Nile Basin Initiative

Transboundary EnvironmentalAction Project

National

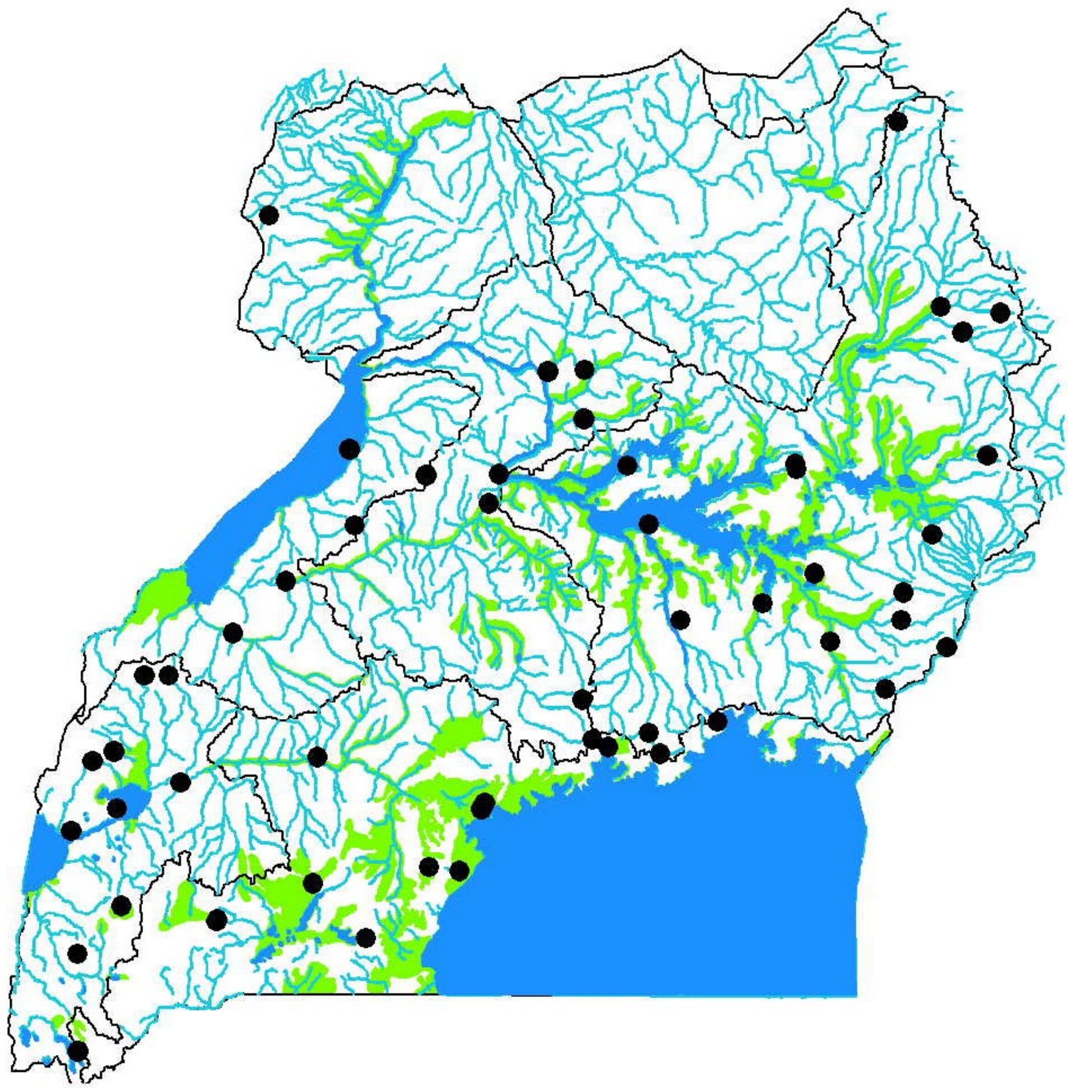
Nile Basin Water Quality Monitoring Baseline Report

for

UGANDA

NILEBASIN INITIATIVE

THE NILE BASIN TRANSBOUNDARY ENVIRONMENTAL ACTION PROJECT



BASELINE STUDY OF THE STATUS OF WATER QUALITY MONITORING IN UGANDA

BY
MOSES OTIM
APRIL 2005

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ACRONYMS AND ABBREVIATIONS

AAS	Atomic Absorption Spectroscopy
BOD	Biological Oxygen Demand
CBO	Community Based Organisation
COD	Chemical Oxygen Demand
DEO	District Environment Officer
DWD	Directorate of Water Development
DSOE	District State of Environment Report
DWO	District Water Officer
EC	Conductivity
FC	Faecal Coliforms
GAL	Government Analytical Laboratory
GIS	Geographic Information System
GPS	Global Positioning
FIRRI	Fisheries Resources Research Institute
HYDROMET	Hydro-meteorological Survey of the Catchments of Lakes Victoria, Kyoga, and Mobutu Sese Seko (Albert)
ILM	Integrated Lake Management
KCC	Kampala City Council
LAKIMO	Lake Kyoga Integrated Management Organisation
LAGBIMO	Lake George Basin Intergrated Management Organisation
LVEMP	Lake Victoria Environment Management Project
LVFO	Lake Victoria Fisheries Organisation
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MOH	ministry of Health
MUIENR	Makerere University Institute of Environment and Natural Resources
MUK	Makerere University Kampala
MWLE	Ministry of Water, Lands and Environment
NEMA	National Environment Management Authority
NGO	Non-Government Organisation
NTEAP	Nile Transboundary Environment Action Project
NWSC	National Water and Sewerage Corporation
PTEA	portable Trace Element Analyser
SOE	State of Environment Report
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
UNBS	Uganda National Bureau of Standards
UNDP	United Nations Development Programme
WAP	Water Action Plan
WPC	Water Policy Committee
WRMD	Water Resources Management Department
WWF	

ACKNOWLEDGEMENTS

The Consultant acknowledges the support provided by various people during the process of this baseline survey and data collection and in generation of this report. My appreciation goes to those who sacrificed their valuable time to provide an input to this baseline survey. Much of the data collection was carried out over a period of two weeks in January 2005, thanks to institutional and individual cooperation.

Finally, this baseline survey would not have been possible without a strong commitment of the NTEAP Coordinator in Uganda, the NBI Water Quality Working Group in Uganda and involvement of the Executive Director, National Environment Management Authority of Uganda, which has proven invaluable.

EXECUTIVE SUMMARY

The Nile basin has for centuries supported livelihoods, and the population here that is mainly rural is heavily dependent on the ecosystem values and services for their survival. However with degradation of riverine ecosystem values and an increased pollution threat from point and non-point sources, the sustainability of this water resource remains in balance if appropriate and sustainable water quality monitoring and management measures are not put in place and past achievements consolidated.

Uganda has a history of water quality monitoring dating back to pre-independence times. An even earlier date is quoted for activities monitoring lake Victoria water quality as early as 1927 (source: FIRRI). The period after independence witnessed development of countrywide water quality monitoring and surveillance structures, with a collapse due to neglect and civil strife between 1978-1986, but rejuvenation of the sector with the Water Action Plan (WAP), 1994. Various reforms initiatives in water quality monitoring and management have since been undertaken, as well as Water Resources management related programmes and projects, and there are ongoing efforts to develop a National Strategy for Water Quality Management.

This report presents the findings of a baseline survey on the status of water quality monitoring and management in the Nile Basin coverage of Uganda, commissioned by the Nile Basin Initiative under the Nile Transboundary Environment Action Project.

The output of this report reflects and includes;

- Water resources management practices in the country, covering the legal and institutional frameworks;
- Institutions or firms involved in water quality management and their capacities;
- Inventory of major rivers, lakes and wetlands and their quality status, as well as water quality issues for each sub-basin;
- Water quality data sheets of key parameters for regular sampling stations, and their significance at local and transboundary level;
- List of geo-referenced water sampling stations on major rivers and lakes;
- Inventory of major point and non–point sources of pollution;
- Inventory of existing laboratories and their physical and technical capacities.
- Suggested actions for improved water quality monitoring and management.

Approach and methodology

The baseline survey was undertaken through free and adequate participation of all the stakeholders and discussion of water quality issues in the Nile Basin, with particular reference to Uganda.

Several approaches were used including document review, field visits, observations, interviews, focus group discussion, and geo-data analysis in a GIS environment.

In the course of this baseline study, no primary data was generated. However the geographical and sampling strategy among stakeholders was such that the study results would be reliable, accurate and had coverage of the studied Nile basin area.

Findings of the baseline survey

The Water Policy, Legal and institutional framework in Uganda

The water sector policy has been shaped by a number of policy initiatives at national level, including the constitution of Uganda, 1995, the National Environment Management Policy (1994), and the decentralization and privatization policies. The Environment Act (1995), The Land Act (1998), The Local Government Act (1997), and The Water Act (1995) and various Environmental Legislations and Regulations, including bye-laws at local levels, have since been developed for the purpose of ensuring sustainable management of Water Resources and the Environment. Uganda is an active member of the global community of Nations, having entered into several regional and international environmental and water resources conventions and agreements.

Management of water resources and water quality monitoring has been traditionally and is legally a state function. The current structure has both central monitoring and regulation, as well as decentralized management. However given the increasing challenges and trends in water quality, the capacities at national, district and local levels need to be strengthened, and roles at all levels and among stakeholders well defined. There is limited involvement of the NGO's in water quality monitoring and management. Management at catchment level needs emphasis, as this provides an opportunity for community and various stakeholder involvement.

Private sector partnership is promising. With the implementation of the permits system and the polluter-pays principle, the private sector is putting in place measures to ensure compliance with environmental regulations. Besides currents strengthening of the DWD Water Permits Unit and of capacities of DWO's and DEO's is an opportunity for improved compliance with water and environmental regulation. However deficiencies in environmental awareness levels among the regulated communities needs to be addressed.

Water quality monitoring institutions

The key player in regular water quality monitoring is the WRMD of DWD under the Ministry of Water, Lands and Environment has the overall responsibility for promoting sustainable and integrated management of water resources in Uganda. WRMD is responsible for monitoring water resources of Uganda in terms of quality and quantity, as well as regulating water use, controlling pollution and promoting provision of clean and safe water for drinking and other purposes such as industrial, agricultural, ecological and recreational uses.

The WRMD has upto 119 water quality monitoring stations for surface water, groundwater and at impact points. Under the LVEMP Water Quality and Ecosystem Management Component the department operates 19 monitoring stations on lake Victoria. The current water quality monitoring is being redefined to cater for issues at watershed level, and transboundary concerns.

FIRRI is mandated to carry out research in fresh water fisheries, fish technology, aquaculture and fish production systems. In relation to water quality, the institute generates, packages, and disseminates scientific knowledge, builds capacity and manages research to guide prevention of pollution and eutrophication of the aquatic environment and control of invasive weeds especially the water hyacinth.

The mandate of NWSC is to operate and provide water and sewerage services in areas entrusted to it by the Water Act, 1995 and the NWSC Act, Cap 150. The NWSC monitors water quality parameters, particularly in relation to drinking water and effluents for areas in its jurisdiction. The Water Act, 1995 s provides for private water supply and sewerage service providers, and formation of user groups and associations to plan and manage point water supply system in their area, doing so to the extent and standard determined by the Minister. Upto 67 water authorities are now involved in water supply, and like NWSC, are legally involved in water source monitoring and quality surveillance.

Ministry of Health through the Department of Environmental Health now has countrywide water quality surveillance activities from drinking water sources to consumption, with capacity to sub-county level. The monitored parameters include faecal coliforms, turbidity, chlorine residuals and pH.

Other institutions that have been involved in regular water quality assessment include the Government Analytical Laboratory, Teaching and Research Institutions such as the Departments of Chemistry, Geology, and MUIENR, as well as the Faculty of Veterinary Medicine at Makerere University. Some projects have had water quality monitoring and research components such as LVEMP and ILM. NGO involvement is rather limited to provision of safe water and sanitary facilities, wetlands management and in education and awareness campaigns.

It is noted that water quality monitoring has been limited by financial, human and physical resources and in some cases inaccessibility to sampling points due to insurgency, the existing management structure, non-prioritisation of water issues at various levels, and lack of coordination of donor support. This has affected the output in terms of scope, regularity, quality and spatial coverage. Stakeholder participation and coordination of activities in water quality monitoring and assessment is still weak, and opportunities for information exchange and knowledge development among the water quality monitoring institutions limited.

Status of water quality analytical laboratories

Laboratories involved in water quality monitoring consulted during this baseline survey include those run by Government Institutions (WRMD, FIRRI, GAL, UNBS), Teaching and Research Institutions (Departments of Chemistry and Geology, Faculty of Veterinary Medicine, MUK) and Private/Commercial laboratories (Chemiphar). Wagtech Uganda Ltd, a major supplier of laboratory equipment in Uganda was also consulted.

There are varying levels of competence in terms of equipment and instrumentation, staffing and staff development opportunities, scope of water quality analysis, quality assurance and accreditation status, laboratory infrastructure including laboratory information systems and in dissemination of outputs.

Given the emerging trends in water quality, with a need for various parameters to be regularly monitored in future, there is surely a need to update in quality assurance and quality control, analytical skills, equipment and analytical scope and in water quality and laboratory information management systems. The staffing levels are rather low at most of these laboratories for a regular nationwide water quality assessment program. For completeness of water quality data as well as regular water quality monitoring, strengths of the various laboratories ought to be utilized, and information exchange or data exchange protocols be established.

A forum for exchange of knowledge in water quality analysis, analytical methods' standardisation, improvement in instrumentation as well as agreed curriculum for training of laboratory analysts and technicians could be established. A few laboratories are now accredited and participate in proficiency testing, and this has enhanced quality control and assurance measures in place.

Water quality: status and concerns

Water quality parameters monitored differ among institutions involved in scope, completeness, and regularity but provide a basis for interpretation of water quality status, background conditions such as catchment land use and soils, pollutant sources and its suitability for aquatic life and other uses such as drinking, recreation, agriculture and industry.

Available water quality data for point sources, non-point sources, rivers and streams, and for lakes, has some extreme values indicating the surface waters are threatened by pollution. Ground water and shallow wells monitoring data show high risk of faecal bacteriological contamnation at various sites.

The major sources of pollution include sewerage and municipal or urban effluents, industrial effluents, domestic effluents, agricultural run-off and changing land use leading to soil erosion, natural conditions, floating aquatic macrophites, as well as atmospheric deposition of pollutants. Detection of pesticide residues and high nutrient loads into surface water bodies is also of concern.

Upto 49,500 tons of nitrogen and 5,700 tons of phosphorous are loaded into lake Victoria annually. The annual BOD load is estimated at 155,580 tons. Municipal and industrial effluent, and urban run-off into the Lake Victoria was estimated at 9,382 kg/day of BOD, 1,847 kg/day of total Nitrogen and 1,253 kg/day of total phosphorus after purification (Mott Macdonald, LVEMP/NWSC- 2001).

The status of water quality in rivers and streams indicates parameters of concern are TSS, TDS, EC, DO, BOD, COD, total coliforms and e-coli. Poor sanitary coverage is of concern, as surveillance results of water sources for drinking such as rivers, streams, boreholes, shallow wells, and protected springs indicate faecal contamination. Poor agricultural practices and ecosystem degradation is seriously contributing to siltation and sedimentation in rivers.

Except for lake Victoria, there is a paucity of water quality monitoring data and activities on other lakes with available data based on occasional grab samples. The results show a tendency to eutrophication and deterioration in water quality of the lakes.

Transboundary concerns for the lakes Edward and Albert need to be addressed. The ongoing redefinition of the WRMD water quality-monitoring network to address water quality issues at watershed and transboundary level needs to be supported.

Different media for sample collection including streambed sediments, aquatic biological tissues, as well as fish, invertebrate, and algal communities and stream habitat are not frequently sampled to aid better understanding of water quality status. The linkage to water use and water resource productivity remains weak. There has been financial limitation of the extent and regularity of water quality monitoring.

Except for DWD, the infrastructure and tools for capture and storage of spatial data, and dissemination of water monitoring output, such as GPS and GIS infrastructure, are lacking, and the utilization of spatial modeling to predict water quality trends or impacts of changing land use and point sources is wanting. Under LVEMP Municipal, Industrial and urban run-off has been mapped and quantified, and a Hydro 3D model to simulate pollutant load into lake Victoria developed.

Conclusions and recommendations

This baseline survey reveals water quality monitoring and management gaps that ought to be addressed. The identified water quality monitoring gaps include inadequacies in spatial and temporal coverage, scope of analysis, laboratory capacities, laboratory information systems, background environmental data and sampling media.

Efforts towards involvement of various stakeholders and decentralised water quality monitoring and management, and building capacity for enforcement of water quality and related environmental regulations, awareness raising and participation in monitoring at district and local levels, and also by the private sector are on-going but need particular emphasis. Appropriate definition of roles, coordination among leading institutions, key players at District and other local levels, and opportunities for information exchange and capacity building need to be improved.

Much as there are management regimes and practices in place to protect water quality, as well as documentation of water quality status there is need for continuity and more accurate information generation particularly presenting the water quality state, water resources and their status as per water quality trends, pressure on basin ecosystem resources and causes, impact of human induced and natural hazards on water resources, and responses adopted to address water quality and environmental change. Water quality status for lakes and their catchment management particularly needs to be addressed. The WRMD Yearbook, DSOE, and SOE's provide such opportunity.

There is also need for emphasis on development of capacities in monitoring and management of water quality, including laboratory infrastructure, human resources, regulation and information systems. Local capacities and awareness, as well as participation by stakeholders and local communities is required for success of water quality management initiatives.

Emphasis and appreciation of the use of modern tools in water quality monitoring and management, such as spatial data capture, analysis and models to help predict future water quality scenario, addressing key environmental concerns in the watersheds, and developing means to track and contain them.

Continuity in development of research techniques and understanding of the Nile Basin water quality and water resource sustainable management practices, as well as development of an information system or reporting framework, opportunities for information exchange and dissemination among stakeholders in water quality management and monitoring should be encouraged.

All these improvement efforts carry structural, human resources and financial implications, and this has been a limitation to the efficacy of existing water quality monitoring and research institutions. Current efforts and recent achievements by the lead agency in Water Quality Monitoring and Management are commendable, particularly in developing a National Water Quality Management Strategy, Water Resources Sub-Sector reforms, among others and provide a strong basis for future sustainable water resources management.

1.0 INTRODUCTION

1.1 The Nile Basin

The Nile Basin is home to an estimated 160 million people. More than 300 million people live in the 10 countries that share and depend on the Nile waters. All of these people rely to a greater extent on the river for their basic needs. 10 countries share the Nile River catchment: Burundi, Democratic Republic of Congo, Egypt, Ethiopia, Eritrea, Kenya, Rwanda, Sudan, Tanzania and Uganda.

The Nile River is the longest in the world. Its catchment most remote headstream originates in the highlands in Burundi and flows approximately 6,670 kilometers until it reaches the Mediterranean Sea in Egypt. The major sources of the Upper Nile are the rainfall over Lake Victoria and the Kagera River, which flows into the lake Victoria, the Mount Elgon catchment on the border of Uganda and Kenya, Mt. Rwenzori on the border of Uganda and DRC, and the catchment areas in Kenya and Tanzania.

The river basin has an area of more than 3,350,000 square kilometers (approximately 1,293,465 square miles). All 10 Nile Basin countries contribute in different manners to the basin and have different needs for the water and other resources of the basin, and transboundary environmental concerns.

The Nile Basin has a range of ecosystems including high mountains, tropical forests, woodlands, savannas, high and low altitude wetlands, arid lands and deserts culminating in an enormous delta in Egypt. The population here that is mainly rural is heavily dependent on the ecosystems values and services for their survival. The following pictures in figure 1.1 provide impressions of the River Nile in Uganda.

Figure 1.1 a): Impressions of River Nile, Uganda

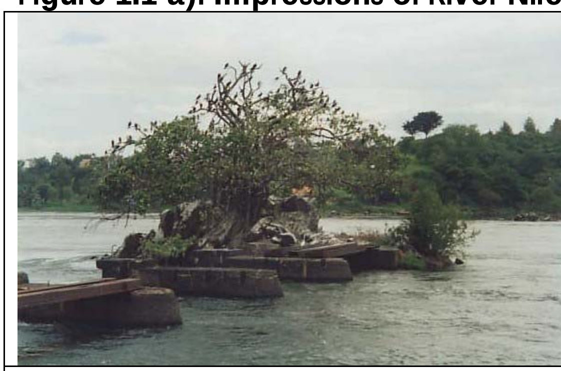
	
The river Nile Lake Victoria outlet at Jinja	Bujagali Falls in Jinja District

Figure 1.1 b): Impressions of River Nile, Uganda

	
Toursm activity on Bujagali Falls on river Nile, Jinja District	The river Nile at Karuma towards lake Albert

1.2 The Nile Basin in Uganda

Uganda is located in the eastern region of Africa and lies between Latitude 1° 30 South and 4° North, and Longitude 29° 30'East and 35° East, and occupies an area of about 241,500 km^2 almost all of which lies in the Nile basin catchment area. The Country is bordered by the Republic of Kenya in the east, Tanzania and Rwanda in the south, Sudan to the north and the Democratic Republic of Congo to the West, as shown in figure 3.

The catchment is known for its ecosystem level biodiversity, mainly forests, savannas, wetlands and aquatic ecosystems. Some of these are transboundary and provide challenges requiring closer cooperation with neighbouring states. Administratively, Uganda has 56 districts with only small portions of Arua, Kotido, Moroto and Nakapiripit Districts lieing outside the eight Nile basin sub-catchments in Uganda.

Figure 1.2: The Nile River Basin

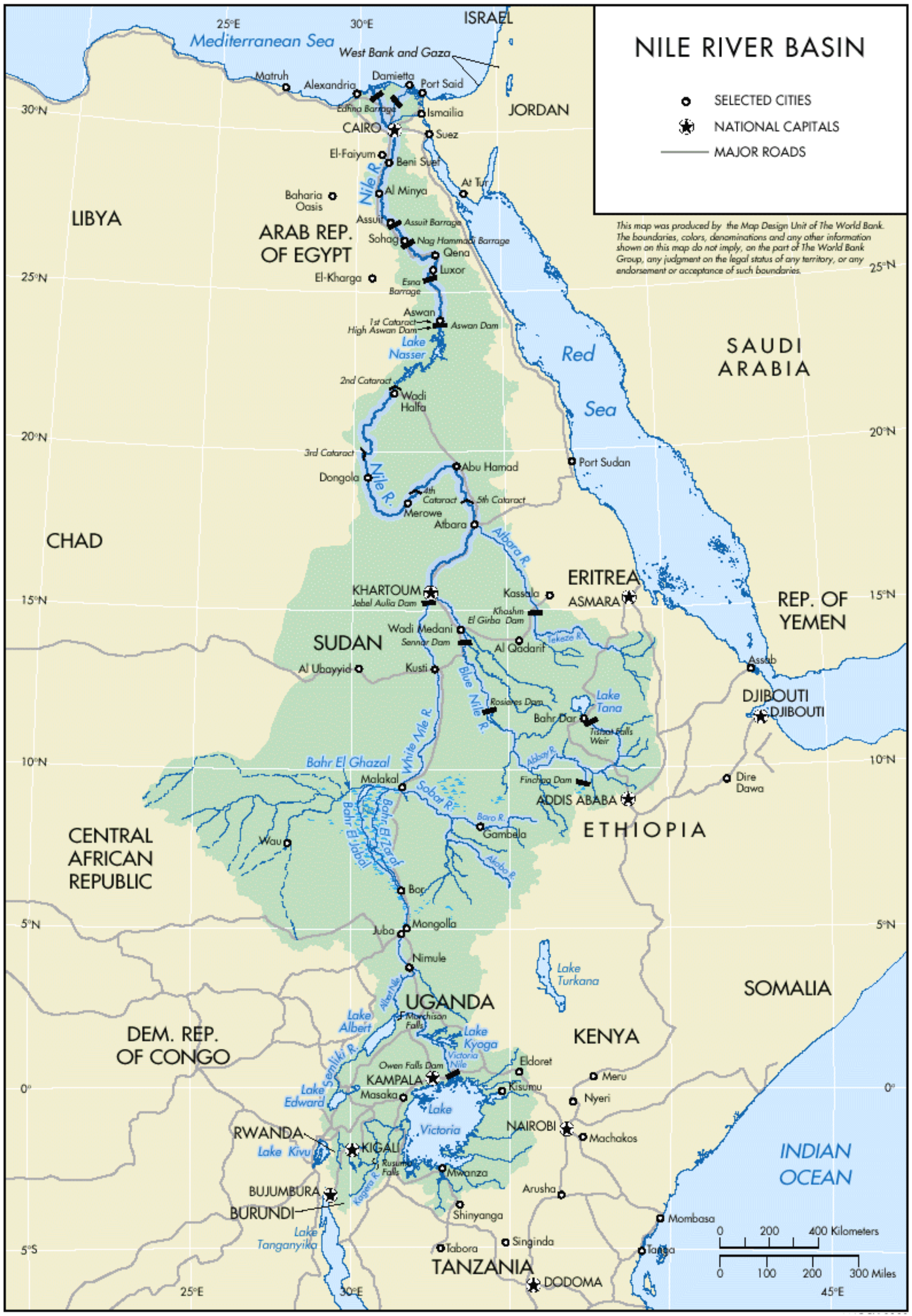


Figure 1.3: Uganda's Geographical location

1.3 Geology

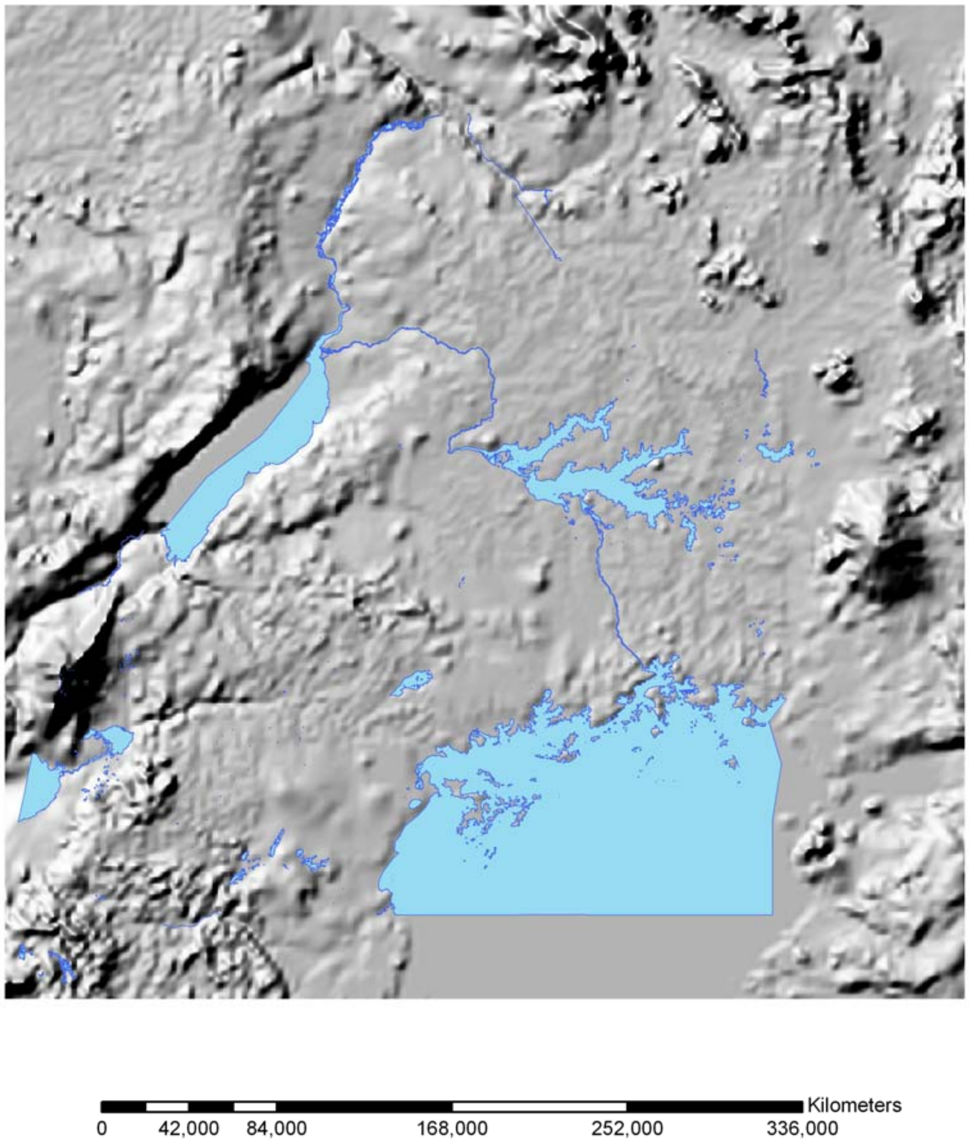
The geological formations of Uganda reveal the country is underlain by some of the world's oldest rocks, some formed as long ago as 3,000 million years ago (pre-Cambrian era) and a large part have been modified and altered by deep-seated mountain building movements which extended throughout the Precambrian era to the beginnings of Cambrian time approximately 500 million years ago.

