Feasibility Study for the Lake Victoria Basin Integrated Water Resources Management Programme with High Priority Investments
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High Priority Investment
Kampala Nakivubo Channel Constructed Wetland

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Acronyms

BOD	Biological Oxygen Demand
DWF	Dry Weather Flow
CDIP	Community Driven Involvement Project
COD	Chemical Oxygen Demand
CW	Constructed Wetlands
DEA	Directorate of Environment Affairs
DWRM	Directorates Water Resources Management
EAC	East African Community
EDF	European Development Fund
EIA	Environmental Impact Assessment
ERP	Economic Recovery Program
EU	European Union
FS	Feasibility Study
FWS	Free Water Surface
GDP	Gross domestic product
GIS	Geographical Information System
GoU	Government of Uganda
GIZ	Gesellschaft für Internationale Zusammenarbeit
HPI	High Priority Investments
HPI	High Priority Investments
HRT	Hydraulic Retention Time
IFI	International Financing Institutions
IWRM	Integrated Water Resources Management
KCCA	Kampala Capital City Authority
JPTF	Joint Pollution Task Force
KFW	German Development Bank
KM	Knowledge Management
KPDP	Kampala Physical Development Plan
LVBC	Lake Victoria Basin Commission
LVEMP-II	Lake Victoria Environmental Management Program - Phase II
LVWATSAN-II	Lake Victoria Water and Sanitation Programme - Phase II
MDG	Millennium Development Goals
MLHUD	Ministry of Lands, Housing & Urban Development
MOU	Memorandum of Understanding
MWE	Ministry of Water and Environment
NEMA	National Environmental Management Authority
NDP	National Development Plan
NFP(O)	National Focal Point (Officers)
NGO	Non-Governmental Organization
NWSC	National Water and Sewerage Corporation
PCE	Policy Committed on Environment
PEAP	Poverty Eradication Action Plan
PIA	Project Implementation Agency
PIU	Project Implementation Unit
PPD	Public-Private Dialogue
RPSC	Regional Policy Steering Committee
RUWASS	Reform of the Urban Water and Sanitation Sector

SAP	Structural Adjustment Programs
SEA	Strategic Environmental Assessment
STEI	Science, Technology, Engineering and Innovation
SWOT	Strength Weakness Opportunity & Threats Analysis
TA	Technical Assistance
TDS	Total Dissolved Solids
TN	Total Nitrogen
TOR	Terms Of Reference
TP	Total Phosphorus
TSS	Total Suspended Solids
TWG	Technical Working Group
UMA	Uganda Manufacturers Association
WATSAN	Water and Sanitation
WIM	Water Intervention Module
WP	Working Package (1, 2 and 3)
WRM	Water Resources Module
WRMIS	Water resources Monitoring Information System
WSDF	Water and Sanitation Development Facilities
WSP	Waste Stabilization Ponds
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 Investments (HPI) projects were selected in four countries, based on a selection process guided by LVBC in close consultation 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 was prepared by the Consultant.

The stakeholders endorsed the selection of the HPIs for further feasibility review during the inception meeting on the 3rd of March 2016 in Kisumu.

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

For Kampala a feasibility study is prepared on Constructed Wetlands (CW) near the Nakivubo Channel.

Kampala is Uganda's administrative and commercial Capital City and is located in the Central Region of Uganda covering a surface area of 195 km^2. It is the only Capital City in East Africa located along the shoreline of Lake Victoria, Africa's largest freshwater lake.

The Nakivubo Wetland, located on the south eastern side of Kampala, covers an estimated surface area of 5.29 km^2; its total catchment area is estimated to extend over 40 km^2. The Nakivubo River and its tributaries are feeding the wetland. The Nakivubo Channel is a major open drainage channel that runs through the centre of the city of Kampala with an approximate length of 9 km and an approximate catchment area of 50 km^2. It traverses through highly

populated slum areas of Makerere Kivulu, three busy markets in the city centre and the Kampala industrial area. The Dry Weather Flow (DWF) is in the range of 50,000 – 60,000 m^3/day and the average annual flow is 100,000 m^3/day. Short peak Wet Weather Flows of 500,000 m^3/day have been recorded (Kansiime & Nalubega, 1999).

The HPI is to have a CW within the Nakivubo Wetland to improve the quality of the water of the channel before discharging into the Lake Victoria[1] and is eventually to act as a tertiary treatment for the Bugolobi Waste Water Treatment Plant (WWTP), now under construction.

Discussions with the Kampala Capital City Authority (KCCA), the National Water and Sewerage Corporation (NWSC) and the Ministry of Water and Environment officials showed support for a full scale CW for the Nakivubo channel. KCCA's remit is to be responsible for municipal services such as solid waste, storm-water drainage and street lightning. Also pollution control of the Nakivubo channel belongs to the remit of KCCA. However, KCCA does neither have experience, nor the capacity to operate such a project.

World Bank funded pilot. Currently, a pilot for the CW is being executed by AWE Consultants[2]. Thereto, a Memorandum of Understanding (MoU) was signed on 29th of March 2016 between NWSC and KCCA. KCCA, with financing from the World Bank through the Ministry of Water and Environment (MWE), is implementing Lake Victoria Environmental Management Project phase II with the objective of reducing environmental pollution and flood frequency in Kampala. KCCA allocated part of the funds under this programme for the design, construction and monitoring of a pilot on CW for treating part of the Nakivubo channel. Under the MoU, ownership of the land remains in the hands of NWSC (article 1). KCCA will be responsible for the construction of the CW system, while NWSC will become responsible for operating and maintaining the system after the construction.

KCCA and NWSC initially already agreed on using the same setting for the CW project that will be constructed under the current KfW-programme, implying that the construction will fall under the responsibility of KCCA and the operations and maintenance, after construction period, will be the remit of NWSC. KCCA would however have to pay a fee to be agreed upon between the two parties to necessitate them do O&M of the system. The actual amount is not yet established but KCCA has a budget line for such works done annually. Since it is very uncertain whether such a fee will be agreed upon in the contract but also whether it will also actually be paid, it was not considered as income to the project. It is a precondition for the implementation of the project, that an adequate contract between KCCA and NWSC is signed, with clear tasks and responsibilities and also financial arrangements including a lease fee.

The presented HPI integrates the outcomes of the pilot into the designs of the HPI as we had AWE as part of the team.

KCCA has experience in constructing large projects, including a US$ 175 mln. project funded by the World Bank. NWSC has experience in running large investment projects, also from development partners. Moreover they operate on a financially sound level. Hence, it will be a sustainable solution.

The pertinent issues addressed in the feasibility study include: land availability, encroachment of the wetland, resettlement/compensation of communities, ground investigations, and financial viability of institutions among others.

There is sufficient land available in the Nakivubo Wetland area for the HPI. The National Environment Management Authority (NEMA) provided already permits for 30 ha to this end[3] and

[1] In line with the recommendations in the In line with the recommendations of the Feasibility Study of the Kampala Sewerage Program (Fichtner, July 2008)

[2] Personal communication with Vice President Consulting Services Air Water Earth (AWE) Ltd., Mr. Kalibbala Herbert Mpagi, PhD, February – June 2016.

[3] NWSC has an ownership title for 5.5 Ha (duration 999 years) and NEMA permits for 25 Ha (duration 50 years)

assures that another 30 ha can be made available. Thus, there is a positive move to acquire the land which is required for the proposed HPI for Uganda. It has to be pointed out that this is a commitment from the highest level of administration[4].

Regarding land titles, the Government of Uganda issued a resolution to stop developments in the wetlands in Uganda. Specifically for the proposed HPI area, all land titles secured after amendment of the constitution of Uganda in 1995 were being cancelled. All those with titles that were given before 1995 were to be compensated. Development in the wetland area, by any developer, involves application for a permit from NEMA, something that NWSC and KCCA have successfully done.

Of utmost importance is the issue of encroachment and compensation of the communities using the area along the channel. There is scattered agricultural use of the wetlands, mainly small-scale farming, both perennial and seasonal crops. The HPI will include planting of wetland vegetation such as papyrus instead of farm food crops. At the fringes of the area, some informal settlements can be seen. The area is also used for trespassing between Kasanvu and Luzira / Bugolobi. It is recommended to involve these communities through the planting and harvesting of the recommended vegetation for a CW, in a controlled manner to ensure optimal benefits and sustainability.

The CW project fits into the Kampala Physical Development Master Plan of 2012 (by KCCA) that was approved by the National Physical Development Committee, as well as NWSC's recently updated Sanitation Master Plan.

Effect of the treatment. The treatment in the CW will have the following effects:

- The CW is designed to treat 45,000 m^3 effluent of the WWTP per day from 135 mgBOD_5/l to 33 mgBOD_5/l (Phase 2);
- As long as the WWTP is not fully operational, the CW will treat Nakivubo channel water (Phase 1). It is to be expected that the BOD_5 in the Nakivubo channel is higher than 135 mgBOD_5/litre;
- In case the BOD_5 in the channel is 200 mgBOD_5/l (JASEM, 2008) and the flow is 45,000 m^3/day:
    - 30,000 m^3/d can be treated;
    - The quality of the Nakivubo channel water after mixing is 98 mgBOD_5/l;
    - Hence, the improvement in terms of BOD_5 is expected to be 51%;
- In case the BOD_5 in the channel is 100 mgBOD_5/l (JASEM, 2008) during the wet season (100,000 m^3/d);
    - 45,000 m^3/d can be treated (hydraulic limits);
    - The quality of the water after mixing is 66 mgBOD_5/l;
    - Hence, the improvement in terms of BOD_5 is expected to be 34%.

Once the Bugolobi WWTP is functioning, it will also treat some of the water of the Nakivubo channel upstream. This will have a positive effect on the water quality upstream of the CW. Hence; the water quality of the Nakivubo channel will be better than shown in the calculations above. See the following text box.

Abstraction by Bugolobi WWTP. *The planned water extraction shall be located upstream from the new Wastewater Treatment Plant. This extraction is planned as a temporary measure- until NWSC has constructed sufficient sewer pipes in order to supply the new WWTP by 100% with sewerage. This temporary period is actually estimated to be approximately 17 years (year 2033). Most probably from mid/end of 2017 on, a flow of about 12,000 m^3/day with a peak extraction of 381 l/s shall be extracted from the Nakivubo Channel. As the hydraulic flow rate at the planned point of extraction is about 1-2 m^3/s in the dry season, a percentage of 15-30% shall be extracted in the dry season and treated together with the sewage and re-discharged with same flow rate about 300 meter downstream though the existing outfall channel from the existing (old) Treatment. A 100% extraction in the dry season shall be avoided in order to keep the biological and limnological activities downstream operational.*
Source: Project Manager: GKW Consult GmbH/PEC Ltd JV, January 2016

[4] Cabinet of Minister's resolution.

The treatment of 45,000 m^3/day requires 70 ha Free Water Surface (FWS) CW, which is a challenge, especially in in Uganda but is being done elsewhere. Table 1 shows the country, size and reference of some very large CW[5]. The cost estimate for the HPI is presented in Table 2.

Table 1: Very Large CWs Worldwide

Country	Constructed wetland type and size	Internet link
USA	6,400 ha (the largest in the world) to treat stormwater	http://www.sfwmd.gov/portal/page/portal/xrepository/sfwmd_repository_pdf/bts_sta.pdf
Oman	780 ha wetlands and ponds	https://www.bauer.de/export/shared/documents/pdf/bre/Constructed_Wetlands.pdf
Malaysia	200 ha wetland	http://plwmos.ppj.gov.my/v_intro_lake_wetland.asp

Large CW are also reported in China and Moldova (20 ha)[6].

Table 2: Cost Estimate for the CW System

Description	**Amount (€ mln.)**
Clearing and grubbing	0.02
Excavation and embankment shaping works	1.17
Constructed wetland basins with macrophytes	3.75
Inlet and outlet infrastructure	0.22
Interval open water ponds	0.08
Sedimentation Basin	1.83
Water Sump and Pumping	1.31
Construction Supervision	0.40
Total	***8.78***
Total (rounded)	***9.00***

The financial analysis is somewhat different from that of a regular project, since there is not a concrete revenue stream from having the CW. It has been assumed that the costs incurred by CW have to be covered by the sewerage surcharge on the water tariff. Hence, the financial analysis has concentrated on how much the surcharge has to increase to cover the costs of the CW.

[5] Source: Internet search 26 October 2016.

[6] Personal communication Frank van Dien, wetlands specialist on 26 October 2016

Figure 1: Cumulative and Year-on-year Cash Flow of Operations

The project generates sufficient revenue to cover operation and maintenance costs, which is shown by the positive cash flow from 2017 onwards. However, the project does not provide a positive return on investment (negative cumulative cash flow).

An assessment was done to analyse the level the sewerage surcharge needs to be raised in order to achieve financial sustainability of the project. NWSC charges all water connections that are close to the sewer lines, and it makes no difference for its tariff between the people that are indeed connected to the sewerage network and the ones that are not connected. However, for the sake of being able to compare with the present surcharge, the analysis concentrates on the percentage increase of the sewerage surcharge.

Table 3 presents the required water bill that is needed to have an acceptable level of the main financial parameters. The Full Cost Recovery ratio under the proposed tariff regime shows that sufficient revenue is generated for future reinvestments. Hence activities are considered to be sustainable. It is important to note that even with the small increase in the water tariff, affordability is not an issue for the lowest income groups (boundary limit: 4 – 5% of household income).

Table 3: Key Results under the New Tariff Regime

Indicator	**Values with a 6.15% increase of the current sewerage surcharge**
Internal Rate of Return of operations – before finance	<0
Net Present Value (10%) – after finance (€)	€ 990,971
Prime costs of treatment (0% discount rate)	€ 0.040 /m^3
Prime costs of treatment (5% discount rate)	€ 0.032 /m^3
Operating Cost Recovery ratio (revenue / O&M)	1.79
Full Cost Recovery ratio (revenues / (O&M + depreciation))	1.00
Affordability (cost increase measured as a % of income for the highest 10% income group as these are connected to water and sewerage system)	3.9%

The increment of the sewerage surcharge is relatively small for the project to be feasible, so from a financial point of view, these investments are viable. It must be noted however, that this is also due to the setting of the project, where the costs are divided over all the people connected to water close to sewers. This seems a logical assumption given that the water bill does not differentiate between the ones connected and the ones not connected to sewerage. Since NWSC already charges for sewerage services, while not providing them, they are able to build up funds for operations and maintenance of the sewerage and treatment facilities. It is therefore advised that NWSC indeed makes these financial provisions. It is also clear that the water tariff might be increased further to accommodate the increased costs of the main WWTP and the networks.

The project has a strong relation with the Bugolobi WWTP that is being constructed upstream of the Nakivubo channel. This WWTP is expected to become operational at the end of 2017 or beginning of 2018, while the related investments in the sewer network will be ready in 2017. With these investments, 11,000 – 12,000 m^3/day can be treated in the new Bugolobi treatment plant. No financial information could be gathered on cash-flow calculations and suggested tariff levels. Also the financial data that were provided through KfW were not sufficient to calculate the level of tariffs that are needed to cover the costs of this new WWTP. Hence, a tariff including the two projects could not be provided.

The current site location and situation is shown in the figures below.

Figure 2 Project Location (1)

Figure 3 Project Location (2)

Figure 4 Project Site (1)

Figure 5 Project Site (2)

Figure 6 Project Site (3)

Figure 7 Project Site (4)

The following tables present the summarized key information of the project.

Table 4 Project Summary of Key Information

General	
Name of the project	Kampala Nakivubo Channel Constructed Wetland
Country	Uganda
Sector	Surface water treatment
Date	January 2016 – April 2016
Project objective	**First phase:** As long as less than 100% of the sewerage service area is connected to the Bugolobi WWTP, the CW is used to clean the highly polluted water from the Nakivubo channel, which currently discharges directly into Lake Victoria. **Second phase:** When 100% of the service area of the WWTP is connected and its wastewater is treated and the channel is clean from sewage, the CW will be used as tertiary treatment for the effluent from the Bugolobi WWTP.
Technical features of the project	There are two treatment systems: • The Bugolobi WWTP; • The treatment of the channel/ wastewater effluent (tertiary treatment). The project concerns the channel water and tertiary treatment of WWTP effluent. Capacity of the treatment plant: 45,000 m^3/day Proposed system: constructed wetlands
Population served	About 60% of Kampala Population.
Implementing agency	Kampala Capital City Authority – KCCA

Investment amount	The investment is estimated at about € 9.0 mln. **Advantages:** Some of the preparatory work has been done such as: • Ground investigation studies in the northern part of the area; • Land acquisition for a part of the area; • Access road, bridge; Preliminary Engineering Design.
Stand-alone project or part of larger project	Stand-alone (first phase), part of larger project (second phase). A € 1.5 million pilot was originally scheduled in the framework of LVEMP II. This covers 30 acres. This project is matched with the HPI under consideration and is to fund detailed design.
Financial sustainability/business model (O&M costs coverage)	Part of the sewerage surcharge
Committed financing (international, government, municipality)	KCCA through LVEMP II In case additional funding is needed, funding from LVEMP III

Issues to be solved/worries	
Resettlement	• There is increasing pressure to construct (luxury) premises by original title owners and there is also encroachment on the land along the channel by communities; • Re-settlement issues despite the fact that legal situation is clear; • There is scattered agricultural use of the wetlands, mainly small-scale farming, both perennial and seasonal crops; • The HPI will include planting of wetland vegetation such as papyrus instead of farm food crops.
Consequences for poor	Positive: • less health hazard; • income generation from harvests of the wetland.
Design issues	Detailed engineering design for the CW is done with funding from LVEMP II. Topographic surveys of the required area have not been done yet.
Environmental impacts	Positive
Scope of the project (elements not covered)	• The inlet of the drinking water supply scheme is located about 5.5 km away from the point where the channel enters the lake; • There's an accumulation of waste especially plastic bottles downstream towards the entrance into the lake. There's need for control of rubbish damping upstream and better solid waste management by KCCA within the City; • The project is expected to have a positive impact on the quality of the abstracted water.
Sustainability	KCCA has experience in constructing large projects, including a US$ 175 mln. project funded by the World Bank. NWSC has experience in running large investment projects, also from development partners.
Financing aspects	There were already investments done to prepare the land i.e. up to € 2.5 mln. Part of this investment can be used (PE-lining is still present and visible in some spots)
Uncertainties	• The soil formation and the depth in some areas are not known. • The amount of sedimentation in the channel is also not known; • The actual flows in the Nakivubo channel and the water quality variations during the year are not known; • The efficiency of a horizontal flow CW as tertiary treatment is not

	known; • Once in 100 years, the 3 m high protection dike against flooding might not be sufficient to prevent flooding of the system. It is not known how much damage is to be repaired after such an event.
Others	**Existing reports:** • JASEM 2008: A study of the degree of pollution in Nakivubo Channel, Kampala, Uganda (John Kayima et al.) • Kansiime & Nalubega, 1999: Wastewater Treatment by a Natural Wetland: The Nakivubo Swamp, Uganda: Processes and Implications; • NWSC, 2011: Kampala Sanitation Programme Lake Victoria Protection Phase II- Nakivubo WWTP Final Design Report

Criteria for project ranking	
Effectiveness, removal BOD	Assuming a design capacity of 45,000 m^3/day and a reduction in terms of BOD from 135 mg BOD_5/l to 33 mg BOD/l, the daily removal is 4.6 ton BOD_5/day
FIETS Sustainability	F = no regret investment I = training needed for implementing agency E = high impact on water quality T = no fail technology, pumping is required, flooding might occur S = people use the area for food production (not formal)
Water quality improvement	An open sewer is being cleaned with immediate effect
Cost-effectiveness Euro/ton BOD removed	€ 8.7 mln. / 4.6 ton BOD_5 = € 1.9 mln. / (ton BOD_5 removed /day)
Leverage of funds / co-funding	Combination with LVEMP II and possibility of additional funding from LVEMP III
Support stakeholders (government, NGOs, local leaders)	KCCA, Ministry of Water and Environment and National water and Sewerage Corporation are extremely positive
Synergy with other projects	In future used as tertiary treatment for Bugolobi WWTP.

Overall conclusion
Very interesting investment opportunity: immediate high impact, no regret, cost-effective, can be implemented as stand-alone but is integrated part of larger project; use of previous investments that are not used at the moment. Integration with LVEMP II project and easily replicated.

1 Introduction

1.1 Background

The 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 their 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 landing i.e. a nuisance to fishermen and passage of their boats 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 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 8.

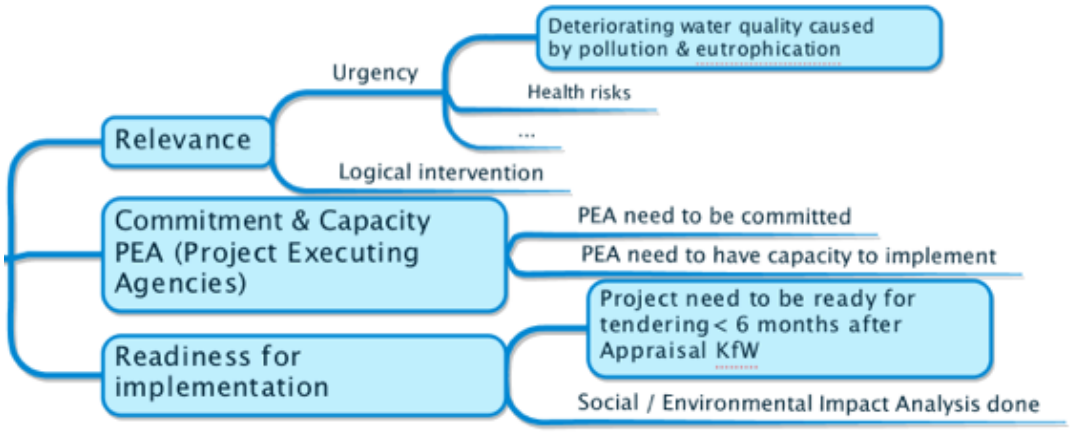

Figure 8: Criteria HPI Project

For the City of Kampala, the HPI on the treatment of the water of the Nakivubo Channel in CW 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 funding agency, 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 Kampala, the selected HPI has two phases:

- Phase 1: treatment of the water of the Nakivubo Channel;
- Phase 2: tertiary treatment of effluent of the Bugolobi Wastewater Treatment Plant (WWTP).

The Government of Uganda, through LVEMP II (World Bank funded) has already initiated a similar project on a smaller scale and this has been integrated in the presented HPI.

1.3 Objective of the Proposed High Priority Investment

Discharge of domestic and industrial waste has resulted in contamination by toxic substances, rendering the Lake Victoria water unfit for human use if not treated. The Nakivubo Channel drains directly into the Inner Murchison Bay and carries with it run-off and wastewater especially from formal and informal settlements, which are characterised with limited sanitation facilities. Hence, the main objective of the proposed HPI is:

- To restore the degraded Nakivubo swamp, through the reconstruction of the wetland for the tertiary treatment of the wastewater effluent and polluted storm water entering the swamp;
- To improve the environmental sustainability of Lake Victoria inner Murchison Bay through reduction of pollution entering the lake through the Nakivubo channel.

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: Uganda Flag
Six equal horizontal bands of black (top), yellow, red, black, yellow, and red (bottom); a white disc is superimposed at the centre and depicts the national symbol, a grey crowned crane, facing the hoist side. (Source: Wikipedia accessed 21 April 2016).

2.1 Uganda

Figure 10: Map of Uganda with Economic and Trade Zones

Map showing Proposed Economic Zones and Trade Areas. Kampala is located within a designated industrial hub-purple zone (source: Vision 2040).

Overview of Uganda

Uganda is the world's second most populous landlocked country after Ethiopia. It has transformed itself from a country with a troubled past into one of relative stability and prosperity. At a glance, Uganda has a population of approximately 38 million people, a GDP of $27 Billion, a GDP growth of 4.8% and inflation rate of 5.2% (World Bank, 2016). The southern part of the country includes a substantial portion of Lake Victoria, shared with Kenya and Tanzania. Uganda lies within the Nile basin, and has a varied but generally a moderate equatorial climate.

Economic Outlook

Over the last 50 years, Uganda has made significant development progress. Since the mid 1980's, the economy has moved from recovery to growth. A number of economic policies and programs such as the Structural Adjustment Programs (SAPs), Economic Recovery Program (ERP), Poverty Eradication Action Plan (PEAP) have been successfully implemented leading to a boost in economic growth. Since 2002, the economy grew consistently at an average of 6.4 percent and has since built sufficient momentum for take-off.[7].

[7] Vision 2040, Ministry of Finance, Planning and Economic Development, Uganda (2015)

The National Development Plan (NDP II), 2015-2019 is the second in a series of six five-year plans aimed at achieving the Uganda Vision 2040. The goal of the NDP II is to propel the country towards middle-income status by 2020 through strengthening the country's competitiveness for sustainable wealth creation, employment and inclusive growth.

Uganda's economic growth rate has averaged at 5.5% between 2010/11 and 2013/14, with the highest being 9.7% in 2010/11. The average growth rate was below the target of 7.2% for the entire NDP I and 8% per annum for the Vision 2040 period. In real terms, the services sector continued to lead and contributed 50.3% of GDP in 2012/13, followed by agriculture with 23.5 % and industry with 18.4%. The most significant sub-sector activities that have grown rapidly over the past five years are shown in Table 5.

