Nile Basin Initiative

Eastern Nile Subsidiary Action Program (ENSAP)

Eastern Nile Technical Regional Office (ENTRO)

Eastern Nile Watershed Management Project

Design of a Water Quality Monitoring System for Eastern Nile Countries

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Design of Water Quality Monitoring System

Final Report

Map reference: ENTRO GIS data base: Ethiopia WBISPP GIS database

Addis Ababa and Stockholm January 2012

WATER QUALITY MONITORING

Contents

This report presents first the specifics of the current assignment, and *Appendix 1* (in a separate volume) the general aspects of water quality sampling and specific aspects related to the sampling of rivers, streams, lakes and reservoirs. More detailed discussions can be found in the references:

1) WMO, 1988: *Manual on Water Quality Monitoring: Planning and Implementation of Sampling and Field Testing*. Operational Hydrology Report No. 27, WMO-No. 680, Geneva.
2) WMO, 2008: Guide to Hydrological Practices Volume I: Hydrology – From *Measurement to Hydrological Information,* WMO-No. 168
3) *USGS, 2005: National Field Manual for the Collection of Water-Quality Data.* Book 9: Handbooks for Water-Resources Investigations.

Acronyms

Alk	Alkalinity
BOD	Biochemical Oxygen Demand
Ca	Calcium
Cl	Chloride
CLEQM	Central Laboratory for Environmental Quality Monitoring, Egypt
DO	Dissolved Oxygen
DBMS	Database management systems
EC	Electrical Conductivity
EEAA	Egyptian Environmental Affairs Agency
FAO	Food and Agriculture Organization of the United Nations
GEMS	Global Environment Monitoring System
GIS	Geographical Information System
IAEA	International Atomic Energy Agency
IAHS	International Association of Hydrological Sciences
ICP	Inductive Coupled Plasma Instrument
IR	Infra-red
ISO	International Organization for Standardization
IT	Information technology
Mg	Magnesium
MoWE	Ministry of Water and Energy, Ethiopia
MoIWR	Ministry of Irrigation and Water Resources, Sudan
MoWRI	Ministry of Water Resources and Irrigation, Egypt
K	Potassium
Na	Sodium
NRI	Nile Research Institute, Egypt
NWRC	National Water Research Center, Egypt
NO_3	Nitrate
NH_4	Ammonia
PO_4	Phosphate
SO_4	Sulphate
SS	Suspended Solids
TDS	Total Dissolved Solids
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
USGS	United States Geological Survey
WDSR	Water Data Storage and Retrieval
WHO	World Health Organization
WMO	World Meteorological Organization
WQMN	Water Quality Monitoring Network

1. INTRODUCTION

Two individual consultants have been engaged by ENTRO for the Design of Basin wide Sediment and Water Quality Monitoring Systems with a guideline on harmonized standard and methods. Contracts were signed individually with ENTRO, with commencement set at 5th June 2011. Due to public holiday in Sweden and Ethiopia, the consultants arrived at ENTRO a few days later, on 8th June 2011. After revision of the work plan in September 2011, the assignments are scheduled for completion late January 2012.The consultants are:

Mr Carsten Staub (Hydrologist and Team Leader), responsible for hydrology and sediment aspects

Dr Per-Olof Seman (Water Quality Specialist), responsible for water quality aspects

The consultants have worked closely together, doing some of their field work jointly, but reports are submitted separately. The Water Quality Specialist submits his reports first, and the Hydrologist/Team Leader will incorporate the reports of the Water Quality Specialist in his report.

The present Final Report on the Design of a Monitoring system is a separate report by the Water Quality Specialist, to be included in the composite report to be prepared by the Team Leader.

The present Design of Monitoring System for Water Quality in Eastern Nile Countries was according to schedule submitted as a first Draft approximately 4 months after commencement of the assignment. After extension of the contract period until end of January 2012 and receipt of comments from the Client this Final Report is provided.

2. BACKGROUND

2.1 Overview of the EN basin programmes

A strategic action programme has been launched to translate the NBI's shared vision into action. This consists of two complementary sub-programmes; a Shared Vision Programme of technical assistance and basin wide capacity building projects to create an enabling environment for cooperative development, and Subsidiary Action Programmes (SAPs) carried out by smaller groups of Nile riparian states, comprising of physical investment at sub-basin level involving two or more countries.

Two groupings for such programmes have formed; one within the Eastern Nile including Egypt, Sudan and Ethiopia (ENSAP[1]) with Eritrea as an observer, and the other covering the Nile Equatorial Lakes Region with the six countries in the southern portion of the basin as well as Sudan and Egypt (NELSAP). The cover shows the Eastern Nile Basin. The Project Identification Document (PID) for ENSAP, approved by the Eastern Nile Council of Ministers in March 2001, establishes the long-term goals and objectives for the first ENSAP investment program for the Integrated Development of the Eastern Nile (IDEN).

[1] Eastern Nile Subsidiary Action Program (ENSAP) – Project Identification Document, Eastern Nile Council of Ministers, 2001

ENSAP has the objective to:
"*ensure efficient water management and optimal use of the resources through the equitable utilization and no significant harm; ensure cooperation and joint action between the Eastern Nile Countries seeking win-win goals; target poverty eradication and promote economic development; and to ensure that ENSAP results in a move from planning to action*".

The PID has outlined seven potential areas of cooperation. One of the seven areas of cooperation agreed upon by the Eastern Nile Riparian Countries is integrated Watershed Management.

The long term objective of the **Eastern Nile Watershed Management Program** (ENWMP) is to improve the standard of living of the populations residing within the selected watersheds of the Nile basin, reduce *soil and water loss*, improve agricultural productivity increase food security, *decrease sediment transport and reduce siltation of reservoirs and canals, reduce erosion and morphological changes along the river*s, and decrease pressure on natural resources.

To achieve the above objectives the countries have embarked on two parallel programmes, explicitly the Cooperative Regional Assessment (CRA) and the Fast Track projects. While the CRA is an effort for identifying long term opportunities for cooperative actions, the fast track watershed projects aim at demonstrating early results of on the ground improved watershed management.

Thus, the objectives of the current assignment fits well into the overall objectives of the ENWMP and specifically the consultants will focus on establishing *a watershed management data and information system; to be able to undertaking a coordinated sediment and water quality monitoring for the Eastern Nile Basin*. The assignment will cover the Eastern Nile Basin as depicted in the map on the cover of this report.

2.2 Design of Basin-Wide Sediment and Water Quality Monitoring System

This section discusses the importance of the present programme. Resource degradation processes in Eastern Nile countries have impacts not only locally, but far downstream within and beyond the borders of the country within which they occur. The most significant impacts of land degradation in the Eastern Nile Basin are:
- loss of soil productivity because of accelerated erosion of the top soil,
- increased siltation of reservoirs for hydropower and irrigation as well as siltation of irrigation canals
- deteriorating water quality due to increased suspended load and sedimentation

At the same time, water quality is, at some locations, adversely affected by the discharge of pollutants into streams and rivers.

The problems related to soil erosion/sedimentation and water quality vary greatly from one area to another. In Ethiopia, with high rainfall, steep slopes and erodible soils, the problem of soil erosion and the associated loss of agricultural production is so far the dominating one. In the near future the several new dam projects will have to deal with the high sedimentation rates in some of the reservoirs and associated bank erosion downstream. High population density and increasing industrialization also leads to increase in the pollution of the rivers.

In Sudan, with its less steep terrain, soil erosion is less common although it is still a problem in some areas. Siltation in existing reservoirs is high and the same is the case for siltation of irrigation canals.

Water quality is still good, although the cities, in particular Khartoum, do contribute to the pollution of downstream rivers. A problem that is specific to Sudan is the sand encroachment of river Nile in the lower part of the Nile, from downstream of the Atbara confluence to Lake Nubia/Nasser. Wind-blown sand settles within the river cross section and enters into the sediment balance of the river. Sand encroachment creates problems locally, by for instance enhancing local flooding and it enters the sediment balance of the Nile, changing the river regime and eventually contributes to the sedimentation in Lake Nubia/Nasser. The sedimentation in Lake Nubia is not seen as a negative impact in Sudan. Here the sedimentation contributes to the development of fertile agricultural land in the new delta that is forming in the Lake Nasser/Nubia. Any use of fertilisers and/or pesticides, in connection with agricultural activities close to the river will impose a risk to the water quality downstream.

Egypt is the country on the ‘receiving end’. The sedimentation in Lake Nasser/Nubia depends on the soil erosion and sediment transport rates including bank erosion and sand encroachment further upstream in Sudan and Ethiopia. But downstream of Lake Nasser/Nubia the sediment balance is affected only by conditions imposed within Egypt, i. e. the sediment trapping by Lake Nasser/Nubia.

When it comes to water quality the situation is different: Pollutions from upstream affect the water quality in Lake Nasser/Nubia and subsequently all the way down to the Mediterranean. Egypt is technically advanced with respect to at least some aspects of monitoring, in particular water quality. Methodologies from Egypt may therefore be applied elsewhere in the Eastern Nile.

The status of monitoring of sediment erosion/transport/deposition in the three countries is likely to reflect the past local need of this data, whereas a new improved monitoring system should take into account downstream effects and changes in the local data need.

This can be illustrated by two examples:

a) Pollution of the water of the Nile upstream in Ethiopia or Sudan will eventually affect the water quality of Nile waters in Egypt. It will therefore be beneficial to try to identify sources of pollution by water quality monitoring in the countries where the pollution is taking place, in order to establish a good basis for remedial actions.
b) Similarly, when it comes to sedimentation problems downstream, it may be beneficial to try to locate the main soil erosion sources in the upstream river reaches (mainly Ethiopia), in addition to monitoring the development of the downstream consequences.

3. OBJECTIVES

According to the ToR:
The over-arching goal of the consultancy service is to establish a basin wide sediment and water quality monitoring system in order to assess the level of erosion and sedimentation rate and determine the impacts (short- and long-term, positive and negative) of the Watershed Management Projects in the basin on erosion, sedimentation rates, and water quality.

The preceding introductory text of the ToR indicates that deteriorating water quality is due to increased suspended load and sedimentation. It is true that increased suspended load in itself causes water quality to deteriorate, but deteriorating water quality for other reasons, unrelated to sediments, may be at least as serious. In the present assignment we have chosen to consider the sediment and the water quality issues as separate and largely unrelated.

The ToR continues to describe how the goal will be achieved:
This goal is to be achieved through two phases of the project. Phase I, which specifically aims at reviewing of existing situation, identification of gaps and planning of follow-up activities and Phase II, which will focus on designing of a basin-wide sediment and water quality monitoring system, development of guideline for the harmonization of standards and development of data management system.

Phase II will be carried out in two Parts: While Part I will concentrate on designing of the monitoring framework (discharge, sediment and water quality) and development of a guideline on harmonized standards and methods on data collection and quality check for information and data sharing among the three EN countries, Part II will focus on the development of basin-wide sediment and water quality data management system.

Specific objectives of Part I of Phase II are:

i. Design a basin-wide monitoring system for sediment/erosion and water quality
ii. Develop a guideline on a harmonization of standards and methods on data collection and quality check for information sharing on sediment and water quality monitoring
iii. Recommend institutional setup to manage the Monitoring activities for each of the three EN countries

The two-phased approach is a classical one: A thorough review of the existing conditions serves to identify the gaps in the existing monitoring system setup, in order to be able to focus improvement efforts where the benefits will be the most significant. In the Consultant's approach, model simulation of sediment transport and water flows play a major role: By adapting the monitoring efforts to satisfy the needs of modelling systems, reliability is enhanced and monitoring efforts can be kept at a minimum

4. APPROACH AND SCOPE OF WORK

4.1 General

It is important to ensure that recommendations on the design of monitoring and data storing/sharing systems correspond well with defined needs in the EN countries. The Consultants are therefore visiting all EN countries for discussions of ideas and suggestions. Meeting with officials both at decision level and at technical level have taken place in all three countries, as well as some field visits to monitoring stations.

Meetings with decision makers identify ongoing and future projects with a need for quality data and/or would have an impact on sediment transport or water quality. Such ongoing projects as well as future projects presently in the pipeline affect the Consultant's recommendations on a future monitoring system. Also the requirements and needs with respect to data sharing were explored in these meetings, and taken into account in recommendations for future data base setup and data sharing procedures.

Meetings with the technical specialists serve to identify wishes and ideas for improvements that would increase quality and/or capacity of the agencies responsible for carrying out the measurements and taking care of the measured data. Another purpose was to meet with technical organizations working with the more high-tech, front-end solutions when it comes to measuring techniques as well as data handling, processing and storage. In case these methodologies are found suitable for larger areas, it may be recommended to expand their use to other areas/countries.

It was important that the visits as described were carried out as early as possible in the assignment in order for the Consultants to take on board the views of national stakeholders in all countries in their work. Revisiting has also taken place to complement earlier collected data.

The Consultant has worked closely with ENTRO throughout the assignment, through meetings with the Coordinator at ENTRO, Dr Solomon Abate and other ENTRO staff during his visits in Addis Ababa.

4.2 Water Quality

Sediment monitoring and water quality monitoring in the rivers should preferably be done simultaneously with discharge measurements. There are usually two objectives to monitor water quality,

a) to provide knowledge on nutrient losses/transport in the basin system
b) to provide data on specific water pollutants, e.g. from agriculture, urban areas and industry

For the latter water quality information may be measured without flow measurement, but for the former the mass flow of nutrients is commonly of interest.

Moreover, the focus on nutrient losses would be stronger in the upper, mainly rural parts of the EN basins, while the downstream areas in Sudan and Egypt are expected to contribute more to water pollution from urban centers and industry as well as to water salinity due to the arid character of the lowlands. The traditional way to monitor direct effluents from point sources like industry, treatment plants or irrigation projects is not considered to be part of this assignment.

5. REVIEW OF PRESENT CONDITIONS

5.1 General

The present conditions in EN countries have been comprehensively reviewed by the Phase I Consultants in Egypt, Sudan and Ethiopia. The WQ consultant generally agrees with the findings of the Phase 1, some comments to the same are given below. The present water quality consultant has also performed his own limited investigations in each country.

For the water quality monitoring, more emphasis has been given to Sudan and Eqypt, since the biggest urban centres are located there and the potential for water pollution the greatest. Field investigations have also been made in Ethiopia.

5.2 Comments on Phase I Findings on Water Quality Monitoring

Phase I findings are commented on, only to the extent that the present Consultant has something to add or has a deviation in opinion. It has to be noted that the Phase I Consultants did a comprehensive study of the present conditions, whereas the present Consultant did more sporadic studies of the existing condition, to a large extent guided by the outcome of the Phase I study, and also focused more on the future system to be developed. The below statements is on water quality.

5.2.1 Phase I Ethiopia

Phase I: The proposal is to introduce 67 Water Quality monitoring stations in the three Ethiopian Nile Basins.
Comment: The Consultant has assessed the current capacity of the water quality monitoring, and argues that initially a focus on fewer stations is preferable, and so are the recommendations provided in Section 7.

Phase I: It has been said that the hydrology department needs to continue as a core major department under the MoWE, where all other departments (irrigation, hydropower, water supply, basin studies, transboundary, etc.) strongly linked with hydrology department as their activity is highly dependent on the hydrologic information that are measured, processed, analyzed and disseminated to them or to the consultant employed by them.
Comment:
Agreed, but when modeling is introduced there will be major benefits in having the essential input data for the models under the same institution, along with the modeling itself. Meteorological data are important input to the models and it would be advantageous to integrate the Hydrology and Water Quality Directorate with the Meteorological Department – still under the MoWE. Secondly, water quality data are also generated by the EPA and other organisations. Such data should be reported to the Hydrology and Water Quality Directorate with to generate a water quality database.

Phase I: Motivation of observers is very poor, mainly due to very low salaries and practical difficulties in carrying out their work (silted and unreadable staff gauges, infrequency of supervisory visits etc.). As a result there are often long series of missing or questionable measurements
Comments: Very true. To improve this situation will increase the costs of manual reading, thereby creating more incentive for installing and (not least) maintaining various types of auto-gauges. A proper evaluation is required to find the most reliable and user friendly type.

5.2.2 Phase I Sudan

Phase I: The bottle neck of hydrological data monitoring in Sudan is the decline of both data quantity and quality during last few decades. This is attributed to fewer measurements, malfunctioning of equipment, and limited data validation.
Comment: It is worrying that there has been a decline. The same tendency can be seen in Ethiopia. If the reason was known it might be easier to do something about it.

Phase I: Capacity building of the staff for field measurements, laboratory analysis, and the subsequent office work of data validation, storage and dissemination.
Comment: A good overall understanding of the monitoring task could be obtained by letting staff circulate from field work to laboratory to data processing and quality check – before they are assigned one specific duty.