Active geological deposition recommenced in Tertiary or possibly late-Cretaceous times with volcanic activity, and the laying down of associated sediments. Rift movements have become very important since this time, and the western rift valley filled with sediments as it formed. The latest stages in formation of the rift valley gave rise to renewed volacanic activity, and a general sag in the centre of the country which produced lake Kyoga drowned valley system and Lake Victoria. The younger rocks are either sediments or of volcanic origin, formed from about 135 million years ago (Cretaceous period) to the present.

The major structural controls in Uganda include the pattern of orogenic fold belts and shear zones in the Precambrian, the form of the Rift valley, the distribution of later volcanic centers and pleitoscene warping. These structures make-up the control of drainage patterns and lake basins in the country, notably the lakes George, Edward and Albert basins in the Western Rift valley in the country, the Rwenzori Mountain horst block and the Mouth Elgon Catchment. Late pleitoscene warping has produced a sag through central Uganda which formed lake Victoria and caused the reversal of westerly flowing rivers in central Uganda to produce the two way flow of river Kafu and other rivers, the catchment divide between lake Victoria and Kyoga, and the drowned valley lake system of Lake Kyoga.

Figure 1.4 provides the structural controls, major lakes and landscape of the Nile Basin in Uganda.

Figure 1.4: Major lakes, structural controls and landscape



1.4 Mineralisation

Mineralisation and mineral exploitation account for some of the elevated background values and point sources of pollution for surface and ground waters in Uganda.

Mineral deposits are found mainly in the argillacous cover formations of the Precambrian. No major metallic ore has been found in the Gneissose and granitised formations though industrial minerals such as vermiculite, magnesite, dolomite and limestone can be found. Traces of gold, copper and chromite have been found and gold exploited locally in Karamoja.

The eastern volcanic formations host carbonatite complexes containing a variety of minerals, including apatite, pyrochlor, zircon, magnetite, titanium and barites. In the Nyanzian system found in the South east (Busia and Tororo District), gold has been recovered from quartz veins in these rocks.

The Buganda-Toro System hosts the Kilembe system which has been exploited in the past for its copper and cobalt sulphide mineralisation, occurring in strongly folded series of shists and rocks of volcanic origin. The other areas where copper mineralization has been noted are Bobong, Lokapeliethe and Loyolo in Karamoja region, and Kampono and Kitaka in Mbarara district**.**

The Karagwe Ankolean system has produced a variety of exploitable minerals, including tin from casseterite ore mainly; Galena at Kampono, Kanyambogo and Kitaka in Kitomi Forest, Mbarara district; others include wolfram, bismuth, niobium and tantalum (Columbite-tantalite), and berrylium. Other minerals include salt deposits in the western volcanic formations, including crater lakes and hot springs such as lake Katwe and Kasenyi in Kasese district, and Kibiro in Hoima district.

There is on-gong exploration for oil in the Pakwach basin, Northern Lake Albert Basin, Southern Lake Albert-Semliki, Lakes Edward-George Basin, and Rhino Camp basin. The exploitation of petroleum could pose a threat to the water systems and ecosystems of the Lake Albert, and Lake Edward basins if not properly undertaken.

1.5 Geomorphology

Most of Uganda forms part of the interior plateau of the Africa continent. It is characterised by flat-topped hills in the central, western and eastern parts of the country. Gneiss and granitized rocks of the Precambrian directly underlie the mainly flat northern part of Uganda, but produce hilly terrain in the peripheral part of the country. In the south and southwest the general less-metarmorphosed precambrian formations give rise to a more incised topography. The sedimentary infill of the western Rift valley floor produces a low relief, which is diversified in the south by the pleitocene lavas and ash crater fields. The rise of the plateau in the eastern and western parts of the country is represented by spectacular mountainous topography found along the borders, such as, the Rwenzori Mountains and Mufumbira volcanoes in the west, and Mt. Elgon, Mt Moroto, and Mt Morungole.

The areas of hilly terrain have been prone to soil erosion, with the most serious affected districts being the steep slopes of Kabale, Kisoro, Bundibudyo, Kasese, Kabarole, Kapchorwa and Mbale districts (NARO, 2001). Other districts such as Kabale, Kisoro, Sironko and Mbale have been prone to landslides. This soil erosion has resulted in increased turbidity and siltation of surface water sources in these areas.

1.6 Catchment soils

The soils of Uganda are defined by a number of parameters, which include parent rock, age of soil and climate. The most dominant soil type is ferralitic soil, which accounts for about two-thirds of the soils found in the country. However swamp alluvium is common in valley bottoms, wetlands and river valleys. The soils vary in productivity with the high productivity soils covering 8% of the area of Uganda (MWLE, 2001).

1.7 Climate

The Inter-Tropical Convergence Zone (ITCZ) and air currents such as the monsoons influence the climate of Uganda. Locally, the amount and distribution of rainfall are dependent on orographic effects, the proximity to water bodies such as lake Victoria, and the main moisture bearing winds. Uganda's rainfall pattern has bi-modal characterists. In most parts of the country, the seasons are fairly well marked – as rainy and dry seasons. Compared to the rest of sub-Saharan Africa (SSA), Uganda is well endowed with one of the most favourable climates for agricultural production, and farming systems are dependent on the amounts of rainfall received. The average annual rainfall in Uganda varies from about 700mm in the semi-arid areas of Kotido district to 2000mm on the Islands of Kalangala in Lake Victoria (NEMA, 1998).

The mean temperatures over the whole country show great variation, depending on elevation and landscape. Temperatures over most of the country range between 15 to 35^{o}C all year round. For areas adjacent to waterbodies such as Lake Victoria, maritime conditions tend to modify the temperatures. The variation in mean monthly and annual evaporation rates is much smaller than corresponding variations in rainfall (SOE, 2002). The movement of the ITCZ is to a great extent responsible for the variations in meteorological factors that determine evaporation.

Temperature and rainfall are the two key variables used to measure climate variability, although the latter is the one most regularly considered. Over the period 1943 to 1999, different regions of Uganda were exposed to varying levels of climatic extremes. The *El Nino* and *La Nina* phenomena associated with climate variability have had a profound impact in Uganda, with physical, environmental and economic impacts (SOE, 2002).

Figure 1.5 provides results of the hydro-climatic study of Uganda by WRMD.

1.8 Land cover

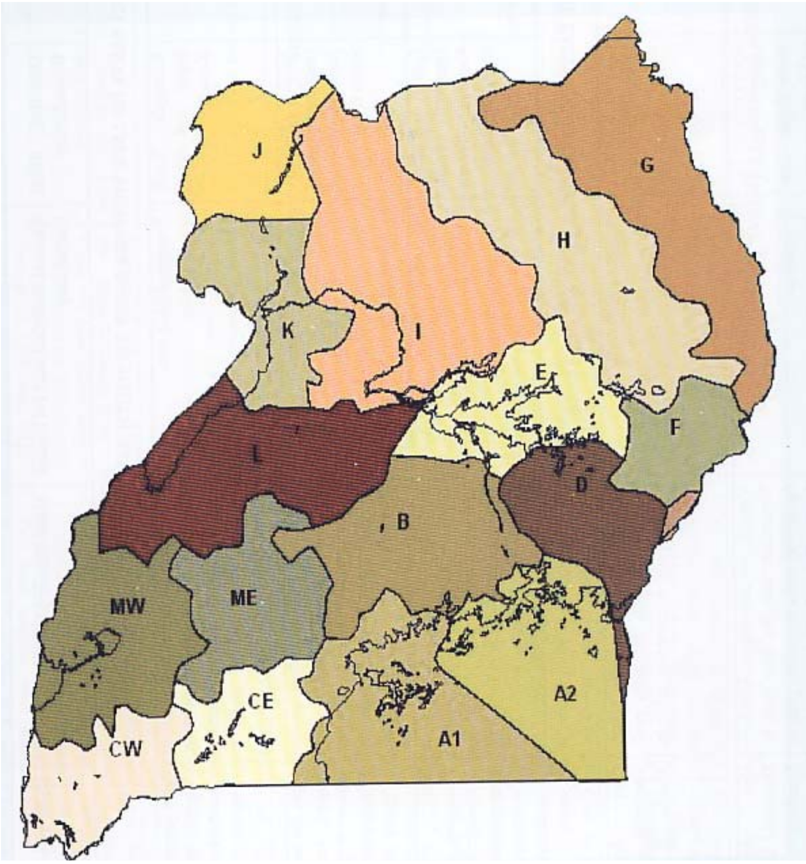
There are 11 main categories of vegetation types, namely:

i. High montane moorland and health
ii. Medium Altitude Forests
iii. Forests/Savanna Mosaic
iv. Moist Thicket
v. Woodland
vi. Wooded Savannah
vii. Grass savannah
viii. Steppe
ix. Bushland and dry thicket
x. Swamp (wetlands)
xi. Post-Cultivation communities.

The National Biomass Study Technical Report (2003) reveals increased encroachment of vegetative cover for subsistence farmland given the growing population, as well as charcoal production and other tree resource uses. This has had consequences such as soil erosion, water source siltation, water quality degradation evident in increased turbidity and microclimate changes.

Table 1.1 provides spatial coverage of land cover types in Uganda.

Figure 1.5: Hydro-Climatic Zones of Uganda



Legend

Zone	Annual rainfall, mm	Standard deviation
Eastern parts of lake Victoria Basin to South Eastern Areas		
A1-E	1414	-
A2	1443	-
D	1316	-
Central Eastern to Central lake Kyoga Areas		
F	1328	-
E	1215	-
Northeastern to North Central Areas		
G	745	145.00
H	1197	169.00
I	1340	155.00
Northwestern to Central Western Areas		
I	1371	185.00
J	1259	195.00
K	1270	135.00
Central Westrrn Areas to Central Region		
MW	1223	-
ME	1021	-
B	1250	-
Southwestern Areas to Western shore of Lake Victoria Basin		
CW	1120	-
CE	915	-
A1-W	1057	-

1.9 Land use

Of the total 241,551km2, 20.5 million ha is the area excluding water, out of which 4.9 million ha is covered by forests and woodlands. Other land cover/land use types comprise bushlands, grasslands, wetlands, subsistence farmland, commercial farmland, built up areas and impediments.

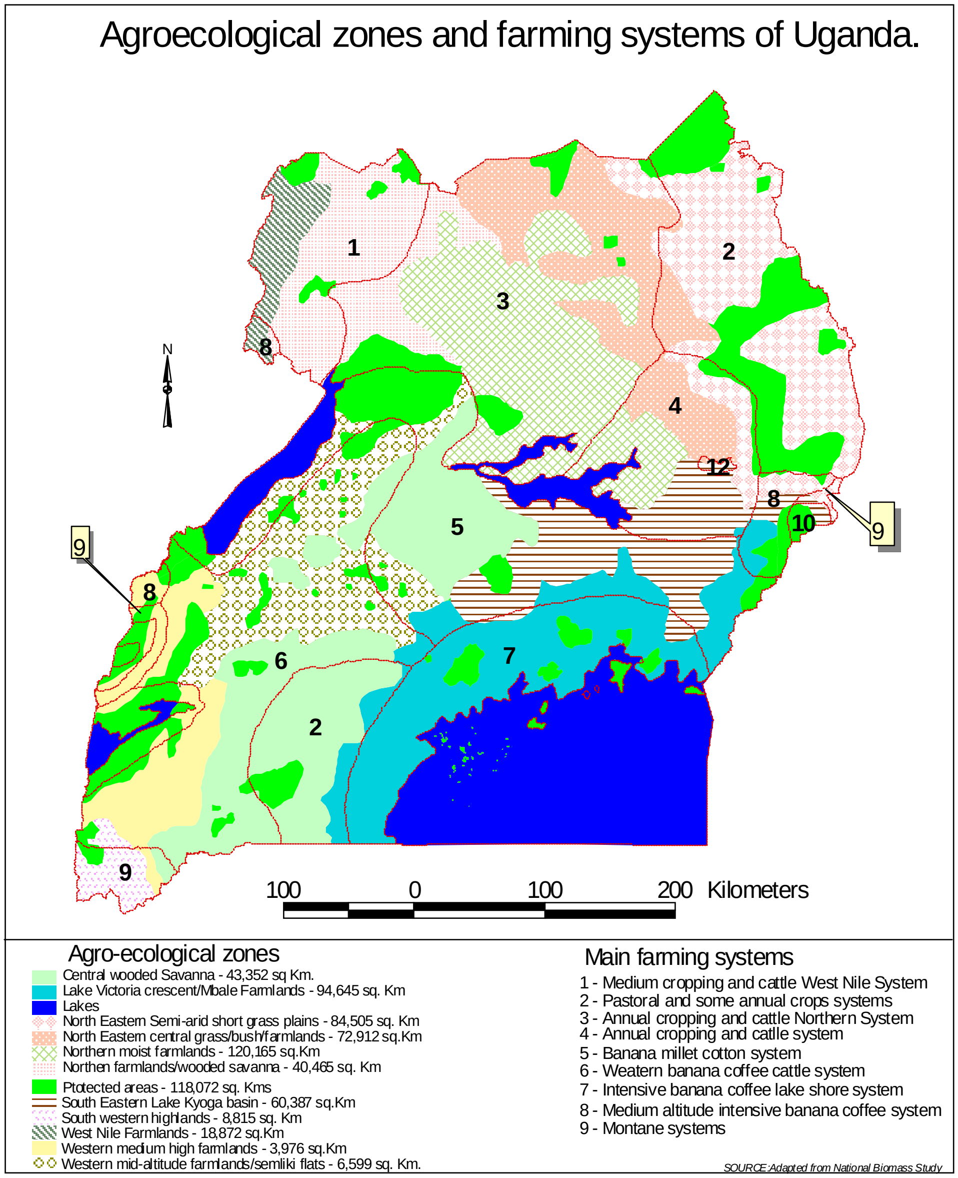
Table 1.1: Land cover in Uganda

Land cover/use	Gross area by land cover/use (ha)	Percentage
Plantations hardwoods	18,682	0.08
Plantations softwoods	16,384	0.07
THF-Normal	650,150	2.69
THF-Degraded	274,058	1.13
Woodlands	3,974,102	16.45
Bushlands	1,422,395	5.89
Grasslands	5,115,266	21.18
Wetlands	484,037	2.00
Subsistance Farmlands	8,400,999	34.78
Commercial Farmlands	68,446	0.28
Built up areas	36,571	0.15
Water	3,690,254	15.28
Impedements	3,713	0.02
Total	24,155,058	100.00

Source: NBS Technical report, 2003

Agriculture constitutes the largest land use category in the country, but land for cultivation has been declining. There is increased demand and use of agrochemicals by commercial farmlands and peasant farmers including fungicides, nematodes, acaricides, herbicides and fertilizers, and this is of concern to environmental management, and in terms of impact on water quality in particular.

Figure 1.6 Agroecological zones and farming systems of Uganda



Agroecological zones and farming systems of Uganda.
N
1
2
3
4
5
6
7
8
9
10
12
100
0
100
200
Kilometers
Agro-ecological zones
Central wooded Savanna - 43,352 sq Km.
Lake Victoria crescent/Mbale Farmlands - 94,645 sq. Km
Lakes
North Eastern Semi-arid short grass plains - 84,505 sq. Km
North Eastern central grass/bush/farmlands - 72,912 sq.Km
Northern moist farmlands - 120,165 sq.Km
Northen farmlands/wooded savanna - 40,465 sq. Km
Ptotected areas - 118,072 sq. Kms
South Eastern Lake Kyoga basin - 60,387 sq.Km
South western highlands - 8,815 sq. Km
West Nile Farmlands - 18,872 sq.Km
Western medium high farmlands - 3,976 sq.Km
Western mid-altitude farmlands/semliki flats - 6,599 sq. Km.
Main farming systems
1 - Medium cropping and cattle West Nile System
2 - Pastoral and some annual crops systems
3 - Annual cropping and cattle Northern System
4 - Annual cropping and catlle system
5 - Banana millet cotton system
6 - Weatern banana coffee cattle system
7 - Intensive banana coffee lake shore system
8 - Medium altitude intensive banana coffee system
9 - Montane systems
SOURCE:Adapted from National Biomass Study

2.0 The Nile Basin Water Resources in Uganda

2.1 Surface water sources

The freshwater sources of Uganda include surface water, ground water, open water bodies and rainfall. The surface water resources in the country fall into eight main sub-basins, namely: Lake Victoria (shared with Kenya and Tanzania), Victoria Nile, Kyoga Nile, Albert Nile, the lakes George and Edward, River Aswa and Kidepo Valley sub-basin. The yield in these catchments, though very small compared to the total Nile outflow, dominates the water resource potential of Uganda. Table 2.1 provides the sub-basin characteristics, table 2.2 the major lakes of Uganda, table 2.3 major rivers of Uganda, and figure 2.1basins, lakes, maor rivers and wetlands of Uganda, and table 2.5 wetlands distribution in Uganda.

Table 2.1: Catchment yields and outflows of the Nile catchments of Uganda

Basin	Area, km^2	Annual average yield, mm	Mean flow (m^3/s)
Victoria Nile	57,669	133.05	1120.35
Kyoga Nile	26796	98.57	1051.73
Edward and George	18624	211.95	159.14
Aswa	26868	102.01	42.91
Albert Nile	20004	96.45	1262.45

Source: DWD, 1998

Of the total area in Uganda, 15.3% is open water, 3.0% permanent wetlands, and 9.4% seasonal wetlands. There is an annual water supply of 66 km^3 in the form of rain and inflows, which is unevenly distributed. Consequently there is limited availability of water in some regions of Uganda. The open water sources are mainly in the form of rivers and lakes.

The most significant water body in Uganda is lake Victoria, which is the second largest fresh water lake in the world and the cradle of the River Nile. The basins of the Lakes Victoria, Edward, George, Albert and Kyoga are rich with floodplains, wetlands and smaller satellite lakes that support abundant biodiversity and food production.

The Lake Albert Basin includes major rivers Semiliki, which drains from the Eastern Republic of Congo, and Waki, Muzizi and Nkussi. The Lake Edward Basin has numerous rivers originating from Rwenzori mountains such as Mpanga, Nyamugasani, Mubuku, and Chambura. The Victoria Nile Basin in the central western part of the country includes rivers Kafu, Tochi and the Kyoga Nile itself. The Albert-Nile basin in the northwest part of the country has Anyau, Oru, and Ora as the major rivers.

River Nile is the only outflow from Lake Victoria. The 130km stretch from Lake Victoria to Kyoga is the Victoria Nile, and the Kyoga Nile drains Lake Kyoga, flowing through a relatively flat terrain, and a series of rapids and falls before lake Albert. In lake Albert the Nile is joined by River Semiliki which drains Lakes George and Edward found in the Rift Valley, then flows from lake Albert over a gentle slope to the Sudan border through the Albert Nile reach.

Lake Victoria is an important purifier and oxygenator for the Nile River, and further downstream, the extensive swampy margins of lake Kyoga further improve water quality and storage role of lake Victoria, with similar roles played by the lakes George, Edward, Albert and associated riverine systems.

Table 2.2: Major lakes of Uganda

Lakes	Total area (Km^2)	Area in Uganda (Km^2)	Height above sea level (m)	Catchment area	Catchment area in Uganda	Maximum Depth (m)
Victoria	**68,457**	**28,665**	**1123**	**184000**	**59,858**	**82**
Albert	**5,335**	**2,913**	**621**	**n.a**	**18,223**	**51**
Edward	**2,203**	**645**	**913**	**12096**	**18,624**	**117**
Kyoga and Kwania	**2,047**	**2,047**	**1,033**	**75000**	**59,669**	**7**
Salisbury (Bisina)	**308**	**308**	**1,047**	**n.a**	**n.a**	**n.a.**
George	**246**	**246**	**914**	**9705**	**n.a**	**3**

Source: SOE, 2002

Table 2.3: Statistics on selected major rivers in Uganda

Maximum mean and minimun flow at selected stations

Station No.	Station name	Catchment area (km^2)	2001 Max	2001 Mean	2001 Min	2002 Max	2002 Mean	2002 Min	2003 Max	2003 Mean	2003 Min
81216	R. Kakinga Index catchment	985	3.04	0.069	0.011	0.019	0.019	0.011	1.113	0.036	0.011
81224	R. Ruizi at Mbarara	2070	92.714	18.019	3.168	84.115	11.459	3.168	20.806	5.768	3.47
81259	R. Katonga at Kla-Masaka road	13930	6.592	2.713	0.905	5.032	2.829	1.09	3.909	1.897	0.332
81260	R. Kibimba at Madu - Kinini Rd	2270	2.275	1.244	0.927	2.155	1.74	1.333	2.241	1.544	1.208
82203	R. Victoria Nile at Mbulambuti	265727	1252.06	1056.526	817.372	1389.077	1165.315	978.195	1333.3	1203.409	965.935
82212	R. Manafwa at Mbale - Soroti Road	4942	13.404	5.454	3.007	13.765	4.425	1.403	12.649	3.924	1.177
82213	R. Namatala at Mbale Soroti Road	124	11.365	2.418	0.794	27.561	1.61	0.827	8.877	1.899	0.561
82217	R. Mpologoma at Budumba	3614	62.04	20.472	2.155	79.906	14.419	1.689	50.875	1.899	0.561
82218	R. Malaba at Jinja -Tororo Rd	1604	52.371	23.411	1.137	57.519	15.539	1.126	47.443	15.043	0.839
82220	R. Enget at Bata - Dokolo Rd	105	3.821	1.193	0.352	3.94	1.289	0.592			
82225	R. Sezibwa at Falls	427	10.631	1.405	0.483	10.733	2.201	0.602	5.311	1.519	0.602
82227	R. Kapiri at Awoja	14123	12.966	6.716	3.372	10.644	7.376	4.397	10.066	5.353	1.74
82228	R. Namalu at Mbale - Moroto Rd	37	2.204	0.335	0.058	1.947	0.183	0.042	1.24	0.21	0.05
82241	R. Simu at Mbale - Moroto Rd	165	14.759	3.33	0.422	5.784	1.62	0.461	14.831	2.967	0.206
82243	R. Sipi at Mbale - Moroto Rd	92	8.313	2.088	0.205	5.423	0.912	0.141	6.626	2.326	0.174
82245	R. Akokorio at Soroti - Katakwi	1401	62.104	20.36	0.299	19.994	4.573	0.325			
83203	R. Kyoga Nile at Masindi Port	338465	1303.247	1095.306	932.018	1286.007	1159.028	1045.001	1383.16	1265.261	1116.982
83206	R. Kyoga Nile at Kamdini	345944	1184.97	1013.408	885.384	1156.88	1054.042	969.145	1184.98	1013.41	885.384
83209	R. Kyoga Nile at Para	35	1451.436	1028.966	770.503	1361.625	1150.342	1004.878	1532.514	111.095	1345.458
83212	R. Tochi II at Gulu - Atura Road	2188	37.542	10.87	0.94	31.657	11.972	1.306	61.856	13.281	1.559
83213	R. Kafu at Kla - GuluRd	12952	79.15	21.14	4.618	92.34	17.374	5.486	45.199	16.348	5.216
84212	R. Mpanga at Kla - Fortportal Rd	401	38.303	4.106	0.313	36.122	4.375	0.253	16.532	3.337	0.489
84215	R. Mpanga at Ibanda - Fortportal Rd	4670	59.691	14.899	2.368	63.602	15.902	2.058	67.983	13.75	3.355
84227	R. Chambura at Kichwamba	660	38.015	9.744	3.137	37.627	7.698	2.919	35.316	9.906	3.52
84228	R. Nyamugasani at Katwe - Zaire Rd	507	29.369	8.262	3.198	21.837	6.073	3.947	17.769	4.484	2.724
84267	R. Mitano at Kanungu - Rweshama Rd	1746	54.698	18.214	4.398	56.331	19.854	7.402	49.494	20.308	7.746
85211	R. Muzizi at Kyenjojo - Hoima Rd	2602	91.045	34.104	19.642	74.233	33.654	19.642	95.05	51.911	30.62