Table 5: Key Perspectives Uganda's Economic Outlook (Source: NDP II)

- *Poverty reduced from 24.5% in FY2009/10 to 19.7% in FY 2012/13;*
- *Under five mortality reduced from 137/1000 live births in 2006 to 90/1000 live births in 2011;*
- *Electricity: installed generation increased from 595MW in 2010 to 825MW in 2012;*
- *Life expectancy at birth increased from 51.5 in 2009/10 to 54.5 years in 2011/12;*
- *Percentage of the population accessing electricity from the national grid increased from 10% in 2009 to 14% in 2013;*
- *Volume of national paved roads increased from 3,264 km (2011) to 3,795km (2013);*
- *Per Capita income increased from USD665 in 2009/10 to USD 788 in 2013/14;*
- *Information and communications, with a GDP share of 9% as of 2013/2014 and a growth rate of 16.8%;*
- *Macro-economic stability and growth;*
- *Sustained peace and security across the entire country.*

Both the Industrial and Services sectors emerged as the most resilient and good performing sectors, demonstrating higher potential for recovery and growth than the agriculture sector. However, the services sector grew at 6.3% overtaking industry by a margin of 0.1%. Average per capita income increased from USD 665 in 2009/10 to USD 788 in 2013/14 at current prices.

Agriculture remains the backbone of Uganda's economy. In 2012/13, the sector accounted for 25.3% of the country's GDP up from 24.7% in 2010/11. The contribution of the sector to GDP in 2013/14 using current prices stands at 24.8%. It employs about 72% of the total labour force (including disguised labour), 77% of whom are women, and 63% are youth most of whom reside in the rural areas.
Safe water coverage in rural areas has improved from 61% to 65% and sanitation coverage has improved from 51% to 70% during the period FY 2005/06 and FY 2013/14. Furthermore, the percentage of people within 1 km of an improved water source increased from 64 % in 2013 to 65% in 2014, and the functionality rate of the existing water sources also increased (from 84% to 85%) during the same time.

As of 2010, 86% of the households in Uganda use a pit latrine. The majority of households (82 %) use toilets that do not have hand-washing facilities while only 8% have hand-washing facilities with water and soap. The low sanitation coverage is attributed to low priority setting among some rural communities and local governments, inappropriate toilet technologies and weak supply and enforcement mechanisms. There have been efforts to educate the populace and increase the demand for improved sanitation services, but with limited progress. In addition, utilisation of the sanitation services remains a major challenge.

Based on the estimated total population served in both large and small towns, there was a continued increase in accessibility to safe water in urban areas (i.e. from 66% to 69% and 70%) in 2011, 2012 and 2013 respectively. Safe water coverage in the large towns like Kampala stands at 77% while piped sewerage is estimated at 6%. The rest of the inhabitants rely on on-site sanitation facilities. Safe water coverage in the small towns has significantly increased from 55% to 60% as a result of completion of new construction works under the Water and Sanitation Development Facilities (WSDFs) arrangements instituted by the Ministry of Water and Environment in the last 3 years.

Debt sustainability analysis for 2013 confirmed that Uganda's total public debt was still sustainable and the country was under no debt distress, over the period of NDP I. The Public Debt-to-GDP ratio in 2013/14 stood at 26% and is projected to peak at about 42% in 2019/20, but will remain below the 2013/14 debt strategy threshold of 50% throughout the projection period. The debt is however still highly sensitive to non-concessional borrowing, given the current structure of the external debt.

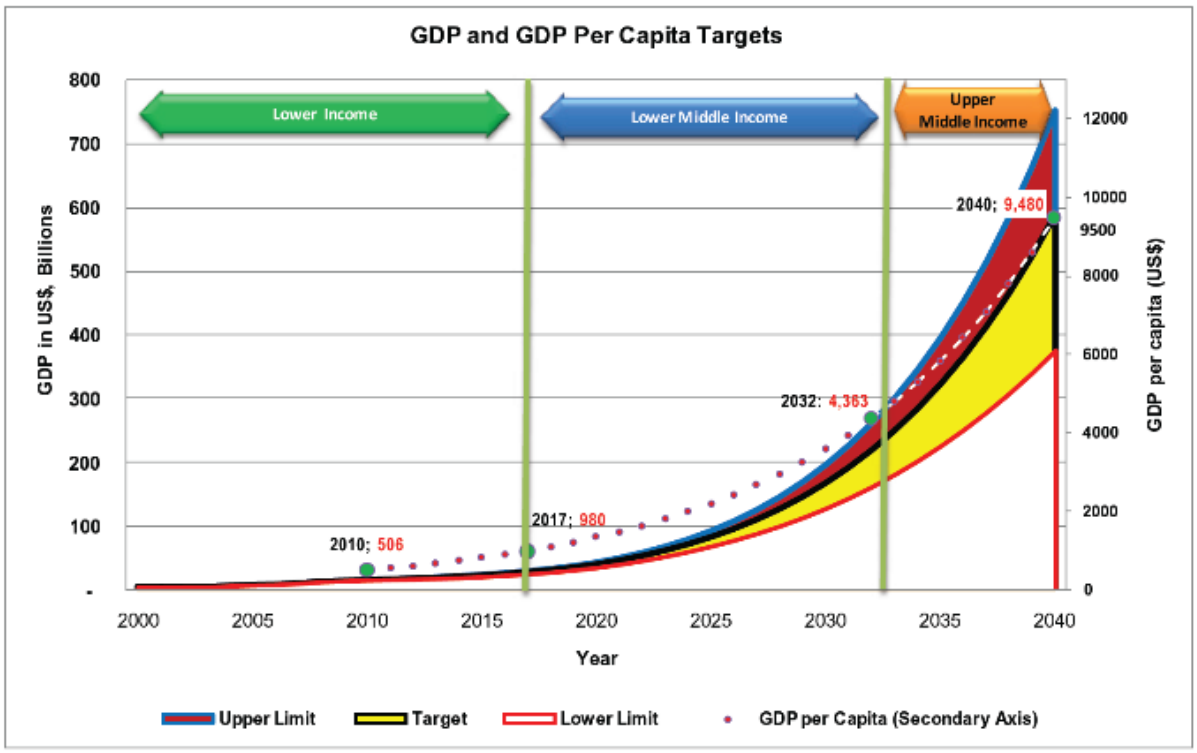

Figure 11: The Growth Path to the Upper Middle Income Status by 2040 (source: Vision 2040)

Generally, Uganda's economy is dominated by agriculture, which contributes more than 60% of its foreign exchange earnings and, 85% of the rural livelihoods. Agriculture accounts for over 40% of the Gross Domestic Product (GDP), 85% of the exports and 80% of the employment sector. Since the late 1980s, the Uganda government has pursued a series of stabilization and pro-market structural reforms. The resultant macroeconomic stability, post-conflict rebound, and investment response generated a sustained period of high growth during 1987-2010. Real GDP growth averaged 7% per year in the 1990s and the 2000s, placing Uganda among the 15 fastest growing economies in the World.

However, over the past decade, the country witnessed more economic volatility and the growth in GDP slowed to an average of just about 5%. With the population increasing at a rate of at least 3% per annum through these decades, per capita income growth decelerated from a rate of 3.6% recorded in the decades of 1990s and 2002, to about 2%. Going forward, take off of a huge public investment program and resumption of private sector economic activity in the post-election era is expected to drive growth. This notwithstanding, the effects of a volatile global economy on demand for Uganda's exports and timing of key infrastructure projects in the country's oil sector, could offset any benefits of improved terms of trade due to low oil prices. Under these circumstances, the Ugandan economy is forecasted to grow at a rate of approximately 5.9% in FY16/17. Growth will increase to 6.8% in FY17/18, and thereafter stay on an upward trajectory into the medium term, if major infrastructure projects are implemented as planned, and private investment intensifies with oil-related activities.

Development Challenges

Uganda surpassed the Millennium Development Goals (MDGs) target on halving poverty by 2015, and made significant progress in reducing the population that suffers from hunger, promoting gender equality and empowering women. But a large proportion of its population is highly vulnerable to falling back into poverty, making achievements of the twin goals a

challenge. With almost half of its people under the age of 15 years (one of the world's youngest populations) and a fertility rate estimated at 5.7 children per woman (2015), Uganda has a very high dependency ratio and population growth that generates 700,000 new labour market entrants every year. Achieving good livelihood would entail overcoming challenges, such as low levels of productivity of both agricultural and non-agricultural sectors; inappropriate urban development; the slow development of infrastructure; and the limited availability of credit. Moreover, the persistently high rates of poverty in the Northern region pose a challenge reducing regional inequality.

Health
Uganda has been among the rare HIV success stories. Infection rates of 30 per cent of the population in the 1980s fell to 6.4% by the end of 2008. Life expectancy at birth was estimated to be 53 years in 2012. The infant mortality rate was approximately 61 deaths per 1,000 children in 2012. Uganda's elimination of user fees at state health facilities in 2001 has resulted in an 80% increase in visits; over half of this increase is from the poorest 20% of the population. The policy has been cited as a key factor in helping Uganda achieve its Millennium Development Goals and as an example of the importance of equity in achieving those goals. The provision of subsidies for poor and rural populations, along with the extension of public private partnerships, have been identified as important provisions to enable vulnerable populations to access health services (*Source: Wikipedia accessed 21 April 2016*).

2.2 Facts and Figures Uganda

Table 6: Facts and Figures of Uganda

Topic	Descriptions
Government type:	Democratic republic
Political situation:	Uganda is a presidential republic, in which the President of Uganda is both head of state and head of government. There is a multi-party system. The government exercises executive power.
Stability:	President Museveni came to power in 1986, after decades of internal strife. Under Museveni, Uganda has experienced relative political stability, democratic progress, and economic growth. The country has made strides in reducing HIV/AIDS, experienced economic growth, and stabilized its north, where the Lord's Resistance Army (LRA) operated for 20 years. Uganda faces numerous challenges, however, including population growth, power and infrastructure constraints, corruption, underdeveloped democratic institutions, and human rights deficits.
Language:	English, Ganda or Luganda (most widely used and taught in school) and Swahili
Population millions:	38.8 (2014), 39.7 (2016) and 63.4 (2030)
Average annual population growth rate % (2010/2015), 2013	3.3
Population below income poverty line (National poverty line) 8 %:	19.5
Population living below income poverty line (PPP $1.25/day) %	37.8
Economic growth (GDP growth in %):	1.8% (2014), 2.1% (2015)
Gross domestic product (GDP), Total (2011 PPP $ billions), 2013	51.4
Gross domestic product (GDP), Per capita (2011 PPP $ billions), 2013	1,368
Gross national income (GNI) per capita, (2011 PPP $), 2014	1,613 (2014)

[8] The percentage of people living below the poverty line decreased from 24.3% in 2009/10 to 19.7% in 2012/13, NDPII, Ministry of Finance, Planning and Economic development, Uganda (2015)

Topic	Descriptions
Unemployment rate (in %):	3.8 (2015) and 1.8 (2014)
Unemployment rate (% of labour force), 2008–2013d	4.2
Inflation rate + forecast 2020 (in %):	6.2 (2016), 6.5 (2017) and 5.38 (2020)
Foreign direct investments (in % of GDP):	4.8(2013), 4.25% (2014)
Net official development assistance received ODA in (% of GNI):	7.04 (2013)
Exports and Imports (% of GDP)	50.7
Imports:	341.90 USD Million in February 2016
Import partners:	India (16.7%), Kenya (15.9%), UAE (11.4%), China (10.9%)
BTI index on banking system:	The general socio-economic development of Uganda has slightly improved but remains at a relatively low level by worldwide comparison. Poverty and inequality are pronounced and partly structurally ingrained. The 2010 HDI ranks Uganda at position 143 out of 169 countries (compared to rank 155 in 2007), with a score of 0.422. Uganda therefore remains one of the poorest countries in the world with 75.6% of the population living on less than $2 a day. Uganda was the first country to benefit from the HIPC debt relief initiative. Its Poverty Eradication Action Plan (PEAP) and the country's Poverty Reduction Strategy Paper (PRSP) serve as the framework for growth and transformation, but the implementation of the policies has been slow and inconsistent in many areas. The overall progress on widespread poverty reduction has been sluggish and rather uneven. Socioeconomic barriers also suffers from a high degree of inequality. The Gini coefficient, which measures the inequality of income distribution, is estimated at 42.6 (slightly above the average of 41.8 for the BTI countries).
Doing business index:	122 in 2015 from 135 in 2014
WEF Global competitive index:	121 (out of 142 economies) in 2011/12 to 129 (out of 148) in 2013/14.

2.3 Kampala

Kampala is Uganda's administrative and commercial Capital City. It is located in the Central region of Uganda and covering a surface area of 195km^2. It is the only Capital City in East Africa located along the shoreline of Lake Victoria, Africa's largest freshwater lake. Figure 12 shows the urbanisation around the Lake Victoria basin. Kampala has a day and night population estimated at 2.5 million people and 1.5 million people, respectively (UBOS, 2014).

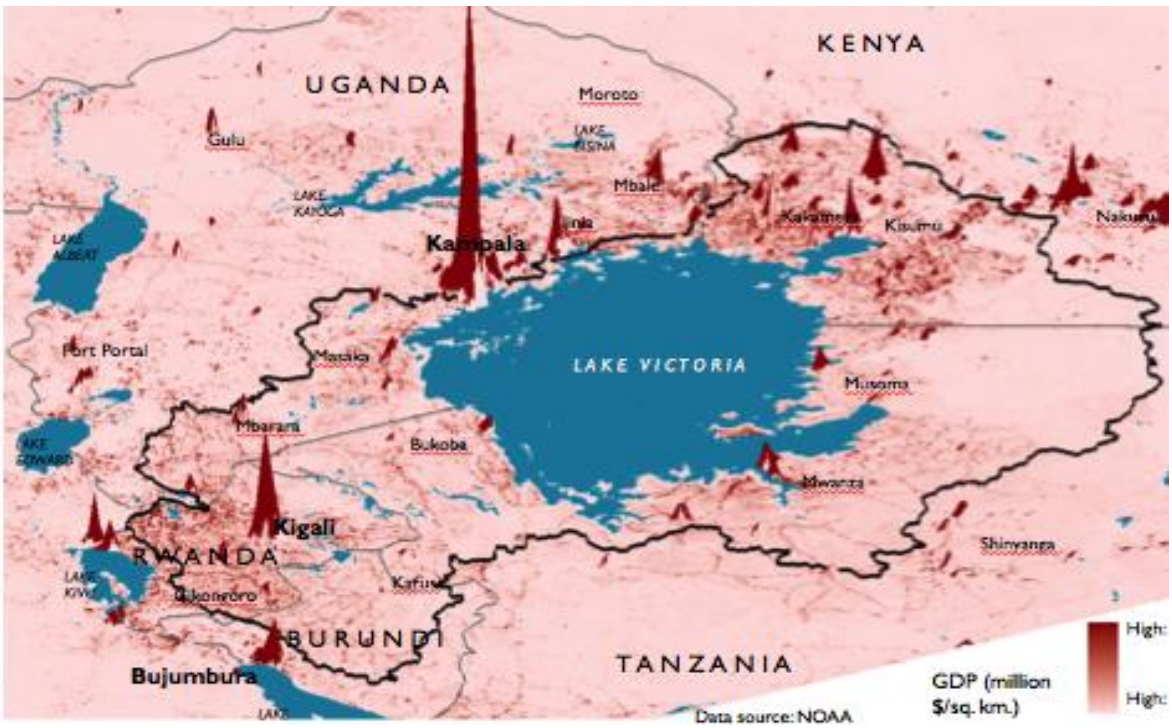

Figure 12: Map Showing Urbanisation around the Lake Victoria Basin

Kampala City has five administrative units, that is, divisions namely: Central, Rubaga, Nakawa, Kawempe, and Makindye. Due to the rapid population growth, there have been developments of unplanned structures and dwelling units often without sanitary facilities, water supply, wastewater drainage systems and solid waste management. Therefore the city is characterised by unplanned settlements especially in the surrounding suburbs.

2.4 Water and Sanitation in Kampala

A drainage master plan conducted in 2002 by the then Kampala City Council and now Kampala Capital City Authority, identified one of the causes to flooding as man-made due to location of informal neighbourhoods in low lying areas i.e. encroachment on natural drainage systems. It should be noted however that some of the encroachers on the wetland include privately owned hotels, schools and factories. Other causes of flooding include: refuse dumping in the drainage systems and agricultural practices incompatible with vegetation of wetlands by the settlers; hence interrupting the natural conveyance and filtration systems.

In Kampala currently 2,000 tonnes of garbage are generated but only 1,100 tonnes are collected[9]; hence, it accumulates on roads and streets. Additionally, only 10% of the city population is sewered. Since Nakivubo channel is the major drain for Kampala this implies that most of the garbage accumulated on the roads and streets and the wastewater generated from households and industries without sanitation ends up there. The Nakivubo Channel discharges into the inner Murchison Bay. This bay, located in the Northern part of Lake Victoria in Uganda is the abstraction point for potable water supply in Kampala city and also the recipient for surface runoff, sewage effluent, industrial and municipal wastes from the city. In addition, rapid population growth and the growing commercial and industrial activities in Kampala, have also led to increased volumes of urban waste and wastewater production. Figure 13 shows the wastewater loads entering Nakivubo Swamp.

[9] Source: KCCA, May 2016

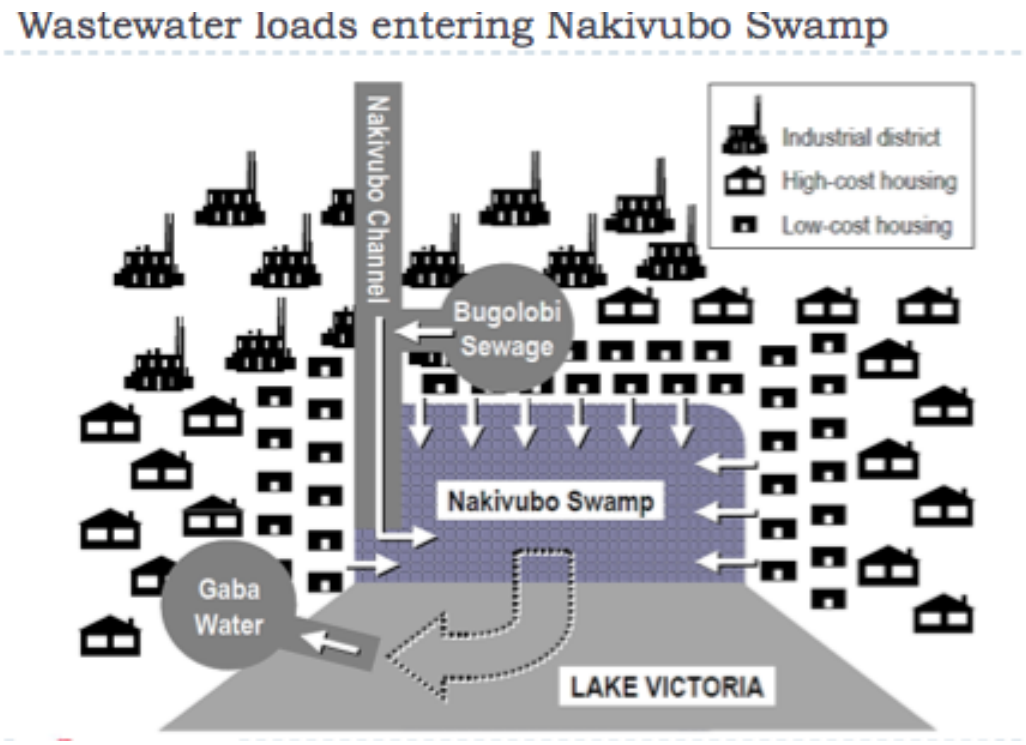

Figure 13: Wastewater Loads Entering Nakivubo Swamp

As a result, Nakivubo Channel contributes a very significant pollution load to the Inner Murchison Bay, due to the organic matter in the waste (mainly from households) and wastewater discharged from slums and un-sewered areas as it traverses through the slums, markets, industries and commercial areas without pre-treatment.

2.5 Sanitation Coverage in Kampala

In Uganda, access to sanitation in urban areas is estimated at 84% (MWE sector performance report 2015). This coverage is however based on reports from small towns only; for large towns like Kampala no data is accessible. However, KCCA is reported to have data on sanitation coverage in Kampala. KCCA currently undertakes a project on enhancing faecal sludge management in Kampala through the private sector. This is KCCA's own initiative. MWSC, with funding from KfW is implementing the Kampala LV-WATSAN project for addressing sanitation in Kampala. A report, indicating what needs to be done is reported to be available.

Regarding wastewater conveyance in Kampala, the sewered area of Kampala serves about 7.3% of the population, covering the Central Business District and the affluent areas (Kampala Sanitation Program Lake Victoria protection Phase II Nakivubo WWTP Final Design Report, 2011). 93%, mainly the urban poor population, rely on various forms of on-site sanitation: pit latrines and septic tanks. Due to various socio-economic and technical reasons, the effluent from latrines and septic tanks are often discharged into the environment without any treatment. This effluent finds its way into the Nakivubo channel and ultimately into the Inner Murchison Bay of Lake Victoria, which is inhabited by a large population of fishermen, and it is also the source of abstraction for the drinking water supply of Kampala.

The impact of poor sanitation facilities, coupled with the lack of hygiene knowledge and practices are very evident in Kampala especially among the low-income residents. These can be seen in the high incidence of sanitation related illnesses such as diarrhoea, cholera and typhoid as witnessed in February 2015 indicating the need for urgent improvement to match socio-economic and environmental needs of the people.

To combat some of the issues mentioned above, KCCA and NWSC's main measures planned were:

- Rehabilitation and expansion of the Nakivubo waterborne sewerage system, including rehabilitation of the existing WWTP at Bugolobi, followed by a new WWTP in the Nakivubo wetland;
- Development of a new waterborne sewerage system at Kinawataka to serve the eastern part of KCCA, this system to include a WWTP;
- Development of a WWTP cum Faecal Sludge Treatment Plant in the Lubigi wetlands, receiving sludge removed from on-site sanitation facilities and which is over loaded at the moment.

During implementation of the WWTP in the Nakivubo wetland, it was discovered that civil works needed to be piled, rendering implementation prohibitively expensive. Hence, it was decided that rather than rehabilitating Bugolobi WWTP, the plant would be modernized and expanded. Hence, the Nakivubo wetland is available for further development and chosen for the presented HPI.

2.6 Problem Analysis

Nakivubo Channel is a major open drainage channel that runs through the centre of the city of Kampala with an approximate length of 9 km and approximate catchment area of 50 km^2 (approximately 25% of the surface area of Kampala). It traverses through highly populated informal areas of Makerere Kivulu, three busy markets in the city centre and the Kampala industrial area.

With regard to quantity, the estimated daily discharge - Dry Weather Flow (DWF) is in the range of 50,000 – 60,000 m^3/day and the average annual flow is 100,000 m^3/day. Short peak Wet Weather Flows of 500,000 m^3/day have been recorded (Kansiime & Nalubega, 1999).

The quality of the wastewater includes pollutants such as faecal waste from households and raised pit latrines, seepage from broken sewer lines, discharges from garages and washing bays, household and healthcare waste from communities and markets, other organic matter, heavy metals, nitrogen, phosphorus and other industrial wastes (from paint, soap and informal industries) and lastly storm water.

Figure 14: Impression Nakivubo Channel (1)

Figure 15 Impression Nakivubo Channel (2)

The wastewater in the channel is later joined by untreated sewerage from Luzira prison and a pharmaceutical industry downstream before crossing the Nakivubo swamp. The retention time for the channel effluent in the swamp is estimated at two days under calm and dry weather conditions, but some other reports have mentioned up to about 5 days (Kansiime & Nalubega, 1999).