Phase I: Proper coordination between all agencies working on data monitoring, processing and publication [MoIWR (HRS, GWWD), EID, DIU, Drinking Water Production corporation, others] is important
Comment: This problem is particularly a Sudanese problem. Indeed good coordination and exchange of data is a necessity. A common database would facilitate coordination. A way forward could be to find a solution for Sudan on the coordination and internal sharing of data. Can this be solved in Sudan it would be possible to solve it anywhere, using a similar model.

5.2.3 Phase I Egypt

Phase I: The monitoring programs in Egypt made it clear that they had grown unreasonably broad - in other words: Today, the network monitors too many parameters at too many locations at different frequencies.
Comment: The monitoring system in Egypt is performed for different purposes, by the Environmental Agency EEAA for environmental monitoring, by Ministry of Health for drinking water quality, by National Water Research Center for other reasons. A data needs assessment is required to determine the monitoring network and the frequency of measurements. For a uniform system in the three countries a number of indicator parameters at a few selected stations are recommended.

The Egyptian automatic network for water quality monitoring may serve as a model for its implementation in the EN countries at selected stations. The current Egyptian system is further described in Section 5.5.

5.3 Ethiopia

5.3.1 Introduction

Organisation
The below description is based on discussions with Alemayehu Tafesse, ENTRO national coordinator, Semunesh Seyom, Head of Hydrology and Water Quality Directorate , Solomon Kebede, Hydrologist and Tesfaye Emiru, Head of Water Quality Team.

The organisation of the monitoring under the MoWE, Hydrology and Water Quality Directorate is considered adequate with but there is no data entry, processing or quality control carried out at the

Hydrological Branch Offices, since this activity is the responsibility of the Hydrology and Water Quality Directorate of the MoWE. This endangers the output quality of the data. There in an ongoing effort to move the responsibility to the regional offices for data digitization, validation and digital transfer to the HQ. Thus capacity building is required at branch offices as well as the Main office. The water quality data collected by regional Hydrology Staff is mainly field test kit monitoring of EC, pH, TDS and turbidity. However, the staff is not yet trained for its use, which is planned for in the near future, still to be implemented

The water quality Team at the directorate is recently established and comprises 3 staff trained in chemistry. They also operate a water quality laboratory, which in principle is capable of analyzing all major anions and cations by spectrophotometry, as well as pH, microbiology etc. but chemicals are outdated. The laboratory is located in small premises at MoWE and there are soon available nearby rooms for expansion. AAS and GC equipment is available for metal and organic analyses, but not complete, and the staff has not been trained in their usage. Recommendations to improve the situation are enclosed in Section 6.

There are plans to join efforts at MoWE for a developed central laboratory for several directorates, and the WQ Team has also prepared a proposal for its laboratory improvement, see *Annex 1.*

Constraints

At the central level the laboratory equipment s for metal analysis by AAS and organic analysis by GC are not complete, and the staff not trained for how to use the equipment. Moreover, the analytical reagents are outdated, and need to be replenished.

Moreover, there are no systemic schedules for collection of samples, for the analysis, QA and for establishment of a water quality database, since the Water Quality Team still is in its infancy.

At regional level, the hydrological staff do not have training in water quality sampling, preservation, storage, transport and analysis except for field kits, which have been provided but again yet training on its use has not been provided, thus those are not used.

Field observations

Field trips were conducted to the Abbay River basin in the period 21st to 25th July 2011, and the Tekeze River basin 5th to 9th August 2011 by the Hydrologist/Team Leader, and his findings are enclosed in his report.

The Baro Akobo Sobat has been visited by the Water Quality expert in August and November 2010 to the Gambella Regional State, as well as in Southern Sudan in February and April 2011, for another assignment for ENTRO, when several monitoring stations were visited, and a basic comprehension of the status of the monitoring stations was accomplished. To complement the impressions from the earlier field visits another field trip to Baro Akobo was conducted during the period 11-15 January, 2012, when gauging stations at Sor, Baro Kella and Gambella and other gauging sites were visited. The Field report is enclosed as *Annex 2*.

5.3.2 Findings

The Field trips in Baro Akobo basin show generally a similar pattern, monitoring stations are commonly in poor conditions, and all efforts to have some automatic recording equipment have proven to be in vain, no such equipment was functional at the site visits. Staff readings are conducted according to schedule at most of the visited stations, but in some cases the staffs need repair.

The current ambition by the ministry to allocate the digitalization of the log books at the regional offices is commendable, and equipment and training to accomplish this is planned for the coming year. Still, the consultant trusts that the maintenance efforts need to be increased to generate quality data. For water quality monitoring training of staff at regional level and headquarters is needed, and recommendations to that effect are included in Section 7.

According to GIRWI Diagnostic Final Report (adapted from BRLi, 2011) the following organisations are involved in monitoring in the water sector

Climate	Weather data (rainfall, temperature, evaporation, wind speed, RH, etc.)	NMA, EIAR Ethiopian Civil Aviation
Surface water	Stream flow Sediment flow Ambient water quality	MoWE – Hydrology Department MoWE – Hydrology Department Nile Basin in EPA EPA
Groundwater	Ground water assessment Aquifer depth Water quality	GSE -hydrogeology MoWE- Ground water team
Drinking water quality	Physical and biological Chemical analyses	Regional Water Bureaus AAWSSA, Town Water Facilities, WWDSE, MoH Health Research Center
Water resources quality	Ambient water quality	MoWE – Hydrology Department River Basin Authorities EPA – Nile Basin Initiative
Environmental monitoring Pollution	Aquatic Ecosystem	EPA - Ecosystem Department EPA - Awash River only
Irrigation	Water use and infrastructure safety	MoWE - River Basin Studies Department & Dam team in Irrigation and Drainage Department
Water quality Water supply and sanitation	Infrastructure Users Coverage	River Basin Authorities – EIAR Water & Health Bureaus Woreda offices CSA

Thus, there is no joint reporting to a common database, but each organisation keeps its own records of the water quality monitoring

BRLi, 2011, states that there is :

- Lack of proper information technology hardware, software and infrastructure,
- Inadequate institutional capacity and high staff turnover,
- Absence of data quality assurance practices and standards,

- Incompatibility of data,
- Budget constraints,
- Different visions, methodologies, technologies, capacities, and policies.

The assessment made during the Phase 1 of the Project is thus confirmed and proposals for improvement are provided in Section 6.

BRLi have made assessments of the monitoring systems and proposals for an improved system in Ethiopia in general in 2009 and for the Tana Beles Project in 2011. The findings of the 2009 report has been summarized by the Phase I consultant as a proposal for a comprehensive water quality monitoring according to the table below.

Station Types	Tekeze	Abbay	Baro Akobo	Total in Ethiopian Nile Basins
Baseline	2	1	3	**6**
Trend	7	5	3	**15**
Trans-boundary	3	1	1	**5**
Impact	3	30	6	**39**
Lake	0	2	0	2
Total	**15**	**39**	**13**	**67**

At the same time the current monitoring stations are usually in poor conditions and the Consultant's appreciation is that this proposal is excessive in the short perspective, although complying with the WMO density criteria. Thus, the current consultant proposes a minimum density programme as specified in Section 6. The minimum water quality programme still complies with the WMO guidelines, which for the three basins would comprise 5 for Tekeze, 10 for Abbay and 4 for Baro Akobo.

5.4 Sudan

Khartoum was visited during the period 13-16 September, and 23-24 November, and the following institutions were visited. The Groundwater and Wadi department was revisited during the period 15 -19 January 2012, when also laboratory facilities and gauging stations were visited, see *Annex 3*.

- ✓ The National focal point for ENTRO, Mr. Ibrahim Balila at the Ministry of Irrigation and Water assistant Eng. Ghada,
- ✓ Mr. Redwan Abdelrahman, Hydrologist, Mr. Babikr Mahgoub, hydrologist and Mr. Ahmed ElAyeb Ahmed, Director at the Ministry of Irrigation and Water Resources, Ground water and Wadi department
- ✓ Laboratory Head Ms. Igbal Saeed
- ✓ UNESCO Chair, Ms. Muna Musnad

5.4.1 Findings

Organisation

Water Quality monitoring is mainly executed by the Groundwater and Wadi department at the main gauging stations in campaigns, discharge monitoring is more frequent during the flood season than low flow, but water quality and sediment monitoring is on a monthly basis. Details are presented in *Annex 3*. Analysis take place in own laboratory of Colour, Turbidity, Conductivity, pH, SS, TDS, Hardness, $CaCO_3$, $Na_2 CO_3$, HCO_3, Cl, SO_4, Ca, Mg, Na, F, NO_2, NO_3, NH_4. Annual reports are prepared from the analytical reports. The analysis is conducted at the central lab which monitors water quality at three locations; White Nile at Malakal (until 2011), Blue Nile at Soba (changed to Manshiya), and Main Nile at Dongola, and usually four times a year.

Constraints

The sampling is conducted by the Egyptian Research Station staff supported by Sudanese staff and parallel analyses are conducted by the Egyptian and Sudan organizations. However, the database management is not joint, and the laboratory results are kept at the laboratory and not in a central database at the Ministry. The analytical reports are provided as hardcopies to the Clients. Any expansion of the laboratory duties would requires more resources, although the staffing seems adequate for their current tasks.

Monitoring network

Phase 1 consultant recommended several stations to be subject to water quality monitoring, namely

a. Blue Nile; Eldiem, and Soba/Manshiya, in addition to Rahad and Dinder. Re-confirm monitoring immediately downstream main effluents sites, e.g., North West Sennar Sugar factory site, el Genied Sugar Factory site.
b. Baro-Akobo-Sobat: Hillet Doleib, Malakal, d/s Jebel Aulia. Re-confirm if additional stations needed on Baro, Akobo, and Pibor, or downstream Sugar factory sites (Kenana, Hagar Assalaya, and While Nile factory).
c. Atbara River, Kubor, el Hilew, d/s Girba dam, Atbara K3.
d. Main Nile: Tamaniat, Dongola. Re-confirm if additional stations needed downstream Atbara town, or downstream Merowe dam.

Out of these proposals under b) all of the proposed stations except Jebel Aulia dam is now located in South Sudan. Thus, sampling points proposed in this report have been adjusted accordingly.

The consultant agrees that such expansion of the water quality monitoring is relevant, and substantial resources need to be mobilized to expand the programme to such extent.

The staff was very interested in ion selective monitoring methods, and promoted the introduction of such monitoring complementary to the ongoing measurements.

5.5 Egypt

In Cairo the consultant visited the following institutions/ persons

- ✓ Dr. Adel Abdel Rashed, The General Secretary of National Water Research Center, NWRC
- ✓ Professor Ashraf El-Sayed, ENTRO, Phase 1 consultant, Deputy Director, Drainage Research Institute National Water Research Center, Ministry of Water Resources and Irrigation
- ✓ Dr. Ekhlass Gamal El-Din, Head of the Central Water Dept. Egyptian Environmental Affairs Agency (EEAA),
- ✓ Dr. Medhat Aziz, Director Nile Research Institute,
- ✓ Professor Yehia Barakat Mohamed Heza, Deputy Director , Construction Research Institute

Comprehensive monitoring of the Nile takes place in Egypt, mainly by NWRC and EEAA, but also Ministry of Health. NWRC comprises a twelve research institutes with various responsibilities on the Nile:
1.Water Management & Irrigation Research Institute (WMRI)
2.Drainage Research Institute (DRI)
3.Water Resources Research Institute (WRRI)
4.Nile Research Institute (NRI)
5.Hydraulics Research Institute (HRI)
6.Channel Maintenance Research Institute (CMRI)
7.Research Institute for Groundwater (RIGW)
8.Construction Research Institute (CRI)
9.Mechanical and Electrical Research Institute (MERI)
10.Survey Research Institute (SRI)
11.Coastal Research Institute (CORI)
12.Environment and Climate Research Institute (ECRI)

The research institutes are organized under the NWRC as depicted in *Figure 5.1 and 5.2.*

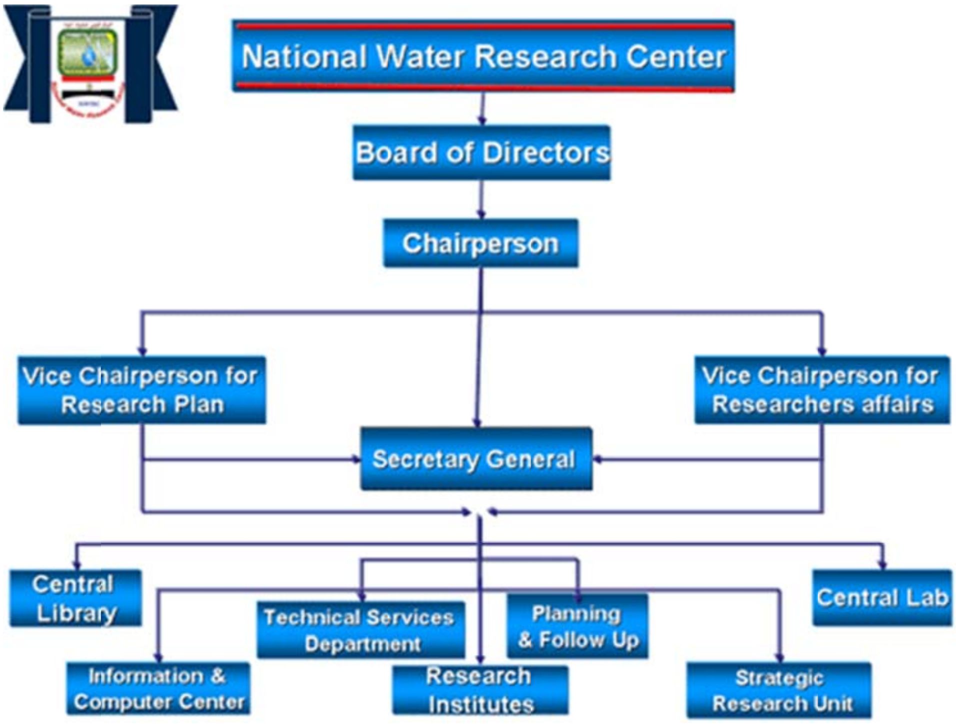


Figure 5.1 NWRC organisation

The Center includes three general administrative departments:
1. Planning and follow-up Department.
2. Research Services Department.
3. Administrative and Financial Department.

Besides the following special units:
1. Strategic Research Unit (SRU)
2. Central Laboratory for Environmental Quality Monitoring (CLEQM)
3. Information / Documentation Center
4. Central Library
5. GIS Unit
6. Gender Equality Unit
7. Printing and Publishing facility.

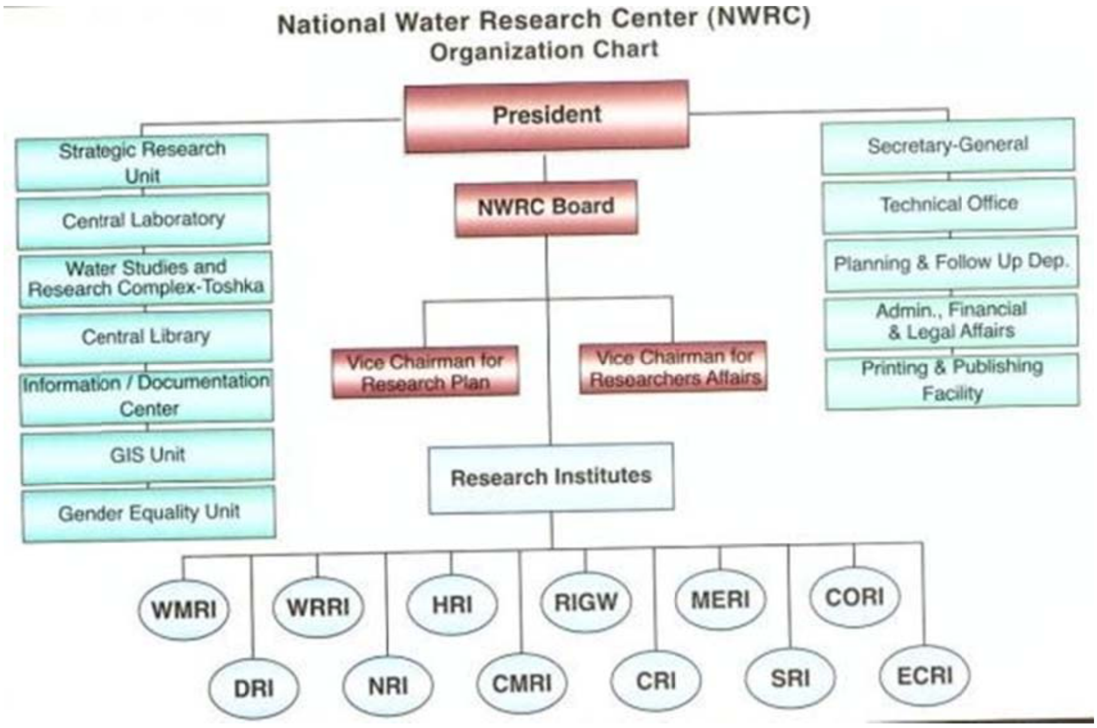


Figure 5.2 NWRC Institutes

The most applicable instrumentation of automatic water quality monitoring takes place in three places in Egypt, in Aswan, Cairo and in the delta. The Cairo station is depicted in *Figure 5.3.*

Figure 5. 3 Water Quality Monitoring station in Cairo.

