202.574	CONTROL CALFONIA
9713937	492380.3	1217.197	ROYONA
9716464	490949	1137.908	SUMA CONTROL
9717355	490548.3	1128.893	RELINICONTROL
9717828	489886.2	1128.872	CONTROMAGOROFANI
9718697	489452.7	1126.662	CONTROL END
9717180	491124.2	1129.651	MAHINA 1
9716042	492945.4	1141.453	MAHINA2
9716812	491781.8	1144.587	MAHINA3
9715794	493853.3	1152.376	MAHINA4
9715601	494450.6	1165.609	MAHINA5
9715292	495156.9	1160.213	MAHINA6
9715843	495354.7	1188.023	MAHINA HANS
9715181	495993.9	1157.927	MAJARUBA CONTROL1
9715295	494379.1	1144.056	CONTROLSTONE

APPENDIX 7: Bill of Quantities Waste Stabilization Pond

		California/ Password Area				
Description		**Qty**	**Unit**	**Rate**	**Amount**	%
Excavation in soft material complete with bush clearing		9,601	cum	€ 11	€ 102,731	1%
In Rock		1,920	cum	€ 43	€ 83,490	1%
Fill	1.41	5,761	cum	€ 26	€ 150,294	1%
Lining			Item		€ 845,479	7%
Accessories: concrete conveyance canals, gates, etc			Item		€ 555,537	5%
Sub-total					**€ 1,737,531**	15%
Screening	**1%**			**€ 1,737,531**	€ 17,375	0%
Grit removal	**1%**			**€ 1,737,531**	€ 17,375	0%
Pumps, pipes, etc.	**7%**			**€ 1,737,531**	€ 121,627	1%
Sub-total: wwtp					**€ 1,893,909**	16%
Sewer Works			Unit	Rate	Amount	
300mm Diameter uPVC pipe Supply and Fit	300	2000	m	€ 157	€ 313,040	3%
250mm Diameter uPVC pipe Supply and Fit	250	1300	m	€ 113	€ 146,952	1%
200mm Diameter uPVC pipe Supply and Fit		1574	m	€ 70	€ 109,485	1%
160mm Diameter uPVC pipe Supply and Fit		2658	m	€ 43	€ 115,583	1%
Sub-total: Sewer Works					**€ 685,060**	6%
Manholes for average depths	Depth Av		Unit	Rate	Amount	

1200mm Diameter RCC		3	70	nr	€	2,235	157,388.47	1%
900mm Diameter RCC		2	192	nr	€	1,191	229,177.43	2%
600mm Square Masonry		1.5	1495	nr	€	217	325,011.31	3%
Sub-total: Sewer Works							**€ 711,577**	6%
Preliminaries and General							**€ 329,055**	3%
Total							**€ 3,619,601**	31%
Contingencies							**€ 361,960.13**	3%
Total							**€ 3,981,561.42**	34%
Total for conveyance							**€ 1,396,638**	
Household Served							1,090	
Cost per House Hold	Network						**€ 1,281**	
	WWTP						**€ 1,738**	
	Preliminaries						**€ 302**	
	Total Investment						**€ 3,321**	
BoD removal in ton/day							0.35	ton/day
Cost per ton							**€ 10.22**	min/ton/day
Capacity building				150000000			**€ 60,140**	
Construction Supervision				750000000			**€ 300,700**	
Project Management Unit				75000000			**€ 30,070**	
							€ 4,372,471	

Table 41: Password and California accost analysis optimization

APPENDIX 8: Design and Bill of Quantities Anaerobic Baffled Reactor

1201 Anaerobic Baffled Reactor 5-Jul-2016

Description	Unit	Value
Maximum number properties	[nrs]	2,000
Minimum number properties	[nrs]	10
Properties	[cap]	1,090
Persons served	[cap]	6,540
Daily Capacity	[m³/day]	523
Peak factor	[ ]	4
Peak flow	[m³/hour]	87
Avg. sewage strength	[mgBOD/l]	240
BOD Load	[kgBOD/day]	126
SCREENING		
maximum velocity	[m'/s]	0.9
cross-section max.	[m²]	0.03
number	[units]	2
width selected	[m']	0.5
height	[m']	0.10
GRIT REMOVAL		
overflow rate	[m'/s]	0.026
forward velocity	[m'/s]	0.21
ratio L/H	[ ]	8
Surface area W*L	[m²]	0.93
number	[units]	2
width W selected	[m']	0.6
length L	[m']	0.78
height H >	[m']	0.10
Water depth avg.flow	[m']	0.01
Grit storage	[l/pers/year]	3
Frequency grit removal	[1/year]	24
Grit storage	[m³]	0.82
Height grit storage	[m']	0.2
Area grit storage	[m²]	4.09
SETTLING COMPARTMENT		