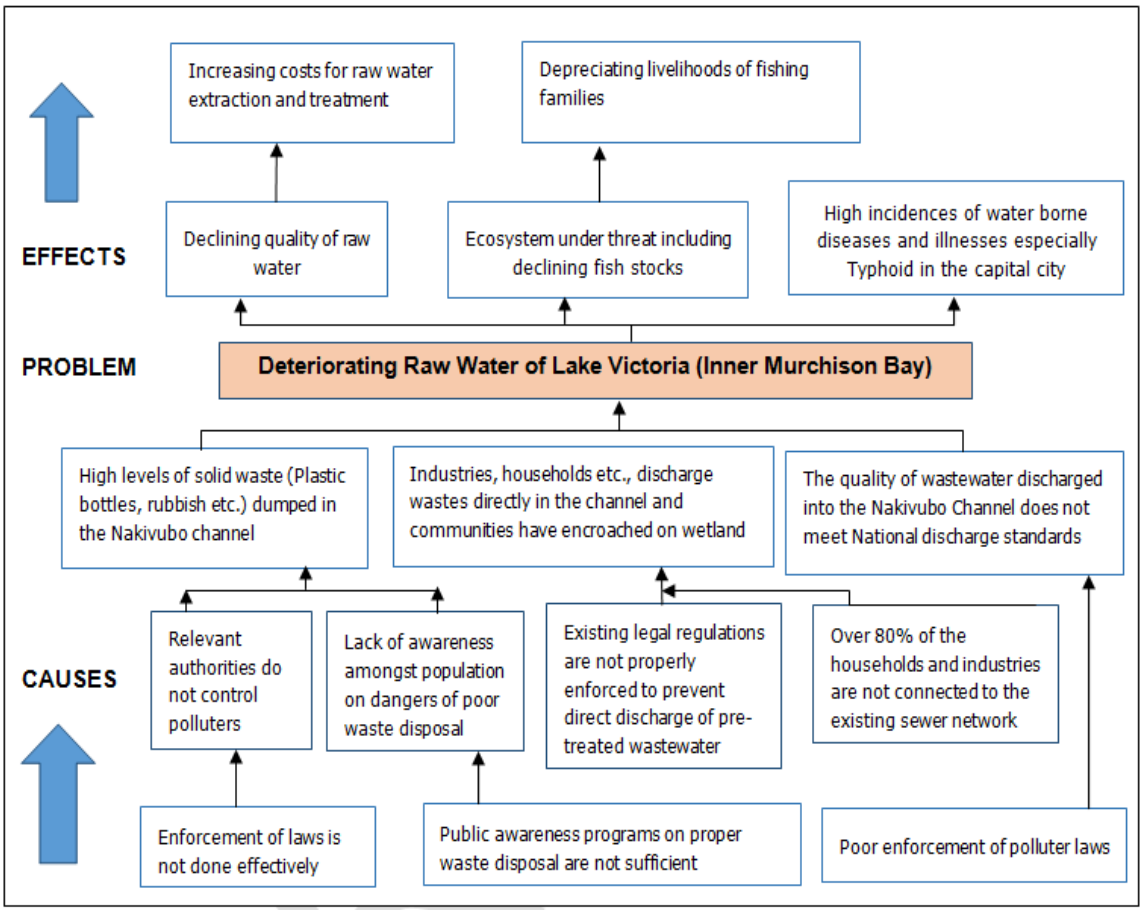

Figure 16: Problem Tree Crude Pollution Inner Murchison Bay

Table 7: Underlying Causes and Proposed Solutions and Measures

Underlying causes for problems	Proposed Solution	Proposed Measures
Poor enforcement of polluter laws by relevant authorities	▪ Use existing government structures to enforce polluter pay principle. This would be a novelty for Uganda; ▪ Increase awareness of polluter laws amongst the communities.	Use LVEMP III funds to support law enforcement; especially in the project area in close liaison with NEMA, KCCA and MWE.
Insufficient awareness programmes on waste disposal	▪ Develop communication messages on poor waste disposal; ▪ Increase awareness programmes for effective behavioural change; ▪ Provide options for solid waste collection.	Use LVEMP III funds to support law enforcement; especially in the project area in close liaison with NEMA, KCCA and MWE.
Solid waste accumulation in the Nakivubo channel causing blockages and flooding	▪ KCCA to improve on solid waste management in the City; ▪ Increase awareness on solid waste management to communities	Use the proposed 1% budget line from the project funding to sensitize communities on solid waste management.

As can be seen from the problem tree in Figure 16, the pollution of the Murchison Bay has a complex set of causes that can never be solved with only the HPI under consideration. The HPI will however minimize the pollution of the Bay by a 'temporary' 'end-of-pipe' solution.

This study recommends a collaborative effort by the relevant stakeholders to advocate and push for a behavioural change campaign amongst the polluters/communities through national media or other means to reduce the pollution upstream and hence improve the quality of wastewater discharged into the channel.

2.7 Donor Involvement and Donor Coordination

The HPI chosen for Kampala is to follow two phases: Firstly, treatment of the water in the Nakivubo Channel; and then later to perform tertiary treatment of effluent of the Bugolobi Wastewater Treatment Plant (WWTP). The study acknowledges that the Government of Uganda (GoU), through the LVEMP II project (World Bank funded) has already initiated a similar project on a smaller scale (*Consultancy Services for the Design of a Pilot Scale Constructed Wetland and Reticulation System in the Nakivubo Wetland, executed by AWE consultants*) and this has been integrated in the presented HPI.

The Nakivubo Channel has been a subject for many researchers and PhDs but little has been done to address the actual problem. However, in the financial year 2014/15, Kampala Capital City Authority secured funding from the Lake Victoria Environment Management Project II (LVEMP II) through the Ministry of Water and Environment (MWE) towards the cost for a project for "Reduction of environmental pollution and flood frequency in Kampala". The primary objectives of the project were to:

- Enhance Nakivubo wetland's purification capacity and efficiency mainly through even distribution and increased retention/ residence time of wastewater and storm water draining from the City;
- Optimise the use of the Nakivubo wetland within the framework of the National Wetlands Policy and other relevant environmental legislation;
- Optimise off-site services and functions of the wetland, notably wastewater treatment; and
- Depending on the performance of the pilot scale CW, advise on development of a full scale CW in the future or restoration measures that would optimise hydrological and water quality regulation.

Following the Feasibility Study for the Lake Victoria Basin Integrated Water Resources Management Programme and the need for identification of HPIs in Kampala, discussions were held with the MWE, KCCA, LVEMP II and the project consultant, AWE, on the possibility of implementing a full scale CW. The CW was agreed upon as the most plausible way forward. In addition, the LVEMP II Coordinator also remarked that additional funding could be set apart under the future LVEMP III project starting in 2017/18.

3 Description of the Proposed HPI

3.1 Introduction

This Feasibility Study has been compiled after extensive data collection from various departments of NWSC, MWE, NEMA and KCCA although there were some challenges of getting data on time, while in other cases data had gaps and could not readily be relied on. We had to rely mainly on previous reports of designs that were done in the same project area. This work aims at presenting feasible and not feasible options, preliminary cost estimates. The options considered include:

1. A new CW;
2. A stabilisation pond system; and
3. Developing a reticulation system at the existing wetland and weir at the outlet culvert to increase retention time and rejuvenate the wetland.

After comparison of these 3 options, a combination of alternative 1, the newly CW and Alternative 3 is considered to be the best, see § 4.8.

3.2 HPI Objective and Indicators

GoU's Vision 2040 is conceptualized around strengthening the fundamentals of the economy to harness the abundant opportunities around the country. The fundamentals include: infrastructure for energy, transport, water, oil & gas and ICT, Science, Technology, Engineering and Innovation (STEI); land; urban development; among others.

In line with this vision, when the Bugolobi WWTP (about 650 m') upstream operates at full capacity serving the complete sewerage area, the CW will treat the effluent of the treatment plant under constructed. Before this is achieved, the proposed intervention will be used to treat the Nakivubo channel flow.

The indicators and assumptions that relate the HPI to this objective are presented in Table 8.

Table 8: HPI Indicators and Assumptions

Indicator	Assumption
By September 2017, the detailed engineering design for the CW to treat 45,000 m^3/day of wastewater from the Nakivubo Channel will be completed.	○ Land acquisition and compensation of communities is done in time; ○ Topographic surveys of the planned area completed; ○ Funds for detailed engineering design released in time.
In 2018, the CW can treat 45,000 m^3/day of wastewater from the Nakivubo Channel. In case the BOD_5 in the channel is 200 mgBOD_5/l, 30,000 m^3/d can be treated and the quality of the Nakivubo channel water after mixing is 98 mgBOD_5/l. In case the BOD_5 in the channel is 100 mgBOD_5/l 45,000 m^3/d can be treated (hydraulic limits) and the quality of the water after mixing is 66 mgBOD_5/l.	○ Detailed engineering design and tendering for design completed in time; ○ Construction and operation of project is successful; ○ Funds for implementation released in time.

Indicator	Assumption
After completion of Bugolobi WWTP and serving the complete service area, its effluent will be treated by the CW (tertiary treatment). Around 40-50% of Total Nitrogen will be removed and 50-60% Total Phosphorus. , say from 13[10] → 6 mg TN/l and from 8.4 → 4 TP/l (see also Table 17).	○ The WWTP will be working at full capacity (45,000 m^3/day) and everybody in the service area is connected. ○ Operation and maintenance of the CW is handled efficiently.

3.3 Target Group in the Priority Area / Sub-sector

Kampala, covering an estimated area of 197 km^2, is the Capital City of Uganda. By share of functions, it is the largest urban centre in Uganda. Similarly, by size of population of individuals, it has the largest share of urban population in Uganda. The functions and population of individuals of the Capital City have been growing over the years; and, their growth has been quite fast. By the 1991 census results, the night population of individuals of the Capital City was estimated to be 774,241.

By the 2014 census results, which are the latest census results for Uganda, it had grown to an estimated 1,507,080, suggesting a growth of approximately 95% in about three decades. The 2014 census results in addition shows that 100% of the night population of individuals in Kampala Capital City is urban. See Table 9.

Table 9: Number of Urban Centres by Type and Urban Population, 1991-2016[11]

Type of Urban Centre	1991			2002*			2014**		
	No.	Population		No.	Population		No.	Population	
		Count	%		Count	%		Count	%
City	1	774,241	46.37	1	1,189,129	40.70	1	1,507,080	20.30
Municipality	13	480,922	28.80	13	745,036	25.50	33	3,249,609	43.76
Town Council	33	338,901	20.30	61	1,065,209	36.46	163	2,361,033	31.79
Town Board/ Township	20	75,589	4.53	20	N/A	N/A	62	308,142	4.15
Total	67	1,669,653	100.00	75	2,921,981	100.00	259	7,425,864	100.00

Notes:

* The urban population of 2002 excludes the population enumerated in Town Boards

** The urban centres are as of March 2016, while the population is as of 2014

Table 10: Population of the Five Largest Urban Centres of Uganda, by the 1991 - 2014 Census Results[12]

District		Urban Centre	Census Population		
			1991	2002	2014
1.	Kampala	Kampala Capital City	774,241	1,189,142	1,507,114
2.	Wakiso	Nansana Municipality	N/A	N/A	365,857
3.	Wakiso	Kira Municipality	N/A	N/A	317,428
4.	Wakiso	Makindye Ssabagabo	N/A	N/A	282,664
5.	Mbarara	Mbarara Municipality	41,031	69,363	195,160
Total			815,272	1,258,505	2,668,223

Notes: N/A. Data not available because the urban centre was not a gazetted urban centre at the time of the Census

[10] PÖYRY 2011

[11] Uganda Bureau of Statistics (UBOS). 2016. The National Population and Housing Census 2014 – Main Report. Kampala, Uganda

[12] Ibid

Table 11: Population Distribution of Kampala by Sex, Residence, Population Type and Census Year 1991 – 2014[13]

Census Year	Sex		Residence		Population Type		Total
	Male	Female	Rural	Urban	Household	Non-Household	
2014	48.06%	51.94%	0.00%	100.00%	97.51%	2.49%	100.00%
2002	47.86%	52.14%					
1991	48.73%	51.28%					

Table 12: Average Household Size and Population Growth Rate for Kampala

Kampala	Population ('000)		Number of	Growth Rate	Population Density	Urbanisation Level	Average Household Size
	2002	2014	Households	2002-2014			
	1189.1	1507.1	416,070	2	7928	100	3.5

The rapid growth of Kampala has had far reaching impacts, namely:

- Increasing demand for the City's land, with increasing pressure for industrial and housing developments;
- Increasing demand for improved infrastructure (both rehabilitation and expansion), with increasing pressure from the industrial and housing developments; and,
- Increasing demand for charcoal and agricultural products, with increasing pressure from the growth in population of individuals in the City.

One outcome of these far reaching impacts, which is observable today, is degradation of the Nakivubo Wetland system, a natural wetland system.

3.4 The Project Area

3.4.1 The Nakivubo Wetland System

The Nakivubo Wetland system is one of two major natural wetland systems in Kampala. The other is Nsooba-Lubigi Wetland system. These two systems also act as the main drainage system of Kampala[14].

The Nakivubo Wetland, located on the south eastern side of Kampala, covers an estimated surface area of 5.3 km^2 and its total catchment area is estimated to extend over 40 km^2. Feeding the Wetland is Nakivubo River and its tributaries, namely: the Kitante, Katunga, Nakulabye, and Lugogo. The dominant vegetation in the Wetland is the papyrus (*Cyperus Papyrus*). Other vegetation are cat tails (*Typha sp.*), common reed (*Phragmites sp.*), and *Miscanthidium* grass[15]. Cutting across the Nakivubo Wetland is a railway line.

[13] *Ibid*

[14] http://www.nemaug.org/atlas/atlas_kampala.pdf

[15] https://cmsdata.iucn.org/downloads/casestudy07nakivubo.pdf

Figure 17: Nakivubo Wetland

This railway line runs from Port Bell (which is located on the shores of Lake Victoria) to hinterland Kampala. The railway line, as Figure 17 and Figure 18 illustrate, effectively divides the Wetland into two zones of human influence, commonly referred to as the Upper and Lower Nakivubo Wetland. Upper Nakivubo Wetland is that section of the Wetland north of the railway line. Lower Nakivubo Wetland is that entering Lake Victoria, south of the railway line. The railway line, at the part it crosses the wetland is constructed on reclaimed land.

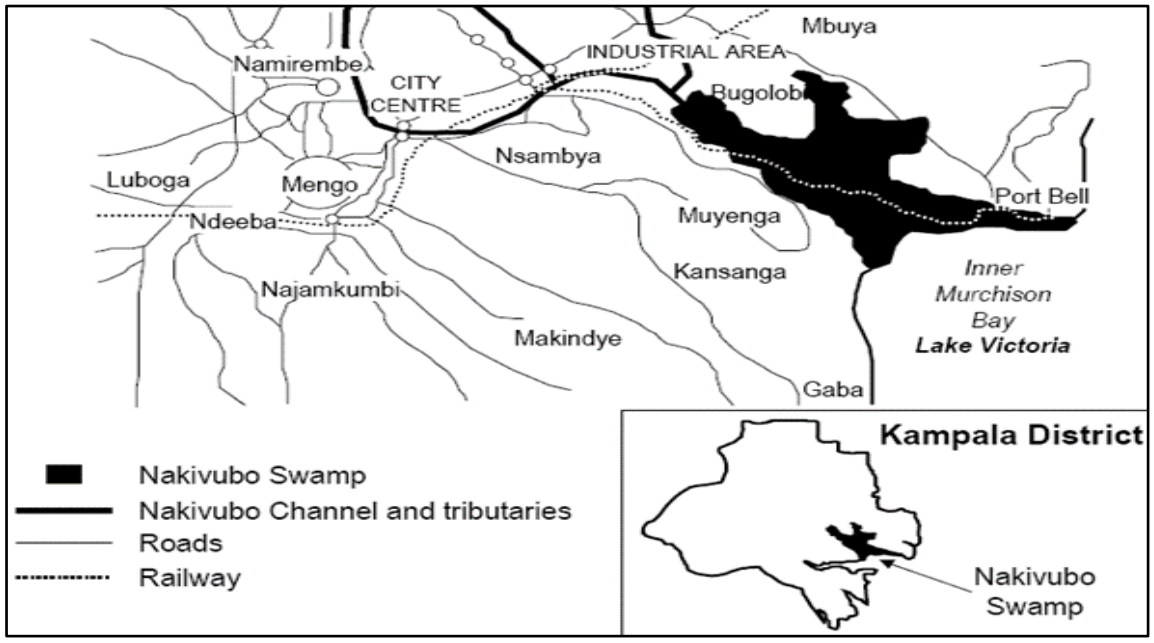

Figure 18: Location of Nakivubo Wetland in Kampala[16]

The drainage system of Nakivubo Wetland is of interest of this report; the wetland is the site proposed for a CW. This wetland used to clean wastewater from Kampala prior to it being discharged into Lake Victoria through Inner Murchison Bay, at a point upstream of the intake of the City's water supply also located at the Inner Murchison Bay. The nature of the wastewater used to clean a mix of partially treated sewage, storm water run-off, and raw sewage. The Nakivubo Wetland has been performing this role of cleaning wastewater from Kampala for more than 40 years. Although the presence of Nakivubo wetland results in a significant improvement

[16] Source: IUCN 2003

of the quality of water entering Inner Murchison Bay, its waste treatment and water purification services are currently not being utilized to their full potential. This is because the two outflows of Nakivubo Channel, through which the majority of wastewater and between 75-85% of nutrients enter the wetland, do not spread wastes over the whole wetland area. Wastewater currently spends only 0.5-2 days in the wetland, and mainly accumulates in lower parts to the south of the railway bridge[17].

3.4.2 Degradation of the Nakivubo Wetland

The rapid growth of Kampala has had far reaching impacts; and, one outcome, which is observable today, is degradation of the Nakivubo Wetland system, namely:

a. The Wetland has been sub-divided and official documents of ownership issued to persons from both private and public sectors. To date, the titles issued are about 60;

Figure 19: Figures Illustrating Areas with a Land Title in the Nakivubo Wetland

b. Approximately 50% of the Wetland has been modified. The modification is more in the upper zone of Nakivubo Wetland; much of the shallow upper zone of Nakivubo Wetland has been reclaimed in favour of both planned and unplanned settlements, industrial development and cultivation. The lower zone is still relatively intact. With the exception of its fringes, its core is covered by a floating mass of papyrus. At its fringes, a small amount of cultivation is evident.

[17] Source: IUCN 2003

Figure 20: Example of Modification in Upper and Lower Zones of Nakivubo Wetland

Figure 21 provides an impression of the Upper Zone, on the left side of the railway line, and of the Lower Zone, on the right hand side of the railway line.

c. The remaining core section of the Wetland (which is about 3 km^2) is under threat of encroachment from settlements, industrial development and cultivation. Regarding the threat of encroachment from settlements, the threat is more from the informal (unplanned) settlement than from the planned settlements in the vicinity as the planned settlements are under strict regulation.

Figure 21: An Impression of Areas with Planned and Unplanned Settlements in Upper Zone of Nakivubo Wetland

d. Every day, large volumes of solid waste are transported by wastewater into the Wetland. This waste includes both biodegradable and non-biodegradable products. Examples observed are plastic bottles (for soda and bottled water), glass, plastic paper, cloth, and medical syringes with or without needles.(Figure 22 and Figure 23)

Figure 22: Solid Waste Transported into Nakivubo Wetland through the Nakivubo Channel

Figure 23 Solid Waste Transportation

3.4.3 Government Policy on all Wetlands Including Nakivubo Wetlands

During field study of this HPI, the observed degradation of Nakivubo Wetland was of major concern and formed basis of major socio-economic discussion. The question it evoked was "If the proposed CW would be implemented in the Nakivubo Wetlands, would the project get an adequately sized site in Nakivubo Wetland, which is free of encumbrances?" In response, the Government of Uganda assured the Project that it would indeed get an adequately sized site that is free of encumbrances.

Cancellation of Titles in Wetlands in Public Land. In 1995, Uganda got a new Constitution; and, in 1998, it enacted a new land law. These laws provide the legal framework outlawing private ownership of wetlands in Uganda. The Government of Uganda has in addition enacted an environment law, which prohibits any development on a wetland that is without a valid permit from the National Environment Management Authority (NEMA). Outlawing of private ownership of wetlands in Uganda as well as regulating any development on them is as a result of Government concern on deteriorating water quality in wetlands, which have been encroached upon. As a follow-up, the Government of Uganda is currently undertaking mapping of wetlands in Uganda to obtain a Wetlands Atlas for Uganda. It has completed mapping of wetlands in Kampala, and produced a Kampala Wetlands Atlas. From the mapping, over 7,000 titles in Kampala will be cancelled. The cancellation of titles will be as per a Cabinet Directive, which states that anyone that acquired a title prior to the new Constitution of Uganda (1995) is eligible for compensation. Otherwise, they are not eligible for compensation. As at the time of consultations, the guidelines on cancellation of the titles had been developed and approved. In connection with Nakivubo Wetland, at the time of consultations, a taskforce was in place to identify the bona fide titleholders and squatters. This task force is also mandated to identify who got their title prior to and after the Constitution of Uganda (1995).

Box 1: Cabinet Directive on the Cancellation of Titles in Wetlands in Public Land in Uganda[18]

Policy Committed on Environment (PCE), through the MWE, presented to Cabinet a Memorandum CT (2012) 172 seeking to address massive wetland degradation. On the 16-04-2014 Cabinet, under Minute 114(CT2014), while discussing the Memo, approved the cancellation of land titles in wetlands on public land acquired unlawfully after 1995, as one of the measures to address the problem of wetland degradation. Cabinet specifically approved the following decisions for action:

(i) As a matter of principle, policy and law, all titles in wetlands on public land acquired unlawfully (after 1995) should be cancelled;
(ii) Use of land in critical ecosystems especially those on the 200m L. shore protection zone should be regulated and the proprietors should apply for and obtain permits to undertake regulated activities as provided for in the law;
(iii) The degraded wetlands whose ecological functions are recoverable should be restored;
(iv) Wetlands portions on public land that had been reclaimed and converted for economic activities for public good and with approval from the controlling/regulating authorities such as NEMA and KCCA, should be declared vanquished and land titles issued therein should not be cancelled.
(v) Clear operational procedures of handling cancellation of titles in wetlands on public land be developed and those procedures should be applied without discrimination.
(vi) The MoLHUD should commence cancellation of land titles issued after 1995 as soon as the Wetlands Atlas is in place, starting with those within Kampala;
(vii) The MWE and NEMA, in consultation with LGs and Police should take immediate steps to ensure that wetlands that were not yet degraded or encroached upon are fully protected and should produce a Wetland Atlas for the whole country;
(viii) The Attorney General should undertake further consultation on the proposal to declare as vanquished wetlands portions on public land that had been reclaimed and converted for economic activities for public good, in order to facilitate appropriate decision making by Cabinet;
(ix) (IX) MWE should put in place a period of sensitisation of the public on the measures that have been approved, given the magnitude of the problem and the possibility of precipitating a crisis through the cancellation of the titles; and
(x) The lists submitted to Cabinet containing an inventory of titles in Kampala, Wakiso, Mukono, Jinja and Kumi were not comprehensive enough and should be taken back for further verification by the MWE.

Availability of an Adequately Sized Site in Nakivubo Wetland for the Proposed Constructed Wetland. The National Water and Sewerage Corporation (NWSC) is one of the institutions with a title to part of Nakivubo Wetland. The title is for 5.5 ha, and was issued by the Ministry of Lands in 1991 for a period of 999 years. In addition to these hectares, NWSC has the user permit from NEMA for 25 ha, and this user permit is valid for 50 years. NWSC has not got a title for the 25 hectares. Thus, the total area of Nakivubo Wetland that NWSC has acquired rights to use is 30 ha. This 30 ha is available for the implementation of a CW. This assurance is from NWSC, which is a Government of Uganda agency established in 1972 with the role of developing and operating urban water supply and sanitation systems in Uganda. In the event that the Project should require more hectares toward effectively implementing a CW, NEMA, which is another Government of Uganda agency, assures that this can be made available. Thus, there is a positive move to acquire the required land for the proposed High Priority Project for Uganda; and this is at the highest level.

[18] Source: http://www.google.com

Figure 24: Meeting of the Feasibility Study Team with Members of the National Technical Steering Committee for the Lake Victoria Environmental Management Project 29 March 2016

Resettlement Concerns. A probable challenge with the proposed site for the CW is encroachment, especially in the form of unplanned settlements and small-scale farming. The small-scale farming includes both perennial and seasonal crops. Examples of the perennial crops farmed are bananas and pawpaw. Examples of seasonal crops are amaranths, yams, maize and sugarcane. Trees are farmed too; one example is Eucalyptus.

Figure 25: Examples of Cultivated Seasonal and Perennial Crops in Nakivubo Wetland

The Government of Uganda assured that this challenge is manageable, and that it is highly unlikely to slow or impede effective implementation of the CW:

a. NEMA is considering applying the concept of ecological offset on some of the titles given prior to 1995. The affected titles would be among those at the current boundary of the Wetland. What this implies is adjustment of the current Wetland boundary to exclude some sections, hence reduction in size of the wetland. This measure has been considered so as to avoid the heavy settlement observed at the current boundary, which would be very expensive to compensate. On application of the concept, the owners of the excluded sections will be required to pay an offset boundary fee. The plan of NEMA is to undertake the offset during the rainy season, which it views as the best time due to the waterline. Thus, the site that would be provided would be free of settlement.

Figure 26: Example of Encroachment on Nakivubo Wetland by Unplanned Settlement

b. For the approximately 30 ha of the wetland that NWSC has rights to utilise, compensation has been made to those that had claim to utilise or occupy it. NWSC has documentation to prove this. Thus, anyone that has returned to the area is there illegally. During the fieldwork it was observed that those utilising this section of the wetland that NWSC claims rights to, are largely low-income earners and, they practise small-scale farming. The consultant's conclusion is that this site is free of major encumbrances. The recommendation therefore is issuance of a notice to the squatters and, this notice should be adequate to enable them harvest their farm produce before leaving.

Thus, there is a positive move from the Government of Uganda to acquire the area that is free of encumbrances, for the proposed HPI for Uganda; and this is at the highest level.

Encroachment on the Constructed Wetland on its Implementation. Another probable challenge with the proposed site for the CW is the low-income earners that have over the years benefited from utilising the resources of Nakivubo Wetland, continuing to do so on the CW on its implementation. During the field study it was observed that there are community driven initiatives proposing how the community can benefit from the natural Wetland but in a controlled manner. The proposal is not to farm food crops, but papyrus and bamboo. Papyrus and bamboo are some of the recommended vegetation for a CW. Food crops are discouraged for three main reasons:

a. The threat of ingestion of harmful substances into the food chain;

b. The threat of physical contact with harmful substances; and,

c. Food crops such as yams require uprooting, an activity which would reduce the efficiency and effectiveness of the CW.

Thus, it is recommended that the project considers incorporation of these community driven initiatives, whereby the community is involved in the planting and harvesting of the recommended vegetation for a CW, but this should be controlled to ensure optimal benefits and sustainability.