The stations are equipped with electrodes for pH, EC, dissolved oxygen, temperature, turbidity, color and N-compounds and the signals are sent via the GSM network and by satellite to the central database center at NWRC in Cairo.

The database center can show on-line registrations and there are statistical packages to generate analytical reports, see example in *Figure 5.4*

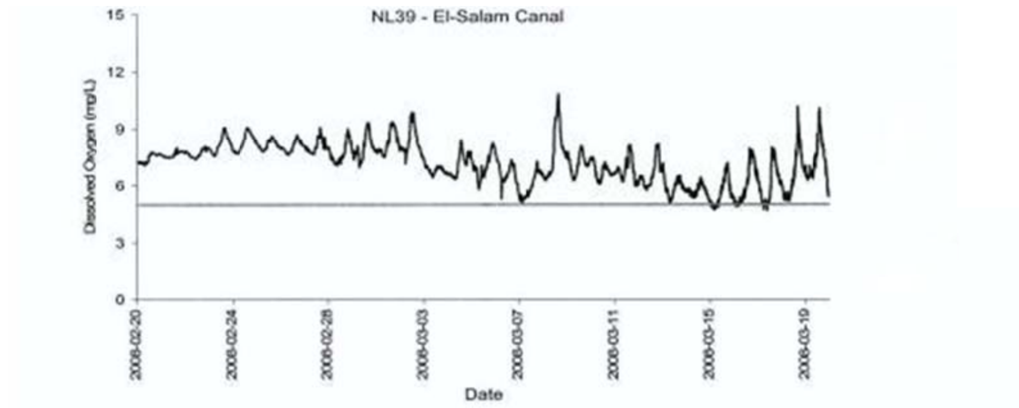


Figure 5.4 Example from DO monthly variations

NRI has conducted a comprehensive monitoring programme since 1999, see sampling points in Figure 5.5. Some 230 points are sampled at last twice a year, and some reference points every month

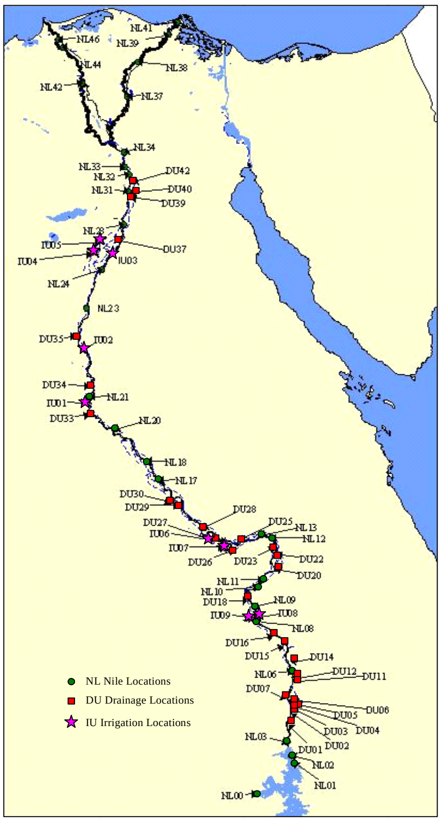


Figure 5.5: National Monitoring Locations Along Nile River and its Branches (NAWQAM, 2002)

In most of the sampling points Physical parameters, Water quantity, Oxygen budget, Nutrients, Major ions, Metals and Microbiological parameters are analyzed, while biocides are analyzed in sites along Rayahs and Upper Nile and Pesticides in Upper Egypt.

Figure 5.6 depicts the 48 sampling stations in the delta for irrigation and 115 for drainage canals operated by DRI

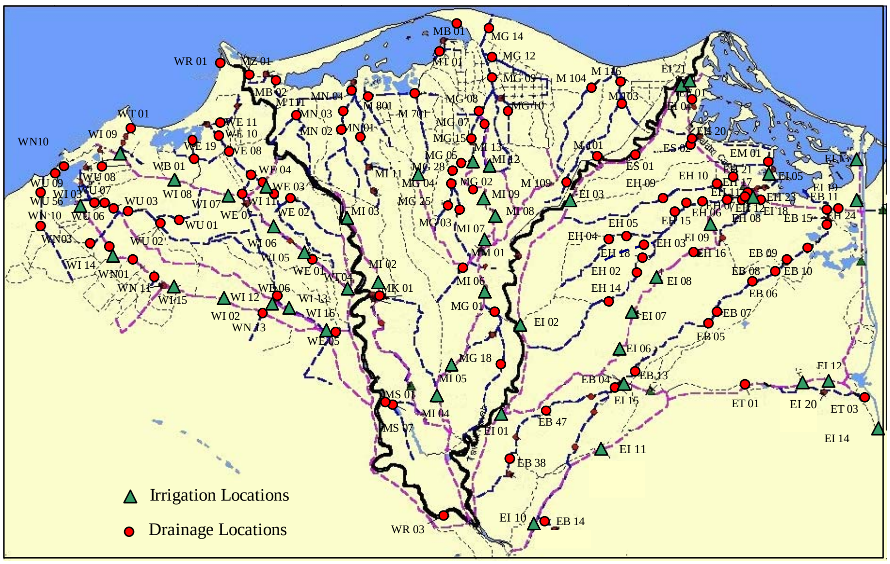


Figure 5.6. Monitoring stations operated by DRI in the Delta

The samples are monitored in Lake Nasser, Nile River and its branches twice a year during minimum and maximum flows approximately in February and August.

In the Nile Delta the sampling is monthly campaigns in the irrigation and drainage systems

Moreover, groundwater is monitored once a year in 223 wells, mainly for salinity and pollution impact in the sampling points depicted in Figure 5.7.

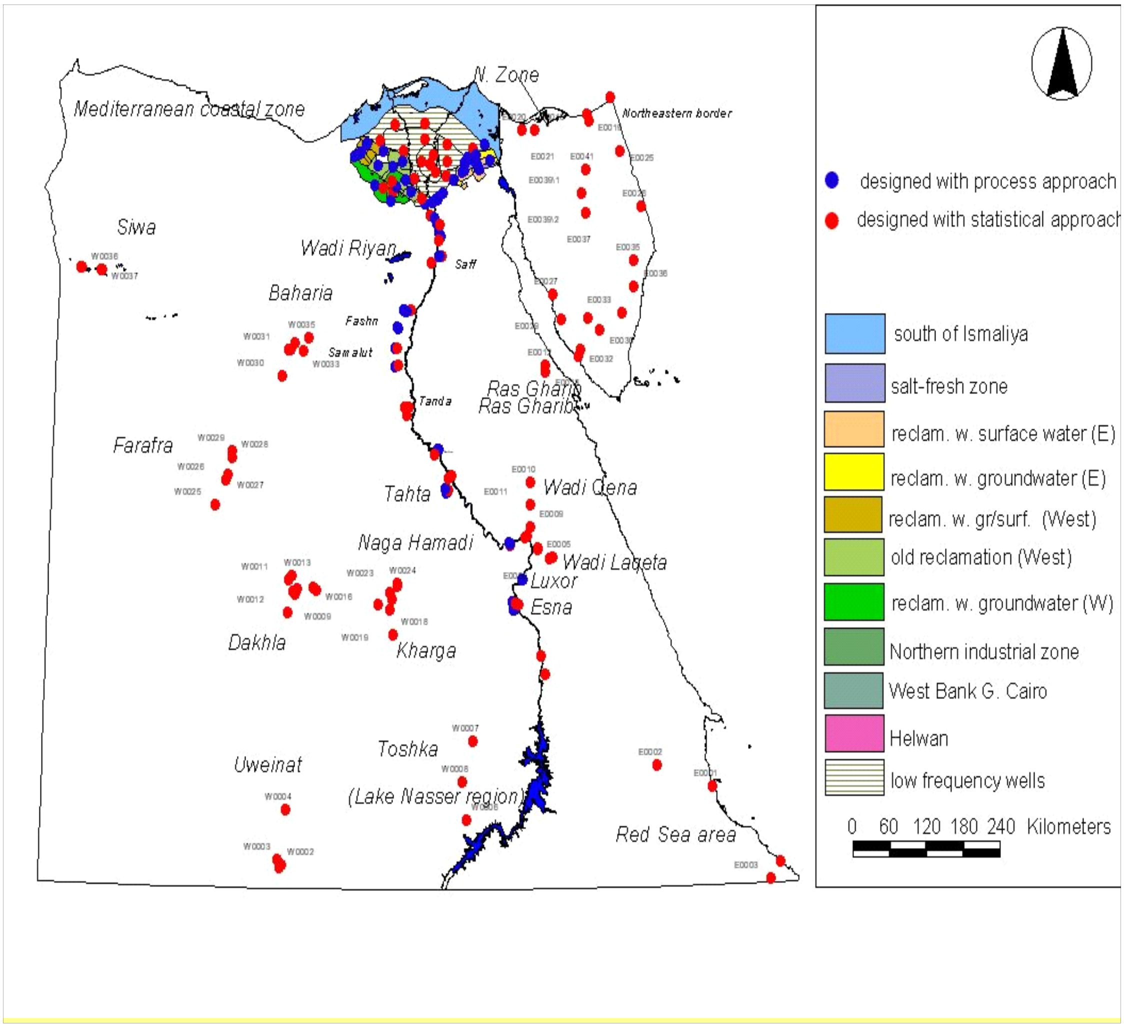


Figure 5.7 Groundwater Network and the Priority Areas (NAWQAM, 2002)

EEAA samples for environmental conditions and pollution in almost 70 sampling points and about 100 industrial discharges. Sampling points are depicted in Figure 5.8, and samples are collected four times a year and once a year for industrial points, samples analyzed for physical parameters, oxygen, major ions, nutrients, metals, microbiology and pesticides.

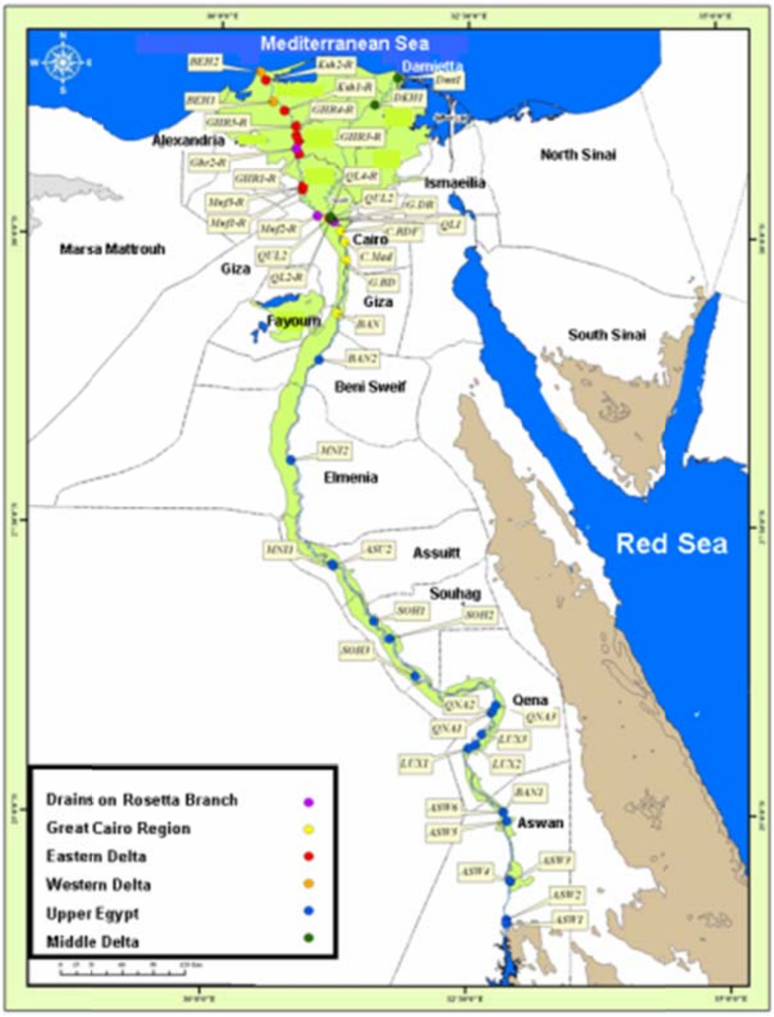


Figure 5.8 EEAA Monitored Sites Along River Nile and Two Branches (EEAA, 2009)

EAAA operates its central laboratory in Cairo and 8 regional lab, all adequately equipped.
Moreover, Ministry of Health and Population monitors drinking water supply to treatment plant at about 150 sites. Finally, there are comprehensive surveys taking place at Lake Nasser, but these are left out here since they mainly focus on sediments.

5.6 Follow-up Investigations

Observations made during the field trips and ideas arising out of interviews and conversations with officials, consultants and ENTRO staff were complemented with further meetings and collection of additional information from various sources. The appended 'text-book' description of water quality monitoring is mainly derived from

1) WMO, 1988: *Manual on Water Quality Monitoring: Planning and Implementation of Sampling and Field Testing*. Operational Hydrology Report No. 27, WMO-No. 680, Geneva.
2) WMO, 2008: *Guide to Hydrological Practices Volume I: Hydrology – From Measurement to Hydrological Information,* WMO-No. 168,
3) *USGS, 2005: National Field Manual for the Collection of Water-Quality Data.* Book 9: Handbooks for Water-Resources Investigations.

Details of equipment, sampling and analytical methods etc. are included in the Appendix.

6. MAIN FINDINGS

6.1 Organisation of monitoring

6.1.1 Ethiopia

Monitoring of the Ethiopian rivers is presently done by the Hydrology and Water Quality Directorate under the MoWE. The Phase I consultant (Ethiopia) has recommended that it remains like that. The present consultant recommends that it is considered to place the Hydrology Section under the Department of Meteorology, which is under the same Ministry. The reason is the following:

In the hopefully not too distant future, hydrological and hydrodynamic models will be set up and applied to simulate run-off and river flow. Input data include precipitation data, water quality as well as discharge data and possibly even sediment transport data, in the case of sediment transport modeling. The model therefore links the meteorological and the hydrometric data. Because of that it is convenient to place the Hydrology and Water Quality Directorate under the Department of Meteorology. This option needs to be discussed and investigated further, and recently a committee has been nominated to evaluate if this would be a feasible reorganization.

River Basin Authorities (RBA) are being established. It is recommended that the field monitoring, data processing and laboratory testing is done by the RBAs, under the guidance of the Hydrology Section. Here the Hydrology Section will ensure unified methods and procedures are applied everywhere.

The hydrology and water quality directorate of MoWE conducts in situ measurements of few water quality parameters with field kits for pH, Total Dissolved Solids, Electrical Conductivity and Turbidity in a few monitoring points during low, medium and high flow. Recently a water quality team has been established, staffed by three chemists, and a small chemical laboratory is managed by the Team. Their capacity and limitations was described in Section 5.

The regional water bureaus also conduct some water quality analyses for water supply projects.
Water Quality monitoring is also conducted by Federal Environmental Protection Authority (EPA). The EPA is responsible to implement the environmental objectives under the constitution and the principles of the Ethiopian environmental policy, including setting of water quality standards.

Moreover, Ministry of Health is concerned with water quality monitoring for drinking water, and several other institutions do water quality campaigns in connection with development projects. However, to the understanding of the consultant there is no regular reporting from other organisations to MoWE's database. In this report the focus is on MoWE's network.

6.1.2 Sudan

The water quality monitoring is mainly organized under the Ministry of Irrigation and Water Resources, MIWR, Ground Water and Wadi's Directorate (GWWD), but as in the other EN countries water quality data is also generated by other institutions and Projects, especially the drinking water corporations, the sewage water corporation, Dams Implementation Unit, DIU, and its dams' projects as well as University Institutions and UNESCO Chair. Research studies have also been made to assess the pollution situation in various parts of the Nile system. Regular monitoring by MIWR takes place since year 2000 at four locations (Blue Nile at Soba, White Nile in Khartoum, Main Nile at Tamaniat, just after the Blue Nile White Nile confluence, and Main Nile at Dongola. Earlier on there was also a sampling station in Malakal. Analyses are performed at the MIWR GWWD laboratory.