85212	**R. Nkusi at Kyenjojo - Hoima**	**2839**	**54.516**	**7.571**	**0.034**	**55.344**	**6.792**	**0.193**	**25.05**	**5.422**	**0.266**
85217	**R. Waki II at Biiso - Hoima Rd**	**343**	**9.903**	**2.742**	**0.367**	**17.102**	**4.385**	**0.791**	**14.664**	**4.763**	**1.366**
87206	**R. Anyau at Arua - Moyo Rd**	**794**	**30.676**	**5.251**	**0**	**28.64**	**4.579**	**0.142**	**29.627**	**4.809**	**0.013**
87208	**R. Oru at Arua - Yumbe Rd**	**431**	**50.975**	**3.612**	**0**	**17.453**	**2.218**	**0.007**	**99.072**	**3.548**	**0**
87212	**R. Ora at Index - Pakwach Rd**	**2775**	**101.363**	**24.443**	**3.594**	**75.345**	**15.222**	**6.06**	**109.839**	**19.944**	**4.253**
87217	**R. Albert at Laropi**	**427131**	**1473.357**	**1185.015**	**977.157**	**1458.052**	**1313.917**	**1098.889**	**1648.207**	**1396.674**	**1220.806**
87218	**R. Nyagak at Nyapea**	**602**	**24.931**	**6.541**	**1.882**	**14.739**	**5.153**	**2.441**	**16.58**	**5.922**	**1.725**
87222	**R. Albert Nile at Panyango**	**413046**	**1372.381**	**895.608**	**591.086**	**1330.617**	**1110.76**	**310.555**	**1663.288**	**1394.73**	**1026.703**

Source WRMD, 2004

Note: Flow in Cubic Metres
Missing values due to insecurity

Figure 2.1: Basins, lakes, major rivers and wetlands of Uganda

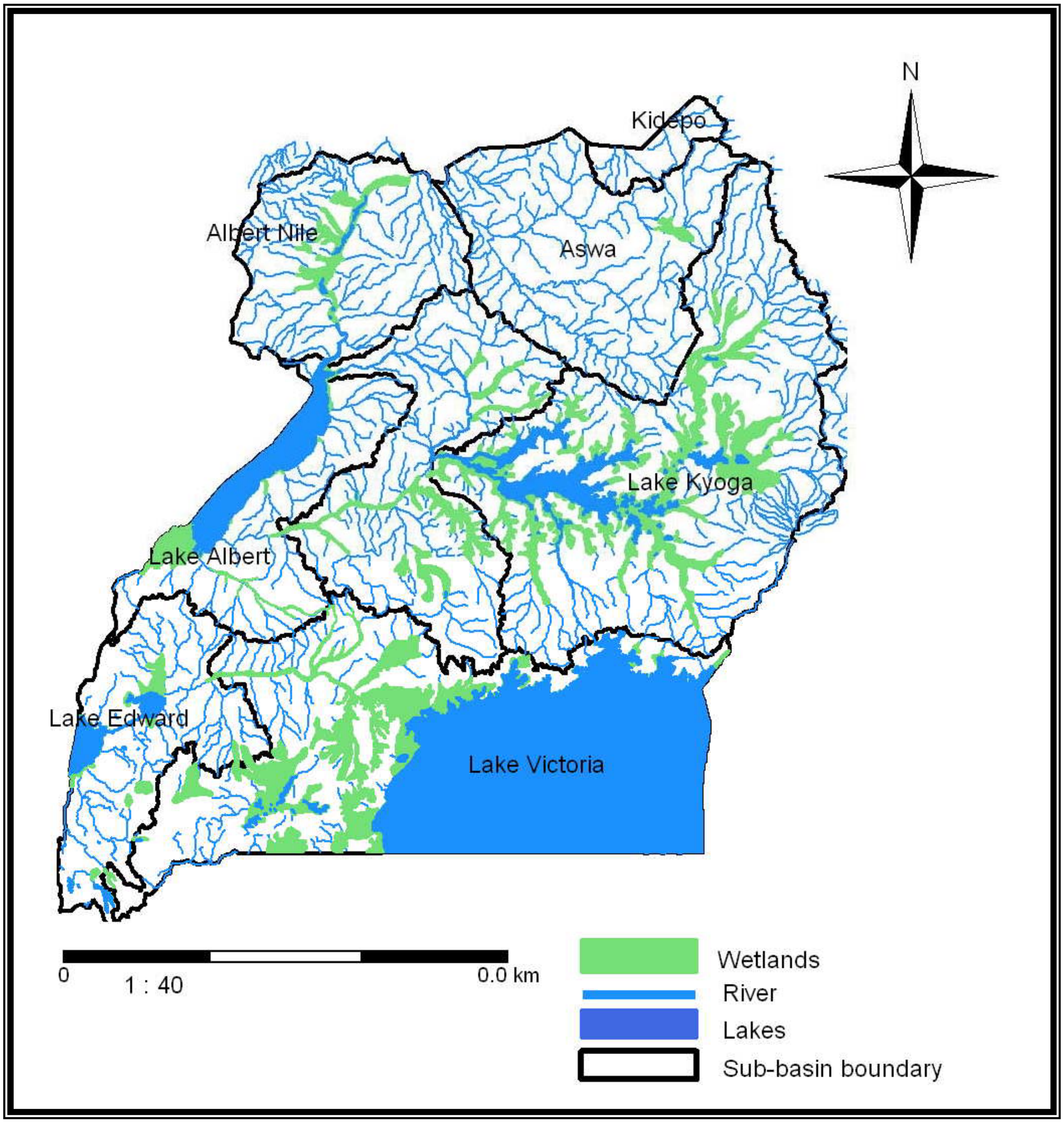
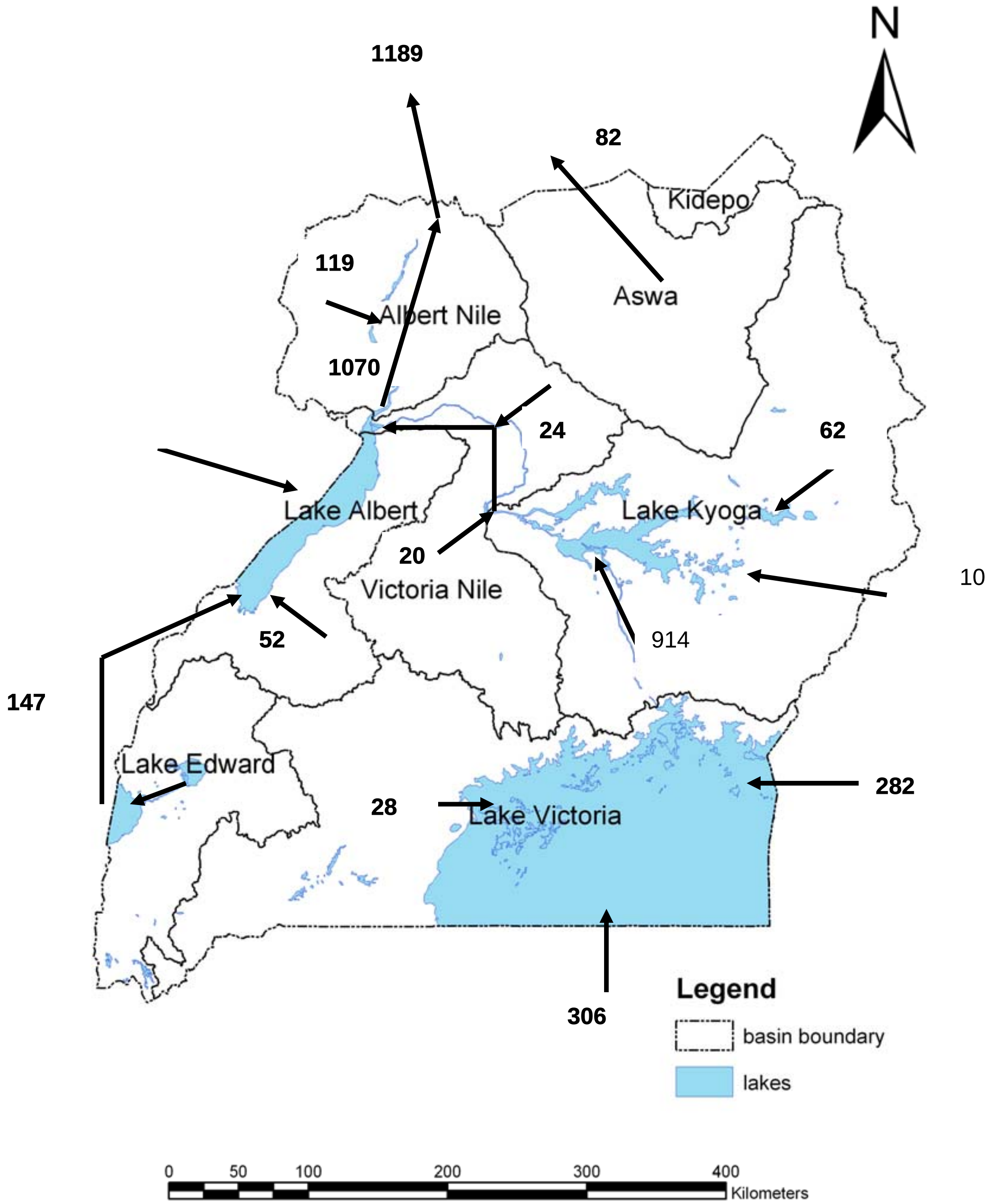


Figure 2.2: Schematic display of water input per catchment into the Nile Basin in m3/sec



Source: SOE, 1998

2.2 Ground Water

Ground water is an important source of drinking water, with upto of 80% of the rural population dependent on it. Hydrological conditions in Uganda favour acquifers in regolith and fractured bedrock. Hydrological and hydrochemical data have been used to develop ground water potential maps to guide regulation and ground water supply development in some districts, and this is underway countrywide. Plans to improve domestic water supply coverage from the current 54% to 95% by 2015 is hinged on groundwater as a supply.

Ground water quality is however threatened by human activities in catchment areas, natural conditions such as geology and means of abstraction. Low sanitary coverage, poor waste management practices and poor protection of shallow wells makes them vulnerable to contamination.

2.3 The Wetlands and their values

According to the Ramsar Convention, wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water that do not exceed 6m at low tide.

Uganda's wetlands cover about, 29,000 sq. km, or 13% of the total area of the country. They comprise swamp (8,832 sq. km), swamp forest (365 sq. km) and sites with impeded drainage 20,392 sq. km (NEMA, 1999). They include areas of seasonally flooded grassland, swamp forest, permanently flooded papyrus, grass swamp and upland bog. As a result of the vast surface area and the narrow river-like shape of many of the wetlands, there is a very extensive wetland edge (MWLE, 2001).

There are basically two broad distributions of wetland ecosystems in Uganda: (a) the natural lakes and lacustrine swamps which include Lake Victoria region, Kyoga swamp complex, L. George area, L. Kyoga area, L. Edward wetlands, L. Albert area, Bunyonyi swamp, Kijanebarola swamp, Bisinia and Opeta lakes area, L. Wamala area and wetlands associates with minor lakes; (b) the riverine and flood plain wetlands which are associated with the major river systems in Uganda. Examples are: R. Nile, R. Kafu, R. Mpologoma and R. Aswa. Except for Sango Bay, the bulk of Uganda's wetlands lie outside protected areas.

Wetlands also have intrinsic attributes, perform functions and services and produce goods of local, regional, national or international importance. Together, they represent considerable ecological, social and economic values. Notable among these are its important water sources for human consumption, agriculture, livestock, and recreation, as well as its ecosystem functions and services such as water purification, water flow, storage and recharge, shoreline stabilisation, micro-climate regulation and biodiversity habitat provision. However due to increasing encroachment by human activities, these wetland values are threatened. Figure 2.3 potrays some encroachment cases on river Katonga, mid southwestern Uganda.

Figure 2.3: Wetland encroachment on river Katonga (Photo by Martin Aryagaruka taken February, 2005).

Wetland encroachment: drainage disruption

Encroachment for maize growing

Sand abstraction

Table 2.4: Some wetlands that require gazettement and high level of protection

District	Wetland Name	Area (Km^2)	Remarks
Masaka	Nabajuzi		Partly converted, water source for Masaka Town.
Bushenyi	Rwanbanjeri-Karugorora	7.8	Partly encroached, vital water source
Kisoro	Kabiranyuma	n.a	Gravity scheme to supply water to about 26,000 people
Kisoro	Nyakagezi	n.a	Gravity scheme to supply water to 6000 people
Kampala	Nakivubo	4.9	Highly encroached upon by yam growers and settlement. Purification of waste water. Now gazetted.
Kampala	Kansanga	4.5	Partly encroached upon upstream, purification of waste water
Kampala	Kinawataka	4.2	Upstream converted for industrial development, purification of waste water
Kampala	Kitante	n.a	Encroached by developers, amenity and storm water retention
Masaka	Nakaiba	n.a	Partly converted, purification of wastewater
Jinja	Kirinya	n.a	Encroached on the edges, purification of waste water.
Mpigi (Entebbe)	Namiro	3.5	Intact, purification of waste water.
Mbale	Namatala	n.a	Partly encroached upstream. However, the wetland is self protecting downstream because of deep water. Water purification, storage, storm water retention.
Kasese/ Bushenyi	Lake George Wetlands	n.a	Existing RAMSAR site, mine water purification
Mpigi	Lutembe Bay Wetlands	n.a	Proposed additional RAMSAR site
Masaka	L. Nabugabo, Kanywa, Kayugi Wetlands	n.a	Proposed RAMSAR site. Has endemic fish that are threatened and depleted in L. Victoria.
Masaka/ Rakai	Sango Bay	n.a	Land use pressure, encroachment
Kumi/ Soroti	L. Opeta/ Bisina Wetlands	n.a	Has high biological diversity. UWA interested in its protection Water source for Kumi Town.

Source: SOE, 2002
Note: n.a – not established

Table 2.5: Wetland distribution per district

District	Total area of district	Present total district wetland area	Total original wetland area in the district	Converted as % total original district wetland	% district contribution to converted wetland area in Uganda	Wetland as % total district area
Central Region						
Kalangala	9,067	40	40	0.0	0.00	**0.4**
Kampala	197	33	41	19.7	0.34	**16.5**
Kiboga	4,046	844	855	1.3	0.47	**20.9**
Luwero/ Nakasongola	9,204	2,422	2,445	1.1	1.17	**26.3**
Masaka/ Sembabule	7,010	1,425	1,436	0.8	0.50	**20.3**
Mpigi	6,414	1,053	1,068	1.4	0.62	**16.4**
Mubende	6,198	758	783	3.2	1.05	**12.2**
Mukono	14,309	987	1,096	10.0	4.60	**6.9**
Rakai	4,909	**1,278**	1,322	3.3	1.84	**26.0**
Regional Total	**61,354**	**8,840**	**9,086**	**2.7**	**10.59**	**14.4**
Eastern Region						
Iganga/ Bugiri	12,792	1,215	1,806	32.7	24,91	9.5
Jinja	768	100	176	43.2	3.20	13.0
Kamuli	4,302	1,080	1,396	22.6	13.32	25.1
Kapchorwa	1,732	105	106	0.8	0.03	6.1
Kumi	2,848	989	1,050	5.8	2.56	34.7
Mbale	2,467	356	423	16.0	2.85	14.4
Pallisa	1,992	711	969	26.6	10.86	35.7
Soroti/ Katakwi	10,016	3,206	3,215	0.3	0.39	32.0
Tororo/ Busia	2,609	787	1,160	32.2	15.73	30.1
Tororo/Busia	760	175	175	23	0.0	27
Regional Total	**39,526**	**8,547**	**10,299**	**17.0**	**73.80**	**21.6**
Northern Region						
Apac	6,541	1,147	1,161	1.2	0.56	**17.5**
Arua	7,879	216	216	0.0	0.00	**2.7**
Gulu	11,716	610	610	0.0	0.00	**5.2**
Kitgum	16,564	592	592	0.0	0.00	**3.6**
Otido	13,245	845	845	0.0	0.00	**6.4**
Lira	7,201	1,091	1,128	3.3	1.57	**15.2**
Moroto	14,352	2,219	2,339	5.1	5.07	**15.5**
Moyo/Adjumani	4,978	234	234	0.0	0.00	**4.7**
Nebbi	2,917	111	112	0.0	0.04	**3.8**
Regional Total	**85,393**	**7,065**	**7,237**	**2.4**	**7.25**	**8.3**
Western Region						
Bundibugyo	2,2,62	912	922	1.2	0.45	40.3
Bushenyi	4,293	183	190	3.8	0.31	4.3
Hoima	5,933	183	183	0.0	0.00	3.1
Kabale	1,730	111	175	36.6	2.70	6.4
Kabarole	8,318	946	962	1.6	0.66	11.4
Kasese	3,390	407	407	0.0	0.00	12.0
Kibaale	4,246	535	546	2.1	0.47	12.6
Kisoro	730	33	56	40.3	0.95	4.6
Masindi	9,443	983	991	0.8	0.35	10.4
Mbarara	10.021	1,109	1,124	1.4	0.64	11.1
Ntungamo	2,056	108	109	0.9	0.04	5.2
Rukungiri	2,860	146	191	23.7	1.90	5.1
Regional Total	**55,282**	**5,654**	**5,856**	**3.4**	**8.47**	**10.2**
Grand Total	**241,550**	**30,105**	**32,481**	**7.32**	**100.00**	**12.5**

Source: SOE, 2002

2.4 Water resources: Use and significance in Uganda

2.4.1 Water for domestic use

The principal sources of water for domestic use are lakes, rivers, and ground water sources water rural areas. Lake Victoria provides fresh water to the population of Uganda, Kenya, and Tanzania directly and through the Nile River, to Sudan and Egypt. Other major fresh water bodies in Uganda include Lake Edward, Lake George, Lake Kyoga, Lake Albert and Lake Opeta.

The access to safe water has increased in the rural areas from 52.8% of the rural population served in 2001 to 55.0% in 2002 (DWD, 2001& 2002). Through the Directorate of Water Development (DWD)'s Rural Water and Sanitation Investment Strategy, there are more boreholes, wells, protected springs and valley tanks installed, increasing access to freshwater by the rural population. The target for the year 2015 is to cover 100% of the rural population.

With the rapidly growing population in Uganda, the demand for fresh water in the domestic sector is also rising because of increasing per capita water usage. Clean, fresh water is vital to the well-being both of the human population and the wider environment. However, water quality is declining due to domestic and industrial discharge, agricultural run-off, and changing landuse resulting in impacts on human and environmental health. The cost of water treatment for lake Victoria water at Gaba water works has since risen, and the cost of portable water at Uganda Shillings 1000 per m^3 (SOE, 2002).

Improved access and planning for further increases in availability has enormous impact on people's quality of life. The improved access to sanitation also has the potential to improve water quality since local water source pollution such as shallow wells, springs, streams and rivers, as well as eutrophication is largely from domestic and municipal sources. Table 2.6 provides projected domestic water demand by catchment.

2.4.2 Water for production

Water for production includes water for agricultural production including water for crops, water for livestock and wildlife, water for aquaculture and water for rural industries. The amount of water that ought to be available per year to meet optimum production requirements by the year 2015 is estimated at 187 million cubic meters, constituted among the four production areas (DWD, 2005). There is great potential for irrigation to increase agricultural production on about 247,230 ha of land, with an estimated ultimate water use of 2572.6 million m^3/yr. By 2001, an estimated 207 million m^3/yr of water was used for irrigation (NEMA 2001). Uganda's livestock population of cattle, sheep and goats was at 4.5 million with an estimated water demand of about 81 million m^3/yr in 1991with projections of up to 255 million m^3/yr by 2010 (NEMA, 1998). Results of National Census

2002 reveal a population of goats, sheep, cattle and pigs of upto 16.031 million (UBOS, 2002).
Required investments in infrastructure for water supply and management systems, as well production related environmental degradation, such as overgrazing leading to soil erosion, siltation and pollution of water sources, is a challenge to this sector.

Table 2.6: Population and water demand projections in the Nile sub-basins, Uganda

Basin	Population in thousands				Water demand (1000m³/year)			
	1991 Rural	1991 Urban	2010 Rural	2010 Urban	1991 Rural	1991 Urban	2010 Rural	2010 Urban
Lake Victoria	3522	580	6006	1205	32138	15877	54805	32987
Lake Kyoga	4658	660	7289	1182	42504	18067	66512	32357
Kyoga Nile	1449	347	2370	772	13222	9499	21626	21133
Lakes Edward/George	2214	119	3649	190	20203	3258	33297	5201
Lake Albert	858	39	1409	62	7829	1068	12857	1697
River Aswa	745	43	1092	58	6798	1177	9964	1588
Albert Nile	1075	73	2009	133	9809	1998	18332	3641
Kidepo Valley	49	1	59	3	447	27	538	82
Other	274	14	242	13	2505	385	1859	1399
Total	14844	1876	24125	3618	135455	51356	219791	100086

Source: SOE, 2002

2.4.3 Other water uses

Other major surface water uses include navigation mainly on the lakes Victoria, Albert, Kyoga and Edward; its role in the recreation, tourism and wildlife sector; provision of raw water for various industrial uses; and in the generation of hydro-electric power. The identified hydro-electric power potential on the river Nile alone in Uganda is estimated at 4000MW. All these uses have water quality requirements and concerns.

The Nile Basin water resource also supports livelihood of millions of people living around the lake, providing fish, irrigation water, tourism and recreation opportunities, communications and transport (UNEP, 2002). It also supports a rich biological diversity, including fisheries described in the following sections.

2.5 Basin water biological biodiversity

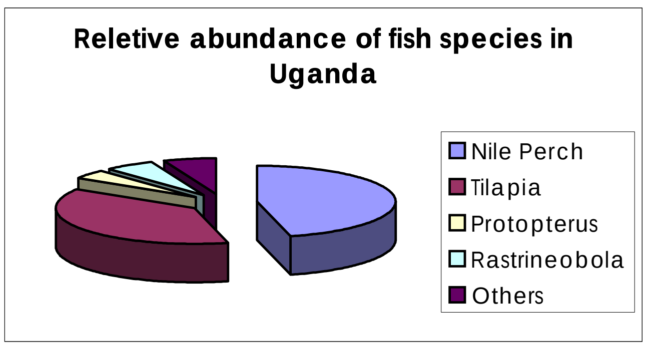
The Nile Basin water resources in Uganda support a variety of biological biodiversity, with diversity within species, between species and of ecosystems, and rich in fauna and flora. Aquatic life, composed of a variety of resources, inhabits the basin ecosystems including lakes, rivers, streams and wetlands.

Deterioration in water quality has direct impact on the aquatic biodiversity, and the threats include eutrophication due to pollution, poor land use practices and degradation of riparian vegetation, and decrease in oxygen levels due to algael blooms.

Uganda's water resources support a lucrative fish industry, supporting both rural and urban populations, as well as an important source of protein. The exports of fish and fish products have become a major commodity item for Uganda, and an important contribution to the diversification of exports.

The most important target fish species are: tilapiines, Lates nitoticus Nile perch, Rastrineobola argentea, Bagrus spp, Haplochromines, clarias spp, Hydrocynus spp, Protopterus aethiopicus, Labeo victorianus, Barbus spp and Alestes spp. Lake Victoria alone is believed to have about 350 fish species.

Figure 2.4: Relative abundance of fish species in Uganda



Fish has continued to record unprecedented increase in earnings, coming second after coffee in foreign exchange earnings in 2002. Its share to total exports increased to 7.7, 17.3 and 18.8 percent in 2000, 2001 and 2002 respectively (UBOS Statistical Abstract, 2003).

Deteroriation in lake water quality is of concern to the fishing industry and results from increasing nutrient loads leading to eutrophication, water weeds such as the water hyacinth depleting oxygen levels leading to fish kills, degradation of the fringing vegetation, industrial and domestic pollution and climate change.

Another source of pollution of the water bodies of significance to the fisheries sector is eutrophication caused by urban and rural discharges, and run-off from agricultural fields. Agricultural fields are the main sources of nitrogen and phosphorous inputs into Lake Victoria. They account for 50% of nitrogen and 56% of phosphorus, from all sources (SOE, 2002).

Table 2.7: Total nutrients inputs into lake Victoria

Source	Total Nitrogen		Total Phosphorous	
	Kg/year	Percentage	Kg/year	Percentage
Urban	8,900,000	0.8	1,100,000	7.9
Rural	356,000,000	32.4	4,200,000	30.1
Agriculture	590,004,845	53.7	7,826,723	56.1
Rainfall	144,627,700	13.1	826,440	5.9
Total	1,099,532,545	100.0	13,953,163	100.0

Source: SOE, 2002

2.6 Water resource quality concerns

Almost all of Uganda's water sources fall within the Nile Basin. Though endowed with a network of drainage systems, there is disparity in the distribution both spatially and in time. The rivers in the north and north east (Karamoja) are very susceptible to seasonal fluctuations in precipitation.

The water resources also face the threat of degradation in quality, with changing land use and encroachment of the riverine ecosystems, degradation of catchment areas due to poor land use practices and deforestation, increased use of agrochemicals, increased effluent discharges and pollutants loads from industries and other point sources into water bodies, inadequate sanitary facilities, and inadequances in water quality monitoring, poor catchment management and enforcement of regulations meant to protect the water sources.

The impacts of deteriorating water quality are already felt in terms of increased costs for raw water treatment, siltation of water sources, algae blooms and the water hyacinth, polluted and unsuitable water sources for drinking, and occurrences of water borne diseases (SOE, 2002).

2.7 Need for the baseline survey

For Centuries the Nile Basin in Uganda has played a critical role in sustaining various ecosystems, supporting community livelihoods, and maintaining a sustainable flow of water and aquatic resources to the benefit of the Nile upstream and downstream communities. With increased demand and pressure on the basin resources due to population increase, land use changes, development pressures and inadequate management capacity, this natural asset faces the threat of quality degradation of its water resource.

To ensure that future generations can enjoy the benefits of this trans-boundary resource, improved management and monitoring is needed. Comprehensive data sets on the basin water resources, existing institutional and legal frameworks for water resources and quality management, water quality management practices and baseline data on water quality monitoring will be an important requisite to inform initiatives towards improved basin water quality monitoring and management under the NBI NTEAP Water Quality Component.