Solid Waste Management and Efficiency of the Constructed Wetland. Another probable challenge with the proposed site for the CW is solid waste transported into it by wastewater from the catchment area of Nakivubo Wetland. During the field study it was observed that it is manageable but on condition of enforcement of environmental law, as well as creatively involving the community. One positive thing observed during the field study is that LVEMP II has through a pilot programme located outside the catchment area of Nakivubo Wetland, successfully engaged community members to manage solid waste. This is part of Community Driven Involvement Project (CDIP) run by persons with disabilities, where plastics are collected and sold to a recently established recycling plant located in Kampala. KCCA has similar

initiatives and with direct impact on Nakivubo Wetland. It is collaborating with LVEMP II. As part of the collaboration, LVEMP II has purchased three trucks, which are to be used to collect solid waste within the catchment area of the Nakivubo Channel. LVEMP II is also willing to add another four trucks. Acknowledged, however, is that the trucks are a temporary measure. Thus KCCA is conducting sensitisation through mass media; and, as part of catchment, it is concentrating on communities along the Nakivubo Channel.

3.5 Partner Structure: Executing Agencies and Intermediaries

Currently, the sectors and institutions that are responsible for pollution management for the Inner Murchison Bay are:

a) Ministry of Water and Environment together with its Agencies namely; National Environment Management Authority (NEMA), National Water and Sewerage Corporation (NWSC) and its directorates namely Directorate of Environment Affairs (DEA) through its district environmental officers and environmental auditors give support, directorates of water development (DWD) and water resources management (DWRM);
b) Kampala Capital City Authority (KCCA). The KCCA has embarked on a campaign to engage industries (private sector) in collaboration with key Government agencies through the Joint Pollution Task Force (JPTF). The main objective of the task force is to increase the coordination among government agencies in regulating industrial pollution through; joint inspections, sensitization and awareness campaigns, enforcement and Public-Private Dialogue (PPD);
c) To fast track participation of industries, the PPD on improving Industrial Wastewater Management in Kampala" was launched in October 2013. This Dialogue is spearheaded by KCCA in collaboration with Uganda Manufacturers Association (UMA), and key agencies in the Ministry of Water and Environment (MWE), with support from German Corporation through the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) – Reform of the Urban Water and Sanitation Sector (RUWASS) programme. The key MWE government agencies involved include; DWRM, DEA, NEMA, and NWSC;
d) Ministry of Lands, Housing & Urban Development (MLHUD) is responsible for putting in place policies and initiating laws that ensure sustainable land management, promote sustainable housing for all and foster orderly urban development. There are plans of transforming slums to planned settlements and have developed guidelines for waste management.

In the table in APPENDIX 3: Relevant Laws and Regulations, the relevant laws are depicted. For this HPI, KCCA will be the implementing agency through the MWE given its mandate to manage public health and environment as well as construction of major drains. NWSC on the other hand will be charged with O&M of the system whilst it is completed

3.6 HPI Cost Estimate

Table 13 shows the cost estimate of the HPI.

Table 13 Cost Estimate HPI

Item Description	**Amount (EURO)**
A. Clearing and grubbing	€24 000
B. Excavation and embankment shaping works	€1 172 000
C. Constructed wetland basins with macrophytes	€3 748 000
D. Inlet and outlet infrastructure	€217 000
E. Interval open water ponds	€77 000
F. Sedimentation Basin	€1 831 000
G. Water Sump and Pumping	€1 135 000
Sub-Total (rounded)	***€8 300 000***
H. Construction Supervision	€400 000
ESTIMATED GRAND TOTAL	**€8 700 000**

3.7 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. 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, electricity and other public services are not included in the investment costs; these are to be provided by the government.

It has also 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 would step in or would co-finance, other financing modalities could be incorporated. If grant funding is to be replaced by loan financing or equity financing, the financial viability of the HPI projects would be lower as financing costs have to be included in the calculations (P&L statement).

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 for new investments.

As for 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.

3.8 Relation with the National Strategy

Currently, the overall Government Policy direction is guided by three major documents, namely the:

- National Strategic Direction (NDP);
- National Resistance Movement Manifesto (2011–2016); and,
- Vision 2040.

The common aspiration of these key policy documents is to transform the Ugandan society from a peasant to a modern and prosperous country within 30 years". Within these policy documents, it is noted that the Water and Environment sectors are key drivers to the transformation process. Underpinning the transformation process is the desire by Ugandans to have world-class infrastructure services including clean, affordable and reliable water services, among others.

It is the Government's objective to ensure that the water resources are efficiently utilised, and all steps are taken to effectively harness water (including rainfall) for human and economic development purposes. There is therefore a call for the proactive and efficient management of water supply and wastewater disposal activities in order to ensure long–term sustainability of service delivery.

3.9 Relation with the City Plan

Under the Kampala Physical Development Plan (KPDP), there were preparations of constructing a new wastewater treatment plant in the Nakivubo Wetland (KCCA, 2012). This also included rehabilitation of the wetland. The WWTP plant was shifted about 600 m upstream of the then proposed site because soil conditions in the Nakivubo wetland would not support heavy concrete structures. However, through the Ministry of Water and Environment, KCCA secured funding from the Lake Victoria Environment Management Project II (LVEMP II) to implement a project for "Reduction of environmental pollution and flood frequency in Kampala" (KCCA, 2014[19]). Under this project, KCCA opted for a CW that would be used to polish the Nakivubo Channel water before it enters the Inner Murchison Bay of Lake Victoria. A consultant

[19] Ministerial Policy Statement Financial Year 2014/15 Vote 122

had already been hired (Project reference: MWE/CONS/14-15/0021320) to carry out a design of a pilot CW which would later be upgraded to a full scale system under the LVEMP II project before the HPI project was conceived. Therefore this HPI fits well within the City Plan.

[20] Consultancy Services for the Design of a Pilot Scale Constructed Wetland and Reticulation System in the Upper Nakivubo Wetland

4 Comparative Analysis

4.1 Introduction

Wetland ecosystems can act as sources, sinks, or transformers of nutrients and carbon. This ability of wetlands has led to a widespread use of natural and CWs for water quality improvement. CW systems are fully human-made wetlands for wastewater treatment, which apply various technological designs, using natural wetland processes, associated with wetland hydrology, soils, microbes and plants. Thus, CWs are engineered systems that have been designed and constructed to utilise and optimise the natural processes involving wetland vegetation, soils, and their associated microbial assemblages to assist in treating wastewater.

Other functions or objectives of CW may include:

- Water storage and flood attenuation;
- Recharging of groundwater;
- Primary production and food web support design (photosynthetic production, wildlife production, food web and habitat diversity, export to adjacent ecosystems, etc.) and
- Human uses (aesthetic, recreational, commercial, educational uses, etc.).

There are various types of CW used for treatment of wastewater as indicated in Figure 27. The treatment efficiency of CW depends on water residence time, temperature, and influent concentration of pollutants, depth, vegetation distribution, hydraulic efficiency and light.

Like CW, Waste or Wastewater Stabilization Ponds (WSPs) are large, man-made water bodies in which wastewater is treated by naturally occurring processes and the influence of solar light, wind, microorganisms and algae. The ponds can be used individually, or linked in a series for improved treatment. There are three types of ponds, that is, anaerobic, facultative and maturation, each with different treatment and design characteristics.

4.2 Input Data

4.2.1 Design Flow

The proposed options are meant to treat ('polish') the effluent of the wastewater treatment plant (WWTP) that is being built at the moment and that will discharge at 650 m distance upstream. The design capacity of the plant is 45,000 m^3/day and this is considered to be the input flow for the design of the proposed HPI options for Kampala.

4.2.2 Water Quality Data

There is a challenge of obtaining consistent and reliable water quality data from the various departments. Consequently, the team relied on the design document ('Kampala Sanitation Programme Lake Victoria Protection Phase II Nakivubo WWTP Final Design Report -Volker Krenn, 2011', referred to as 'PÖYRY 2011') for the WWTP that was supposed to be constructed but was cancelled as the most relevant and reliable data and will be referred to more often.

4.2.3 Terrain Data

Data on size & profile of the terrain being unavailable, we used Google Earth[21].

[21] Google Earth of course lacks the details we needed but it was all we had and we are grateful for it.

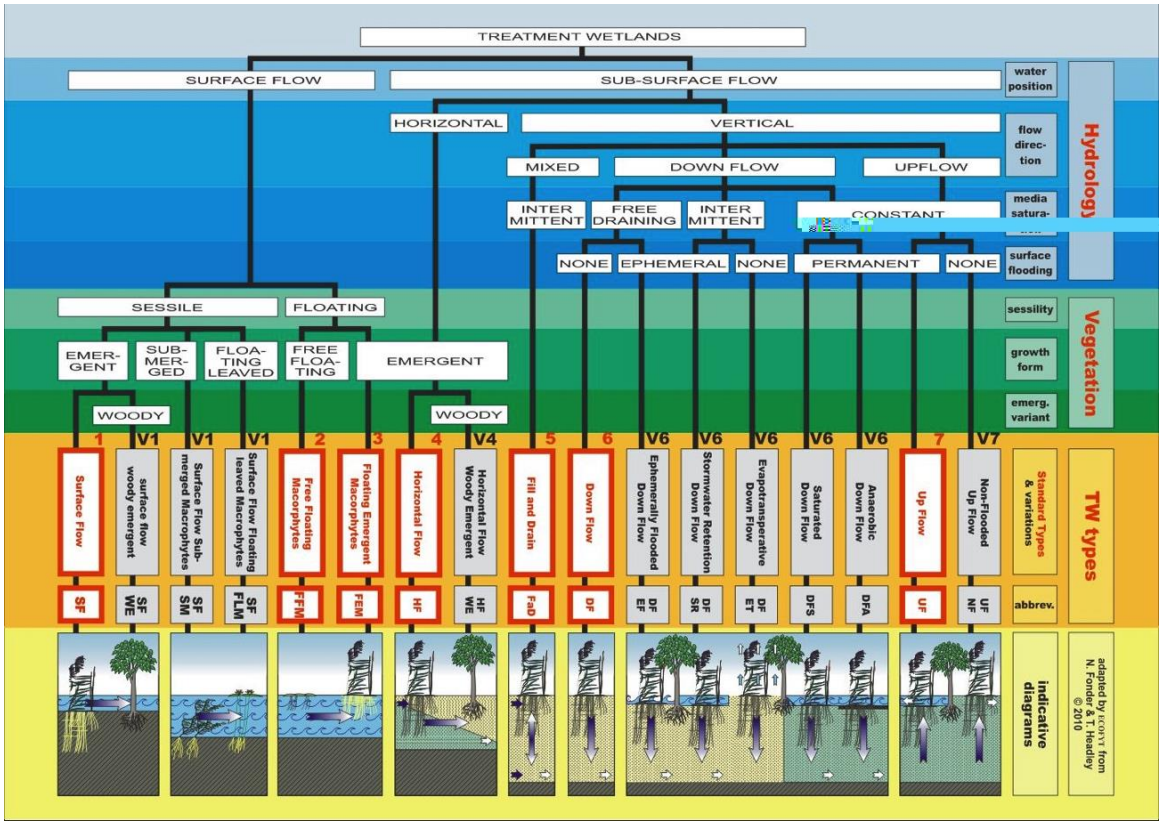

Figure 27: Classification and Configuration of CWs for Wastewater Treatment22

4.2.4 Geotechnical Data

Data on soil structure and characteristics was taken from the Geotechnical Investigation report undertaken for Roko Construction Limited[23].

4.2.5 Data on Plans, Now and in the Future

There is a two track thought on the actual purpose of the proposed HPI system:

- Eventually the wetland is supposed to treat ('polish') the effluent of the WWTP that is being built at the moment and that will discharge at only 650 m distance upstream of the proposed CW system. The capacity of that plant is designed at 45,000 m^3/day so that was taken to be the input figure for the wetland as well. We consider the design document for this WWTP[24] as the most concrete data set, so this document is used and referred to, usually;
- The proposed HPI will handle the Nakivubo channel seasonal flows i.e. 45,000 m^3 equivalent to the dry weather flow.

Currently, the channel receives untreated effluent from a number of commercial and industrial activities with relatively high concentration of pollutants like BOD, COD, suspended solids etc., as indicated in Figure 28. KCCA together with NEMA are planning to enforce treatment of all effluent reaching the channel. Thus if this is achieved, it is anticipated that when the wetland system will be receiving only the channel water, it will not be overloaded.

[22] Source: Fonder & Headley, 2010

[23] Geotechnical Investigation Report (TECLAB – 10-2012)

[24] Kampala Sanitation Programme Lake Victoria Protection Phase II Nakivubo WWTP Final Design Report (Volker Krenn, 03-2011)

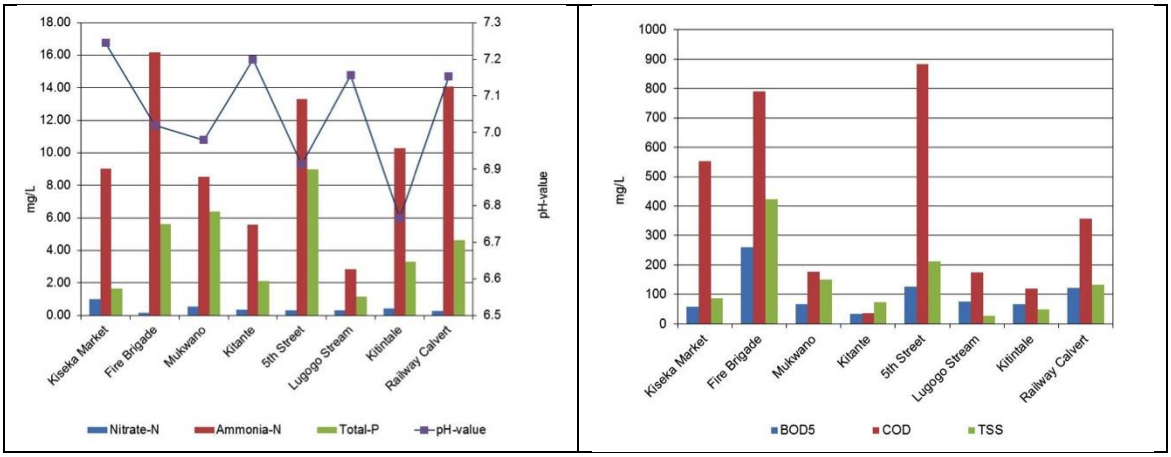

Figure 28: Water quality characteristics along the Nakivubo Channel [25]

Figure 29: Dark Coloured Wastewater after Passing through the Existing Nakivubo Wetland

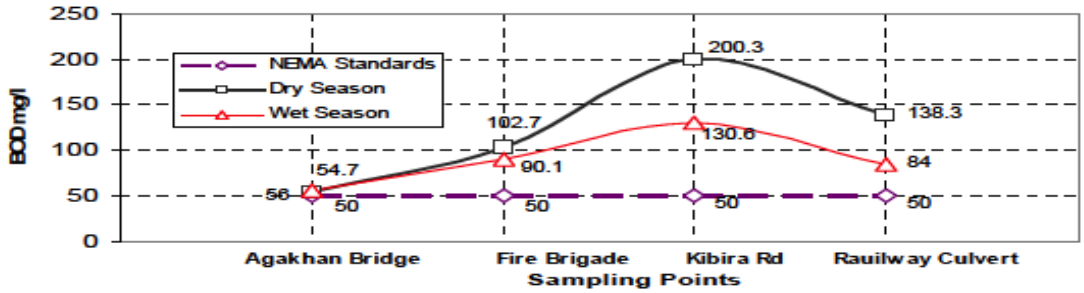

Figure 30: Trend of water quality along the Nakivubo Channel (Source: Kayima et al 2008)

Having to treat and polish the 45,000 m^3 of WWTP effluent is a serious task, hydraulically. Therefore it is proposed that the wetland should not be designed to treat more water, nor more pollution (the load of the parameters in kg per day) than what can be calculated / estimated from that effluent. The desired treated water or effluent quality as per Uganda National effluent discharge standards is given in Table 15.

[25] Source: National Water & Sewerage Corporation (Note: Kiseka market is near the starting point of the channel)

Table 14: Discharge Standards in Uganda[26]

Parameter	Unit	Standard Value
Total Suspended Solids (TSS)	mg/l	100
Total Dissolved Solids (TDS)	mg/l	1200
Turbidity	NTU	300
pH	-	6.0 – 8.0
Temperature	°C	20 – 35
Biochemical Oxygen Demand (BOD_5)	mg/l	50
Chemical Oxygen Demand (COD)	mg/l	100
Soluble Reactive Phosphorus	mg/l	5
Total Phosphorus (TP)	mg/l	10
Sulphites	mg/l	1
Sulphates	mg/l	500
Nitrate-nitrogen	mg/l	20
Nitrite – nitrogen	mg/l	2
Ammonium – nitrogen	mg/l	10
Total Nitrogen (TN)	mg/l	10
Colour	TCU	300
Total Coliforms	CFU/100ml	10,000
Faecal Coliforms	CFU/100ml	5,000

The pollutant loading calculations prepared by the design consultant of the Nakivubo WWTP (PÖYRY, 2011) on the influent quality (Table 15 15) are used as the basis our influent quality.

There is a calculation done by the designers of the Nakivubo WWTP on their influent quality as presented in Table 16.

Table 15: Loads over the Years

Parameter	Year		
	2013	2023	2033
BOD_5 [kg/day]	11,110	12,550	15,200
COD [kg/day]	20,860	23,550	28,500
TSS (including 0% return flows from sludge treatment)	12,221	13,805	16,720
Total nitrogen TN (including 10% return flows from sludge treatment)	3,119	3,493	4,180
Total-P	1,023	815	380
Specific BOD_5 [g/cap/day]	40	40	40
Population connected to WWTP	277,750	313,750	380,000

From Table 15, the calculated water quality considered for the design is presented in Table 16.

Table 16: Calculated Nakivubo WWTP Influent Quality (PÖYRY, 2011, Figure 50, Page 69)

Parameter (mg/l)				
BOD_5	**COD**	**TSS**	**Total - N**	**Total-P**
338	633	372	93	8

Using values in Table 16, a rather conservative approach was taken on the desired effluent quality of the CW. Not because of insufficient trust in their works or design but merely due to mishaps that may occur during start-up and operation of the plant, such as electrical failures or not having reached the desired number of connections caused by an incomplete sewer infrastructure.

[26] The list provides more parameters the ones given are more relevant for the design under consideration.

Removal efficiency of 60% was considered for BOD_5, COD and TN parameters (where it was assumed that the TN would mostly be Kjeldahl nitrogen and ammonium nitrogen, being rather fresh wastewater). For TP, a different approach was used. If the decline in phosphorous discharge would not be met, the calculated value of 8 mg/l for WWTP influent would not be met, influencing the effluent quality highly. Therefore, a slightly conservative starting point as effluent of the WWTP was taken with respect to TP.

Consequently, using values in Table 16 the influent quality for the wetland system was set at values presented in Table 17.

Table 17: Estimated FWS System Influent Quality

Daily flow (m^3/day)	BOD_5 (mg/l)	COD (mg/l)	TSS (mg/l)	Total-N (mg/l)	Total-P (mg/l)
45,000	135	253	37	13	8.4

4.3 Design of Proposed HPI

4.3.1 Constructed Wetland

The first option considered in the design of the CW was a subsurface system, either vertical or horizontal (see Figure 27). Subsurface systems use substrate materials as sand and gravel, such materials cannot be found in the soil of the Nakivubo swamp. Hence it should be mined elsewhere and then transported to the Nakivubo site. Given that the subsurface system would require 15,750 thirty-ton trailers of sand and/or gravel, the idea of subsurface wetlands was dropped, as it would be costly both for the construction and operation phases. In addition, Kampala Capital City Authority (KCCA) had already expressed favour of a Free Water Surface system (FWS) for the pilot system so this was considered for the next design criterion.

4.3.1.1 Hydraulic Retention Time

The primary design criterion for this (not too extreme) pollution concentration is merely based on time spent in the system. A three day Hydraulic Retention Time (HRT) is, based on both literature and experience supposed to be sufficient to get to values close to the target discharge values as well to the background values of surface water of reasonable quality.

In our design, given the shape of the terrain, it was not possible to achieve exactly 3 days retention time in the wetland itself, 2.7 days was the maximum, which is sufficient.

A summary of the design calculations for the CW system is presented in Table 18 and the layout relative to other areas of the wetland catchment presented in Figure 31.

Table 18: Design Calculations for the CW System

Description	Unit	Value
Daily Capacity	m^3/day	45 000
Avg. sewage strength	mgBOD/l	135
Bacteriological Quality	E-coli/l	1E+07
Breakdown rate BOD at 22°C.	1/day	0.42
Breakdown rate E-coli at 22°C	1/day	3.68
Sedimentation Tank		
Retention time	Days	0.90
Volume	m^3	40 500
Depth	M	1.62
Surface area	m^2	27 000
Desludging interval	Years	5
Per person sludge production	liters/year	1
Sludge	m^3	1 545
Extra depth	M	0.06
Total depth	M	1.68
Organic loading	gBOD/m^3/d	150
BOD removal lower layers	%	0%

Description	Unit	Value
Remaining BOD	mgBOD/l	135
BOD effluent	mgBOD/l	98
BQ effluent	E-coli/l	2E+06
Efficiency BOD removal	%	27%
Efficiency E-coli removal	%	77%
Land requirement	Ha	2.7
Parallel CW Cells		
Number of parallel cell-lines	No	25
Overall retention time	Days	2.7
Number of wetlands in cell-line	No	16
Retention time per cell	Days	0.17
Volume per cell	m^3	277
Effective depth	M	0.35
Surface area per cell	m^2	826
Width per cell-line	M	8.65
Length per cell-line	M	96
BOD removal lower layers	%	0%
Remaining BOD	mgBOD/l	98
BOD effluent	mg/l	33
BQ effluent	E-coli/l	1E+03
Efficiency BOD removal	%	66%
Efficiency E-coli removal	%	100%
Land requirement	ha	58.5
Sludge drying	Ha	0.3
Summary		
Net Land requirement	**Ha**	**61.2**
Gross Land requirement	**Ha**	**67.3**
Total retention time	***Days***	***3.60***

Figure 31: Proposed Configuration of the Proposed Nakivubo CW System

4.3.1.2 Pumping

The water level of the Nakivubo channel is about 1.0 m below the surface of the Nakivubo valley. It is desired that water flows, well controlled, over the surface of the designed CW. However, this is not achievable without interference unless the entire surface area required is lowered or the water is raised and thereafter flows by gravity to the subsequent units of the CW.

With the first option, it would require lowering 61 hectares by 1.00 m and given the water table in the area, this would not be an appropriate option. This leaves no other alternative apart from pumping. Pumping will therefore require raising 45,000 m^3 per day for probably more than 2.00 m into the first pond (sedimentation basin) from where the water could flow by gravity all the way to the end.

In November 2016, KfW has suggested to have a weir installed instead of / in combination with a pump. This would enable to channel the complete Dry Weather Flow to the CW. This would require (re-) negotiations with KCCA as they did forbid the application of in-channel structure for the intake of the WWTP Bugolobi. KCCA want to prevent any negative backflow impact in case of flooding. See text box.

Due to the good topographic conditions, a weir with negative backflow impact in cases of floods could have been avoided. A 0.5 m wide concrete U-channel shall cross the complete width of the Nakivubo channel. This U-channel has a downstream step of 0.85 m in order to create o shooting- self-cleaning- flow speed over the screens. It is covered with metal bars in form of screens with 50mm spacing- thus allowing trees, stones, bottles to pass over the screens and not to be stucked on a possible weir. The screen elements are fixed with hinges in the concrete structure and thus can be lifted for cleaning purposes – but cannot be stolen or eroded. On the left side in downstream direction a regulating penstock is installed. At same location- but facing downstream a flushing penstock is installed which can be opened from time to time to release sands or hardened sediments downstream.

Source: Project Manager: GKW Consult GmbH/PEC Ltd JV, January 2016

During our conversations with GKW Consult in on 23 June 2016, we were informed that KCCA instructed the GKW Consult to construct a channel parallel to the Nakivubo Channel where the pump could be located. Hence, for the time being, we assume that the intake construction of the CW can/will be the same as the intake for the WWTP Bugolobi: a structure parallel to the channel with a pump in order to eliminate any risk of flooding.

The pump will be an important factor in the total costs of the system, moreover since this was the former site where the WWTP had been projected originally - and then discarded since the clayish soil does not allow heavy structures. It is proposed that the inlet pumping station that had been designed for the WWTP in Nakivubo wetland, whose details are given below, be adopted for the CW system with slight modification in the number of pumps, hydraulic lift or head and design flow per pump. However, this is a technical design issue that needs more attention and specific knowledge. It is not elaborated in this Feasibility Study.