6.1.3 Egypt

In Egypt water quality data is generated by i) the NWRC and its institutes, ii) Ministry of Health and iii) Egyptian Environmental Affairs Agency (EEAA). Phase I consultant concluded that there are too many organisations, too many campaigns and too many parameters monitored. The objectives of the three organisations are different, thus streamlining their efforts may be a difficult task, and coordination efforts are appreciated.

However, the database management system including the automated ion-selective water quality monitoring that NWRC operates may serve as an example for data generation and sharing between organizations within the country and region. EEAA also have a web based GIS, which is connected to their database, which has the potential to be integrated with NWRC

6.1.4 EN Region

There is to the consultants' understanding no protocol for data sharing between countries established, although discussed for years. We trust that ENTRO would have a facilitating role to establish such protocol, especially in the light of the ongoing DSS Project, where all NBI countries are involved.

6.1.5 Conclusions

Current water quality monitoring is at different stages of advancement in the three EN countries. To enable efficient sharing of water quality data between countries one responsible institution in each country need to be nominated as the data holding center, and procedures to collect, analyse and report data streamlined. The minimum requirements as specified in Section 7 would form the basis for the data sharing of water quality data. Thus, we propose that the ministries of water in the countries will be nominated as the national data holders

7. PROPOSALS FOR IMPROVED WATER QUALITY MONITORING NETWORK

7.1 Introduction

The Consultant's recommendations for an improved water quality system comprises proposals on the location, sampling frequency and parameters to be analysed, in the field and at the laboratory, equipment and staffing of field offices and headquarter and proposals for the operational plan to introduce a uniform system in the EN region.

7.2 Proposed Location of Stations for Water Quality Monitoring

The following principles have been adopted for the proposed water quality stations, a) existing gauging stations for hydrometry are priority no 1, b) population centres and other point sources of water pollution like industries, large-scale farms and c) access. Another criteria is to have a relatively small number of stations within a reasonable spatial distribution, which may be expanded to a larger network as further resources become available (cf the no of stations proposed by Phase 1 consultant). The proposed stations may be revised upon input from the Hydrologist on the status of the gauging stations. The proposed monitoring points are organized in the following categories

1. Basin level, and at country boundary level (B)
2. Sub-catchment level (S), and
3. For special purpose (pollution monitoring) (P)

The stations at country boundary level are proposed to be of the automatic type, described below, while the others would comprise traditional water sampling and laboratory analysis. The table below describes the proposed stations for each country and category. The stations are tentatively located in the Basin Maps for each of the basins overleaf, Figure 7.1-7.3 the proposed sampling points in Ethiopia, which will be updated in connection with the Hydrology Report. Some points may be unique for Water Quality and other joint with Hydrology. The proposed station list has been assessed in connection with the field trips and updated in cooperation with MoWE hydrologist.

Ethiopia (Station Number according to MoWE, Hydrology and Water Quality Directorate)

Basin	*No*	*Station No*	*River/Lake*	*Site*	*Category*
Tekeze	3	121004	Geba	Nr. Mekele	S
	5	121006	Tekeze	Nr. Embam	S
	10	121011	Mesanu	Nr. Mekele	S, P
	11	121012	Metere	Nr. Ainal	S, P
	12	121014	May Dungu	Nr. Adwa	S, P
	13	121015	May Midim	Nr. Adwa	S, P
	19	122002	Tekeze	@ Humera	B, P
	20	123001	Angareb	Nr. Abdi	B, P
	21	124001	Goang	Nr. Metem	B, P
Abbay	1	111001	Lake Tana	@ Bahir Dar	S, P
	2*	Replaced by new station 'Chimba' downstream			S
	3*	Replaced by new station 'Chimba' downstream			S

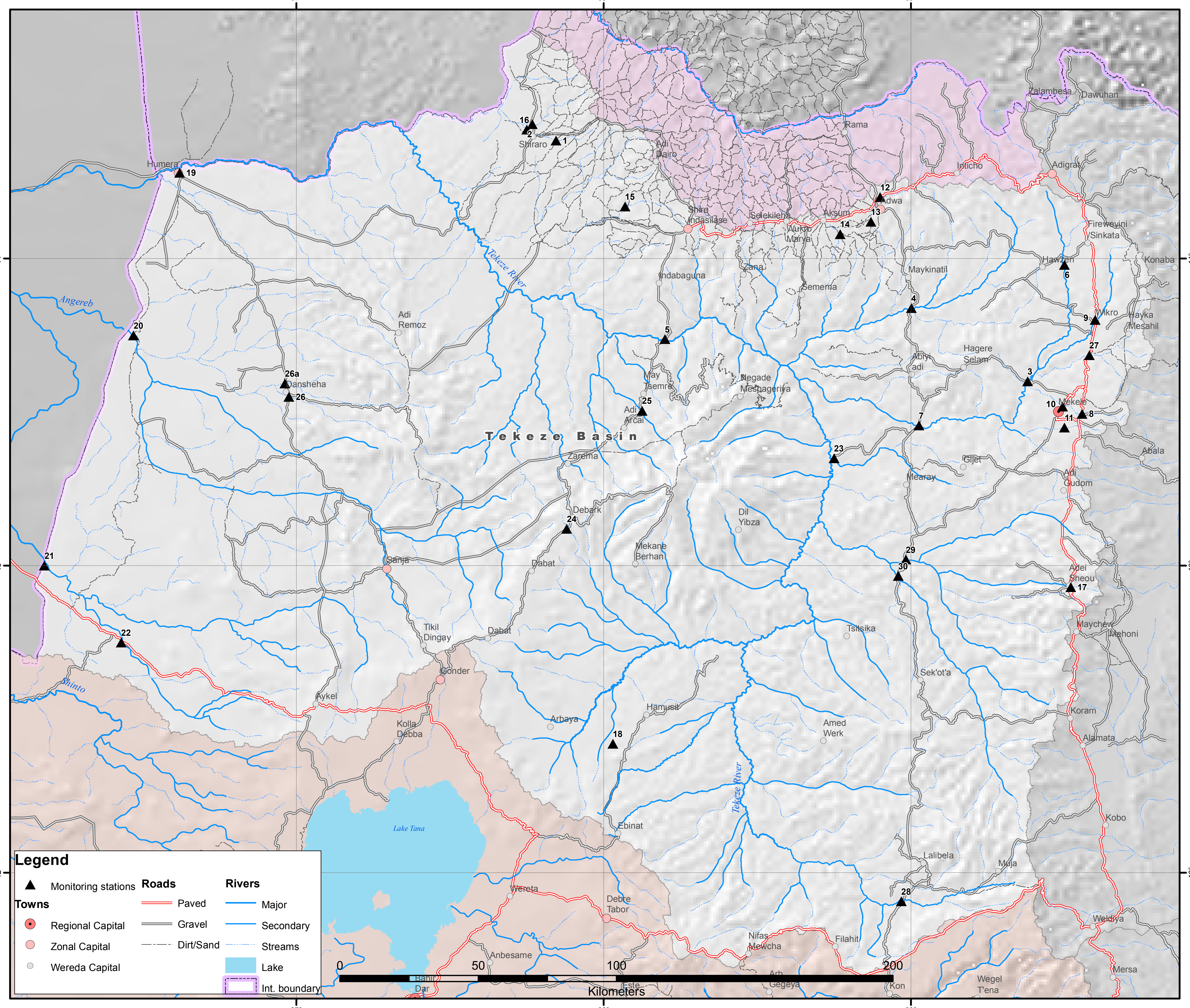
	5	111005	Ribb	Nr. Addis	P
	7	111007	Megesh	Nr. Azezo	P
	11	111013	Zufil	Nr. Debre	S
	13	111015	Ribb	Nr. Gasai	S
	20	112001	Abbay	Nr. Kessi	S, P
	22	112003	Abbay	@ Bahir Dar	S, P
	55	113005	Guder	@Guder	S, P
	56	113008	Chemoga	Nr. Debre	S, P
	64	113023	Dura	Nr. Metek	S, P
	67	113029	Ardy	Nr. Metek	S, P
	68	113031	Huluka	Nr. Ambo	P
	81	114005	Dabana	Nr. Abasi	S
	86	114010	Tato	Nr. Gutie	S, P
	88	114013	Dabana	Nr. Bunob	S, P
	92	115003	Hoha	Nr. Asosa	S, P
	101	116002	Abbay	@ Border	B, P
	104		Adiya	Nr. Nekemt	S, P
Baro Akobo	1	102003	Baro	@ Itang	S, P
	2	102002	Baro	@ Gambella	S, P
	3	101001	Sor	Nr. Metu	S
	4	101007	Gumero	Nr. Gore	S, P
	28*	New number	Kella	Nr. Birbir confl.	S

Sudan (proposed water quality sampling station, numbering according to figure)

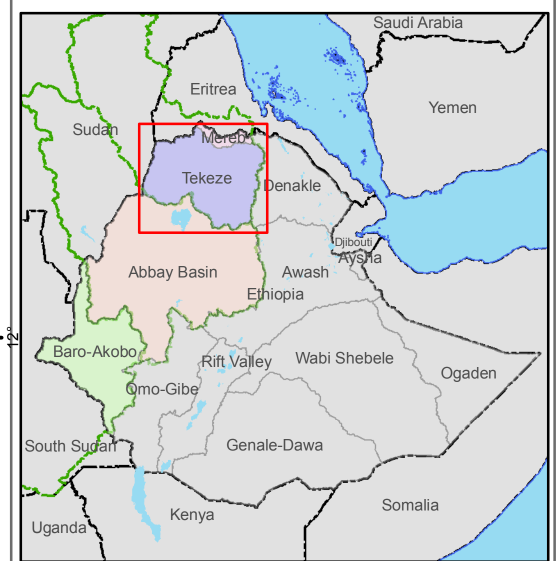
Basin	*No*	*Station No*	*River/Lake*	*Site*	*Category*
Blue Nile	1		Blue Nile	Eldiem	B
	2			Soba/Manshiya	S, P
	3			Rahad	S
	4			Dinder	S
				d/s NW Sennar Sugar factory	P
				d/s Genied Sugar factory	P
White Nile	5		White Nile	d/s Jebel Aulia	S
				d/s sugar factories	P
Atbara	6		Atbara	Kubor	S
	7			El Hilew	S
	8			d/s Girba Dam	S
	9			Atbara K3	S
Main Nile	10		Main Nile	Tamaniat	S, P
	11			d/s Atbara	P
	12			Dongola	B

Figure 7.4 shows schematically the location of the proposed sampling points in Sudan.

Monitoring stations & River Network of Tekeze River Basin

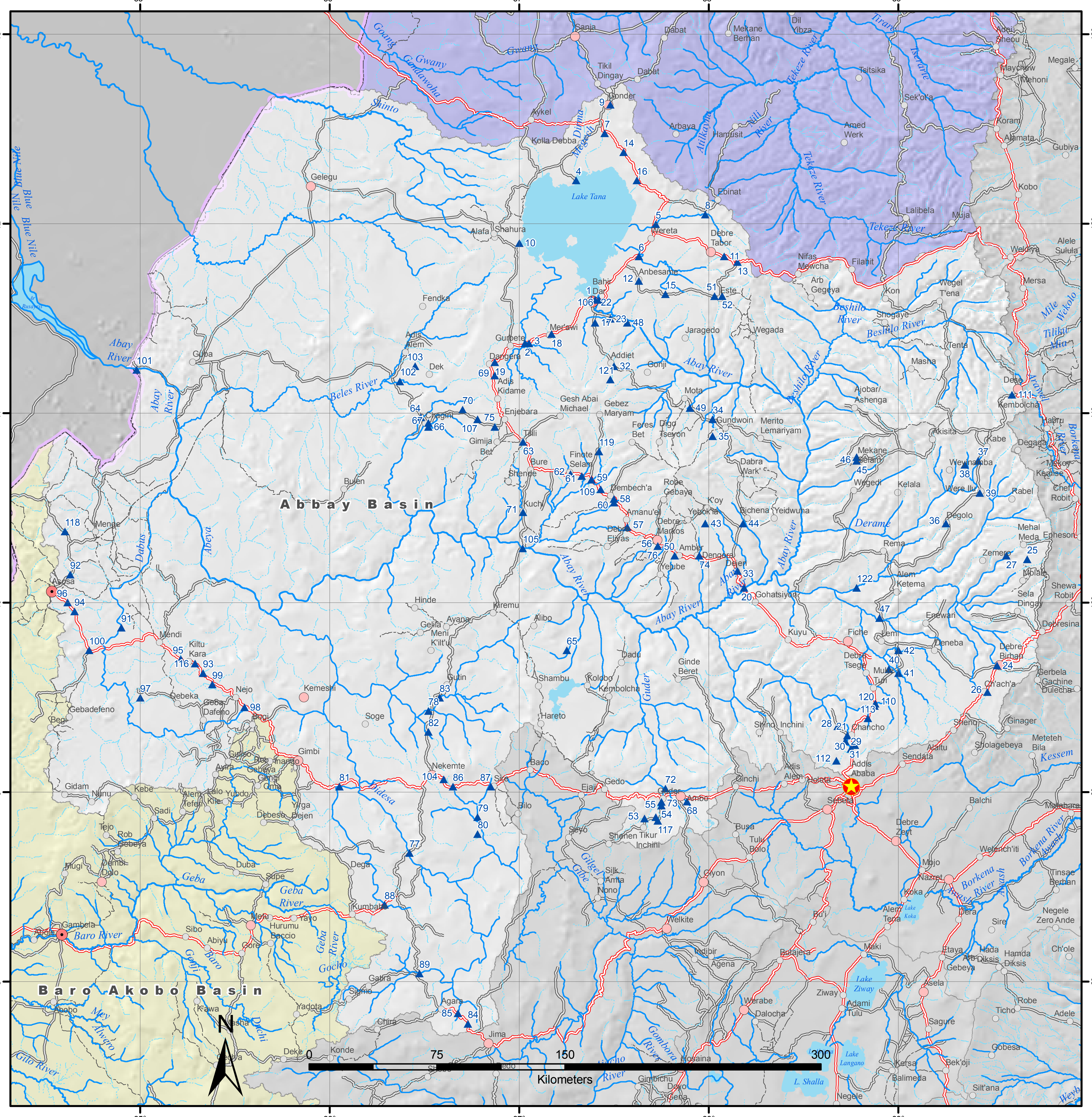


NO	Staion_No	On River	Location
1		INDAASA	Nr. RAMA
2	121019	MEHAQUAN	Nr. RAMA
3	121004	GHEBA	Nr. MEKEL
4	121005	WORIE	Nr. MAIKE
5	121006	TEKEZE	Nr. EMBAM
6	121007	SULLUH	Nr. HAWSI
7	121008	GHEBA	Nr. ADI K
8	121009	DOLO	NR. QUIHA
9	121010	GENFEL	@ WUKRO
10	121011	ILLALA	Nr. MEKEL
11	121012	METERE	Nr. AINAL
12	121014	MAY DUNGU	Nr. ADWA
13	121015	MAY MIDIM	Nr. ADWA
14	121017	AYEHIDA	Nr. AXUM
15	121018	SEBTTA	Nr. ADIDA
16	121019	MOLGE	Nr. SHIRA
17	121020	ATSELA	Nr. ADISH
18	122001	ZAREMA	@ ZAREMA
19	122002	TEKEZE	@ HUMERA
20	123001	ANGAREB	Nr. ABDI
21	124001	GOANG	Nr. METEM
22	124002	GENDAWOHA	Nr. KOKIT
23		TEKEZE	Nr. YECHI
24		ASERA	Nr. DEBAR
25		BUYA	Nr. MAITS
26		MEKEZO	Nr. DANSH
27	121013	AGULA	NR. AGULA
28		TEKEZE	NrKULMESK
29		ZAREMA	Nr. YECHI
30		TSERARIE	Nr. SEKOT
26a		MEKEZO	Nr. DANSH



January 2012, Addis Ababa Ethiopia.

