2.2 Geology

2.2.1 Geological Units (Stratigraphy)

The geological interpretation was made based on the following sheets:

- Geological Map of Tanganyika (Scale 1:2,000,000 A.M. Quennell, Tanganyika Geological Survey, 1959)
- Geological Map, 1st Edition (Scale 1:125,000, Mineral Resource Division, Dodoma, 1966 Quarter Degree Sheet)

A simplified geological map (based on the Geological Map of Tanganyika, 1959) is presented in Figure 2.2-1 (at the end of this chapter). The geologic timetable in comparison with the geological unit in the study area is shown in Table 2.2-1.

Table 2.2-1: Geologic Timetable of the Study Area

EONS	ERAS	PERIODS	EPOCHS	EPOCKS AND ROCK FORMATION AT MWANZA AND MARA REGIONS			
				EPOCHS		Abbriviation: Formation and Rocks	
						Sediment and	Volcanic and Plutonic
Phanerozoic	Cenozoic	Quaternary	Holocene	Kainozoic	Neogene	**N**: alluvial, lacustrine, terrestrial, fluviatile, marine deposits	**Nv**: alkaline volcanics; basalt; pyroclastics
			Pleistocene				
		Tertiary	Pliocene				
			Miocene				
			Oligocene				
			Eocene		Paleogene	P: marine deposits	
			Paleocene				
	Mesozoic	Cretaceous		Mesozoic	Cretacious	C: continental and marine sediments	
		Jurassic			Jurassic	J: estuarine and marine deposits	
		Triassic			Karroo	K: continental sediments	
	Paleozoic	Permian		Paleozoic			
		Carboniferous			Bukoban	**B**: mudstone; shale and phyllite; sandstone; arkose; quartzite; congromerate; limestone	Bv: basalt and andesite
		Devonian					
		Silurian					
		Ordovician					
		Cambrian					
Pre-cambrian	Proterozoic	Ediacara or Vendian		Proterozoic			Gp: granite and granodiorite
		Neoproterozoic			Karagwe – Ankolean and Ukingan	A: phyllite; schist; quartzite; sandstone G: augen gneiss; migmatite; porphyry	**Gl**: granite and granodiorite
		Mesoproterozoic					
		Paleoproterozoic					
	Archean			Archean	Usagaran and Ubedian	X: marble; quartzite; schist and gneiss	**Gl**: granite and granodiorite
					Kavirondian	**V**: quartzite; phyllite	
					Nyanzian	**Z**: banded ironstone; meta-volcanics; schist and porphily	**Gs**: granite and granodiorite (foliated, gneissose or migmatitic
					Dodoman	**D**: schist; gneiss; quartite	
	Hadean						

* Geologic time reflects the Geological Society of America (GSA) 1999 Geologic Timescale, compiled by A.R. Palmer and J. Geissman -- S. Rieboldt, Nov. 2002

** Epochs and Rock Formation in the Mwanza and Mara regions are compiled, referring to the Summary of the Geology of Tanganyika (A.M. Quennel, A.C.M. Mckinlay, W.G. Aitken, 1956)

*** Bold abbreviation indicates the rocks observed in the study area.

In general, geological formations observed in the area can be divided into the following three units by age:

- **Precambrian plutonic, volcanic and metamorphosed rocks** (granite and granodiorite, schist, gneiss, meta volcanics)
- **Paleozoic sedimentary rocks** (Bukoban series; mudstone, shale and phyllite, sandstone, congromerate and limestone)
- **Neocene deposits** (alluvium, laterite, marine and lake origin sediments, fan and terrace deposits and volcanic rocks)

Precambrian rocks occupy about 80% of the total land area of the Mwanza and Mara regions. Out of the Precambrian rocks, plutonic rocks such as granite and granodiorite are commonly exposed in the area. The assemblage formed by Petrozoic – Archean granite and greenstone is located in the central nucleus of the country, and the so-called Tanzania Craton, surrounded by Proterozoic belts. Paleozoic (ot pre-Karroo) rocks are only found in a few areas, mostly in the Mara region. Neocene deposits are common in the surface geological observations and the sediments are chiefly distributed at the lake and riverside.

2.2.2 Geological Structures and Hydrogeology

Geological field reconnaissance in reference with the geological maps and the existing reports identified the following geological units in the study area. The geological structure will be described on the basis of the identified geological units and its hydrogeological character.

a. Precambrian Plutonic, Volcanic and Metamorphosed Rocks

a.1 Granite and Granodiolite (Gl, Gs)

The activities of the plutonic units are divided into three phases from the Proterozoic to Archean epoch. The lower synorogenic granite is foliated, gneissose and migmatic. The lower member of the units also includes metamorphosed rock such as migmatic gneiss and hornblende schist as the basement rock unit. The younger orogenic granite mainly consists of granite and granodiolite. Generally, the difference in age of the granite rocks is hardly distinguished at the outcrops, but it can be differentiated by the topographical features (elder granite is relatively flat due to the longer erosion process).

Figure 2.2-3: Granite Outcrop

The rock units are the major exposure of the Mwanza and Mara regions, and widely distributed. Aquifers are commonly found at the deep weathered crust of the mass rock joints as fissure water; therefore, lineament analysis and resistivity sounding of the granite area is important for water source identification.

However, the results of past drilling based on geophysical surveys in the area show a poor record for successful production wells.

a.2 Nyanzan System (Z)

The Nyanzan Series consist mainly of banded ironstone and metavolcanic schist and porphily, and is considered the oldest formation in the study area. Widely dispersed in the study area, the series forms higher and sharp ridges. The number of successful wells in this formation is few, but some extensive aquifers are found in some areas.

Figure 2.2-4: Gneiss with Quartz Vein

a.3 Kavirondian Series (V)

The Kavirondian Series consists of quartzite, phylite, conglomerates and volcanics but only a few outcrops are found in the area west of Serengeti and a small potion of Sengerema. The hydrogeological character is not well understood.

a.4 Usagaran and Ubedian Series (X)

The Usagaran and Ubedian Series is mainly distributed at the eastern edge of the Serengeti District. It consists mainly of metamorphosed rocks of sedimentary and volcanic origin.

b. Paleozoic Sedimentary Rocks

b.1 Bukoban System (B)

The Bukoban System consists of sedimentary rocks such as sandstone and shale. The rock is basically named at Bukoba and Karagwe, and the distribution of this formation in the area is very minimal, at the boundary of the Tarime, Serengeti and Musoma Districts.

c. Neocene Deposits

c.1 Unconsolidated – Semi Consolidated Sedimentary Deposit (N)

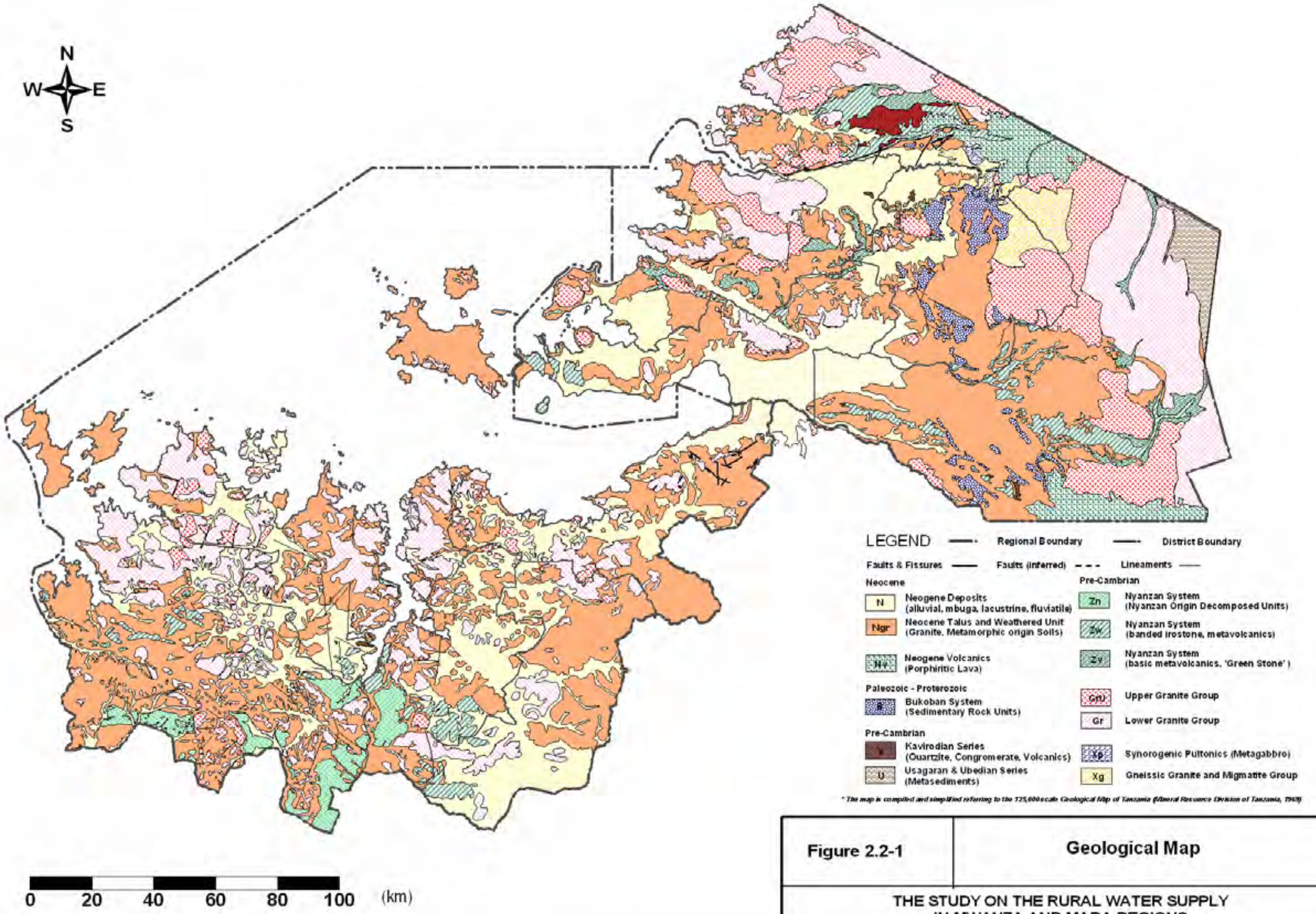
The sediments consist of sand, silt and gravel, but their origin is not identified due to the similarity of the supplied material of the sediments. The unit is exposed most significantly in western Bunda, north Tarime and south Kwimba. A portion of the Neocene Deposit has some shallow aquifers with good yield, but with reference to hydrogeological studies conducted by SIDA (Water Master Plan for the Mara, Mwanza and West Lake Regions, Final Report Volume 6, Hydrogeology Studies, United Republic of Tanzania, SIDA, Brokonsult AB, 1973), few areas could be targeted for potential portable water extraction due to the fine grained nature of the deposits.

Therefore, the unit was not considered as a high potential aquifer, but the possible target area shall be examined through the well inventory survey, and drilling and pumping tests conducted in this study program. The area is mainly composed of the Precambrian Plutonic Units, and laterites are widely distributed on the surface. Some of the granular terrace deposits around the granite forms potential shallow unconfined aquifers.

c.2 Neocene Volcanic (Nv)

The unit is distributed in parts of the Serengeti and Tarime Districts in the Mara region. Porphyritic lava sheets are developed along the fissure at the rift faulting in Tarime, and the extension of Neocene Volcanics is distributed between Lake Eyasi and Lake Natron. The wide lava plain was formed in the Serengeti area called the Serengeti Plain. The volcanic rock is composed of basalts, phonolite, trachyte and pyrocrastics.

The past drilling program revealed that potential deep aquifers exist in the Serengeti Plain, as well as some springs. However, the water is generally trapped in the fissures in the rock units, and the distribution is not well identified in the area.



* The map is compiled and simplified referring to the 125,000 scale Geological Map of Tanzania (Mineral Resource Division of Tanzania, 1969)

Figure 2.2-1 Geological Map

THE STUDY ON THE RURAL WATER SUPPLY
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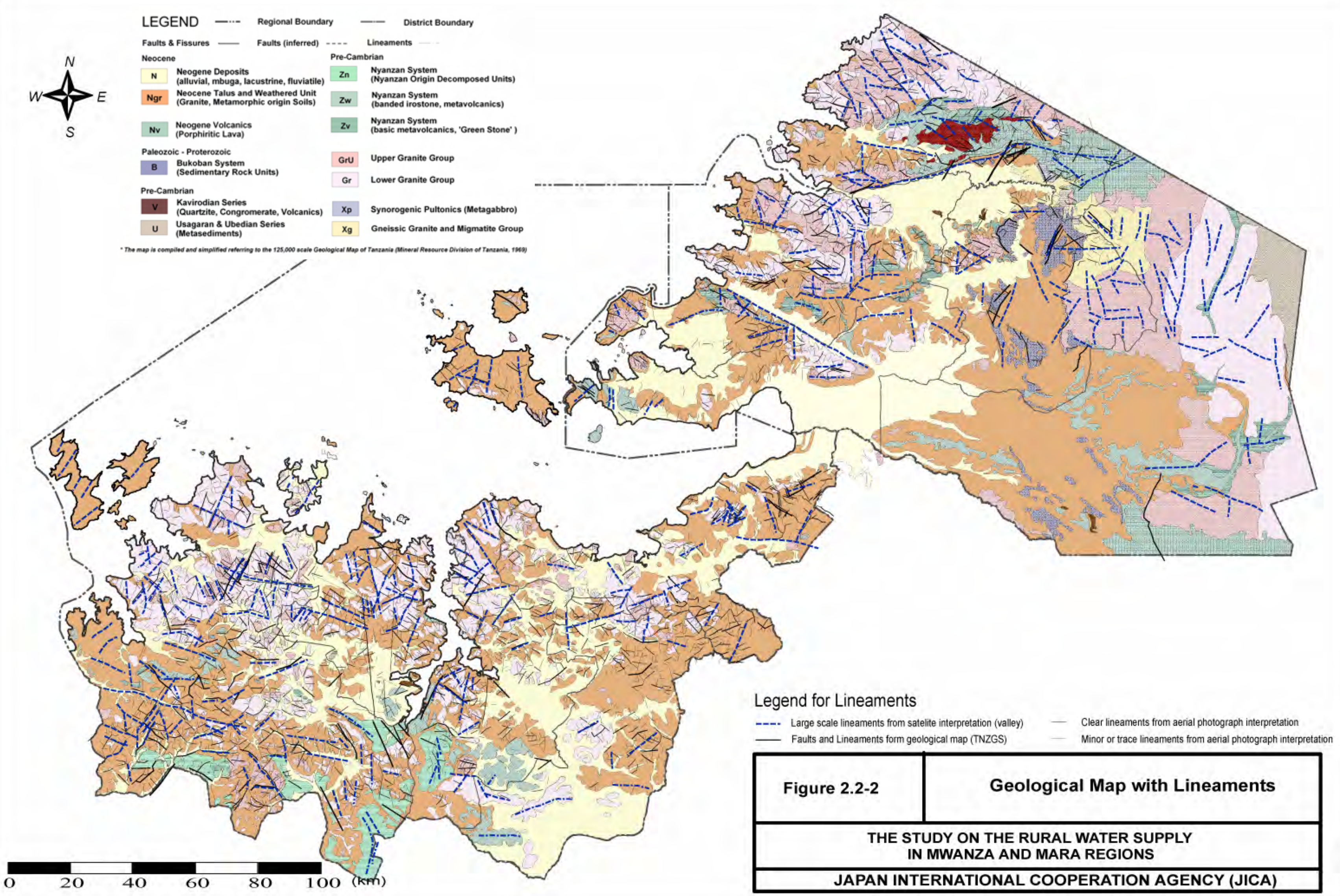

Figure 2.2-2 **Geological Map with Lineaments**

**THE STUDY ON THE RURAL WATER SUPPLY
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Chapter 3

Water Resources and Water Supply System Survey

3 Water Sources and Water Supply System Survey

3.1 Well Inventory Survey

The objective of the well inventory survey was to collect hydrogeological information on the study area. The survey items were the location of the well, the well specification (such as depth, diameter, well identification number, construction year, water levels and yield) and its water quality (pH, temperature, EC and ORP).

In addition to the well related data, village profiles on the selected villages were also conducted. The general village profiles were mainly targeted to achieve the main water source of the respective villages, its use, the structure of the organization in regard to the O&M for their water supply and, most importantly, the location of the villages.

3.1.1 Selection of Wells in the Villages

The selection of wells in the villages was based on existing data and reports containing general information on existing drilled holes in the study area.

The most updated borehole catalog (from 1999 to 2004) was found in DDCA. The catalog includes data on 82 drilled holes in the Mwanza region and seven holes in the Mara region. However, the coordination of the drilled holes is not indicated.

Therefore, with reference to the wells and boreholes listed in the 929 village lists, well records in the regions and districts were also referred to with the assistance of the counterpart staff and the engineers in the Local Government Units.

Table 3.1-1 presents the number of wells surveyed in the study.

Table 3.1-1: Number of Wells Surveyed

Region	District	Surveyed Villages	Functional Wells from List		Surveyed Wells	
			SW	BH	SW	BH
Mwanza	Misungwi	17	36	12	10	5
	Sengerema	76	95	3	4	2
	Kwimba	41	35	41	10	14
	Magu**	31	84		17	8
	Geita	64	35	41	2	21
	Ukerewe	35	65	0	19	0
	Nyamagana & Ilemela	5	5	0	1	0
Sub Total of Mwanza		263	272	99	62	50
Mara	Bunda	28	36	3	17	0
	Musoma	68	65	13	51	1
	Tarime	129	134	14	22	11
	Serengeti	27	35	11	10	5
Sub Total of Mara		262	270	41	100	17
Total		515	542	140	162	67

** The list for Magu did not divide SW and BH and the number of wells not functioning. The number was not included in the total.

A total of 515 villages were selected to conduct the survey of both shallow wells and deep boreholes. The total number of surveyed shallow wells is 162 and that of boreholes is 67.

The total number of surveyed wells is small due to the limited number of holes, even though a total of 515 villages were visited. Most of the wells existing in the villages were unprotected hand-dug wells (361 wells), which are categorized nearly equal to surface water. In addition, most of them were dry and the well specification could not be obtained.

The number of existing and measurable boreholes was very few in the area, due to reasons such as not being able to open the pump house and dry holes. Therefore, not all of the surveyed holes were measurable.

3.1.2 Survey Items in Questionnaire

The survey items of the well inventory survey are classified into two major categories:

a. General village information regarding the water source, its use and maintenance

b. Specific well inventory survey

The survey was conducted mainly in the company of a district official, and interviews with the village officer were followed by the individual well inventory survey.

a. General Village Information

Due to the limited information concerning the villages on the submitted list from the Tanzanian government, and little knowledge of the profiles of the villages by the concerned local government officials, it was decided that general profiles of the villages would be collected at the same time of the well inventory survey. The following items were surveyed in the village.

1) Village Location

The village location was estimated using the topographical map during the preparation stage; it was essential to determine the location of villages using GPS and the topographical map. The location was pointed at the location of the village center, where the village office exists, by UTM coordinates with Easting and Northing.

2) Water Source Information

This item is to identify the main water sources that the village depends on. The number of water sources, its use and the water quality were identified.

- Water sources (dug wells, shallow wells, borehole wells, springs, dams, lakes and others)
- Water use (drinking, cooking, washing, bathing, agriculture, livestock and others)
- Condition of water (quality (good or bad) and water supply duration (every day, seasonal)

3) Organization for the Water Source

This item is to understand the organization structure for the water supply system, and the O & M condition of the village.

- Organization and funds prepared for water supply (existence of village water committee, availability of village water fund (amount of the fund if applicable), number of water users groups, number of non-functional water users groups)
- The organization in charge of repairs of the water supply facility (village government, village water committee, water users association, water users group, nobody, DWE, etc.)
- The organization responsible for daily maintenance (village government, village water

committee, water users association, water users group, nobody, DWE, etc.)

- Water charge
- Fund raising method (pay bucket, monthly contribution, Ifoghongo, fines/penalty, collection of charges when the facility breaks down, etc.)
- Latest fund available for O & M
- Where the money is saved (bank account, person, etc.)

b. Well Inventory Survey

Based on the information from local government officials, it was known that only a few functioning boreholes exist in the area. The method of finding the existing wells in the area was limited to going to the well and confirming the current status. Open hand-dug wells, which are dug by hand without any protection, were not counted as wells, as the nature of this source is similar to ponds, and it was not possible to get any specification. Some villages included open hand-dug wells, but they were marked as dug wells, not as shallow wells.

1) Well Location

The location of the well was recorded on-site by GPS and Easting, Northing on UTM and the elevation. For additional information, the distance from the center of the village (village office) was also recorded.

2) Well Specification

Referring to the well specification list possessed by DDCA, the following information was collected and measured at the site:

- Well number
- Surface protection
- Construction year
- Well depth
- Drilling diameter
- Casing diameter
- Screen position
- Depth at which water was struck
- Geology at screen depth
- Geology at surface
- Static water level
- Dynamic water level
- Yield
- Specification of the pump (type of pump, capacity)

3) Water Quality

Water samples were collected and tested for the following parameters using portable measuring instruments

- pH, temperature, electric conductivity and ORP

3.1.3 Result of the Survey

Location of surveyed villages is presented in Figure 3.1-1. The results of the survey are indicated by survey category. The general facts and findings regarding the water source, water use, and maintenance and operation are described below, and the data is tabulated in the Data Report.

a. General Village Information on Water Supply

a.1 Main Water Source in the Village

The main water sources of the surveyed villages are shown in Figure 3.1-2 and Figure 3.1-3.

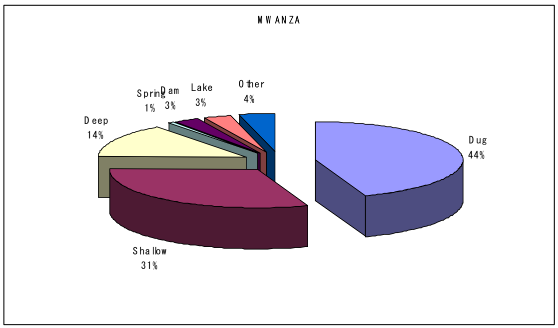

Figure 3.1-2: Water Source in Mwanza

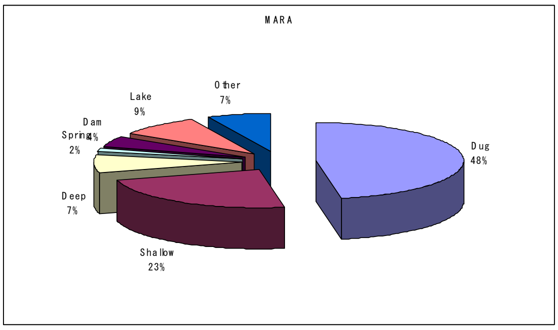

Figure 3.1-3: Water Source in Mara

The main water sources in the selected villages are dug wells and shallow wells, accounting for more than 70% of all water sources. In the Mara region, dug wells account for 48%, while only 44% in Mwanza. Mwanza uses shallow wells more than in Mara, with its proportion at 31%. The most significant difference between both regions is the proportion of deep wells, which is 14% in Mwanza and only 7% in Mara. In contrast to deep wells, lake water accounts for a much higher proportion in Mara (9%), and than in Mwanza (3%), despite the fact that the amount of coastline of the lake is much larger in Mwanza. The villages that use springs and dams as water sources are few, with these sources accounting for less than 6%. Others are mainly water from rivers, streams, and ponds and some of them are tapped water supplied by a piped scheme.

a.2 Water Use

Most of the villages use their water sources for domestic purposes, such as drinking, cooking, washing and bathing. The water sources used for agriculture and livestock vary, but according to the study a portion of the main domestic water is used for farming purposes as well. The number of wells used for various purposes is indicated in Figure 3.1-4 and Figure 3.1-5.

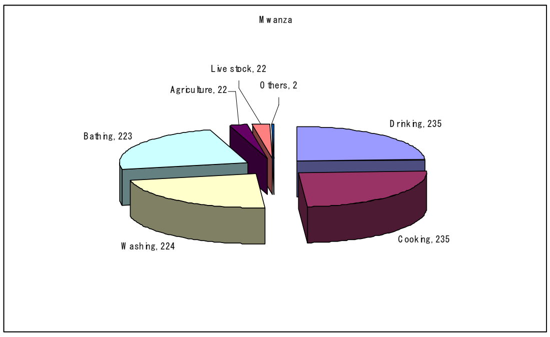

Figure 3.1-4: Water Use in Mwanza

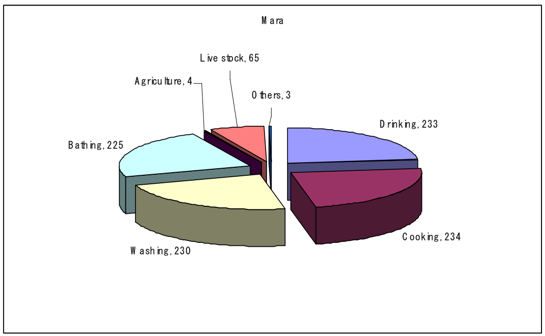

Figure 3.1-5: Water Use in Mara

a.3 Water Condition

A significant number of the 201 villages gave answers for the water quality in the study area, and 165 gave answers regarding the condition of the seasonal water availability. Figure 3.1-6 indicates the percentage of villagers who feel the water tastes good or bad. The figure shows that almost 70 % of the villages feel the taste is good, but the percentage of villagers who feel the taste is bad is higher in Mwanza than in Mara. Figure 3.1-7 presents the seasonal availability of the water. A higher proportion of Mara villages get water throughout the year compared with Mwanza.

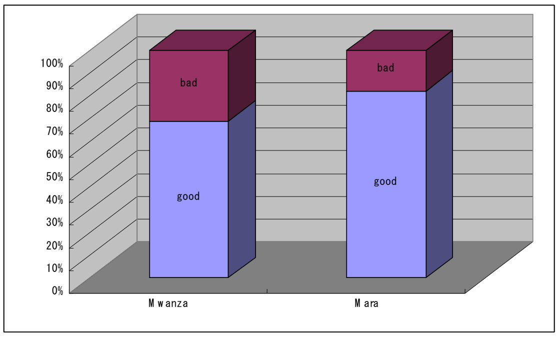

Figure 3.1-6: Water Taste

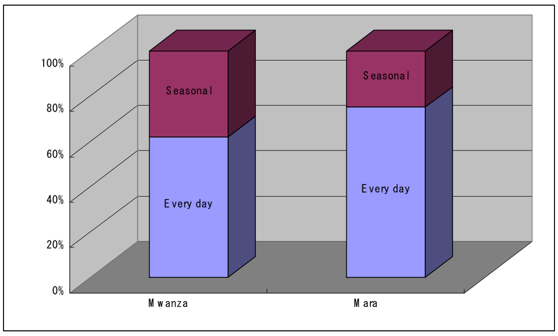

Figure 3.1-7: Water Availability through a Year

b. Well Inventory

Out of the 515 villages, the number of identified wells was 229. The wells were located by GPS, and the measurement of these wells was conducted on 162 shallow wells and 67 deep wells. The number of wells drilled in the area was no less than 500 in the two regions from the list provided by the hydrogeologist in the region, although most of them were dry or not functioning during the survey period. The location of the surveyed wells is shown in Figure 3.1-8. The composition of the surveyed wells (well numbers) by district is presented in Figure 3.1-9.