- Type of pump: Archimedean screw pump
- Number of pumps in operation: 1
- Number of stand-by pump: 1
- Design flow per pump Q = 625 litres/s
- Total pumping capacity (normal operation) 520 litres/s
- Diameter of pump: 1.8 m
- Angle of installation: 38°
- Number of flights: 3
- Highest Hydraulic lift, H: 4 m
- Efficiency estimated: 65%
- Power demand of pump: $\frac{P = 9.81 * Q*H = 9.81 * 0.625 * 4.00}{\eta} = \frac{}{0.65} = 37.7$ kW
- Rated motor power per unit selected: P = 40 kW

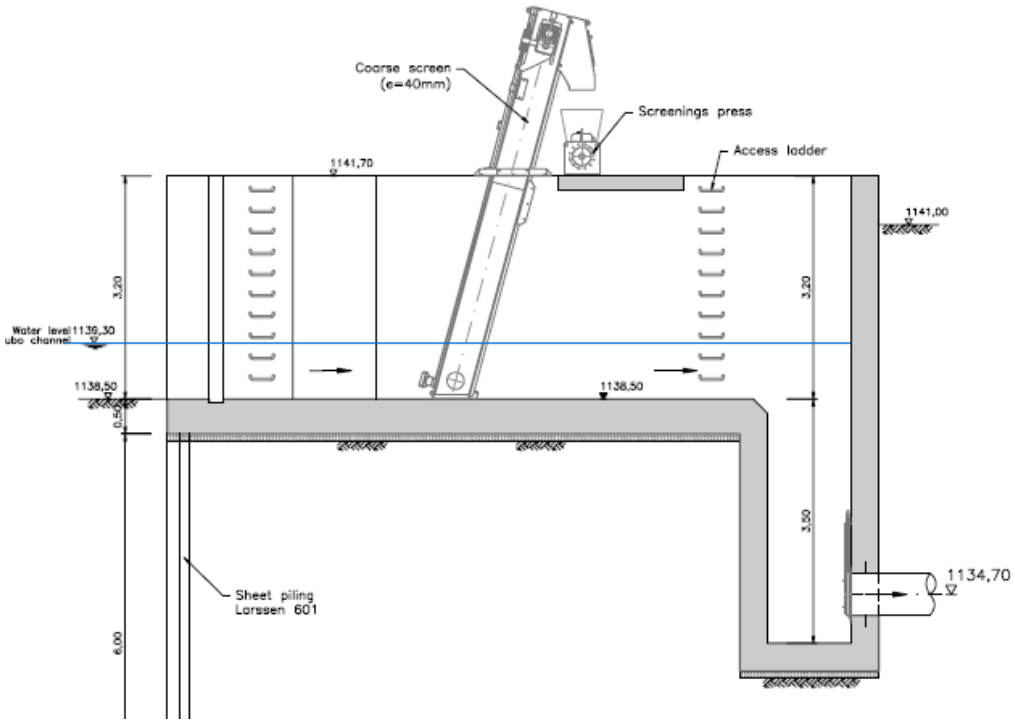

Figure 32: Proposed Water Intake

Adopted from NWSC, 2011

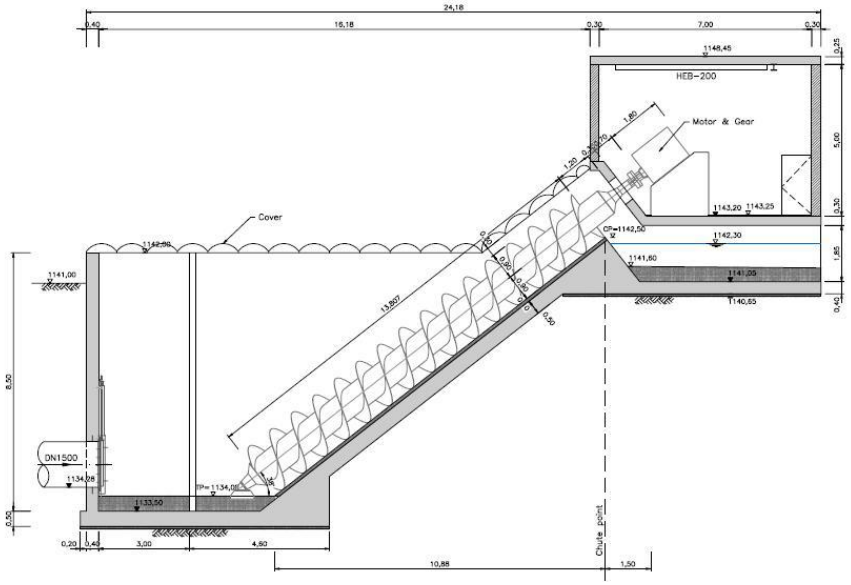

Figure 33: Inlet Pumping Station – Longitudinal Section

4.3.1.3 Sedimentation Pond

In this first pond, the water should preferably loose a large quantity of its finer solids, which calls for the possibility of retention. With the designed pond area and flow, the critical flow velocity or overflow rate is about 0.02 mm/s with HRT of about 0.9 days in the elevated sedimentation pond. This means that all particles with settling velocity greater than 0.02 mm/s will completely settle.

The triangular shape is meant as a way of reducing the velocity of the water down, gradually and spread it over the entrance structures of the FWS wetlands. The entire bottom of the sedimentation pond should constructed using compacted gravel or rock or a mixture of the two.

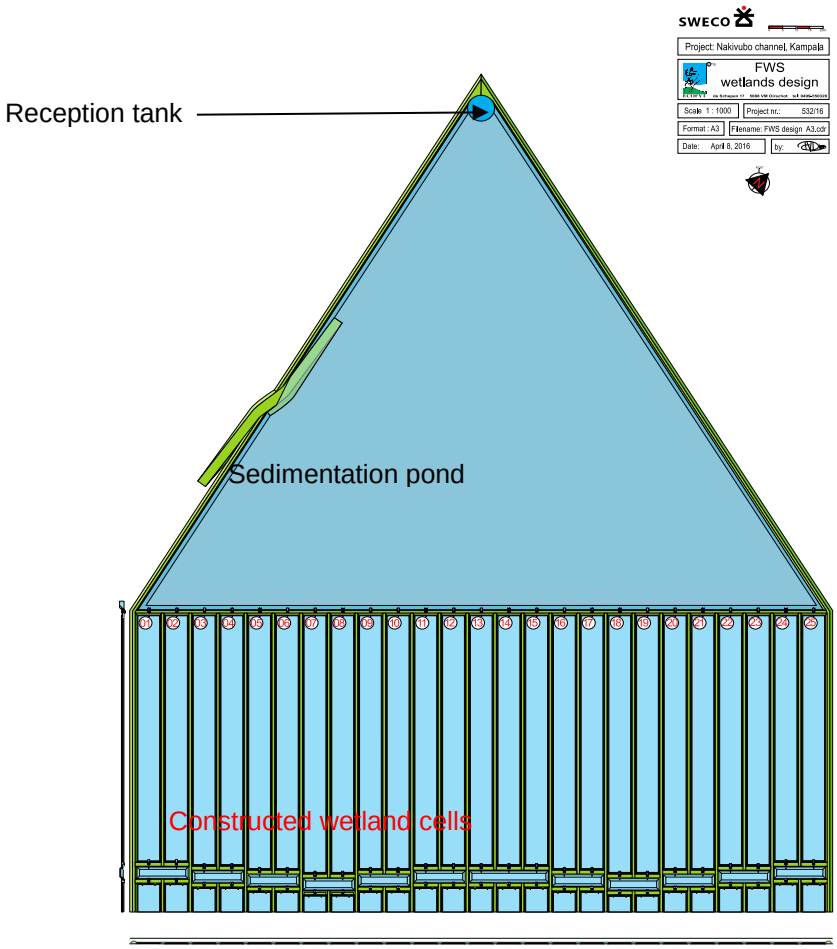

Figure 34: Layout Sedimentation Pond relative to the CW Cells

4.3.1.4 Reception Tank

The water is pumped in a concrete reception tank at the top of the elevated sedimentation basin. This structure was chosen to break the force of the pumping power and the erosion that could be the effect of it. It is a circular tank with a volume of 150 m³, diameter of 10 m' and a height of 2 m'. The water will overflow at one half of the tank because that side is lower. It would also be possible to give that half side adjustable V-notches to divide the water in an optimal way over the triangular sedimentation pond.

4.3.1.5 Shape

During the design, less attention was paid on the possible beautification/ attractiveness of the system. A lot of space was needed first and keeping it basically simple and replicable (there are two identical sets of 25 x 8 wetlands) would help on both cost factors and to keep the intervention doable.

4.3.1.6 Consideration for 25 Parallel CW Cell Lines

The daily flow of 45,000 m³ must be divided over a wide surface. But water tends to always find the simplest and fastest route. The wetland design is based on controlling the flow and to prevent short-circuiting in the system. The more channels built, the narrower they get and the lower the chance that the water will find a short path, creating dead zones and thus decreasing the HRT.

On the other hand, the construction of too many dikes between the FWS wetlands would cost more surface area for the entire system. Therefore a 260 m wide rectangular shape was projected in the Nakivubo valley with 25 parallel ditches, each 8.65 m wide.

4.3.1.7 Consideration for 8 Linear FWS Cells

The above-mentioned rectangular configuration gave the possibility for a length of 830 m with 8 wetland cells or beds resulting in a length of approximately 95.5 m per bed. This would give manageable patch of land/wetland in terms of spot related maintenance spread harvesting of vegetation.

4.3.1.8 Consideration for Interval Ponds

With the interval ponds, it is possible to take any cell out of operation, without hampering the general use of the lines. The interval ponds give the possibility to bypass any wetland cell and redirect the water over the next two cells in the line. Every time you will find that two stretches of FWS cells (the total length of 830 m and 2 x 8.65 m wide) belong together.

4.3.2 Stabilization Pond System

Another option considered was the waste stabilisation pond system (WSP) with a schematic layout presented in Figure 35.

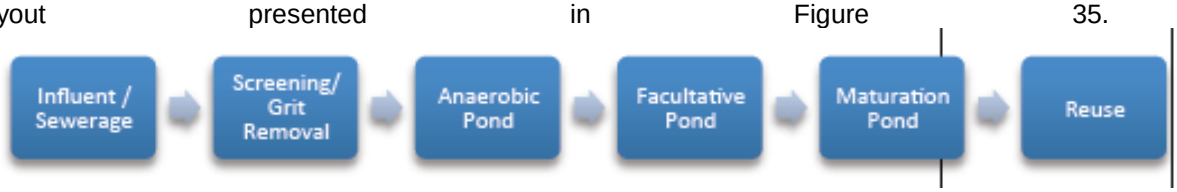

Figure 35: Schematic Layout of a WSP System

The design requirements for the WSP system are presented in ***Table 19***.

Table 19: Design Values for the WSP System as an Alternative

Parameter	Unit	Value
Anaerobic Ponds		
Retention time	days	1.00
Volume	m^3	45,000
Depth	m	2.5
Surface area	m^2	18,000
Desludging interval	years	5
Per person sludge production	litres/year	1
Sludge	m^3	1,545
Extra depth	m	0.09
Total depth	m	2.59
Organic loading	$gBOD/m^3/d$	135
BOD removal lower layers	%	30%
Remaining BOD	mgBOD/l	95
BOD effluent	mgBOD/l	67
Bacteriological effluent quality	E-coli/l	2E+06
Efficiency BOD removal	%	51%
Efficiency E-coli removal	%	79%
Facultative Ponds		
Retention time	days	5.53
Volume	m^3	248,830
Effective depth	m	1.50
Surface area	m^2	165,887
BOD removal lower layers	%	0%
Remaining BOD	mgBOD/l	67
BOD effluent	mg/l	20
BQ effluent	E-coli/l	1E+05
Efficiency BOD removal	%	70%
Efficiency E-coli removal	%	95%

Maturation/Fish Pond		
Retention time	days	0
Volume	m^3	-
Effective depth	m	1.50
Surface area	m^2	-
BOD removal lower layers	%	0%
Remaining BOD	mgBOD/l	20
BOD effluent	mg/l	20.2
Bacteriological effluent quality	E-coli/l	1E+05
Efficiency BOD removal	%	0%
Efficiency E-coli removal	%	0%
Fish production	kg/month	0
Sludge drying	ha	0.3
SUMMARY		
Net Land area requirement	ha	18.70
Gross/Net		1.25
Gross Land requirement	**ha**	**23.4**
Total retention time	**days**	**7**

4.3.3 Improvement of Reticulation in the Existing Wetland

The third option is to improve the water reticulation in the existing wetland aiming at increasing the retention and rejuvenation of the wetland. This would need the construction of a weir at the railway culvert.

Figure 36: Reticulation System in Existing Nakivubo Wetland

4.4 Construction of Wetland

Due to lack of data, it was not possible to carry out calculations on soil transport (cut-and-fill or cut-to-spoil) in the terrain. It is assumed that the entire works can be done in soil balance; without adding soil from elsewhere or moving surplus soil to another place.

4.4.1 Survey

A complete survey of the area preferably at a grid of 25 m' or less, would provide more detailed information regarding where soil should be removed or cut and where it should go to.

4.4.2 Levelling

Before the construction starts, the terrain should be levelled while maintaining the existing slope (the longitudinal slope), but in the other direction (latitudinal) there should not be any slope to make sure that every line of FWS wetlands receives the same amount of water.

4.4.3 Dikes

In the design drawings, all dikes are made with 45° slopes. The inner dikes are set at heights of 0.60 m, to divide the FWS cells that store water at a depth of 0.35 m. The proposed elevation should be sufficient for that cause, making these dikes higher would cost more room for the water transportation.

The outer dikes are set at a height of 3 m' as they have to protect the CW against floods with a frequency of more than 1:100 years. See text box below.

According to the Kampala Drainage Master Plan the water level for a return period of 10 years does not differ much from the water level for a return period of 100 years. This is caused by the topography of the valley: The bottoms of the valleys are very flat whereas the hills on both sides of the valleys are considerably steep. Consequently the ground level for the Nakivubo WWTP was fixed to a level of 1139.00 masl in the Feasibility Study. The topographic survey was carried out in December 2010. It is obvious that there is a big difference between the as-built drawings and the reality surveyed recently. The actual channel width is not 30 m' but only 15 m'; the channel depth is not 2 m' but only 0.80 m'. And the most important point is the highest flood level. After heavy rainfalls the lower parts of the Namuwongo slum are flooded by the storm water flow in the Nakivubo Channel. The highest flood level reaches a value of 1140.66 masl. Highest flood level of Nakivubo Channel: 1140.66 masl To be on the safe side, it was decided to use a ground level of 1141.00 masl for the design of the new Nakivubo WWTP. The average existing ground level of the Nakivubo wetland in the area of the future treatment plant is about 1138.00 masl, which means that there will be a filling of about 3 m.

Source: Kampala Sanitation Programme, Lake Victoria Protection Phase II, Nakivubo WWTP, Final Design Report, PÖYRY Environment GmbH – Report Quality Assurance, 1/3/2011

4.4.4 Floating Mat

Floating mat means that even though it looks like land, it actually is water, possibly even deep water. There was a tiny patch of floating mat at the far end of proposed site of the CW that was noted during the field visit on March 30, 2016. It was not very far from one of the culverts and in this design it would match the last pond in the line, after the last FWS wetlands set. Would the soil survey discover more areas like that where wetlands or dikes are projected, that area needs to be filled with clay.

4.4.5 Access Roads

There is need to construct an access road around the system to facilitate operation and maintenance activities. This road should not be less than 3 m wide and should be strong enough to carry trucks of several tons. In the sedimentation pond, a maintenance ramp (compacted gravel/ rock) has been provided which should connect directly to the access road. The sedimentation pond may need maintenance at a 3 - 5 year interval basis.

4.4.6 Wetland Vegetation

Introducing new plant species is not a common practice in wetland building. Therefore, the best thriving, locally available marsh plants have been considered to avoid unforeseen trouble on that level. Marsh plant species (macrophytes) in the Nakivubo swamp area include: *Typha* sp.,

Cyperus papyrus L., *Phragmites* sp., and *Miscanthidium sp*. (and many smaller species). It is required to consider (one or more) plant species that have good water purifying qualities and also have an additional socio-economic value.

4.4.6.1 Papyrus

Of the plants mentioned, Papyrus has the greatest possibilities to have a commercial value. There is also a history of use of this plant. That is why it has been chosen as the main species in the wetland. It was also originally the most dominant plant in the Nakivubo wetland. Papyrus is used for weaving mats, making brooms and other crafts. There is also a possibility to make artisanal paper from it, which can be used for tourist products (as is a common practice in Egypt).

4.4.6.2 Bamboo

In the adjacent informal area, there has also been an initiative to do a trial with bamboo. Bamboo is a common plant within the Lake Victoria catchment although its use in water treatment locally is not yet known. But we appreciate such initiatives from the direct environment and think that it can be used as a means of getting the local people involved. Though this initiative never got beyond words, of course bamboo is a plant with sheer endless economic possibilities.

It is however not a plant (in general, there may be exceptions) that grow in flooded habitats and that is exactly what a FWS wetland is. But in and around the connecting ponds, there would be room for such species for beautification or recreational purposes. In the ponds it could be planted on 'created' islands, probably with a sandy, organic, permeable topsoil structure so the water that is to be treated would be able to reach their roots.

4.4.7 Phosphorus and Nitrogen

One of the functions of the wetland should be that it is able to remove the remaining nitrogen and phosphorus (N&P). This is not always easy to manage. Bacteria in the water and in the detritus will transform the Ammonium nitrogen into Nitrate and Nitrite and even partially into N_2 and the plants will live on the nitrogen (they prefer the nitrate form) and the Phosphorus. Phosphorus will also bind to the smaller particles and thus precipitate in the system. These are the processes to 'fix' N and P - while harvesting is the process to take N & P out of the system. It has been mentioned before: harvesting serves an essential function in the final result of the wetland. Plants that die off in the cells will eventually release the N & P that they accumulated.

4.4.8 Beautification

The primary goal of the wetlands is to improve the water quality. This feasibility study has focused mainly on 'functional engineering' but there are more sides to designing. Some social as well as economic aspects were taken into consideration but it would be helpful getting the neighbouring communities to really start to like and appreciate the place. That may help to keep the location tidy and hence make it a long lasting success. Beautification is therefore a serious matter and should be considered in any design, if people are involved.

4.4.8.1 Interval ponds

The basic concept is a bit dull and repetitive. The irregular shapes of the interval ponds, however, are chosen in order to create a somehow attractive system. While walking alongside the beds, one can be able to look deep in the system at the interval ponds yet not strait through it because of the somewhat curved design. It's a tiny adjustment to make the design not too 'industrial'.

4.4.8.2 Connecting North and South

There are plans to bridge the area with a new 'high road'. KCCA has confirmed that it will follow the path as given in the design of the HPI (Appraisal mission, June 2016). Care needs to be taken that the road has adequate culverts to let the water pass without any interruption. This is outside the scope of this study.

4.4.8.3 'Communicating Ponds'

Between the two FWS systems the area is not wide enough to continue the FWS systems. Instead of making it very complicated we came up with a set of ponds on both sides of the path we mentioned earlier. These ponds can be beautified: the sides could be planted with multiple locally available marsh plants and even decorative flowering plants like Canna (big yellow, orange or bright to dark red flowers) which are found in many places all over Kampala. We also designed islands in those ponds; they could for instance be planted with bamboo, as mentioned in the chapter 'Wetland vegetation'. Palm trees would be another option because they are also present at the proposed HPI site.

4.4.8.4 The 'Catwalk'

Ideally the wetland is that attractive that it could serve as a public green space as suggested in a recent World Bank funded study. See impression in Figure 37. The status of this study is not clear.

Figure 37: Concept Vision Nakivubo Park[27]

[27] Source: Promoting Green Urban Development in African Cities, A preliminary investigation of the potential costs and benefits of rehabilitation of the Nakivubo wetland Kampala, Uganda December 2015 – DRAFT, prepared by Prepared for AECOM, on behalf of The World Bank and the KCCA by Jane Turpie, Liz Day, Dambala Gelo Kutela, Gwyneth Letley, Chris Roed and Kat Forsythe

Alternatively, a meandering, wooden path all across the wetland, connecting all dikes, which are 25 cm higher than the surrounding water table, built on poles standing in the wetland and (to allow people passing each other) some 2 m wide could be constructed. Such an investment would not be 'functional' in the common sense. But it would give a possibility to get people to really appreciate their new wetland. The papyrus species can certainly be considered a decorative, elegant plant. Walking this winding path would bring you across and over full-grown cells, freshly harvested cells, cells with young vegetation, interval ponds. In the middle it could be elevated platforms, where you can oversee the 200 cells of that system, maybe even see the precipitation pond in the beginning, the connecting ponds and their vegetated islands, and with the other FWS wetland further away. And on the elevated platform a fairly traditional hut would be the office of the wetland manager. The platform could well be located above one of the bigger interval ponds (there is one set of interval ponds that communicates with three lines of wetland cells instead of two).

4.4.9 Biodiversity

Biodiversity is not a primary design criterion for CWs. We 'create nature' but we already restricted ourselves to the plants that have optimal effects for water purification, combined with economic value. However, if the CW becomes a healthy environment it will attract others species.

4.4.9.1 Plants

Though we suggest a monoculture of papyrus, there is a possibility to also bring a variety of floating plants in the interval ponds. On the islands and around the connecting ponds there is hardly any restriction towards plant species that can be chosen.

4.4.9.2 Insects

If flowering plants are used, many species of insects are attracted. Dragonflies (also feed on mosquito larvae) are surely in their element in swamp areas and several butterflies probably as well. In this context, one has to consider mosquitoes: swamps and mosquitoes are highly related. Yet literature usually tells that CWs do not per se increase the amount of mosquitoes. It might be wise to do some continued research on this matter but it is most unlikely that the Nakivubo swamp in its actual state would be poor in mosquitoes and a CW would be rich in them. It is most conceivable that it will not really differ much.

It is a public perception that wetlands provide breeding grounds for mosquitoes and cause mosquito problems. Whilst virtually any water source is a potential breeding ground for mosquitoes, wetlands can be designed to reduce mosquito habitat (Sarneckis, 2002). Monitoring of mosquito populations in communities before and after wetland construction has shown that well-designed wetlands do not necessarily cause an increase in mosquito numbers (Sarneckis, 2002). Manipulation of physical components, such as water levels and vegetation cover, in combination with chemical and biological control agents, can be used to maintain mosquito populations at low numbers.

Physical control: Water level fluctuations can be detrimental to mosquitoes, by either drowning or stranding their larvae. Maintaining water movement through the wetland can help also decrease mosquito populations. Therefore, the water level needs to be adjusted when need arises with the intention of controlling mosquito breeding apart from harvesting of plants. Periodic harvesting of dense stands of emergent vegetation and sediment build-up will help reduce the production of mosquitoes.

Biological control: This is generally achieved to some degree through predation by other organisms. Natural predators of mosquitoes include fish, predacious mosquito larvae, other insects, spiders, fungal diseases, nematodes, protozoans, aquatic birds, frogs and some reptiles. Macroinvertebrates, such as waterbugs (Hemiptera), dytiscidae beetle larvae (Coleoptera), dragonflies (Anisoptera) and damselflies (Zygoptera) are generally more successful predators of mosquito larvae than fish in heavily vegetated areas (Chester 1990). When a system is not heavily vegetated, fish and some larvicides derived from bacteria are generally the most effective means of controlling mosquito numbers.

4.4.9.3 Birds

There are specific birds that live and thrive in marshes, some only come there for foraging or getting nesting materials. Again: if it gets to be healthy system it is more likely that the number of birds grow than diminishes. The ultimate gain would be if the Crested Crane would return to the Nakivubo area because it is the national bird of Uganda, it used to live here in larger quantities but the local people sigh if the subject comes to table: it is said that they left, because the swamp lost all attractiveness as a habitat for this bird.
They have not completely disappeared however, a couple was spotted, flying by, as we had one of the meetings with the local authorities.

4.4.10 Conflicts to Consider

In the Nakivubo WWTP design document, an emergency chlorination basin of 1,150 m^3 precedes the wetlands[28].

Page 11 of the WWTP document states:
"If the performance of the restored wetlands is good and the concentration of the faecal coliforms in the effluent of the wetlands is below 10,000 Nr/100mL, there will be no effluent chlorination. But if the restored wetlands cannot remove enough coliforms and the effluent concentration of the wetlands is higher than 10,000 Nr/100mL, the chlorination will be used."

According to us, that would be contra productive to the processes expected in the wetlands. We advise not to use the chlorination.

4.5 Effect of the Treatment on the Quality of the Water in the Nakivubo Channel

A major issue is the question what effect the treatment in the CW will have on the quality of the water in the Nakivubo channel. In the following table this effect is calculated. The outcomes are:

- The CW is designed to treat the effluent of the WWTP from 135 mgBOD_5/l to 33 mgBOD_5/l (Phase 2);
- As long as the WWTP is not fully operational, the CW will treat Nakivubo channel water (Phase 1). It is to be expected that the BOD in the Nakivubo channel is higher than 135 mgBOD_5/litre;
- In case the BOD_5 in the channel is 200 mgBOD_5/l:
    - 30,000 m^3/d can be treated;
    - The quality of the water after mixing is 98 mgBOD_5/l (assuming 45,000 m^3/d flow in the channel);
    - Improvement is 51%;
- In case the BOD_5 in the channel is 100 mgBOD_5/l during the rainy season (100,000 m^3/d);
    - 45,000 m^3/d can be treated (hydraulic limits);
    - The quality of the water after mixing is 66 mgBOD_5/l;
    - The improvement is 34%.

Table 20: Effect of CW on the Quality of the Water in the Nakivubo Channel

Situation > 2040		
Description	***unit***	***value***
Discharge effluent WWTP	m^3/d	45 000
Dry season flow Nakivubo channel	m^3/d	45 000
BOD effluent WWTP / influent CW	mgBOD_5/l	135
BOD effluent CW	mgBOD_5/l	33
BOD removed	kg BOD/d	4 590
Nakivubo channel dirtier		

[28] We were not able to obtain the design of the Bugolobi WWTP

Situation > 2040		
BOD Nakivubo channel	mgBOD_5/l	200
BOD effluent CW	mgBOD_5/l	49
Discharge treated	m³/d	30 397
BOD Nakivubo channel downstream	mgBOD_5/l	98
% Improvement	% BOD_i	51%
Wet season		
Wet season flow Nakivubo channel	m³/d	100 000
Expected quality wet season	mgBOD_5/l	100
Discharge treated	m³/d	45 000
BOD effluent CW	m³/d	25
BOD Nakivubo channel downstream	mgBOD_5/l	66
% Improvement	% BOD_i	34%

Once the Bugolobi WWTP is functioning, it will also treat some of the water of the Nakivubo channel upstream. This will have a positive effect on the water quality upstream of the CW. Hence; the water quality of the Nakivubo channel will be better than shown in the calculations above. See the following text box.