Monitoring stations & River Networks of Abbay River Basin



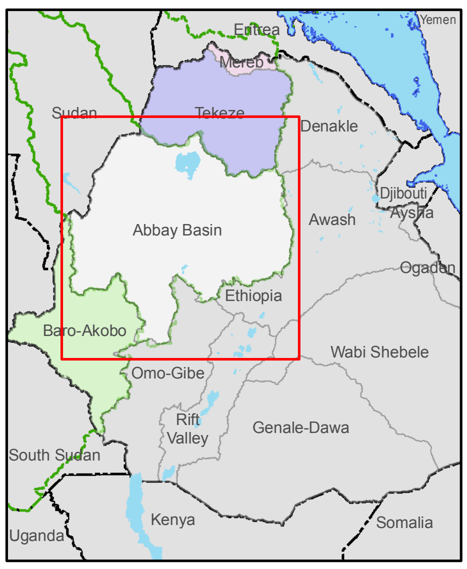
Legend

- Monitoring stations
- Capital City
- Regional Capital
- Zonal Capital
- Wereda Capital
- Paved
- Gravel
- Dirt/Sand

Rivers

- Major Rivers
- Secondary Rivers
- Streams
- Lake
- International boundary

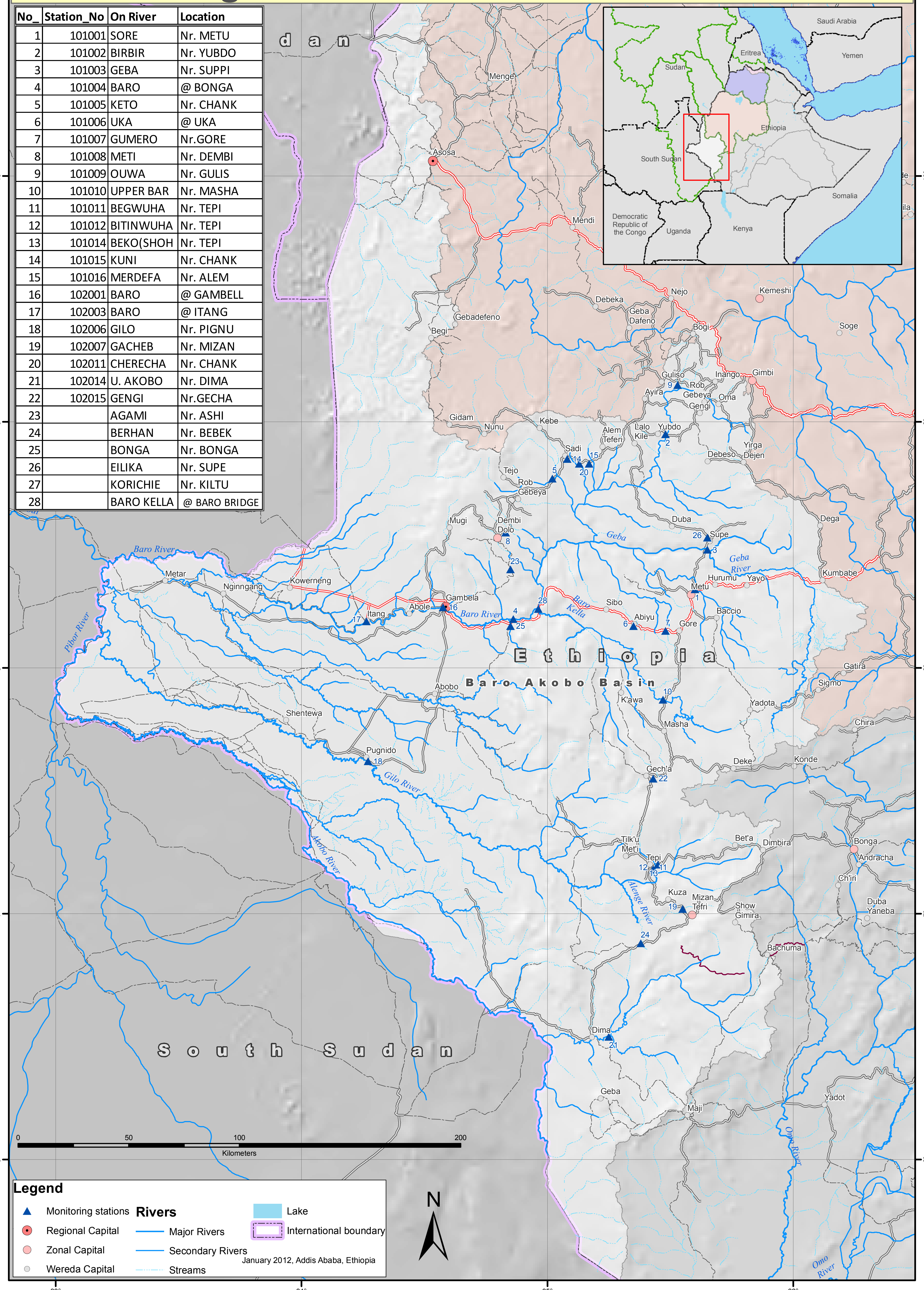
No_	Station_No	On River	Location
1	111001	LAKE TANA	@ BAHIR D
2	111002	GELGEL A.	Nr. MARAW
3	111003	KOGA	@ MERAWI
4	111004	LAKE TANA	@ GORGORA
5	111005	RIBB	Nr. ADDIS
6	111006	GUMARA	Nr. BAHIR
7	111007	MEGECH	Nr. AZEZO
8	111009	UPPER RIB	ON D.TABO
9	111010	ANGAREB	Nr. GONDE
10	111011	LAKE TANA	@ KUNZILA
11	111013	ZUFIL	Nr. DEBRE
12	111014	GELDA	Nr. AMBES
13	111015	RIBB	Nr. GASAI
14	111016	GEMERO	Nr. MAKSE
15	111017	FEGODA	Nr ARB GE
16	111018	GARNO	Nr. INFRA
17	111019	EZANA	Nr. BAHIR
18	111020	BERED	@ MEREWI
19	111021	AMEN	@ DANGILA
20	112001	ABBAY	Nr. KESSI
21	112002	MUGHER	Nr. CHANC
22	112003	ABBAY	@ BAHIR D
23	112004	ANDASSA	Nr. BAHIR
24	112007	BERESSA	Nr. DEBRE
25	112009	WIZER	Nr. MEHAL
26	112010	CHACHA	@ CHACHA
27	112011	SHY	Nr. MEHAL
28	112012	ALELTU	Nr. CHANC
29	112013	DENEBA	Nr. CHANC
30	112014	SIBILU	Nr. CHANC
31	112015	ROBA	NR. CHANC
32	112016	SHINA	Nr. ADIET
33	112017	MUGA	Nr. DEJEN
34	112018	AZUARI	Nr. MOTA
35	112019	TIGDAR	Nr.GUNDE
36	112020	GEBREGURA	Nr. DEGOL
37	112021	SELGI	Nr. KABE
38	112022	MECHELA	Nr. KABE
39	112023	JOGOLA	@ WEREILU
40	112027	ALELTU	Nr. MUKA
41	112028	ROBI JIDA	Nr. MUKA
42	112029	ROBIGUMER	Nr. LEMI
43	112030	TEME	Nr. MOTA
44	112031	SUHA	Nr. BICHE
45	112032	BOREDA	Nr. MEKAN
46	112033	LEGE CORA	Nr. MEKAN
47	112034	JEMMA	Nr. LEMI
48	112036	MENDEL	Nr. TIS A
49	112037	SEDIE	Nr. MOTA
50	112038	YEDA	Nr. AMBER
51	112039	CHENA	Nr. ISTAY
52	112040	WENKA	Nr. ISTAY
53	113001	BELLO	Nr. GUDER
54	113002	FATTO	Nr. GUDER
55	113005	GUDER	@ GUDER
56	113008	CHEMOGA	Nr. DEBRE
57	113011	JEDEB	Nr. AMA N
58	113012	GUDLA	@ DEMBECH
59	113013	BIRR	Nr. JIGA
60	113014	TEMCHA	Nr. DEMBE
61	113015	LEZA	Nr. JIGA
62	113017	LAH	Nr. FINOT
63	113019	FETTAM	@ TILILE
64	113023	DURA	Nr. METEK
65	113026	NESHI	Nr. SHAMB
66	113028	DONDOR	Nr. METEK
67	113029	ARDY	Nr. METEK
68	113031	HULUKA	Nr. AMBO
69	113033	QUASHINI	Nr. ADDIS
70	113034	BUCHIKSI	Nr. KIDAM
71	113036	L. FETTAM	@ GALIBED
72	113037	DEBIS	Nr.GUDER
73	113038	INDRIS	@ GUDER
74	113039	BOGENA	@ LUMAME
75	113040	MISSINI	@ KOSSOBE
76	113041	ABAHIM	@ DEBREMA
77	114001	DIDESSA	Nr. ARJO
78	114002	ANGAR	Nr. NEKEM
79	114003	SIFA	Nr. NEKEM
80	114004	WAMA	Nr. NEKEM
81	114005	DABANA	Nr. ABASI
82	114006	UKE	Nr. NEKEM
83	114007	LITTLE AN	@ ANGAR G
84	114008	YEBU	@ YEBU
85	114009	URGESSA	Nr. GEMBE
86	114010	TATO	Nr. GUTIE
87	114012	INDRIS	Nr. SIRE
88	114013	DABANA	Nr. BUNOB
89	114014	DIDESSA	Nr. DEMBI
90	114019	TEMSA	Nr. AGARO
91	115002	DABUS	Nr. ASOSA
92	115003	HOHA	Nr. ASOSS
93	115004	HUJUR	Nr. NEDJO
94	115005	HAFFA	Nr. ASSOS
95	115006	SECHI	Nr.MENDI
96	115007	GAMBELLA	Nr. ASOSS
97	115008	ALELTU	@ NEDJO
98	115009	DILLA	Nr. NEDJO
99	115010	KOMIS	Nr. GORI
100	115011	MUTSA	Nr. BAMBA
101	116002	ABBAY	@ SUDAN B
102	116004	GILGEL BE	Nr. MANDU
103	116005	MAIN BELE	@ BRIDGE
104		ADIYA	Nr. NEKEM
105		ABBAY	Nr. BURE
106		ABBAY	Nr. PEDAG
107		AYO	Nr. KOSSO
108		BUSO	Nr. BOREN
109		CHEREKA	@ YECHERE
110		TILKU DUB	Nr. DUBER
111		GERADO	Nr. DESSI
112		GERBI	Nr. SULUL
113	112044	GORFO	Nr. GORFO
114		KELKEL	Nr. GOBIE
115		KILTI	Nr. DURBE
116		KORICHE	Nr. KILTU
117		MELKE	Nr. GUDER
118		SHELKOLE	Nr. KOMOS
119		TALIA	Nr. JIGA
120		TINSHU DU	Nr. DUBER
121		TUL	Nr. ADET
122		WENCHIT	Nr. ALEM
123		DIRMA	Nr. KOLA
124		SHEGEZ	Nr. ADET



January 2012, Addis Ababa, Ethiopia.

Monitoring Stations of Baro - Akobo River Basin

No_	Station_No	On River	Location
1	101001	SORE	Nr. METU
2	101002	BIRBIR	Nr. YUBDO
3	101003	GEBA	Nr. SUPPI
4	101004	BARO	@ BONGA
5	101005	KETO	Nr. CHANK
6	101006	UKA	@ UKA
7	101007	GUMERO	Nr.GORE
8	101008	METI	Nr. DEMBI
9	101009	OUWA	Nr. GULIS
10	101010	UPPER BAR	Nr. MASHA
11	101011	BEGWUHA	Nr. TEPI
12	101012	BITINWUHA	Nr. TEPI
13	101014	BEKO(SHOH	Nr. TEPI
14	101015	KUNI	Nr. CHANK
15	101016	MERDEFA	Nr. ALEM
16	102001	BARO	@ GAMBELL
17	102003	BARO	@ ITANG
18	102006	GILO	Nr. PIGNU
19	102007	GACHEB	Nr. MIZAN
20	102011	CHERECHA	Nr. CHANK
21	102014	U. AKOBO	Nr. DIMA
22	102015	GENGI	Nr.GECHA
23		AGAMI	Nr. ASHI
24		BERHAN	Nr. BEBEK
25		BONGA	Nr. BONGA
26		EILIKA	Nr. SUPE
27		KORICHIE	Nr. KILTU
28		BARO KELLA	@ BARO BRIDGE



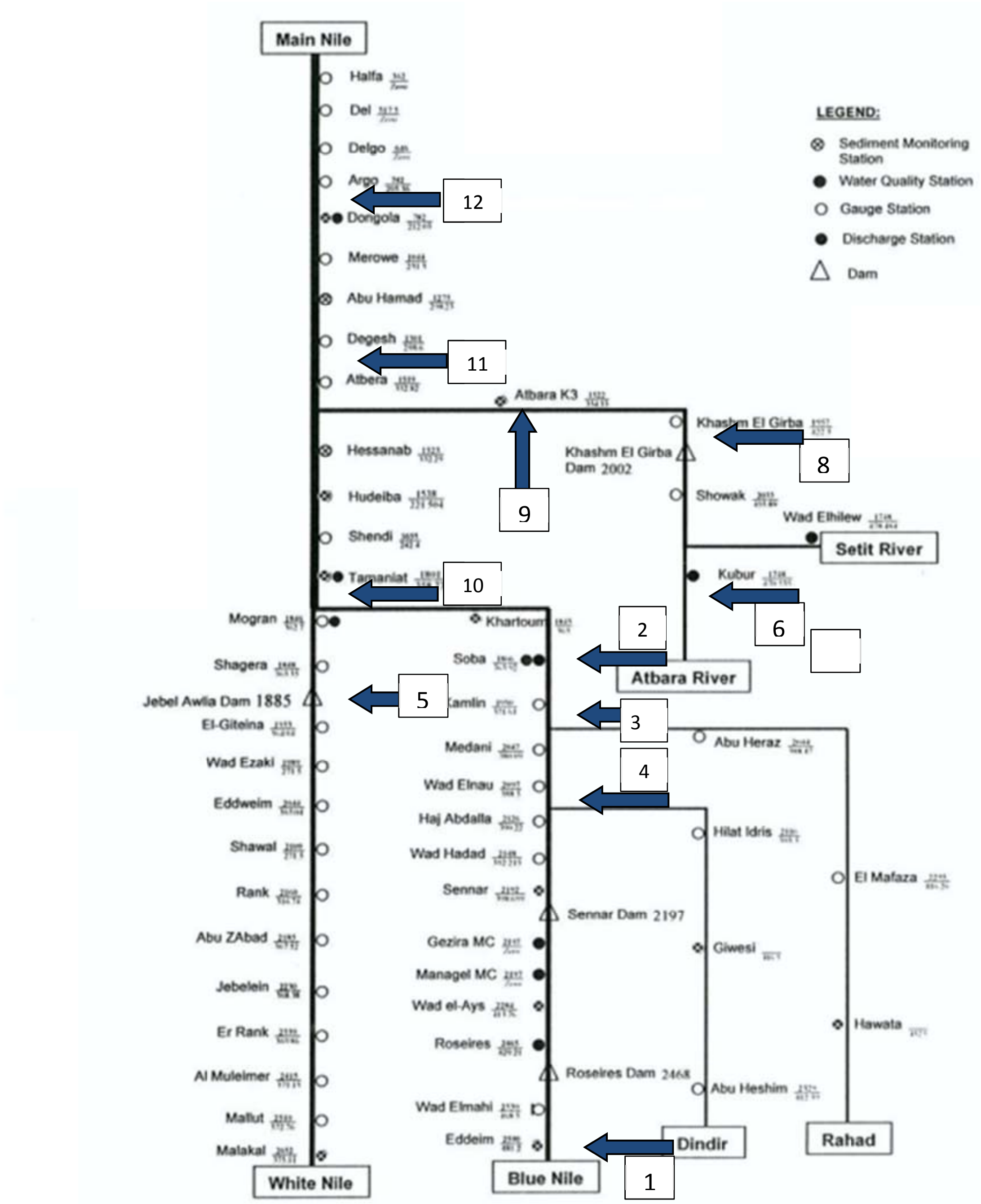


Figure 7.4 MIWR existing monitoring stations, and proposed water quality stations

In Egypt the Phase 1 consultant has proposed minor revisions on the ongoing sampling programmes, e.g. two more canals to be monitored in the irrigation and drainage systems in the delta, and to add pesticides to the parameter list. He also proposes to apply the same monitoring programme in the Lakes area. The current consultant agrees that the comprehensive monitoring programmes in Egypt need no further expansion, sampling points, sampling frequencies and parameters analysed seem adequate for the purposes of each organisation, as well as the methods for QA and database management systems.