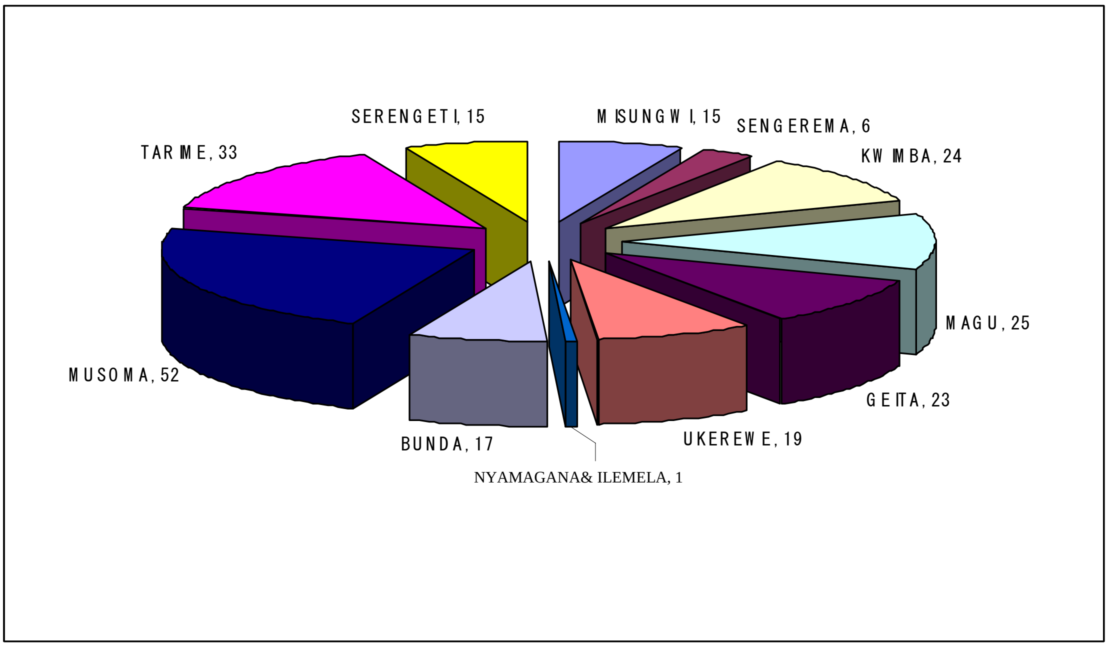

Figure 3.1-9: Surveyed Well Numbers by District

The surveyed wells do not cover all the wells in the district, but they represent the tendency of the existing wells. The total number of surveyed wells in the Mwanza and Mara regions is almost the same, being 112 for Mwanza and 117 for Mara. The maximum number is given in Musoma at 52, and the minimum of 1 in Nyamagana and Ilemela District.

Figure 3.1-10 and Figure 3.1-11 indicate the surveyed wells by district for shallow wells and deep wells respectively.

The term shallow well was defined as a well with a depth of less than 20 meters, which extracts water from a shallow unconfined aquifer regardless of its type (i.e., ring well, tube well, borehole). The term deep well was applied to wells more than 20 meters in depth, which extract water from deeper aquifers, such as fissure water and deep, confined aquifers.

The figures show the trend of the source in the district. In general, the mountainside has a greater number of deeper wells and shallower wells are at the lakeside.

In fact, coastal districts of the lake such as Sengerema, Bunda and Ukerewe have few or no deep wells surveyed, while the mountainous areas of Geita, Kwimba and Tarime have a larger number of deep wells.

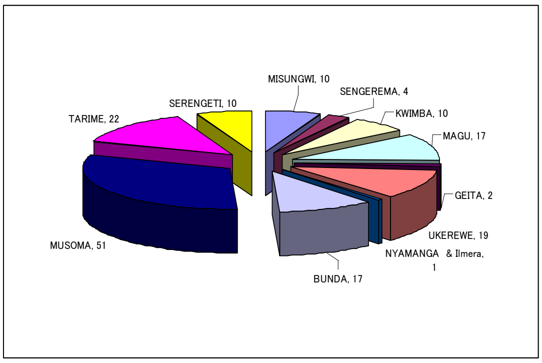

Figure 3.1-10: Surveyed Shallow Wells

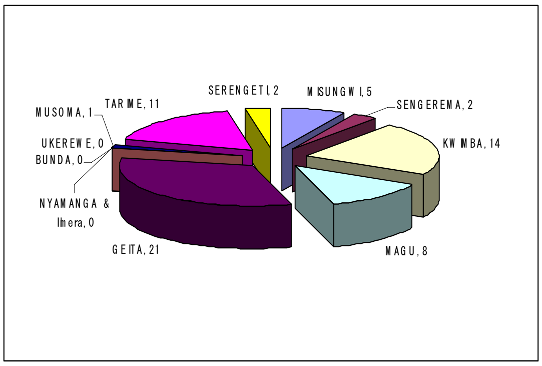

Figure 3.1-11: Surveyed Deep Wells

The following table presents the average, minimum and maximum of the parameters by shallow and deep well.

Table 3.1-2: Main Parameters of Well Inventory Survey by Shallow(S) and Deep(D) Well

	Depth		SWL		Yield (l/m)		pH		EC	
	S	D	S	D	S	D	S	D	S	D
Average	8.9	56.5	3.4	15.3	35.3	52	6.98	7.04	331	77
Min	3	20	0.1	0.7	0.03	0	2.2	4.96	0.4	1
Max	19	100	10.3	57.4	448	381	10.2	8.13	7170	850

Yields and pH show a similarity in both types of wells, but the EC level indicates a relatively higher value in the shallow wells.

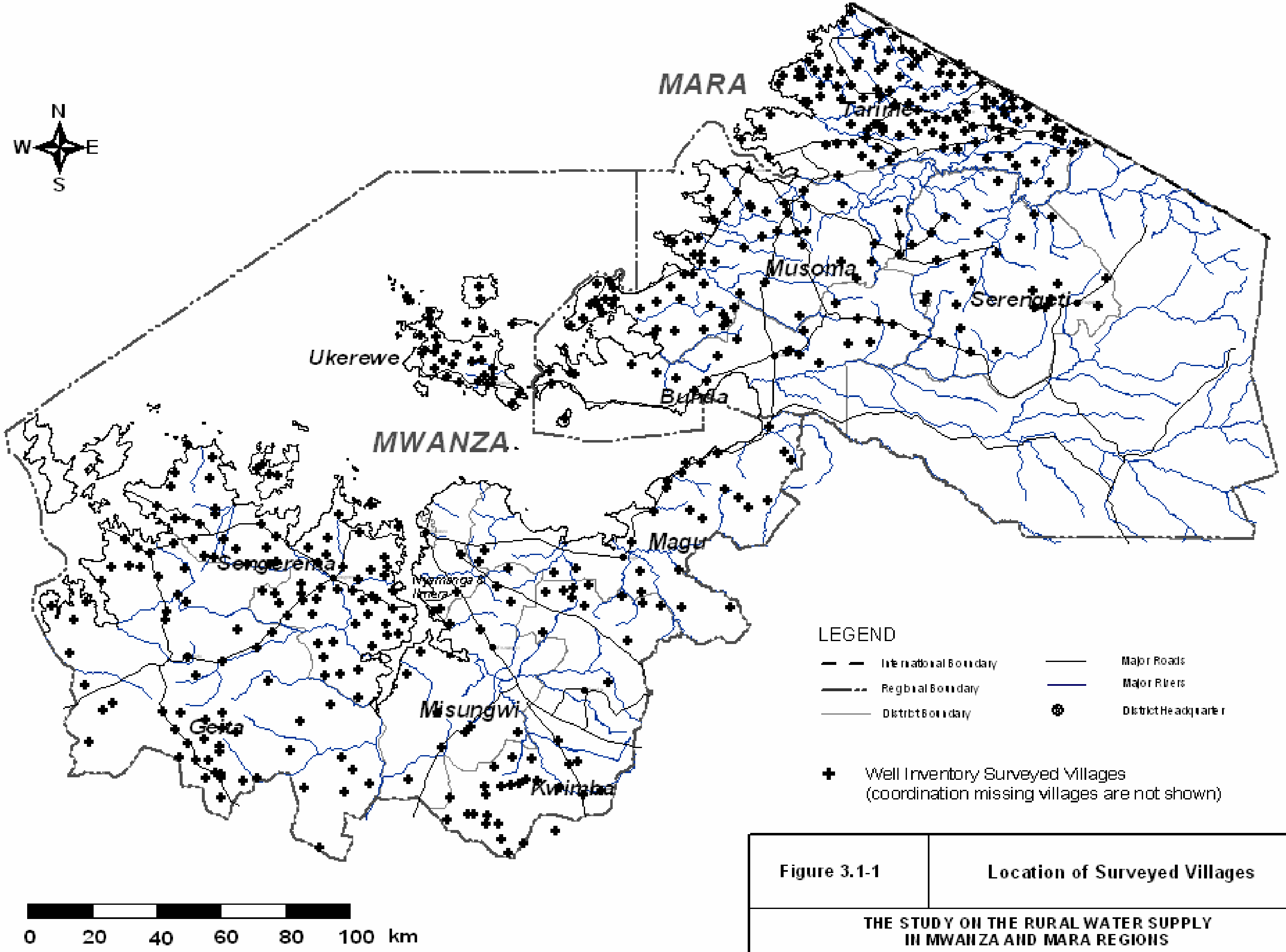

Figure 3.1-1 **Location of Surveyed Villages**

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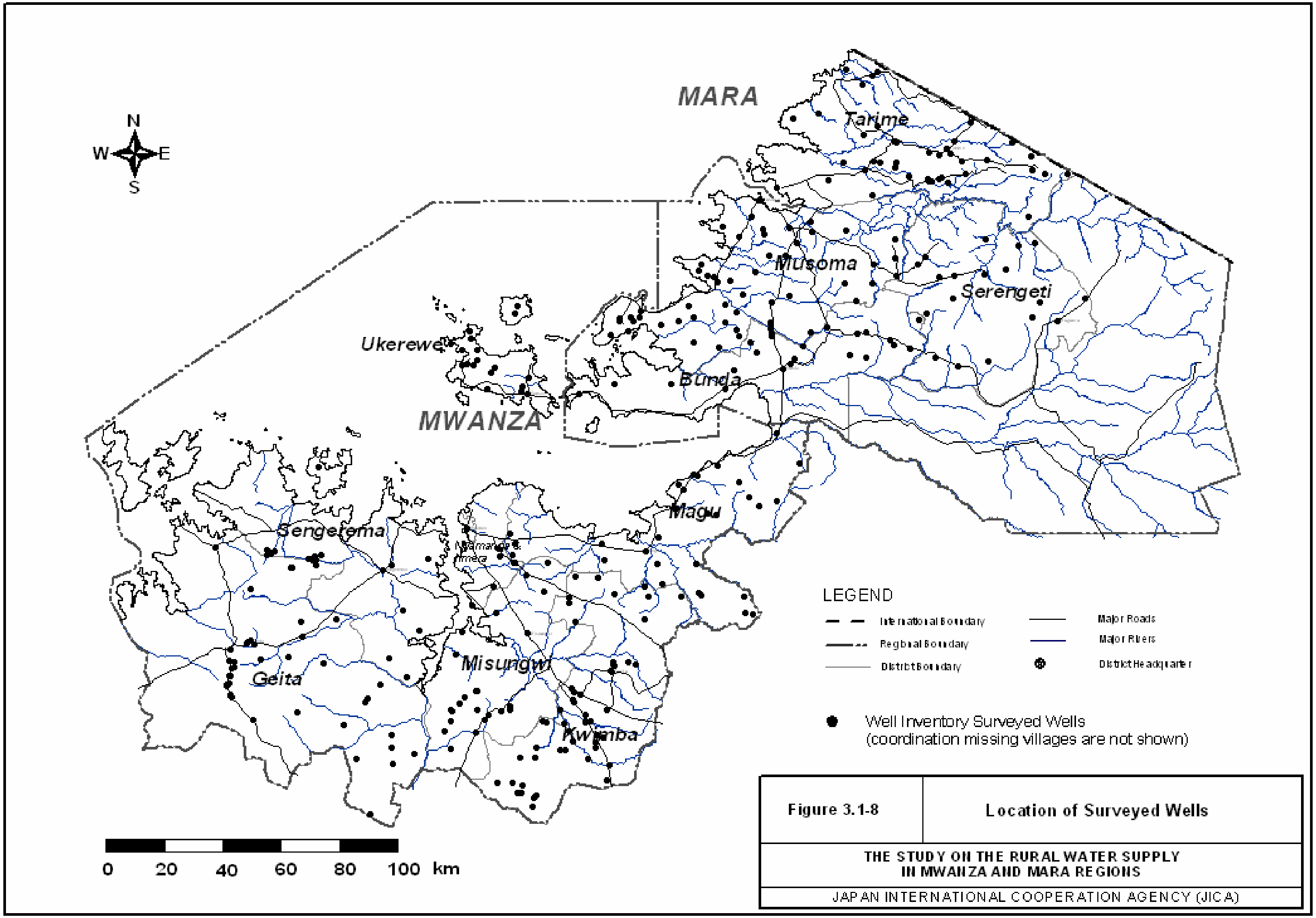

Figure 3.1-8 **Location of Surveyed Wells**

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3.2 Water Quality Survey (Two stages)

Water quality analysis was conducted on groundwater and surface water (lake water, river water, pond water, dam water, etc.) to confirm the nature and safeness of the water for potable purposes. In addition to examination of the safety of the water, the quality was examined to determine whether there is a seasonal fluctuation during a year.

3.2.1 Determination of the Water Quality Survey Points

The water samples are taken from locations which represent the respective water sources by area, considering the following aspects by water source. The location of the respective sampling points is presented in Figure 3.2-1and listed in Table 3.2-1.

a. Groundwater (30 samples+10 samples from test well):

Groundwater samples were taken from a total of 30 points which satisfy the following:

- From the existing boreholes distributed in the districts of Misungwi, Sengerema, Kwimba, Geita, Magu in Mwanza Region, and Bunda, Musoma, Tarime and Serengeti Districts in Mara Region to assess the groundwater quality by district.
- From the existing boreholes distributed in the River Basin of Magogo/Moame, Nyaruhwa, Simiyu, Suguti, 3 South Shore Streams, Isenga, Mori, Gurumeti and Mara to assess the tendency of the groundwater by River Basin
- From the existing boreholes drawing from representative shallow and deep aquifers by the aquifers in granite, Neocene deposits (basically shallow wells of which the aquifer is in decomposed granite, alluvium) and some other geological formations (i.e., meta volcanic and metamorphic rocks).
- From the test boreholes made in this study to collect further water quality information together with the existing boreholes.

b. Lake Water (12 samples)

The lake water samples were taken along the coast of the lake in the districts of Mwanza, Sengerema, Geita, Magu and Ukerewe in Mwanza Region and Tarime, Musoma and Bunda in Mara Region.

The respective points were in locations where the target villages concentrate close to the lake, and at possible intake points for the water supply facilities. It should be noted that the points were determined not only in view of the water supply, but also to know the general condition of lake water at the lake shore in order to investigate the degree of pollution.

c. River Water (5 samples)

River samples were taken in order to examine the water quality of the respective rivers in the two regions.

However, even at the end of the wet season, sampling points were limited to water-bearing rivers distributed in the northern part of the two regions. Samples were taken from the Simiyu, Mbarageti, Gurumeti, Mara and Mori rivers, which represent the River Basins of Simiyu, Mbarageti, Grumeti, Mara and Mori respectively.

d. Scheme (15 samples)

Water samples were taken from the outlets of pipe distribution systems to examine the water distributed after treatment. However, not all of the treatment plants are functional. The original water sources of the sampled water are lakes, dams, springs and boreholes.

e. Pond (6 samples)

Some samples were taken from ponds or so-called charcoal dams. The water is mainly used for agricultural purposes, but is also used as potable water.

3.2.2 Methodology and Water Quality Items

The water quality survey consists of water sampling at the site, and laboratory tests. The sampling schedule was divided into four phases, I, II, III, IV, of which phase I and IV and phase II and III represent the analysis value in the wet and dry season respectively.

The total number of the samples are 154, 68 samples taken in the dry season, 68 in the wet season and 18 samples from the test wells.

The schedule of the site sampling, and the methods and standards used in the site analysis and laboratory analysis are described below.

a. Water Sampling Schedule

The site sampling was initially planned to be conducted in two phases. Representative sampling in the wet season was to done at the end of the wet season, which is the end of May to early June (phase I, a total of 65 samples), and sampling in the dry season was to be done in early September (phase II, a total of 65 samples).

The water samples from the test drilling wells were also to be collected in September (a total of 10 samples) and November, which represent the dry and wet seasons respectively.

However, due to bad weather at several locations and terrible road conditions, the site sampling in the wet season ended with the collection of 32 samples. Also, the drilling progress was delayed due to mechanical problems with the drilling facilities. Therefore, the sampling schedule had to be modified as follows.

A total of 68 samples, 2 sites from Lake Victoria and 1 site from dam/pond were selected to supplement the initial 65 sampling points.

a.1 Sampling in Dry Season

A total of 30 samples were collected in early August 2005 (Phase II dry season), and the remaining 38 samples and site measurements were conducted in early September 2005 (Phase III - dry season). The second sampling from existing water sources started from the beginning of September, which represents water quality in the dry season.

a.2 Sampling in Wet Season

A total of 32 samples were collected in early June 2005 (Phase I – wet season), and the remaining 36 were collected in October 2005 (Phase IV – wet season).

a.3 Sampling of Test Drilling Well

A total of 10 test wells were drilled and a test hole in Serengeti (JT10) was a dry hole. Therefore, 9 water samples were collected at the test wells at the pumping test stage as the initial water sampling (during middle October to middle November). Other 9 samples were collected in early December.

Table 3.2-1: Water Quality Sampling Points

Type	District	Name of Location	Eastings	Northings	Elevation (m)	Source Type	SN	Well Type	Aquifer Type	River Basin	Sampling Date	
											Dry	Wet
Shallow Well	Magu	Bugatu Shallow Well	567744	9711629	1162	WELL	SW1	Shallow	N	Simiyu	16/9/2005	08/06/2005
	Magu	Malili Shallow Well	589132	9729450	1245	WELL	SW2	Shallow	Ngr	Simiyu	16/9/2005	09/06/2005
	Magu	Kitumba Shallow Well	505488	9716246	1192	WELL	SW3	Shallow	Gr	South1	16/9/2005	10/06/2005
	Sengerema	Kishinda	466964	9693320	1189	WELL	SW4	Shallow	Ngr	Nyaruhwa	09/08/2005	18/10/2005
	Sengerema	Sotta	468277	9670425	1194	WELL	SW5	Shallow	Zw	Nyaruhwa	10/08/2005	16/10/2005
	Sengerema	Buswelu Bulyaheke	436375	9711620	1211	WELL	SW6	Shallow	Gr	South3	10/08/2005	17/10/2005
	Geita	Ihaya buyaga	416201	9681812	1248	WELL	SW7	Shallow	Ngr	South3	11/08/2005	18/10/2005
	Bunda	TAMAU Borehole	594548	9766050	1146	WELL	SW8	Shallow	N	Grumeti	12/08/2005	10/10/2005
	Bunda	Nyaburundu-Kiberenge	621976	9798288	1408	WELL	SW9	Shallow	Ngr	Suguti	13/08/2005	10/11/2005
	Bunda	Ligamba A	600862	9776894	1402	WELL	SW10	Shallow	Gr	Suguti	13/08/2005	10/10/2005
	Musoma rural	Nyakiswa Shallow well	588274	9798086	1234	WELL	SW11	Shallow	Ngr(Zn)	Suguti	14/09/2005	10/12/2005
	Tarime	Mriba Medium Well	682981	9845976	1815	WELL	SW12	Shallow	Nv	Mara	15/09/2005	13/10/2005
	Tarime	Wegita shallow well	654262	9841270	1189	WELL	SW13	Shallow	Bo	Mara	15/09/2005	13/10/2005
	Misungwi	Ngaya Nyabusalu Shallow Well	487418	9686064	1141	WELL	SW14	Shallow	Gr	South2	17/09/2005	14/06/2005
Deep Well	Tarime	Roche Deep well	630323	9878022		WELL	DW1	Deep	GrU	Mori	15/09/2006	13/10/2005
	Magu	Kabila Medium Well	569354	9698628	1212	WELL	DW2	Deep	Gr/Ngr	Simiyu	16/09/2005	07/06/2005
	Magu	Nyangh'anga Med -Well	556077	9702394	1209	WELL	DW3	Deep	Gr/Ngr	Simiyu	16/09/2005	08/06/2005
	Magu	Ng'wamanyili Deep Well	560540	9730052	1140	WELL	DW4	Deep	Gr/Ngr	South1	16/09/2005	09/06/2005
	Kwimba	Ilumba Medium Well	546038	9674968	1205	WELL	DW5	Deep	Gr/Ngr	Magogo/Moame	18/09/2005	11/06/2005
	Kwimba	Pump-H Kadashi Well-Sch.	557039	9692048	1222	WELL	DW6	Deep	Gr/Ngr	Simiyu	18/09/2005	11/06/2005
	Kwimba	Gulung'wa Deep Well	504417	9634248	1190	WELL	DW7	Deep	Zw	Isanga	18/09/2005	13/06/2005
	Kwimba	Buyogo Deep Well	526865	9650558	1199	WELL	DW8	Deep	Gr/Ngr	Magogo/Moame	18/09/2005	13/06/2005
	Misungwi	Isenengeja Deep Well	483405	9644582	1184	WELL	DW9	Deep	Gr/Ngr	Isanga	17/09/2005	14/06/2005
	Misungwi	Ng'obo Shilalo Pump-H	502269	9657230	1218	WELL	DW10	Deep	Zw	Magogo/Moame	17/09/2005	15/06/2005
	Misungwi	Manawa Ng'wawile Well	488740	9640322	1229	WELL	DW11	Deep	Gr/Ngr	Isanga	17/09/2005	15/06/2005
	Serengeti	Robanda D-Well	690226	9763770	1364	WELL	DW12	Deep	Zw	Grumeti	14/09/2005	21/06/2005
	Kwimba	Lunere	529677	9657476	1162	WELL	DW13	Deep	Gr	Magogo/Moame	15/08/2005	19/10/2005
	Serengeti	Nyansurura Borehole	678249	9819114	1274	WELL	DW14	Deep	Bo	Mara	15/08/2005	14/10/2005
	Tarime	Ingri Juu D- well	629505	9859771		WELL	DW15	Deep	Gr	Mori	15/09/2005	13/10/2005
	Musoma rural	MasusuraD-well	614009	9819482	1199	WELL	DW16	Deep	Gr	Mara	14/09/2005	10/12/2005
Test Well (Deep Well)	Misungwi	Busongo	493757	9654871		WELL	JT1	Deep	GrU	Isanga	02/10/2005	04/12/2005
	Sengerema	Busekeseke	422973	9714204		WELL	JT2	Deep	Gr	South 3	20/10/2005	03/12/2005
	Kwimba	Nyamatala	534811	9704344		WELL	JT3	Deep	Gr/GrU	South 1	09/10/2005	04/12/2005
	Magu	Igekemeja	506021	9712335		WELL	JT4	Deep	Gr	South 1	06/10/2005	02/12/2005
	Geita	Ikina	424547	9646862		WELL	JT5	Deep	N/GrU	Isanga	18/10/2005	03/12/2005
	Ukerewe	Buhima	494415	9775670		WELL	JT6	Deep	Gr	Ukerewe	12/11/2005	05/12/2005
	Bunda	Mcharo	605056	9777588		WELL	JT7	Deep	Ngr	Suguti	14/10/2005	03/12/2005
	Musoma rural	Saragana	577723	9792642		WELL	JT8	Deep	Zv	Suguti	27/10/2005	01/12/2005
	Tarime	Raranya	923004	9866836		WELL	JT9	Deep	Gr	Mori	18/11/2005	01/12/2005
Piped Schime	Magu	Pump-H Lake-Vic Scheme	542118	9722418	1132	SCHEME	SC1				13/09/2005	08/06/2005
	Misungwi	Mbarika Lake-Vic Pump-H	480565	9678082	1164	SCHEME	SC2				17/09/2005	14/06/2005
	Misungwi	Usagara D-Well Pump-H	498273	9701882	1196	SCHEME	SC3				13/09/2005	16/06/2005
	Tarime	Nyandurumo Springs	656951	9847876	1179	SCHEME	SC4				15/09/2005	17/06/2005
	Tarime	Tagota Water Scheme	653454	9850024	1487	SCHEME	SC5				16/09/2005	17/06/2005
	Sengerema	Nyamazugo lake victoria	449065	9718605	1195	SCHEME	SC6				10/08/2005	17/10/2005
	Sengerema	Lumeya Lake Victoria	431437	9730040	1132	SCHEME	SC7				10/08/2005	17/10/2005
	Sengerema	Isaka Spring	419955	9723090	1182	SCHEME	SC8				10/08/2005	17/10/2005
	Sengerema	Sengerema Treated water	460245	9706688	1192	SCHEME	SC9				11/08/2005	19/10/2005
	Geita	katoma Spring	392242	9720252	1158	SCHEME	SC10				11/08/2005	18/10/2005
	Ukerewe	Murutunguru TTC	503690	9775864	1223	SCHEME	SC11				13/08/2005	10/11/2005
	Bunda	Kasahunga Lake Victoria	557846	9760878	1123	SCHEME	SC12				12/08/2005	10/10/2005
	Bunda	Guta Lake Victoria P. House	582784	9770360	1140	SCHEME	SC13				12/08/2005	10/11/2005
	Bunda	Guta After chrolination	596915	9776194	1354	SCHEME	SC14				13/08/2005	10/11/2005
	Serengeti	Msati scheme	668106	9809380	1346	SCHEME	SC15				15/08/2005	14/10/2005
Lake Victoria	Magu	Pump-H Kalemelala I Lake-Vic	582162	9746887	1145	LAKE	LV1				16/09/2005	09/06/2005
	Magu	Lake Victoria Bulima	562764	9738332	1131	LAKE	LV2				16/09/2005	09/06/2005
	Magu	Pump-H Kalemelala I Lake-Vic	552010	9728824	1141	LAKE	LV3				16/09/2005	10/06/2005
	Mwanza	Milongo Lake-Vic Mwanza	488368	9722048	1135	LAKE	LV4				19/09/2005	16/06/2005
	Tarime	Shirati Lake Victoria	611985	9873608	1137	LAKE	LV5				15/09/2005	20/06/2005
	Sengerema	Buyagu - Lake Victoria	477391	9684635	1195	LAKE	LV6				10/08/2005	16/10/2005
	Sengerema	Nyakahako	463294	9724224	1195	LAKE	LV7				10/08/2005	17/10/2005
	Sengerema	Lushamba-kanyara	414653	9748788	1135	LAKE	LV8				11/08/2005	17/10/2005
	Geita	Katoma lake victoria	394543	9724282	1195	LAKE	LV9				11/08/2005	18/10/2005
	Ukerewe	Chabilungo Lake Victoria	498296	9768158	1140	LAKE	LV10				13/08/2005	10/11/2005
	Musoma	Musoma Lake Victoria	589324	9836716	1142	LAKE	LV11				14/08/2005	10/12/2005
	Musoma rural	Bukima Lake victoria	545786	9800072	1137	LAKE	LV12				14/08/2005	10/12/2005
River	Magu	Simiyu River Bridge	551283	9715372	1134	RIVER	RV1			Simiyu	16/09/2005	10/06/2005
	Bunda	Rubana River Bunda	596710	9768052	1138	RIVER	RV2			Grumeti	16/09/2005	16/06/2005
	Tarime	Ryamisanga Mara River	608395	9831367	1136	RIVER	RV3			Mara	16/09/2005	18/06/2005
	Tarime	Randa Mori River	623590	9852126	1175	RIVER	RV4			Mori	15/09/2005	20/06/2005
	Serengeti	Ft. Ikoma River Grumeti	682678	9768180	1321	RIVER	RV5			Grumeti	14/09/2005	21/06/2005
Dam and Pond	Kwimba	Malya Dam Pump-H	558338	9669988	1240	DAM/POND	DP1			Magogo/Moame	18/09/2005	11/06/2005
	Misungwi	Misungwi Scheme Dam	510735	9685494	1234	DAM/POND	DP2			Magogo/Moame	17/09/2005	15/06/2005
	Tarime	Tagota Dam Tarime	654122	9849570	1496	DAM/POND	DP3			Mori	15/09/2005	17/06/2005
	Tarime	Nyanjage Dam / Pond	627944	9839458	1197	DAM/POND	DP4			Mori	15/9/2005	20/06/2005
	Geita	Geita Dam	412477	9680768	1238	DAM/POND	DP5			South3	11/08/2005	18/10/2005
	Geita	Nyalubele pond	466646	9655028	11558	DAM/POND	DP6			Isanga	10/08/2005	16/10/2005

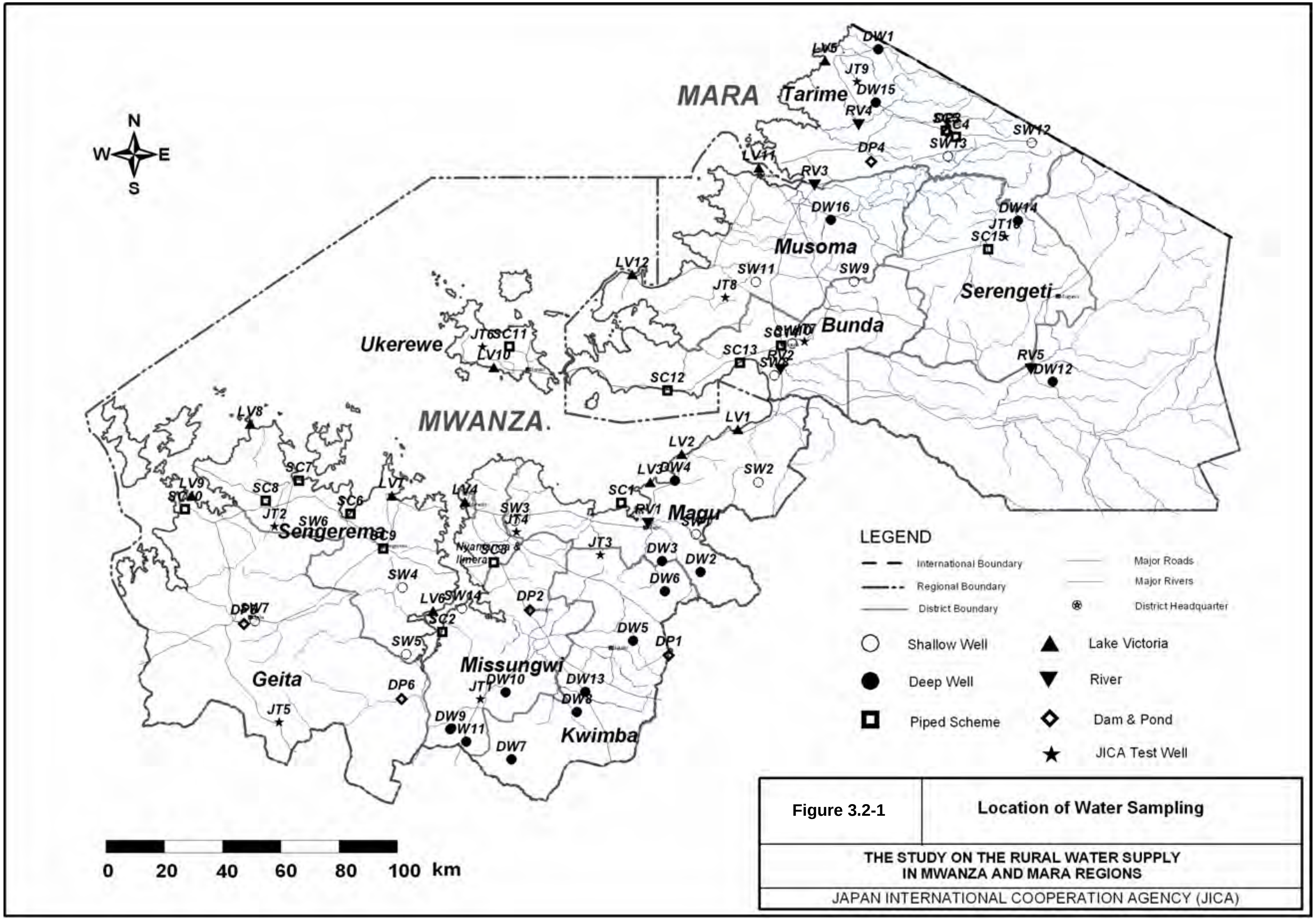


Figure 3.2-1 **Location of Water Sampling**

THE STUDY ON THE RURAL WATER SUPPLY
IN MWANZA AND MARA REGIONS

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

b. Field Water Quality Measurement

The 14 parameters for on site water quality measurements are as follows:

Water temperature, electric conductivity (EC), pH, oxidation-reduction potential (ORP), Fe, Mn, F, NO_3^-, As, NH_4^+, coliform, general bacteria, taste and odour.