Positive aspects about water resource management and quality monitoring in Uganda are institutional developments in the management of water resources and quality, a favourable policy and legal framework such as the Water Action Paln (1994), the Environment Act (1995) and Water Act (1995), recently concluded and ongoing catchment management projects, on-going policy and strategy reviews for water quality monitoring and management, on-going water quality monitoring and research, and the emerging forum to address transboundary water quality concerns under the NBI.

The Nile Trans boundary Environmental Action Project (NTEAP) is one of the eight Projects under the Nile Basin Initiative (NBI) Shared Vision Program. The main objective of this Project is to provide a strategic environmental framework for the management of the trans boundary waters and environmental challenges in the Nile River Basin. This project component aims at increasing the understanding of the current state of water quality and priority needs for transboundary cooperation between the Nile countries and contribute to building greater capacity for water quality monitoring and management.

2.8 Overview of objectives and outputs of the survey

The baseline survey aimed at assessment of the existing water quality information in the Nile Basin area of Uganda, and identifying major information gaps and needs. The institutional, technical and professional capacities were assessed. This section has presented an inventory of the major lakes, rivers and wetlands, and the water quality issues arising in Uganda. Section 3 presents the organization and methodology applied to obtain desired output of this baseline survey.

The major outputs of this survey are presented in section 4. Section 5 presents identified water quality management gaps and recommendations on how they should be addressed, and suggested actions for improved water quality monitoring and management.

3.0 BASELINE SURVEY ORGANISATION AND METHODOLOGY

The Baseline Study to determine the status of water quality monitoring was a comprehensive survey carried out to achieve the stated objectives in the TOR's in appendix 7.

To come up with desired results outlined in the Terms of reference, the Consultant had to ensure free and adequate participation of all the stakeholders and exhaustion of all water quality concerns at stake in the trans-boundary Nile Basin, with particular reference to Uganda.

The following aspects were put into perspective:

- Natural factors and Socio-economic (human activity) issues in the Nile basin catchment area and their impact on the basin water quality;
- Policy, Institutional and legal frameworks in water resource management and quality monitoring;
- Water quality management practices, existing capacities for monitoring and management of water quality;
- Existing gaps in to water quality monitoring and management.

The significance of the Nile Bain water resources in Uganda, and the need for water resources quality monitoring and management is stressed in section 2 to ensure future generations enjoy the benefits of the Nile Basin. Comprehensive information on the status of water quality monitoring and management practices and capacity will be an important requisite for future policy-making, monitoring and management responses. Planners, managers, policy makers and researchers alike need to understand the complexity of factors involved.

In this section the methods used to collect baseline data for water quality monitoring are reviewed. Several approaches were used including document review, field visits, observation, interviews, focus group discussion, and geodata analysis.

3.1 Review of Existing Documentation

Documents readily available relating to the Nile Basin Water Resource and related ecosystems, its management and local socio-economic aspects were reviewed. The data sources included private, public and research institutions, NGO/CBO sources, as well as reports of various water resource and basin management projects, water sector reforms, management plans and related concerns. However there was a paucity of current documented information in parts of the studied Nile Basin as discussed in section 4.

Existing information on water quality and management regimes of the Nile Basin water resource in Uganda was reviewed, including documentation from previous, recently concluded and existing management projects, and from various stakeholders such as Ministries (Lands, Natural Resources and Environment; Ministry of Health; Agriculture, Animal Industries and Fisheries; National Environment Management Authority, Directorate of Water Development, Laboratories both Government and under private ownership, Research Institutions – such as NARO, FIRI, MUK, and other sectoral agencies). These documents included but not limited to project documents, strategic plans, sectoral year plans, quarterly reports, annual reports, results framework, monitoring plans, and all other available reports, with particular reference to the Nile Basin water resource in Uganda. Of interest as well was establishing existing water quality monitoring and management regimes, parameters monitored, emerging water quality concerns and management instruments.

From districts environmental and socio-economic profiles proved quite informative. Water resource use models, land use and human activity likely to have an impact on water quality and documentation of pressure on Nile Basin water resource quality, and efforts towards sustainable basin management proved useful to this study.

Besides existing spatial data including land use, land cover, soils and geology, hydrological and meteorological data, population distribution, socio-economic information, and water quality monitoring points were of use in establishing spatial impact of pollution sources and changes in Nile Basin water quality.

This data review of existing data helped guide planning of baseline survey activities, as well as determining the field itineraries.

3.2 Consultations with key stakeholders

Interviews were held with key stakeholders previously, recently and currently involved in water resources monitoring and management, environmental health, within the study area coverage. These included Government Agencies, Research Institutions, professionals involved in Nile Basin water quality research and NGO'S/CBO'S involved in water resources management. There an opportunity for resulting document review by various stakeholder workshop, as well as an enrichment from participants at a stakeholder consultative workshop for the development of the national water quality management strategy. The list of stakeholders, including individuals and institutions consulted and data collection instruments are provided in appendix 1 and 2.

3.3 Use of Focus Group Discussions

The use of focus groups proved important where the questionnaire would not capture all the necessary information and where time limitations would not allow participation of all potential respondents. To address this problem, qualitative information was collected from respondents to supplement information collection from questionnaires and face to face interviews. This was applied to laboratory staff, research officers, industry staff, water resources management and quality monitoring staff.

The focus group were made of people purposely selected by the investigator to share their knowledge, views, perceptions and experiences of basin area water resources, water quality management practices and monitoring regimes. The consultant was in a position to identify different user or stakeholder groups and related concerns about the Nile Basin water resource.

3.4 Specialised data

During the baseline survey, specialised data to aid understanding of Nile basin Catchment background and processes with impact on its water quality was collected, most of it in digital GIS formats. This included human activities, the geology, geomorphology, soils, drainage system (surface hydrology), earth surface processes, pollution sources, biodiversity and ecological systems within the Nile basin area in Uganda.

Water quality data collected was summarised, and inventory of water quality monitoring and analysis laboratories developed, and key parameters of transboundary importance and their influencing factors identified.

3.5 Geographical Strategy and study population

In the course of this baseline study, no primary data was generated. However an effort was made to ensure the study results were reliable, accurate and had coverage of the studied Nile basin area. Water quality baseline data, water quality sampling and monitoring points, pollutant point sources and selection of respondents among Local Governments (DEO's, DWO's) and sub-catchments for land use description all reflects attempts to have Basin wide coverage.

Surveys were conducted by selecting a representative of the population from which data was collected, and the findings generalized to represent that population. The listing of respondents and participating institutions is provided in appendix 2. Upto 40 respondents provided an input to this study.

3.6 Field visits

This enabled professional observation of the physical environment and assessment condition of water resources, catchment landuse, level of degradation and/or regeneration in catchment, activities of the local communities, pollutant point sources and compliance efforts by regulated communities/industry, and to triangulate findings from documents reviews. This was limited to districts around the lake Victoria basin, including Kampala, Wakiso, Masaka, Mukono, Jinja and also Mbale and Kasese district.

3.7 The Manpower Strategy

Given the scope and duration of this assignment, the consultant had to utilize services of two research assistants to administer questionnaires and carry out rapid assessments of land use, water environment concerns and physical condition of rivers, lakes and wetlands in selected districts. In the process, they had to ensure a good inventory of responses, and preparation of observations. Careful selection of respondents was key to the success of required data collection process.

The research assistants were selected based on qualification and previous baseline surveys in environmental management. To ensure successful data collection in addition to the training, research assistants were given enabling hints such as impression, approach, confidentiality, and interactiveness of the interview.

4.0 BASELINE SURVEY RESULTS

This section presents results of the baseline study to determine the status of water quality monitoring in Uganda, including:

- A brief history of water resources monitoring and management activities, strategic and sectoral reforms;
- An overview of existing water resources management practices in the country, covering the legal and institutional frameworks;
- Institutions or firms involved in water quality monitoring and management, and their capacities;
- Water quality status of major rivers, lakes and wetlands and their quality status based on regular water quality monitoring data;
- Spatial presentation of water quality monitoring points including impact points, rivers, lakes and ground water;
- Inventory of existing laboratories and their physical and technical capacities.

Water quality data are presented in a convenient spreadsheet format, for the regular monitoring stations both of Lead agencies, Research Institutions, and the regulated community/industry, in a digital format.

The water quality criteria include hydrological, trophic, physical, chemical, Microbiological and hygienically relevant parameters. Other environmental data collected include pollutant loads into selected major lakes and wetlands. Quality control and assurance mechanisms in place for some of the laboratories are also presented.

Baseline data to aid spatial analysis of water quality results have been provided, including geology, soils, hydrology (stream networks, rivers, sub-basin boundaries, water bodies), population distribution, landuse, landscape, agro-ecological zones, and pollutant point sources.

4.1 Water Resource Policy, Legal and Institutional Framework

4.1.1 Background and rationale

Uganda's Freshwater faces challenges from a growing population, modernization of agriculture, urbanization and industrial activities, poverty in rural and peri-urban areas, changing land use and land cover, soil degradation and erosion, wetland degradation, and other poor environmental practices.

Degradation of the country's surface water has implications on its fishing industry, safe and clean water access, water requirements for industry and production, recreation and the tourism industry, environmental health and overall economic development.

Considering the fact that almost all Uganda's surface water resources are part of the Transboundary Nile Basin, with the country just like others in the basin faced with a higher demand for the water resource, mechanisms need to be in place to protect water quality and for its proper utilization.

The responses from the Uganda Government in terms of Policy, Sectoral Reforms, Legal Frameworks, Regulation and Action Plans are presented below.

4.1.2 History of water resources monitoring and management activities by Water Resources Management Department (WRMD)

The present day WRMD started as a hydrological services unit under the then Ministry of Public Works, supporting the design of bridges and culvert crossings for the road network during the colonial period. With the introduction of meteorology as a discipline, the unit expanded after 1967, establishing a countrywide monitoring network designed and operated by “HYDROMET”, a UNDP funded project. Neglect and civil strife between 1978 – 1986 resulted in the collapse of this network, only to be revitalized by the Water Action Plan (WAP), 1994.

The WAP identified priority action areas to revitalize the water resources management sub-sector, including:

- Strengthening of the water resources monitoring network
- Establishing water resources databases
- Initiation of assessment services, and
- Establishment of a water permits unit.

WAP also provided the Government of Uganda with guidelines and strategies for the protection of and development of Uganda’s water resources and a structure for their management at national, district and local levels. Most of these priority areas have been initiated, a water regulation framework now in place, and consolidation of these achievements by undertaking comprehensive water sector reforms on-going.

Several Water Resources Management programmes and projects have been funded since by various external support agencies since 1993, the main ones including the National Water Action Plan, WAP (1993-1994), the Water Resources Assessment Project, WRAP (1996-2000), the Sector Programme Support, SPS (1997), Support to Water Resources Management Department, SWRMD (200-2003), and the WRM Sub-Component of the Water Sector Program Support, WSPS 2 (2003-2007).

Besides the WRMD, other institutions with a history of involvement in water quality monitoring, surveillance and management include the Department of Environmental Health in the Ministry of Health, and the Fisheries Department now in the Ministry of Agriculture, Animal Industries and Fisheries.

4.1.3 Policy Framework for Water Resources Management

After the enactment of the Constitution of Uganda, 1995, The Water Statute, 1995, The National Policy for the Conservation and Management of Wetland Resources, 1995 and The National Environment Statute, 1995 the National Water Policy, 1999 was developed and promotes an integrated approach to manage the water resources in ways that are sustainable and most beneficial to the people of Uganda. The future framework for management and functioning of the water sector is based on the Water Act (1995), National Water Policy (1999), The Local Government Act (1997), and on-going water sector reforms. The Water Policy was developed under two distinct categories, namely;

i. Water Development and use
ii. Water Resources Management.

Water Resources Management covers objectives, principles and strategies for Monitoring, assessment, allocation and protection of the resources and management framework.

Box 1: Overall objective of the Government of Uganda for Water Resources Management.

> "To manage and develop water resources of Uganda in an integrated and sustainable manner, so as to secure and provide water of adequate quantity and quality for all social and economic needs of the present and future generations with the full participation of all stakeholders".

Source: National Water Policy, Ministry of Water, Lands and Environment, 1999.

The National Water Policy recognises the need for participation of multi-ministerial, multi-donor, and multi-displinary implementation strategies, necessitating good coordination and collaboration at all levels.

The National Water Policy also embraces international resolutions, declarations and guidelines for the improvement of the water sector situation at country level, such as;

- International Drinking Water Supply and Sanitation Decade (IDWSSD);
- UN Conference on Environment and Development (UNCED) – Rio de Janeiro (June 1992). Of interest is the Agenda 21 Chapter on freshwater resources;
- Regional obligations including membership in the Nile Basin Initiative (NBI), Inter-Governmental Agency for Drought (IGAD) 1986, Kagera Basin Organisation (KBO) 1997, lake Victoria Fisheries Organisation (LVFO) 1994, and the Lake Victoria Environment Management Programme (LVEMP), among others.

Uganda is an active member of the global community of Nations, having entered into several regional and international environmental conventions and agreements.

4.1.4 The legal framework

The Constitution

The Constitution for the Republic of Uganda includes basic Policy statements related to the water sector. Under the National Objectives and Directives Principles of State Policy, the following are some of the relevant articles to the water sector.

XIII: Protection of Natural Resources

The State shall protect important natural resources, including land, water, wetlands, minerals, oil, fauna and flora on behalf of the people of Uganda.

XXI: Clean and Safe Water (Objective XXI)

The State shall take all practical measures to promote a good water management system at all levels.

XXVII: The Environment

i) The state shall promote sustainable development and public awareness of the need to manage land, air and water resources in a balanced manner for the present and future generations.

Ariticle 39: Right to a clean Environment

Every Ugandan has a right to a clean and healthy environment.

The National Environment Management Policy, 1994

The National Environment Policy goal is the promotion of sustainable economic and social development that enhances environmental quality without compromising the ability of future generations to meet their own needs. The National Environment Management Policy and subsequent Act include a key policy objective on water resources conservation and management, and more specific policy objectives, which have relevance to Water Resources Management.

The National Environment Policy has been fundamental in the development of the Water Policy.

The National Environment Act, 1995

This Act provides for sustainable management of the environment, establishment of an Authority as a coordinating, monitoring and supervisory body for that purpose (The National Environment Management Authority) and for other matters incidental to or connected with the foregoing.

The Water Act, 1995

This Act provides for the use, protection and Management of Water Resources and Supply, and provides for the constitution of water and sewerage authorities, and facilitates devolution of water and sewerage undertakings.

Notable among the objectives of this Act are the promotion of rational management and use of waters of Uganda; promoting the provision of clean and safe sufficient water supply to domestic purposes to all persons; allowing orderly development and use of water resources for purposes other than domestic (such as livestock watering, irrigation, agriculture, industrial, commercial and mining purposes, hydroelectric power generation, preservation of flora and fauna etc) in ways which minimize harmful effect to the environment; and the control of pollution and promoting safe storage, treatment, discharge and disposal of waste which may pollute water or otherwise harm the environment and human health. It also provides for penalties for offenders.

The Mining Act, 2003

Provides for the ownership, prospecting and mining of minerals in Uganda. It reserves all minerals and mineral oils in Uganda to the government and regulates the granting of permits, licenses and leases for prospecting and mining.

It also provides that no water of any springs, streams, rivers, watercourse or natural water supply controlled by the government shall be dammed, diverted or in any way interfered with without the consent of the minister. It also makes it an offence for any person in the course of prospecting of mining operations to permit any poisonous or noxious matter to be discharged into any natural water supply.

The Public Health Act (1964)

The Act consolidates the law in the respect of Public health. It places duties on the Urban and local authorities in matters pertaining to public health. This Act is currently under review.

The National Water and Sewerage Corporation Act, CAP 150

This Act provides for a corporation to operate and provide water and sewerage services in areas entrusted to it by the Water Act, 1995.

The Local Government Act, 1997

The enactment of the Local government Act of 1997, defined roles for the different levels of governance in the provision and management of water related services and activities. This Act provides for devolution of Powers and Services to Local Governments and increased community participation. Some districts have been able to produce Environment

Action Plans to Village Level among which protection of water sources is highlighted, though there is varied capacity in Water Resources and Environmental Management.

The Water Act provides for management of water resources at local levels, providing for formation of water user groups and associations to collectively plan and manage point water supply systems in their area.

Other laws of relevance to Water Resources and Water Quality Management include the Land Act 1998, The Town And Country Planning Act Cap 30, The Fish Act 1951, the Control of Agricultural Chemicals Act, 1989.

4.1.5 Enabling Regulations for Water Resources and Water Quality Management

The Water Resources Regulations, 1998

This regulations defines procedures of application and regulation of water abstraction permits**.**

The Water (waste discharge) Regulations, 1998

This regulation provides for 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.

Section 15 (1) makes it an obligation for every industry, establishment or holder of a waste discharge permit to install anti-pollution equipment for the treatment of effluent or waste discharge emanating from the industry.

Section 17 provides for sampling of effluent and wastewater analysis by environmental inspectors, and section 18 provides for waste discharge fees and lays the basis for the polluter-pays principle.

The National Environment (Standards for Discharge of Effluents into Water or on Land) Regulations, 1999

This statutory Instrument defines standards for effluent and wastewater before discharge into water or land, provided in appendix 5. It provides for the obligation to mitigate pollution, and the requirement to keep records of the amount and quality discharged, quarterly reporting by discharge permit holders to the lead agency (Water Resources Management Department), and penalties for offenders.

NEMA has delegated requirements and enforcement of the Environment Act and the National Environment (Standards for Discharge of Effluents into Water or on Land) Regulations, 1999, requiring pre-treatment and discharge of effluents to the Director of Water Development under the National Environment (Delegation of Waste Discharge Functions)

Instrument, 1999. This function is currently handled by the Water Permits Unit of WRMD.

The other related statutory instrument on waste management is **the National Environment (Waste Management) Regulations, 1999,** which provides for handling, limitation of generation, treatment, transportation and disposal of waste, as well as penalties for offenders.

The National Policy for the Conservation and Management of Wetlands Resources, 1995
This policy establishes the principles by which wetlands resources can be optimally utilized, aims at ending practices which reduce wetland productivity, maintaining wetland functions and values, and integration of wetlands concerns into the planning and decision making of other sectors.

The National Environment (Wetlands, River Banks And Lake Shores Management) Regulations, 2000
This regulation provides for the management of wetlands, lake shores and river banks, ensuring water catchment conservation, sustainable utilisation and conservation of resources involved, promoting the integration of wise use of resources, and prevent and control of pollution and degrading activities.

This regulation also provides for a mandatory environmental impact assessment for developments within wetlands, lake shores or river Banks likely to have significant environmental impacts, as well as annual environmental audits. It also provides for application procedures for permits for regulated activities in these protected areas, defines regulated activities, wetlands of international importance, and names rivers and lakes for which buffer zones of upto 100 and 200m respectively are mandatory (see appendix 6).

The Environment Impact Assessment Regulations, 1998
This regulation defines projects and activities for which an Environment Impact Assessment is required, procedures for Environment Impact Assessment, and provides for self-environmental auditing.

Section 20 (3) of the National Environment Act, 1995 requires that all projects or policies that may, are likely to or will have significant impacts on the environment be subjected to Environment Impact Assessment so that adverse impacts can be eliminated or mitigated. In addition Environmental Impact Assessment (EIA), as a tool for better planning, permits the integration of environmental concerns into the project planning process at the earliest possible planning and design stages. This regulation is of particular concern to the Water Environment, as several undertakings have been near water bodies or in their catchment areas.

The National Environment (Hilly And Mountainous Areas Management) Regulations, 2000

This regulation aims at;

a) Facilitating sustainable utilization and conservation of resources in mountainous and hilly areas by and for the benefit of the people and communities living in the area;
b) Promoting the integration of wise use of resources in mountainous and hilly areas into the local and national management of natural resources for socio-economic development;
c) Regulating and promoting efficient and sustainable use of resources in mountainous and hilly areas so that the functions and values derived from are maintained for present and future generations.

The hilly areas and mountains in Uganda are known for their catchment values. Of interest are the Mt. Elgon and Mt Rwenzori that are a source of numerous rivers and streams, and whose landcover degradation and soil erosion is having a siltation impact on these rivers. **The National Environment (Minimum Standards For Management Of Soil Quality) Regulations, 2001** provides for the requirement of soil conservation measures to be undertaken in cultivation or other undertakings.

Bye-laws

In accordance with the Local Government Act 1997, local governments have developed bye-laws some of which directly affect water resources quality management. An example is the Kampala City Council waste management ordinace of 2003, that has seen improvement of waste collection and disposal in the City, that had hitherto found its way into the Nakivubo channel, polluting wetlands on the northern shores of lake Victoria.

4.2 Water Resources: Water Quality Management structure, monitoring and Management Functions

Management of the water resource is such that both central monitoring and regulation and decentralized management are applied.

4.2.1 National Structure for Management of Water Resources

Management of water resources provides challenges to the existing structure. These include the transboundary nature of surface water resources, increased demand of safe water for the growing population and development activity, and the decentralisation and devolution of powers to local governments and required capacities for water quality monitoring, and enforcement of regulations and bye-laws.

At National level, the parent Ministry is the Ministry of Water, Lands and Environment, with responsibility for initiating National Policies, setting standards and priorities for water resources management in the country. The Water Policy Committee (WPC) plays an advisory role to the Minister, and initiates revisions to legislations and regulations, as well as coordinating sector plans and projects affecting water resources. The functions and composition of the WPC are stipulated in the Water Act, 1995.

At District level, Environment and Natural Resources committees have been set up, as well as departments of Environment and Natural Resources. These departments at the districts coordinate existing extension staff such as in water, environment, lands, community development, health, and agriculture, among others.

For urban areas, the municipality or town councils play a leading role in water supply in partnership with user groups, and take responsibility in licencing of industries and sewerage waste disposal, with the assistance of extension staff.

At sub-county level, LC 3 committees take responsibility in implementing water provision and sanitation service plans from the districts, as well as protecting of water sources and resources.

At the local level, water user groups at village level manage and protect point water sources and also natural resources such as wetlands through their respective committees or Associations. The Local Councils (LC1-LC3) play a role in setting local priorities and enforcing bye-laws.

4.2.2 Management structure for WRMD

WRMD is one of two departments of DWD of the Ministry of Lands and Environment. The department is divided into two divisions namely the Water Resources Division responsible for monitoring, assessing and advising on the quantitative aspects of national and transboundary water resources, and made up of hydrology and hydrogeology sections.

International water resources issues include the Nile waters and safeguarding of water quality of lakes such as Victoria, Albert, and Edward that are transboundary, and this is a National Function carried out at the Directorate of Water Development.

The water quality and pollution control division is responsible for monitoring, assessing and advising on the water quality aspects of water resources. The Water Permits Unit that has been responsible for implementation of the water regulation and coordination of all activities related to permits has been elevated to a division level to be referred to as the Water Regulation Division. Each of these Divisions is headed by an Assistant Commissioner.

NEMA has delegated Management of wastewater discharge permit system to DWD, considering the detailed technical expertise required and the need to adhere to international and national standards.

At district level, comments on applications for waste discharge are made, public hearings organized and monitoring of compliance with permit conditions carried out by the District Environment Office.

The holders of wastewater discharge permits provide quarterly reports to DWD on the status of effluent discharged. Penalties on waste discharge into open water or river courses have been introduced based on effluent quality and load and annual environmental audits have to be submitted to NEMA by the permit holders.

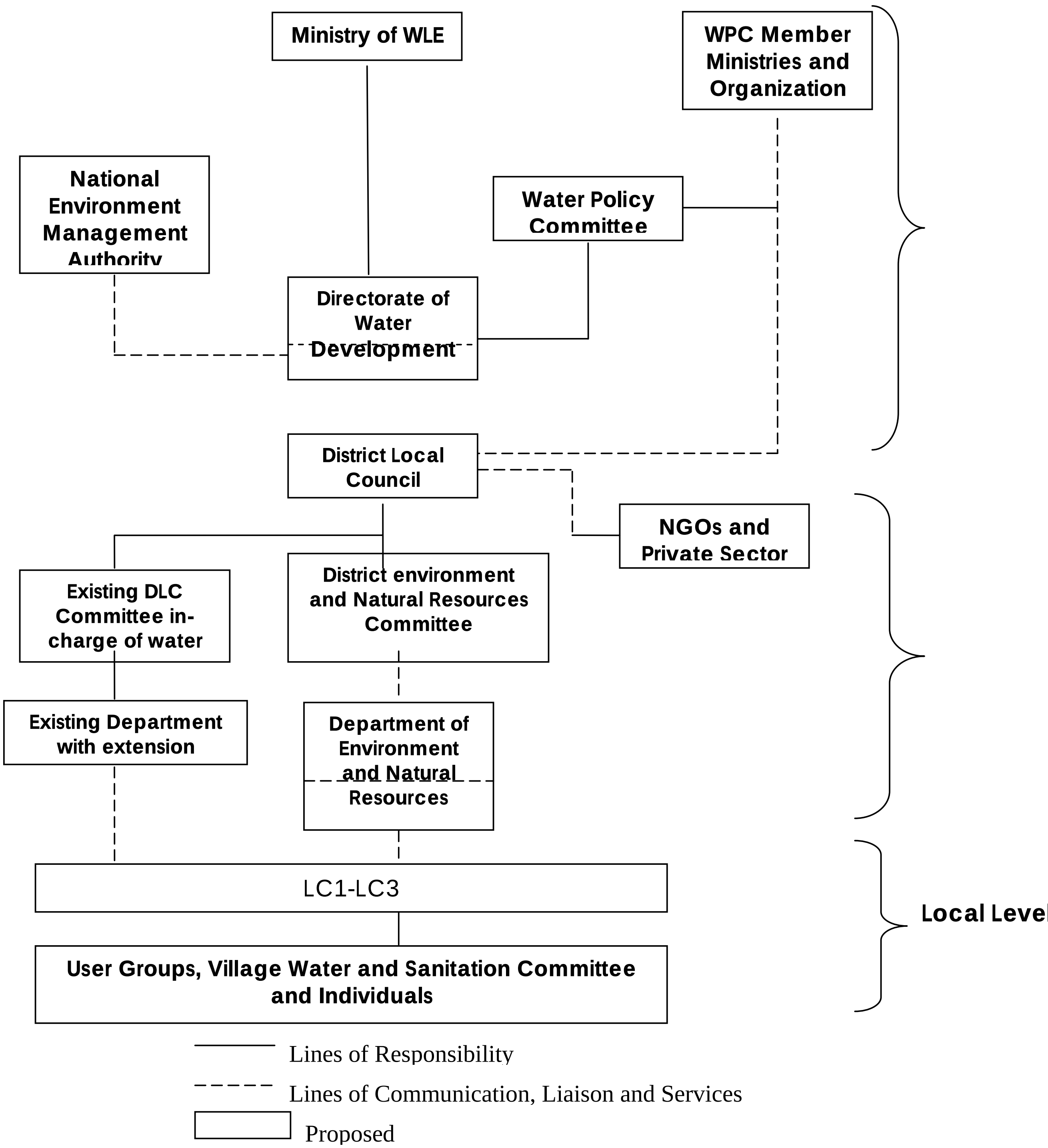
NEMA designates environmental inspectors as per the National Environment (Designation Of Environmental Inspectors) Notice, 2004, and also Environmental Practitioner as per the National Environment (Conduct and Certification of Environmental Practioners) Regulations, 2001 to ensure impacts on the environment, the water environment in particular, are minimized.