Hydraulic detention time peak flow	[hours]	1.50
Liquid volume	[m³]	131
Average sludge production	[litres/cap/year]	25
Desludging interval	[months]	12
Sludge volume	[m³]	164
Volume settling compartment	[m³]	295
number	[units]	2
Depth sludge compartment	[m']	1.50
Surface Area 1 compartment	**[m²]**	**98**
length/width	[1/1]	1.50
Width	[m']	8.10
Length	[m']	12.15
Freeboard	[m']	0.30
Total depth	[m']	1.80
BAFFLE AREA		
Upflow velocity	[m/hr]	1.80
Surface Area upflow 1 chamber	**[m²]**	**24**
Width	[m']	8.10
Length	[m']	3.00
Length down flow area 1 chamber	[m']	1.00
Total area 1 chamber	**[m²]**	32
Number of upflow chambers in series	[nrs]	4
Length baffled area	[m']	16
Surface area baffled area	**[m²]**	130
Total length	[m']	**28.15**
Total width	[m']	**16.20**
Total area	**[m²]**	**456**

	Bill of Quantities					
1201	**Anaerobic Baffled Reactor**					
12301	Land acquisition	[/m²]	1,820	€ 17	€ 30,940	11%
12302	Excavation	[/m³]	820	€ 45	€ 36,900	14%
12303	Concrete for foundation, walls, top	[/m²]	990	€ 83	€ 82,170	30%
	Sub-total				**€ 150,010**	56%
	SCREENING		**20%**	**€ 150,010**	€ 30,002	11%
	GRIT REMOVAL		**20%**	**€ 150,010**	€ 30,002	11%
	Piping		**40%**	**€ 150,010**	€ 60,004	22%
	Total investment				**€ 270,018**	100%
O&M	**Anaerobic Baffled Reactor**					
20004	General O&M	[/unit]	**2%**	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
20004	General O&M	[/unit]	2%	€ 270,018	€ 5,400	
	NPV O&M				**€ 36,237**	
	NPV O&M & Investment				**€ 306,255**	

APPENDIX 9: Design and Bill of Quantities Communal Septic Tanks

1008	**Septic Tank**					
	Maximum		**100**			
	Properties served	[nrs]	100	100		
	Household size	[cap/hh]	10			
	Persons served	[cap]	1000			
	Annual faecal sludge production	[litres/cap/year]	40			
	Daily wastewater production	[lcd]	48			
	Desludging interval	[years]	2			
	Volume sludge	[m^3]	80.0			
	Wastewater retention just before desludging	[days]	2.0			
	Volume warsterwater	[m^3]	96			
	Total volume tank	[m^3]	176.00			
	Width	[m']	0.8			
	Height liquid	[m']	0.8			
	Length first chamber	[m']	183.33			
	Length second chamber	[m']	91.67			
	Freeboard	[m']	0.3			
	Total tank depth	[m']	1.1			
1008	**Septic Tank**					
1000 5	Toilet cistern-flush toilet plus cistern	[nrs]	100	€ 27	€ 2,700	0.5%
1100 2	Permanent (masonry) superstructure plus foundation	[nrs]	100	€ 250	€ 25,000	4.9%
1210 2	Reinforced concrete 10 cm thick	[/m^2]	440.0	€ 29	€ 12,760	2.5%
1210 2	Reinforced concrete 10 cm thick	[m^2]	606.8	€ 29	€ 17,596	3.5%
	Total Investment for 100 hh				**€ 58,056**	11.5%
	Pumps, pipes, etc.		**2%**	**€58,057**	€ 1,161	0.2%
	Sub-total: wwtp				**€59,218**	11.7%
	Sewer Works					
		Qty	**Unit**	**Rate**	**Amount**	
	200mm Diameter uPVC pipe Supply and Fit	2,000.00	m	€ 70	€139,140	27.5%
	160mm Diameter uPVC pipe Supply and Fit	3,211.00	m	€ 43	€139,614	27.6%
	Sub-total: Sewer Works				**€278,754**	55.1%