The challenge, as interpreted by the consultant is to avoid duplication of efforts and overlaps, specifically between EEAA and NWRC, and link EEAA's and NWRC's database management systems in an efficient way to generate a National Water Quality Database. We understand that a web based Database is under development at NWRC, and EEAA publish annually their monitoring reports at their website

7.3 Proposed analytical parameters and sampling frequency

The organisation of the above monitoring stations into three categories motivates a slightly different approach to the sampling / analytical procedures. Secondly, the status of the current water quality monitoring in the three EN countries is at different levels of advancement, which necessitates that the procedures are somewhat different until the monitoring has reached a status that is reasonably equal in the countries. Section 7.8 describes the Consultant proposal to implement capacity building programmes and standardization of sampling, and data management procedures to streamline the water quality management systems in the EN countries. The analytical programme is divided into a base programme, which would be run at normal conditions. If any parameter would show abnormally elevated values, the extended programme would apply.

Table 7.1 Proposed sampling frequencies and analytical parameters

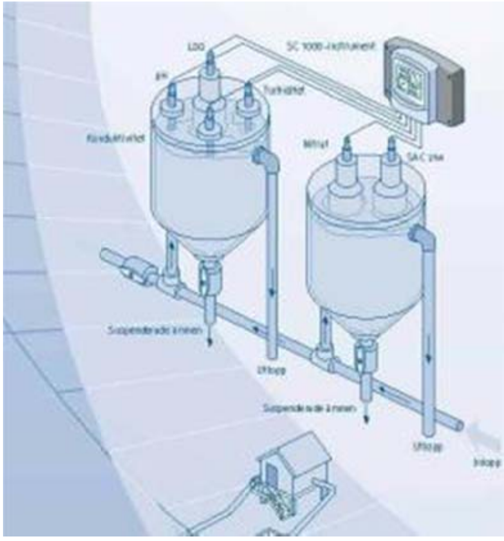
Type of station	*Sampling and analysis method, parameters*	*Frequency*
Basin / Border Base Programme Extended Programme	Water discharge or level, TDS, TSS, Transparency, Temp, pH, EC, DO, Ca, Mg, Na, Cl, SO_4, Alk, NO_2, NO_3, NH_4, Tot N, PO_4, P-Tot. Additionally: BOD, COD fecal coliforms if organic pollution is suspected, Heavy metals if metal pollution is suspected GC/MS analysis if Pesticide or other organic chemicals are suspected	Four times a year, selected stations equipped with continuous sensors for at least temp, pH, EC. Monthly at selected stations
Sub-basin	Same as Basin programme	Four times a year
Special Purpose (P)	Water discharge or level, TDS, TSS, Transparency, Temp, pH, EC, DO, Ca, Mg, Na, Cl, SO_4, Alk, NO_2, NO_3, NH_4, Tot N, PO_4, P-Tot., BOD and Fecal coliforms	Monthly

7.3.1 Typical analytical accuracies

Analytical Methods for the typical compounds are described in *Annex 4* including the appropriate ISO or other standard as well as the typical detection limit and accuracy of the analytical method.

7.4 Measuring techniques for automatic monitoring

The proposed automatic water quality monitoring stations comprise sensors, data storage and transmission and database management systems, which are further detailed in *Appendix 1, Section 5 and 9.* Manual sampling and sample preparation techniques are presented in *Appendix 1, Section 3.* A summary of the relevant techniques for the EN region is provided below. Figure 7.5 shows an example how an automatic sampling station may be equipped.



A typical setup of an automatic analyzing station would comprise:

- Power supply (solar cell with battery backup)
- Sensors for pH, EC, temp, TDS, (N-compounds)
- Loggers (data collection platform, DCP)
- Data transmission equipment (GSM, satellite) to the regional/central data storage center

When the stations are combined with level monitoring, pressure transducers for level are included as sensors

Figure 7.5 Schematic example of an automatic analyzing station

7.4.1 Location of sites for automatic monitoring

The proposed monitoring network for automatic water quality should be established in a few but well established monitoring points at borders and confluences between major streams with a technology common for the EN countries. The consultant thus recommends that such water quality monitoring stations are established at

- ✓ the border between Ethiopia and Sudan on the Tekeze/Atbara, (site 19, 20, 21, Figure 7.1)
- ✓ the border between Ethiopia and Sudan on the Abbay/Blue Nile, site 101, Figure 7.2
- ✓ upstream the confluence between Blue Nile and White Nile in Khartoum (site 2, Figure 7.4)
- ✓ downstream Khartoum (site 10, Figure 7.4)
- ✓ Downstream Atbara (site 11, Figure 7.4)
- ✓ the border between Sudan and Egypt (Dongola Station, site 12, Figure 7.4)

At the border between Ethiopia and South Sudan on the Baro Akobo, the Consultant trusts that such station need to be postponed until proper road access is available.

The estimated costs for a solar powered multi-ion analyzing equipment with a GSM data transmitter is ca 10 000 USD per unit.

7.5 Field Sampling Equipment

The water quality equipment for field monitoring and sampling will depend of the size of the river. The following standard equipment is recommended for a monitoring team on a small stream.

No	*Item*	*Note*
1	pH meter	Buffers
2	EC, TDS and Temperature meter	
3	DO-meter	Calibration solution
4	Grab sampler / sampling rod	
5	Bottles, specific for the parameters to analyze	for BOD and microbiology specific bottles and ice is required
6	Storage containers for bottles	
7	Labels, pens, notebooks, logs, gps, maps.	

For bigger streams and rivers sampling may be taken by boat or cableway, thus specific equipment like inflatable or permanent boat, engine, echo sounder, and isokinetic samplers may be required. Different types of samplers for grab and isokinetic sampling is presented in *Appendix 1, Section 8*.

Other equipment required for flow and sediment measurement is specified in the Hydrology Report.

7.6 Laboratory facilities

Laboratories which are accredited according to the applicable ISO standards need to be engaged in the analysis of the parameters specified above, and also parallel monitoring of the water quality in order to calibrate the sensors, and to provide correlation data with other chemical parameters than those monitored electronically. Requirements on the laboratories and the sampling/analysis methods are described in *Appendix 1*, *Section 5-6.* Below is summarized the requirements for the EN countries.

A modern central laboratory shall contain ICP for metal analyses, GC/MS for organic compounds, ion chromatographs, Multichannel analyzers and Ion Chromatography for anions and cations, Nitrogen Analyzer, Mercury Analyzer, Spectrophotometers as well as standard instrumentation for pH, temp, BOD, turbidity etc., and sample preparation and storage equipment, carousels, fridges etc. The laboratory equipment shall be integrated into a Laboratory Information Management System, LIMS, where samples are registered and all analytical results stored, verified and output reports generated to form a laboratory analysis database, which can export data after validation to the overall database management system.

We propose that one national laboratory in each country has the overall responsible for the physical chemical analysis in order to facilitate quality control and capacity building of staff (of its own laboratory and possibly satellite laboratories). We understand that in Egypt, most analyses are made either at Central Laboratory for Environmental Quality Monitoring, CLEQM or NRI’s lab as well as EEAA’s labs in Cairo and 8 regional labs. At least CLEQM is certified.

In Sudan the analyses are mainly conducted at the Ground Water and Wadis (GWWD) directorate, thus the future development of that laboratory to match the requirements of this programme is recommended. The current status needs upgrading and financial resources in order to increase the number of sampling stations and analyses, and to introduce a proper data management system.

In Ethiopia there is currently no obvious institution that would serve as the lead laboratory for water quality analysis. However, in order to facilitate the database management of joint water quality and hydrological data, the consultant proposes that the central laboratory is established under MoWE. There are such plans underway in the Ministry.

7.7 Data Analysis and Quality Assurance

All data shall be scrutinized, and standard quality controls performed, e.g. by checking for consistency, ion balance between cat- and anions, details of QA is specified in *Appendix 1, Section 10.* The most important QA for water quality actions are summarized in Table 7.2.

Table 7.2: Checking water quality data against physio-chemical laws

1. Dissolved solids

All results expressed in mg l–1 should comply with the check:
0.1 x TDS > [TDS – (Na+K+Mg+Ca+Cl+SO_4 + 4,42 NO_3 + 0.61(Alk) + 3.29NO_2 + SiO_2 + F)], NO2, S1O2 and F are optional, i.e., validation check can be used without them, but they should be included, if available.

2. Ion balance

(a) Standard requirements (8 to 12 ions)
Ions should be converted to meq l–1 and subjected to the check:
[Cations – anions] x 100 < 3 %
[Cations + anions]
where cations = Na+K+Mg+Ca+NH_4
and anions = Cl+SO_4 +NO_3 +HCO_3 +NO_3 +PO4 + F
PO_4, NH_4, NO_2 and F are optional, i.e., the balance can be checked without them;
(b) Minimum requirements (6 ions)
This rough check can be used where only major ions have been measured.
Results should be converted to meq l^{-1} and be subjected to the check:
[Cations – anions] x 100 < 10 %
[Cations + anions]
where cations = Na + Mg + Ca
and anions = Cl + SO_4 + HCO_3

3. Conductivity

0.55 conductivity (µs cm–1) < TDS < 0.7 conductivity (µs cm–1) where TDS = Total Dissolved Solids

4. General checks for water quality

Total solids	> total dissolved solids
Total solids	> settleable solids
Saturation of dissolved oxygen	< 200
mg l^{-1} dissolved oxygen	< 20
BOD5 (total)	> BOD5 (filtrate)
BOD5 (total)	> BOD5 (settled)
COD	> BOD
Total oxidized nitrogen	> nitrate
Total hardness	> temporary hardness
Total cyanide	> cyanide – excluding ferrocyanide
Total phenols	> monohydric phenols
Total phenols	> polyhydric phenols
Total dissolved chromium	> chromate
Oil (total)	> oil (free)
Oil and grease	> oil (free)
Total oxidized nitrogen	= nitrate plus nitrite
Total hardness	= Ca + Mg
Total phenols	= monohydric and polyhydric phenols

Source: World Meteorological Organization/Food and Agriculture Organization of the United Nations, 1985: *Guidelines for Computerized Data Processing in Operational Hydrology and Land and Water Management* (WMO-No. 634)

Other consistency controls would be to plot analytical data of time series from the relevant sampling points, to check expected patterns or comparisons with related parameters to identify outliers, and find out if the data value shall be considered in the database, corrected or disregarded.

7.8 Institutional Aspects and Operational Plan

7.8.1 Introduction

As reported above several organisations in the EN countries generate water quality data, primarily hydrological and environmental institutions. In order to facilitate data exchange between institutions and countries, we recommend that one institution in each country would be responsible for the national database management for water quality (and other water related data), and the other institutions that generate data would be obliged to report to the central database. Communication and coordination efforts to that effect are underway both in Ethiopia and in Egypt, but there are still decisions required on how to implement such systems. The Ministries for Water are recommended to shoulder the responsibility to be the national database holder.

The following is proposed to be the basic requirements for implementation of a unified system starting from field level to central level. The principal layout of the system is depicted in *Figure 7.6.*

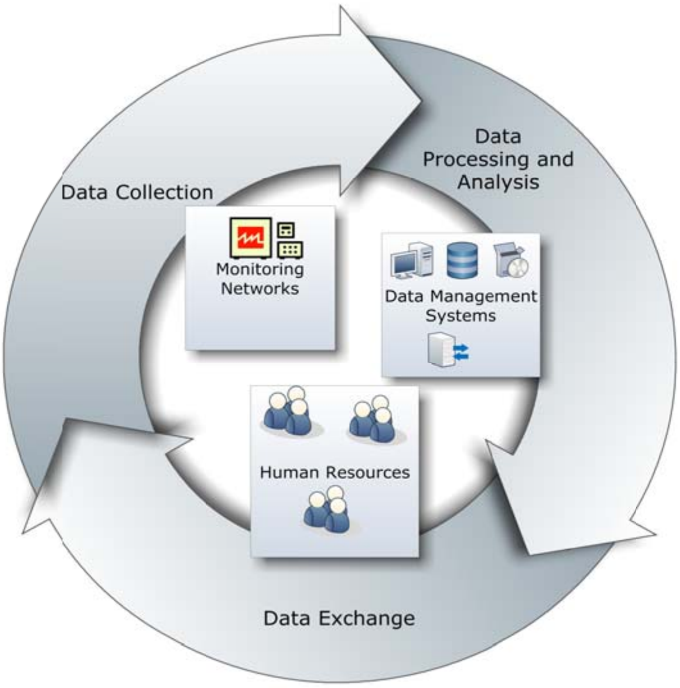


Figure 7.6 Schematic structure of the data management system

7.8.2 Resources and Staff Development

Adequately trained staff shall be engaged in the water quality monitoring, specifications on suitable requirements and training is presented in *Appendix 1, Section 12*. The most relevant requirements are described below.

Field and Regional Staff
Duties
Trained in the calibration and use of field instruments, sampling equipment handling, download and entry of data into logbooks and databases, specification of analysis requests. Keeping of hard copies of log books, data forms and send original data forms to Head Quarter staff on a regular basis.

Training
The staff shall ideally be trained to make both monitoring of discharge, sediment and water quality during monitoring campaigns. Typically the staff would comprise one regional head with B.Sc. degree in a relevant chemistry/water field and technicians with diploma certificates in relevant fields.

Head Quarter Staff
Head quarter staff would be a laboratory head, water chemists, a water quality manager and database managers. The laboratory head shall typically have a M.Sc. in Analytical Chemistry, while other laboratory staff have B.Sc. level of training with experience from organic and inorganic water quality analysis. Depending on the size of the laboratory, the staff will be specialized on a specific analytical instrument of versatile on handling several instruments.

The water quality manager would have the overall responsibility for organising the water quality monitoring campaigns, specification and procurement of instruments, budgets, staff recruitment and management.

The database specialists would enter water chemistry data to the database, as well as be responsible for QA of the data provided by the regional offices. Preferably, the database specialists will manage both water quality data as well as hydrological data. Thus, the majority of the database staff would be engaged in the hydrological part of the data management.

7.8.3 Institutional and Technical Arrangements

Field Offices
The main responsibility for the primary water quality data collection rests with the regional/field office staff in the three EN countries, who will collect the data and water samples and enter field data into a database. The field staff will ship the collected samples to the central laboratory (or regional lab, if available). They will also be responsible for the primary Quality Assurance of the collected data. The basic level of field data registration is proposed to be monitoring of pH, EC, temp and TDS, and storing the data in a data logger. The data logger shall be emptied manually, or when transmission conditions a favourable, data to be transmitted directly to the Head Quarters, where Quality Control will take place before entering into the central database. For water quality data there is no need for real time transmission, but batch wise transmission of collected data is deemed sufficient.

The equipment needed for the data management at the regional offices would comprise:

- two PCs with b/w and colour printer and a DVD/CD Reader/Writer.

Head Quarters
The national Head Quarters will have the responsibility for analytical laboratories, data processing and analysis, data storage and exchange with other organisations. The requirements for the analytical laboratories have been specified Section 7.6.

Database Centers
The database centers need to have the water quality database linked to the hydrological database.

The equipment needed for the data management at the central offices would comprise:

- Four PCs in a network with a server and with laser printers, plotter (A0), digitizer (A0), scanner (A3), a DVD/CD Reader/Writer, back-up storage and peripherals

The database centers would thus be responsible for the following activities:

- Validation, correction, processing and compilation of field and laboratory data, stage and stream flow, sediment transport and water quality parameters
- Hydrological analysis as required for the validation of data and for preparation of yearbooks and reports.
- Preparation of yearbooks and reports in tabular and graphical format.
- Data Exchange and dissemination of information (yearbooks and reports)

The recommended way of information and data exchange would be a database website, to which external and internal users would have different levels of access, to read, download or to edit, depending of the status of the users.

EN Region

The national database centers are expected to report in a uniform format to ENTRO, the protocol for data exchange to be defined by ENTRO. The regional database may be located at a server at ENTRO or subcontracted to an external server.

Thus, the data collection, transfer, storage and exchange can be illustrated schematically as presented in *Figure 7.7.*

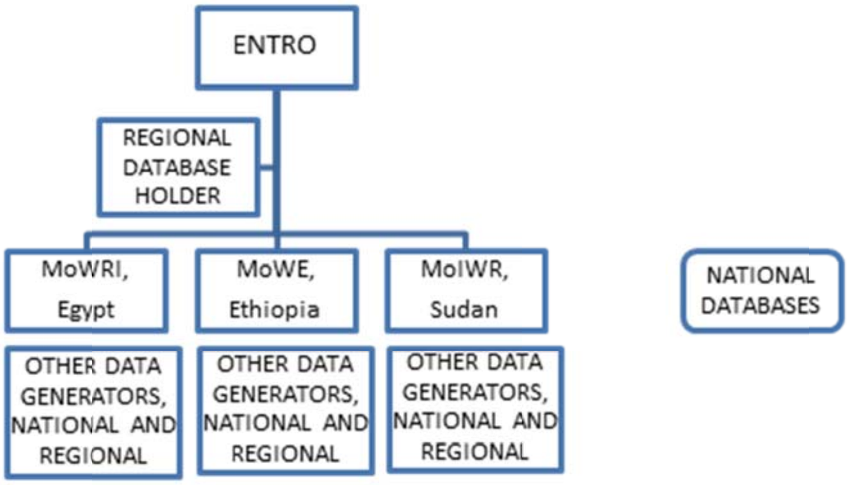


Figure 7.7 Schematic database hierarchy

In order to accomplish the proposed organisation of the hydrological and water quality data management in a sustainable way the following decisions are required at national levels.