Table 3.2-2 shows the specification of the field measurement.

Table 3.2-2: Specification of the Field Measurement

Item	Equipment	Measurement Range	Remark
Water Temperature	Thermometer	0 ~ 99 ℃	Accuracy: 0.1℃
EC	EC meter	0 ~ 19.99 S/m	Error: 0.5%
pH	pH meter	0 ~ 14	Accuracy: 0.01 pH
ORP	ORP meter	0 ~ ±1999 mV	Error: ±2 mV
Iron (Fe)	Pack test	0.05 ~ 2 mg/L	Influenced by a little contents of copper, etc.
	Pack test	0.2 ~ 10 mg/L	Influenced by a little contents of Chromium, Mercury, etc.
Manganese (Mn)	Pack test	0 ~ 20 mg/l	Not influenced by the coexisting materials
Fluoride (F)	Pack test	0 ~ 5 mg/l	Influenced by a little contents of iron, phosphate, etc.
Nitrate (NO_3)	Pack test	0.23 ~ 10 mg/L as NO_3-N (1 ~ 45 mg/L as NO_3)	Not influenced by the coexisting materials
Ammonia (NH_4)	Pack test	0.08 ~ 4 mg/L as NH_4-N (0.1 ~ 5 mg/L as NH_4)	Influenced by a little contents of iron, etc.
Arsenic	AAN-Hironaka type Field Kit	0.00 ~ 1.00 mg/L	Error may occur at low level (0.01~0.05 mg/L)
Coliform	Pack test		
General bacteria	Pack test		

c. Laboratory Analysis

In the laboratory, the following 40 parameters were analyzed for each sample:

Coliform group, coliform （E.Coli or heat-resistant coliform bacteria）, Pb, As, Se, Cr, Cn, Cd, Ba, Hg, F, NO_3^- , color, turbidity, pH, total filterable residue (TFR), total dissolved solids (TDS), total hardness ($CaCO_3$), Ca, Mg, SO_4^{2-}, Cl^-, Fe, Mn, Cu, Zn, BOD, Oxygen as $KMnO_4$, ammonia (NH_3＋NH_4^+), Bo, Ni, Mo, NO_2^-, residual chlorine, Na^+, water temperature, EC, K^+, HCO_3^- , Total Phosphorus (TP).

Total Suspended Solids (TSS) was measured instead of TFR, as TFR and TDS indicate similar meaning values despite a different method of analysis.

The parameters analyzed were considered from the drinking water standards of Tanzania, and major ions which may affect human health.

The standard method used, the measurements and the accuracy (effective digits) are specified in Table 3.2-3 at the end of this section.

3.2.3 Description of Water Quality Items

Tanzania has its own drinking water standard which is shown in the STANDARDS OF QUALITY OF DOMESTIC WATER IN TANZANIA. In addition, TZS 574 (Part 1) (– Drinking Water – Specification Part 1: The requirements for drinking water and bottled drinking water) was established in 1999. In 2004, WHO published the Guidelines for Drinking-water Quality (Third edition). The Tanzanian standard and the WHO guideline values for drinking water are shown in Table 3.2-4.

Table 3.2-4: Water Quality Standards

Group		Parameter		Unit	Tanzanian Standards		TZS 574	WHO Guideline (2004)	
					AllowableValue	UpperLimit	GuidelineValue	GV (*1)	ACV (*2)
Substances listed in Tanzanian Standards	1. Bacteri-ological	Coliform	CT	MPN/100ml	0	1 - 3	0	0	-
		Escherichia coli	E-coli	MPN/100ml	0	0	0	0	-
	2. Toxic Substances	Lead	Pb	mg/l	0.05	0.10	0.05	0.01	-
		Arsenic	As	mg/l	0.05	0.05	0.05	0.01 (P)	-
		Selenium	Se	mg/l	0.01	0.05	0.01	0.01	-
		Chromium	Cr	mg/l	0.05	0.05	0.05	0.05 (P) (*3)	-
		Cyanide	Cn	mg/l	0.10	0.20	0.01	0.07	-
		Cadmium	Cd	mg/l	0.01	0.05	0.005	0.003	-
		Barium	Ba	mg/l	1.00	1.00	1.00	0.7	-
		Mercury	Hg	mg/l	n.m	n.m	0.001	0.001 (*4)	-
		Silver	Ag	mg/l	n.m	n.m	-	-	-
	3. Affecting Human Health	Fluoride	F	mg/l	1.50	8	1.5	1.5	-
		Nitrate	NO_3	mg NO_3/l	30.0	100	10	50 (*5)	-
	4. Domestic Use Concerning Items	Color		TCU	15	50	15	-	15
		Turbidity		NTU	15	30	5	-	5
		Taste		dilution (*7)	n.o	n.o	n.o	-	-
		Odour		dilution (*7)	n.o	n.o	n.o	-	-
		pH			6.5 - 8.5	6.5 - 9.2	6.5 - 8.5	-	-
		Total Filterable Residue		mg/l	1,500	2,000	-	-	-
		Total Dissolved Solids	TDS	mg/l	-	-	1,000	-	1,000
		Total Hardness	($CaCO_3$)	mg/l	500	600	500	-	-
		Calcium	Ca	mg/l	200	300	250	-	-
		Magnesium	Mg	mg/l	150	100	100	-	-
		Magnesium+Sodium SO_4		mg/l	1,000	1,000	-	-	-
		Sulfate	SO_4	mg/l	400	600	400	-	250
		Chloride	Cl	mg/l	250	800	250	-	250
		Iron	Fe	mg/l	0.3	1.0	0.3	-	0.3
		Manganese	Mn	mg/l	0.1	0.5	0.1	0.4 (C)	0.1
		Copper	Cu	mg/l	1.5	3.0	1.0	2 (*8)	1
		Zinc	Zn	mg/l	5.0	15.0	5.0	-	3
		Biochemical Oxygen Demand	BOD	mg/l	6.0	6.0	-	-	-
		Oxygen abs $KMnO_4$		mg/l	10.0	20.0	-	-	-
		Ammonium (NH_3+NH_4)		mg/l	0.5	2.0	0.5	-	1.5
		Total Nitrogen (Excluding NO_3)		mg/l	0.1	1.0	-	-	-
		Surfactants		mg ABS/l	1.0	1.0	-	-	-
		Organic Matter (As Carbon in Chloroform)		mg/l	0.5	0.5	-	-	-
		Phenolie Substances (As Phenol)		mg/l	0.002	0.002	-	-	-
Substances not listed in Tanzanian Standards	5. Substances Setted WHO-GV	Boron	B	mg/l	-	-	-	0.5 (T)	-
		Nickel	Ni	mg/l	-	-	-	0.02 (P)	-
		Antimony	Sb	mg/l	-	-	-	0.02	-
		Molybdenum	Mo	mg/l	-	-	-	0.07	-
		Nitrite	NO_2	mg NO_2/l	-	-	-	3 (*5)/ 0.2 (P) (*6)	-
	6. Substances Setted WHO-AV	Residual Chlorine	Cl	mg/l	-	-	-	-	0.6 - 1.0
		Hydrogen Sulfide	H_2S	mg/l	-	-	-	-	0.05
		Alminium	Al	mg/l	-	-	0.2	-	0.2
		Sodium	Na	mg/l	-	-	200	-	200
	7. Others	Temperature	T	℃	-	-	-	-	-
		Electrical Conductivity	EC	mS/m	-	-	-	-	-
		Potassium	K	mg/l	-	-	-	-	-
		Bicarbonate	HCO_3	mg/l	-	-	-	-	-
		Total Phosphate		mg/l	-	-	-	-	-

(*1) : Guideline Value
(*2) : Acceptable Value
(*3) : For total chromium
(*4) : For total mercury (inorganic plus organic)
(*5) : Short-term exposure
(*6) : Long-term exposure
(*7) : Number of necessary dilution until taste or odor disappear
(*8) : Staining of laundry and sanitary were may occure below guideline value
(P) : Provisional guideline value, as there is evidence of a hazard, but the available information on health effectis limited.
(C) : Concentrations of the substance at or below the health-based guideline value may affect the appearance, taste, or odour of water, leading to consumer complaints.
(T) : Provisional guideline value because calculated guideline value is below the level that can be achieved through practical treatment methods, source protection etc.
n.o : not objectional
n.m : not mentioned

3.2.4 Result of Water Quality Analysis

The results of the water quality analysis in the field and laboratory are discussed below. The results of the water quality analysis by parameter are shown in the tables attached at the end of this section.

The discussions on each substance are based on the dry season to avoid confusion with the wet season, followed by a description of seasonal variation.

a. Results of Field Measurement

Table 3.2-5 shows the results of the water quality survey by field measurement. The seasonal fluctuation by the source is also indicated.

Temperature is in the range of 21.2 to 31.1 degrees (C). Most of the sources show a variation in range from 23 to 29 degrees. Water sources of deep wells indicate a maximum of 31 degrees in the wet season, which may be caused by the effect of the deep groundwater level (in general, the groundwater temperature increases about 1 degree per 100m) or some volcanic activity in the ground. However, the overall temperature is within the allowable level. Except for lake water, temperature is lower in the dry season.

Electrical Conductivity (EC, mS/m) represents the level of salinity of the water and/or other considerable elements resolved in the water. There is no standard value for the range, but in general, an EC value exceeding 3000 μ S/m is not suitable for drinking purposes.

An EC value of 49400 μ S/m is from a shallow well in Bunda, and its aquifer is in Neocene sediments. Not only this well, but most of the well sources indicate relatively high EC values of around 1000 μ S/m. This high value is mainly due to the geological background, which results in dissolved ions such as Fe, Mn and F or, marine sediments of high salinity.

Nitrate (NO_3) is harmful to human health (in the form of nitrite) if it exceeds the standard limit. The values fall under than the permissible limit of 50 mg/l, which was set by WHO (2002).

Ammonia has no immediate health relevance; therefore, no health-based guideline value is proposed. However, ammonia can compromise disinfection efficiency, result in nitrite formation in distribution systems, cause the failure of filters for the removal of manganese and cause taste and odour problems (WHO, 2004). Results from the shallow wells, dams/ponds and lake indicate a higher value of the acceptable limit (WHO Guideline, 2002) of 1.5 mg/l.

The **pH** value is in the range of the upper limit of the Tanzanian Standards for **pH** of 6.5 – 9.2, except the value of water from the schemes, shallow wells, lake and dam/pond. The pH of water from the schemes ranges from 5.5 to 10.2. Some shallow wells have a lower pH value than 6.5. The value of schemes with high or low pH shall be checked occasionally to distribute safe water.

The **oxidation-reduction potential (ORP)** is one of the parameters to indicate the oxidation condition of the water. There is no standard for this value. Relatively high values can be found in the water of rivers and schemes.

Except some wells and schemes (spring sources) **Manganese (Mn), Flouride (F) and Arsenic (As)** values fall within the Tanzanian Upper Limit.

Some of the well water indicates a higher value of **Iron (Fe)**. There is usually no noticeable taste at iron concentrations below 0.3 mg/litre, although turbidity and colour may develop.

Table 3.2-5: On Site Analysis Results

Type	District	Name of Location	SN	DRY SEASON														WET SEASON													
				Temp	EC	NO3	NH4	pH	ORP	Fe	Mn	F	As	Bacteria	Coliform	Taste	Odour	Temp	EC	NO3	NH4	pH	ORP	Fe	Mn	F	As	Bacteria	Coliform	Taste	Odour
				°C	µS/cm	mg/l	mg/l		mv	mg/l	mg/l	mg/l	mg/l					°C	µS/m	mg/l	mg/l		mv	mg/l	mg/l	mg/l	mg/l				
Shallow Well	Magu	Bugatu Shallow Well	SW1	24	1013.00	5	1.00	7.77	191	0.00	0.0	3.0	<0.01	4	5	slightly salty	Unobjectionable	26.4	9.06	5	5.00	7.13	270	0.00	0.0	1.5	<0.01	14	12	slightly salty	Unobjectionable
	Magu	Malili Shallow Well	SW2	25.2	1740.00	45	0.20	7.20	171	0.00	0.0	3.0	<0.01	7	19	Unobjectionable	Unobjectionable	26.4	177.00	45	2.00	8.6	250	0.00	0.0	1.5	<0.01	18	29	Unobjectionable	Unobjectionable
	Magu	Kitumba Shallow Well	SW3	25.8	582.00	45	0.20	6.39	88	0.00	0.0	1.5	<0.01	7	16	Unobjectionable	Unobjectionable	26.7	58.50	45	0.50	7.23	21	0.00	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Sengerema	Kishinda	SW4	27.0	653.00	20	0.20	6.71	82	0.00	0.0	1.5	<0.01	14	7	slightly salty	Unobjectionable	26.7	594.00	20	1.00	6.64	97	0.00	0.0	1.5	<0.01	8	15	slightly salty	Unobjectionable
	Sengerema	Sotta	SW5	25.8	770.00	5	0.50	7.12	32	0.00	0.0	1.5	<0.01	21	10	slightly salty	Unobjectionable	26.1	699.00	5	0.20	7.01	154	0.00	0.0	1.5	<0.01	8	14	Unobjectionable	Unobjectionable
	Sengerema	Buswelu Bulyaheke	SW6	25.3	1068.00	2	0.20	7.10	90	2.00	0.5	0.8	0.01	112	79	Unobjectionable	Unobjectionable	26.1	690.00	2	0.50	6.64	-53	0.10	0.0	1.5	<0.01	10	16	slightly salty	Unobjectionable
	Geita	Ihaya buyaga	SW7	25.2	273.00	0	0.20	6.37	50	0.00	0.0	0.8	<0.01	12	5	Unobjectionable	Unobjectionable	24.1	240.00	0	0.20	6.38	109	0.10	0.0	0.4	<0.01	7	18	slightly salty	Unobjectionable
	Bunda	TAMAU Borehole	SW8	27.8	49400.00	1	1.00	7.64	96	0.00	0.0	0.4	<0.01	8	3	Very Salty	Unobjectionable	29.6	44700.00	1	0.50	7.6	51	0.00	0.0	0.8	0.01	57	80	Very Salty	smell
	Bunda	Nyaburundu-Kiberenge	SW9	24.9	299.00	1	1.00	7.55	68	2.00	0.0	0.4	<0.01	3	0	Unobjectionable	Unobjectionable	27.4	380.00	1	2.00	6.6	-92	2.00	0.0	0.8	0.01	12	24	Unobjectionable	smell
	Bunda	Ligamba A	SW10	27.5	297.00	5	0.20	7.98	78	0.00	0.0	0.4	<0.01	12	7	Unobjectionable	Unobjectionable	28.4	225.00	5	0.50	6.03	118	0.00	0.0	0.8	0	28	39	Unobjectionable	Unobjectionable
	Musoma rural	Nyakiswa Shallow well	SW11	27.3	400.00	45	0.50	6.41	110	0.00	0.0	0.8	0.01	11	25	Unobjectionable	Unobjectionable	28.3	321.00	45	0.40	6.1	137	0.00	0.0	0.4	0.01	32	49	Slightly salty	Unobjectionable
	Tarime	Mriba Medium Well	SW12	24.2	504.00	45	2.00	6.40	84	1.00	0.0	0.4	0.01	5	14	slightly salty	Unobjectionable	23.8	427.00	45	0.50	6.2	-4	0.00	0.0	0.4	0.01	58	71	Unobjectionable	Unobjectionable
	Tarime	Wegita shallow well	SW13	27.8	2062.00	45	2.00	7.28	51	0.00	0.0	0.8	0.01	13	19	slightly salty	Unobjectionable	24.3	2160.00	45	0.20	7.23	5	0.00	0.0	0.8	0.03	42	62	Salt	Unobjectionable
	Misungwi	Ngaya Nyabusalu Shallow Well	SW14	26.1	260.00	1	0.50	7.20	241	0.10	0.0	1.5	0.01	31	49	Unobjectionable	Unobjectionable	27.3	27.00	1	0.20	7.32	202	0.50	0.0	1.5	<0.01	9	6	Unobjectionable	Unobjectionable
Deep Well	Tarime	Roche Deep well	DW1	25.3	1010.00	2	0.20	7.30	138	0.00	0.0	1.5	<0.01	4	7	slightly salty	Unobjectionable	27.9	760.00	2	0.20	7.35	2	0.00	0.0	1.5	<0.01	8	14	slightly salty	Unobjectionable
	Magu	Kabila Medium Well	DW2	24.1	751.00	2	0.20	8.13	177	0.00	0.0	1.5	<0.01	7	11	Unobjectionable	Unobjectionable	31.1	5.25	2	2.00	7.56	257	0.50	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Magu	Nyangh'anga Med -Well	DW3	24	1027.00	10	0.20	7.51	193	0.00	0.0	1.5	<0.01	13	19	Unobjectionable	Unobjectionable	26.1	14.85	10	1.00	6.52	273	0.00	0.5	0.8	<0.01	0	0	Unobjectionable	Unobjectionable
	Magu	Ng'wamanyili Deep Well	DW4	26.5	1900.00	45	0.00	7.40	166	0.00	0.0	1.5	<0.01	9	13	Unobjectionable	Unobjectionable	25.7	161.30	45	0.00	8.31	228	0.00	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Kwimba	Ilumba Medium Well	DW5	27.1	962.00	45	0.20	7.40	151	0.00	0.0	1.5	<0.01	15	28	Unobjectionable	Unobjectionable	26.1	102.70	45	0.20	7.01	55	0.00	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Kwimba	Pump-H Kadashi Well-Sch.	DW6	27.1	858.00	5	0.00	7.47	85	0.00	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable	25.9	85.90	5	0.20	7.59	19	0.00	0.0	1.5	<0.01	5	2	Unobjectionable	Unobjectionable
	Kwimba	Gulung'wa Deep Well	DW7	26.8	2330.00	45	1.00	6.70	203	0.10	0.0	1.0	0.01	5	18	slightly salty	Smell	26.3	192.40	45	2.00	6.78	138	0.50	0.0	0.4	0.01	0	0	Unobjectionable	Smell
	Kwimba	Buyogo Deep Well	DW8	27.8	860.00	45	0.20	6.60	125	0.00	0.0	1.5	<0.01	11	20	Unobjectionable	Unobjectionable	27.3	85.20	45	0.20	7.34	238	0.00	0.0	1.5	<0.01	3	2	Unobjectionable	Unobjectionable
	Misungwi	Isenengeja Deep Well	DW9	24.2	819.00	45	0.20	7.38	193	0.00	0.0	1.5	<0.01	15	27	Unobjectionable	Unobjectionable	27.8	82.40	45	0.50	7.62	224	0.00	0.0	1.5	<0.01	8	2	Unobjectionable	Unobjectionable
	Misungwi	Ng'obo Shilalo Pump-H	DW10	26.7	1419.00	2	0.50	7.31	-62	2.00	0.0	0.8	<0.01	28	43	Unobjectionable	Unobjectionable	26.2	132.90	2	0.50	7.95	175	0.00	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Misungwi	Manawa Ng'wawile Well	DW11	25.7	1059.00	20	0.50	7.01	196	0.20	0.0	1.5	<0.01	23	36	Unobjectionable	Unobjectionable	27.5	115.00	20	0.40	7.45	229	0.00	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Serengeti	Robanda D-Well	DW12	23.3	1000.00	20	0.50	7.20	277	0.50	0.0	1.5	<0.01	0	0	slightly salty	Unobjectionable	25.5	99.50	20	2.00	7.1	257	0.00	0.0	1.5	0.01	7	2	Unobjectionable	Unobjectionable
	Kwimba	Lunere	DW13	26.6	1692.00	45	0.40	7.41	241	0.00	0.0	1.5	<0.01	0	0	slightly salty	Unobjectionable	26.6	1440.00	45	0.50	7.34	12	0.05	0.0	0.8	<0.01	14	25	slightly salty	Unobjectionable
	Serengeti	Nyansurura Borehole	DW14	26.3	892.00	1	0.20	7.01	29	0.20	0.5	0.8	<0.01	0	0	Unobjectionable	Unobjectionable	25.7	824.00	1	0.20	6.99	37	0.00	0.0	0.8	<0.01	5	16	Unobjectionable	Unobjectionable
	Tarime	Ingri Juu D- well	DW15	25.5	1120.00	0	0.20	7.10	150	0.00	0.0	1.5	<0.01	5	16	slightly salty	Unobjectionable	25.7	895.00	0	0.40	6.98	113	0.00	0.0	1.5	<0.01	4	10	slightly salty	Unobjectionable
	Musoma rural	MasusuraD-well	DW16	28.5	1070.00	2	2.00	7.15	-65	0.00	0.0	1.5	<0.01	5	9	slightly salty	Unobjectionable	28.2	880.00	2	0.20	7.14	-136	0.10	0.0	1.5	<0.01	0	0	slightly salty	Unobjectionable
Test Well (Deep Well)	Misungwi	Busongo	JT1	(15.5)	96.50	20	0.00	8.50	287	0.00	0.0	1.5	<0.01	6	8	slightly salty	Unobjectionable	27.8	921.00	20	0.20	6.86	168	0.00	0.0	1.5	<0.01	14	18	slightly salty	Unobjectionable
	Sengerema	Busekeseke	JT2	(13.0)	21.10	2	0.00	7.81	337	0.00	0.0	0.0	<0.01	72	47	Unobjectionable	Unobjectionable	26.4	245.00	0	0.20	6.57	228	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable
	Kwimba	Nyamatala	JT3	(16.3)	71.50	10	0.00	7.84	315	0.00	0.0	1.5	<0.01	49	22	Unobjectionable	Unobjectionable	27.4	631.00	20	0.50	6.83	203	0.00	0.0	1.5	<0.01	7	12	Unobjectionable	Unobjectionable
	Magu	Igekemeja	JT4	(14.7)	33.20	10	0.00	7.87	327	0.00	0.0	0.8	<0.01	19	7	Unobjectionable	Unobjectionable	28	342.00	10	0.50	6.78	236	0.00	0.0	1.5	<0.01	22	29	Unobjectionable	Unobjectionable
	Geita	Ikina	JT5	(14.8)	22.00	1	0.00	7.69	328	0.00	0.0	0.0	<0.01	33	9	Unobjectionable	Smell	26.1	254.00	0	0.00	6.81	254	2.00	0.0	0.8	<0.01	19	31	Unobjectionable	Smell
	Ukerewe	Buhima	JT6	(15.3)	12.60	2	0.00	8.62	361	0.00	0.0	0.4	<0.01	55	72	Unobjectionable	Unobjectionable	26.2	117.20	1	0.00	5.5	207	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable
	Bunda	Mcharo	JT7	(15.4)	37.60	10	0.00	8.23	309	0.00	0.0	0.0	<0.01	19	3	slightly salty	Unobjectionable	26.5	967.00	1	0.00	7.23	274	0.00	0.0	1.5	<0.01	0	0	slightly salty	Unobjectionable
	Musoma rural	Saragana	JT8	(16.7)	85.80	2	0.00	7.97	301	0.00	0.0	1.5	<0.01	16	18	Unobjectionable	Unobjectionable	27.3	779.00	10	0.20	7.01	193	0.00	0.0	0.8	<0.01	8	17	Unobjectionable	Unobjectionable
	Tarime	Raranya	JT9	(19.8)	43.00	2	0.00	8.21	325	0.00	0.0	1.5	<0.01	8	43	Unobjectionable	Unobjectionable	26.5	452.00	0	0.50	6.29	66	1.00	0.0	0.8	<0.01	0	0	Unobjectionable	Unobjectionable
Piped Schime	Magu	Pump-H Lake-Vic Scheme	SC1	26.1	100.80	1	0.20	7.41	116	0.00	0.0	0.4	<0.01	19	27	Unobjectionable	Unobjectionable	26.8	44.50	1	1.00	7.87	240	0.20	0.0	0.4	<0.01	1	0	Unobjectionable	Unobjectionable
	Misungwi	Mbarika Lake-Vic Pump-H	SC2	22.5	210.00	0	0.50	6.80	238	0.05	0.0	0.8	<0.01	72	91	Unobjectionable	Unobjectionable	28.7	17.10	0	0.50	7.73	190	0.00	0.0	1.5	<0.01	17	9	Unobjectionable	Unobjectionable
	Misungwi	Usagara D-Well Pump-H	SC3	26	928.00	10	0.20	7.17	63	0.00	0.0	1.5	<0.01	0	0	slightly salty	Unobjectionable	25.8	10.50	10	0.50	7.57	214	0.00	0.0	0.4	<0.01	3	2	Unobjectionable	Unobjectionable
	Tarime	Nyandurumo Springs	SC4	21.4	199.00	5	0.20	6.81	-69	10.00	1.0	0.8	0.01	2	8	Unobjectionable	Unobjectionable	25.7	16.50	5	0.50	7.6	424	0.50	1.0	0.4	<0.01	5	3	Unobjectionable	Unobjectionable
	Tarime	Tagota Water Scheme	SC5	21.2	216.00	0	0.50	7.13	498	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable	25.1	23.00	0	0.20	6.1	530	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable
	Sengerema	Nyamazugo lake victoria	SC6	26.7	91.30	0	0.50	9.82	32	0.00	0.0	0.4	<0.01	7	2	Unobjectionable	Unobjectionable	27.5	86.10	0	1.00	8.1	10	0.00	0.0	0.4	<0.01	21	34	Unobjectionable	Unobjectionable
	Sengerema	Lumeya Lake Victoria	SC7	27.1	106.00	1	0.20	10.17	43	0.00	0.0	0.8	<0.01	7	3	Unobjectionable	Unobjectionable	27.1	90.30	1	0.20	10.1	6	0.00	0.0	0.4	<0.01	26	41	Unobjectionable	Unobjectionable
	Sengerema	Isaka Spring	SC8	25.5	45.10	0	1.00	5.83	216	0.00	0.0	0.4	<0.01	17	6	Unobjectionable	Unobjectionable	24.4	41.40	0	0.20	5.42	184	0.00	0.0	0.4	<0.01	1	3	Unobjectionable	Unobjectionable
	Sengerema	Sengerema Treated water	SC9	24.0	94.20	1	0.20	8.00	75	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable	25.5	89.80	1	0.20	8.48	396	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable
	Geita	katoma Spring	SC10	28.8	46.40	1	0.20	6.38	122	0.00	0.0	0.4	<0.01	16	8	Unobjectionable	Unobjectionable	24.1	47.00	1	0.20	6.13	125	0.05	0.0	0.0	0.01	3	6	Unobjectionable	Unobjectionable
	Ukerewe	Murutunguru TTC	SC11	26.4	61.30	20	0.50	6.30	180	0.10	0.0	0.4	<0.01	5	2	Unobjectionable	Unobjectionable	27.9	46.30	20	0.20	5.53	117	0.05	0.0	0.4	<0.01	1	3	Unobjectionable	Unobjectionable
	Bunda	Kasahunga Lake Victoria	SC12	28.0	100.50	1	0.20	8.91	19	0.00	0.0	0.4	<0.01	7	4	Unobjectionable	Unobjectionable	29.1	87.20	1	1.00	9.25	10	0.00	0.0	0.4	<0.01	38	52	Unobjectionable	Unobjectionable
	Bunda	Guta Lake Victoria P. House	SC13	28.6	95.30	1	0.50	8.28	31	0.00	0.0	0.4	<0.01	13	7	Unobjectionable	Unobjectionable	31.1	96.00	1	0.50	7.33	95	0.10	0.0	0.4	<0.01	14	23	Unobjectionable	Unobjectionable
	Bunda	Guta After chrolination	SC14	28.5	102.40	2	0.50	7.78	105	0.00	0.0	0.4	<0.01	14	9	Unobjectionable	Unobjectionable	89.4	16.00	2	0.00	7.74	16	0.00	0.0	0.8	<0.01	0	0	Unobjectionable	Unobjectionable
	Serengeti	Msati scheme	SC15	24.8	128.70	2	0.20	6.80	34	0.00	0.0	0.8	<0.01	19	10	Unobjectionable	Unobjectionable	25.3	119.10	2	0.20	6.68	107	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable
Lake Victoria	Magu	Pump-H Kalemelala I Lake-Vic	LV1	25.8	100.00	0	0.00	8.40	90	0.00	0.0	0.4	<0.01	40	57	Unobjectionable	Unobjectionable	24.0	10.80	0	2.00	8.84	234	0.00	0.0	0.4	<0.01	3	11	Unobjectionable	Unobjectionable
	Magu	Lake Victoria Bulima	LV2	28.1	100.10	0	0.50	8.90	80	0.00	0.0	0.4	<0.01	34	52	Unobjectionable	Unobjectionable	27.9	11.40	0	2.00	9.48	144	0.00	0.0	0.4	<0.01	3	1	Unobjectionable	Unobjectionable
	Magu	Pump-H Kalemelala I Lake-Vic	LV3	26.9	100.00	0	0.50	9.90	85	0.00	0.0	0.4	<0.01	29	43	Unobjectionable	Unobjectionable	24.7	13.00	0	1.00	8.66	251	0.00	0.0	0.4	<0.01	7	4	Unobjectionable	Unobjectionable
	Mwanza	Milongo Lake-Vic Mwanza	LV4	27.1	345.00	45	1.00	7.79	78	0.20	0.0	0.4	<0.01	92	116	Unobjectionable	Unobjectionable	25.6	97.50	45	1.00	7.14	205	0.00	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Tarime	Shirati Lake Victoria	LV5	27.1	110.00	0	0.20	9.30	56	0.00	0.0	0.4	<0.01	14	39	Unobjectionable	Unobjectionable	25.6	10.30	0	0.20	7.8	18	0.00	0.0	0.8	<0.01	23	11	Unobjectionable	Unobjectionable
	Sengerema	Buyagu - Lake Victoria	LV6	24.6	157.30	1	0.40	9.43	24	0.00	0.0	0.8	<0.01	14	8	Unobjectionable	Unobjectionable	28.4	143.10	1	0.00	9.15	39	0.05	0.0	1.5	<0.01	31	47	Unobjectionable	Unobjectionable
	Sengerema	Nyakahako	LV7	24.1	45.10	0	0.50	5.71	211	1.00	0.0	0.8	<0.01	9	4	Unobjectionable	Unobjectionable	22.7	38.90	0	0.20	5.71	180	1.00	0.0	0.4	0.01	19	33	Unobjectionable	Unobjectionable
	Sengerema	Lushamba-kanyara	LV8	24.1	89.40	0	0.20	8.60	83	0.00	0.0	0.4	<0.01	29	17	Unobjectionable	Unobjectionable	25.3	85.30	0	0.20	8.33	104	0.00	0.0	0.4	<0.01	56	76	Unobjectionable	Unobjectionable
	Geita	Katoma lake victoria	LV9	27.5	97.10	0	0.20	9.79	85	0.00	0.0	0.4	<0.01	29	16	Unobjectionable	Unobjectionable	25.1	87.00	0	0.20	10.05	30	0.00	0.0	0.4	<0.01	13	28	Unobjectionable	Unobjectionable
	Ukerewe	Chabilungo Lake Victoria	LV10	24.5	95.40	0	0.20	7.98	10	0.00	0.0	0.4	<0.01	12	8	Unobjectionable	Unobjectionable	25.1	69.30	0	0.20	6.79	101	0.05	0.0	0.4	0.01	17	26	Unobjectionable	Unobjectionable
	Musoma	Musoma Lake Victoria	LV11	24.0	90.50	0	0.50	8.32	34	0.00	0.0	0.4	<0.01	24	14	Unobjectionable	Unobjectionable	27.2	83.70	0	0.50	9.5	-110	0.00	0.0	0.4	0.01	32	48	Unobjectionable	Unobjectionable
	Musoma rural	Bukima Lake victoria	LV12	26.3	87.00	1	0.50	7.93	38	0.00	0.0	0.4	<0.01	37	18	Unobjectionable	Unobjectionable	24.9	77.90	1	0.20	8.34	13	0.05	0.0	0.4	0.01	89	114	Unobjectionable	Unobjectionable
River	Magu	Simiyu River Bridge	RV1	24	709.00	0	0.20	8.14	179	0.00	0.0	1.5	0.01	38	49	Unobjectionable	Unobjectionable	26.3	43.70	0	0.20	8.07	31	0.00	0.0	1.5	<0.01	49	24	Unobjectionable	Unobjectionable
	Bunda	Rubana River Bunda	RV2	24.7	200.00	0	0.50	8.20	133	0.10	0.0	0.4	0.01	19	28	Unobjectionable	Unobjectionable	28.8	20.40	0	0.40	7.35	416	0.00	0.0	0.4	<0.01	0	0	Unobjectionable	Unobjectionable
	Tarime	Ryamisanga Mara River	RV3	23.7	194.50	0	0.50	6.88	210	0.50	0.0	0.8	<0.01	21	33	Unobjectionable	Unobjectionable	26.1	19.40	0	1.00	6.7	183	1.20	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Tarime	Randa Mori River	RV4	25.6	230.00	0	0.50	7.90	116	0.10	0.0	0.8	<0.01	19	34	Unobjectionable	Unobjectionable	25.6	16.50	0	0.50	7.7	47	0.50	0.0	1.5	<0.01	0	0	Unobjectionable	Unobjectionable
	Serengeti	Ft. Ikoma River Grumeti	RV5	23.4	1340.00	0	1.00	8.90	183	0.00	0.0	1.5	<0.01	25	39	Unobjectionable	Unobjectionable	26.5	26.20	0	0.50	8	37	0.00	0.0	0.8	<0.01	0	0	Unobjectionable	Unobjectionable
Dam and Pond	Kwimba	Malya Dam Pump-H	DP1	24.3	156.00	0	0.50	7.95	124	0.00	0.0	0.8	0.01	21	37	Unobjectionable	Unobjectionable	24.4	13.40	0	0.50	8.24	13	0.00	0.0	0.4	<0.01	42	14	Unobjectionable	Unobjectionable
	Misungwi	Misungwi Scheme Dam	DP2	22.2	390.00	0	0.40	7.60	224	0.40	0.0	0.4	<0.01	56	79	Unobjectionable	Unobjectionable	25.4	30.10	0	5.00	7.32	227	0.00	0.0	0.4	<0.01	0	3	Unobjectionable	Unobjectionable
	Tarime	Tagota Dam Tarime	DP3	26.2	149.00	2	0.20	9.50	48	0.00	0.0	1.5	<0.01	20	31	Unobjectionable	Unobjectionable	28.9	10.60	2	0.50	8.9	344	0.50	0.0	0.4	<0.01	7	2	Unobjectionable	Unobjectionable
	Tarime	Nyanjage Dam / Pond	DP4	24.5	150.00	1	0.20	7.50	127	0.00	0.0	0.4	<0.01	20	39	Unobjectionable	Unobjectionable	23.3	9.30	1	0.00	7.1	66	0.00	0.0	0.8	<0.01	19	13	Unobjectionable	Unobjectionable
	Geita	Geita Dam	DP5	23.7	136.00	0	0.20	7.41	81	0.00	0.0	0.4	<0.01	31	19	Unobjectionable	Unobjectionable	24.5	129.70	0	0.20	7.69	71	0.00	0.0	0.4	<0.01	29	48	Unobjectionable	Unobjectionable
	Geita	Nyalubele pond	DP6	27.4	224.00	45	0.50	6.43	91	0.00	0.0	0.8	<0.01	19	11	Unobjectionable	Unobjectionable	28.6	133.70	45	0.20	6.32	160	0.00	0.0	1.5	<0.01	9	18	Unobjectionable	Unobjectionable