4.2.3 Private service providers, User Groups and Associations

The National Water and Sewerage Corporation Act mandates NWSC to operate and provide water and sewerage services in areas entrusted to it under the Water Act. NWSC effectively operates in fifteen towns namely: Kampala (including Kajjansi and Nansana), Jinja/Njeru, Entebbe, Tororo, Mbale, Masaka, Mbarara, Gulu, Lira, Fort Portal, Kasese, Kabale, Arua, Bushenyi/Isahaka, and Soroti. Other towns gazetted as NWSC's areas of operation include Iganga, Mukono, Malaba and Lugazi. Its distribution network includes 16 water treatment plants and 13 sewerage treatment plants.

The Water Act, 1995 Part III - Water Supply and Sewerage, Division 7: Water and sewerage Areas, Authorities, User Groups and Associations provides for private water supply and sewerage service providers, and formation of user groups and associations to plan and manage point water supply system in their area, doing so to the extent and standard determined by the Minister.

Figure 4.1: Organisational Structure for Water Resources Management, MWLE



4.2.4 River basin and Catchment Water Resources Management

The Management structure of the Water Resources Management department has no functional river basin or catchment Management, though this would be useful in regulating and monitoring activities with impact on such important ecosystems. River Kagera sub-catchment contributes the highest total phosphorus and Nitrogen loads to lake Victoria (the Yearbook of WRMD, 2002-2003), mainly from urban establishments.

However, for transboundary water resources, such as Lake Victoria, Lake Albert, Lake George and Edward, there are projects in place involved in catchment management, though without regular water quality monitoring components, except for lake Victoria. There is also NGO involvement in catchment/river basin management such as Nature Uganda in the conservation of Katonga river wetlands.

4.2.5 The Private sector

The private sector has interests in quality of water for industrial production, such as an input in the beverage industry, agricultural use such as horticulture, irrigation and aquaculture among others. However with the growing population, modernisation of agriculture and industrial growth, there is a growing number of point and non-point sources of pollutants. With the pollutant-pays-system in place, several of these private developers have put in place mechanisms to limit and monitor their discharges in compliance with national standards.

The private sector has as well contributed to the generation of data and information on water quality status and water quality assessment through compliance, water quality assessments and water quality analytical services. Besides there have as well been investments in laboratories for water quality assessment such as Chemiphar, UNBS, and SGS with full accreditation status.

4.2.6 Non-Governmental organizations

The involvement of NGO’s in the management of water resources is rather limited, but there is a strong presence in the provision of clean and safe water, in sanitation services, improvement of livelihoods among fishing communities in the country protection of ecosystems and catchment areas and in education and awareness campaigns.

Within some districts, some NGO’s are active in water source protection and in wetland management and pollution prevention. An example is the Jinja Wetlands Women’s Organisation active in Jinja Municipality and initiatives by Nature Uganda to protect Wetlands of the Katonga River catchment area through education and awareness raising efforts among local communities.

The Directorate of Water Development is backing the strengthening of the capacity of water and sanitation non-governmental organisations and community-based organisations in Uganda. The capacity building programme will help members of the Uganda Water and Sanitation Network (UWASNET) play a greater role in meeting the target for full coverage of water supply and sanitation services by 2015. UWASNET has helped DWD in awareness raising workshops particularly among local communities.

The National Environment Action Plan recognises the contribution civil society can make towards protecting the environment and conserving natural resources (MNR, 1995). Considering limited institutional capacities, the NGO'S can play a significant role in the implementation of environmental management policies and action plans. Their involvement at community level implies they have a better chance of mobilisation at grassroot level, especially in environmental education and awareness capaigns.

4.2.7 Basin and Catchment conservation projects

Various international organisations are involved in management of various Nile Basin catchment areas in Uganda. Some of these include IUCN in Mt. Elgon through MERECP; WWF through the Rwenzori Mountains Conservation and Development, the Lake Albert Eastern Catchment Management Initiative, Conservation of Biodiversity in the Albertine Rift Valley Forests of Uganda; and the World Bank Funded LVEMP.

4.2.7.1 Lake Victoria Environment Management Programme (LVEMP)

LVEMP is a regional and comprehensive environmental development programme. The fundamental objective of the Project is to restore a healthy, varied lake ecosystem that is inherently stable and can support, in a sustainable way, the many human activities in the catchment and in the lake itself.

The project is implemented through relevant national government departments and institutions. Regional and national coordinating mechanisms are in place to ensure timely and quality implementation of the various components of the Project. Its components with impacts on water quality include Catchment Afforestation, Land Use Management, Wetlands Management, rehabilitation of Industrial and municipal wetlands, Water Quality Monitoring, Water Hyacinth Control and Fisheries Management.

4.2.7.2 Lake Kyoga Integrated Lake Management Project (LAKIMO)

LAKIMO aims at 'having the Environment and natural resources sustainably managed' in the lake Kyoga catchment. LAKIMO is obliged to have all projects and programs conforming to environment regulations, to adopt soil and water conservation measures around the lake and its catchment area, to reduce on the enchroachment to the wetland areas by the community and to have mitigation measures in place to ensure correction of environmental impacts resulting from the proces of delivering services. The emphasis is on siltation, pollution and catchment management and to monitor agriculture activities in the catchment area.

LAKIMO works with the Local Authorities and Technical departments, such as the Fisheries departments in dealing with water quality issues. The project limitation has been lack of resources to facilitate their activities.

4.2.9 Other Government and Research Institutions

A number of Government and research institutions have undertaken research and provide services to other Government agencies, NGO's, Industries and Local Governments in water quality analysis and assessment, and these include the Government Analytical Laboratory, the Departments of Chemistry, Geology, Botany and Zoology, the Institute of Environment and Natural Resources (MUIENR), the faculty of Veterinary Medicine at Makerere University, the FIRRI under MAAIF, and the WID.

4.2.10 Water Quality Monitoring and surveillance

4.2.10.1 Water Resources Management Department

DWD through the Water Resources Management Department has the national role of monitoring, assessing and forecasting of water resources and water quality, managing surface water, groundwater and water quality data banks, and disseminating data on water resources to relevant agencies and users.

This role has traditionally been centralized, and current practice remains so partly due to legal aspects, and secondly due to investment in infrastructure and required resources for decentralization of activities involved. However, there have been efforts to build capacity at district level. A water resources Management Decentralisation Strategy has been developed and there is an effort through the Sector wide approach to planning to bring on-board several stakeholders in water quality monitoring, with the National Water Quality Monitoring Strategy due September, 2005.

However, the capacities at district level and local user groups are limited for checking compliance with bye-laws, regulations and permits, as well as water quality surveillance and monitoring.

4.2.10.2 The Fisheries Resources Research Institute

The Fisheries Resources Research Institute (FIRI) based in Jinja is a technical arm of the National Agricultural Research Organisation (NARO), whose scope of research covers capture fisheries, fishing technology, fish production processes, aquatic environment, aquaculture, and post-harvest handling. FIRI generates and disseminates scientific knowledge to guide prevention of pollution and eutrophication of major water bodies and in the control of invasive weeds.

4.2.10.3 Water and Sewerage service providers

National Water and Sewerage Corporation and other private water supply and sewerage service providers generate water quality monitoring data for water sources and discharged sewerage effluent for areas under its coverage.

4.2.10.4 Department of Environmental Health, Ministry of Health

The Ministry of Health Department of Environmental Health has a water quality surveillance structure and has developed capacity to sub-county level. At the sub-county level, regular surveillance is carried out by the Health Inspectors and their interest has mainly been in safety of water sources for drinking, with parameters monitored including faecal coliforms, pH, residual chlorine and turbidity.

4.2.10.5 The GAL, Ministry of Internal Affairs

Established as a Forensic Laboratory, GAL now has capacity for water quality analysis for various parameters, including organic contaminants such as pesticides and trace metals. The laboratory supports various research activities, and provides water assessment services to the private sector. Its mandate though limits involvement in regular nationwide water quality monitoring.

4.2.10.6 The Wetlands Inspection Division

The Wetlands Inspection Division has been developing an inventory of wetlands countrywide. In this exercise they have been able to measure basic parameters such as pH, conductivity, DO, turbidity, colour to establish the status of water quality in these wetlands.

4.3 Water Quality Monitoring laboratories, their capacities and regional initiatives

The key institutions involved in regular water quality monitoring with operational water quality monitoring networks include the Department of Water Resources Management, National Water and Sewerage Corporation, and the Fisheries Research Institute. Some academic and research Institutions have regular water quality assessment and research components, but mainly at Makerere University. The Ministry of Health has a regular surveillance of water sources for drinking countrywide.

4.3.1 Water Resources Management Department

The Water Quality and Pollution Control Division falls under the Water Resources Management Department (WRMD) of DWD, which has the overall responsibility for promoting sustainable and integrated management of water resources in Uganda. WRMD is responsible for monitoring water resources of Uganda in terms of quality and quantity, as well as regulating water use, controlling pollution and promoting provision of clean and safe water for drinking and other purposes such as industrial, production and recreational uses.

The Water Quality division is headed by an Assistant commissioner and has upto 12 water analysts, 6 technicians and 3 support staff. The Division has the laboratory section for routine analysis, and the Monitoring and Assessment Section for field and network operations as well as data management and information dissemination.

The Water Quality Laboratory has benefited from the recent Water Resources Assessment Project, WRAP, funded by DANIDA, and continues to receive support under the Support to Water Resources Management Department II (SWRMD II). This funding has been utilized to improve laboratory infrastructure, developing MIS and Quality Assurance Systems, strengthening the capacity of the Water Permits Unit, dissemination of water resources data and information, upgrading laboratory equipment, staff training, and supporting the WRM decentralization strategy.

The laboratory is in a position to carry out a range of chemical, biological and microbial parameters in water and wastewater (see appendix 3). There is also capacity for analysis of trace metals and pesticides. The laboratory puts emphasis on standards, and currently applies the ISO guide 17025 Specifications, and an effort towards laboratory accreditation is in advanced stages with South African National Accreditation System (SANAS) for ISO/IEC 17025. There exist quality control checks through sampling to analysis, to check the accuracy and precision of methods applied, as well as participation in external proficiency testing schemes, such as those organized by AQUACHECK and GEMS/WATER.

The WRMD network for water quality monitoring comprises 119 stations of 5 different types, including surface water, groundwater, pollution impact points, water treatment facilities and sewerage treatment facilities. A special network exists for lake Victoria under LVEMP consisting of 19 monitoring stations. The WRMD Water Quality Section now monitors atmospheric pollutant deposition on lake Victoria. Regularity of sampling for some of these stations on quarterly basis has at times been hampered by financial constraints, inadequacy of human and physical resources. The water quality monitoring network is presented in appendix 4. this network is currently under review to address watershed and sub-basin arising water quality issues and enable integration of data sets with other stakeholders.

4.3.2 The Fisheries Resources Research Institute

FIRI is mandated to carry out research in fresh water fisheries, fish technology, and aquaculture and fish production systems. The goal of the institute is to generate and transfer improved technologies and policy recommendations aimed at ensuring sustainable fish production and a healthy environment in which fish is produced. In relation to water quality, the institute generates, packages, and disseminates scientific knowledge, builds capacity and manages research to guide:

- Prevention of pollution and eutrophication of the aquatic environment;
- Control of invasive weeds especially the water hyacinth.

The activities of FIRRI in regular water quality monitoring and surveillance date back to 1927. FIRRI has planned quarterly water quality monitoring programmes for lake Victoria, Lake Kyoga and neighbouring satellite lakes, lake Albert, Lake George and Edward. Other water quality data available include for River Nile, and various crater lakes in western Uganda. FIRRI has also been very active in the lake Victoria Environment Management Project.

The FIRRI laboratories have capacity for analysis of water productivity related parameters and a range of pollutants, including trophic, physico-chemical, trace metals, and microbiological parameters, and liases with other institutions such as the veterinary department at Makerere University for analysis of organic pollutants.

4.3.3 National Water and Sewerage Corporation, and other service providers

The mandate of NWSC is to operate and provide water and sewerage services in areas entrusted to it by the Water Act, 1995. The NWSC has an operating laboratory capable of analysis of a range of water quality parameters, particularly in relation to drinking water and effluents. These include physico-chemical, trophic and microbiological water quality criterion parameters. The laboratory also offers water resources assessment services to various NGO's, researchers and the private sector.

NWSC regularly monitors quality of its water sources and sewerage effluents, and has thus developed a useful monitoring network and database to inform this baseline survey. The monitoring stations have coverage of all towns, 16 for water sources and 13 for sewerage effluents. Raw water samples are analysed twice daily to assess treatment process requirements, and treated water analysed twice daily for compliance with portable water standards. Samples from water supply sources are anlysed weekly to ensure its compliance to standards. Sewerage treatment and effluent quality monitoring is undertaken monthly to ensure compliance with effluent standards.

The Water Act, 2003 that provides for private service providers also puts emphasis on monitoring standards of supplied water, and implies even water sources ought to be monitored. There is however limitation in capacity to carry out such analysis by these private service providers.

4.3.4 The Government Analytical Laboratory

Established as a Forensic Laboratory, the Government Analytical Laboratory has established capacity for analysis of various water quality parameters and other environmental samples. The water samples include including physico-chemical, trace metals, micro-biological, organic pollutants including pesticide residues and trophic water quality criteria. The department liases with various government institution in water quality and environmental monitoring, assessment and research, including NEMA, WRMD, FIrRI, UNBS, Makerere University departments of Chemistry, Geology and Veterinary Science. The limitation here is the lack of a regular monitoring network.

4.3.5 Academic and research Institutions

The Department of Chemistry conducts various research in water quality as well as pollution. The department has established capacity for water quality analysis for physico-chemical parameters, and more importantly trace metals and organic pollutants, as well as research into their speciation.

The Department of Geology has for long provided services to various organizations and researchers in trace metal analysis, and has capacity for soils and rock analysis.

A number of other Government and Private institutions are involved and have capacities in water quality analysis and assessment, but their analysis are not regular, and some are demand based. Some of these institutions are involved in various research activities in water quality and this will be of great relevance in informing the NTEAP water quality component.

4.3.6 NEMA

NEMA is building capacity to enforce water quality discharge regulations especially by industries, and to this effect mobile water quality testing kits have been provided to Environment Officers of the Industrialised Districts including Mbale, Jinja, Kampala, Mukono, Masaka, Mbarara and Kasese. The sampling points if geo-referenced will help inform the process of managing point source pollution.

The mobile kits (POTAKIT 1 and PTEA supplied by Wagtech) have capacity for analysis of trace metals and a range of physico-chemical parameters.

4.3.7 The regulated community: Industry

Various industries have acquired capacity for water quality assessment and analysis. The range of parameters analysed are defined by the effluent discharge permits held. Two industries visited in the course of this survey with capacity to treat effluents, and a regular water quality and environmental monitoring programme include Uganda Breweries based at Portbell, Kampala, and Kasese Cobalt Company processing Plant located in Kasese, South Western Uganda near Lake George. Several industries now hold effluent discharge permits and have regular effluent monitoring programs. Upto 29 waste discharge permits were issued as of 31st December, 2003 (WRMD Yearbook, 2002-2003).

However it has to be noted here that regular water quality and effluent monitoring programs for other land use and non-point sources such as commercial farmlands are yet to be developed. There are as well activities that are localized for which bye-laws need to be developed to limit water pollution. An example is Crude liquor (Waragi) distillation along river Sironko, in Sironko District and other rivers countrywide.

4.3.8 LVEMP: Water Quality Monitoring and Ecosystems Management Component

LVEMP started as a 5 year project in 1997, got an extension ending in 2005 and a 15 year second phase is due to start July 2005. The project comprises 10 components addressing issues related to fisheries management and research, sustainable wetlands management, water hyacynth control, catchment afforestation, land use management and pollution control, industrial and municipal waste management, water quality and ecosystem management, applied training, and micro projects.

Water Quality Monitoring and Ecosystems Management Component is implemented by WRMD, and this component has been able to:

- Establish a water quality monitoring network lake-wide on lake Victoria
- Collect and analyse data that has provided information on sedimentation rates in the lake
- Determine the extent of eutrophication
- Determine point and non-point sources of pollution and their major pathways
- Establish the water mass balance for lake Victoria

The Water Quality Monitoring Component provides qualitative and quantitative information on nutrient, eutrophication and pollution, phytoplankton communities and their composition, algal blooms and their dynamics and lake zooplankton.

An Inventory and characterization of industries, municipalities, towns, some villages and settlements and their liquid effluents that enter the lake have been done and point sources of pollution or "hot spots" identified, this component being under NWSC.

The inventory and ecological characteristics of both fringing and non-fringing wetlands has been established and information on buffering capacity as well as sustainable utilization of wetlands documented, this component being under WID.

4.3.9 The Lake Victoria Fisheries Organisation

The Lake Victoria Fisheries Organization (LVFO), was established through a Convention signed by the three lacustrine states in June 1994. LVFO serves as a successor body to the CIFA Sub-Committee for Lake Victoria, and is charged with broad responsibilities for fostering effective cooperation between the Contracting Parties in order to develop and adopt a common approach to the conservation and management of the Lake's living resources to ensure ecosystem health and sustainability. LVFO's headquarters are at Jinja, Uganda.

Other roles include harmonization of legislation, policies, regulations and management approaches in the three East African countries; acting as a body for conflict resolution; and joint management action for the three riparian states in the area of Lake Victoria development.

4.3.10 The Nile Basin Water Resources Project

This project funded by the FAO between 1996 –2003 helped in

- Establishing a limited transboundary water resources monitoring network of automatic weather stations and dataloggers at selected water level stations on the Nile, Lake Albert and Lake Victoria
- Helped develop a basin-wide data base for use in the Decision Support Tool, and development of a Nile Basin Water Resources Management and Decision Support Tool; and
- Provided Human Resource training in legal matters.

4.4 Water Quality: Baseline Status

Water quality parameters monitored differ among institutions involved as well as in completeness but provide a basis for interpretation of water chemistry, background conditions such as catchment land use and soils, pollutant sources and its suitability for aquatic life and other uses such as drinking, recreation, agriculture and industry.

The data obtained from existing monitoring networks, and from research institutions and the private sector such as industry constitutes an informative basis for this baseline survey.

4.4.1 Point and non-point sources

The point sources for pollutants include industrial effluents, sewerage and municipal effluents, and domestic effluents, with urban centers accounting for 77% of pollutant load into lake Victoria (SOE, 2002). However it is of interest to note the threat posed by agricultural run-off and changing landuse.

Table 4.1 provides total pollution loads of urban run-off, industry and fishing villages into **lake Victoria**, with urban centers contributing upto 68% after purification through wetlands, river systems and other natural purification systems. In the report "Management of Industrial and Municipal effluent and Urban run-off in lake Victoria basin" by Mott MacDonald, 2001, point sources of pollutants and trails have were mapped for Urban Centres in the Districts around lake Victoria, including Busia, Bugiri, Iganga, Jinja, Mukono, Kampala, Mpigi, Masaka, Kabale and Ntungamo. The results show Kampala contributing upto 65% of BOD, 73% of total Nitrogen, and 73% of total phosphorus from urban centers discharged into lake Victoria. The towns of Kampala, Masaka and Mbarara are in dander of polluting their own water sources. The report also identifies poor sanitation and waste management practices being responsible for pollution from fishing villages. A simulation of pollutant load under current and a control scenario with the Hydro 3 Model was also carried

Figure 4.2: Municipal waste and run-off impact on water quality

	
Domestic effluent: poor sanitary infrastructure thus direct discharge into the natural environment	Municipal effluents: the Nakivubo Channel, Kampala

Table 4.1: Total pollution load discharged into lake Victoria after purification, kg/day

Point source type	BOD	Total Nitrogen – N	Total phosphorus - P
Urban centers	6,337	1,500	1,017
Fishing villages	2,000	251	131
Industry	1,045	96	105
Totals	9,382	1,847	1,253

Impact points monitored by the WRMD network between 2003 and 2004 indicate varying pollution levels, both in time and spatially. Pollution is evident at various regularly sampled impact points such as in streams and swamps of discharge of industrial and urban effluent. Kyambogo, Kinawataka, Bwaise, and Kitante streams/swamps in Kampala District, and Nakayiba swamp in Mbarara are such cases. Table 4.2 provides extreme values at these points monitored for the years 2003 to 2004. Trace metal residues in lake sediments and in tissues of common fish species in lake George (Lwanga M.H, Denny, P and Kansiime F, 2002) is evidence of the impact of mining activity.

Table 4.3 provides effluent loads characteristic of industries in Uganda. Investments in effluent treatment plants, cleaner production measures, compliance support from regulatory authorities is still inadequate. Most of these effluents do no comply with standards provided in appendix 5. Some of the pollutant load results from poor housekeeping practices in industry, and adoption of cleaner production measures, as well as end of pipe technologies such as construction of effluent treatment plants and the efforts to encourage tertiary treatment with constructed wetlands, could alleviate the situation.

Table 4.2: Extreme values at monitored impact points, 2003 - 2004

	Highest recorded values	**Effluent Std**	**Drinking Water Std**		**WHO, GV**
			GV	MAC	
Temperature, 0c	27.6	20-35			Acceptable
Colour, TCU	650	300			15TCU
DO, ppm	0				
EC, uS/cm	7120				
pH	11.8	6.0-8.0	5.5-8.5	5.0-9.5	
Turbidity, NTU	1116	300	10	30	5
Talk, ppm	100				
TDS, ppm	6700	1200	1000	1,500	1000
TSS105, ppm	2554	100			
TSS500, ppm	1060	100			
Thardness, ppm	130	100	600	800	500
CaHardness, ppm	115				
Tirons, ppm	53.58	10	1	2	0.3
Oil and Grease, ppm	118.5	10			
K, ppm	146.9				
Na, ppm	1071.2				
PO4, ppm	21.05	5			
Tphosphorus, ppm	17.67	10			
SO4, ppm	4500	500	250		
NO2, ppm	49.4	2	0	1	1
NO3, ppm	26.86	20	0	11	11
BOD, ppm	402	50			
COD, ppm	1012	100			

Source WRMD, 2005

Table 4.3 Effluent loads characteristic of industries in Uganda

Industry Type	Load estimate basis	Total BOD, kg	Total COD, kg	TSS, kg	Total Nitrogen -n, kg	Nitrate – N, kg	Ammonia - N, kg	Total phosphorus -P, kg	Ortho phosphate -P, kg	Water usage, m^3
Fish Processing	Per tonne of processed fish	8.58	22.61	3.73	0.13	-	0.09	0.07	0.04	24.85
Bakery	Per tonne of product	0.33	1.18	1.18	0.01	-	-	-	-	0.20
Confectionery	Per tonne of product	7.16	23.28	0.21	0.10	-	0.05	0.01	-	4.00
Fruit Juices	Per cubic metre of product	2.16	2.32	1.00	0.03	-	0.02	0.01	-	2.99
Dairy products	per cubic metre of product	1.81	3.68	1.68	0.12	-	0.06	0.05	0.03	4.44
Abattoirs	per tonne of dressed carcass	7.00	22.38	29.41	1.57	0.02	0.51	0.63	0.63	13.10
Soap works	per tonne of product	1.44	3.71	0.32	0.11	-	0.07	0.01	-	2.00
breweries	Per cubic metre of product	4.35	17.49	9.23	0.30	0.01	0.10	0.45	0.09	5.94
Soft drinks	Per cubic metre of product	2.07	7.76	0.71	0.03	-	0.02	0.05	0.02	6.97

Source: Mott MacDonald, LVEM/NWSC 2001

4.4.2 Water quality: rivers, streams and wetlands

WRMD operates 36 stations for monitoring trends in the major rivers listed in appenidix 4. The monitoring network data indicates variation in river water quality both in space and time. Parameters of concern include TSS, TDS, EC, DO, BOD, COD, total coliforms and e-coli. For the year 2000 to 2003, all the rivers monitored had high total coliforms and e-coli, indicatibng faecal contamination. TSS varied with seasonal changes and with the extent of agricultural activities and ecosystem degradation in the river catchment area, the highest recorded in the rainy season. The impact of high siltation and sedimentation has been loss of river aquatic productivity, and physical disruption of flow regimes (WRMD Yearbook, 2002-2003).

For the period 2003-2004, low DO levels were measured at River Mpologoma at Budumba, River Muzizi at Fort Portal Hoima road, River Katonga at Kampala-Masaka and Kabamba-Nkonge road, and River Bukora at Kasensero road. High BOD, nutrient and TDS levels indicate anthropogenic activity in the catchments.

However there is need for data completeness, background information, and prioritization of monitored parameters. Background values for soils ,river water and sediments, and information on river catchment land use and socio-economics could aid better undertanding of the water quality status.

The total alkalinity values above 100ppm indicate self buffering capacity of the rivers, though higher values could render the river water unsuitable for irrigation and other domestic use. The majority of the rivers monitored had total alkalinity values between 20-200mg/l typical of fresh water. The table 4.4 presents a summary of extreme values of regularly monitored river water quality parameters.