Abstraction by Bugolobi WWTP. *The planned water extraction shall be located upstream from the new Wastewater Treatment Plant. This extraction is planned as a temporary measure- until NWSC has constructed sufficient Sewer pipes in order to fill the new WWTP by 100% with sewerage. This temporary period is actually estimated to be approximately 17 years (year 2033). Most probably from mid/end of 2017 on, a flow of about 12,000 m^3/day with a peak extraction of 381 l/s shall be extracted from the Nakivubo Channel. As the hydraulic flow rate at the planned point of Extraction is about 1-2 m^3/s in the dry season, a percentage of 15-30% shall be extracted in the dry season and treated together with the sewage and re-discharged with same flow rate about 300 meter downstream though the existing outfall channel from the existing (old) Treatment. A 100% extraction in the dry season shall be avoided in order to keep the biological and limnological activities downstream operational.*

Source: Project Manager: GKW Consult GmbH/PEC Ltd JV, January 2016

4.6 Cost Estimate of the Proposed HPI and Cost Estimates of Alternative Scenarios

In Table 22 the estimated costs for the CW system are indicated.

Table 21: Estimated Cost for the CW System

Item Description	**Unit**	**Qty**	**Rate (EURO)**	**Amount (EURO)**
A. Clearing and grubbing	ha	61	400	24,400
B. Excavation and embankment shaping works				
Sedimentation basin	m^3	4,211	14.00	58,958
Constructed wetland	m^3	79,471	14.00	1,112,591
C. Constructed wetland basins with macrophytes		-		
Topsoils	m^3	86,074	7.90	679,987
Compacted clay liner	m^3	89,219	12.26	1,093,825
Compacted rock	m^3	3,436	138.00	474,196
Macrophyte planting (10 shoots per square metre)	m^2	496,800	3.00	1,490,400
Landscaping and grassing	m^2	2,907	3.25	9448
D. Inlet and outlet infrastructure				

Item Description	Unit	Qty	Rate (EURO)	Amount (EURO)
Outlet manholes	nr	230	400.00	92,000
Inlet manholes	nr	230	400.00	92,000
UPVC pipes 6m length	nr	920	21.54	19,817
uPVC caps	nr	460	3.72	1,711
UPVC elbow joints	nr	460	8.34	3,836
UPVC 90 degree T joints	nr	925	8.40	7,767
E. Interval Open Water Ponds		-		
Top soils	m^3	3,390	7.90	26,783
Compacted clay liner	m^3	3,899	13.00	50,691
F. Sedimentation Basin		-		
400mm compacted rock	m^3	12,075	138.00	1,666,350
Compacted clay liner	m^3	12,075	12.26	148,040
Inlet chamber mass concrete	m^3	17	140.00	2,415
Access ramp - crushed rock 200mm	m^3	104	138.00	14,283
G. Water Sump and Pumping		-		
Concrete works	LS	1	85,000.00	97,750
Pumping system	nr	1	1,000,000	1,150,000
Bar screen (c = 40mm)	nr	2	25,000.00	57,500
Sub-Total (rounded)				**8,300,000**
H. Construction Supervision		LS	805,000.00	400,000
Sub-Total				**8,700,000**
ESTIMATED GRAND TOTAL				
I. Annual Operation and Maintenance requirements				
Installation and commissioning including training	Year	1	14,085	14,085
Energy requirements for pumping station	Year	1	57,890	57,890
Maintenance of pumping station	Year	1	36,622	36,622
Environmental concerns and remediation	Year	1	19,719	19,719
Labour	Year	1	42,125	42,125
Maintenance of CW - Pipe & accessories, dikes & embankments	Year	1	8,614	8,614
Sub-Total				**179,055**

4.7 Comparison of Proposed HPI with Alternative Scenarios

An assessment for each of the three options/scenarios was undertaken against a set of defined objective criteria, and then scored options ranked. That is:

- A new CW;
- A stabilisation pond system; and
- Developing a reticulation system at the existing wetland and weir at the outlet culvert to increase retention time and rejuvenate the wetland.

Table 22: Waste Water Management Option Appraisal Scores

CRITERION	Constructed Wetland SCENARIO I	Score	Waste Stabilisation Ponds SCENARIO II	Score	Natural Swamp SCENARIO III	Score
Investment Cost / Ease of construction (€)	€ 9 million	0	€ 5 million	+	€ 3 million	++
Land requirement (Ha)	61	0	23.4	++	61	0
Process Control	Level Quantity per cell	++	Quantity	+	Adjustable weir at end	--
Aesthetics	Imitating nature	++	Plain Black water / Ugly	--	Back to nature	++
Maintenance	Cutting plants, cleaning weirs, pump and sediment	0	Sludge weir and floating matter	+	Cutting plants and entrance clearance	++
Ease of Operation	Needs instruction and supervision	0	Business as Usual	++	Complicated	-
Socio-economic	Lots of Labour, Harvest, Incomes	++	Chased away	-	Chased away	-
Water Quality - BOD, N, P	Good	++	Okay	+	No	0
Energy	Medium	--	Medium	--	Good	+
Possibility for Upgrading/Expansion	Not possible for other areas	0	Just add	++	Okay	0
Malaria	Good	++	Bad	+	Okay	0
Innovatively	Good	++	Okay	0	Okay	0
Safety	Fair	++	Okay	0	Okay	0
	TOTAL	**8+**	**TOTAL**	**7+**	**TOTAL**	**3+**

4.8 Conclusion of the Analysis

As shown in Table 22, the analysis favours the CW scenario as the most plausible option for investment. The analysis looked critically at the ability to remove pollutants i.e. BOD, the energy requirements, innovativeness, safety and lastly controlling vector breeding, especially malaria causing parasites. The analysis did not look critically yet at the function of the CW during phase 2 when it serves as tertiary treatment. It is known that horizontal flow CW may not function well when it comes to tertiary treatment: the aerobic / anaerobic conditions needed for nitrification and denitrification are not that favourable. *Hence a combination between the CW north of the road and a 'natural' swamp south of the road is recommended for further elaboration in the detailed engineering phase.*

5 Project Implementation

If project financing follows the proposed timeframe of September 2016, the implementation period is planned as follows:

- Detailed engineering design;
- Procurement of construction works;
- Construction of works and construction supervision;
- Defects Notification Period.

5.1 Detailed Engineering Design

During this stage, the Consultant (already procured by KCCA for Pilot project) will conduct the full scale CW design under LVEMP II funding including; topographic surveys, detailed drawings and total cost estimates. This activity is anticipated to take three (5) months elapsing in July - November of 2016. However, the necessary land permits and resettlement plans should also be handled at this stage.

5.2 Procurement of Construction Works

A specialised Contractor will preferably be sole sourced to carry out the construction of the project. The Consultant in liaison with KCCA project team will identify the specialised Contractor. The period of procurement of the Contractor is estimated at 1-2 months and therefore project commencement is expected at October – November of 2016.

5.3 Construction of Works and Construction Supervision

The specialised Contractor will commence construction of works under supervision of the Consultant on behalf of KCCA. The period of construction is estimated at 12 months and therefore project completion is expected to be early 2018.

5.4 Defects Notification Period

A defects liability period of 6 months is anticipated where the performance of the CW will be monitored and rectified in case of mishaps in design or quality of works. Eventually after completion of the Bugolobi WWTP with the plant running at its full capacity, its effluent will be connected to the CW to further polish the water and this is estimated to be done in July 2018

6 Operation and Maintenance

6.1 Introduction

The FWS CW system consists of 400 FWS cells each approximately 8.65 m wide by 95.5 m long. It is proposed that the people who are currently carrying out agricultural activities in the swamp (many of them live in the adjacent slum) be employed to carry out operation and maintenance activities of the system but under supervision and guidance of a person knowledgeable in operation of CWs (Central Manager). This would replace the lost source of income for such people.

This approach requires proper supervision and guidance. There should be some sort of manager (probably one per set of 200 wetlands) who needs to know who is harvesting at any moment and who should tell others when it will/could be their turn. It would really disturb the function of the wetlands if too many systems are put dry at the same time in order to harvest the plants. This is of the same importance for the locations of the cells that are set dry.

6.2 Harvesting

In each FWS cell, provision has been made to adjust the water level. This is useful when harvesting: if the plants are cut above the usual water level of 35 cm, much organics would be left on the soil of the bed. To avoid suffocation and dying of plant shoots, the water level should be lowered during harvesting. In addition, this would allow removal of dead plant material like leaves, etc. to avoid creating an ever-growing organic layer (detritus). Most macrophytes will not grow properly when cut below the water level: the stems would fill with water, drowning the plants. This often leads to the dying of the plant. Harvesting could be done as often as twice per year or depending on the growing speed or cycle of the plants.

Harvesting of macrophytes like papyrus is not only a source of income to the operators or harvesters but as plants they take up nutrients like nitrogen and phosphorus compounds from the water. In the process of harvesting, the nutrients are taken away from the system and this also gives way to new plants with more capacity to uptake more nutrients from the water column. Harvesting (also called translocation of nutrients, from the point of view of waste water purification) is actually a primary task in the maintenance and performance of the wetlands.

Between the cells there are dikes separating them, transportation of the harvest can be done, first over the bottom of the cells or the longitudinal dikes (1.00 m wide) and then over the dikes of the interval ponds, which are 1.50 m wide.

6.3 Water Level Control

Adjusting the water table is done in the manholes of the wetlands; each cell has a (covered) manhole in the beginning and a similar manhole at the end. If the first manhole (upstream) is opened all the water flowing here, enters into the pipe, feeding the wetland. With a special fitting cap, the entrance can be blocked, thus cutting off the water flow to the cell. We prefer caps because valves are expensive, can easily be left open or closed or damaged, thus affecting the smooth operation of the system.

At the end side of each of the CW cell a similar structure should be built because the water level is communicating with the (interval) pond at that end. In the manhole there, a (160 mm) pipe structure with two pipes (160 mm diameter) standing up is visible, a lower one and a higher one.

The lower one should get a similar cap and then the cell is isolated from the continuous flow. Note that the higher pipe is an emergency exit in case mistakes are made in the levelling regime: at 50 cm, the water will overflow, instead of using the 60 cm dikes. Eventually the plants would consume the water that was trapped in the cell and the bed would fall dry. But probably this will take too long. Per system, there is a total of 400 beds to be harvested, twice per year so time is a limiting factor.

6.4 Central Wetland Manager

If one person is in charge of the water regime, the chance for mishaps is reduced to the minimum. This must be someone who truly understands the principles of the wetland and is seen as the authority that has the wellbeing of the wetland as well of its users in mind. He/she should have a permanent post (probably right in the middle of the wetland, we'll come back to that later) and he would be the one who hands out the pump mentioned above. He should know all the users and he should keep records on which user has the pump and when.

An easy, logical plan for that registration was proposed: he has a mock up of his entire system (maybe as a table or as a wall "decoration" in which there is a button in every cell; green on one side (indicating normal operation), brown on the other side (indicating dry phase). He would also have one red button, which he uses to replace the green button with, of the user who currently has the pump (if more pumps would be necessary, he would have more red buttons). Anyone coming to his office would see immediately which cells are out of water and also who has the pump, and where it is.

Apart from this central operational function, the wetland manager (since there is no specific heavy labour involved this role can be assumed either by a man or a woman) should also have the knowledge and overview to tell any farmer why he could not have the pump right now and to inform him when it will be his turn.

This might be a method of operation that gives insight on the entire wetland system to all and thus connecting the users towards a communal goal: maximum harvest as well as best possible water quality.

6.5 Water Quantity Control

According to the study on the degree of pollution in the channel published in 2008[29] the BOD is sometimes 200 - where we took 135 mg/l for design criterion. In fact the channel water will probably be loaded heavier during the first years of operation.

We can simply not afford to overload the system. Eventually it is meant to polish the effluent of the WWTP and if by then the wetland has accumulated more pollution and is actually dirtier than the incoming water, the effect would be deteriorating the quality instead of enhancing it. For this reason, we suggest that the water at the inlet point (in or very near the pump installation) is monitored at a very regular basis.

Furthermore, the total load of BOD and COD should match the design criteria (45,000,000 litres of 135, respectively 253 mg per litre). Hence, the discharge per day should be matched in order not to surpass the maximum permissible load per day.

Regulating the flow would not be a task of the central wetland manager in our point of view, though he had better be informed about the daily flow in order to understand the flow consequences in the system. The water analyses incl. computing the appropriate water quantity and the regulating of the daily quantity probably are too different tasks to put in one hand but it is of course possible that one (right) person could do it all.
This influencing of the flow will probably best be done by either controlling the speed (rpm) of the pump or by adjusting the operating time.

[29] JASEM 2008: A study of the degree of pollution in Nakivubo channel, Kampala, Uganda (John Kayima et al.)

Again, all persons involved should have to understand that these tasks serve one primary task: making sure that the Nakivubo CWs can operate for the longest time possible, with the best effluent quality. Surely, pumping and treating 20,000 m^3, while 45,000 m^3 or more are flowing through the channel may initially look like sub-optimal waste water treatment – but there is NO alternative if sustainability of the system is set as core value. In the end, the maximum of water treated will be the result.

6.6 Sedimentation Pond

Every couple of years, the sedimentation pond should be cleaned from the accumulated solids. This could be done in a wet situation using a water/sludge vacuum cleaner, from a small vessel that transports the silt to trucks. Or it could be done by taking the entire system out of function, pumping the water fraction of the pond divided over the first FWS beds, avoiding putting the settled sludge in, of course. In both cases, the removed waste will be very liquid. It probably should be dried somewhere or transported to the sludge drying beds at the NWSC WWTP in Bugolobi.

7 Legal and Institutional Analysis

7.1 The Institutional Setting of the Water Sector

The overall government policy is guided through three major policy documents:

- The National Strategic Direction (NDP);
- The National Resistance Movement Manifesto (2011 – 2016);
- Vision 2040.

The common aspiration of these key policy documents is to transform the Ugandan society from a peasant to a modern and prosperous country within 30 years. Within these documents it is noted that the water and environment sectors are key drivers to the transformation process. It is government's objective to ensure that water resources are efficiently utilized and all steps are taken to effectively harness water for human and economic development purposes. The NWSC being a major player within the water and environment sector therefore plays a crucial role in implementing these government aspirations.

7.2 National Water and Sewerage Corporation (NWSC)

NWSC is a government parastatal and was established in 1972 with a mandate of developing, operating and maintaining water supply and sewerage services in designated urban areas in Uganda. NWSC was established by the National Water and Sewerage Corporation Decree, Decree 34/1972. This was superseded by the Revised NWSC Act, dated 22 December, 1995 (chapter 317).

Main elements of the Act:

NWSC shall continue in existence as Body Corporate. The Corporate may do and suffer all acts and body corporates may lawfully do or suffer: acquire, hold and dispose of real and personal property, sue or be sued in its corporate name.

The objects of the corporation shall be to operate and provide water and sewerage services in areas entrusted to it under the Water Act. The functions of the corporation shall be (Part II, Article 4):

- To manage the water resources in ways which are most beneficial to the people of Uganda
- To provide water services for domestic, stock, horticulture, industrial, commercial, recreational, environmental and other beneficial users
- To provide sewerage services in any area in which it may be appointed to do so under this Act or the Water Act
- To develop the water and sewerage systems in urban centers and big national institutions throughout the country.

The corporation shall operate on sound commercial practice and shall ensure that its revenues are sufficient to provide for:

- All depreciation, amortization and interest costs;
- All operation and maintenance costs; and
- A reasonable return on investments.

The powers of the corporation are i.a. (part II, Article 5):

- They may set tariffs and charges, make and levy rates and fix terms and conditions for work done or services, goods or information supplied by it[30];
- Engage consultants;
- Participate in the formation of a company, trust, partnership or other body;
- Subscribe to or otherwise acquire and hold and dispose of, any interest in a partnership or other body where it has interest;
- Enter in a partnership or any arrangement for sharing a profit, union of interest, cooperation, joint venture, reciprocal concession or otherwise, with any person or body carrying out on or engaged in, or about to carry on or engage in, any business or transaction, whether within or outside Uganda, which is capable of being conducted so as to directly benefit the corporation;
- Apply for, obtain and hold, whether on its behalf or jointly with any person, any industrial property rights;
- Enter into agreements and arrangements for the commercial exploitation of industrial property rights;
- Carry on, within or outside Uganda, any business or activity that is capable of being conveniently carried on by the corporation using the surplus resources that are not immediately required in carrying out the corporation's functions under this Act.

The Board of Directors (part III) consists of the Chairperson, the Managing Director NWSC and seven other Directors, one of whom must be the Director of the Directorate of Water Development. The Board shall be the policy-making body of the corporation and shall decide the policies and strategies to be followed by the corporation in achieving its objectives and carrying out its functions; ensure that the corporation and the Managing Director perform their functions and exercise their respective powers in a proper, efficient and economical manner, in accordance with the policies and strategies established by the Board.

The Directors other than the Managing Director shall be appointed by the Minister for a period of three years and shall be eligible for re-appointment for another term (Part III, article 8). The Managing Director shall be appointed by the Board for a term of 5 years (Part IV, article 16).

As to appointment of Directors, the Minister shall appoint persons having qualifications relevant to, or experience in the following fields: business of the corporation, public finance, banking or economics, water supply and sanitation, business management. The Minister may appoint a person employed by a public authority to be a director.

The Board shall from time to time prepare a three-year corporate plan (Part V, article 19-22). The plan shall be in a form approved by the Minister and shall include, i.a.:
- Objectives of the plan;
- Overall strategies;
- Performance indicators and targets (maintaining financial viability, reserves for future demand for the services of the corporation, improved accessibility);
- Financial matters (financial targets, overall financial strategies (including setting of tariffs, investments, borrowing) forecast on revenues and expenditures;
- Details of the significant tariffs;

The funds of the corporation shall consist of (Part VI, art 26):
- Moneys from time to time appropriated by the Parliament;
- All moneys received by the corporation for goods and services provided under this Act;
- Moneys borrowed by the corporation;
- Such other monies received by or made available to the corporation for purposes of performing its functions;

[30] In fact, tariffs setting proposals still need to be authorized by the MWE. MWE has a Regulation Unit within the Directorate of Water Development which regulates the entire urban water and sanitation sub-sector, including NWSC

The Minister may give written directions to the Board on matters of general policy and the Board shall, subject to this Act, comply with those directions (Part VII, art 31). The directions should be published in its annual report.

The corporation may borrow such sums as may be required by it from sources within Uganda or, with prior approval by the Minister responsible for finance, from sources outside Uganda for the purpose of meeting any capital expenditure (Part VII, art 32).

There is a separate Water Act (chapter 152) on the regulatory functions of for example the water sector. To a large extent, these are the functions that are granted to the authority and that are also described before, but there are also some additions or explications, such as on performance contracts regulation.

The Minister shall enter into performance contracts with each authority appointed by him or her, and a contract shall include among other things:

- Terms of reference of the authority relating to its rights and obligations;
- The extent of the authority's interest in any land, or works constructed or financed by the Government or works constructed by the authority;
- Terms of reference of the authority relating to the operations of the authority in the exercising of its functions;
- Provisions under this Part of the Act, if any, that will not apply to the authority;
- The period of the contract; and
- Any other information or matter that the Minister and the authority may find necessary for the better operations of the authority.

In the performance of the contract, an authority shall make a report to the Minister on the achievements of the authority since the making of the contract or the last report by the authority at such intervals and in a manner that the Minister may prescribe in relation to that authority.
A water authority may, by notice in writing, require an owner of land within the water supply area:

- To connect the land to the authority's works;
- To remove any existing connection between that land and the authority's works; or
- To carry out any works or repair that the authority considers necessary for the provision of the services.

The Minister may, by notice in the Gazette, fix fees and charges for i.a. services provided by the Minister, the director, and a public authority or authorized person under this Part of the Act. The charges and fees fixed under subsection (1) shall be in accordance with pricing policies established by the water action plan or other policy as may be determined by the Government.

7.3 Financial Performance of NWSC

NWSC is a financially sound institution. For the last two years it operated on a profitable level[31]. The income increased from 184 billion UGX at the end of FY13-14 to almost 222 billion UGX at the end of FY14-15. Water consumption and sewerage income increased by 15% from 171 billion UGX at the end of FY13-14 to 196 billion UGX in FY14-15. This improvement was largely due to increased water sales resulting from a takeover of towns and an increase in the volume of water sold from 61 million m^3 to 66 million m^3. Despite the higher income, the profits, though positive, decreased. Profits after depreciation & amortization, financing costs and taxation amounted 6.9 billion UGX in FY14-15 against 7.7 billion UGX in FY13-14. Main reason for the lower profits is the increased costs. Administrative costs increased by 25% (due to higher monitoring and travel costs because of the takeover of new towns), staff costs by 31% (staff increase because of takeover of 44 new towns) and maintenance costs by 15%. Reducing NRW is receiving considerable attention; reasons that the percentage losses reduced from 33.7% in FY13-14 to 31% in FY14-15.

[31] Report of the auditor general on the financial statements of the national water and sewerage corporation for the year ended 30th, June 2015

7.4 Organization Structure of NWSC

In Figure 38, the organization structure of NWSC is given.

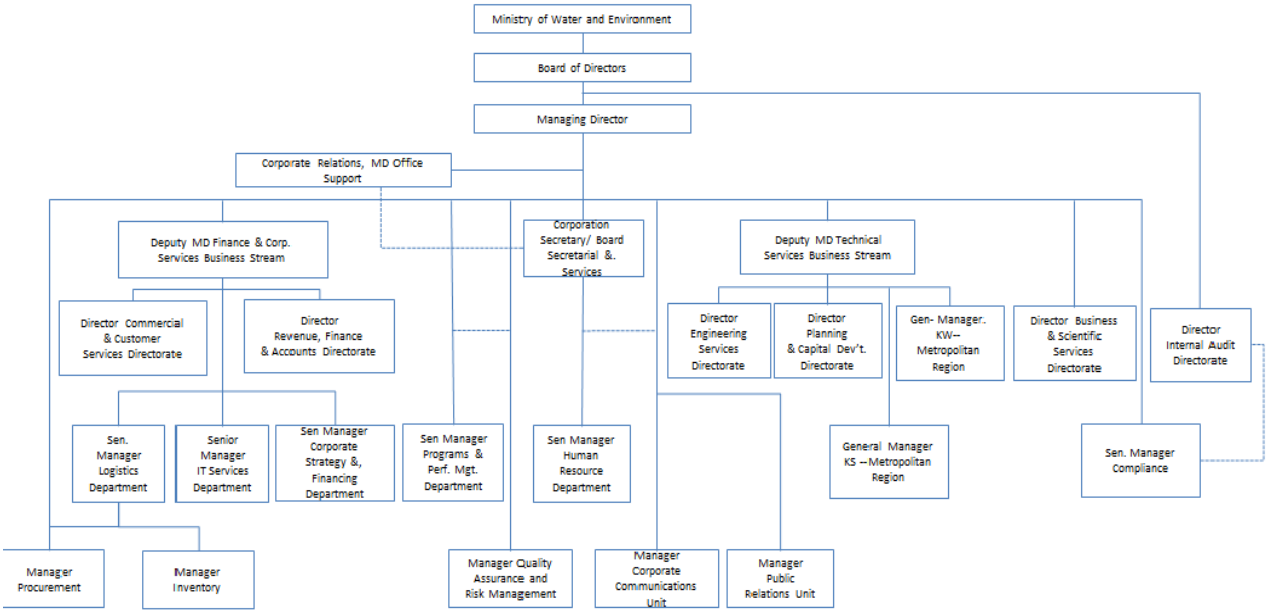

Figure 38: Organisation Structure of NWSC

At the end of FY14-15, 2,752 staff were working with NWSC. The above chart reveals that Finance & corporate service have an important position; they have one of the two deputy MDs, the other being the technical services stream. High attention is given to quality assurance, internal audit, compliance and relations management, with each having their own department. Planning and capital development attaches also high attention through an own directorate. There is no separate department for sewerage, but this may be needed when the extension of networks and the second WWTP is realized.

In the following table the SWOT analysis of the 5-year strategic direction is given.

From this SWOT analysis it follows that the current network coverage is below expectations, there is lack of investment funds, a high level of NRW and arrears, lack of interaction with clients and inadequate customer service systems. But there are also strengths (internal) and opportunities (external) such as good governance structures, competent and committed staff, potential to diversify income and financing sources, political stability and good public image and good will.

The prevailing five-Year Strategic Direction (2013 – 2018) is drafted along the 4 perspectives of the balanced-score card and aims at:

- Increased coverage (reaching full coverage in the medium term);
- Increased supply reliability;
- Improved asset management aiming at tackling the water losses;
- Increased customer interface;
- Increased revenue growth;
- Improved mobilization of resources to invest;
- Improved staff capacity development and welfare;
- Enhanced research and innovation;

The strategic plan has to be operationalized through the annual budget and the respective divisional operational plans and is undertaken through tactical Performance Improvement Plans (PIPs).