▩ > Tanzania Upper Limit
▨ > Tanzanian Allowavle Value
░ > WHO GV & ACV
▢ > Tanzanian Allowavle Value

No health-based guideline value is proposed for iron (WHO, 2004). The wells indicating higher than the figure may have turbid water.

Coliform and Bacteria are not allowed to exist based on the Tanzania (allowable value) and WHO (guideline value) standards. However, the results indicate that most surface water has coliform at a level exceeding the upper limit of 3 set by Tanzanian Standards. Wells other than deep wells are also infected with coliform and bacteria, which are at a higher level than other surface water. This is mainly due to the closed system of the well where once it is infected, it breeds within the system. The shallow wells shall be well protected to prevent contamination from coliform and bacteria.

The result of field tests indicate that **shallow wells** provide inferior water quality with higher contents of F, Fe and NH4 as well as contamination from bacteriological substances. **Deep wells** are characterized by relatively higher contents of NO3 and F compared with other water sources. These contaminated wells are mostly found in the District of Kwimba, Magu and Missungwi. Presumably the well water dissolves many ions of metals and saline substances resulting in a higher EC value.

Lake, river and pond/dam water is represented by contamination of coliform and bacteria. The values of the water from the outlet of the **scheme** vary, indicating the level of maintenance and the treatment method of the original source of respective scheme.

b. Results of Laboratory Analysis

The laboratory test results are described below. As mentioned, the results in the dry season are referred to check the individual values.

The classification of the parameters is based on the Group classified in the Tanzanian Standards. The substances showing relatively high values are compiled in maps, which are presented in the tables and figures attached in the Data Book.

b.1 Toxic Substances

Lead (Pb), arsenic (As), selenium (Se), chromium (Cr), cyanide (Cn), cadmium (Cd) barium (Ba) and mercury (Hg) are categorized as toxic substances.

Lead (Pb) is identified in the wells (3 holes Sengerema and 1 in Kwimba) and schemes (3 schemes in Sengerema and a scheme in Bunda and Ukerewe). The highest value is 0.64 mg/l in the shallow well of Sengerema, while the WHO guideline value is 0.01mg/l.

High **Cadmium (Cd)** content was identified in the Bunda shallow well with a value of 0.58 mg/l, while the WHO guideline value is 0.003 mg/l (0.05 mg/l for the upper limit of the Tanzanian Standard.

Three shallow wells in Magu, Sengerema and Bunda have a relatively high **Barium (Ba)** content (3.0, 2.0 and 4.0 mg/l respectively) which exceeds the Tanzanian Standard (allowable value, upper limit and guideline) of 1.0 mg/l (WHO guideline value is 0.7 mg/l).

Mercury (Hg) is identified in the Kwimba deep well and the rivers of Mara and Serengeti. The basement rock units (Pre-Cambrian) are affected by several hydrothermal activities. Therefore, there are a lot of mine activities extracting ores from the concentration of the minerals such as Gold and Silvers. Presumably, the content of Hg is due to concentration in the local portion of the mineralized rocks. Hg is also used for the separation process of gold from other minerals (amalgam). There are some gold deposits and gold mines upstream from the Mara River, The content of the toxic substances shall be monitored in the rivers with toxic substances.

The **Arsenic (As), Selenium (Se), Chromium (Cr), Cyanide (Cn)** content is low or less than the detectable limit of the analysis.

b.2 Substances Affecting Human Health

Fluoride (F) and nitrate (NO_3) fall into this category. The effect of fluoride is mainly health problems associated with the condition known as fluorosis, which may occur when fluoride concentrations in groundwater exceed 1.5 mg/L.

Laboratory testing of **Fluoride (F)** detected much higher values compared with the field pack tests mentioned in subsection “a. Results of Field Measurement”. Although all values are less than the upper limit of 8 mg/l (Tanzanian Standards), 5 boreholes exceed the guideline value of 1.5 mg/l (WHO, allowable value of Tanzanian Standard). The high fluoride boreholes include three deep wells in Kwimba, two shallow wells in Sengerema, The river sample from Simyu also shows a high value of fluoride. In general, the fluoride content is relatively high in well water (above 1.0 mg/l) especially in the districts of Kwimba, Magu and Sengerema.

Nitrate (NO_3) of a shallow well exceeds the upper limit set by the Tanzanian Standard (100 mg NO_3/l) but most of the test results indicate a value lower than the upper limit. However, applying the WHO guideline value (50 mg NO_3/l, short-term exposure), two shallow wells in Musoma and Tarime fall above the standard value.

In conclusion, wells with higher fluoride and nitrate content exist mostly in the Magu and Kwimba Districts. The background of the groundwater itself indicates a relatively high concentration of fluoride. In contrast, surface water, excluding water from the Simiyu River, has a relatively low value of fluoride and nitrate.

b.3 Substances Concerning for Domestic Use

Color and Turbidity mostly do not satisfy the standards. Applying a standard of 15 TCU for color, and 5 NTU for turbidity, river samples have extremely high turbidity with a maximum of 584 TCU and 164 NTU in color. Some shallow wells, parts of the lake and ponds/dams also show high values.

The values are at an allowable level for drinking water and have no direct affect on health, but the villagers in the study area only accept this water because of the poor availability of pure drinking water.

Odour and Taste are basically tested in the field sampling phase. With some exception of salty or slightly salty taste, most of the samples are within an unobjectionable level.

There are no health-based guidelines for **Total Dissolved Solids (TDS).** A TDS level of less than 600 mg/l is generally considered to be good; drinking-water becomes significantly and increasingly unpalatable at TDS levels greater than about 1,000 mg/l (WHO).

Some of the values in the wells exceed the level of 600 mg/l but all the samples are at an acceptable level of less than 1,000 mg/l.

The degree of **total hardness** of water may vary considerably to the consumers and the domestic water source. The surface water in the study area indicates less than 100mg/l of total hardness and is identified as “soft water”. In contrast, the well water exceeds 200mg/l. The values indicate less than 500mg/l in general (Tanzanian Standard – allowable level), except for two boreholes in Kwimba and Bunda.

The **Chloride (Cl)** content is relatively high in the water from boreholes, and some exceed the acceptable value of 250 mg/l (WHO). The **Iron (Fe)** content is high in the boreholes as well, compared to surface water such as lakes and rivers. Some of the values indicate more than 5mg/l, while the acceptable WHO value is 0.3 mg/l. **Manganese (Mn)** values are mostly lower than 0.1 mg/l (acceptable level by WHO) with three exceptions, i.e. two boreholes and one scheme. The **Copper (Cu)** content is mostly below the detectable limit and most of the values are less than 1 mg/l (acceptable level by WHO). All values of **Zinc (Zn), Nickel (Ni) and Molybdenum (Mo)** are less than the acceptable value of 1 mg/l (WHO).

BOD is an indicator for the presence of biodegradable organic matter in a sample of water. It can be used to infer the general quality of the water and its degree of pollution. Lakes, schemes, rivers, and ponds/dams exceed the allowable value of 6.0 mg/l, and some shallow boreholes exceed the value.

Boron (Bo) is found naturally in groundwater, but its presence in surface water is frequently a consequence of the discharge of treated sewage effluent, which arises from the use of some detergents, into surface waters. The WHO guideline value is 0.5 mg/l (guideline value). Water from the Rubana and Ryamisanga Rivers, and shallow wells in Misungwi exceed the guideline value, which may indicate the affect of detergents. However, the deep borehole in Kwimba shows 0.99 mg/l of Boron, and may be due to a high content in the groundwater.

If an excess of **phosphate (PO_4)** enters a waterway, algae and aquatic plants will grow wildly, choke up the waterway and use up large amounts of oxygen. This condition is known as eutrophication or over-fertilization of receiving waters. There is no guideline indicated in the standards. In general, water from rivers, wells and ponds/dams rather than lake water which may indicate less affect of the fertilizer.

3.2.5 Characteristic of the Water by Source and Assessment of Water Quality

a. Classification of Water

The classification of water will be made to identify the general tendency of the water source.

The classification of water by the source type using a trilinear diagram is shown in Figure 3.2-2 and Figure 3.2-3 to understand the general composition of the water.

A large variation was found in the water of wells. The well water is distributed mainly over domains adjacent to IV, V and I with some exceptions. This means that the nature of the aquifer itself and the depth of the aquifer varies by area. Some wells indicate a high content of chloride (Cl) as anion, which may indicate that the nature of some aquifers is similar to sea water (Typically, sea water falls in domain IV). A more detailed study shall be made for the classification of the aquifers to find the tendency of the aquifers by type.

Most of the water from Lake Victoria falls in domain I and V, and river water also falls in domain I and V. This fact fits together with the general tendency that natural fresh water falls in domain I and the adjacent domain V.

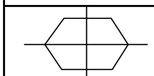
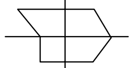
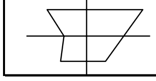
Pond water also falls in domain I and V; its nature is relatively close to that of fresh water.

Scheme water also varies the same as the well water, and falls in domain I, III and V. The consideration of the difference of water source and the degree of the treatment is the reason for the variation, but it also indicates a similar tendency to that of fresh water.

Ca ions tend to increase in the dry season compared to the wet season. On the other hand, the Cl content decreases in the dry season.

Hexagrams are shown in Figure 3.2-4 and Figure 3.2-5. In general, the pattern of each diagram shows the character of freshwater – shallow aquifers while the diagram of deep wells has a larger pattern compared to other water sources. The general classification of water source by hexagram is shown in the following table.

Table 3.2-6: General Classification of Water Source by Hexagram

Classification of the Shape of Hexa Diagram	Major Dissolved Ions		Type by Trillinear	Type of Water	Well	Scheme	Lake	River	Dam /Pond
	Anion	Cation							
	Ca^{2+}	HCO_3^{1-}	**Type I**	Originated in rain water. River, Lake, Shallow Aquifer	SW 2-SW 7, SW 9-SW 12, DW 5, DW 7- DW 9,DW 11,DW 12, DW 13, DW 16	SC1-SC15	LV1-LV12 (LV3 is not balanced)	RV1-RV2, RV3,RV5	DP1-DP5
	$Na^+ + K^+$	HCO_{32-}	**Type II**	Unconfined aquifer, Deep Groundwater	SW 1,DW 1-DW 4 , DW 6, DW 10, DW 13, DW 14, DW 16	–	–	RV1,RV4	–
	$Na^+ + K^+$	Cl^-	**Type IV**	Sea water, Hotspring	SW 9, SW 13	–	–	–	–

a.1 Well

The samples of 30 wells indicate the character of the water by depth and by area. **Deep wells** are not so affected by bacteria but they contain a series of metal ions such as Fe, Pb, Cr, Se, Ba and F. Looking at the Standards of Water Quality of Tanzania and WHO, some of the parameters exceed the allowable value. Granite fissure type aquifers in **Kwimba and Magu** indicated a high content of F. This fact indicates a similar tendency with the report of SIDA, 1979.

Shallow Wells have a large variation by area. The shallow well in Bunda (Tamau Borehole), which extracts water from an aquifer in Neocene deposits, has an extremely high concentration of Cl^-, $SO4^{2-}$, Cd, Na^+, and K^+, and the EC value exceeds 40,000 μS/m. The well will not be used as a drinking water source. Shallow wells also have a high concentration of coliform and bacteria, and also indicate a high EC value. This is largely depending on the well structure for protection against surface contamination.

Measures should be taken to deal with the wells which exceed the limit for the parameters. However, in general, the water from deep wells is relatively safe in comparison with the water from shallow wells. With shallow wells, the safety of the water largely depends on the aquifer extracted; aquifers other than those in Neocene deposits seem to have safer water. In addition to the aquifer, the structure of the well should also be considered for protection against surface contamination.

a.2 Lake

Samples from 12 points on the coast of **Lake Victoria** indicate that the water is safe in general. BOD is generally high and turbidity is high in some areas. Most of the locations are influenced by bacteriological contamination, such as general bacteria and coliform. The water from the lakes shall be treated and filtered for potable purposes.

a.3 River

River samples were taken from the Simiyu, Rubana, Ryamisanga, Mori and Grumeti **Rivers**. It is also noted that the water itself is safe except the rivers of Mara and Grumeti, which contain Hg above the allowable value of Tanzanian standards. The river water also indicates a high value for colour, turbidity, BOD, $SO4^{2-}$ and some bacteriological contamination. The treatment of those items is necessary.

a.4 Scheme

The water from the outlet of schemes also varies. It mostly presents the character of the water source such as lakes, springs and boreholes. The high value of color and bacteriological contamination shows that the treatment procedure is not functioning adequately. The variation of the values also indicates the degree of maintenance.

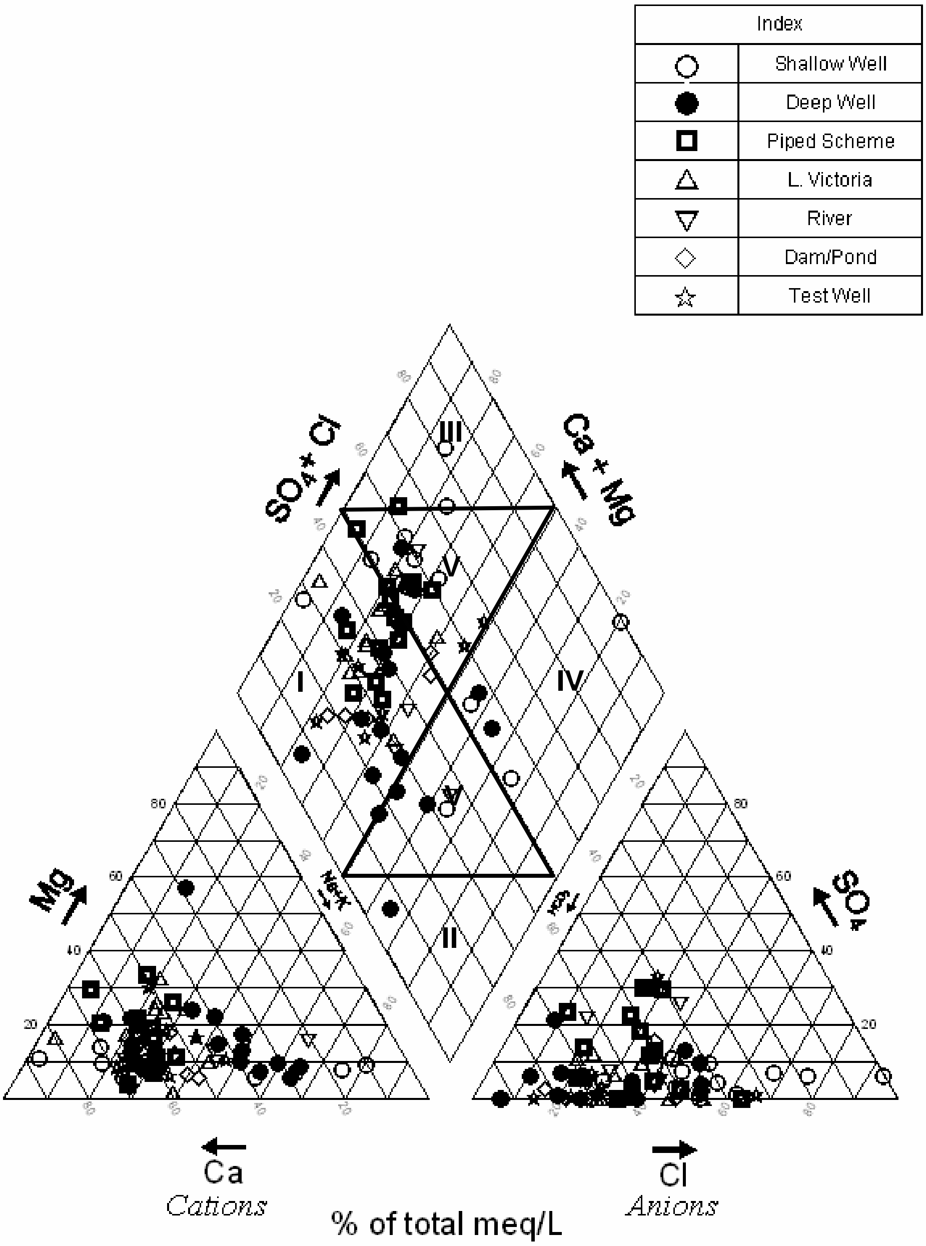


Figure 3.2-2 Trillinear Diagram (dry season)

THE STUDY ON RURAL WATER SUPPRY IN MWANZA AND MARA REGIONS
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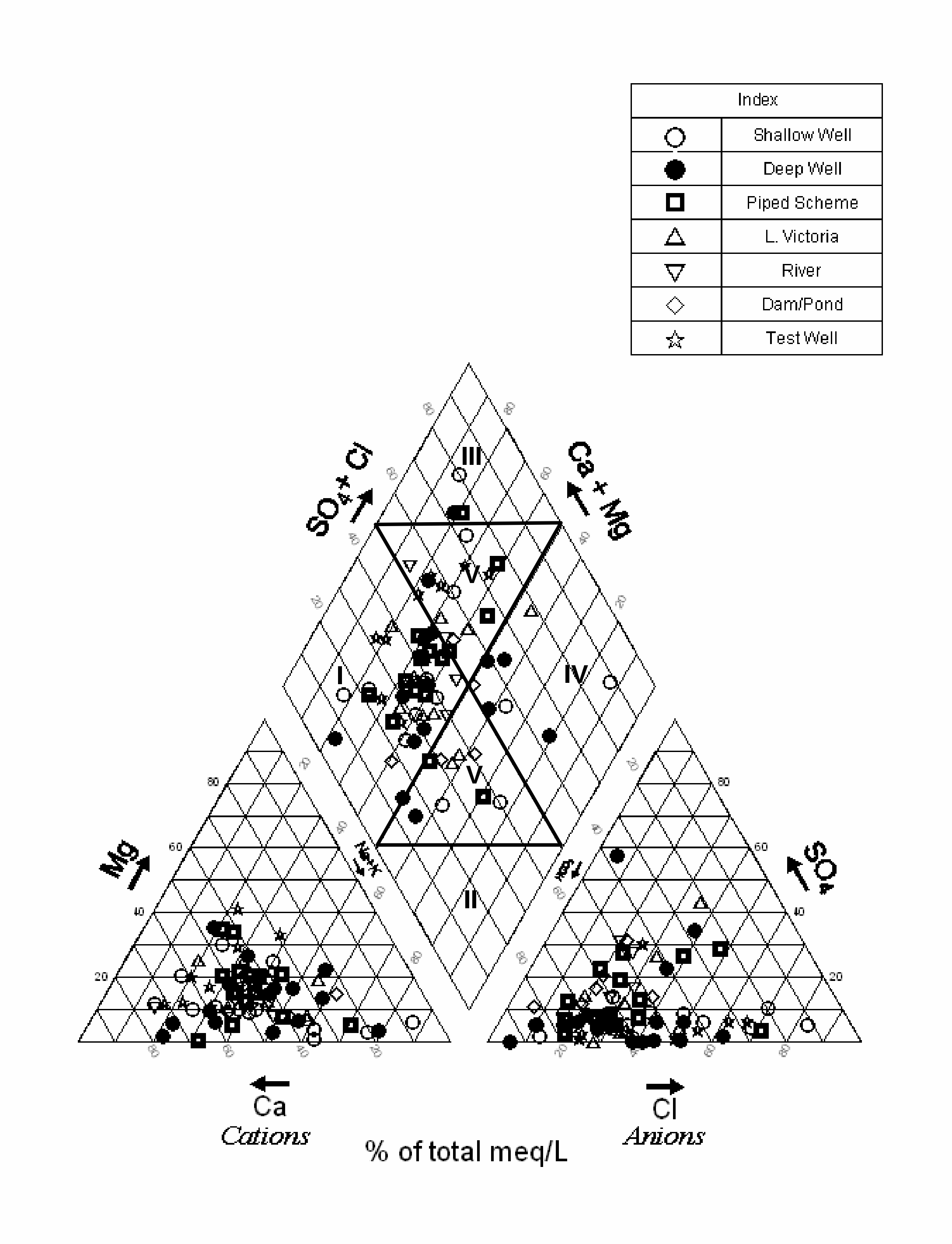


Figure 3.2-3	**Trillinear Diagram (rainy season)**

THE STUDY ON RURAL WATER SUPPRY IN MWANZA AND MARA REGIONS
IN THE UNITED REPUBLIC OF TANZANIA

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

a.5 Dam/Pond

The nature of the water appears to be almost the same as that of surface water. Some of the samples show high BOD and colour but no significant substances in the water. The water also requires treatment before drinking, as the water suffers from bacteriological contamination.