Table 4.4: Extreme values for monitored river water quality parameters, 2003-2004

	Extreme recoorded values	Effluent Std	Drinking Water Std			Aquatic life, GV
			GV	MAC	WHO, GV	
Temperature, 0c	28	20-35			Acceptable	Max. 34
Colour, TCU	580	300			15TCU	
DO, ppm	0					Min 5.0
EC, uS/cm	580					
pH	8.7	6.0-8.0	5.5-8.5	5.0-9.5		6.5-8.5
Turbidity, NTU	138	300	10	30	5	
Talk, ppm	330					
TDS, ppm	998	1200	1000	1,500	1000	2000
TSS105, ppm	310	100				
TSS500, ppm	115	100				
Thardness, ppm	285	100	600	800	500	
CaHardness, ppm	190					
Tirons, ppm	14.97	10	1	2	0.3	
OilGreaseLab, ppm		10				0
K, ppm	9.2					
Na, ppm	46.5					
PO4, ppm	1.93	5				
Tphosphorus, ppm		10				
SO4, ppm	60	500	250			
NO2, ppm	3	2	0	1	1	
NO3, ppm	0.71	20	0	11	11	
BOD, ppm	3.9	50				
COD, ppm	101	100				

Source: DWD, 2005

4.4.3 Lake water quality

Only lake Victoria now has a regular water quality monitoring netork under LVEMP water Quality and Ecosystems Management component implemented by the WRMD. No comprehensive work is going in the other lakes at the moment, under DWD, except for occasioinal grab samples that indicate high salinity and a tendency to eutrophication for lake s George, Edward and Albert in Western Uganda, and a deterioration in quality for lake Kyoga (WRMD Yearbook 2002-2003).

Additional data obtained from FIRRI under the LVEMP water hyacinth research component indicates a significant gradient in trophy among the sites sampled, ranging from mesotrophic to hypertrophic conditions. The three crater lakes and Lake Nabugabo showed low concentrations of chlorophyll *a* (5-13 µg L^{-1}). Lake Nabugabo results show fresh water quality characteristics, with neutral pH and extremely low conductivity. The low chlorophyll *a* concentrations in the swamp sample were probably caused by the high turbidity (secchi depth only 10 cm).

The highest chlorophyll a values were recorded in Lake George, Lake Edward and Lake Mburu and in the finger pond, Jinja indicating hypertrophic conditions. All three sampling sites from Lake Victoria were intermediate. pH was highest in Lakes George, Edward and Mburu while neutral in two out of three Crater lakes. In contrast secchi depths were highest in the mesotrophic crater lakes (> 100 cm) and lowest in the hypertropic and shallow lakes George, Edward, and Mburu (< 50 cm) **(Okello Okello William, 2004).**

The high values of colour, TDS, EC, TSS, pH, hardness, nutrient content, BOD, and COD, and in some cases depleted oxygen levels and pH are of concern. However background information and more analytical data is required in interpreting these values, such as catchment landuse, and pollutant loads from rivers and streams. Different media for sample collection including lake sediments, aquatic biological tissues, as well as fish, invertebrate, and algal communities if sampled and analysed could aid better understanding of lake water quality status. Besides, spatial distribution of these pollutants and their fate in the lake environments needs to be studied.

Table 4.5: Extreme values for lake water quality parameters monitored by WRMD network, 2003 to 2004

Parameter	Extreme values
Colour, TCU	325
DO, ppm	1.96
EC, **uS/cm**	640
pH	10
Turbidity, NTU	60.1
Total alkalinity, ppm	310
TDS, ppm	400
TSS105, ppm	72
TSS500, ppm	50
Thardness, ppm	325
CaHardness, ppm	68
K, ppm	71.5
Na, ppm	134
PO4, ppm	1.82
Tphosphorus, ppm	2.39
SO4, ppm	36
Cl, ppm	44
NO2, ppm	0.088
NO3, ppm	0.79
NH4, ppm	3.7
Tnitrogen, ppm	55.6
BOD, ppm	46.2
COD, ppm	72

Source: WRMD, 2005

Table 4.6: Water quality for selected lakes Trophic Parameters

	pH		Secchi (cm)		Conductivity (μScm^{-1})		SRSi (mgL^{-1})		Temp (°C)		Integrated Chl-a (μgL^{-1})		Net Chl-a (μgL^{-1})		Ammonia (μgL^{-1})		SRP (μgL^{-1})		TP (μgL^{-1})		Nitrate (μgL^{-1})	
Site	May	June	May	June	May	June	May	June	May	June	May	June	May	June	May	June	May	June	May	June	May	June
Swamp between Kiranzi and Nabingora	**7**	**-**	**10**	**-**	**66**	**93**	**27,3**	**7,76**	**28**	**20**	**0**	**0**		**122**	**18**	**17**	**26**	**15**	**167**	**109**	**290**	**59**
Nyabikere Crater Lake	**7**	**-**	**110**	**-**	**287**	**288**	**28,4**	**17,7**	**25**	**24**	**8**	**13**	**15**	**42**	**1729**	**1983**	**119**	**70**	**425**	**335**	**40**	**24**
Nkuruba Crater Lake	**7**	**8**	**-**	**314**	**387**	**373**	**4,31**	**5,7**	**24**	**24**	**7**	**9**	**26**	**37**	**506**	**850**	**41**	**34**	**82**	**71**	**20**	**11**
Lake George (Kahenge)	**10**	**10**	**10**	**20**	**343**	**345**	**34,9**	**27,2**	**28**	**25**	**128**	**78**	**174**	**111**	**18**	**52**	**14**	**41**	**138**	**191**	**205**	**71**
Lake Edward (Katwe)	**10**	**9**	**30**	**40**	**590**	**592**	**8,59**	**10,5**	**28**	**26**	**44**	**23**	**291**	**326**	**26**	**10**	**12**	**8**	**132**	**115**	**80**	**64**
Nkugute Crater Lake	**9**	**8**	**-**	**-**	**103**	**120**	**0,72**	**0,11**	**25**	**25**	**5**	**5**			**24**	**8**	**16**	**7**	**57**	**23**	**20**	**11**
Lake Mburo	**10**	**8**	**30**	**30**	**122**	**136**	**8,28**	**7,99**	**26**	**24**	**37**	**40**	**283**	**443**	**19**	**13**	**14**	**12**	**125**	**161**	**140**	**46**
Lake Nabugabo	**8**	**8**	**100**	**90**	**20**	**20**	**3,23**	**2,17**	**25**	**25**	**8**	**11**	**300**	**235**	**94**	**18**	**2**	**8**	**25**	**29**	**80**	**19**
Lake Victoria (Ggolo)	**7**	**9**	**120**	**120**	**82**	**108**	**0,59**	**0,08**	**23**	**25**	**10**	**8**	**266**	**183**	**11**	**8**	**3**	**5**	**57**	**51**	**25**	**16**
Lake Victoria (Murchison Bay)	**6**	**-**	**80**	**80**	**100**	**100**	**0,95**	**0,44**	**26**	**26**	**13**	**23**	**360**	**1169**	**28**	**25**	**5**	**8**	**122**	**105**	**150**	**199**
Lake Victoria (Napoleon Gulf)	**-**	**9**	**100**	**110**	**94**	**98**	**0,34**	**0,08**	**27**	**26**	**11**	**10**	**501**	**501**	**19**	**5**	**3**	**7**	**70**	**75**	**45**	**14**
Finger Pond Jinja	**-**	**9**	**11**	**20**	**1134**	**1095**	**18,2**	**21,8**	**31**	**26**	**33**	**22**	**621**	**248**	**24**	**18**	**25**	**12**	**222**	**213**	**60**	**46**

Source: FIRRI, 2004

Box 2: Water Quality: The LVEMP Water Quality and Limnology study

The LVEMP Water Quality and Limnology study

The objectives of this study can be summarized broadly as follows:

- Defining on-going changes in lake limnology and water quality and the causes of the changes, model and predict their short and long term
- Quantify the different process and their roles
- Provide necessary information on lake circulation and water quality to the water quality Management Model, which will guide future water water quality management decision within the lake and its catchment

Selected results

Water quality data collection has involved the establishment of a basin-wide water quality-monitoring network and focused on non-point and point source pollution and sediment loadings, and eutrophication of the lake. The data collected so far has provided valuable information for development of policies and programmes to save the lake from further deterioration.

Kagera sub-catchment, with 33% of total discharges into the lake, accounts for the highest total phosphorus and nitrogen loads into the lake. There are also significant pollution loads from urban establishments. Point sources of pollution have been mapped. Land based activities have contributed to eutrophication of inshore areas due to high nutrient inputs with the offshore areas less affected.

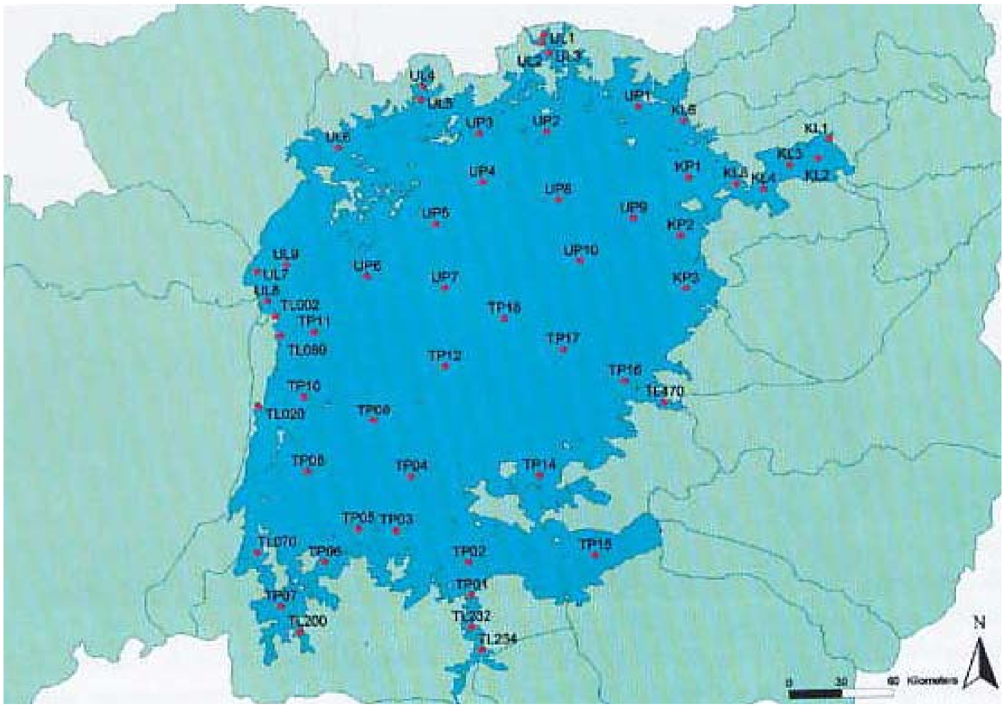
Sedimentation in the lake is generally low, at 1mm/year. However some of the gulfs, bays and rivers are endangered due to high sedimentation inputs from the catchments.

This study has collection of a very large amount of data on rainfall, river discharges, sediments, nutrients, atmospheric deposition and eutrophication. There is however a need for emphasis of evaporation data from the catchments, and awareness raising among catchment communities.

Source:

RMD Yearbook, 2002-2003

Figure 4.3: Water quality monitoring stations on lake Victoria



Source: WRMD, 2004

4.4.4 Groundwater sources

Groundwater is the main source of drinking water in rural areas of Uganda. The quality of groundwater is highly dependent on aquifer catchment landuse, area geology, depth of abstraction and type of technology for abstracting the water. The ground water sources are commonly protected as springs, deep well drilling, and shallow wells preferred for the low cost involved. Shallow wells however face the risk of contamination from and seasonal fluctuations in quality and quantity.

Sanitary surveys in nine districts of high shallow well potential indicate 50% of the wells had medium to high risk contamination, major source of contamination being faecal bacteriological contamnation, high turbidity and high iron content. Higher levels of contamination of groundwater sources are reported in urban centers, schools and other areas of high population density. Such contamination is of serious health risk, with occurance of waterborne diseases likely (WRMD Yearbook, 2002-2003).

Table 4.7 presents results of water quality surveillance for borehole water in major urban centers by the Ministry of Health Environmental Health Department.

Table 4.7: Borehole water surveillance results in major urban centers

Town	No. of samples	No. of failures	Range FC/100ml
Mbale	29	23	1-85
Soroti	162	11	1-8
Tororo	53	1	1
Mbarara	6	1	1
Total	250	36	1-85

Source: Ministry of Health, 1999

Figure 4.4: Shallow groundwater source pollution (Photo by Moses Otim, January 2005)

A protected spring in Kawempe Division, Kampala threatened by pollution from urban run-off	Municipal wastes: these are likely sources of contamination of protected springs in Kampala

4.4.5 Private sector initiatives: some case studies

4.4.5.1 Kasese Cobalt effluent monitoring trail

The Kasese Cobalt Plant is located at Kasese, in South Western Uganda, and processes tailings of the defunct Kilembe Copper mine. The resulting effluent is subjected to precipitation and treatment in tailings dams prior to discharge of clear effluent into the Rukooki river. The Company undertakes weekly monitoring of its effluent trail, including prior and after discharge into river Rukooki, at twelve sites. The Plant has an Environmental Laboratory with capacity to carry out analysis of all discharge permit parameters, including trace metals and other physico-chemical criteria.

4.4.5.2 Uganda Breweries

The UBL beer plant is located at Portbell, on the north shores of lake Victoria, in Kampala District. It pollutant load into the lake has been of concern, amounting to 3500 mg/l of BOD, 3400 mg/l in TSS and pH of upto 11, at a discharge rate of 3750m^3/hr (SOE, 2002).

However the plant has since invested in an effluent treatment plant and with clean technology practices, and regular effluent monitoring, this load is set to comply with national standards, i.e 50mg/l of BOD, 1200 mg/l of TDS and pH 6-8.

4.4.5.3 Waste Management by KCC

Prior to the KCC Waste Management Ordinance, waste collection and disposal was the sole responsibility of the Engineering department of Kampala City Council. According to the District SOE 1997, the department was only able to collect 25% of all generated solid waste. 80% of the household waste was not accessible or collected. Until 2002, the City had no Land Fill site, with waste damped at Kitezi in the Peri-urban sub-county of Nangabo.

Construction of a Land Fill and Leachate treatment plant started in 1997 and completed in 2002. The City now generates an estimated 1000 tonnes per day. Waste Management has since become an income generating activity. Waste collection has been decentralized to the Divisions, garbage collection services procured by public tendering, and waste collection paid for by the producers. KCC has contracted Management of the Mpererwe Sanitary Landfill at Kiteezi, Nangabo sub-county, Wakiso District to a private company – Dott Services. There are plans to start power generation from these solid wastes by KCC (Source: DEO, KCC).

Figure 4.5: KCC waste landfill and leachate treatment plant at Kitezi (Photo by Moses Otim, January 2005)

	
Kitezi land Fill site	Leachate Plant at Kitezi

Hazardous waste management still remains a challenge to many urban areas in Uganda, particularly from hospitals, pharmaceutical industries, chemical industries, garages, fuel depots and service stations. There is as well inadequacy in Clean Technology practices that would greatly limit waste generation at source, as well as inadequate facilities for waste treatment or disposal such as landfills or incinerators, and also waste segregation and waste conversion into useful products. Leachate form urban solid waste can be a serious source of contamination both of groundwater and surface water resources.

4.4.6 Water quality concerns: response from the Districts

A questionnaire was administered to selected DEO's and DWO's of industrialized (5) and predominantly rural districts (2), and neighbouring major water bodies and these included, Kampala, Wakiso, Mbarara, Mukono, Nakasongola, Mbale and Jinja. There is general agreement on emerging water quality concerns resulting from: industrial pollution; faecal and domestic pollution; degradation of river banks and lake shores as well as wetland reclamation, thus increased turbidity and siltation; limited awareness levels on impact of activities and chang in land use on water quality; centralized water quality monitoring with limited capacity at district level to monitor and enforce legislation that protects the water environment; and little or no cordination between district departments with assignments related to water quality monitoring and management.

It is of interest here to note some activities such as liquor distillation in river systems (Crude Waragi distillation) with impact such as increased BOD, and faecal contamination of water sources due to lack of sanitary facilities, but with no bye-laws at local level against the practice, but silent resistance among communities affected (Source: DEO, Mbale).

4.4.7 Water quality research

The department of chemistry conducts various research in water quality as well as pollution. Regular monitoring of organic pollutants at the shores of lake Victoria including organochlorine pesticides, pyrethroids, organophoshates, and carbamates. The sites being monitored on quarterly basis include the Napoleon Gulf, Murchison Bay, Waiya Bay and Kisubi Bay to ascertain impact of agricultural activities on lake water quality. The land use includes Sugarcane estates, tea estates, and horticultural farms. Heavy metal trails and their speciation in lake Victoria have as well been studied. Such research has at times had financial constraints, and most of the findings are unpublished.

4.4.8 Summary of major threats to water quality

Based on analytical results from monitoring networks, a review of literature and responses from the districts and other persons consulted, the following are the water quality concerns/major threats within the Nile basin in Uganda.

i. Siltation: This has resulted mainly from degradation of wetland, riverine or lake shore ecosystems, and degradation of land cover, leading to increased water turbidity and physical impact on flow regimes;

ii. Atmospheric deposition: This is of concern particularly for major water bodies, such as lake Victoria;
iii. Urban run-off and Industrial effluent streams discharged into water bodies or local streams and rivers not meeting national standards;
iv. Agricultural run-off: With increasing modernisation of agriculture, and a higher demand and application of agrochemicals such as fertilizers, pesticides, acaricides, agrochemicaluse on agricultural lands poses pollution threat to water systems;
v. Eutrophication: nutrient loads into the water bodies will lead to increased eutrophication, as well as de-oxygenation, thus threatening aquatic life and lake productivity. The proliferation of water hyacinth causing biodiversity and economic losses in the near-shore areas of lake Victoria is an example;
vi. Limited monitoring of water quality status in lakes to lake Victoria, with the status of other lakes and their catchment management not emphasized;
vii. Data on the quantification of pollutant load, effect and fate on major water is lacking, except for lake Victoria and its catchment;
viii. Wetland degradation: encroachment on wetlands particularly around industrialized districts such as Kampala will lead to loss of pollutant filtration values, and more pollutants discharged into surface water systems;
ix. Limited capacities: At National, district and within the private sector, capacities for enforcement of environmental regulation and in water quality assessment and monitoring are limited;
x. Population pressure contributing to the existence of “hot spots”, caused by human waste, urban runoff, municipal effluent discharges, and environmental degradation.

4.5 Collaboration among institutions in Water Quality Monitoring

Given the various stakeholders involved in Water Quality Monitoring, collaboration among lead institutions is required. To strengthen water resources assessment and forecasting functions, various data sets are required and these are under the custody of various stakeholders.

Though the WRMD operates a number of weather monitoring stations, but the Department of Meteorology has climatic data of national coverage. WRMD has signed an understanding with UMD to have rainfall records digitised and continuous data update.

The limitation for geo-data sharing in future includes an absence of national harmony in data set geo-references. The SDI efforts are yet to succeed in this effort.

Under LVEMP and the design of NBI provide opportunities for networking among lead institutions with WRMD including WID, NWSC, Makerere University (MUIENR, Civil Engineering Department), NEMA, and FIRRI. Such collaboration and stakeholder involvement is required to avoid duplication of activities and ensure maximum utilization of available resources.

At the District and local levels, such networking is still limited, with duplication of activities in water quality monitoring and management likely among stakeholders. Their participation in developing the National Water Quality Management Strategy together with other stakeholders is expected to alleviate the current situation.

4.6 Inventory and capacity of Laboratories

4.6.1 Laboratory status

During the survey, a number of laboratories were visited to establish capacity in water quality monitoring. Of interest was equipment available and their state, scope of analysis of water and other environmental samples, staffing levels and staff development opportunities, quality control and assurance measures, as well as accreditation status. The laboratories visited included those run by Government Institutions (WRMD, FIRI, GAL, UNBS), Teaching and Research Institutions (Departments of Chemistry and Geology, MUK) and Private/Commercial laboratories (Chemiphar).

For all these laboratories, there is an effort, and in some cases a need for improvement in capacity, scope of analysis and efficiency. There have been varied levels of investments in instrumentation, staffing and staff training, laboratory information systems, quality assurance and acccreditation systems. There is also a need for continued research on the fate of pollutants in the water systems.

Given the emerging trends in water quality, with a need for various parameters to be regularly monitored in future, there is surely a need to update in quality assurance and control, analytical skills, equipment and analytical scope and in water quality and laboratory information management systems. The staffing levels are rather low at most of these laboratories for a regular nationwide water quality assessment program. For completeness of water quality data as well as regular water quality monitoring, strengths of the various laboratories ought to be utilized.

A few laboratories are now accredited and participate in proficiency testing, and this has enhanced quality control and assurance measures in place. An inventory of water quality assessment laboratories is presented in appendix 4.

4.6.2 Training and development opportunities

For all the laboratories visited, there are thresholds in terms of academic qualification for entry levels. For example for laboratory Technicians, a Diploma in Laboratory technology is a requirement while for Analysts, a

Bachelors Degree is required. The Major training institutions include Makarere University and Kyambogo University, with the former concentrating on teaching at undergraduate and graduate levels as well as research, while the latter offers undergraduate and diploma programmes in Chemistry and laboratory technology.

The training opportunities once on the job include tailor made courses, and formal university courses. Workshops and seminars have as well been utilized to enhance knowledge and skills development as well as information exchange among laboratory personnel. Some laboratories and institutions have developed capacity to offer training services and these include UNBS, the Department of Chemistry and Faculty of Veterinary Science (MUK), NWSC, WRMD and GAL.

5.0 CONCLUSION AND RECOMMENTATIONS

5.1 Water quality monitoring gaps

This baseline survey reveals that there exist water quality monitoring and management gaps that ought to be addressed.

The identified water quality monitoring gaps include inadequacies in spatial and temporal coverage, scope of analysis, laboratory capacities, laboratory information systems, background environmental data and sampling media.

Existing water quality monitoring networks need to be redesigned to address issues at local, sub-catchment or river basin, lake water quality, national and transboundary concerns. Land use patterns, agricultural systems, point and non-point sources of pollutants, and the nature and composition of municipal and domestic wastes have since changed, both in intensity and coverage, requiring a well thought regular sampling strategy and network.

Different media for sample collection including ground water, streambed sediments, aquatic biological tissues, as well as fish, invertebrate, and algal communities and stream habitat are not frequently sampled to aid better understanding of water quality impacts and status. Though various media analysis have been carried out, the efforts have been project driven.

The analytical scope should also be in a position to address emerging concerns. Pesticides used in agricultural fields and on livestock, trace metal discharges in water environments, oil wastes, radionuclides and xenobiotics from pharmaceutical waste, atmospheric pollutants and particulate matter are now of concern. The current efforts to redefine the water quality monitoring network ought to look into such arising concerns.

Given these challenges, the existing laboratories will have to reinvent to address these water quality information gaps. Such efforts ought to focus on improvement in human resources knowledge base and numbers, laboratory equipment upgrades, investment in laboratory quality control and assurance measures and in laboratory information systems. Outsourcing of some of the water quality analytical and monitoring services by the lead agency looks an option for improved efficacy, but requires development of capacities of other stakeholders.

Besides fora and mechanisms for knowledge development and information exchange should be looked into by key players in water quality monitoring, research and management. Such fora would address issues like standardization of methods of analysis, water quality monitoring networks review, defining of roles in water quality monitoring, information exchange on key water quality parameters and skills development in laboratory instrumentation.

At the local level, appropriate means of water quality monitoring and surveillance, as well as collaboration and linkages among stakeholders needs to be developed. Data bases for monitoring or surveillance results of water quality could be developed at district level, and utilized in water resource management efforts.

However it has to be noted that water quality monitoring in some Nile Sub-basins such as Aswa, Albert Nile and Kidepo have been limited by insecurity, with some of the infrastructure destroyed.

5.2 Water quality management gaps

Management of water quality issues for surface water is still more at the centre, with capacity for enforcement of water quality and related environmental regulations and participation in monitoring at district and local levels limited. There is also little coordination and linkages among likely key players at National and District level, with limited opportunities for information exchange.

There is weakness at the moment for water quality management at river basin or catchment level, and in transboundary management of some lakes. However it is at this level that water quality monitoring output could best inform policy makers particularly in decentralized set-ups, CBO/NGO and local participation ensured, and water quality surveillance more effectively managed. Under LVEMP, there has been an attempt to map out pollution hotspots and their trails into lake Vicoria (Mott MacDonald, 2001). Such an effort could be encouraged at sub-county level with support from District technical staff.

However information on water quality and related environmental information generation, access and dissemination, as well as awareness at these local levels is limited and should be developed.

Enforcement and compliance with environmental regulation also needs to be improved. Regulations on waste management, effluent disposal, soil quality, land use, wetland and shoreline use, environmental assessments and audits for developments likely to have impacts on water quality should be given emphasis and enforcement strengthened. Water permits regulation function has an opportunity to be effective if well administered at District level by Technical Officers. Development of standards and guidelines on water quality will as well require a research effort. Only national standards for effluent discharge and drinking water currently exist.

Faecal contamination of water sources requires improvement of water supply and sanitary coverage, but in some areas like Fishing Villages a radical change in cultural practices (Mott MacDonald, 2001) and use of bye laws.

Support at national and local levels for compliance enforcement also needs attention. Local communities will require improved levels of awareness of impacts of activities on water systems to actively participate in water resource management. Industries will require compliance support, particularly in adoption of Cleaner Production measures and in end-pipe technology investments.

5.3 Spatial issues and tools in water quality assessment

Spatial data bases, including land use and land cover, soil types, physiography, ecological zones, geological characteristics, basin and sub-catchment boundaries, rainfall station data and stream flow rates will enable proper choice of sampling station networks, as well as better assessment and understanding of surface water and ground water conditions at local, regional and national scales. Such spatial data has been utilized in recent water quality studies such the management of industrial and Municipal effluents and urban run-off in Lake Victoria Basin (Mott MacDonald, 2001), the Hydro-Climatic Study of Uganda, the Low Flow Study of Uganda, the LVEMP Water Quality and Limnology study and the Wobulenzi groundwater study (WRMD Yearbook, 2002-2003).

Except for WRMD, tools for capture and storage of spatial data, such as GPS and GIS infrastructure, are lacking, and the utilization of spatial modeling to predict water quality trends or impacts of changing land use, point and non-point pollutant sources is limited. Preparation of accurate national water quality maps will thus require an intensive nationwide water quality assessment, a review of the existing monitoring network, integration of data sets and monitoring activities by other stakeholders, proper inventory and updates to available data.

Several data sets for Water quality modeling are now readily available with various institutions including Ministry of Agriculture for soils, land cover and land use with the National Forestry Authority, Department of Meteorology for meteorological data, National Environment Management Authority for point sources, and WRMD for hydrological information. However, most of these data sets require updating to suitable scales for accurate and reliable water quality modeling, and the data compatibility issues resolved. An emphasis for models could be placed at watershed or sub-basin level.