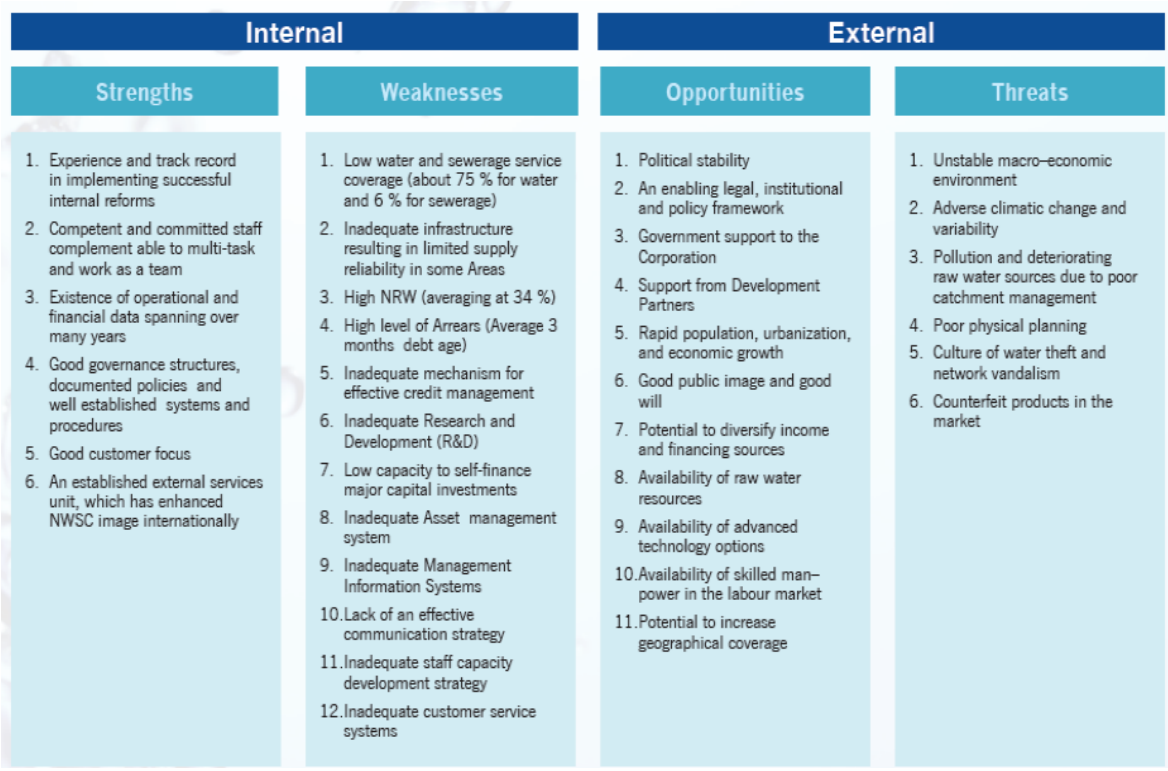

Figure 39: SWOT Analysis of NWSC

The future agenda determined in 2013 is set by 10 goals and targets:

1. Carry out network expansion and intensification to increase service coverage from 75% and 6% for water and sewerage respectively, to 100% and 30%;
2. Increased geographical coverage: increasing services to more small towns. Ensure that services are extended from the 28 towns to 80 towns in Uganda;
3. Capital Investment efficiency. Ensure capital projects are implemented using least cost investment unit costs to create maximum value-for-money;
4. Environmental protection. Ensure that NWSC conforms with national laws, regulations and standards;
5. Asset Management Efficiency. Reduce water losses from a level of 34% to less than 25% and enhance costs optimization of operations;
6. Working Capital Management. Reduce debt age form the level of 3 months to less than 2 months and reduce creditor days from 90 to 45 days;
7. Business Growth. Increase customer base from 317,000 connections to at least 450,000 connections, increase the annual turnover from UGX 168 billion to at least 278 billion and ensure that at least 50% of the towns break even;
8. Water production capacity and supply reliability. Increase production from 250 million litres /day to 400 litres/day and hence increase supply reliability to 24/7 in all towns;
9. Customer satisfaction. Increase customer satisfaction index from the level of 86% to at least 95%;
10. Business Process re-engineering. Review processes, structures and procedures and implement strengthening measures through focus on costs structure, technologies, staff welfare, research, training and development.

It is very good that the goals and targets are set and that they are made tangible and accountable. How to operationalize these will be given in the respective PIPs. The main worry is the growth strategy as an ex-ante target. To cover at least 80 towns of Uganda and have operations break even in at least 50% of the towns implies a heavy financial burden for NWSC, not only in terms of financing investments but also because of the high NWR and the fact that some 50% of the towns will not break even.

Effective from July 1st 2015 the corporation operates in 110 towns (areas)/urban centres including Kampala, Kitgum, Pader, Mityana, Kisoro, Hoima and Nebbi among others.

7.5 Assessment on Sustainability NWSC

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

- They are financially sound; their cost-recovery level is over 100% and their collection ratio is also high (in FY2011/12 it was 98%32);
- 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 Partners
- They have capable staff operating WW systems.

7.6 Responsibilities KCCA and NWSC under the Project

KCCA's remit is to be responsible for municipal services such as solid waste, storm-water drainage and street lightning. Also pollution control of the Nakivubo channel belongs to the remit of KCCA. However, KCCA does neither have experience, nor the capacity to operate such a project.

Currently a pilot for the enhanced wetlands is run. Thereto, a Memorandum of Understanding (MoU) was signed on 29th of March 2016 between NWSC and Kampala Capital City Authority (KCCA). KCCA with financing from the World Bank through the Ministry of Water and Environment (MWE) is implementing Lake Victoria Environmental Management Project phase II with the objective of reducing environmental pollution and flood frequency in Kampala. KCCA allocated part of the funds under this programme for the design, construction and monitoring of a pilot enhanced wetlands system for treating part of the Nakivubo channel. Under the MoU, ownership of the land remains in the hands of NWSC (article 1). KCCA will be responsible for the construction of the enhanced wetlands system, while NWSC will become responsible for operating and maintaining the systems after the construction.

KCCA and NWSC initially already agreed on using the same setting for the CWs project that will be constructed under the current KfW-programme, implying that the construction will fall under the responsibility of KCCA and the operations and maintenance, after construction period, will be the remit of NWSC. KCCA would however have to pay a fee to be agreed upon between the two parties to necessitate them do O&M of the system. The actual amount is not yet established but KCCA has a budget line for such works done annually.

[32] Corporate Plan JULY 01, 2012 - JUNE 30, 2015

8 Financial and Economic Analysis

8.1 Tariff Setting

The regulatory functions presently remain the responsibility of the MWE as per the Water Act Chapter 152 and the mode of regulation is by contracts.

The MWE has a Regulation Unit within the Directorate of Water Development, which regulates the entire urban water and sanitation sub-sector, including NWSC. This Unit could in the medium to long term be transformed into an established structure within the Ministry, or form the starting point for an Independent Regulatory Body (depending on the long term decisions on mode of regulation).

As part of its functions, the regulation unit reviews requests and proposals for new tariffs and adjustment of existing tariffs, including those submitted by NWSC, before submission to the Director and Minister for approval and ensuring that only approved tariffs are applied.

There are two options to charge user fees for covering the O&M costs of the CWs:

- First of all, to charge the households, industries and, mostly informal, settlers which directly discharge to the channel, on the basis of the polluters-pay principle;
- Secondly, to cover these O&M costs through the wastewater surcharge of the people connected to the sewer network. The disadvantage is that under this option the non-polluters will be charged extra;
- Although the first option is fairer also with a view to the polluters pay principle, it is proposed to choose for the second option for the following reasons:
    - NWSC will be the operator for the system and not KCCA. It is in NWSCs remit to charge for water and sewerage services through the water and sewerage tariffs. Thus charging for the costs of the CWs through the tariffs is more logical and pragmatic;
    - In the future, the CWs will be used as a tertiary treatment for the WWTP anyways;
    - It is hard to identify exactly which households, industries and informal settlers are the polluters of the channel. Information on polluters is lacking;
    - Collection of fees via the water tariff is easier than charging informal settlers via other ways where the payment records would be dubious and the collection efforts would be high;
    - The level of unfairness of this system of charging will diminish when more and more people are connected to the sewer system and consequently the costs of cleaning the channel will be decreasing.

Therefore, it is proposed to add the costs of operating the CWs to the total costs of the wastewater collection and treatment and cover these costs through the water and sewerage tariffs.

The Water Act (2006) reveals the tariff levels for water and sewerage and the tariff formulae. The prevailing water tariff is given in the following table.

Table 23: Current Water and Wastewater Tariffs (in UGS) Including Tariff Indexation & Sewerage Surcharge

Consumer Category	New Tariff w.e.f. **1st Nov, 2015 Ug.sh/m3**	Cost per Jerrican w.e.f. **1st Nov 2015 Ug.sh/m3 VAT Inc**
Public Standpipe	1,533	36.2
Domestic	2,490	58.8
Institution / Government	3,065	72.3
Commercial <500m3/ m	3,760	88.7
Commercial 500 – 1500m3/m	3,760	88.7
Commercial >1500m3/ m	3,005	70.9
Weighted Water tariff	2,668	63

In addition, there is a connection fee. Up to 50 meters from NWSC service point all material costs and other costs such as roads reinstatement will be covered by the corporation; beyond the distance of 50 meters all costs are charged to the applicant.

Table 23 shows that the tariff system is quite complex and involves many different tariffs.

The tariff formula for the yearly change in water tariffs is:

T0 (a?I + b?FI?FX+ c?K) = T1

- T_0 = tariff level at end of year zero
- a = proportion of tariff associated with local salaries and locally sourced goods based on the pervious years audited financial accounts
- ? = Change
- I = Domestic retail price index as published by the Bureau of Statistics and based on underlying inflation rate
- b = the proportion of the tariff associated with foreign costs, i.e. foreign inputs in the production process based on the previous years audited financial accounts
- FI = Foreign retail price index based on the US Bureau of Labor Statistics
- FX = US Dollar to shilling exchange rate based on the Bank of Uganda mid exchange rate as at 30th of June of each financial year
- c = proportion of tariff associated with electrical power based on % of electricity costs to total costs as a proxy (audited financial accounts)
- K = price of electrical power per unit
- T_1 = Indexed tariff at beginning of year 1

Hence, tariff increases are applied on a yearly basis and a combination of the domestic prices index, exchange rate, foreign price index and the electricity tariff.

The sewerage tariff is a surcharge to the water tariff.

For domestic clients it is 80% of the water charge, for other categories it is 100% of the water tariffs.

8.2 Financial Analysis: Assumptions

Table 24 below presents the assumptions applied for the financial analysis.

Table 24: Assumptions in the Financial Analysis

Variable	Value	Unit	Source / rationale
Generic			
Exchange rate UGX to EUR	3,792	x UGX to 1 euro	www.xe.com
Exchange rate USD to EUR	0.89	x USD to 1 euro	www.xe.com
Construction period	1	Years	Assumption
Project duration	20	Years	Assumption
Period of operations	2,018		Assumption
Operational days per year	365	Days	Assumption
Revenues			
Revenues	No direct revenues attached to the project		Assumption
Cost estimates (in Euro)			
See chapter 4 for Constructed cost estimates			
A. Clearing and grubbing	24,400	Ha	Expert judgement project team
B. Excavation and embankment shaping works	1,171,549	M^3	Expert judgement project team
C. Constructed wetland basins with macrophytes	3,747,856	M^3	Expert judgement project team
D. Inlet and outlet infrastructure -	217,131	Number	Expert judgement project team
E. Interval open water ponds -	77,474	M^3	Expert judgement project team
F. Sedimentation Basin -	1,831,088	M^3	Expert judgement project team
G. Water Sump and Pumping -	1,305,250	Nr/LS	Expert judgement project team
Sub-Total	**8,374,748**		
H. Construction Supervision	400,000		
Grand total	8,774,748		
Grand total (rounded)	**9,000,000**		
I. Annual Operation and Maintenance requirements	179,055	Year	

8.3 Financial Analysis: Results

The results are somewhat different from a regular project, since there is not concrete revenue stream from having the CWs. It has been assumed that the costs incurred by CWs have to be covered by the sewerage surcharge on the water tariff. Hence, the financial analysis has concentrated on how much the surcharge has to increase to cover the costs of the CWs.

Figure 40 presents the year-on-year cash flow of the project under operations (before financing).

Figure 40: 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 2017 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. NWSC makes no difference for its tariff between the people that are connected to the sewerage network and the once that are not connected. However, for the sake of being better able to compare the situation with and without project, the percentage increase on the sewerage surcharge is considered.

Table 25 presents the required sewerage bill that is needed to have an acceptable level of the main financial parameters. The Full Cost Recovery ratio under the proposed tariff regime shows that sufficient revenue is generated for future reinvestments. Hence activities are sustainable. It is important to note that even with the small increase in the water tariff, affordability is not an issue for the lowest income groups (boundary limit: 4 – 5% of household income).

Table 25: Key Results under the new tariff regime

Indicator	**Values with a 6.15% increase of the current sewerage surcharge**
Internal Rate of Return of operations – before finance	<0
Net Present Value (10%) – after finance (€)	990,971
Prime costs of treatment (0% discount rate)	0.040 €/m^3
Prime costs of treatment (5% discount rate)	0.032 €/M^3
Operating Cost Recovery ratio (revenue / O&M)	1.79
Full Cost Recovery ratio (revenues / (O&M + depreciation))	1.00
Affordability (cost increase measured as a % of income for the highest 10% income group as these are connected to water and sewerage system)	3.9%

With the foreseen small increase in tariffs, a sensitivity analysis does not really make sense. There are of course risks to the project, but these are provided elsewhere in the Feasibility Study.

The project should ideally not be looked in isolation but in relation to the Bugolobi treatment plant that is being constructed upstream. This WWTP is expected to become operational at the end of 2017 or beginning of 2018, while the related investments in the sewer network will be ready in 2017. With these investments 11,000 – 12,000 m^3/day can be treated in the new Bugolobi treatment plant. No financial information could be gathered on cash-flow calculations and suggested tariff levels. Also the financial data that were provided through KfW were not sufficient to make a rough calculate the level of tariffs that are needed to cover the costs of this new WWTP. Hence, a tariff including the two projects could not be provided.

8.4 Conclusion

The increment of the water tariff is so small that the project is feasible, so from a financial point of view, these investments are viable. It must be noted however, that this is also due to the setting of the project, where the costs are divided over all the people connected to water. This seems a logical assumption given that the water bill does not differentiate between the once connected and the once not connected to sewerage services.

Since NWSC already charges for sewerage services, while not providing them, they are able to build up funds for operations and maintenance of the sewerage network and treatment facilities. It is therefore advised that NWSC indeed makes these financial provisions.

It is also clear that the water tariff might be increased further to accommodate the increased costs of the main WWTP and the networks.

Apart from the financial analysis, the economic benefits in terms of increased health for the population, a lower level of water-borne diseases will be very high, adding further to the attractiveness of the project.

9 Project Risk Analysis

The success of the project is based on the following assumptions:

- The stakeholders commitment and participation remains positive;
- The Consultant design is sound and sustainable;
- Construction works are supervised and managed efficiently;
- Materials necessary for construction are accessible;
- Resettlement, compensation and land accessibility is managed in time;
- The CWs perform well and the effluent quality is good;
- The neighbouring community is willing to take care of operation and maintenance 'for free' as far as they can use the harvest 'for free'.

The risk levels have been rated High, Medium and Low depending on the probability and likelihood of their occurrence (see Table 27). The following risks have been identified for this HPI;

- Incomplete data: inaccurate and inaccessible data on the quality and quantity of the water in the Nakivubo channel;
- Delay in preparation of the design;
- Problems with availability of land;
- Possibility of poor ground formations;
- Political interference;
- Enforcement of the polluter pays principle.

Table 26: Consequences of Failure

	Consequence of Failure			
Likelihood of Failure	**RISK LEVEL**	LOW	MEDIUM	HIGH
	LOW	**Low**	**Medium**	**High**
	MEDIUM	**Low**	**Medium**	**High**
	HIGH	**Medium**	**High**	**Very High**

The following risks should be mitigated before project implementation;

Table 27: Risks and Mitigating Measures

#	Risk Factor	Risk Level	Mitigating measures
1	Incomplete data	Very high	Diligent field surveys, sampling of water quality, measuring water quantity. LVEMP II has agreed to pay for this. As past experience shows that release of LVEMP II funds can be cumbersome, pressure of donors is required.
2	Delay in Design	Low	• With availability of funding from LVEMP II, delays in design will be minimised; • Cooperation from key stakeholders such as NWSC on ground investigation studies will speed up the process.
3	Land availability	Low	Assurance from NEMA and NWSC on land availability and access was positive.

#	Risk Factor	Risk Level	Mitigating measures
3	Possibility of poor ground formations	Medium	The land requirement is over 60 ha, comprehensive soil tests were done on 5.5 ha by NWSC, the rest of the land has not been studied yet. However most of the structures that require solid foundations (pumps sumps) are in the surveyed area.
4	Political Interference	Medium	Election period has ended; therefore, the need for pleasing voters is low.
5	Enforcement of Polluter Pays Principle	High	• If enforcement fails due to political positioning of Industry owners, the wastewater will have high loads of heavy metals etc. and this could damage the CW; • Additionally, poor waste management upstream of the channel has resulted in increased garbage hence causing load to the system.

10 Environmental and Social Impacts and Mitigation Measures

10.1 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 yet been identified, e.g. actions for labour management, contractor management and performance in accordance with good international construction practices. This chapter also aims to define certain aspects of the tender documents to be prepared for the implementation of the CW.

It also 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.

A description of the positive and negative environmental and social impact of the proposed HPI are given i.e., a distinction between:

- Pre-construction phase;
- Construction phase;
- Post-construction phase;
- Operation and maintenance phase.

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

10.2 Pre-Construction Mitigation Measures

Public Information to prepare for Construction Works

The project affected people and general public shall be informed through the Kampala Capita City Authority 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 existing infrastructure being used by the neighbouring communities.

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

Table 28: Mitigating Measures during Pre-construction Phase

Impact	Mitigation Measures
Detailed Engineering Design of CW	○ Confirm size of land required and types of pumps and other mechanical equipment. ○ Confirm that designed system meet the national wastewater effluent standards. ○ Conduct topographic surveys and soil tests to ensure construction works progress well.

Impact	Mitigation Measures
Malaria Risks (Design)	○ Ensure biological prevention measures into the design of the CW to prevent breeding of disease spreading parasites such as: malaria
Water Quality Monitoring	○ Ensure regular chemical and biological effluent tests are conducted by NWSC i.e. BOD, COD, total nitrate, phosphate, etc.)
Electricity	○ Confirm capacity of central electricity net, to supply sufficient energy to CW plant pumping stations and to other consumers of the electricity net; ○ Confirm sufficient stand-alone back up energy capacity for the pumping station
Public Information Campaigns	○ Notify communities directly affected on the project and the planning on implementation and mitigating measures taken ○ Notify them how it will affect their lives and daily activities
Resettlement Action Plan for WWTP and maturation ponds	○ Implement land acquisition and implement Resettlement Action Plans with the foreseen activities (public hearings, allocation of land and compensation)
Employment	○ Determination of the number of local people that can be employed by the project, short-term and permanent
Benefits/costs to local economy	○ Assessment on how local economy will be affected by the project; positive effects (employment, services provision) and negative (disappearance of economic activities)
Social impacts	○ Neighbourhoods and social relations will be influenced by the works during construction and afterwards through the project. Neighbourhood meetings will have to be organised where people can express their views and where worries and possible negative impacts can be accommodated

10.3 Construction Mitigation Measures

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

Table 29: Mitigating Measures during Construction

Impact	Source / Subject	Mitigation Measures
Disturbance to local residents during construction works	Location of construction works close to neighbouring living areas	○ The Contractor shall submit construction yard logistics to the Client, including means of separation from living areas
Wastewater discharge to neighbouring residents	Wastewater and drainage at construction site	○ The Contractor shall attend to storm water drainage on construction site, to prevent 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	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

Impact	Source / Subject	Mitigation Measures
		or a private waste service provider regarding to the provision of waste containers. o 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. o Burning of waste on site or in waste containers is prohibited. o Any hazardous waste may not be stored on site in excess of a 90 calendar day period.
Site contamination	Sanitation	o The Contractor shall install toilets on the site and place them in a designated area. o The Contractor shall also establish hand washing facilities and soap to maintain good hygiene on site. Staff shall be sensitised to use these facilities at all times.
Noise	Construction noise	o Construction works related noise levels must be kept within acceptable limits. The noise and sound generated shall adhere to the Ugandan noise standard specifications and take account of nearby residents when work is performed at night. o The playing of loud music at the construction yard is prohibited. o The Contractor should keep the local community informed of unavoidable noisy activities and their duration.
Surface Water pollution	Chemical and hazardous materials	o All hazardous materials shall be placed in containment areas on sealed floor surfaces and 100m away from any water bodies. o The Contractor must remove contaminated wastewater resulting from construction activities and dispose of it at a licensed commercial wastewater treatment facility. o 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. o A storm water management plan must be prepared by the Contractor and approved by the relevant authorities and /or the Independent Engineer.
Safe water use	Leakage and wasting	o 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	o Construction work site shall be managed in such a way as to minimise destruction of the surrounding wetlands/ paddy fields. o Nuisance and pollution of the surrounding wetlands shall be fully prevented, including dust, noise, wastewater emissions, and particularly waste generation and disposal. o 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. o In case of emergencies accidents with impacts on the wetland ecology beyond the boundaries of the

Impact	Source / Subject	Mitigation Measures
		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 construction yard shall remain fenced at all times. ○ A speed limit of about 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 pipe 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 hold during the construction phase. Specific attention should be given to communication about public health & safety risks and measures to mitigate these.
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.

Impact	Source / Subject	Mitigation Measures
		○ 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 the region. ○ 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
Complaints point	Negative social impact	○ There should be a possibility (place, person allocated as a liaison) where people from the neighbourhood can complain or ventilate their worries
Employment opportunities	Labour recruitment	○ Where possible local residents, including women, shall be given the opportunity to apply for construction jobs
Gender issues/ disadvantaged groups	Positive discrimination	○ Due weight should be given to provide economic opportunities to the disadvantaged groups
Resettlement Plan	Compensation	○ The implementing agency should ensure that the resettlement plan is properly implemented, implementing the measures that have been agreed upon within the timeframe given
Public Information Campaign	Information provision to local communities	○ The contractor should inform local communities at regular intervals on progress, bottlenecks & positive factors encountered, changes to be made and other planning aspects
Monitoring		○ The implementation Agency should monitor the proper implementation of the plans and measures by the contractor

10.4 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;
- 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;
- The Contractor must repair any damage that the construction works has caused to neighbouring properties.

10.5 Mitigation Measures During Operation and Maintenance

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

Table 30: Mitigating Measures during the Operational Phase

Impact	Mitigation Measures
Effluent water quality	○ Establish effluent monitoring program in line with National discharge standards
Monitoring and reporting	○ The operator should maintain records of effluents as well as other pollutants that may have an impact on the environment. The information should be reviewed and evaluated to improve the effectiveness of the monitoring.
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.
Water Quality Monitoring and Analysis	○ Ensure regular chemical and biological effluent tests are conducted by NWSC i.e. BOD, COD, total nitrate, phosphate etc.)
Malaria Risks (Operations)	○ Operate and maintain biological malaria prevention measures during operations of CW. Promote regular distribution of malaria nets to inhabitants the existing health centres
Local employment	○ Stimulate the use of local labour and development of local activities supportive to the operations of the project, for example by using local collectors or using labour for harvesting of CW papyrus etc.
Social impact	○ The contact point and liaison possibility should remain in existence for the people of the neighbourhood
Electricity Supply	○ Ensure capacity of central electricity net, to supply sufficient energy to pumping stations throughout operations and ○ Operate and maintain stand- alone back up energy capacity for and pumping station
Labour Opportunities	○ Assess operational job opportunities for local residents

11 Conclusions and Recommendations

Table 31 presents the conclusions and recommendations of the Feasibility Study on the CW in Kampala.

Table 31: Conclusions and Recommendations

Conclusions	Recommendations
The current status of Nakivubo channel presents a mixture of domestic, industrial and solid waste pollutants. This has led to discharge of wastewater of unacceptable environmental standards into Lake Victoria.	In the immediate term, treatment of the Nakivubo channel water is required, as a limited percentage of the population, industries and institutions are connected to the Bugolobi WWTP. Otherwise, in the short term, Nakivubo channel water will remain grossly polluted.
KCCA through the LVEMP II hired a Consultant (AWE, Air Water Earth in Kampala), to do a pilot (CW) to treat the Nakivubo Channel water before discharge into Lake Victoria. On discussion with the KCCA it was mentioned that the intention was to scale up the pilot later if funds where available.	○ Proceed with detailed engineering design of full-scale CW using the funds from LVEMP II. ○ Identify funding of the proposed project
KCCA had already started on the development of the project and is proposed to be the implementing agency for this proposed project.	We recommend KCCA to remain the owner of the project and delegate the operations to NWSC after the construction to avoid creation of another independent project implementation unit.
The operation and management of the CW requires knowledge and skills that calls for experienced institutions and this falls outside the competences and mandate of KCCA.	NWSC should be responsible for the O&M of the CW given their mandate and the fact that they can easily impact a surcharge on the polluters through their existing systems.