Further discussions on the analysis results and the relationship of water quality by type and location will be made after the completion of all the sampling and laboratory tests.

b. Seasonal Difference of the Analysis Results

In reference to the hydrological analysis, the climate change of the area can be divided into two phases: a dry season and a wet season (rainy season)

The main difference in the chemical composition of water in each season is mainly caused by the dilution of water by rain and concentration in the dry season. The chemical composition of rainwater largely depends on the local hydrological cycle, the chemical composition of the surface soils and the agricultural activities in the area; but in general, rainwater dissolves few chemical components other than H_2O. Data on the composition of rainwater, such as ions and other substances, is not found in the case of Tanzania. Therefore, the composition of rain in other countries is shown in the following tables as a reference.

Table 3.2-7: Composition of Water

	Sea Water	River Water		Rain Water
		World	Japan	Japan
Na^+	10,500	5.3	6.7	1.1
Mg^{2+}	1,300	3.1	1.9	0.36
Ca^{2+}	400	13.3	8.8	0.97
K^+	380	1.5	1.19	0.26
Sr^{2+}	8	–	0.057	0.011
Cl^-	19,000	6	5.8	1.1
SO_4^{2-}	2,650	8.7	10.6	4.5
HCO_3^-	140	51.7	31	–
CO_3^{2-}	18	–	–	–
Br^-	65	–	–	–
F^-	1.3	–	0.15	0.089
I^-	6×10^{-2}	–	0.0022	0.0018
SiO_2 (disolved)	6	10.7	19	–
H_3BO_3	26	–	–	–

Figures are ppm after Kitano,Y.(1992): Water Geochemistry. Encyclopedia of Earth System Science, Volume 4, 449-462p., Academic Press, Inc. (USA).

Table 3.2-8: Composition of Rain Water (England and Japan)

	F	Na	Mg	Al	Si	P	S	Cl	K	Ca	Sc	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Se	Br	Rb	Sr	Mo	Cd	In	Sb	I	Cs	La	Ce	W	Au	Hg	Pb	Th
Japan	0.089	1.1	0.36	0.11	0.83	0.014	1.5	1.1	0.26	0.97		0.0014			0.23			0.00083	0.0042	0.0016				0.011	0.00006				0.0018								
England		2.3		0.16				4.1		<1.1	4.2E-05	0.0041	0.0029	0.0081	0.2	0.00025	<0.006*	0.023*	0.085	0.0016	0.00034*	0.017	0.00067*			<0.0177*	<0.00059*	0.0018	<0.0025	0.00017*	<0.0003*	0.00042*	0.00035*	0.00001	<0.0002	0.039*	0.00012*

*Figures are ppm,data after Perison,D.H., Cawse,P.A. and Cambray,R.S.(1973, Nature, **241**, 252.), Sugawara,K.(1967, "Chemistry of the Earth's Crust", II, 510, Israel Progaram for Sci. Translation, Ltd., Jerusalem)*

As rainwater includes only a small amount of substances such as metal ions, the most common tendency of surface water change is the concentration of substances (excluding volatile substances) in the dry season, followed by dilution in the rainy season. Groundwater (excluding shallow unconfined aquifers) will not be greatly affected by the seasonal difference.

Recognizing that it is inadequate to fully explain the reason for the seasonal change based on only two samplings in a year, the tendency of the change is described below. It should be noted that the specific changes in water quality by season shall be monitored frequently at the same sampling location with careful examination of the nature of circumstance.

Figure 3.2-6 presents the matrix of the change in values of each substance by season. The dark color indicates a dilution of more than 500%, the gray color more than 120%, and the light gray less than 80% (concentrated).

The substances of Ph, Pb, As, Se Cd, Ba, Hg, Mn, Cu Zn Cr, Ni, Mo, chlorine, temperature and COD have few differences between the seasons.

In general, EC, TSS, TDS, K, NO_3^-, total hardness, Ca, Mg and PO_4 are diluted in the wet season. Substances such as NO_3^- and PO_4 are presumably affected by fertilizer used on farms and/or detergents for washing. Accordingly, these substances are washed away in the dry season.

On the other hand, the values of other substances such as F, NH_4^+, B, NO_2^- and Na^+ are increasing.

Other substances vary by the sampling point or the source of sampling.

b.1 Shallow Well

The most particular changes are a reduction of EC, TSS, Ca, Cl^-, K^+, PO_4 in wet season and an increase of coliform, bacteria, F, NH_4^+, B, NO_2, HCO_3^- and Na^+ in dry season.

b.2 Deep Well

This high variation by season was not expected. In the wet season, the value of EC, TDS, total hardness, Mg, K^+, PO_4 and F increased, and B was reduced. Although the difference in values is almost within 20%-40%, this fact suggests that even the deep boreholes are affected by seasonal difference.

b.3 Piped Scheme

The value varies by scheme, but in general, most of the substances tend to be reduced in the wet season.

b.4 Lake Victoria

The tendency of seasonal change is a reduction in value for most of the parameters. However, some sampling points show an increase of coliform, B, F, and Na^+.

b.5 River

As with Lake Victoria, most of the values tend to decrease. However, boron, color and turbidity increase in the rainy season. This may be largely due to the fact that surface dirt concentrates in surface run off water, which flows into the rivers.

b.6 Dam/Pond

The tendency is almost the same as with rivers.

c. Water Quality by the River Basin

Table 3.2-9 presents the laboratory test results by river basin. The specific parameters that indicate relatively high values are shown.

The composition of the chemicals also varies, and there is no clear difference by river basin.

However, basins which have permanent rivers (Mara and Simiyu) are low in color and turbidity as a result of the sustainable washout of the surface soils. The river basins of Mori, Grumeti and Suguti as well as some rivers in the South Basins have a high content of Fe and BOD.

Some of the shallow wells in the basins of Grumeti, Isanga and Mara show a high content of TDS, total hardness and Ca.

As for toxic substances, fluoride is relatively high in Grumeti, Isanga, Magogo/Moame, and the Simiyu basins. The deep wells in these river basins have a high content. Sources high in NO_3^- content can be found in the basins of Isanga, Magogo/Moame, Mara, Nyarulwa, Simyu and South1.

Table 3.2-9: Laboratory Test Results by River Basin

Basin	District	Name of Location	Well Type	Laboratory																																	
				T. Coliform	Esc. Colif	Pb	Cr	CN	Cd	Ba	Hg	F	NO3	Color	Turbidity	pH	TSS	TDS	T-Hardness	Ca	Mg	SO4	Cl	Fe	Mn	BOD	NH4	Mo	NO2	Residue Cloride (mg/l)	EC	K	PO4	COD	HCO3	Na	Organic Phosphate (mg/l)
				count/100ml	count/100ml	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	mg/l	mg Pt/l	NTU		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		µS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	
Grumeti	Bunda	TAMAU Borehole	Shallow	6	2	<0.01	0.05	0.009	0.58	4	<1	1.1	3	14	0	7.64	270.00	24700.00	3110.0	980.00	517.59	1560.00	17600	0.06	0.0	21	1.41	<0.01	0.06	0.0	55700.00	33.32	1.67	724	75	8600.00	0.12
	Serengeti	Robanda D-Well	Deep	0	0	<0.01	<0.01	0.000	<0.001	0	<1	1.4	7	14	3	7.28	22.00	478.00	218.0	116.00	24.79	3.30	67	0.02	0.0	0	1.14	<0.01	0.01	0.0	956.00	5.33	0.19	0	459	132.50	<0.01
	Bunda	Rubana River Bunda		11	18	<0.01	<0.01	0.009	<0.001	0	1	0.8	4	117	541	7.1	584.00	95.60	55.0	42.00	3.16	24.10	13	3.45	0.0	10	1.21	<0.01	0.00	0.0	191.30	11.05	2.38	31	87	15.10	0.67
	Serengeti	Ft. Ikoma River Grumeti		17	28	<0.01	1.00	0.001	<0.001	0	2	1.7	3	0	0	8.5	558.00	642.00	190.0	67.00	29.89	48.90	144	0.21	0.0	0	0.46	<0.01	0.05	0.0	1281.00	18.45	0.81	10	556	222.40	0.2
Isanga	Kwimba	Gulung'wa Deep Well	Deep	2	8	<0.01	<0.01	0.001	<0.001	0	1	1.3	5	263	56	6.7	1111.00	1129.00	689.0	362.00	79.46	70.00	259	1.15	0.9	0	4.39	2.13	2.59	0.0	2260.00	6.40	1.92	0	382	127.50	0.47
	Misungwi	Isenengeja Deep Well	Deep	10	19	<0.01	<0.01	0.002	<0.001	0	1	1.5	13	0	0	7.59	119.00	404.00	249.0	105.00	34.99	0.00	112	0.02	0.0	0	0.17	0.27	0.16	0.0	808.00	3./88	0.58	0	305	85.70	0.01
	Misungwi	Manawa Ng'wawile Well	Deep	11	20	<0.01	<0.01	0.000	<0.001	0	<1	1.1	41	83	22	7.4	319.00	510.00	202.0	179.00	5.59	21.10	207	0.44	0.0	0	0.27	<0.01	0.07	0.0	1022.00	3.44	1.21	0	305	80.00	0.73
	Geita	Nyalubele pond		14	3	0.11	<0.01	0.001	<0.001	0	<1	0.6	48	91	17	6.43	668.20	111.80	28.0	22.00	1.46	0.00	38	0.95	0.0	4	0.59	<0.01	0.07	0.0	246.00	5.31	0.29	20	71	18.00	0.02
Magogo/Moame	Kwimba	Ilumba Medium Well	Deep	7	17	<0.01	<0.01	0.000	<0.001	0	2	1.3	33	0	0	7.57	10.00	480.00	252.0	185.00	16.28	0.00	73	0.02	0.0	0	0.10	<0.01	0.03	0.0	960.00	9.53	0.78	0	367	110.90	<0.01
	Kwimba	Buyogo Deep Well	Deep	0	0	<0.01	<0.01	0.001	<0.001	0	<1	1.6	26	0	0	6.8	190.00	410.00	229.0	146.00	20.17	21.00	115	0.04	0.0	0	0.21	<0.01	0.02	0.0	819.00	0.28	0.39	0	339	83.00	<0.01
	Misungwi	Ng'obo Shilalo Pump-H	Deep	9	17	<0.01	<0.01	0.000	<0.001	0	<1	1.1	4	7	2	7.59	291.00	689.00	325.0	147.00	43.25	105.00	32	2.23	0.0	0	0.17	0.09	0.04	0.0	1380.00	10.25	0.44	0	443	217.70	<0.01
	Kwimba	Lunere	Deep	0	0	0.1	<0.01	0.001	<0.001	1	<1	4.9	49	0	0	7.41	45.00	715.00	129.5	89.00	9.84	18.70	381	0.01	0.0	0	0.13	<0.01	0.02	0.0	1670.00	0.20	1.00	0	557	218.90	0.01
	Kwimba	Malya Dam Pump-H		19	29	<0.01	<0.01	0.002	<0.001	0	<1	0.7	2	0	99	7.7	122.50	77.50	46.0	35.50	2.55	0.00	11	0.54	0.0	19	0.48	<0.01	0.06	0.0	155.60	7.08	1.78	84	67	13.80	0.01
	Misungwi	Misungwi Scheme Dam		38	52	<0.01	<0.01	0.001	<0.001	0	1	0.9	7	491	102	7.2	1132.00	187.80	83.0	64.00	4.62	35.90	60	1.45	0.0	28	1.54	<0.01	0.25	0.0	375.00	5.22	0.61	61	145	51.10	0.23
Mara	Tarime	Mriba Medium Well	Shallow	8	17	<0.01	<0.01	0.001	<0.001	0	<1	0.6	72	0	0	6.65	309.00	251.00	119.0	88.00	7.53	1.60	67	0.50	0.0	0	0.34	<0.01	0.21	0.0	251.00	15.38	0.41	0	70	43.90	0.04
	Tarime	Wegita shallow well	Shallow	10	21	<0.01	<0.01	0.001	<0.001	0	<1	1.1	115	0	0	7.64	765.00	1115.00	716.0	456.00	63.18	91.90	683	0.62	0.3	0	1.68	<0.01	0.60	0.0	2230.00	25.41	0.97	10	444	185.90	0.06
	Serengeti	Nyansurura Borehole	Deep	0	0	<0.01	<0.01	0.000	<0.001	0	<1	1.2	3	7	2	7.01	92.00	448.00	391.0	66.00	78.98	0.00	131	0.09	0.3	4	0.19	<0.01	0.05	0.0	995.00	3.99	1.04	20	416	34.60	0.01
	Musoma rural	MasusuraD-well	Deep	2	5	<0.01	<0.01	0.001	<0.001	0	<1	1.2	4	0	0	7.34	31.00	529.00	284.0	119.00	40.10	30.70	86	0.54	0.0	0	0.12	0.72	0.08	0.0	1059.00	4.60	0.86	0	470	129.60	0.21
	Tarime	Ryamisanga Mara River		14	25	<0.01	<0.01	0.002	<0.001	0	3	1.0	4	67	16	7.13	485.30	94.70	45.0	26.00	4.62	0.00	26	1.67	0.0	21	0.57	<0.01	0.03	0.0	189.20	8.35	0.49	61	74	23.60	0.07
Mori	Tarime	Roche Deep well	Deep	1	5	<0.01	<0.01	0.001	<0.001	0	1	1.4	4	7	3	7.1	207.00	473.00	185.0	99.00	20.90	25.20	34	0.05	0.0	0	1.34	<0.01	0.02	0.0	947.00	14.47	1.42	0	456	140.90	<0.01
	Tarime	Ingri Juu D- well	Deep	2	9	<0.01	<0.01	0.000	<0.001	0	<1	1.4	1	0	0	7.1	88.00	552.00	334.0	224.00	26.73	0.00	23	0.05	0.0	0	0.27	<0.01	0.02	0.0	1058.00	7.63	0.73	0	556	89.40	0.01
	Tarime	Randa Mori River		24	38	<0.01	<0.01	0.003	<0.001	0	<1	1.0	4	141	31	7.2	369.60	110.40	72.5	52.00	4.98	21.00	22	1.08	0.0	16	0.48	<0.01	0.02	0.0	221.00	6.23	0.92	31	40	17.00	0.11
	Tarime	Tagota Dam Tarime		16	23	<0.01	<0.01	0.001	<0.001	0	<1	0.7	3	0	0	8.72	412.00	67.90	36.0	23.00	3.16	0.00	13	0.74	0.0	10	0.35	<0.01	0.07	0.0	136.20	3.93	0.74	41	61	14.30	0.08
	Tarime	Nyanjage Dam / Pond		15	29	<0.01	<0.01	0.001	<0.001	0	1	0.9	1	14	3	7	87.30	72.70	51.0	28.00	5.59	1.60	8	0.44	0.0	24	12.90	<0.01	0.02	0.0	145.10	3.47	0.07	61	71	11.60	0.01
Nyaruhwa	Sengerema	Kishinda	Shallow	3	8	0.64	<0.01	0.000	<0.001	1	<1	1.0	31	0	0	6.71	214.00	326.00	190.0	124.00	16.04	19.30	196	0.00	0.0	0	0.13	<0.01	0.01	0.0	717.00	2.66	0.73	0	243	50.80	0.02
	Sengerema	Sotta	Shallow	16	6	0.12	<0.01	0.003	<0.001	2	<1	1.6	10	7	3	7.12	92.00	388.00	314.0	175.00	33.78	18.60	207	0.01	0.0	0	0.30	<0.01	0.02	0.0	97.70	3.61	0.84	0	392	37.40	0.05
Simiyu	Magu	Bugatu Shallow Well	Shallow	2	11	<0.01	<0.01	0.001	<0.001	0	<1	1.5	7	0	0	7.79	20.00	539.00	132.0	82.00	12.15	20.00	89	0.01	0.0	0	0.01	<0.01	0.03	0.0	1079.00	1.07	1.16	0	359	215.10	<0.01
	Magu	Malili Shallow Well	Shallow	5	14	<0.01	<0.01	0.001	<0.001	0	<1	0.7	46	14	2	7.2	271.00	1651.00	219.0	162.00	13.85	59.10	275	0.00	0.0	8	0.15	<0.01	0.06	0.0	1651.00	0.77	1.09	20	484	270.20	0.02
	Magu	Kabila Medium Well	Deep	4	6	<0.01	<0.01	0.001	<0.001	0	1	1.5	3	0	0	8.22	119.00	361.00	99.0	54.00	10.94	0.00	16	0.01	0.0	0	0.03	<0.01	0.12	0.0	722.00	0.31	0.87	0	377	154.20	<0.01
	Magu	Nyangh'anga Med -Well	Deep	4	9	<0.01	<0.01	0.001	<0.001	0	<1	1.3	15	0	0	7.83	333.00	507.00	145.0	82.00	15.31	28.80	81	0.04	0.0	0	0.17	<0.01	0.03	0.0	1013.00	2.76	1.06	0	423	179.90	0.02
	Kwimba	Pump-H Kadashi Well-Sch.	Deep	0	0	<0.01	<0.01	0.001	<0.001	0	<1	1.6	11	0	0	7.74	95.00	425.00	163.0	101.00	15.07	25.60	49	0.03	0.0	0	0.06	<0.01	0.02	0.0	849.00	1.53	0.96	0	368	146.70	0.01
	Magu	Simiyu River Bridge		26	38	<0.01	<0.01	0.006	<0.001	0	1	1.2	3	59	12	8.26	252.20	355.00	146.0	94.00	12.64	18.60	87	0.26	0.0	0	0.54	<0.01	0.06	0.0	707.00	9.96	1.21	0	423	101.30	0.33
South1-3	Magu	Kitumba Shallow Well	Shallow	4	13	<0.01	<0.01	0.002	<0.001	0	<1	1.2	42	14	2	6.34	231.00	289.00	159.0	113.00	11.18	21.50	69	0.13	0.0	0	0.18	<0.01	0.02	0.0	579.00	8.27	0.25	0	163	53.80	0.02
	Magu	Ng'wamanyili Deep Well	Deep	8	17	<0.01	<0.01	0.001	<0.001	0	<1	1.3	48	14	3	7.4	476.00	926.00	275.0	182.00	22.60	116.20	286	0.86	0.0	0	0.77	<0.01	4.26	0.0	1852.00	79.00	1.23	0	492	278.50	0.07
	Misungwi	Ngaya Nyabusalu Shallow Well	Shallow	26	40	<0.01	<0.01	0.003	<0.001	0	<1	1.1	2	102	491	6.8	1077.00	122.80	22.0	10.00	2.92	14.50	42	3.70	0.0	0	1.34	<0.01	0.00	0.0	246.00	4.75	0.95	10	82	49.80	0.02
	Sengerema	Buswelu Bulyaheke	Shallow	91	48	0.08	<0.01	0.002	<0.001	0	<1	1.6	5	362	76	7.1	256.00	504.00	256.0	213.00	10.45	8.30	315	3.90	0.2	18	0.75	<0.01	0.05	0.0	1090.00	6.85	0.00	61	470	84.20	0
	Geita	Ihaya buyaga	Shallow	7	3	<0.01	<0.01	0.001	<0.001	0	<1	0.6	2	7	0	6.37	563.50	136.50	72.0	53.00	4.62	0.00	93	0.22	0.0	0	0.18	<0.01	0.00	0.0	295.00	1.09	0.78	0	139	21.00	0.03
	Geita	Geita Dam		21	5	0.06	<0.01	0.015	<0.001	1	<1	0.4	2	29	38	7.41	411.90	68.10	37.0	20.00	4.13	3.00	25	0.52	0.0	53	0.37	<0.01	0.01	0.0	153.70	2.26	0.11	128	58	11.80	0.01
	Bunda	Nyaburundu-Kiberenge	Shallow	0	0	<0.01	<0.01	0.000	<0.001	0	<1	0.4	4	506	115	7.55	615.80	144.20	102.0	78.00	5.83	0.00	31	6.35	0.0	14	1.42	<0.01	0.28	0.0	279.00	4.77	0.91	51	136	<0.01	0.05
Suguti	Bunda	Ligamba A	Shallow	9	5	<0.01	<0.01	0.001	<0.001	0	<1	0.5	29	0	0	7.98	431.40	148.60	72.0	54.00	4.37	15.10	61	0.42	0.0	0	0.21	<0.01	0.05	0.0	329.00	4.34	0.80	0	81	13.00	0.07
	Musoma rural	Nyakiswa Shallow well	Shallow	6	18	<0.01	<0.01	0.001	<0.001	0	1	0.4	67	0	0	6.86	80.00	199.50	130.0	87.00	10.45	11.00	101	2.13	0.0	8	0.40	<0.01	0.08	0.0	399.00	15.46	0.33	20	41	12.90	0.12

■ > Tanzania Upper Limit
▩ > Tanzanian Allowavle Value
▨ > WHO GV & ACV
□ > Tanzanian Allowavle Value

d. Water Quality by Aquifer

The difference of water quality by aquifer is also examined.

Table 3.2-10 shows the water quality analysis results by aquifer. The substances not exceeding the standard limit (WHO or Tanzanian Acceptable Limit) are excluded from the table to identify the aquifers not suitable for extraction for potable purposes.

As indicated, the results also vary by well location and no significant difference can be observed by type of aquifer.

The water quality of deep boreholes in the granite group including the intermediate zone, the secondary deposits and the weathered zone provides the safest water in the series of aquifers. However, the fluoride in the granite is relatively high, and the deep well in the Kwimba district exceeds the Tanzanian allowable limit. NO_3 is also relatively high in this aquifer. The same hole in Kwimba exceeds the upper limit of the Tanzanian standard. Shallow wells in the group contain high iron content.

The deep wells of Bukoban and Nyanzan aquifer, which are composed of meta-sedimentary rocks and metamorphosed rocks, also seem to be safe water sources with the exception of the high Fe content.

Not aquifer-wise, shallow wells contain many toxic substances such as Cd, Ba, Pb and substances that originated from the ground surface such as NH_4 and BOD. Turbidity is also high in some shallow wells in the granite member.

The traditional water sources presumably contain similar substances as shallow wells. Therefore, in terms of water quality, the water supply is not safe in the study area unless river or lake water is used as the source.