Other than capturing, storage and analysis of water quality data, Geo-information systems applications could provide opportunity for predicting and spatial visualization of status of water quality, and dissemination of information and building awareness among stakeholders involved.

5.4 The Future

Currently there are management regimes and practices in place to protect water quality, as well as documentation of water quality status. But there is need for a holistic approach for continuity and more accurate information generation particularly presenting the water quality state, water resources and their status in relation to water quality trends, pressure on basin ecosystem resources and causes, impact of human induced and natural hazards on water resources, and responses adopted to address water quality monitoring and management gaps.

There ought to be an emphasis water quality information systems and spatial tools and models to help visualize and predict future water quality scenario, addressing key environmental concerns in the basin, and means to track and contain them. Though outside the scope of this study, natural hazards and their impacts on water quality can as well be predicted or modeled with GIS tools.

Continuity in development of research techniques, technical capacity and understanding of the Nile Basin water quality and water resource sustainable management practices, development of an information system and reporting framework, as well as information exchange, dissemination and coordination of activities among stakeholders and external support in water quality management and monitoring is encouraged. At local levels especially at the districts, the “position” of water resources monitoring and management needs to be addressed.

Current efforts and recent achievements by the lead agency in Water Quality Monitoring and Management are commendable, particularly in developing a National Water Quality Management Strategy, redefining water quality monitoring roles, and stream lining co-ordination and linkages among stakeholders involved among others are commendable and provide a strong basis for future sustainable water resources management.

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APPENDICES

Appendix 1: Instruments for data collection
QUESTIONNAIRE: Baseline Survey, Water Quality Monitoring (District)

1. Name of Respondent
   ………………………………………………………………………

2. District……………………………Position………………………………………

3. For how long have you been working with this Industry/Institution?
   A - Less than 5 Years B - Between 5 and 10 Years C - More than 10 Years

4. What activities is your office involved in related to water resourses and quality assessment, effluent monitoring and management.

Concern	**Impact on water quality**
e.g Wetland degradation	Increased sediment load, siltation

5. Do you have a regular water quality/effluent monitoring program in the District? Please indicate the parameters monitored and how often they are tested, under the following criteria:
   a. Physico-Chemical Parameters
   b. Organic Contaminants
   c. Trophic parameters (e.g chrolophyll conceration, phytoplancton species, DO)
   d. Microbiological and hygienically-relevant Parameters
   e. Hydrological Parameters (e.g flow rates)

6. What other water resource assessment and environmental data are collected by your office. Indicate monitoring points/station, for what purpose and how often.

What kind of data	Why the data are collected	Stations/sampling sites (Preferably GPS readings)	How often
Quality of sediment in streambed and soils in background			

7. What arrangements exist for water quality, environmental data and other information acquisition or exchange between the district with lead agencies and stakeholders in water quality and water resources assessment?

8. How is environmental controlling and repoting being carried out by your District?

9. What are the limiting factors or problems encountered in your water quality assessment and monitoring programmes?

    a. ....
    b. ....
    c. ....
    d. ....

10. How are local communities and other stakeholders (industries, local communities, NGO's, CBO's, Municipalities) involved in water quality management programs in your area, and what impact has this involvement had on catchment water quality.

11. What do you suggest as a measure to improve existing practices and strategies in water resources assessment and water quality monitoring at district level?

QUESTIONNAIRE: Baseline Survey, Water Quality Monitoring (Laboratory)

1. Name of Respondent ……………………………………………………………………

2. Laboratory……………………………Position…………………………………… ………

3. For how long have you been working with this Institution?
   A - Less than 5 Years B - Between 5 and 10 Years C - More than 10 Years

4. What activities is your laboratory involved in related to water resourses and quality assessment, effluent monitoring and management?

5. What do you consider the major water quality concerns within the Nile basin catchment in Uganda? Kindly provide baseline water quality data monitored by your laboratory.

Concern	**Impact on water quality**
e.g Wetland degradation	Increased sediment load, siltation

6. Do you have a regular water quality/effluent monitoring program? Please indicate the parameters monitored and how often they are tested, under the following criteria:
   a. Physico-Chemical Parameters
   b. Organic Contaminants
   c. Trophic parameters (e.g chrolophyll conceration, phytoplancton species, DO)
   d. Microbiological and hygienically-relevant Parameters
   e. Hydrological Parameters (e.g flow rates)

7. What other water resource assessment and environmental data are collected by your laboratory. Indicate monitoring points/station, for what purpose and how often.

What kind of data	Why the data are collected	Stations/sampling sites (Preferably GPS readings)	How often
Quality of sediment in streambed and soils in background	To quantify the storage, behavior, and transport of water and chemicals in the soils and sediment		

8. What is the scope of water quality analysis in your laboratory and what facilities are available?

i. Facilities

Facilities	Number	Type, model	Purpose	Operational status

ii. Analytical scope

Water Quality Criteria	Parameter analysed	Method or instrumentation in use	Quality Control/Assurance measure
Physico-chemical			
Trophic			
Hydrological			
Microbiological			
Organic contaminants			

9. Kindly indicate your status as per the following:

a) Organisation structure, Staffing level and staff development opportunities;
b) Laboratory information system;
c) Laboratory accreditation;
d) Generation of catchment baseline data.

10. What arrangements exist for water quality, environmental data and other information acquisition or exchange with other agencies and stakeholders in water quality and water resources assessment?

11. What are the limiting factors or problems encountered in your water quality assessment and monitoring programmes?

   a. ……………………………………………………
   b. ……………………………………………………
   c. ……………………………………………………
   d. ……………………………………………………

12. How are local communities and other stakeholders (industries, local communities, NGO's, CBO's, Municipalities) involved in water quality management programs, and what impact has this involvement had on catchment water quality.

13. What do you suggest as a measure to improve existing practices and strategies in water resources assessment and water quality monitoring by your laboratory?

Appendix 2: List of Consulted individuals and Institutions

Individual	Institution	Position
Adong Florence	Water Resources Management Department	Assistant Commissioner
Matovu Abdullah	Water Resources Management Department	Water Quality Manager
Eng. Badaza John	Water Resources Management Department	Head, Water Permits Unit
Mugabe Robert	Water Resources Management Department	Senior Analyst
Etimu Simon	Water Resources Management Department	Senior Analyst,
Okot Okumu James	Water Resources Management Department	Consultant
Okwerede Lans	National Water and Sewerage Corporation	Senior Analyst
Kitimbo Peter	Government Analytical Laboratory	Senior Analyst
Sebagala B.M. Silver	Uganda Cleaner Production Centre	Deputy Director
Kasande Robert	Ministry of Energy and Mineral Development	Principal Geologist
Byekwaso Evaristo	National Environment Management Authority	Compliance and Monitoring Officer
Lubega George	National Environment Management Authority	Natural Resource Management Specialist/Aquatics
Arumadri Joel	National Environment Management Authority	Information Systems Specialist
Waswa John	Department of Chemistry, MUK	Lecturer/Laboratory Manager
Namakambo Norah	Wetlands Inspection Division	Senior Wetlands Inspector
Dr. Kansiime Frank	Institute of Environment and Natural Resources, MUK	Director
Kiberu John Mary	Department of Geology, MUK	Lecturer
Kasaka Moses	Department of Geology, MUK	Laboratory Manager
Dr. John Baliwa	Fisheries Resources Research Institute	Director
Dr. Wanda	Fisheries Resources Research Institute	Researcher

Okello William	Fisheries Resources Research Institute	Research Assistant
Magumba K. Moses	Fisheries Resources Research Institute	Chief Laboratory Technician
Luyima Paul	Ministry of Health	Assistant Commissioner
Odongo Robert	Ministry of Health	Senior Health Environmentalist
Dr. Mugabi David	LAKIMO	Coordinator
Chamber Richards	Uganda Breweries Ltd	Operations Manager
Dr. Ndifuna Abdul	Uganda National Bureau of Standards	Head Microbiology Laboratory
Ejalu B. Patricia	Uganda National Bureau of Standards	Analyst
Kateu K. Kepher	Chemiphar Laboratory	Quality Assurance Manager
Mbabazi Julius	Chemiphar Laboratory	Analyst
Wabusa Sam	Wagtech Uganda Ltd	Business Manager
Kabasiita Juliet	Kasese Cobalt Company Ltd	Chief Environment Officer
Kakai Mary Wamimbi	Mbale District Local Government	District Environment Officer
Nabihamba Ernest	Jinja Municipal Council	Senior Environment Officer
Musoke Solomon	Mukono District Local Government	District Environment Officer
Joan Kironde	Wakiso District Local Government	District Environment Officer
Musingwire Jaconious	Mbarara District Local Government	Principal Environment Officer
Martin Aryagaruka	Enviro-Impact and Management Consults Ltd	Principal Consultant

Appendix 3: Inventory of laboratories involved in water quality analysis

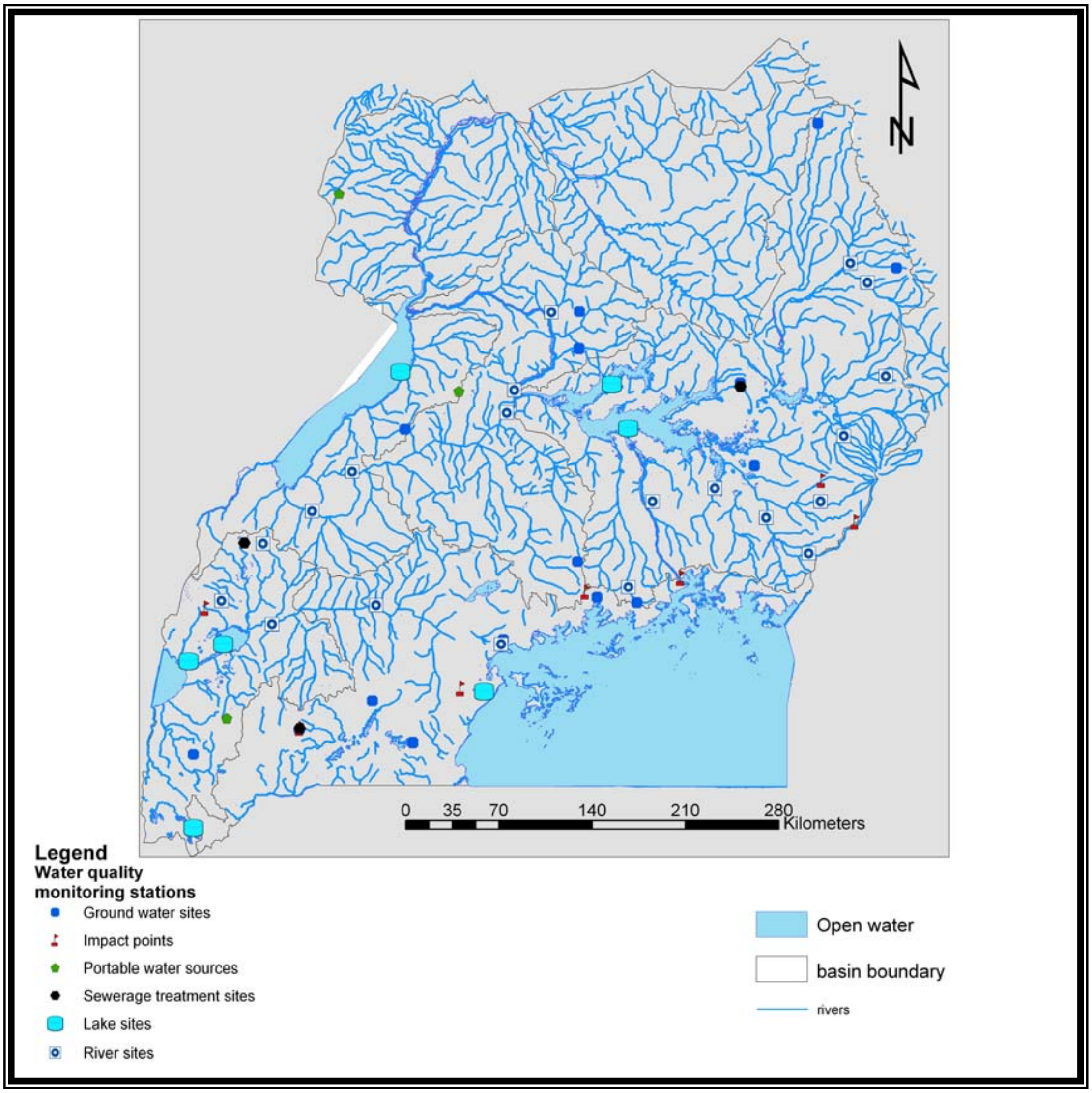
Laboratory	Parameters	Key Instrumentation	Quality Control/ Assurance measures	Accreditation
1. WRMD	Physico-chemical	Electrometric, Titrimetric, Spectrophotometry	Equipment calibaration, Internal checks, Reference standards, Proficiency testing with SANAS – South Africa, Aquacheck.	On-going
	Trace metals	AAS 300		
	Organic pollutants	Gas chromatography		
	Trophic	Microscopic		
	Microbiological	Filter membranes, ELE-ParaquaLab		
2. NWSC	Physico-chemical	Electrometric, Titrimetric Spectrophotometry	Equipment calibaration, Internal checks, Reference standards	On-going
	Trace metals	na		
	Organic pollutants	na		
	Trophic	Microscopic		
	Bactereological/hygenic	Filter membranes, ELE-ParaquaLab		
3. FIRI	Physico-chemical	Electrometric, Spectrophotometers, Thermoreactor (CR 3000), GC, Secchi disc	Instrument calibration, Internal checks, reference standards	na
	Trace metals	AAS, ALPHA 4		
	Organic pollutants	na		
	Trophic	Methanol extraction, Utermohl – 1958, inverted Microscopes (Leica DM), Seabird (surveyor 4a – 52712)		
	Bactereological/hygenic	na		

4. GAL	Physico-chemical	Electrometric, Spectrophotometers, GC, Secchi disc	Equipment calibration, Internal checks, Reference standards	na
	Trace metals	AAS, ALPHA 4		
	Organic pollutants	GC, HPLC		
	Trophic	na		
	Bactereological/hygenic	na		
5. UNBS	Physico-chemical	Electrometric, Spectrophotometric	Equipment calibaration, Internal checks, Reference standards, Proficiency testing with SANAS – South Africa	Accredited
	Trace metals	AAS Shimadzu		
	Organic pollutants	GC		
	Trophic	na		
	Bactereological/hygenic	ELE-ParaquaLab		
6. Chemiphar	Physico-chemical	Electrometric, Spectrophometers, Anion Chromatography - (Dionex Dx 100)	Equipment calibaration, Internal checks, Reference standards, Proficiency testing	Accredited
	Trace metals	ICP, GCMS		
	Organic pollutants	GCMS Agilent – GC6890, GC – Varian 3800, 2400		
	Trophic	na		
	Bactereological/hygenic	ELE-ParaquaLab		
7. Chemistry dept, MUK	Physico-chemical	Electrometric, Titrimetric, Spectrophotometry – Pharmaspec 1700.	Equipment calibaration, Internal checks, Reference standards	On-going
	Trace metals	AAS		
	Organic pollutants	GC (3), HPLC – Gilson 806		
	Trophic	Microscopic		
	Bactereological/hygenic	Filter membranes, ELE-ParaquaLab		

8. Geology Dept, MUK	**Physico-chemical**	**Electrometric**		
	Trace metals	**AAS**		
	Organic pollutants	**na**		
	Trophic	**na**		
	Bactereological/hygenic	**na**		

Note: na – not available or applied

Appendix 4: Water Resources monitoring networks
Appendix 4.1.1: Map of Water quality monitoring network, WRMD



Appendix 4.1.2: Water quality monitoring network: locations with geo-references

Site Id	Site Name	Longitude	Latitude	UTMX	UTMY
Gs1943	**Apac Hospital Borehole**	**32.53298**	**1.97965**	**447688.00**	**419083.00**
Gws001	**Portbell Ground Waster Site At Portbell - Kampala**	**32.575**	**0.32**	**461126.62**	**231912.21**
Gws002	**Nkokonjeru Ground water Site - Mukono**	**32.929**	**0.249**	**491042.00**	**227867.00**
Gws003	**Mbarara Ground water at UNICEF Camp - Mbarara**	**30.649**	**0.606**	**237924.00**	**132193.00**
Gws004	**Bombo Ground water Site at Bombo Army Barracks - Luwero**	**32.52**	**0.73**	**446590.00**	**258583.00**
Gws005	**Busia Ground Water Site**	**34.1**	**0.47**		
Gws006	**Soroti Ground Ground Water Site**	**33.68**	**1.68**	**568468.00**	**393072.00**
Gws007	**Morulinga Ground water Site at Kangole - Moroto**	**34.484**	**2.745**	**663515.00**	**468094.00**
Gws008	**Moroto Ground Water Site at Prison Barracks - Moroto**	**34.661**	**2.532**	**685610.00**	**479527.00**
Gws009	**Kabong Ground Water Site at Kabong Hospital - Kotido**	**34.14**	**3.48**	**626743.72**	**588680.38**
Gws010	**Apac Ground Water Site at DWD Offices - Apac**	**32.71**	**1.98**	**447688.00**	**419083.00**
Gws012	**Rakai Ground Water Site at Civic Centre - Rakai**	**31.41**	**0.7**	**323063.00**	**122599.00**
Gws013	**Lyantonde Ground Water Site at Kyabazala, Lyantonde - Rakai**	**31.094**	**0.247**	**292718.00**	**153988.00**
Gws014	**Kasese Ground Water Site at Kasese Cobalt Co. Ltd - Kasese**	**30.012**	**0.211**	**292718.00**	**153988.00**
Gws015	**Loro Ground Water Site at CPAR Tree Nursery, Loro - Apac**	**32.632**	**2.234**	**447915.00**	**446983.00**
Gws016	**Hoima Ground water Site at Hoima Hospital - Hoima**	**31.339**	**1.441**	**316927.00**	**358289.00**
Gws017	**Osera Ground water Site - Pallisa**	**33.698**	**1.172**	**579080.00**	**331067.00**
Gws018	**Nkozi Ground Water Site - Mpigi**	**31.98**	**0.01**	**390810.00**	**200005.00**
Gws019	**Rukungiri Ground Water Site - Rukungiri**	**29.978**	**1.227**	**158323.00**	**113700.00**
Mip001	**R. Ruizi at NWSC New Water Treatment Works**	**30.649**	**0.606**	**238252.00**	**133264.00**
Mip002	**R. Ruizi at NWSC Old Lagoons**	**30.649**	**0.606**	**238252.00**	**133264.00**
Mip002A	**R. Ruizi at NWSC Lagoons (After discharge)**	**30.649**	**0.606**	**238252.00**	**133264.00**
Mip003	**NWSC Lagoons - Mbarara (Effluent Discharge)**	**30.649**	**0.606**	**238252.00**	**133264.00**
Mip004	**R. Ruizi Down Stream FREBA Tannery**	**30.649**	**0.606**	**238252.00**	**133264.00**
Mip005	**Nakayiba Stream at NWSC Lagoons (After Discharge)**	**31.734**	**0.335**	**359035.19**	**163265.40**
Mip005A	**Nakayiba Stream at NWSC Lagoons (Before Discharge)**	**31.734**	**0.335**	**359035.19**	**163265.40**
Mip006	**Nakayiba Stream atnyendo - Masaka Road**	**31.734**	**0.335**	**359035.19**	**163265.40**
Mip007	**Nakayiba Stream Mbarara By Pass (Kyakumpi)**	**31.734**	**0.335**	**359035.19**	**163265.40**

Mip008	Masaka NWSC Lagoons (Effluent Discharge)	31.734	0.335	359035.19	163265.40
Mip009	Nakivubo Channel (Bridge over Portbell Railway Line)	32.575	0.323	452626.57	236003.91
Mip010	Nalukolongo Channel	32.575	0.323	452626.57	236003.91
Mip011	Natete Stream	32.575	0.323	452626.57	236003.91
Mip012	Bwaise Stream (Upsteam)	32.575	0.323	452626.57	236003.91
Mip013	Bwaise Stream (Downsteam)	32.575	0.323	452626.57	236003.91
Mip014	Lugogo Channel	32.575	0.323	452626.57	236003.91
Mip015	Kitante Stream	32.575	0.323	452626.57	236003.91
Mip016	Bat Valley Stream (Spring)	32.575	0.323	452626.57	236003.91
Mip017	Kinawataka Swamp	32.575	0.323	452626.57	236003.91
Mip018	Kyambogo Stream	32.575	0.323	452626.57	236003.91
Mip019	L. Victoria at Kirinya Bay Opposite NWSC Lagoons	33.203	0.438	524026.82	246356.19
Mip020	L. Victoria at Masese	33.203	0.438	524026.82	246356.19
Mip021	R. Nile at Owen Falls Bridge	33.203	0.438	524026.82	246356.19
Mip022	Mbale NWSC Old Lagoons (Effluent Discharge)	34.167	1.081	629761.25	319809.46
Mip023	Mbale NWSC New Lagoons (Point of Confluence)	34.167	1.081	629761.25	319809.46
Mip024	Mbale Soap Works (Railway Bridge)	34.167	1.081	629761.25	319809.46
Mip025	Mbale Soap Works (Up stream)	34.167	1.081	629761.25	319809.46
Mip026	River Lwakhaka (Road Bridge Kenya - Uganda Boarder)	34.39	0.8	654589.70	288751.85
Mip027	R.Nyamwamba at Kasese Kilembe road	30.012	0.211	167286.11	223655.98
Mip028	R. Rukoki at Kasese F/Portal road	30.012	0.211	167280.11	223655.98
Mip029	R. Rukoki at Kasese Kampala Railway Bridge (After discharge)	30.012	0.211	167280.11	223655.98
Mip029A	R. Rukoki at Kasese - Kampala Railway Bridge(Before discharge)	30.012	0.211	167280.11	223655.98
Mip030	R. Rukoki (KCCL Effluent)	30.012	0.211	167280.11	223655.98
Mip031	R. Sebwe at Kasese F/Portal road	30.012	0.211	167280.11	223655.98
Pws001	Soroti Water Works (Intake)	33.61	1.71	568810.30	390608.42
Pws001A	Soroti Water Works (Treated Water)	33.61	1.71	568810.30	390608.42
Pws001B	Soroti Water Works (distribution)	33.61	1.71	568810.30	390608.42
Pws002	Masindi Water Works (Intake)	31.81	1.65	568810.30	390608.42
Pws002A	Masindi Water Works (Treated Water)	30.899	3.024	357408.19	386898.70
Pws002B	Masindi Water Works (Distribution)	30.899	3.024	357408.19	386898.70

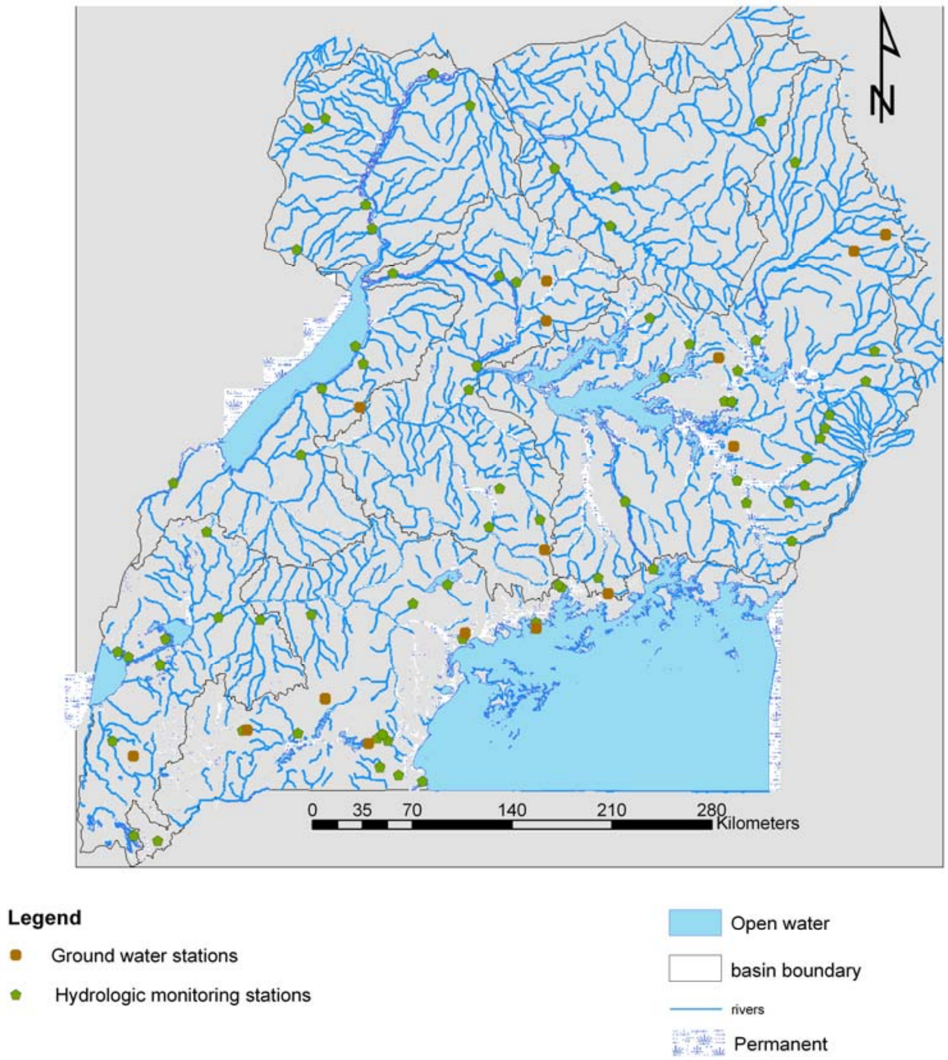
Pws003	Arua Water Works (Intake)	30.899	3.024	267709.44	535451.21
Pws003A	Arua Water Works (Treated Water)	30.899	3.024	267709.44	535451.21
Pws003B	Arua Water Works (Distribution)	30.899	3.024	267709.44	535451.21
Pws004	Kyaruzinga Water Works Bushenyi (Intake)	30.184	0.536	183515.75	140811.67
Pws004A	Kyaruzinga Water Works Bushenyi (Treated Water)	30.184	0.536	183515.75	140811.67
Pws004B	Kyaruzinga Water Works Bushenyi (Distribution)	30.184	0.536	183515.75	140811.67
Sts001	Soroti Sewerage Works (Influent)	33.61	1.71	568774.15	390482.51
Sts001A	Soroti Sewerage Works (Effluent)	33.61	1.71	568774.15	390482.51
Sts002	F/Portal Sewerage Works (Effluent)	30.275	0.671	196674.92	272752.44
Sts002A	F/Portal Sewerage Works (After Discharge)	30.275	0.671	196674.92	272752.44
Sts002B	F/Portal Sewerage Works (Before Dischage on R. Mugunu Upstream)	30.275	0.671	196674.92	272752.44
Swl001	L. Nabugabo at Green View	31.88	0.354	376485.39	160944.72
Swl002	L. Kijjambarora at Kibona Village	31.396	0.7		
Swl003	L. Nakivali at Rukinga Fishing Village	30.898	-0.79		
Swl004	L. Wamala at Kitinika Fishing Village	31.967	0.384		
Swl005	L. Kyoga at Bukungu	32.869	1.438	484563.53	359156.53
Swl006	L.Kwania at Nabyeso	32.797	1.854	472274.16	392160.01
Swl007	L. Albert at Butiaba	31.32	1.818	313876.02	401520.58
Swl008	L. George at Kasenyi	30.15	-0.032	180796.55	196613.63
Swl009	L. Edward at Katwe	29.882	-0.149	154798.46	183698.39
Swl010	L. Bunyonyi at Kyabahinga	29.935	-1.27	158596.40	58251.27
Swr001	R. Katonga at Kampala - Masaka_road	31.933	-0.117	389119.62	196562.11
Swr002	R. Katonga at Kabamba -Nkonge_road	31.174	0.223	295436.18	225902.60
Swr003	R. Bukoora at Kasensero road	31.583	-0.899		
Swr004	R. Sezibwa at Sezibwa Falls	32.863	0.35600	484673.59	239650.50
Swr005	R. Nile at Masindi Port	32.093	1.695	398998.32	387643.77
Swr006	R. Lumbuye at Kaliro - Nawaikoke Road	33.445	1.019	549470.43	313831.37
Swr007	R. Mpologoma at Budumba	33.7	1.05	588040.98	291756.27
Swr008	R. Malaba at Busitema	34.052	0.585	619794.77	264984.86
Swr009	R. Manafwa at NWSC Treatment Works	34.158	0.937	628727.59	303889.49
Swr010	R. Simu at Mbale - Moroto	34.287	1.299	646146.48	353149.79