APPENDIX 1: Literature

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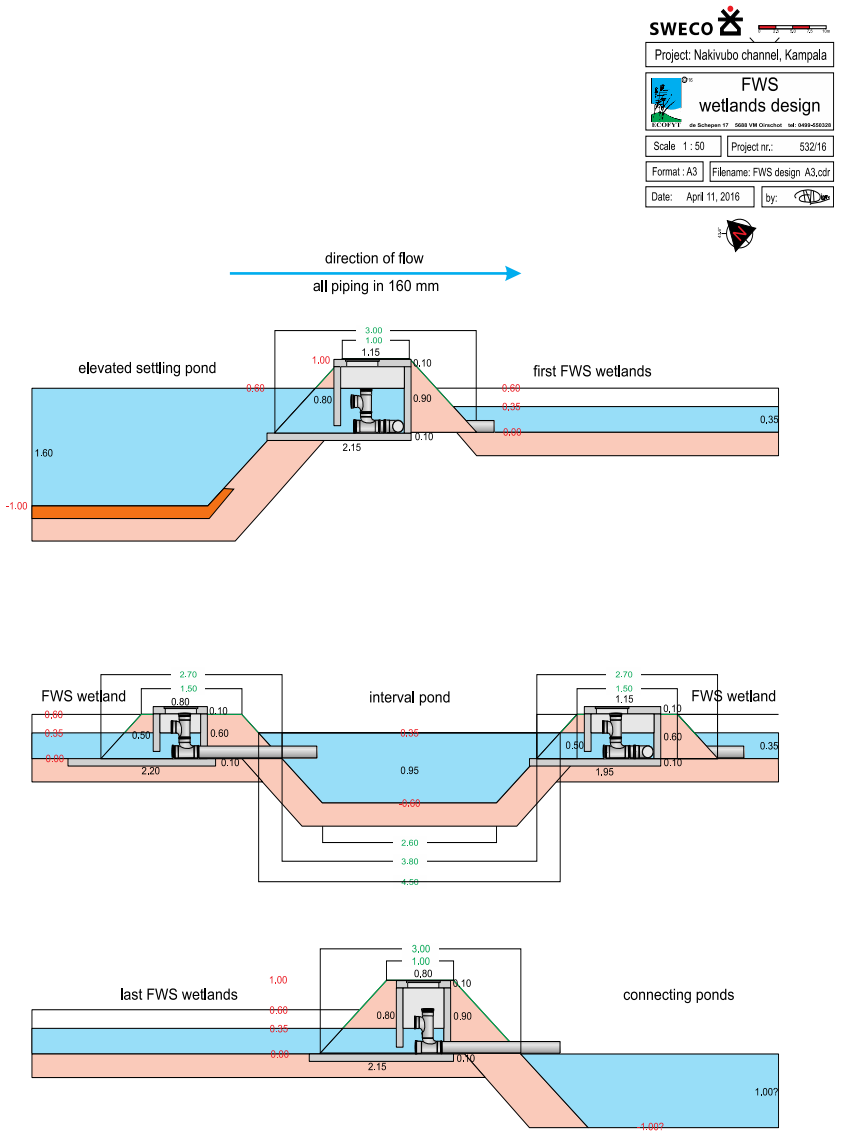
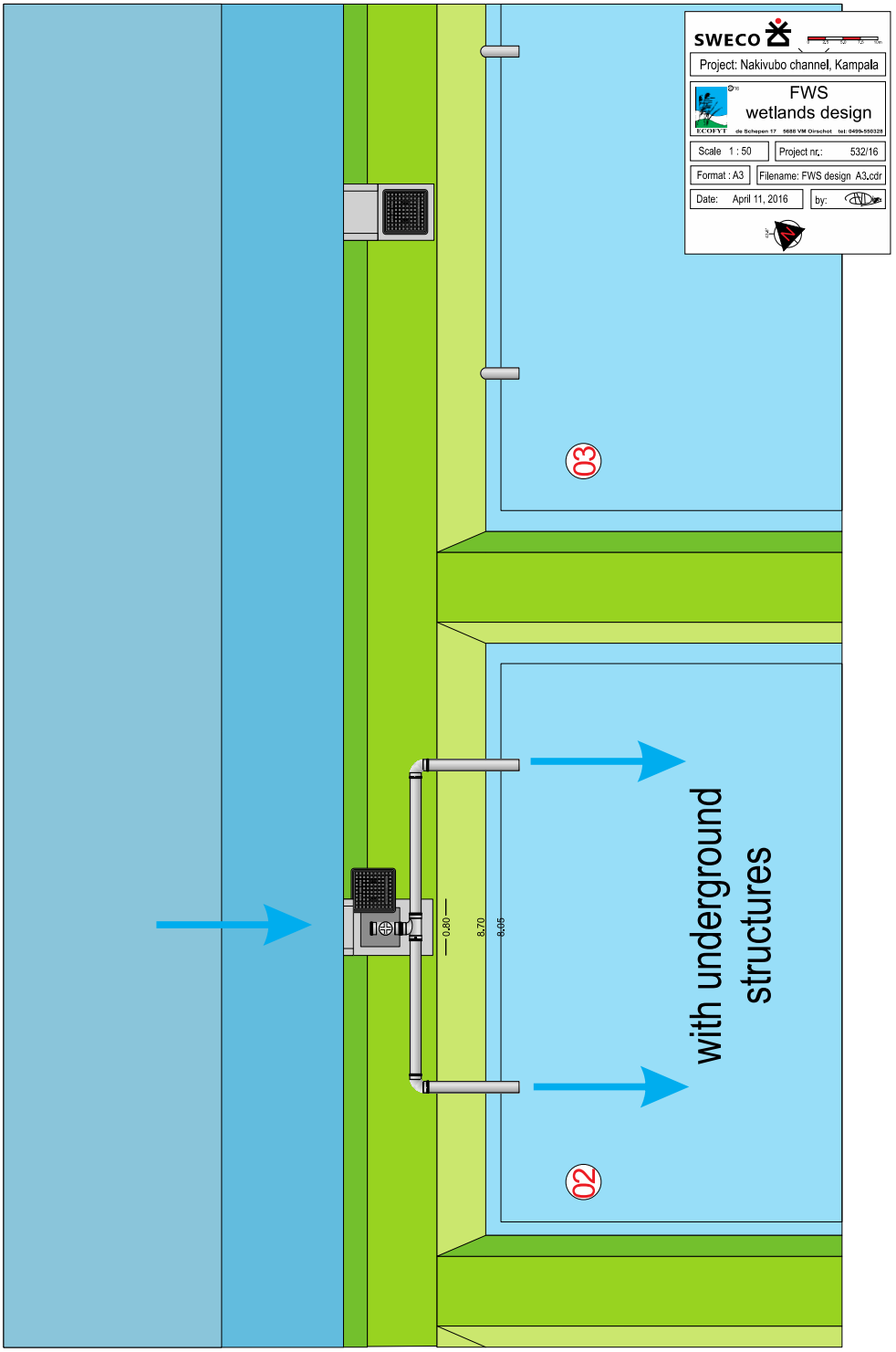
APPENDIX 2: Construction Details

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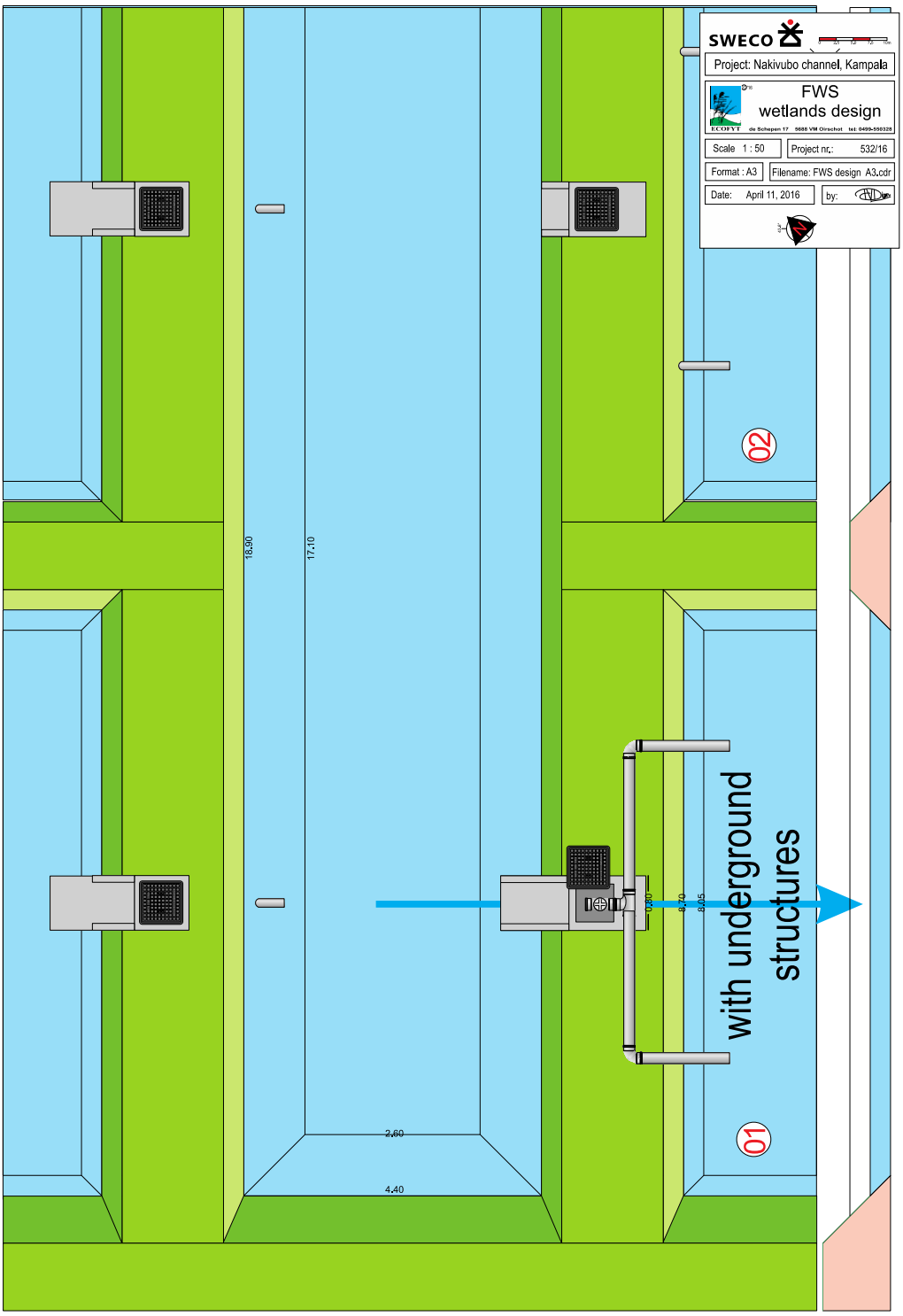
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with underground
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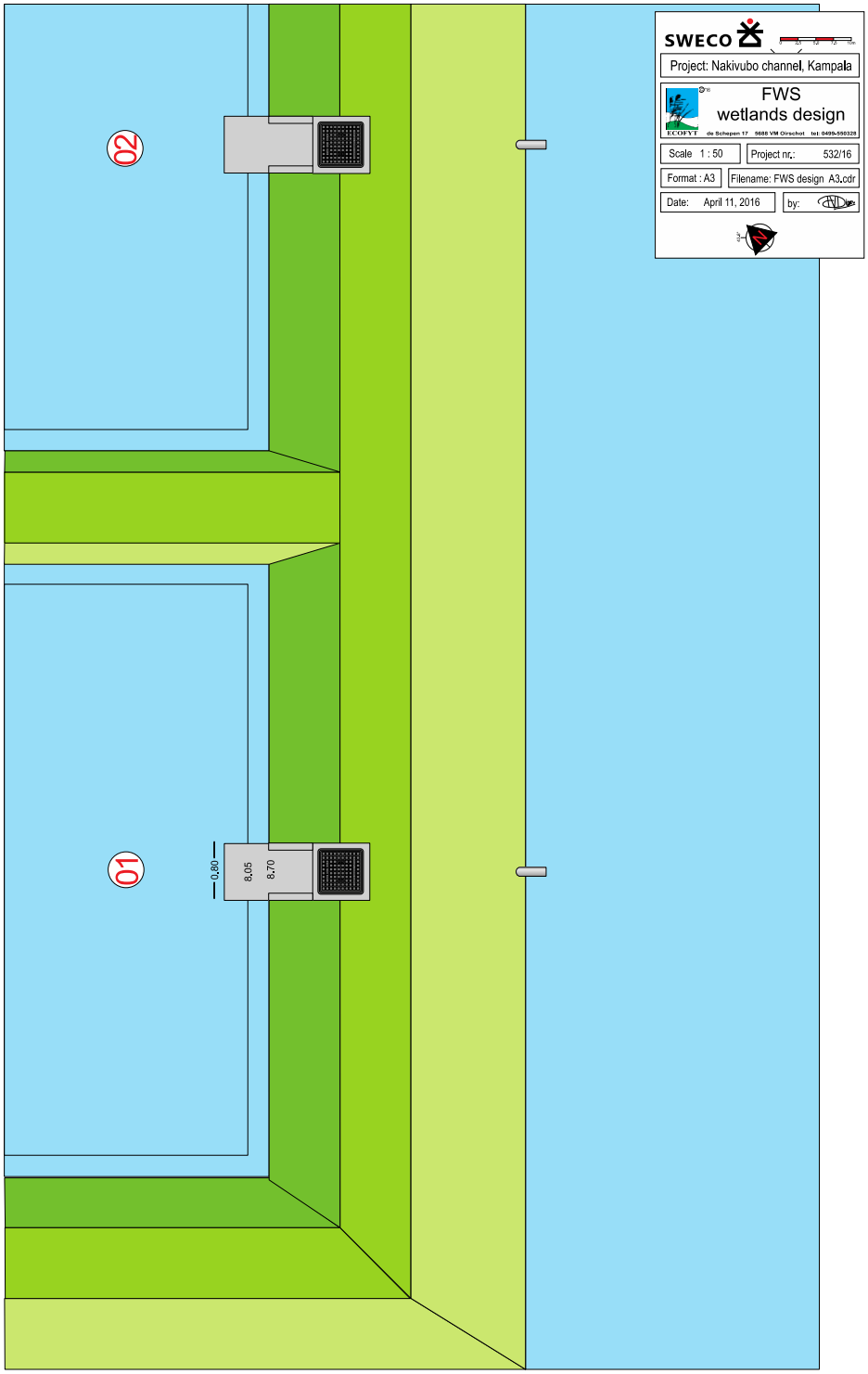
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Date: April 11, 2016
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APPENDIX 3: Relevant Laws and Regulations

No.	**Law**	**Mandate/Obligations imposed**
a)	**The Constitution of Uganda, 2005**	• The state to ensure that all Ugandans enjoy rights and opportunities and access to clean and safe water. • The state to take all practical measures to promote a good water management system at all levels. • The state to promote development sustainable development and the public awareness of the need to manage water resources in a balanced and sustainable manner for the present and future generations • Every Ugandan has a right to a clean and healthy environment (Article 39)
b)	**The Water Act 2000, Cap 152** The Water Act cap 152 is the principal law for the management of water resources in Uganda. The Act provides for the use, protection and management of water resources and supply; and, also provides for the constitution of water and sewerage authorities and facilitates the devolution of water and sewerage undertakings	• A person who is responsible for the production, storage, discharge or deposit of any waste or is engaged in any trade; or owns or occupies any premises, shall not cause or permit any waste to be discharged directly or indirectly into any water unless he or she gets a waste discharge permit • A person who does not have a permit commits an offence when he or she causes or allows waste to come into contact with any water or waste to be discharged directly or indirectly into water or water to be polluted.
b(i)	**The Water (waste discharge) Regulations, S 152-4** These regulations provides for the establishment of standards for effluent or waste before discharge into water or on land, prohibition on the discharge of effluent or waste, and the requirement for waste discharge permits	• Every industry, establishment or holder of a waste discharge permit to install antipollution equipment for the treatment of effluent or waste discharge emanating from the industry • Sampling of effluent and wastewater analysis by environmental inspectors and waste discharge fees which are a basis for the polluter-pays principle
c)	**The National Environment Act Cap 153** The Act provides for sustainable management of the environment, establishment of the National Environment Management Authority as a coordinating, monitoring and supervisory body for that purpose	• The true and total costs of environmental pollution are borne by the polluter • Every person has a right to a healthy environment • Environmental Impact Assessment is to be undertaken by the developer on the following waste disposal projects: sites for solid waste disposal; sites for hazardous waste disposal; sewage disposal works; major atmospheric emissions; offensive odours • Prohibition of the environment is permissible according to the standards by NEMA and with a permit • NEMA in consultation with the lead agency to establish criteria and procedures for the measurement of water quality) minimum water quality standards for all the waters of Uganda and for different uses • NEMA in consultation with the lead agency is to establish standards for the discharge of effluent into water; prescribe measures for the treatment of any effluent before discharge into the sewage system and require that the operator of a plant undertake such works as it considers necessary for the treatment of effluent before it is discharged into the water • No person is permitted to carry out activities in relation to a river or lake without a permit • No person is permitted reclaim or drain any wetland; erect, construct, place, alter, extend, remove or demolish any structure that is fixed in, on, under or over any wetland or disturb any wetland by drilling or tunnelling in a manner that has or is likely to have an adverse effect on the wetland or deposit in, on or under any wetland any substance in a manner that has or is likely to have an adverse effect on the wetland or destroy, damage or disturb any wetland in a manner that has or is likely to have an adverse effect on any plant or animal or it habitat or introduce or plant any exotic or introduced plant or animal in a wetland without approval of NEMA

c(i)	**The National Environment (Standards for Discharge of Effluents into Water or on Land) Regulations, SI 153-3** The Regulations addresses discharge of effluents on to land or water	• Set the maximum permissible limits for effluent or waste water before it is discharged into water or on land • Empower the Executive Director or a person authorised by him or her to issue guidelines and recommend the method of treatment of effluent for industries or establishments so as to ensure assimilation by the water or land into which the effluent is discharged • Impose a general obligation on every industry or establishment to install at its premises, antipollution equipment for the treatment of effluent and chemical discharge emanating from the industry or establishment • A lead agency to keep a record of the amount of waste generated by the activity and of the parameters of the discharge and submit the record the executive director and to any other relevant lead agency, every three months from the commencement of the activity for which the permit was issued
c(ii)	**The National Environment (Delegation of Waste Water Discharge Functions) Instrument S.1 No. 153-4** The Act delegates the functions to the Director of the Directorate of Water Resources Management	• An operator of a plant should undertake pre-treatment of effluent before discharge into any water to and any waiver of the limitations on the use of lakes and rivers
c(iii)	**The National Environment (Waste Management) Regulations, S 153-2** The Regulations address the management of solid wastes	• These Regulations apply to all categories of hazardous and non-hazardous waste; to the storage and disposal of hazardous waste and its movement into and out of Uganda and to all waste disposal facilities, landfills, sanitary fills and incinerators • A person licensed to own or operate a waste treatment plant or disposal site must ensure that the waste treatment plant or disposal site is a radius of at least one thousand metres away from a residential or commercial area and from water sources; the waste treatment plant or disposal site is enclosed and secure from scavengers and the waste treatment or disposal site has hazard and safety signs.
c(iv)	**The National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, SI 153-5** These regulations provide for the management of wetlands, lake shores and river banks, ensuring water catchment conservation, sustainable utilization and conservation of resources involved, promoting the integration of wise use of resources, and prevent and control of pollution and degrading activities.	• Minimising and controlling pollution in wetlands • Preventing siltation of rivers and lakes and control pollution or degrading activities • Taking special measures are essential for the protection of riverbanks and lakeshores such as preventing soil erosion, siltation and water pollution
c(v)	**The Environment Impact Assessment Regulations, Statutory Instrument 153—1** The regulations provide the procedure of conducting EIAs	• No developer shall implement a project for which and EIA is required under the Act and under these Regulations unless the EIA has been concluded in accordance with the Regulations • In case a project affects water, that the lead agency for shall make written comments on the project brief and transmit them to the executive director of NEMA within fourteen working days of receiving it and where the lead agency fails to make comments and transmit them to the executive director within the period specified in the executive director may proceed to consider the project brief • An environmental impact study shall be conducted in accordance with terms of reference developed by the developer in consultation with the NEMA and the lead agency. The Lead Agency is also required to make

		comments on the EIS and transmits them back to the Executive Director (ED) within thirty working days of receiving the environmental impact statement
d)	**The Local Government Act Cap 243** This Act defines roles for different levels of government in provision and management of water and sanitation related activities	• The provision of water services and maintenance of facilities is a responsibility of local councils in districts and urban centres with the support and guidance of relevant central government agencies. • Prescribes the functions of Government that the District Councils are responsible for including forests, wetlands, environment, sanitation and protection of streams/river banks and lakeshore (Part 2) • Prescribes the functions for which the Urban Councils are responsible including: providing sanitary services and providing water services outside the jurisdiction of National Water and Sewerage Corporation (Part 3) • Provides for services and functions that the district councils can devolve to the Lower Local government including: the protection of wetlands, the protection and maintenance of local water resources and any other functions the District may delegate (Part 4)
d(i)	**The Local Governments (Kampala City Council) (Solid Waste Management) Ordinance S 1 243 – 21** The Ordinance was made under sections 38 and 40 of the Local Government Act. This Ordinance applies to all areas of the district, including private premises, Government-owned properties and council properties	• That disposal of refuse on the ground shall be by controlled sanitary landfill method. It also requires that no person other than the council shall operate or maintain a sanitary landfill without a permit issued by the council or otherwise than in accordance with this Ordinance and any other written law in force. The applicant to operate a sanitary landfill shall be accompanied by a plan showing the following among other things depth to ground water and proximity to surface water or drainage courses • That a landfill operator to prevent the pollution of surface or groundwater and prevent or eliminate any public nuisance on the premises • A landfill operator is required to provide at the premises adequate water supply
e)	**The Kampala Capital City Act, 2010** The Act establishes the Kampala Capital City Authority (KCCA) as the governing body of the city	• KCCA is mandated among other things to construct and maintain major drains, developing Physical Development Plan for the Capital City and the metropolitan area and provide safe water and sanitation in the communities • The division Urban Councils are mandated among other things to manage public health and environment
g)	**The Public Health Act Cap 281** The Act consolidates the law in the respect of Public health. It place duties on the Urban and local authorities in matters pertaining to public health	• Every local authority can take all lawful, necessary and reasonably practicable measures for preventing any pollution dangerous to health of any supply of water which the public within its district has a right to use and does use for drinking or domestic purposes, whether the supply is derived from sources within or beyond its district and for purifying any such supply which has become so polluted. Such Local authority can take measures, including if necessary, proceedings at law, against any person so polluting any such supply or polluting any stream so as to be a nuisance or danger to health.
h)	**The National Water and Sewerage Corporation Act Cap 317** The Act establishes the National Water and Sewerage Corporation (NWSC) as a water and Sewerage Authority and gives it the mandate to operate and provide water and sewerage services in areas entrusted to it on a sound commercial and viable basis	• Presently, NWSC operates and provides water and sewerage services for 97 large urban centres across the country including Kampala City. It must ensure that the wastewater effluent meets the required national standards.

APPENDIX 4: 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.

Approach. We present the question and the response in this note. After discussion with KfW and LVBC, the excerpts will be incorporated into the final FS reports, due 30 November 2016.

HPI Kampala Question 1. *The implementation of a 70 ha Free Water Surface (FWS) Constructed Wetland (CW) seems to be challenging. Provide some references worldwide of similar projects.*

HPI Kampala Question 2. *The restoration of 70 ha wetlands close to existing communities might lead to nuisance and pests such as mosquito breeding, snakes and crocodiles. Indicate how these pests can be controlled.*

Answer HPI Kampala/ Mosquito breeding and other pests. At the moment the area is also an area that is prone to mosquito breeding and snakes can be expected. Hence, not much difference is expected between the situation before and after the implementation of the constructed wetlands. In the Final Feasibility Study we have stated the following on insects (section 4.4.9.2):

If flowering plants are used, many species of insects are attracted. Dragonflies (also feed on mosquito larvae) are surely in their element in swamp areas and several butterflies probably as well. In this context, one has to consider mosquitoes: swamps and mosquitoes are highly related. Yet literature usually tells that constructed wetlands do not per se increase the amount of mosquitoes. It might be wise to do some continued research on this matter but it is most unlikely that the Nakivubo swamp in its actual state would be poor in mosquitoes and a constructed wetland would be rich in them. It is most conceivable that it will not really differ much.

It is a public perception that wetlands provide breeding grounds for mosquitoes and cause mosquito problems. Whilst virtually any water source is a potential breeding ground for mosquitoes, wetlands can be designed to reduce mosquito habitat (Sarneckis, 2002). Monitoring of mosquito populations in communities before and after wetland construction has shown that well-designed wetlands do not necessarily cause an increase in mosquito numbers (Sarneckis, 2002). Manipulation of physical components, such as water levels and vegetation cover, in combination with chemical and biological control agents, can be used to maintain mosquito populations at low numbers.

***Physical control:** Water level fluctuations can be detrimental to mosquitoes, by either drowning or stranding their larvae. Maintaining water movement through the wetland can help also decrease mosquito populations. Therefore, the water level needs to be adjusted when need arises with the intention of controlling mosquito breeding apart from harvesting of plants. Periodic harvesting of dense stands of emergent vegetation and sediment build-up will help reduce the production of mosquitoes.*

***Biological control:** This is generally achieved to some degree through predation by other organisms. Natural predators of mosquitoes include fish, predacious mosquito larvae, other*

insects, spiders, fungal diseases, nematodes, protozoans, aquatic birds, frogs and some reptiles. Macroinvertebrates, such as waterbugs (Hemiptera), dytiscidae beetle larvae (Coleoptera), dragonflies (Anisoptera) and damselflies (Zygoptera) are generally more successful predators of mosquito larvae than fish in heavily vegetated areas (Chester 1990). When a system is not heavily vegetated, fish and some larvicides derived from bacteria are generally the most effective means of controlling mosquito numbers.