Table 3.2-10: Laboratory Test Results by Aquifer

Type	District	Name of Location	Eastings	Well Type	Laboratory																		Laboratory																
					T. Coliform	Esc. Colif	Pb	As	Cr	CN	Cd	Ba	Hg	F	NO3	Color	Turbidity	pH	TDS	T-Hardness	Ca	Mg	SO4	Cl	Fe	Mn	BOD	NH4	Mo	NO2	Residue Cloride	Temp	EC	K	PO4	COD	HCO3	Na	Organic Phosphate
					count/100ml	count/100ml	mg/l	μg/l	mg/l	mg/l	mg/l	mg/l	μg/l	mg/l	mg/l	mgPt/l	NTU		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	(mg/l)	°C	μS/cm	mg/l	mg/l	mg/l	mg/l	mg/l	(mg/l)
Neocene Sediment	Magu	Bugatu Shallow Well	567744	Shallow	10	21	<0.01	<1	<0.01	0.001	<0.001	0	<1	1.1	115	0	0	7.64	1115.00	716.0	456.00	63.18	91.90	683	0.62	0.3	0	1.68	<0.01	0.60	0.0	25.7	2230.00	25.41	0.97	10	444	185.90	0.06
	Bunda	TAMAU Borehole	594548	Shallow	0	0	<0.01	<1	<0.01	0.000	<0.001	0	<1	1.2	3	7	2	7.01	448.00	391.0	66.00	78.98	0.00	131	0.09	0.3	4	0.19	<0.01	0.05	0.0	25.0	995.00	3.99	1.04	20	416	34.60	0.01
Volcanics	Tarime	Mriba Medium Well	682981	Shallow	91	48	0.08	<1	<0.01	0.002	<0.001	0	<1	1.6	5	362	76	7.1	504.00	256.0	213.00	10.45	8.30	315	3.90	0.2	18	0.75	<0.01	0.05	0.0	24.6	1090.00	6.85	0.00	61	470	84.20	0
Decomposed and Secondary Deposits of Pre-Cambrian	Magu	Malili Shallow Well	589132	Shallow	9	5	<0.01	<1	<0.01	0.001	<0.001	0	<1	0.5	29	0	0	7.98	148.60	72.0	54.00	4.37	15.10	61	0.42	0.0	0	0.21	<0.01	0.05	0.0	25.2	329.00	4.34	0.80	0	81	13.00	0.07
	Sengerema	Kishinda	466964	Shallow	26	40	<0.01	<1	<0.01	0.003	<0.001	0	<1	1.1	2	102	491	6.8	122.80	22.0	10.00	2.92	14.50	42	3.70	0.0	0	1.34	<0.01	0.00	0.0	25.5	246.00	4.75	0.95	10	82	49.80	0.02
	Geita	Ihaya buyaga	416201	Shallow	0	0	0.1	<1	<0.01	0.001	<0.001	1	<1	4.9	49	0	0	7.41	715.00	129.5	89.00	9.84	18.70	381	0.01	0.0	0	0.13	<0.01	0.02	0.0	24.8	1670.00	0.20	1.00	0	557	218.90	0.01
	Bunda	Nyaburundu-Kiberenge	621976	Shallow	2	9	<0.01	<1	<0.01	0.000	<0.001	0	<1	1.4	1	0	0	7.1	552.00	334.0	224.00	26.73	0.00	23	0.05	0.0	0	0.27	<0.01	0.02	0.0	25.9	1058.00	7.63	0.73	0	556	89.40	0.01
	Musoma rural	Nyakiswa Shallow well	588274	Shallow	2	5	<0.01	<1	<0.01	0.001	<0.001	0	<1	1.2	4	0	0	7.34	529.00	284.0	119.00	40.10	30.70	86	0.54	0.0	0	0.12	0.72	0.08	0.0	25.1	1059.00	4.60	0.86	0	470	129.60	0.21
Bukoban Series	Tarime	Wegita shallow well	654262	Shallow	4	13	<0.01	<1	<0.01	0.002	<0.001	0	<1	1.2	42	14	2	6.34	289.00	159.0	113.00	11.18	21.50	69	0.13	0.0	0	0.18	<0.01	0.02	0.0	25.7	579.00	8.27	0.25	0	163	53.80	0.02
	Serengeti	Nyansurura Borehole	678249	Deep	4	6	<0.01	<1	<0.01	0.001	<0.001	0	1	1.5	3	0	0	8.22	361.00	99.0	54.00	10.94	0.00	16	0.01	0.0	0	0.03	<0.01	0.12	0.0	25.6	722.00	0.31	0.87	0	377	154.20	<0.01
Intermediate of Ngr and Granite Rock Units	Magu	Kabila Medium Well	569354	Deep	4	9	<0.01	5	<0.01	0.001	<0.001	0	<1	1.3	15	0	0	7.83	507.00	145.0	82.00	15.31	28.80	81	0.04	0.0	0	0.17	<0.01	0.03	0.0	25.7	1013.00	2.76	1.06	0	423	179.90	0.02
	Magu	Nyangh'anga Med -Well	556077	Deep	8	17	<0.01	<1	<0.01	0.001	<0.001	0	<1	1.3	48	14	3	7.4	926.00	275.0	182.00	22.60	116.20	286	0.86	0.0	0	0.77	<0.01	4.26	0.0	25.6	1852.00	79.00	1.23	0	492	278.50	0.07
	Magu	Ng'wamanyili Deep Well	560540	Deep	7	17	<0.01	<1	<0.01	0.000	<0.001	0	2	1.3	33	0	0	7.57	480.00	252.0	185.00	16.28	0.00	73	0.02	0.0	0	0.10	<0.01	0.03	0.0	26.2	960.00	9.53	0.78	0	367	110.90	<0.01
	Kwimba	Ilumba Medium Well	546038	Deep	0	0	<0.01	<1	<0.01	0.001	<0.001	0	<1	1.6	11	0	0	7.74	425.00	163.0	101.00	15.07	25.60	49	0.03	0.0	0	0.06	<0.01	0.02	0.0	25.8	849.00	1.53	0.96	0	368	146.70	0.01
	Kwimba	Pump-H Kadashi Well-Sch.	557039	Deep	0	0	<0.01	<1	<0.01	0.001	<0.001	0	<1	1.6	26	0	0	6.8	410.00	229.0	146.00	20.17	21.00	115	0.04	0.0	0	0.21	<0.01	0.02	0.0	25.4	819.00	0.28	0.39	0	339	83.00	<0.01
	Kwimba	Buyogo Deep Well	526865	Deep	10	19	<0.01	<1	<0.01	0.002	<0.001	0	1	1.5	13	0	0	7.59	404.00	249.0	105.00	34.99	0.00	112	0.02	0.0	0	0.17	0.27	0.16	0.0	25.8	808.00	3./88	0.58	0	305	85.70	0.01
	Misungwi	Isenengeja Deep Well	483405	Deep	11	20	<0.01	<1	<0.01	0.000	<0.001	0	<1	1.1	41	83	22	7.4	510.00	202.0	179.00	5.59	21.10	207	0.44	0.0	0	0.27	<0.01	0.07	0.0	25.6	1022.00	3.44	1.21	0	305	80.00	0.73
	Misungwi	Manawa Ng'wawile Well	488740	Deep	1	5	<0.01	<1	<0.01	0.001	<0.001	0	1	1.4	4	7	3	7.1	473.00	185.0	99.00	20.90	25.20	34	0.05	0.0	0	1.34	<0.01	0.02	0.0	25.9	947.00	14.47	1.42	0	456	140.90	<0.01
Nyanzan Group	Sengerema	Sotta	468277	Shallow	2	11	<0.01	<1	<0.01	0.001	<0.001	0	<1	1.5	7	0	0	7.79	539.00	132.0	82.00	12.15	20.00	89	0.01	0.0	0	0.01	<0.01	0.03	0.0	25.3	1079.00	1.07	1.16	0	359	215.10	<0.01
	Kwimba	Gulung'wa Deep Well	504417	Deep	6	2	<0.01	<1	0.05	0.009	0.58	4	<1	1.1	3	14	0	7.64	24700.00	3110.0	980.00	517.59	1560.00	17600	0.06	0.0	21	1.41	<0.01	0.06	0.0	24.7	55700.00	33.32	1.67	724	75	8600.00	0.12
	Misungwi	Ng'obo Shilalo Pump-H	502269	Deep	5	14	<0.01	<1	<0.01	0.001	<0.001	0	<1	0.7	46	14	2	7.2	1651.00	219.0	162.00	13.85	59.10	275	0.00	0.0	8	0.15	<0.01	0.06	0.0	25.9	1651.00	0.77	1.09	20	484	270.20	0.02
	Serengeti	Robanda D-Well	690226	Deep	3	8	0.64	<1	<0.01	0.000	<0.001	1	<1	1.0	31	0	0	6.71	326.00	190.0	124.00	16.04	19.30	196	0.00	0.0	0	0.13	<0.01	0.01	0.0	25.2	717.00	2.66	0.73	0	243	50.80	0.02
Granite	Tarime	Roche Deep well	630323	Deep	7	3	<0.01	<1	<0.01	0.001	<0.001	0	<1	0.6	2	7	0	6.37	136.50	72.0	53.00	4.62	0.00	93	0.22	0.0	0	0.18	<0.01	0.00	0.0	23.9	295.00	1.09	0.78	0	139	21.00	0.03
	Sengerema	Buswelu Bulyaheke	436375	Shallow	0	0	<0.01	<1	<0.01	0.000	<0.001	0	<1	0.4	4	506	115	7.55	144.20	102.0	78.00	5.83	0.00	31	6.35	0.0	14	1.42	<0.01	0.28	0.0	25.1	279.00	4.77	0.91	51	136	<0.01	0.05
	Bunda	Ligamba A	600862	Shallow	6	18	<0.01	<1	<0.01	0.001	<0.001	0	1	0.4	67	0	0	6.86	199.50	130.0	87.00	10.45	11.00	101	2.13	0.0	8	0.40	<0.01	0.08	0.0	25.8	399.00	15.46	0.33	20	41	12.90	0.12
	Misungwi	Ngaya Nyabusalu Shallow Well	487418	Shallow	8	17	<0.01	<1	<0.01	0.001	<0.001	0	<1	0.6	72	0	0	6.65	251.00	119.0	88.00	7.53	1.60	67	0.50	0.0	0	0.34	<0.01	0.21	0.0	25.4	251.00	15.38	0.41	0	70	43.90	0.04
	Kwimba	Lunere	529677	Deep	16	6	0.12	<1	<0.01	0.003	<0.001	2	<1	1.6	10	7	3	7.12	388.00	314.0	175.00	33.78	18.60	207	0.01	0.0	0	0.30	<0.01	0.02	0.0	25.0	97.70	3.61	0.84	0	392	37.40	0.05
	Tarime	Ingri Juu D- well	629505	Deep	2	8	<0.01	<1	<0.01	0.001	<0.001	0	1	1.3	5	263	56	6.7	1129.00	689.0	362.00	79.46	70.00	259	1.15	0.9	0	4.39	2.13	2.59	0.0	25	2260.00	6.40	1.92	0	382	127.50	0.47
	Musoma rural	MasusuraD-well	614009	Deep	9	17	<0.01	<1	<0.01	0.000	<0.001	0	<1	1.1	4	7	2	7.59	689.00	325.0	147.00	43.25	105.00	32	2.23	0.0	0	0.17	0.09	0.04	0.0	25.5	1380.00	10.25	0.44	0	443	217.70	<0.01
	Magu	Kitumba Shallow Well	505488	Shallow	0	0	<0.01	<1	<0.01	0.000	<0.001	0	<1	1.4	7	14	3	7.28	478.00	218.0	116.00	24.79	3.30	67	0.02	0.0	0	1.14	<0.01	0.01	0.0	25.7	956.00	5.33	0.19	0	459	132.50	<0.01

▨ > Tanzania Upper Limit
▨ > Tanzanian Allowavle Value
▨ > WHO GV & ACV
▢ > Tanzanian Allowavle Value

3.2.6 Supplementary Survey

The water quality analysis was conducted in the phase two survey. The sampling points and objectives are described as follows:

1) 8 points (2 samples at each point) at Lake Victoria to examine the water quality at planned intake of water supply system

2) 3 points from the bore hole at the planned level II system (pipe distribution system) to examine the water quality of water to be served to the village.

Since 12 points on the coast of Lake Victoria were analyzed in the phase 2 study and it indicates that the water is safe in general. BOD, turbidity is high in some areas. Most of the locations are influenced by bacteriological contamination, such as general bacteria and Coliform.

Therefore, the intake point was set at some 80 to 100 m from the side of the lake shore to minimize the influence of waste and pollution by human activity.

The same methodology, procedure and standard methods for laboratory tests were applied to the analysis as set as the analysis of phase one study. The survey items are indicated as follows:

1) Site Analysis Items

Water Temperature, Electric Conductivity (EC), pH, Oxidation-Reduction Potential (ORP), Odour and Taste
2) Laboratory Analysis Items

Coliform, Lead (Pb), Arsenic (As), Selenium (Se), Chromium (Cr), Cyanide (Cn), Cadmium

(Cd), Barium (Ba), Mercury (Hg), Fluoride (F), Nitrate (NO_3)+ Nitrite (NO_2), Color, Turbidity, pH, Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Total Hardness ($CaCO_3$), Calcium (Ca), Magnesium (Mg), Sulfate (SO_4), Chloride (Cl), Iron (Fe), Manganese (Mn), Copper (Cu), Zinc (Zn), Biochemical Oxygen Demand (BOD), Oxygen abs $KMnO_4$ (as COD), Ammonium (NH_3 + NH_4), Boron (B), Sodium (Na), Bicarbonate (HCO_3), Total Phosphorus (TP)

a. Water Quality of Intake Point at Lake Victoria

In general, the water sampling was carried out 80 – 100 m from the lake shore, and the depth was not more than 5m from the lake water surface, and more that 3m from the bottom of the lake. The analysis results are shown in Table 3.2-11.

The location map of the water sampling point is indicated in Figure 3.2-7.

The water at the intake point for the pipe distribution has generally good water quality, compared to the results taken at the close side of the lake shore. None of the points exceed the Upper Limit of Tanzanian standard and even the Allowable Limit. However some traces of bacteriological contamination (Coliform of 2-8 count/100ml) can be observed. Therefore, pretreatment plant before distribution shall be strongly recommended for the future use of the water source of Lake Victoria.

b. Water Quality of New Test Wells for Level II System

The water quality test was planned for the 3 new drilled test holes at phase II in order to examine the water quality for portable purpose. The location of the sampling point is presented in Figure 3.2-7.

The groundwater quality in the selected village can be qualified as portable water for the Level II system.

Table 3.2-12 Water Quality Results of Supplementary Survey (Borehole)

S/No	Name of Location	District	Water level (m)	Sampling Date	FIELD						LABORATORY													
					Temp	EC	pH	ORP	Taste	Odour	CN	Fe	Mn	F	pH	Ba	NH_4	NO_3	Color	Turbidity	TSS	TDS	Coliform	T-Hardness
					°C	mS/m		mv			mg/l	mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg Pt/l	NTU	mg/l	mg/l	count/100ml	mg/l
1	Lunele	Kwimba	3.580	25/06/2006	26.3	71.80	7.58	193	Unobjectionable	Unobjectionable	<0.001	0.07	0.0	3.580	7.65	0	0.13	4.43	7	2	40.0	250.00	0	103
2	Saragana	Musoma	7.705	22/06/2006	26.4	47.40	7.64	190	Unobjectionable	Unobjectionable	<0.001	0.02	0.0	0.474	7.90	0	0.21	7.97	0	0	20.0	196.10	2	120
3	Buswelu	Sengerema	-	10/07/2006	-	-	-	-	-	-	<0.001	2.40	1.1	1.340	6.40	0	2.42	0.11	464	96	160.0	105.10	9	112

S/No	Name of Location	District	Water level (m)	Sampling Date	LABORATORY																			
					Ca	Mg	PO_4	SO_4	Cl	BOD	COD	B	HCO_3	Na	Cd	Cr	Cu	As	Pb	Zn	Se	K	Hg	Organic Phosphate
					mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	µg/l	mg/l	mg/l	µg/l	mg/l	µg/l	mg/l
1	Lunele	Kwimba	3.580	25/06/2006	40.41	25.85	0.73	19.3	49	0	0	0.01	260	104	<0.001	<0.01	<0.01	<1.00	<0.01	<0.01	<1.00	1.14	<1.00	0.02
2	Saragana	Musoma	7.705	22/06/2006	57.59	44.62	0.75	17.2	47	0	0	0.01	258	28	<0.001	<0.01	<0.01	<1.00	<0.01	<0.01	<1.00	0.29	<1.00	0.01
3	Buswelu	Sengerema	-	10/07/2006	72.00	9.72	0.01	0.0	32	3	20	0.03	192	8.19	<0.001	<0.01	<0.01	<1.00	<0.01	<0.01	<1.00	1.06	<1.00	<0.01

▓ >Tanzanian Upper Limit ░ >Tanzanian Allowable Value □ > WHO GV & AV

Table 3.2-3: Method and Standards of Laboratory Analysis

S/N	Quality Parameter	Standard Methods used	Units	Analysis Method	Detection limits	Units	Procedure	Check System of the Value	Title of the reseacher of Final Value
1	Bacteria	Membrane filtration using m endo broth MF Dehydrated	CFU/100m	Membrane Fitration	0	CFU/100m	Direct Count Method	2 Replication	Head EE Department
2	Escherichia coli	Membrane filtration using m FC broth base Dehydrated	CFU/100m	Membrane Fitration	0	CFU/100m	Direct Count Method	2 Replication	Head EE Department
3	Lead	AAS	mg/l	Atomic Absorption Spectophotometer (A	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
4	Arsenic	AAS	mg/l	AAS	0.05	μg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
5	Selenium	AAS	mg/l	AAS	0.05	μg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
6	Chromium	AAS	mg/l	AAS	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
7	Cyanide	Method 8027: Water Analysis Handbook 4th edition by Hach (2002)	mg/l	Spectrophotometer DR/2010	.001 – 0.24	mg/l	Pyridine-Pyrazalone	2 Replication	Head EE Department
8	Cadmium	AAS	mg/l	AAS	0.001	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
9	Barium	Method 8014: Water Analysis Handbook 4th edition by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–100	mg/l	Turbidimetric method using BarVer 4 powder Pil	2 Replication	Head EE Department
10	Mercury	AAS	mg/l	AAS	0.05	μg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
11	Fluoride	Model 51928 Fluoride electrode instructional manual pp 36-37by Hach (2002)	mg/l	Ion Specific Eletrode	0.001	mg/l	Ion Specific Eletrode method	2 Replication	Head EE Department
12	Nitrate	Method 8039: Water Analysis Handbook ,4th edition pp 573, by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–30	mg/l	Cadmium reduction method	2 Replication	Head EE Department
13	Color	Method 8025: Water Analysis Handbook ,4th edition pp 363, by Hach (2002)	TCU	Spectrophotometer DR/2010	5–500	TCU	Platinum -cobalt standard method	2 Replication	Head EE Department
14	Turbidity	FWPCA Methods for chemical Analysis of Water and Wastes, 275 (1969)	NTU	Bausch and Lomb Spectronic 21D	0–205	NTU	Absorptometric method	2 Replication	Head EE Department
15	Taste	–	–	Mouth taste		–		2 Replication	Head EE Department
16	Odour	–	–	Smelling		–		4 People	Head EE Department
17	pH	Sension 156 Portable Multiparameter by Hach company	–	Potentiometric (PH meter)		–	Direct Measurement Method	2 Replication	Head EE Department
18	Total Filterable Residue		mg/l					2 Replication	Head EE Department
19	Total Dissolved Solids	Sension 156 Portable Multiparameter by Hach company	mg/l	Potentiometric (TDS meter)	0.01	mg/l	Direct Measurement Method	2 Replication	Head EE Department
20	Total Hardness	Method 8213: Water Analysis Handbook ,4th edition pp 125, by Hach (2002)	mg/l	Titrimetric	1.0-4000.0	mg/l	TITRATION METHOD BY using EDTA Method	2 Replication	Head EE Department
21	Calcium	AAS	mg/l	AAS/Titration	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
22	Magnesium	AAS	mg/l	AAS	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
23	Sulfate	Method 8051: Water Analysis Handbook ,4th edition pp 965, by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–70.00	mg/l	Tubidimetric Sulfa Ver 4 method	2 Replication	Head EE Department
24	Chloride	Standard Methods for water and wastewater examination, 20th edition pp 4-67, method 4500-Cl-B	mg/l	Titrimetric	1	mg/l	Mohr Argentometric Method by using silver nitrat	2 Replication	Head EE Department
25	Iron	Method 8146: Water Analysis Handbook ,4th edition pp 483, by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–3.00	mg/l	1,10-Phenanthroline using Ferover Reagent	2 Replication	Head EE Department
26	Manganese	Method 8034: Water Analysis Handbook ,4th edition pp 515, by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–20.0	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
27	Copper	AAS	mg/l	AAS	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
28	Zinc	AAS	mg/l	AAS	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
29	Biochemical Oxygen Demand	BODTrak Instrument manual pp 19-29 by Hach (1998)	mg/l	BOD TRACK		mg/l		2 Replication	Head EE Department
30	Oxygen abs KMnO4	Reactor Digestion method, Procedures for water and wastewater Analysis pp 2-79-2-82 by Hach company	mg/l	Reactor digestion method	0–1500	mg/l	Dichromate Reactor Digestion Method	2 Replication	Head EE Department
31	Ammonia-Nitrogen (NH3)	Method 8038: Water Analysis Handbook ,4th edition pp 621, by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–2.50	mg/l	Nessler Method	2 Replication	Head EE Department
32	Boron	Method 10061: Water Analysis Handbook ,4th edition pp 175, by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–1.50	mg/l	Azomethine-H method	2 Replication	Head EE Department
33	Nickel	AAS	mg/l	AAS	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
34	Antimony	AAS	mg/l	AAS	0.05	μg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
35	Molybdenum	AAS	mg/l	AAS	5	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
36	Nitrite Nitrogen	Method 8507: Water Analysis Handbook ,4th edition pp 603, by Hach (2002)	mg/l	Spectrophotometer DR/2010	0–0.300	mg/l	Diazotization method	2 Replication	Head EE Department
37	Residual Chlorine	Standard Methods for water and wastewater examination, 20th edition pp 4-63, method 4500-Cl G	mg/l	DPD Method	0–2	mg/l	DPD Method	2 Replication	Head EE Department
38	Sodium	AAS	mg/l	AAS	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
39	Temperature	Sensio156 Portable Multiparameter by Hach company	oC	Themometer		oC		2 Replication	Head EE Department
40	Electrical Conductivity	Sension156 Portable Multiparameter by Hach company	μS/cm	Conductivity Meter	0.01	μS/cm	Direct Measurement Method	2 Replication	Head EE Department
41	Potassium	AAS	mg/l	AAS	0.01	mg/l	Extraction and Direct Measurement using AAS	2 Replication	Head EE Department
42	Bicarbonate	Method 8203: Water Analysis Handbook ,4th edition pp 125, by Hach (2002)	mg/l	Titrimetric	1.0-4000.0	mg/l	Sulphuric Acid with phenolphthalein indicator and	2 Replication	Head EE Department

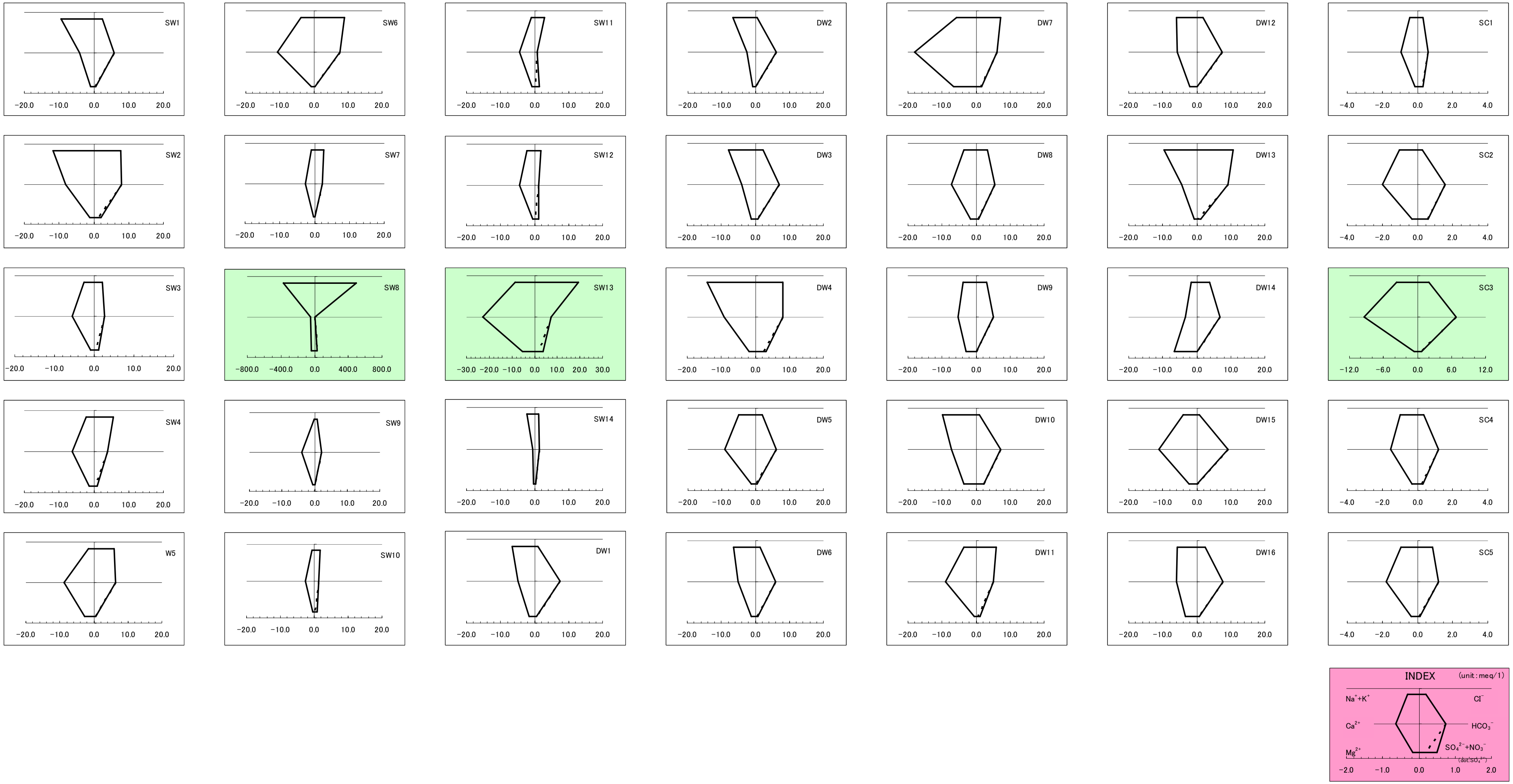


Figure 3.2-4: Hexa Diagram (Dry Season) (1/2)

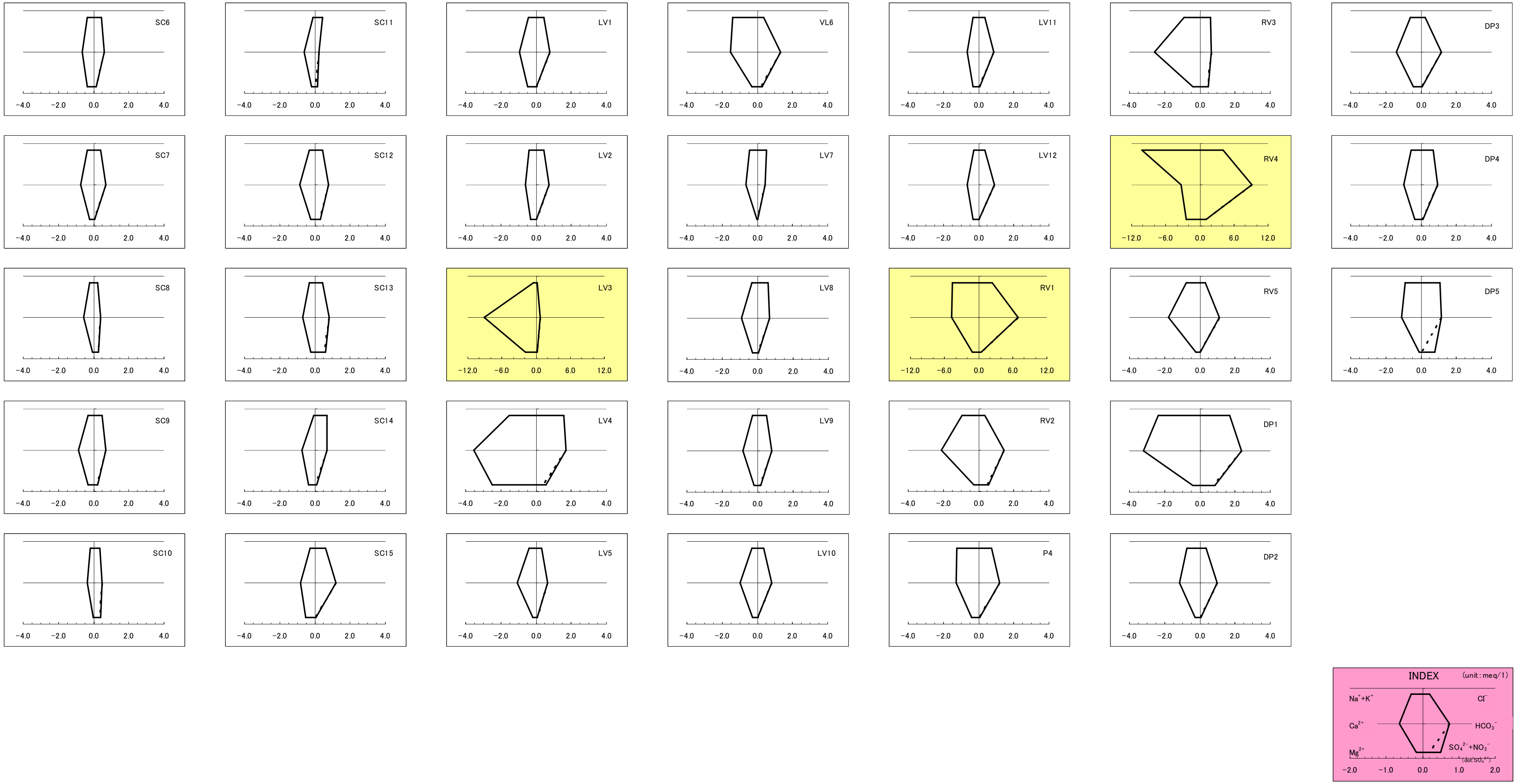


Figure 3.2-4: Hexa Diagram (Dry Season) (2/2)