1. Nomination of a national database holder, and specification of the technical and staff requirements, proposals for the same as provided above
2. Nomination of a central laboratory and provision of the specified staff and technical resources
3. Improvement of the regional and field offices according to the provided recommendations on staff and equipment
4. Provision of the resources required to upgrade the monitoring systems to the proposed standard

7.9 Overall Conclusions and Recommendations

There is an overall need to improve the quality of the primary data collection, which can be made via more intensive monitoring in fewer sampling points with regard to hydrological stations. For water quality the status and the objectives are different, the current monitoring takes place in few stations and the network needs to be expanded.

In Ethiopia substantial emphasis need to be addressed to water quality monitoring, from instrumentation and capacity building of field staff to be responsible for sampling efforts, shipping of samples to a central laboratory and digitization of field data to be transferred to the central database. Secondly, the central laboratory needs to be adequately equipped, the staffed trained in the use of the equipment and chemicals provided as well as other consumables. Finally, the organisation of analytical data in a central database needs to be implemented.

In Sudan the proposed expansion of the water quality sampling network would mainly need reinforcement of the laboratory and improvement of the water quality data management as long as Egypt is supporting the water quality sampling efforts with boats, equipment and staff. If Egypt is not willing to participate in the proposed expanded network, Sudan has to manage and budget the staff, equipment and laboratory facilities.

The coordination and data exchange between the water quality databases in Egypt needs further attention and cooperation efforts between EEAA and NWRC.

Although the EN countries are at different stages of advancement towards an adequate water quality monitoring system, the consultant trusts that a starting point would be to sample in a similar manner the proposed sampling points, and enter the results in a database system which is built in a similar way in the three countries.

To facilitate the start-up one may consider to select a few parameters that can be registered in the field, e.g. temp, pH, EC, DO, TDS, and enter the data in a uniform manner into a database located at one national institution.

The national databases can easily be made available for various users in a web-based application, where password entries for the authorized staff in the EN countries can enter, view or collect data, as prescribed by an agreed data sharing protocol.

When national systems are streamlined a joint database within ENTRO could be developed, including a system to systematically collect and store relevant data and information for efficient watershed management planning, monitoring, and evaluation.

Capacity building of individuals and institutions such as staff training on the use of field equipment and lab instruments, as well as database management are instrumental for a successful water quality management system.

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ANNEX 1 Minutes of Meetings, Ethiopia

MoM with Semunesh Seyom, Head of Hydrology and water quality directorate, MoWE 09 January 2012

The preparation of digital transfer of monitoring data from the regions is underway, so far log books are sent to Addis for QA and digitization. But of course the QA shall be made at first level. Capacity building is required to get a proper reporting of the monitoring from regions to central dept.

Telemetry is developed at a few stations for real time monitoring, but there are some problems on the gprs system to get the data transmission to function properly. Data receiving and storage equipment is already available at MoWE.

The water quality laboratory is under establishment, and I will meet the Water Quality Team 10 January. Currently few parameters like conductivity, pH, TDS is monitored by field kits.

MoM with Alemayehu Tafesse 09 January 2012

SEIA unit is established to review /approve the EIA reports for the Ministry projects. Alemayehu is the head of that directorate.

MoM Belay Seyoum 09 January 2012 evening

Four different maps are generated for each Basin, all with the gauging stations on, with the official station identification numbering of MoWE on each station. An overlay of the current and planned network is underway, with the different road classes. The locations of the gauging stations are derived from either from correct coordinates or from map locations by the description in the database, thus the exact location on the map may not be correct. The four maps comprise for each of the three basins gauging stations combined with River networks, Mean Annual Rainfall, Erosion Hazard and sub-catchments.

For this Water Quality Report only the hydrological and water quality network for each basin is presented

MoM Solomon Kebede, Hydrologist 10 January, 2012

We went through planned field trip. Will depart 11 Jan 1400 hrs for Jimma to take on three stations, 101001 Sor, Baro Kella, Baro in Gambella and others as the time schedule would allow. Border station has been there long time ago? But no road access and no plan to establish a new station until road access is available. Planned return on Saturday 14th

Belay has received the full database file which is the base for the map that Solomon uses in the field, and agreed to correct the missing identifications.

MoM Tesfaye Emiru, Head Water Quality Team, Hydrology and WQ Directorate

3 staff, all chemists are on the team. Tesfaye has developed a proposal for improvement of the laboratory. Currently there is at theoretical possibility to analyse major anions and cations, by spectrophotometry, but chemicals are outdated. The laboratory is located in small premises and

there may soon be available nearby rooms for expansion. AAS and GC equipment is available, but not complete, and the staff has not been trained in their usage. The laboratory facilities at the Ministry were visited, and comprise one room for analysis and another store room, see pictures below.

The proposal developed by Tesfaye was sent by email, and is summarized below. It includes also strengthening of the regional capacity, capacity building of the staff, which will be taking the discrete samples in selected water quality points. They are also contemplating to utilize the regional water bureau's laboratories, if those exist, and a survey of their capacity is planned for within short.

Moreover, a new laboratory is planned to be organized under the Water Study and Design Enterprise.


The request to upgrade the laboratory prepared by Ato Tesfaye is motivated in the table below. His investment estimate to be able to service the stakeholders of the table is ca. 700 000 USD including training of staff

No	**Beneficiaries**	**Lab. Service required**
1	Water supply and Sanitation	• To check the quality of water for new established water supply schemes • To carry out over all water quality monitoring of the country • To supply standard quality water for drinking • To protect public water supply sources from pollution • To create water quality awareness for the community • To apply water treatment technologies
2	Hydrology	• To conduct sediment load analysis of rivers and lakes • To get data for water quality of surface and ground water
3	Basin development study and water utilization control	• To study water quality of different basins for master plan studies • To evaluate effectiveness of water shed management activities • To monitor and evaluate soil and water conservation activities in different watersheds, etc.
4	Boundary and Trans boundary Rivers Affairs Department	• To Determine and monitor Water quality of Trans boundary Rivers
5	Irrigation and Drainage Development study	• For construction of irrigation development • To determine irrigation water and soil quality • To control the level of pesticides and fertilizers in the soil and water • To monitor and evaluate water quality of drainage water from irrigated farm

6	Research and Development Coordination	• To conduct research on different water quality issues and problems • To access water quality data
7	Dam and Hydropower Design	• To determine water quality of Rivers and Reservoirs • To check water quality of dam for strengthening water shade management • To study and control Eutrophication problem of Reservoirs • To protect dams and reservoirs from sediment
8	Water resources control and License directorate	• To monitor and control industrial, agricultural and domestic effluent discharge into water bodies, etc. • To give permit for the proper usage of water resources
9	Regional water bureaus	• For training water quality technicians • To share experiences in water quality analysis and instrument use • To share water quality data • To crosscheck and evaluate proper functioning of their laboratories, etc.
10	Investors, researchers and academicians	• Water quality information and data for water resources • Advanced water quality analysis
11	Other stakeholders	• Water quality data • Advanced water quality analysis • Practical water quality Training

No	Item	Quantity
1	Atomic Absorption Spectrophotometer (Flame, graphite) furnace	1
2	Mass Spectrophotometer	1
3	Laptop computers	4
4	Desktop computers	4
5	Magnetic stirrer	2
6	Ion selective electrode for fluoride analysis	2
7	Centrifuge	1
8	Solvent extractor for waste water and pesticide analysis	1
9	Solvent	-
10	Different chemical reagents	-
11	Chimney	-
12	Laboratory safety wares	-
13	Soft wares	

Moreover, the following staffing is estimated for the development of the laboratory services

No.	Experts	Quantity
1	Federal Water quality experts	6
2	Regional water quality experts	9
3	Lab Technician	3

This would be a more than double ambition level than the current standard. The consultant agrees that the ambition level needs to be substantially increased to meet the requirements of the lab. Before requesting for investment proposals, a comprehensive assessment of the potential of existing equipment should be made.

ANNEX 2 Field Report Baro Akobo

A field tour to the Baro Akobo catchment was conducted 11-14 January 2012 to study the gauging stations in the basin, their status and applicability for stage, flow and water quality monitoring. The field visits were made together with Ato Solomon Kebede, MoWE. The part of the tour which is located within the catchment is depicted on Google Earth map, figure 1.

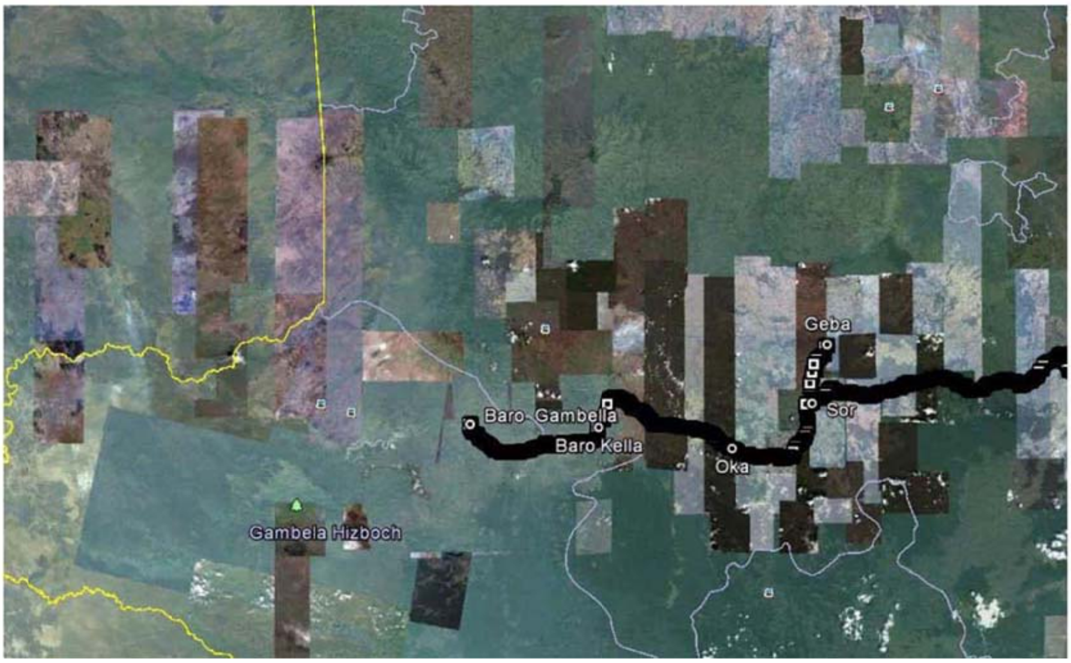

Figure 1. Field trip route and visited sites

Day 1
Road transport Addis Abeba Jimma, overnight stay

Day 2
Visit at the regional office in Jimma, discussions with Ato Seyoum Yirga, technician at the office. He described the routines at the office including presentation of the field kits for monitoring of pH, temperature and EC. No training was yet provided on how to handle the instruments, thus they are still not used. The logbook from staff gauge readings are until now collected from gauge readers and send every three months to Addis for digitization, but from this year digitization will take place at the regional office, and sent by telecommunication to Addis. Still the logbooks will be sent to Addis for QA of the sent files. The monitoring of the Baro Akobo is usually the responsibility of the Assosa office, but due to staffing problems, Jimma is currently responsible (totally 38 stations).

Road transport Jimma-Gambella, visits at the below stations. A hand held Garmin Etrex HCx was used to generate coordinates of the visited sites and the track is superimposed on Google earth.

Sor
Station No 3 with MoWE ID no 1001001 is located ca 500 m upstream of the road bridge over river Sor, see picture 2 and map 7.3. The monitoring section is good with a free flowing control level

downstream of the site. The site is equipped with staff gauges, mechanical recorder, and a cableway setup for flow monitoring. Staff gauges are read twice a day, and logbooks are collected every three months from the regional office in Jimma. The cableway setup is not functional and flow monitoring has been disrupted. The mechanical flow recorder is not used due to lack of registration paper, thus this station is planned for installation of a data logger this year. The tower needs desilting before installation of the logger. Picture 2 – 5 shows the site, and the installations.

Figure 2. View from Sor bridge upstream towards gauging station, tower at distance

Figure 3. Sor monitoring tower

Figure 4. Sor staff gauges and cableway

Figure 5. Sor damaged cableway

There are no obvious water pollution upstream from the site, but the sub-catchment may be subject to water quality monitoring.

Baro Kella

The station at Baro Kella has no MoWI ID number, but is located on the map as a new number 28, 500 m downstream of the checkpoint at the bridge for the Gambella Regional state. Figures 6 - 7 show the installations at the site. The station has during this year been desilted and a data logger for recording of the levels installed. The software to download the logs is however missing, thus the manual readings is currently the source of information. The flow section is district and should give good readings. There are no urban areas close to the site, thus water quality monitoring for pollution impact is not necessary, but may serve its purpose to give information on the tributary quality.

The cableway is used for 2-3 days flow monitoring campaigns during flood season and the equipment seems to be in workable order. As practiced at other sites, the cables and equipment are kept at the regional office.


Figure 6. Gauging equipment with logger


Figure 7. Installation for cableway

Day 3

Baro at Gambella

The Baro at Gambella has ID no 102001, se map, figure 7.3. Flow measurements take place at the bridge, see figure 8, at flooding conditions with the standard MoWE equipment. The flow section is >100m wide and not distinct at low flow. The staff gauges and mechanical registration tower is located about 1 km downstream of the bridge, se figure 9, 10 and 11. The tower needs to be desilted and the upper staff rehabilitated.

The site is valid for water quality monitoring since Baro is draining Gambella town.

Figure 8. Baro bridge at Gambella

Figure 9. Level gauging section

Figure 10. Staff gauges

Figure 11. Gauging tower

Oka

Nr 6 Oka is a small stream with ID No 101006, see map. The recording tower has been damaged during the flood and needs rehabilitation, see pictures 12-13, however the staff gauges are is usable condition and located at a reasonable suitable section. The section at the bridge is not suitable for flow monitoring, since the flow is restricted and turbulent. Since the stream is small flow measurements could take place by a cableway downstream from the bridge, close to the staff gauges.


Figure 12. Oka damaged recording tower and staff


Figure 13. Bridge over Oka

Since the upstream area is rural and a small catchment, this site is not relevant for water quality monitoring.

Geba

The Geba station is located at a bridge on the Geba, nr 3, with ID no 101003 and is located ca 25 km North of the Sor bridge. The site comprises a rather narrow gorge and it is equipped with staff gauges only. These are in operational conditions.

The river section at the bridge is turbulent and it is not suitable for flow measurements. It should be moved ca 50 m downstream as a cableway, but such construction would incur rather high costs due to access and a rather deep gorge. The site is presented in figures 14 and 15.


Figure 14. Bridge over Geba


Figure 15. Geba staff gauges

Water quality monitoring at Geba would only be relevant for tributary monitoring, no major pollution sources are expected upstream.

Sake

A final short stop was made at Sake bridge, a tributary to the Geba, where staff gauges are located at a good section of the channel, see figure 16.

Figure 16. Sake staff gauge

Day 4

Return to Addis Ababa.

Findings and recommendations

The tour to the Baro Akobo and follow up discussions with the responsible staff has revealed that all the studied stations need rehabilitation, maintenance or upgrading to provide reliable results. Specifically no recording stations are in proper working order. At many places one or more staff gauges need to be maintained. At some of the places, where mentioned, the flow section is not ideal. The overriding location factor of the sites is access, and a compromise between access and location always needs to take place.

The standard of the staff readings at the sites and flow measurements is not commented upon in this report, since those have not been studied. The ongoing delegation of authority to the regions to manage the raw data is recommendable, and needs as specified go hand in hand with capacity development and furnishing of equipment, and appropriate methods, for level, flow, water quality sampling/testing as well as the data management at the regional offices.

Since water quality monitoring is new to the regions, and to the Head office, specific attention need to be given to the capacity building of the technicians and chemists, as well as to the furnishing of material for the missing items to the laboratory to make it operational.

The actual location maps over the basins and the station identification are at times derived from real coordinated and at other times derived from maps. Moreover, the maps are not updated when old stations are replaced by new, and there are several locations without an unique ID No.