Swr011	R. Sipi at Mbale - Moroto Road	34.314	1.382	646146.48	353149.79
Swr012	R. Namalu at Mbale - Moroto Road	34.599	1.788	677771.63	398009.06
Swr013	R. Olumot at Soroti - Moroto Road	33.848	1.854		
Swr014	R. Omaniman at Kangole Trading Center	34.478	2.437	664057.60	468716.02
Swr015	R. Lokorimoru at Nyakwai - Matany Road	34.03	2.5		
Swr016	R. Alamacha at Lopei	34.333	2.579	651078.63	483078.63
Swr017	R. Moroto at Atwari Road	33.221	2.37		
Swr018	R. Tochi at Lira - Kamdini Road	32.342	2.227	427005.68	446224.80
Swr019	R. Nile at Mbulamuti Cable Way	33.026	0.93700	502810.67	303868.15
Swr020	R. Kafu at Kampala -Gulu Road	32.042	1.543	393389.41	370873.35
Swr021	R. Nkuzi at F/Portal - Hoima_road	31.000	1.14000	277367.37	326383.20
Swr022	R. Muzizi at F/Portal - Hoima_road	30.730	0.87000	247287.35	296538.91
Swr023	R. Mpanga at Kamwenge - Ibanda road	30.462	0.10100	217410.61	211476.68
Swr024	R. Mpanga at Mubende - Fortportal_road	30.400	0.65000	210522.82	272220.95
Swr025	R. Mubuku at F/Portal - Kasese_road	30.121	0.26100	179426.13	229187.17
Swr026	R. Mitano/Mirara at Rukungiri - Kambuga Road	29.822	-0.78400		
Ruizi NWSC	R. Ruizi at NWSC New Water Treatment Works	30.649	-0.60600	238252.00	133264.00

Note:

Gws - Ground water site
Mip – Impact Points
Pws –Portable water source
Sts – Sewerage treatment site
Swl – Lake site
Swr – River site

Appendix 4.2: Hydrologic Monitoring Stations in Uganda
4.2.1: Map of Hydrologic Monitoring Stations in Uganda



Appendix 4.2.2: Hydrologic Monitoring Stations in Uganda, Locations with geo-references

STN_NO	STATION_NA	LATITUDE	LONGITUDE	UTMX	UTMY
82243	R. Sipi at Mbale - Moroto Road	1:22:57.8	34:18:51.8	646146.48	353149.79
82241	R. Simu at Mbale - Moroto Road	1:17:54.5	34:17:14.4	643140.38	343854.62
82240	R. Sironko at Mbale - Moroto Road	1:14:10.2	34:15:25.0	639764.35	336967.44
82231	R. Kelim (Greek) at Mbale - Moroto Road	1:35:53.6	34:32:38.0	671664.48	377019.69
82228	R. Namalu at Mbale - Moroto Rd	1:47:17.3	34:35:56.1	677771.63	398009.06
82227	R. Kapiri at Kumi - Soroti Road	1:40:01.2	33:44:13.6	581904.94	384570.46
82222	R. Abuket at Kumi - Serere Road	1:27:12.2	33:39:15.0	572690.84	362951.96
82221	R. Agu at Kumi - Serere Road	1:28:06.7	33:41:59.6	577772.06	362632.57
82218	R. Malaba at Jinja - Tororo Road	0:35:06 N	34:03.07 E	619794.77	264984.86
82217	R. Mpologoma at Budumba	0:49:37.3	33:47:24.9	588040.98	291756.27
82213	R. Namatala at Mbale - Soroti Road	1:06:31.1	34:10:21.5	630385.43	322864.28
82212	R. Manafwa at Mbale - Tororo Road	0:56:13.1	34:09:27.6	628727.59	303889.49
82203	R. Victoria Nile at Mbulamuti	0:52:00 N	33:00:00 E	503022.15	292638.33
81269	R. Sio at Luhalali near Bunadeti	0:49:38 N	34:03:26 E	617550.69	291756.54
84212	R. Mpanga at Kampala - Fort Portal Road	0:38:37.1	30:23:36.4	209790.67	271515.42
83219	R. Kigwe at Semuto - Wobulenzi Road.	0:43:25.4	32:29:45.0	443264.01	279978.10
83218	R. Mayanja at Kapeeka - Kakunga Road	0:40:55.1	32:10:18.0	407526.53	275009.00
82225	R. Sezibwa at Falls	0:21:20.5	32:51:46.9	484080.51	239355.40
81268	Nakivubo Channel - Railway Bridge	0:17:53.9	32:37:53.7	458245.86	232595.99
81267	Nakivubo Channel - 5th Street	0:18:52.0	32:36:39.0	456131.69	234419.84
81266	L. Wamala at Lubajja	0:18:53.5	31:54:48.4	378400.52	234443.01
81260	R. Kibiaba at Kinoni - Mubende Road	0:11:32.6	31:41:44.9	354210.89	221161.03
81259	R. Katonga at Kampala - Masaka Road	0:02:03.6	32:00:26.2	389119.62	196562.11
81216	R. Kakinga Index Catchment	0:07:04.9	31:03:12.7	283113.57	213278.02
81202	L. Victoria at Jinja Pier (81202)	0:24:51.6	33:12:27.1	522673.03	245453.49
87218	R. Nyagak at Nyapea	2:26:01.4	32:57:26.0	272763.19	469470.20
87217	R. Albert Nile at Laropi (87217)	3:33:07.6	31:48;47.5	368100.32	593005.38
87212	R. Ora at Inde - Pakwach Road	2:43:03.6	31:23:33.7	321244.23	500805.73
87208	R. Oru at Arua - Yumbe Road	3:16:01.6	31:08:07.9	292748.87	561607.76
87206	R. Anyau at Arua - Moyo Road	3:12:06.6	31:01:48.7	281025.60	554414.70
85217	R. Waki II at Biiso - Hoima Road	1:42:30.5	31:22:39.6	319453.00	389218.42
85212	R. Nkussi at Kyenjojo - Hoima Road	1:07:48.2	30:59:40.7	275769.15	325284.97
85211	R. Muzizi at Kyenjojo - Hoima Road	0:52:16.1	30:43:47.5	247262.95	209663.61
83213	R. Kafu at Kampala - Gulu Road	1:32:34.8	32:02:32.5	393389.41	370873.35
83212	R. Tochi II at Gulu - Atura Road	2:13:37.8	32:20:30.8	426736.07	446495.17
83209	R. Kyoga Nile at Paraa	2:17:00.0	31:33:49.9	340222.80	452753.94
83203	R. Kyoga Nile at Masindi Port	1:41:40.9	32:05:33.7	398998.32	387643.77
85201	L. Albert at Butiaba	01:49:11N	31:19:39. E	313876.02	401520.58
82205	L. Kwania at Kachung	1:55:00 N	32:59:00 E	530882.27	379614.31
81201	L. Victoria at Entebbe Pier	0:04:00 N	32:28:00 E	440571.06	207671.19
81223	R. Kagera at Masangano	1:14:00 S	31:26:00 E	360832.15	96379.07
81224	R. Ruizi at Mbarara Water Works (	0:37:00 S	30:39:00 E	238363.88	132084.01
81248	R. Nyakizumba at Maziba	1:19:00 S	30:05:00 E	175310.60	54580.91
81258	R. Bukora at Katera	0:54:00 S	31:36:00 E	344136.97	100795.28

81270	R. Bukora at Mutukula - Kyotera R	0:51:00 S	31:29:00E	331149.69	106318.55
81271	R. Kisoma at Mutukula - Kyotera R	0:41:00 S	31:32:00 E	336708.41	124748.78
81272	R. Ruizi at New Waterworks (8127	0:37:04 S	30:37:03 E	234707.84	132009.38
81273	R. Lwanda at Kyotera - Rakai Road	0:40:0 S	31:28:00 E	329288.24	126585.25
81274	R. Kisoma Upper Stream at Kyotera	0:38:50 S	31:30:00 E	332997.25	129353.90
81277	R. Kisoma Upper at Kyotera - Raka	0:38:50 S	31:30:00 E	332997.25	129353.90
82201	L. Kyoga at Bugondo Pier	1:37:20.2	33:16:42.2	530358.40	379362.22
82220	R. Enget at Bata - Dokolo Road	2:00:00 N	33:11:00 E	520305.54	421362.91
82245	R. Akokorio at Soroti - Katakwi Road	1:51:50 N	33:51:15 E	594733.26	405725.80
82254	R. Mpologoma at Tirinyi-Mbale Road	0:58:00 N	33:44:00 E	581509.51	307156.40
82251	Wamboli at Nabiswera - Gulu Road	0:55:0 N	32:14:24 E	415060.51	301630.13
82252	R. Omunyal Upper at Tiririri - Ot	1:50:00 N	33:26:00 E	548112.38	402945.47
83206	R. Kyoga Nile at Kamdini	2:16:00 N	32:16:00 E	414675.45	450859.64
84206	L. Edward at Katwe	0:09:00 S	29:54:00 E	15798.46	183698.39
84207	L. George at Kasenyi	0:02:00 S	30:08:00 E	180796.55	196613.63
84215	R. Mpanga at Fort Portal - Ibanda Road	0:06:00 N	30:28:00 E	217930.77	211366.00
84227	R. Chambura at Kichwamba	0:12:00 S	30:06:00 E	177084.90	178167.78
84228	R. Nyamugasani at Katwe - Zaire Road	0:07:00 S	29:50:00 E	147368.17	187386.97
84267	R. Mitano at Kanungu - Rwensama Road	0:41:00 S	29:48:00 E	143677.94	124655.33
87221	R. Albert Nile at Laropi (87221)	3:33:00 N	31:49:00 E	368485.49	592770.50
87222	R. Albert Nile at Panyango. (8722	2:34:00 N	31:26:00 E	325739.81	484103.25
82239	R. Longiro - Near Kotido	2:59:24 N	34:006:00 E	622161.88	530554.05
84251	L. Bunyonyi at Bwama Island	1:17:00 S	29:56:00 E	158596.40	58251.27
85205	R. Semliki at Bweramule	0:57:00 N	30:11:00 E	186410.26	305433.25
85214	R. Wambabya at Buseruka	1:33:00 N	31:07:00 E	290389.78	371716.39
86201	R. Aswa I at Puranga	2:35:00 N	32:56:00 E	492506.75	485838.11
86202	R. Aswa II at Gulu - Kitgum Road	2:57:00 N	32:35:00 E	453613.91	526375.34
86212	R. Pager at Kitgum	3:15:00 N	33:53:00 E	598056.63	559569.36
86213	R. Agago at Kitgum - Lira Road	2:50:00 N	32:58:00 E	496213.65	513470.93
87207	R. Ayugi at Atiak - Laropi Road	3:21:00 N	32:03:00 E	394382.03	570630.90

Appendix 5: Standards for discharge of effluent or waste water

Appendix 5.1: National Standards for discharge of effluent or waste water

1,1,1 - trichloroethane	3.0 mg/l
1,1,1 - dichloroethane	0.2 mg/l
1,1,2 - trichloroethane	1.06 mg/l
1,2 - dichloroethane	0.04 mg/l
1,3 - dichloropropene	0.2 mg/l
Aluminium	0.5 mg/l
Ammoium Nitrogen	10 mg/l
Arsenic	0.2 mg/l
Barium	10 mg/l
Benzene	0.2 mg/l
BOD5	50 mg/l
Boron	5 mg/l
Cadium	0.1 mg/l
Calcium	100 mg/l
Chloride	500 mg/l
Chlorine	1.0 mg/l
Chromium (total)	1.0 mg/l
Chromium (VI)	0.05 mg/l
Cirrus - 1,2 - dichloroethylene	0.4 mg/l
Cobalt	1.0 mg/l
COD	100
Clifford Organisms	10,000 counts /100 ml
color	300 TCU
copper	1.0 mg/l
Cyanide	0.1 mg/l
Detergents	10 mg/l
Dichloromethane	0.2 mg/l
Iron	10 mg/l
lead	0.1 mg/l
Magnesium	100 mg/l
Manganese	1.0 mg/l
Mercury	0.01 mg/l
Nickel	1.0 mg/l
Nitrate - N	20 mg/l
Nitrite - N	2.0 mg/l
Nitrogen Total	10 mg/l
Oil and grease	10 mg/l
pH	6.0 - 8.0
Phenols	0.2 mg/l
Phosphates (total)	10 mg/l
Phosphates (Soluble)	5.0 mg/l
Selenium	1.0 mg/l
Silver	500 mg/l
Sulfate	1.0 mg/l
Sulfide	1.0 mg/l
TDS	1200mg/l
Temperature	20 - 35^{0}C
Tetra Chloroethylene	0.1 mg/l

Tetrachloromethane	**0.02mg/l**
Tin	**5 mg/l**
Total suspended solids	**100mg/l**
Trichloroethlylene	**0.3 mg/l**
Turbidity	**300NTU**
Zinc	**5 mg/l**

Appendix 5.2: Proposed standards for pesticides in discharged effluent or wastewaster

Pesticide	Proposed standard, ppm
Carbonfuran	**0.04**
Chlordane	**0.003**
Chlorofenviphos (supona)	**0.0007**
Cypermetrhin ((Ripcord EC)	**0.02**
2,4D	**0.03**
Dalapon	**0.2**
1,2- dichloropropane	**0.02**
Dichlorvos (Vapona)	**0.001**
Dinoseb	**0.007**
DDT	**0.002**
Dimetheote (Rogor 40%)	**0.004**
Diquat	**0.02**
Endohall	**0.1**
Endrin	**0.002**
Glyphosate	**0.7**
Lindane	**0.0002**
Oxamyl	**0.2**
Heptachlor	**0.00003**
Methoxychlor	**0.02**
Toxaphene	**0.001**
Bromacil (Hyvar -X)	**0.002**
Malathion (Carbafos)	**0.0001**
Paraquat (Gramoxone)	**0.06**
Diazinon (No-Bag)	**0.014**
Maneb (Dithane M-22)	**0.035**
Ziram (Carbazine)	**0.007**
Mancozeb 80 (Dithane M-45)	**0.02**
Penitrothion (Sumithion)	**0.002**
Zineb (Dithane M-44)	**0.02**
Permethrin (Doom)	**0.02**
Picloram	**0.5**
Simazine	**0.002**

Appendix 6: Rivers and lakes for which buffer zones of upto 100m and 200m respectively must be maintained

Rivers	Lakes
R. Nile from Lake Victoria to Lake Albert	L. Victoria
R. Aswa	L. Kyoga
R. Katonga	L. Albert
R. Nkusi	L. Edward
R. Kafu	L. George
R. Rwizi	L. Bisina
R. Kagera	L. Mburo
R. Mpanga	L. Bunyonyi
R. Manafwa	L. Kijanirabarora
R. Mpologoma	L. Kwania
R. Semliki	L. Wamala
R. Mubuku	L. Mutanda
R. Mayanja	L. Mabere
R. Sezibwa	L. Opeta
R. Malaba	L. Nabugabo
R. Sipi	L. Nkugute
R. Namatala	L. Katunga
R. Sironko	L. Nyabihoko
R. Muzizi	L. Nakivale
R. Nabuyonga	

Appendix 7: Terms of Reference

TERMS OF REFERENCE FOR A NATIONAL CONSULTANT TO CARRY OUT A BASELINE STUDY TO DETERMINE THE STATUS OF WATER QUALITY MONITORING.

Nile Basin Initiative
Nile Transboundary Environmental Action Project

1.1 Nile Trans boundary Environmental Action Project (NTEAP)

The Nile Trans boundary Environmental Action Project (NTEAP) is one of the eight Projects under the Nile Basin Initiative (NBI) Shared Vision Program and is of five years duration. The main objective of this Project is to provide a strategic environmental framework for the management of the trans boundary waters and environmental challenges in the Nile River Basin. The NTEAP, is expected to meet its objectives through, the provision of a forum to discuss the broad development paths for the Nile Basin with a broad range of Stakeholders; improving the understanding of the relationship between water resources development and the environment; enhancement of basin wide cooperation and enhancement of environmental management capacities of basin wide institutions and the NBI.

The NTEAP's overall key outputs/ impacts are expected to be:

- Increased regional cooperation in environmental and water management fields,
- Increased basin-wide community action and cooperation in land and water
- Increased number of basin-wide networks of environmental and water professionals and increased number of experts knowledgeable on the environment,
- Greater appreciation of river hydrology and more informed discussion of development
- Expanded information, knowledge base and know how on land and water resources available to professionals and NGOs,
- Greater awareness of the linkages between macro/sectoral policies and the environment,
- Greater awareness and increased capacity on transboundary water quality threats.

1.2 The Basin Wide Water Quality Monitoring Component

The Basin wide Water Quality Monitoring Component is one of the six Components of the NTEAP. This Component will initiate a basin-wide dialogue on water quality and improve understanding of transboundary water quality issues, improve capacities for monitoring and management of water quality and initiate exchange and dissemination of information on key-parameters.

Transboundary cooperation will be increasingly important to maintain appropriate water quality for drinking water, irrigation, and industry and to support human health and livelihoods and ecosystem functions in the Nile Basin. This project component will increase the understanding of the current state of water quality and priority needs for transboundary cooperation between the Nile countries and will contribute to building greater capacity for water quality monitoring and management. Exchange of experiences on regulatory issues and on water quality information between countries will facilitate improved decision making by governments and other resource users. The present project component also aims to create a starting point for increased regional transboundary water quality assessment and collaborative action. Basin-wide dialogue among relevant stakeholders will help develop a common vision and goal for water quality management for the Nile Basin.

2.0 OBJECTIVES OF THE STUDY

This Component aims at enhancing the national capacities for water quality monitoring in all the Nile Basin riparian countries. This will be achieved through the assessment of the existing water quality information in each country and identifying major information gaps and needs. The institutional, technical and professional capacities in each country will also be assessed.

In order to present a fair and balanced national water quality baseline status report, the consultant will be expected to consult widely with government Ministries and departments, institutions and sector actors involved in water resources management, mainly the Ministries of Water and Environment. The Consultant will need to refer to documents such as the annual reports and databases where they exist. Reference may also be made to documents such as the State of Environment Reports. elevant documents in other Ministries such as Health and Local Government could also have useful information.

Particular attention should be paid to recent and ongoing work or projects in the Nile Basin within those countries, especially water quality related studies. The Consultant will be required to collect and summarize all available water quality data especially on key parameters of Transboundary importance. He should indicate the regular sampling points and give their geo references as these data will be used to establish a Nile surface water quality Map and Atlas.

Before going into the water quality management practices within the Nile basin portion of a particular country, which is the focus of this study, the consultant will be expected to give a general broad overview of the water resources management practices in the country.

3.0 STUDY LOCATION

This baseline study will be carried out concurrently in the nine riparian countries of the Nile basin; Burundi, D. R. Congo, Egypt, Ethiopia, Kenya, Rwanda, Tanzania, Sudan and Uganda. In those countries where the Nile Basin is only a small part of the country, the study will focus on the part of the country that lies within the Nile Basin. However the Consultant will be expected to give the overall national water quality control and water resources management practices in the country.

4.0 STUDY DURATION AND DISTRIBUTION OF RESPORTS

The study will be carried over a period of three and half weeks (25 days). The Consultant will be expected to produce an Interim Report after two weeks for review and comments **(9 copies)** to be distributed as follows:

NPC – 1, PMU – 2, PSC -1, TAC – 2, WQWG – 2, Nile-SEC- 1

The Final Draft Water Quality Baseline Report will be submitted immediately after the National Workshop and will be in **11 copies** with the additional copies being circulated to UNDP and the WB. The Report will also be submitted in a word format in a floppy diskette.

5.0 SCOPE OF WORK

The Consultant will be expected to comprehensively undertake the following:

A. Present the status of the institutional and legal framework for water resources management and water quality control in the country and the status of policy formulation and strategies on water resources management, clearly indicating who are the major sector actors and how they relate to each other,
B. Indicate the status of formulation or enforcement of water quality standards, guidelines and regulations,
C. Give an inventory of the major rivers and lakes including wetlands, stating their quality status and their national or trans boundary importance,
D. Give an overview of the water quality and pollution control activities, the water quality monitoring programs, and the water resources assessment practices and strategies, clearly indicating the major sources of pollution,
E. State if any regular water quality monitoring program exists; the number and type of existing water sampling stations, the frequency of sampling, and the parameters tested,
F. Record the water quality data for each of the water quality monitoring stations, ensuring that the data for both the dry and wet seasons is captured,
G. Ensure that the analytical data recorded for each of the regular sampling stations is properly geo- referenced and has results of basic

parameters of trans boundary importance to facilitate the drawing of a Nile Basin Surface Water quality map. This is of utmost importance,

H. Indicate the number and type of analytical laboratory facilities and their operational status, stating if water quality assurance programs exist, and whether the laboratories are accredited,

I. Critically examine the cadre and staffing levels in the water quality testing laboratories and state if staff training programs or institutions exist,

J. Indicate the analytical scope and capabilities of the laboratories stating if any other environmental monitoring tests are carried out,

K. State if communities are involved in water quality control, and if any NGOs and CBOs are also involved, and in what roles,

L. Ensure that the collected information has identifiable benchmarks that can be used as baseline indicators upon which subsequent actions can be measured, in order to gauge progress.

M. Determine the level of awareness with respect to water quality monitoring, management and information exchange.

N. Indicate and suggest actions by the NTEAP to address the identified gaps in water quality monitoring.

O. Compile all the above findings into a National Water Quality Monitoring Baseline Report and submit copies to the PMU as stipulated.

P. Work closely with the water quality monitoring working group members and national project coordinators .

6.0 EXPECTED OUTPUTS

A Comprehensive national water quality baseline report comprising of:

i. Overview of water resources management practices in the country, covering the legal and institutional frameworks,

ii. List of institutions or firms involved in water quality management and their capacities,

iii. Inventory of major rivers, lakes and wetlands and their quality status,

iv. Water quality data sheets of key parameters for regular sampling stations,

v. List of geo- referenced water sampling stations on major rivers and lakes,

vi. Inventory of major point and non –point sources of pollution ,

vii. Inventory of existing laboratories and their physical and technical capacities,

viii. Identified water quality management gaps and recommendations on how they should be addressed.

ix. Suggested actions, water quality monitoring status indicators and how they should be measured.

7.0 MONITORING AND SUPERVISION

This will be carried out by the PMU and the NPC. The Members of the Water Quality Working Group will also be on hand to offer invaluable advice and assistance.

8.0 METHODOLOGY AND STANDARDS

The Consultant will be expected to employ the most effective methodology to achieve results. This study will basically involve the collection of existing information from relevant institutions, mainly the Ministries of Water and Environment. The Consultant will not be expected to generate any primary data within the specified time, unless it is absolutely necessary. In addition the Consultant will be expected to:

o Design and use questionnaires that are realistic and capable of capturing accurate information,
o Collect most of the data from existing secondary sources,
o Use credible support staff in data and information collection,
o Prepare clear and concise reports,
o Ensure that the reports are delivered on the specified dates,
o Communicate any unforeseen deviation from the agreed consultancy plan immediately, with clear justifications and proposed remedial course of action

9.0 REFERENCE DOCUMENTS

The following documents would be availed as reference background material:

i. Trans boundary Environmental Analysis(TEA)
ii. Project Appraisal Document(PAD)
iii. Project Implementation Plan(PIP)
iv. Country level documents available at the PMU and NPCs offices.

10.0 TIME FRAME

It is envisaged that the Study would commence at the beginning of the 3rd week of October, 2004 and be finalized by the 3rd week of November (Estimated 25 working days).

11.0 RENUMERATION

The Consultant will be renumerated in accordance with the standard official UNDP rates for National Consultants. Reimbursable expenses will be made according to an agreed and approved plan

12.0 QUALIFICATIONS OF THE CONSULTANT

• Advanced degree in water resources management, environmental or related field of study.
• Extensive experience in water quality control and management
• At least ten years of experience in water resources or environmental management.
• Excellent knowledge of general environmental issues

- Experience working in Africa, particularly in the Nile Basin countries is an advantage.
- Fluency in spoken and written English; knowledge of French an added advantage.
- Excellent presentation and communication skills.
- Excellent analytical skills.
- Good computer skills.
- Experience in having worked with/for an international or donor organization is an advantage.