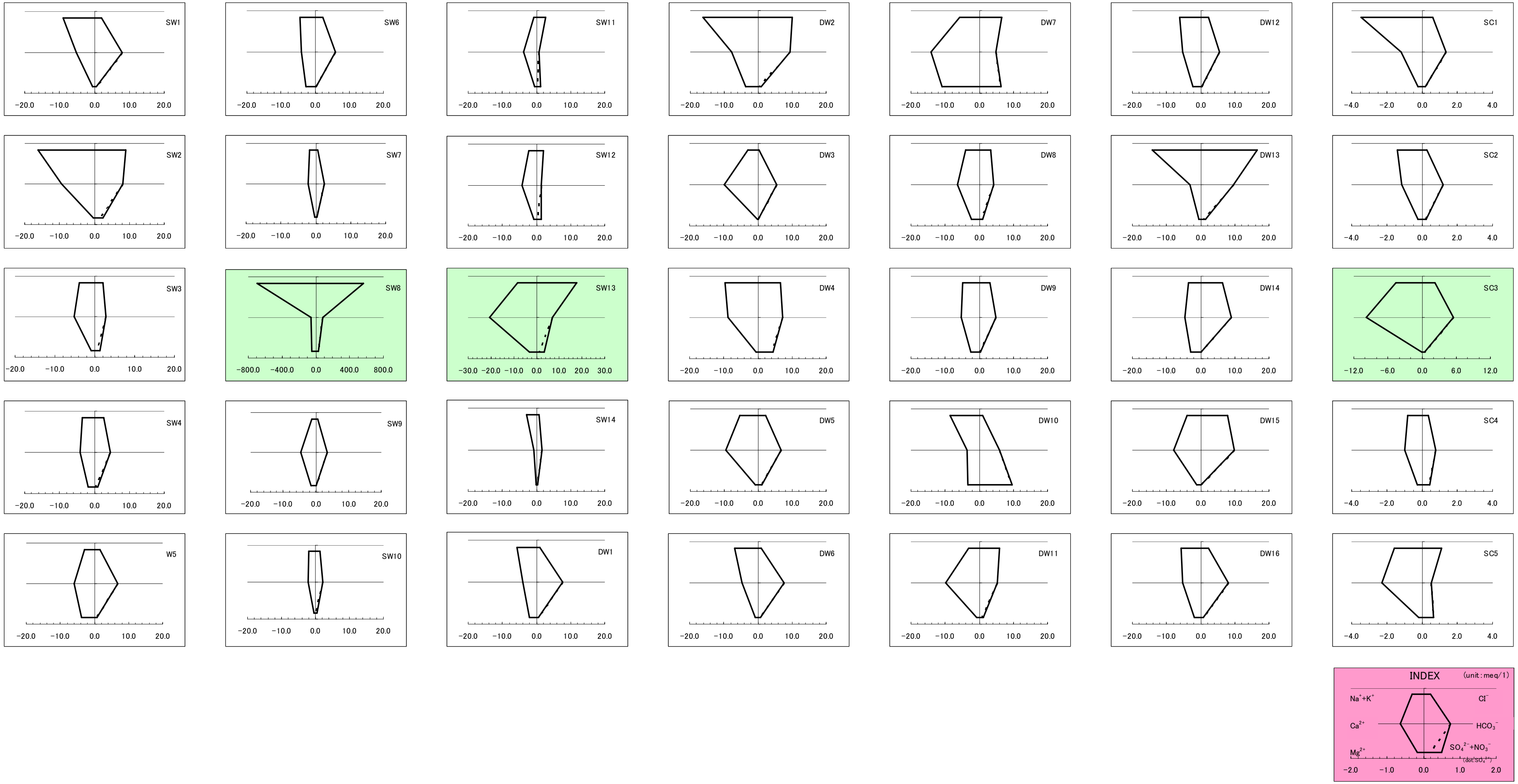


Figure 3.2-5: Hexa Diagram (Wet Season) (1/2)

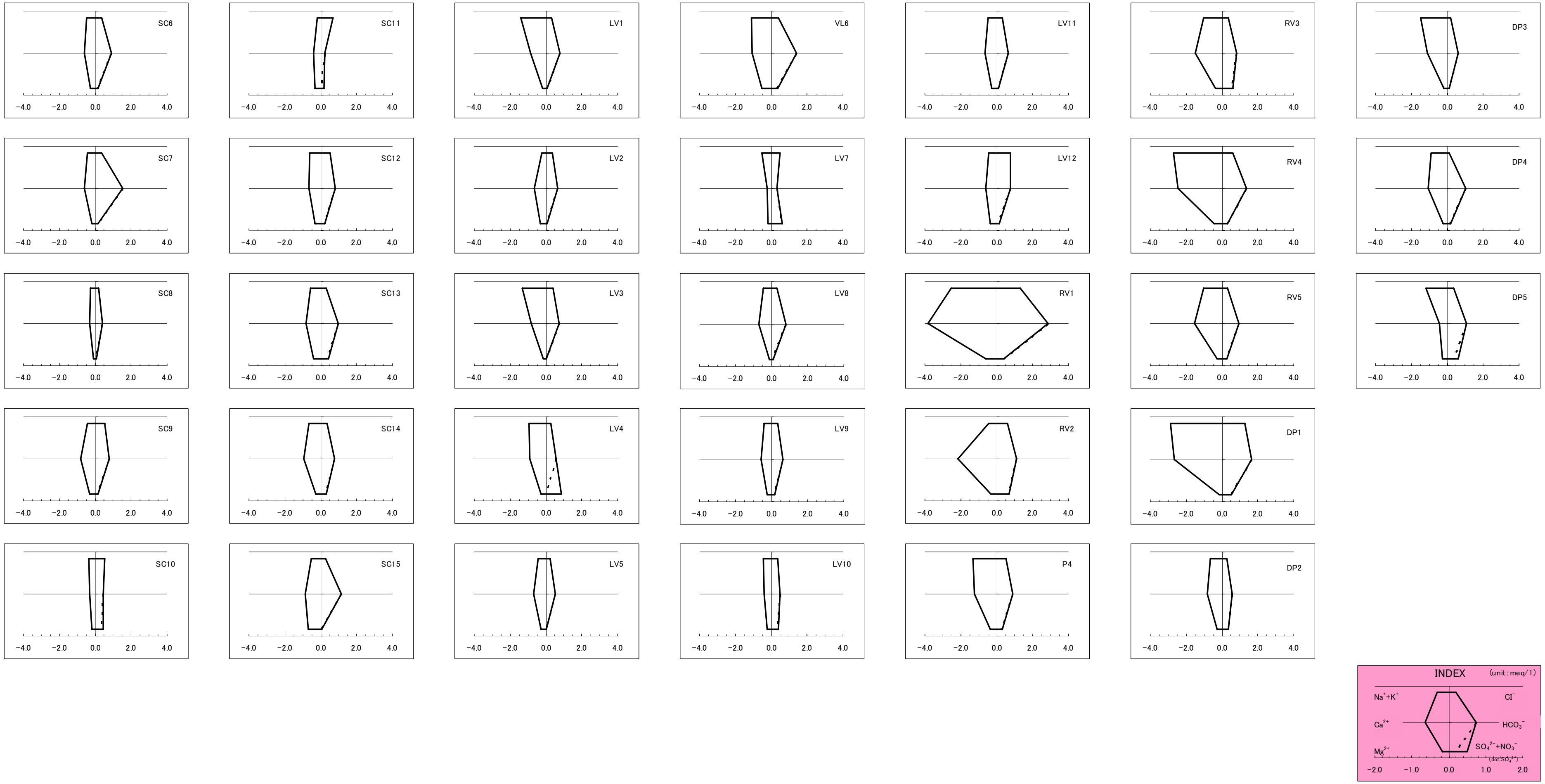


Figure 3.2-5: Hexa Diagram (Wet Season) (2/2)

Type	District	Name of Location	SN	Well Type	Field														Laboratory																				Laboratory																			
					Temp	EC	NO3	NH4	pH	ORP	Fe	Mn	F	As	Coliform	Esc. Colif	Taste	Odour	T. Coliform	Esc. Colif	Pb	As	Se	Cr	Cyanide	Cd	Ba	Hg	F	NO3	Color	Turbidity	PH	TSS	TDS	T-Hardness	Ca	Mg	SO4	Cl	Fe	Mn	Cu	Zn	BOD	NH4	B	Ni	Mo	NO2	Residue Chlorine	Temp	EC	K	PO4	COD	HCO3	Na
					°C	μS/m	mg/l	mg/l		mv	mg/l	mg/l	mg/l	μg/l					count/100ml	count/100ml	mg/l	μg/l	μg/l	mg/l	mg/l	mg/l	mg/l	μg/l	mg/l	mg/l	mg Pt/l	NTU		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l		°C	μS/cm	mg/l	mg/l	mg/l	mg/l	mg/l
Shallow Well	Magu	Bugatu Shallow Well	SW1	Shallow	0.91	111.81	1.00	0.20	1.09	0.71	#DIV/0!	#DIV/0!	2.00	#VALUE!	0.29	0.42	#VALUE!	#VALUE!	0.40	3.67	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	0.38	1.00	#DIV/0!	#DIV/0!	1.09	0.07	1.23	1.02	0.80	1.85	0.85	1.20	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.00	0.00	0.07	#VALUE!	#VALUE!	#VALUE!	0.85	#DIV/0!	1.02	1.23	7.48	1.87	#DIV/0!	0.74
	Magu	Malili Shallow Well	SW2	Shallow	0.95	9.83	1.00	0.10	0.84	0.68	#DIV/0!	#DIV/0!	2.00	#VALUE!	0.39	0.66	#VALUE!	#VALUE!	0.56	2.80	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.50	#VALUE!	#DIV/0!	#VALUE!	0.09	0.84	#DIV/0!	0.67	0.84	0.83	2.45	1.10	0.87	4.75	0.78	0.87	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.11	0.06	#VALUE!	#VALUE!	#VALUE!	0.61	#DIV/0!	1.05	1.22	11.16	1.82	#DIV/0!	0.98
	Magu	Kitumba Shallow Well	SW3	Shallow	0.97	9.95	1.00	0.40	0.88	4.19	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	2.00	#VALUE!	0.00	#VALUE!	1.06	0.86	#DIV/0!	#DIV/0!	0.88	0.85	1.16	1.04	1.09	0.94	0.96	0.95	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	1.00	#VALUE!	#VALUE!	#VALUE!	0.57	#DIV/0!	1.03	1.16	4.92	0.39	#DIV/0!	0.97
	Sengerema	Kishinda	SW4	Shallow	1.01	1.10	1.00	0.20	1.01	0.85	#DIV/0!	#DIV/0!	1.00	#VALUE!	1.75	0.47	#VALUE!	#VALUE!	1.00	0.89	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	0.97	0.83	#DIV/0!	#DIV/0!	1.02	1.43	1.11	1.10	1.49	0.74	1.00	2.09	#DIV/0!	#DIV/0!	#VALUE!	2.07	#DIV/0!	0.50	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	0.66	#DIV/0!	1.01	1.21	1.69	1.40	#DIV/0!	0.86
	Sengerema	Sotta	SW5	Shallow	0.99	1.10	1.00	2.50	1.02	0.21	#DIV/0!	#DIV/0!	1.00	#VALUE!	2.63	0.71	#VALUE!	#VALUE!	3.20	0.60	#VALUE!	#VALUE!	#VALUE!	#VALUE!	3.00	#VALUE!	#DIV/0!	#VALUE!	1.30	0.76	#DIV/0!	#DIV/0!	1.02	3.07	1.10	1.02	1.48	0.73	0.85	3.83	#DIV/0!	#DIV/0!	#VALUE!	1.33	#DIV/0!	0.89	6.00	#VALUE!	#VALUE!	#VALUE!	0.83	#DIV/0!	0.98	0.14	1.60	2.00	#DIV/0!	0.95
	Sengerema	Buswelu Bulyaheke	SW6	Shallow	0.97	1.55	1.00	0.40	1.07	-1.70	20.00	#DIV/0!	0.53	#VALUE!	11.20	4.94	#VALUE!	#VALUE!	13.00	4.36	#VALUE!	#VALUE!	#VALUE!	#VALUE!	2.00	#VALUE!	#DIV/0!	#VALUE!	1.38	1.85	5.40	5.43	1.08	0.98	1.47	1.18	2.73	0.31	0.53	3.80	4.19	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	1.39	1.76	#VALUE!	#VALUE!	#VALUE!	1.33	#DIV/0!	0.96	1.59	2.06	0.00	#DIV/0!	1.30
	Geita	Ihaya buyaga	SW7	Shallow	1.05	1.14	#DIV/0!	1.00	1.00	0.46	0.00	#DIV/0!	2.00	#VALUE!	1.71	0.28	#VALUE!	#VALUE!	3.50	0.38	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.73	0.67	0.50	0.00	1.00	9.39	1.08	1.14	1.23	0.95	0.00	5.17	0.96	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.67	1.00	#VALUE!	#VALUE!	#VALUE!	0.00	#DIV/0!	0.93	1.16	1.73	1.47	#DIV/0!	0.95
	Bunda	TAMAU Borehole	SW8	Shallow	0.94	1.11	1.00	2.00	1.01	1.88	#DIV/0!	#DIV/0!	0.50	#VALUE!	0.14	0.04	#VALUE!	#VALUE!	0.19	0.04	#VALUE!	#VALUE!	#VALUE!	0.56	9.00	#VALUE!	#DIV/0!	#VALUE!	0.78	1.17	#DIV/0!	#DIV/0!	1.02	0.52	1.09	0.89	0.84	0.92	0.95	0.88	1.00	#DIV/0!	1.71	#VALUE!	0.50	0.22	3.00	#VALUE!	#VALUE!	#VALUE!	0.40	#DIV/0!	0.97	1.23	0.67	2.53	3.43	0.02
	Bunda	Nyaburundu-Kiberenge	SW9	Shallow	0.91	0.79	1.00	0.50	1.14	-0.74	1.00	#DIV/0!	0.50	#VALUE!	0.25	0.00	#VALUE!	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	0.59	2.01	6.75	8.21	1.15	2.68	0.79	0.59	0.82	0.30	0.00	1.63	1.76	#DIV/0!	#VALUE!	#VALUE!	1.00	0.59	2.80	#VALUE!	#VALUE!	#VALUE!	10.75	#DIV/0!	1.01	0.76	1.18	1.52	1.00	0.64
	Bunda	Ligamba A	SW10	Shallow	0.97	1.32	1.00	0.40	1.32	0.66	#DIV/0!	#DIV/0!	0.50	#VALUE!	0.43	0.18	#VALUE!	#VALUE!	0.53	0.19	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.67	1.15	0.00	0.00	1.31	1.35	1.18	1.06	1.20	0.78	9.44	1.27	6.00	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	1.23	7.00	#VALUE!	#VALUE!	#VALUE!	2.33	#DIV/0!	0.99	1.31	1.37	2.16	#DIV/0!	0.62
	Musoma rural	Nyakiswa Shallow well	SW11	Shallow	0.96	1.25	1.00	1.25	1.05	0.80	#DIV/0!	#DIV/0!	2.00	1.00	0.34	0.51	#VALUE!	#VALUE!	0.25	0.49	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.73	1.53	0.00	0.00	1.11	0.32	1.22	1.24	1.16	1.43	0.57	1.05	11.21	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	1.35	1.00	#VALUE!	#VALUE!	#VALUE!	2.88	#DIV/0!	1.03	1.22	1.65	0.94	#DIV/0!	0.87
	Tarime	Mriba Medium Well	SW12	Shallow	1.02	1.18	1.00	4.00	1.03	-21.00	#DIV/0!	#DIV/0!	1.00	1.00	0.09	0.20	#VALUE!	#VALUE!	0.21	0.35	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	1.00	0.94	0.00	0.00	1.06	15.45	1.15	0.98	1.06	0.82	0.15	0.91	3.13	#DIV/0!	#VALUE!	#VALUE!	0.00	0.81	1.00	#VALUE!	#VALUE!	#VALUE!	0.47	#DIV/0!	0.98	0.58	1.83	1.00	0.00	0.76
	Tarime	Wegita shallow well	SW13	Shallow	1.14	0.95	1.00	10.00	1.01	10.20	#DIV/0!	#DIV/0!	1.00	0.33	0.31	0.31	#VALUE!	#VALUE!	0.24	0.34	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.93	0.74	0.00	0.00	1.07	1.53	1.07	1.26	1.11	1.66	1.84	1.10	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.00	0.60	0.14	#VALUE!	#VALUE!	#VALUE!	1.01	#DIV/0!	1.00	1.07	1.29	0.74	1.00	1.04
	Misungwi	Ngaya Nyabusalu Shallow Well	SW14	Shallow	0.96	9.63	1.00	2.50	0.98	1.19	0.20	#DIV/0!	1.00	#VALUE!	3.44	8.17	#VALUE!	#VALUE!	8.67	40.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	0.89	0.64	0.28	7.22	0.93	1.62	1.08	1.00	0.63	2.00	0.84	1.75	3.94	#DIV/0!	#VALUE!	#VALUE!	0.00	#DIV/0!	0.01	#VALUE!	#VALUE!	#VALUE!	0.00	#DIV/0!	1.01	1.08	23.63	1.08	0.33	0.88
Deep Well	Tarime	Roche Deep well	DW1	Deep	0.91	1.33	1.00	1.00	0.99	69.00	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.50	0.50	#VALUE!	#VALUE!	0.13	0.36	#VALUE!	#not app	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.97	1.33	#DIV/0!	1.50	0.96	0.80	1.24	1.04	1.24	0.88	1.12	1.06	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	6.12	6.00	#VALUE!	#VALUE!	#VALUE!	0.83	#DIV/0!	1.02	1.24	1.81	3.38	#DIV/0!	0.97
	Magu	Kabila Medium Well	DW2	Deep	0.77	143.05	1.00	0.10	1.08	0.69	0.00	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.28	0.06	#DIV/0!	#DIV/0!	1.09	0.42	0.48	0.29	0.35	0.24	0.00	0.05	0.02	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.02	0.06	#VALUE!	#VALUE!	#VALUE!	3.69	#DIV/0!	1.08	0.48	1.49	2.12	0.00	0.66
	Magu	Nyangh'anga Med -Well	DW3	Deep	0.92	69.16	1.00	0.20	1.15	0.71	#DIV/0!	0.00	1.88	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	1.45	150.28	0.00	#DIV/0!	1.20	2.13	1.92	0.70	0.42	6.30	#DIV/0!	6.75	#DIV/0!	0.00	#VALUE!	#VALUE!	#DIV/0!	0.19	0.06	#VALUE!	#VALUE!	#VALUE!	1.31	#DIV/0!	1.04	1.92	36.32	1.54	#DIV/0!	1.27
	Magu	Ng'wamanyili Deep Well	DW4	Deep	1.03	11.78	1.00	#DIV/0!	0.89	0.73	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.97	1.90	#DIV/0!	#DIV/0!	0.89	1.33	1.40	1.34	1.03	3.21	0.61	1.24	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	0.50	#VALUE!	#VALUE!	#VALUE!	99.16	#DIV/0!	1.03	1.40	7.47	1.15	#DIV/0!	1.10
	Kwimba	Ilumba Medium Well	DW5	Deep	1.04	9.37	1.00	1.00	1.06	2.75	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	0.67	1.37	0.00	0.00	1.08	2.00	1.28	1.06	0.97	1.43	0.00	0.94	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	0.10	#VALUE!	#VALUE!	#VALUE!	0.62	#DIV/0!	1.06	1.28	1.98	0.91	#DIV/0!	0.90
	Kwimba	Pump-H Kadashi Well-Sch.	DW6	Deep	1.05	9.99	1.00	0.00	0.98	4.47	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	0.00	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.29	0.83	0.00	0.00	1.02	0.33	1.20	1.24	1.10	1.59	1.14	1.44	3.00	#DIV/0!	#VALUE!	#VALUE!	0.00	#DIV/0!	0.07	#VALUE!	#VALUE!	#VALUE!	0.28	#DIV/0!	1.05	1.19	9.27	1.20	0.00	0.78
	Kwimba	Gulung'wa Deep Well	DW7	Deep	1.02	12.11	1.00	0.50	0.99	1.47	0.20	#DIV/0!	2.50	1.00	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	0.00	#VALUE!	1.72	0.35	18.79	28.00	0.99	4.83	1.33	0.83	1.28	0.60	0.24	1.09	1.46	#DIV/0!	#VALUE!	0.94	#DIV/0!	3.57	0.01	#VALUE!	#VALUE!	#VALUE!	8.67	#DIV/0!	1.02	1.33	1.74	1.85	#DIV/0!	1.30
	Kwimba	Buyogo Deep Well	DW8	Deep	1.02	10.09	1.00	1.00	0.90	0.53	#DIV/0!	#DIV/0!	1.00	#VALUE!	3.67	10.00	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.50	#VALUE!	#DIV/0!	#VALUE!	0.41	1.03	#DIV/0!	#DIV/0!	0.93	1.12	1.29	0.95	1.14	0.73	0.87	0.95	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	0.10	#VALUE!	#VALUE!	#VALUE!	0.53	#DIV/0!	1.03	1.28	0.17	0.57	#DIV/0!	1.33
	Misungwi	Isenengeja Deep Well	DW9	Deep	0.87	9.94	1.00	0.40	0.97	0.86	#DIV/0!	#DIV/0!	1.00	#VALUE!	1.88	13.50	#VALUE!	#VALUE!	1.43	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	1.08	0.53	#DIV/0!	#DIV/0!	1.00	0.84	1.19	1.10	1.01	1.18	#VALUE!	1.02	0.02	#DIV/0!	#VALUE!	5.19	#DIV/0!	#DIV/0!	0.07	#VALUE!	#VALUE!	#VALUE!	6.83	#DIV/0!	1.03	1.19	#VALUE!	1.14	#DIV/0!	1.03
	Misungwi	Ng'obo Shilalo Pump-H	DW10	Deep	1.02	10.68	1.00	1.00	0.92	-0.35	#DIV/0!	#DIV/0!	0.53	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	1.14	1.71	#DIV/0!	#DIV/0!	0.95	1.72	1.21	1.34	2.07	1.04	0.23	0.91	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	0.10	#VALUE!	#VALUE!	#VALUE!	1.18	#DIV/0!	1.02	1.21	2.59	1.26	#DIV/0!	1.20
	Misungwi	Manawa Ng'wawile Well	DW11	Deep	0.93	9.21	1.00	1.25	0.94	0.86	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	0.66	1.66	0.30	0.33	0.99	0.44	1.06	0.87	0.92	0.62	0.63	0.99	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	13.55	0.07	#VALUE!	#VALUE!	#VALUE!	0.65	#DIV/0!	1.02	1.07	0.53	0.37	#DIV/0!	0.94
	Serengeti	Robanda D-Well	DW12	Deep	0.91	10.05	1.00	0.25	1.01	1.08	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	0.00	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	0.46	70.72	#DIV/0!	#DIV/0!	1.03	0.21	1.27	0.98	1.07	0.89	0.21	0.87	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	14.19	0.42	#VALUE!	#VALUE!	#VALUE!	0.42	#DIV/0!	1.05	1.27	3.47	0.25	#DIV/0!	1.37
	Kwimba	Lunere	DW13	Deep	1.00	1.18	1.00	0.80	1.01	20.08	0.00	#DIV/0!	1.88	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	3.22	0.95	0.00	0.00	0.98	0.56	1.11	1.39	1.41	1.35	0.83	0.65	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.43	1.80	#VALUE!	#VALUE!	#VALUE!	0.41	#DIV/0!	0.94	1.30	1.25	1.56	#DIV/0!	0.95
	Serengeti	Nyansurura Borehole	DW14	Deep	1.02	1.08	1.00	1.00	1.00	0.78	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	1.27	1.21	#DIV/0!	#DIV/0!	1.00	0.51	1.07	1.63	0.72	2.20	#DIV/0!	0.58	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.50	23.00	#VALUE!	#VALUE!	#VALUE!	1.40	#DIV/0!	0.98	1.19	1.58	8.67	#DIV/0!	0.75
	Tarime	Ingri Juu D- well	DW15	Deep	0.99	1.25	#DIV/0!	0.50	1.02	1.33	#DIV/0!	#DIV/0!	1.00	#VALUE!	1.25	1.60	#VALUE!	#VALUE!	2.00	1.80	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	1.01	0.40	0.00	0.00	1.02	0.44	1.21	1.51	1.42	1.75	0.00	0.08	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.23	0.08	#VALUE!	#VALUE!	#VALUE!	0.75	#DIV/0!	1.02	1.16	2.02	2.43	#DIV/0!	0.93
	Musoma rural	MasusuraD-well	DW16	Deep	1.01	1.22	1.00	10.00	1.00	0.48	0.00	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.97	1.14	#DIV/0!	0.00	1.03	0.34	1.19	1.39	1.10	1.72	0.98	1.05	6.00	#DIV/0!	#VALUE!	3.00	#DIV/0!	0.43	0.13	#VALUE!	#VALUE!	#VALUE!	1.15	#DIV/0!	0.98	1.19	2.05	2.39	#DIV/0!	0.96
Piped Schime	Magu	Pump-H Lake-Vic Scheme	SC1		0.97	2.27	1.00	0.20	0.94	0.48	0.00	#DIV/0!	1.00	#VALUE!	19.00	#DIV/0!	#VALUE!	#VALUE!	14.00	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.64	1.71	0.61	#DIV/0!	0.99	29.22	0.56	0.71	0.79	0.54	1.58	0.50	4.36	#DIV/0!	#VALUE!	#VALUE!	0.00	0.81	0.50	#VALUE!	#VALUE!	#VALUE!	0.00	#DIV/0!	1.03	0.57	8.50	3.02	0.00	0.45
	Misungwi	Mbarika Lake-Vic Pump-H	SC2		0.78	12.28	#DIV/0!	1.00	0.88	1.25	#DIV/0!	#DIV/0!	0.53	#VALUE!	4.24	10.11	#VALUE!	#VALUE!	6.78	20.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	0.94	22.10	0.67	16.50	0.82	0.16	1.46	1.65	1.74	1.45	2.64	1.00	1.54	#DIV/0!	#VALUE!	#VALUE!	0.30	#DIV/0!	5.67	#VALUE!	#VALUE!	#VALUE!	2.43	#DIV/0!	1.04	1.46	9.41	4.50	0.39	1.28
	Misungwi	Usagara D-Well Pump-H	SC3		1.01	88.38	1.00	0.40	0.95	0.29	#DIV/0!	#DIV/0!	3.75	#VALUE!	0.00	0.00	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	1.09	55.25	53.43	39.00	0.94	2.67	1.29	1.09	0.96	13.50	1.04	0.89	2.50	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	11.40	2.13	#VALUE!	#VALUE!	#VALUE!	9.23	#DIV/0!	1.04	1.29	7.91	1.89	#DIV/0!	1.25
	Tarime	Nyandurumo Springs	SC4		0.83	12.06	1.00	0.40	0.90	-0.16	20.00	1.00	2.00	#VALUE!	0.40	2.67	#VALUE!	#VALUE!	0.50	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	1.57	21.14	2.59	1.18	0.91	0.45	1.39	1.42	1.55	1.23	0.60	1.00	3.81	2.29	#VALUE!	#VALUE!	0.00	#DIV/0!	0.08	#VALUE!	#VALUE!	#VALUE!	0.70	#DIV/0!	1.03	1.38	3.80	1.71	0.00	1.57
	Tarime	Tagota Water Scheme	SC5		0.84	9.39	#DIV/0!	2.50	1.17	0.94	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	1.92	26.52	0.19	0.28	1.19	0.43	1.03	0.95	0.78	1.70	0.15	0.79	9.00	#DIV/0!	#VALUE!	#VALUE!	0.00	#DIV/0!	0.13	#VALUE!	#VALUE!	#VALUE!	1.49	1.00	1.03	1.03	3.55	1.85	0.00	2.21
	Sengerema	Nyamazugo lake victoria	SC6		0.97	1.06	#DIV/0!	0.50	1.21	3.20	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.33	0.06	#VALUE!	#VALUE!	0.13	0.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	3.00	#VALUE!	#DIV/0!	#VALUE!	0.41	0.00	0.76	1.00	1.13	3.93	1.04	1.19	1.08	1.29	1.35	1.15	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.36	0.35	1.60	#VALUE!	#VALUE!	#VALUE!	1.00	#DIV/0!	4.34	1.07	1.43	0.02	0.50	0.70
	Sengerema	Lumeya Lake Victoria	SC7		1.00	1.17	1.00	1.00	1.01	7.17	#DIV/0!	#DIV/0!	2.00	#VALUE!	0.27	0.07	#VALUE!	#VALUE!	0.20	0.03	#VALUE!	#VALUE!	#VALUE!	#VALUE!	2.00	#VALUE!	#DIV/0!	#VALUE!	0.45	#DIV/0!	2.07	2.00	1.03	3.29	1.33	1.19	1.21	1.17	0.24	1.21	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.46	1.03	1.67	#VALUE!	#VALUE!	#VALUE!	0.25	#DIV/0!	0.98	1.25	1.62	0.11	0.67	0.46
	Sengerema	Isaka Spring	SC8		1.05	1.09	#DIV/0!	5.00	1.08	1.17	#DIV/0!	#DIV/0!	1.00	#VALUE!	17.00	2.00	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	2.00	#VALUE!	#DIV/0!	#VALUE!	0.19	0.00	0.00	0.40	1.07	0.16	1.08	1.36	1.83	0.80	7.81	1.14	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.74	0.60	#VALUE!	#VALUE!	#VALUE!	0.50	#DIV/0!	0.98	1.20	5.95	1.88	#DIV/0!	0.96
	Sengerema	Sengerema Treated water	SC9		0.94	1.05	1.00	1.00	0.94	0.19	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.44	1.21	#DIV/0!	#DIV/0!	1.13	11.76	1.04	1.06	1.09	1.03	1.71	0.94	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.55	4.00	#VALUE!	#VALUE!	#VALUE!	0.17	#DIV/0!	0.97	1.12	1.48	0.41	#DIV/0!	0.87
	Geita	katoma Spring	SC10		1.20	0.99	1.00	1.00	1.04	0.98	0.00	#DIV/0!	#DIV/0!	#VALUE!	5.33	1.33	#VALUE!	#VALUE!	7.00	1.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.24	0.54	0.27	0.47	1.05	1.90	0.94	0.60	1.17	0.22	1.04	0.72	1.80	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.82	1.61	#VALUE!	#VALUE!	#VALUE!	0.27	#DIV/0!	1.02	1.00	0.67	2.16	#DIV/0!	1.11
	Ukerewe	Murutunguru TTC	SC11		0.95	1.32	1.00	2.50	1.14	1.54	2.00	#DIV/0!	1.00	#VALUE!	5.00	0.67	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.21	1.10	#DIV/0!	#DIV/0!	1.14	1.93	1.32	0.88	1.50	0.56	0.00	0.60	0.12	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.83	3.00	#VALUE!	#VALUE!	#VALUE!	1.00	#DIV/0!	1.00	1.33	1.54	2.06	#DIV/0!	1.00
	Bunda	Kasahunga Lake Victoria	SC12		0.96	1.15	1.00	0.20	0.96	1.90	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.18	0.08	#VALUE!	#VALUE!	0.13	0.03	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.51	1.01	0.76	0.63	1.02	4.58	1.11	1.00	1.31	0.75	1.31	0.84	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.00	0.97	1.50	#VALUE!	#VALUE!	#VALUE!	0.07	#DIV/0!	0.99	1.15	1.34	0.41	0.24	0.92
	Bunda	Guta Lake Victoria P. House	SC13		0.92	0.99	1.00	1.00	1.13	0.33	0.00	#DIV/0!	1.00	#VALUE!	0.93	0.30	#VALUE!	#VALUE!	2.00	0.25	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.49	0.82	0.78	0.86	1.16	6.44	0.99	0.74	0.88	0.63	1.46	1.45	0.68	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	1.23	2.00	#VALUE!	#VALUE!	#VALUE!	0.07	#DIV/0!	0.98	1.01	1.28	0.85	#DIV/0!	0.83
	Bunda	Guta After chrolination	SC14		0.32	6.40	1.00	#DIV/0!	1.01	6.56	#DIV/0!	#DIV/0!	0.50	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	0.87	1.38	1.32	1.50	1.03	1.43	1.13	0.97	0.79	1.21	0.12	1.85	0.93	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	1.44	2.50	#VALUE!	#VALUE!	#VALUE!	0.13	1.00	0.98	1.20	1.27	1.17	#DIV/0!	0.90
	Serengeti	Msati scheme	SC15		0.98	1.08	1.00	1.00	1.02	0.32	#DIV/0!	#DIV/0!	2.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.69	1.81	#DIV/0!	#DIV/0!	1.04	4.39	1.06	0.83	0.94	0.77	0.00	2.20	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	0.92	2.50	#VALUE!	#VALUE!	#VALUE!	1.50	#DIV/0!	0.98	1.18	1.10	1.35	#DIV/0!	1.06
Lake Victoria	Magu	Pump-H Kalemelala I Lake-Vic	LV1		1.08	9.26	#DIV/0!	0.00	0.95	0.38	#DIV/0!	#DIV/0!	1.00	#VALUE!	13.33	5.18	#VALUE!	#VALUE!	11.00	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	3.03	11.05	#DIV/0!	2.67	0.90	129.47	1.10	1.59	1.12	2.40	0.00	1.45	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.00	0.82	0.11	#VALUE!	#VALUE!	#VALUE!	1.46	#DIV/0!	1.05	1.10	11.14	8.25	0.00	1.00
	Magu	Lake Victoria Bulima	LV2		1.01	8.78	#DIV/0!	0.25	0.94	0.56	#DIV/0!	#DIV/0!	1.00	#VALUE!	11.33	52.00	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	3.15	0.66	1.00	0.60	0.94	1.85	1.17	1.00	0.92	1.07	0.00	1.15	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.18	1.54	0.06	#VALUE!	#VALUE!	#VALUE!	1.64	#DIV/0!	1.05	1.18	5.42	1.47	0.33	1.13
	Magu	Pump-H Kalemelala I Lake-Vic	LV3		1.09	7.69	#DIV/0!	0.50	1.14	0.34	#DIV/0!	#DIV/0!	1.00	#VALUE!	4.14	10.75	#VALUE!	#VALUE!	12.00	49.00	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.00	#VALUE!	#DIV/0!	#VALUE!	2.05	#DIV/0!	3.14	4.00	1.05	10.71	0.12	11.46	11.38	11.63	4.13	0.64	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.00	1.48	0.42	#VALUE!	#VALUE!	#VALUE!	3.16	#DIV/0!	1.04	1.15	6.91	2.32	0.32	1.00
	Mwanza	Milongo Lake-Vic Mwanza	LV4		1.06	3.54	1.00	1.00	1.09	0.38	#DIV/0!	#DIV/0!	0.27	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	2.01	0.19	#DIV/0!	0.00	1.07	33.45	3.39	6.29	3.94	9.54	12.06	5.50	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	1.68	60.63	0.06	#VALUE!	#VALUE!	#VALUE!	45.56	#DIV/0!	1.02	3.39	27.75	2.30	1.00	3.03
	Tarime	Shirati Lake Victoria	LV5		1.06	10.68	#DIV/0!	1.00	1.19	3.11	#DIV/0!	#DIV/0!	0.50	#VALUE!	0.61	3.55	#VALUE!	#VALUE!	1.10	6.25	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	2.07	3.84	0.76	2.67	1.14	16.84	1.14	1.13	1.50	0.73	2.06	1.38	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	3.00	#DIV/0!	0.06	#VALUE!	#VALUE!	#VALUE!	0.79	#DIV/0!	1.05	2.29	6.35	5.50	4.10	1.25
	Sengerema	Buyagu - Lake Victoria	LV6		0.87	1.10	1.00	#DIV/0!	1.03	0.62	0.00	#DIV/0!	0.53	#VALUE!	0.45	0.17	#VALUE!	#VALUE!	0.46	0.11	#VALUE!	#VALUE!	#VALUE!	#VALUE!	5.00	#VALUE!	#DIV/0!	#VALUE!	0.94	0.88	0.74	1.00	1.05	10.66	1.10	1.00	1.48	0.62	0.69	0.93	0.22	#DIV/0!	#VALUE!	#VALUE!	0.70	0.73	2.50	#VALUE!	#VALUE!	#VALUE!	0.71	#DIV/0!	0.97	1.38	1.49	2.25	0.65	0.94
	Sengerema	Nyakahako	LV7		1.06	1.16	#DIV/0!	2.50	1.00	1.17	1.00	#DIV/0!	2.00	#VALUE!	0.47	0.12	#VALUE!	#VALUE!	0.50	0.06	#VALUE!	#VALUE!	#VALUE!	#VALUE!	16.00	#VALUE!	#DIV/0!	#VALUE!	0.30	0.00	0.90	2.71	1.01	1.99	1.19	1.00	2.60	0.11	0.00	1.06	3.88	#DIV/0!	#VALUE!	#VALUE!	1.00	0.42	0.80	#VALUE!	#VALUE!	#VALUE!	0.01	#DIV/0!	0.95	1.26	1.33	0.97	1.00	1.44
	Sengerema	Lushamba-kanyara	LV8		0.95	1.05	#DIV/0!	1.00	1.03	0.80	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.52	0.22	#VALUE!	#VALUE!	0.56	0.22	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.41	0.34	0.00	#DIV/0!	1.06	6.51	0.99	1.57	1.29	2.14	#DIV/0!	1.82	#DIV/0!	#DIV/0!	#VALUE!	10.00	#DIV/0!	1.07	2.00	#VALUE!	#VALUE!	#VALUE!	0.57	#DIV/0!	0.99	1.08	1.17	0.45	1.00	0.83
	Geita	Katoma lake victoria	LV9		1.10	1.12	#DIV/0!	1.00	0.97	2.83	#DIV/0!	#DIV/0!	1.00	#VALUE!	2.23	0.57	#VALUE!	#VALUE!	0.71	0.13	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.44	0.67	0.00	0.00	1.00	23.56	1.24	1.17	1.42	0.92	1.00	1.50	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	1.36	2.33	#VALUE!	#VALUE!	#VALUE!	0.50	#DIV/0!	0.96	1.23	1.61	0.05	1.00	1.26
	Ukerewe	Chabilungo Lake Victoria	LV10		0.98	1.38	#DIV/0!	1.00	1.18	0.10	0.00	#DIV/0!	1.00	#VALUE!	0.71	0.31	#VALUE!	#VALUE!	0.73	0.23	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.50	0.34	0.10	0.25	1.19	33.71	1.69	1.70	2.50	1.17	0.00	0.96	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	1.00	0.84	6.00	#VALUE!	#VALUE!	#VALUE!	4.60	#DIV/0!	1.00	1.88	1.66	0.09	1.00	1.69
	Musoma	Musoma Lake Victoria	LV11		0.88	1.08	#DIV/0!	1.00	0.88	-0.31	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.75	0.29	#VALUE!	#VALUE!	1.13	0.36	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.56	0.58	3.14	1.60	0.89	2.99	1.00	1.04	1.00	1.07	0.48	1.18	1.43	#DIV/0!	#VALUE!	#VALUE!	0.63	0.55	2.00	#VALUE!	#VALUE!	#VALUE!	0.11	#DIV/0!	0.95	1.23	1.73	0.32	0.67	1.33
	Musoma rural	Bukima Lake victoria	LV12		1.06	1.12	1.00	2.50	0.95	2.92	0.00	#DIV/0!	1.00	#VALUE!	0.42	0.16	#VALUE!	#VALUE!	0.57	0.12	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.72	0.39	0.00	0.40	0.97	1.78	1.11	0.97	1.08	0.88	0.00	0.46	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	0.30	2.71	2.25	#VALUE!	#VALUE!	#VALUE!	2.00	#DIV/0!	1.00	1.20	2.84	0.20	0.32	1.17
River	Magu	Simiyu River Bridge	RV1		0.91	16.22	#DIV/0!	1.00	1.01	5.77	#DIV/0!	#DIV/0!	1.00	#VALUE!	0.78	2.04	#VALUE!	#VALUE!	1.86	7.60	#VALUE!	#VALUE!	#VALUE!	#VALUE!	6.00	#VALUE!	0.00	#VALUE!	0.16	28.13	0.34	0.32	1.02	0.61	1.90	1.36	1.22	1.73	0.93	1.85	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	0.21	#VALUE!	#VALUE!	#VALUE!	0.92	#DIV/0!	1.04	1.89	6.46	1.14	0.00	2.43
	Bunda	Rubana River Bunda	RV2		0.86	9.80	#DIV/0!	1.25	1.12	0.32	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	4.50	#VALUE!	#DIV/0!	#VALUE!	1.32	0.90	0.20	3.34	0.97	1.45	1.00	0.95	0.98	0.87	0.79	0.62	15.68	#DIV/0!	#VALUE!	#VALUE!	0.59	40.42	0.01	#VALUE!	#VALUE!	#VALUE!	0.03	#DIV/0!	1.05	1.00	2.14	1.35	0.61	1.28
	Tarime	Ryamisanga Mara River	RV3		0.91	10.03	#DIV/0!	0.50	1.03	1.15	0.42	#DIV/0!	0.53	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#DIV/0!	#VALUE!	#DIV/0!	#VALUE!	0.86	2.24	0.51	0.55	1.06	3.09	1.15	1.07	1.04	1.12	0.00	1.37	1.78	#DIV/0!	#VALUE!	#VALUE!	1.31	1.11	0.02	#VALUE!	#VALUE!	#VALUE!	0.99	#DIV/0!	1.04	1.14	3.44	0.71	1.49	1.32
	Tarime	Randa Mori River	RV4		1.00	13.94	#DIV/0!	1.00	1.03	2.47	0.20	#DIV/0!	0.53	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	3.00	#VALUE!	#DIV/0!	#VALUE!	1.41	0.75	0.38	0.40	0.94	52.80	1.51	1.51	1.73	1.14	0.83	1.83	0.77	#DIV/0!	#VALUE!	#VALUE!	0.57	1.40	0.05	#VALUE!	#VALUE!	#VALUE!	0.31	#DIV/0!	1.04	1.51	8.96	1.48	0.41	0.78
	Serengeti	Ft. Ikoma River Grumeti	RV5		0.88	51.15	#DIV/0!	2.00	1.11	4.95	#DIV/0!	#DIV/0!	1.88	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	1.90	6.63	0.00	0.00	1.06	2.74	5.55	2.71	1.37	5.86	3.37	6.86	1.91	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	0.30	#VALUE!	#VALUE!	#VALUE!	1.69	#DIV/0!	1.03	11.07	11.90	0.99	#DIV/0!	6.62
Dam and Pond	Kwimba	Malya Dam Pump-H	DP1		1.00	11.64	#DIV/0!	1.00	0.96	9.54	#DIV/0!	#DIV/0!	2.00	#VALUE!	0.50	2.64	#VALUE!	#VALUE!	1.06	7.25	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	0.00	#VALUE!	1.47	0.83	0.00	6.19	0.93	6.45	1.28	1.05	1.15	0.81	0.00	1.00	2.45	#DIV/0!	#VALUE!	#VALUE!	0.58	1.40	0.05	#VALUE!	#VALUE!	#VALUE!	2.04	#DIV/0!	1.04	1.28	4.73	5.39	1.38	1.16
	Misungwi	Misungwi Scheme Dam	DP2		0.87	12.96	#DIV/0!	0.08	1.04	0.99	#DIV/0!	#DIV/0!	1.00	#VALUE!	#DIV/0!	26.33	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	1.05	3.32	2.31	2.27	0.98	2.78	1.41	1.38	1.21	2.71	1.57	1.33	5.80	#DIV/0!	#VALUE!	#VALUE!	0.60	0.43	0.03	#VALUE!	#VALUE!	#VALUE!	3.32	#DIV/0!	1.08	1.41	6.57	2.77	0.40	1.42
	Tarime	Tagota Dam Tarime	DP3		0.91	14.06	1.00	0.40	1.07	0.14	0.00	#DIV/0!	3.75	#VALUE!	2.86	15.50	#VALUE!	#VALUE!	3.20	#DIV/0!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	0.50	#VALUE!	#DIV/0!	#VALUE!	1.41	30.94	0.00	0.00	0.98	7.67	1.47	1.24	1.44	1.00	0.00	1.44	2.47	#DIV/0!	#VALUE!	#VALUE!	2.00	#DIV/0!	0.03	#VALUE!	#VALUE!	#VALUE!	1.30	#DIV/0!	1.00	1.47	26.55	12.33	2.05	1.79
	Tarime	Nyanjage Dam / Pond	DP4		1.05	16.13	1.00	#DIV/0!	1.06	1.92	#DIV/0!	#DIV/0!	0.50	#VALUE!	1.05	3.00	#VALUE!	#VALUE!	1.15	4.83	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	1.80	13.26	1.00	1.00	0.99	2.82	1.48	1.59	1.27	2.30	0.33	1.33	1.63	#DIV/0!	#VALUE!	#VALUE!	#DIV/0!	#DIV/0!	0.06	#VALUE!	#VALUE!	#VALUE!	0.68	#DIV/0!	1.03	2.96	6.19	0.50	6.10	1.92
	Geita	Geita Dam	DP5		0.97	1.05	#DIV/0!	1.00	0.96	1.14	#DIV/0!	#DIV/0!	1.00	#VALUE!	1.07	0.40	#VALUE!	#VALUE!	1.17	0.18	#VALUE!	#VALUE!	#VALUE!	#VALUE!	15.00	#VALUE!	#DIV/0!	#VALUE!	0.55	0.72	2.07	12.67	1.02	20.59	1.03	1.12	0.95	1.42	0.45	8.33	2.26	#DIV/0!	#VALUE!	#VALUE!	0.60	0.78	8.00	#VALUE!	#VALUE!	#VALUE!	0.67	#DIV/0!	0.96	1.16	1.58	0.92	0.91	0.92
	Geita	Nyalubele pond	DP6		0.96	1.68	1.00	2.50	1.02	0.57	#DIV/0!	#DIV/0!	0.53	#VALUE!	2.11	0.61	#VALUE!	#VALUE!	3.50	0.21	#VALUE!	#VALUE!	#VALUE!	#VALUE!	1.00	#VALUE!	#DIV/0!	#VALUE!	0.64	3.20	0.79	0.77	1.01	5.14	1.67	1.22	2.44	0.43	0.00	2.92	1.00	#DIV/0!	#VALUE!	#VALUE!	1.00	1.31	6.83	#VALUE!	#VALUE!	#VALUE!	3.33	#DIV/0!	0.97	1.83	2.23	1.32	1.00	1.11