Thus, the location on the enclosed maps, which is provided from the MoWE database, may not be correct, and some stations are closed while other are recently established. Thus, a review of station numbering and the location on the maps, as well as an updated coordinate list is recommended.

ANNEX 3 Khartoum visit 15-19 January 2012

Visit at gauging and sampling sites on the Blue Nile

Mr Redwan Abdelrahman guided to the current gauging and monitoring sites on the Blue Nile in Khartoum, see Figure 1 below, and the sampling procedures have been described by Mr Babikr Mahgoub

Magnimir bridge Buri/Bahri Bridge Manshiya bridge

Figure 1. Gauging and sampling stations on the Blue Nile in Khartoum

At the Magnimir and Manshiya sites staff levels are read every 2hrs during flood periods and 2-3 times per day during low flow. Flow velocity is taken by boat across the section at 25 cm from surface, at 25%, 50%, 65% and 80 % of depth, and 75 cm from river bed in 15-20 points across the river at the Buri/Bahri Bridge at low flow conditions, and at Manshiya during flood conditions two to seven times per month, most frequent during flood season. Sediment and water quality samples are taken every month in the center section. The temperature, EC, pH and D.O. is monitoring in the field. Velocity and flow is monitored at the same levels, across the river section in 15-20 points, and depth is recorded by ecosounding equipment. Bedload samples are taken at the same time. The sampling is conducted by the Egyptian Research station, and supported by Sudan MoIWR staff, and sediment and water samples simultaneously taken for analysis by the MoIWR lab and an Egyptian lab. Selected pictures from the sites are shown below.

Magnimir comprises staff gauge at low levels and demarcation on the bridge foundation for high levels

Manshiya bridge located ca 10 km upstream of Bahri bridge replaces since 2 years back the Soba station, which was located another ca 10 km upstream. Also here the levels are read on staffs at low levels while high levels are demarcated on concrete walls on the river bank. The low level staffs need to be rehabilitated to cover the full range properly. The area here is subject to flooding (as well as other areas in Khartoum, mainly along the Blue Nile).

Similarly, on the main Nile monitoring and sampling takes place at Tamaniat at low flow and Shampat bridge at high flow. The Egyptian Team is also monitoring at El Shagira at the White Nile.

Figure 2. Magnimir monitoring station

Figure 3. Manshiya bridge monitoring station

Figure 4. Manshiya high level staffs

Figure 5. Manshiya low level staffs

Visit at MoIWR Water Quality Laboratory

Discussion with Ms. Igbal Saheed, laboratory Head and her staff. The laboratory was established water quality laboratory for rural water supply analysis in 1988. From 1994 the laboratory became part of the MoIWR, and responsible for the water quality analyses on the Nile, and many other clients including certification of the water quality of ground water wells.

They analyse ca 70 samples per month and have a staff of 10 chemists and 4 technicians. The instrumentation allows standard analyses of major cations and anions in a manual wet chemistry manner, and metals are analyses with AAS. Thus the following analyses are generally made: Colour, Turbidity, Conductivity, pH, SS, TDS, Hardness, $CaCO_3$, Na_2CO_3, HCO_3, Cl, SO4, Ca, Mg, Na, F, NO_2, NO_3, NH_4. Occasionally bacteriological analysis is made with the membrane method. Analytical reports are provided to the client as hard copies and the database of analytical results is kept at the laboratory. Standard QA is made by checking ion balance and attention to outlier results. Annual reports are prepared from the analytical reports.

Intercalibration with other laboratories is made regularly, e.g. with parallel analyses at Ministry of Health, the urban water corporation laboratory and Sudan standardization organisation. There is no international accreditation of the laboratory.

Constraints

Consumables, like reagents and glassware has been provided by NBI, IAEA and the ministry, but there is always a need for upgrading of some materials. The following examples were mentioned: A carousel to the Hach spectrophotometer would increase the capacity, there is a need for certified standard solutions, and to improve bacteriological analyses culture media is required.

The data management at the laboratory need to be improved to enable that analytical results are transferred as digital files to the Clients/databases.

Assessment

The laboratory would be able to increase the efficiency if some additional funding would be made available. The proposed increase of sampling points on the Nile system would thus require that the laboratory to change from the rather manual methods to automated analysis and digital data management.

ANNEX 4 Detection limits, uncertainties/accuracies for chemical compounds and analytical methods

Detailed scope of accreditation

Item No	Object of testing Materials/ Products	Field of testing		Type of testing /Property (Detection limit -L.D; measurement uncertainty-U)	Testing method (Standard, Regulation, Validated method)
1.	DRINKING WATER-ICE	Physical-chemical analyses	1.	Determination of turbidity L.D.: 0,1 NTU U: 5,52%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 118 (ASTM D 1889-81B)
			2.	Determination of temperature Range: -30 °C - 100°C U: 0.6 °C	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 111
			3.	Determination of pH Range: 0 – 14 U: 3.66%	JUS HZ1.111 (1987)
			4.	Determination of electrical conductivity L.D.: 0,1 µS/cm U: 0.56%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 143 (ASTM D 1125-77)
			5.	Determination of calcium L.D.: 0.8 mg/l U: 5.34%	Standard Methods for examination of water and wastewater 19th edited by Andrew D. Eatonand Greenberg, 3500Ca D
			6.	Determination of sodium L.D.: 0,1 mg/l U: 6,65%	Standard Methods for examination of water and wastewater 19th edited by Andrew D. Eatonand Greenberg, 3500Na D
			7.	Determination of potassium L.D.: 0,1 mg/l U: 10,15%	Standard Methods for examination of water and wastewater 19th edited by Andrew D. Eatonand Greenberg, 3500K D
			8.	Determination of alkalinity L.D.: 5 mg $CaCO_3$/l ili 1 ml 0,1 N HCl/l U: 14,76%	JUS.HZ1.124 (1974)
			9.	Determination of total hardness L.D.: 0,1° dH U: 2,72%	Standard Methods for examination of Water and Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg, 2340
			10.	Determination of total solids L.D.: 5 mg/l U: 9,08%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 129 (EPA 160.2 -1992)
			11.	Determination of nitrites L.D.: 0,005 mg/l U: 3,09%	Standard Methods for examination of water and wastewater 19th edited by Andrew D. Eatonand Greenberg, 4500-NO_2B, Colorimetric method
			12.	Determination of nitrates L.D.: 0,04 mg/ U: 13,5%	Standard Methods for examination of water and wastewater 19th edited by Andrew D. Eatonand Greenberg, 4500NO_3-B. UV spectrophotometric screening method
			13.	Determination of ammonia L.D.: 0,02 mg/l U: 14,34%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 179 (ASTM D 1426-71)

Item No	Object of testing Materials/ Products	Field of testing	Type of testing /Property (Detection limit -L.D; measurement uncertainty-U)		Testing method (Standard, Regulation, Validated method)
		Physical-chemical analyses	14.	Determination of Kjeldahl nitrogen L.D.: 3 mg/l U: 11,1%	Handbook for Kjeldahl digestion – a recent review of the classical method with improvements, Developed by Tecator, 2nd edition, May 2006.
			15.	Determination of trihalomethanes L.D.: 0.0005 mg/l U: 10.25%– 13.78%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 6232B
			16.	Determination of mineral oils L.D.: 0,0025 mg/l U: 30,8%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 430 (ASTM D 3921-85)
			17.	Determination of total oils and fats L.D.: 0,0025 mg/l U: 23,68%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 563 (ASTM D 3921-85)
			18.	Determination of phenols L.D.: 0,0005 mg/l U: 12,32%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, page 299 (ASTM D 1783-B)
			19.	Determination of iron L.D.: 0,005 mg/l U: 24,56%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500Fe B
			20.	Determination of manganese L.D.: 0,0025 mg/l U: 9,53%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500Mn B
			21.	Determination of copper L.D.: 0,0025 mg/l U: 12,26%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500Cu B
			22.	Determination of zinc L.D.: 0,0025 mg/l U: 9,22%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500 Zn B
			23.	Determination of phosphates L.D.: 0,01 mg/l P U: 17,03%	Standard methods for the Examination of Water and Wastewater 19th edition, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 1995 4500-P D
			24.	Determination of fluorides L.D.: 0,02 mg/l U: 12,26\1%	* Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, a) ion selective electrode, page 326 (ASTM D 1179-80)
			25.	Determination of cobalt L.D.: 0,0025 mg/l U: 14,03%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500 CoB
			26.	Determination of barium L.D.: 0,001 mg/l U: 10,5%	Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water

Item No	Object of testing Materials/ Products	Field of testing	Type of testing /Property (Detection limit -L.D; measurement uncertainty-U)		Testing method (Standard, Regulation, Validated method)
		Physical-chemical analyses	27.	Determination of cadmium 1.L.D.: 0,0005 mg/l U: 9,46% 2..L.D.: 0,0002 mg/l U: 21,62%	1. Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500 Cd B 2. Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water (according to DIN-38406-E19-2), page 13
			28.	Determination of cianides 1. L.D.: . 0,005mg/l U: 12,42% 2. L.D.: 0,03 mg/l U: 10,78%	1.Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 4500 CN-C 2. Drinking water-standard methods for examination of hygienic safety, Beograd 1990, Federal Health Protection Bureau, a) ion selective electrode, page 277 (ASTM D2036-81)
			29.	Determination of total chromium L.D.: 0,005 mg/l U: 7,58%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500Cr B
			30.	Determination of arsenic L.D.: 0,001 mg/l U: 20,5%	Atomic absorption spectrophotometry Cookbook Section 4 Measuring conditions by element of furnace analyses method, Shimadzu corporation, page 10
			31.	Determination of mercury L.D.: 0,0001 mg/l U: 9,62%	Determination of Mercury in Hg Standard Solutions at the Lower Range Limit, Organic application note Leco AMA 254, Form no. 203-823-111, Leco corporation, 2003.
			32.	Determination of nickel L.D.: 0,005 mg/l U: 7,56%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500Ni B
			33.	Determination of lead 1.L.D.: 0,005 mg/l U: 22,0% 2..L.D.: 0,005 mg/l U: 13,18%	1. Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500 PbB 2. Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water (according to DIN-38406-E6-3), page 17
			34.	Determination of antimony L.D.: 0,005 mg/l U: 14,04%	Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water (according to German drinking water regulation), page 23
			35.	Determination of selenium L.D.: 0,001 mg/l U: 14,86%	Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water (according to DIN-38405-D23-1), page 18, 19

Item No	Object of testing Materials/ Products	Field of testing		Type of testing /Property (Detection limit -L.D; measurement uncertainty-U)	Testing method (Standard, Regulation, Validated method)
		Physical-chemical analyses	36.	Determination of volatile aromatic components L.D.: 0.00001 mg/l U: 9.67% - 16.75%	Environmental protection agency (EPA) Method 5021 A
			37.	Determination of polychlorinated biphenyls-PCBs 1.L.D.: 0.000025mg/l U: 13.11% 2..L.D.: 0,000025 mg/l U: 9.25%-13.75%	**1.** Standard Methods for examination of Water and Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 6431 B- **2.** Standard Methods for examination of Water and Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 6431 C
			38.	Determination of polycyclic aromatic hydrocarbons-PAHs L.D.: 0.00001mg/l U: 13.20% - 23.20%	Standard Methods for examination of Water and Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 6440 C
			39.	Determination of organochlorine pesticides L.D.: 0.000005mg/l U: 10.43% - 25.86%	Standard Methods for examination of Water and Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 6630 C
			40.	Determination of organophosphorus pesticides L.D.: 0.00005mg/l U: 13.65%-29.73%	Environmental protection agency (EPA) Method 8141 A

5.	**WATER AND WASTE-WATER**	**Physical-chemical analyses**	54.	Determination of polychlorinated biphenyls-PCBs 1.L.D.: 0.000025mg/l U: 10.77% 2..L.D.: 0,00001 mg/ U: 9.38%-13.04%	1. EPA Method 8080 A 2. EPA Method 8270 C
			55.	Determination of polycyclic aromatic hydrocarbons L.D.: 0.00001mg/l U: 10.41%-24.74%	EPA Method 8270 C

Item No	Object of testing Materials/ Products	Field of testing	Type of testing /Property (Detection limit -L.D; measurement uncertainty-U)		Testing method (Standard, Regulation, Validated method)
		Physical-chemical analyses	56.	Determination of organochlorine pesticides L.D.: 0.000005mg/l U: 14.69%-25.35%	EPA Method 8080 A
			57.	Determination of organophosphorus pesticides L.D.: 0.00005mg/l U: 11.76%-28.87%	EPA Method 8141 A
			58.	Determination of chromium L.D.: 0,005 mg/l U: 7,58%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg Method: 3500 CrB
			59.	Determination of cobalt L.D.: 0,0025 mg/l U: 14,03%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg Method: 3500CoB
			60.	Determination of copper L.D.: 0,0025 mg/l U: 12,26%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg Method: 3500 Cu B
			61.	Determination of nickel L.D.: 0,005 mg/l U: 7,56%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg Method: 3500NiB
			62.	Determination of zinc L.D.: 0,0025 mg/l U: 9,22%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg Method: 3500ZnB
			63.	Determination of iron L.D.: 0,005 mg/l U: 24,56%	Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg Method: 3500FeB
			64.	Determination of barium L.D.: 0,001 mg/l U: 10,5%	Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water (according to German drinking water regulation), page 21
			65.	Determination of lead 1.L.D.: 0,005 mg/l U: 22,0% 2..L.D.: 0,005 mg/l U: 13,18%:	1..Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500 PbB 2. Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water (according to DIN-38406-E6-3), page 17

Item No	Object of testing Materials/ Products	Field of testing	Type of testing /Property (Detection limit -L.D; measurement uncertainty-U)		Testing method (Standard, Regulation, Validated method)
			66.	Determination of cadmium 1. L.D.: 0,0005 mg/l U: 9,46% 2. L.D.: 0,0002 mg/l U: 21,62%	1. Standard Methods for examination of Water Wastewater-19th Edition 1995, edited by Andrew D.Eaton,Lenore S.Clasceri and Arnold E.Greenberg 3500 CdB 2. Atomic absorption spectrophotometry Cookbook Section 5a Measuring conditions of relevant elements in drinking water (according to DIN-38406-E19-2), page 13
			67.	Determination of mercury L.D.: 0,0001 mg/l U: 9,62%	Determination of Mercury in Hg Standard Solutions at the Lower Range Limit, Organic application note Leco AMA 254, Form no. 203-823-111, Leco corporation, 2003.
			68.	Determination of chemical oxygen demand-COD L.D.: 30 mg/l U: 5,84%	JUS/ISO 6060
			69.	Determination of alkalinity L.D.: 5 mg $CaCO_3$/l ili 1 ml 0,1 N HCl/l U: 14,76%	JUS.HZ.124 (1974)

Item No	Object of testing Materials/ Products	Field of testing	Type of testing /Property (Detection limit -L.D; measurement uncertainty-U)		Testing method (Standard, Regulation, Validated method)
			78.	Determination of manganese content L.D.: 1,25 mg/kg U: 16,18%	1. Official Methods of Analysis of AOAC International 16th Edition, 3rd Revision,1997, AOAC Method 990.08
			79.	Determination of nickel content L.D.: 2,5 mg/kg U: 8,21%	1. Official Methods of Analysis of AOAC International 16th Edition, 3rd Revision,1997, AOAC Method 990.08
			80.	Determination of zinc content L.D.: 1,25 mg/kg U: 7,28%	1. Official Methods of Analysis of AOAC International 16th Edition, 3rd Revision,1997, AOAC Method 990.08
			81.	Determination of mercury L.D.: 0,0001 mg/kg U: 16,44%	2. Organic application note Leco AMA 254, Form no. 203-823-112, Leco corporation, 1999.
			82.	Determination of organophosphorus pesticides L.D.: 0.005mg/kg U: 11.43%-14.79%	EPA Method 8270 C
			83	Determination of organophosphorus pesticides L.D.: 0.005mg/kg U: 10.66%-28.42%	EPA Method 8141 A
			84.	Determination of organochlorine pesticides L.D.: 0.0005mg/kg U: 10.14%-17.13%	EPA Method 8270 C
			85.	Determination of organochlorine pesticides L.D.: 0.0005mg/kg U: 14.93%-36.6%	EPA Method 8080 A
			86.	Determination of polycyclic aromatic hydrocarbons L.D.: 0.001mg/kg U: 12.18%-27.71%	EPA Method 8270 C
			87.	Determination of polychlorinated biphenyls L.D.: 0.001mg/kg U: 9.11%-15.09%	EPA Method 8270 C
			88.	Determination of polychlorinated biphenyls L.D.: 0.0025mg/kg U: 9.83%	EPA Method 8080 A