Manholes for average depths	**Depth Av**	**Qty**	**Unit**	**Rate**	**Amount**	

1200mm Diameter RCC			3	10	nr	€ 2,235	€ 22,348	4.4%
900mm Diameter RCC			2	30	nr	€ 1,191	€ 35,739	7.1%
600mm Square Masonry			1.5	100	nr	€ 217	€ 21,739	4.3%
Sub-total: Sewer Works							**€ 79,826**	15.8%
Preliminaries and General							**€ 41,780**	8.3%
Contingencies							**€45,958**	9.1%
Total							**€505,536**	100%
for				**140**	**units**	**€505,536**	**€70,775,040**	

APPENDIX 10: MEMO Questions raised by KfW

Background. In the final workshop on the Feasibility Studies for the "LVB IWRM Programme with High Priority Investments (HPI)" on 3 November 2016, a ranking of the 4 HPIs will be presented on the basis of the results of the Draft Final Feasibility Studies which were submitted for final review in August 2016, taking into account final feedback and questions received from KfW. On 24 October 2016, KfW requested clarification on some aspects of the FS of the selected HPIs.

Aim of this memo. To clarify the pending issues that were raised by KfW so that an unambiguous decision can be made.

HPI Mwanza. Question on intervention logic and relevance. HPI Mwanza is a no-nonsense, relatively conservative straightforward project. How does this fit into KfW's ambition to contribute to the improvement of Lake Victoria's water quality? What is the logic of this project and what is its relevance?

HPI Mwanza. Question on intervention logic and relevance. This logic is explained on page b of the Executive Summary in the Final Draft FS.

> ***HPI Mwanza.*** *The project area is Mwanza City, the second largest city in Tanzania. Mwanza is located in the north of Tanzania, directly along the shore of Lake Victoria.*
>
> *The City of Mwanza wants to reduce the pollution load of Mwanza town currently discharged into the Lake Victoria. The rocky soils in Mwanza do not favour affordable on-site sanitation systems (mainly cess pits). The topography (hills) favours the 'illegal' emptying of full pits during the rains. Therefore, Mwanza has chosen off-site sanitation (sewerage) as the preferred wastewater management system in the future, expecting the town will grow to 1.9 million inhabitants in 2035.*
>
> ***Master Plan COWI.*** *A Wastewater and Sanitation Master Plan[27] is being prepared for the expansion of sewerage. The Master Plan[28] (only draft versions are available) foresees the operation of 3 Wastewater Treatment Plants in the short term: the existing one (WWTP Ilemela) in the north, the planned WWTP Igoma in the east (to be funded by EIB) and the new WWTP in the south, proposed at Mkuyuni, along the railway track. High-density neighbouring areas are to be connected to the sewerage system* ***by gravity*** *to the WWTP Mkuyuni, thus improving sanitary conditions immediately.*

On 26 October we have sent enquiries to Cowi, MAUWASCO (Utility of Mwanza) and UN-Habitat (Lead Agency in Mwanza). Up to now there are no signals that the situation has changed or that the thinking on the set-up of the Master Plan has changed in such a way that the Mkuyuni WWTP is no longer required. Hence, as far as we can see at the moment the intervention logic remains as it is written in the Final Draft.

The answer or Cowi[29] is presented in the following text box.

[27] By COWI

[28] Master Plan & Short-Term Investment Plan, Strategy and Project Selection, Wastewater and Sanitation, COWI, 8 April 2016 (Water Supply and Sanitation for Mwanza Town and Satellites

[29] Christophe Schmandt, team leader COWI Master Plan on 27 October 2016 per e-mail.

Thanks for your note. I am happy to answer as MP consultant, but of course any official note should come from Mwauwasa.

- *The draft Master Plan was submitted on 26 August 2016; we are going through an extended sparring process as per Mwauwasa´s re-evaluation of investment priorities. The final MP is expected by the end of the year.*
- *The design is proceeding now with Igoma WWTP & collection network works, as first ww investment priority – to provide coverage to "hinterland" industrial corridor and populated areas. The final detailed design is expected by the end of the year.*
- *Yes, the Mkuyuni WWTP for M-South remains as priority for third wwtp in Mwanza, which will help alleviate the existing treatment plant (Ilemela), for example taking over coverage of the industrial corridor along the southern coast area, plus expand service to more populated areas in the south.*