Colum Number = % of DRY/WET ■ = more than 50% ▩ = more than 1.2 % ░ = less than 0.8 % ☐ = between 0.8 - 1.2 %

Figure 3.2-6: Matrix of Seasonal Difference of Water Quality

Table 3.2-11: Water Quality Result of Supplementary Survey (Lake Victoria)

S/No			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Northings			9713222	9712829	9771156	9770623	9819754	9820876	9799843	9796774	9742585	9741042	9748207	9745164	973003	9731919	9706914	9705330
Eastings			36389297	36388738	36534078	36533732	36574890	36577467	36547470	36549395	36440454	36434060	36421523	36425305	36431337	36429075	36385880	36387477
Name of Location			Buligi site 1	Buligi site 2	Namalama site1	Namalama site 2	Kiembe site 1	Kiembe site 2	Butata site 1	Butata site 2	Nyakabanga site 1	Bugolo site 2	Bulyaheke site 1	Bulyaheke 2	Lumeya site 1	Nyambeba site 2	Kaseni site 1	Kaseni site 2
District			Geita	Geita	Bunda	Bunda	Musoma (R)	Musoma (R)	Musoma (R)	Musoma (R)	Sengerema	Sengerema	Sengerema	Sengerema	Sengerema	Sengerema	Geita	Geita
Sampling Date			28/2/2006	28/2/2006	2006/2/3	2006/2/3	2006/3/3	2006/3/3	2006/4/3	2006/4/3	2006/6/3	2006/6/3	2006/6/3	2006/8/3	2006/8/3	2006/8/3	2006/1/3	2006/1/3
FIELD	Temp	°C	21.3	21.6	27.3	27.6	25.3	25.6	24.6	24.8	23.5	26.9	27.5	27.2	24.9	29.6	23.5	24.1
	EC	mS/m	7.61	7.70	7.35	7.29	7.83	7.66	7.37	7.33	8.63	7.33	7.36	7.46	8.22	8.01	7.64	7.66
	pH		8.40	8.47	8.30	8.50	8.20	9.30	7.90	8.00	9.20	7.90	9.10	8.50	9.70	9.20	8.60	8.65
	ORP	mv	10	15	12	9	62	19	39	47	10	31	-48	18	-46	-71	24	31
	Taste		Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
	Odour		Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable	Unobjectionable
LABORATORY	CN	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Fe	mg/l	0.13	0.05	0.05	0.02	0.05	0.06	0.03	0.01	0.03	0.02	0.02	0.00	0.08	0.04	0.12	0.08
	Mn	mg/l	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	F	mg/l	0.590	0.350	0.210	0.310	0.360	0.260	0.550	0.900	0.900	0.310	0.260	0.260	0.210	0.110	0.210	0.160
	pH		7.97	8.55	8.52	8.32	8.35	9.41	8.08	8.23	8.98	8.59	8.20	8.32	9.55	8.93	8.45	8.36
	Ba	mg/l	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	NH4	mg/l	0.10	0.06	0.03	0.01	0.01	0.03	0.06	0.05	0.12	0.06	0.06	0.06	0.17	0.21	0.06	0.05
	NO3	mg/l	1.72	1.81	1.33	0.66	0.66	2.03	0.84	1.90	0.75	1.81	1.50	1.81	2.12	1.64	2.03	1.72
	Color	ｍｇＰt/l	0	7	0	0	0	7	7	14	14	14	14	7	7	22	36	22
	Turbidity	NTU	5	3	0	0	0	2	2	3	8	3	2	3	2	6	6	8
	TSS	mg/l	80.0	70.0	30.0	50.0	50.0	60.0	90.0	60.0	50.0	60.0	20.0	40.0	100.0	70.0	80.0	110.0
	TDS	mg/l	38.10	38.50	36.80	36.40	39.20	38.30	36.90	36.60	43.10	36.60	36.80	37.30	41.10	40.10	38.20	38.40
	Coliform	count/100ml	2	5	4	2	7	0	0	8	2	0	7	0	18	11	5	3
	T-Hardness	mg/l	38	39	35	27	28	27	27	21	25	25	26	29	34	27	20	29
	Ca	mg/l	17	26	11	16	15	13	14	15	15	15	12	14	15	13	13	22
	Mg	mg/l	5.103	3.159	5.832	2.673	3.159	3.402	3.159	1.458	2.43	2.43	3.402	3.645	4.617	3.402	1.701	1.701
	PO4	mg/l	0.07	0.09	0.13	0.10	0.09	0.09	0.13	0.14	0.11	0.14	0.13	0.13	0.15	0.10	0.20	0.11
	SO4	mg/l	4.9	6.6	3.3	0.0	4.9	6.6	3.3	0.0	3.3	0.0	3.3	1.6	8.3	3.3	8.3	10.6
	Cl	mg/l	16	17	16	17	21	19	23	23	13	17	15	13	11	14	13	14
	BOD	mg/l	0	0	0	0	0	2	0	3	0	0	0	3	8	6	0	0
	COD	mg/l	0	0	0	0	0	0	0	10	0	0	0	10	12	15	0	0
	B	mg/l	0.05	0.03	0.01	0.01	0.03	0.01	0.01	0.04	0.01	0.01	0.06	0.03	0.06	0.01	0.01	0.01
	HCO3	mg/l	46	35	47	42	41	41	49	44	51	49	43	45	58	42	46	56
	Na	mg/l	18.90	13.80	34.20	12.80	13.80	16.30	11.60	10.80	11.70	18.50	10.40	10.50	10.80	20.70	13.60	7.20
	Cd	mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	Cr	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Cu	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	As	µg/l	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
	Pb	mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
	Zn	mg/l	0.05	0.03	0.03	0.03	0.02	0.03	0.04	0.04	0.04	0.03	0.02	0.02	0.23	0.06	0.03	0.02
	Se	µg/l	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
	k	mg/l	2.00	1.90	2.04	1.81	1.81	1.96	1.85	1.84	1.82	2.17	1.74	1.75	1.65	1.57	1.68	1.79
	Hg	µg/l	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00
	Organic Phosphate	mg/l	<0.01	0.01	0.01	<0.01	0.01	<0.01	0.01	<0.01	0.01	0.02	0.01	<0.01	0.02	<0.01	0.01	<0.01

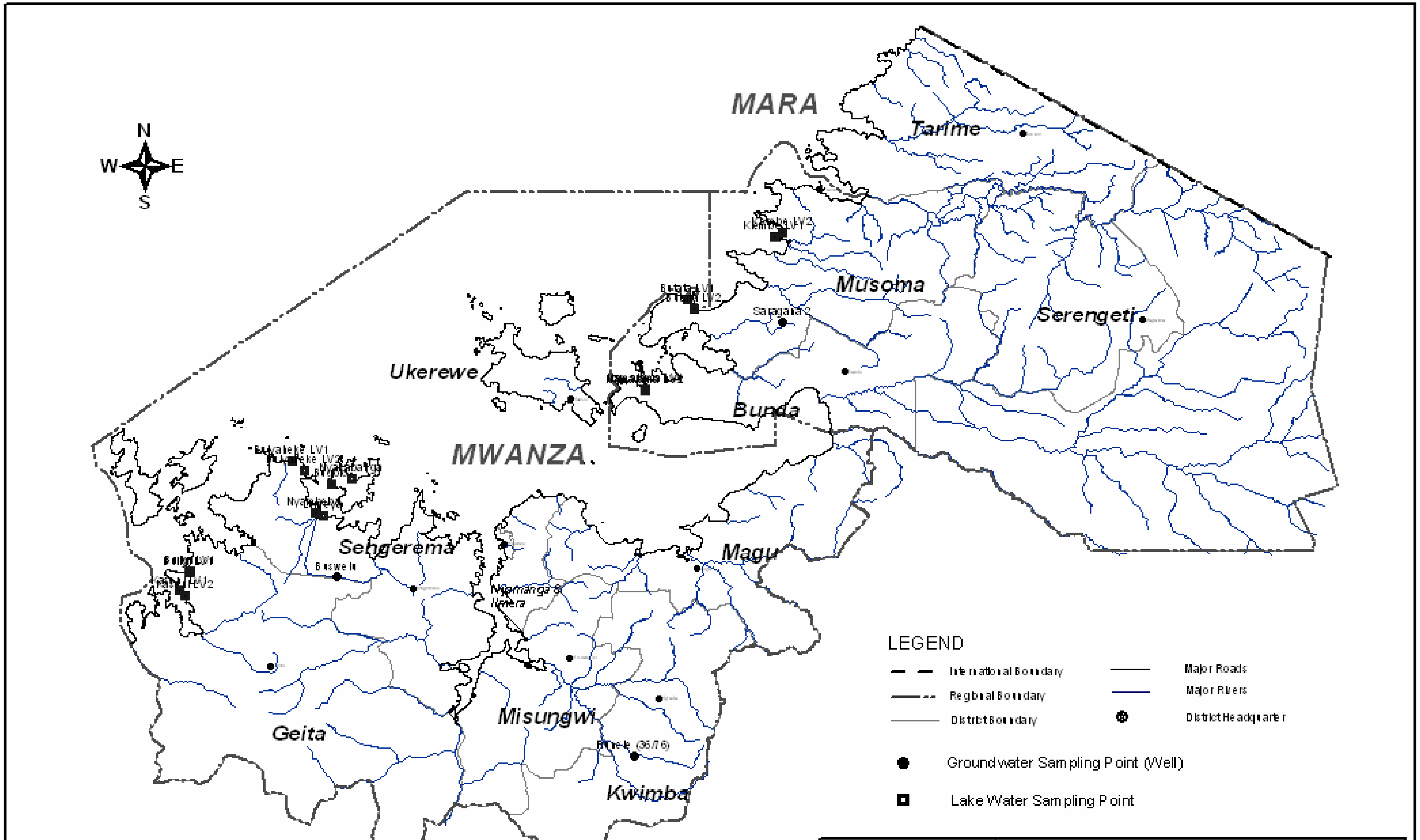


Figure 3.2-7	Location of Water Sampling (Phase II)

THE STUDY ON THE RURAL WATER SUPPLY
IN MWANZA AND MARA REGIONS

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

3.3 Existing Water Supply System

3.3.1 General Condition of Water Supply

a. Nationwide Water Supply Condition

In order to secure the supply of safe water, the Ministry of Water generally recommends the following ways of water supply to inhabitants.

- Piped schemes
- Protected wells
- Wells (Shallow wells, Boreholes) with hand pumps
- Protected springs

According to the "National Rural Water Supply and Sanitation Programme Draft Volume 1 Main Report September 2004", water supply to 56% of the total population of Tanzania (88% of urban, 46% of rural) in 2001 was based on the above-mentioned systems. This survey is a plan to build water supply facilities for local areas in the Mwanza and Mara regions. Table 3.3-1 shows the water supply rates for all regions, including these two. In the two years between 2001 and 2003, the water supply rate nationwide for local areas grew by 20%, to 53.5%. This indicates that arrangement of water supply infrastructure has been steadily facilitated by international organizations, such as World Bank, and also by bilateral country cooperation.

However, the service rates of rural water supply in the Mwanza and Mara regions are still 47.0% and 44.4% respectively, both less than the national average of 53.5%. Out of 20 regions, Mwanza is ranked 15th and Mara 17th. Therefore, further facilitation of water supply is an urgent issue for both regions.

Table 3.3-1: Rural Population by Regions and Service Coverage

No.	Region	Rural population	Service population	Service rate （%）
1.	Dodoma	1,384,639	1,070,339	78.53
2.	Mtwara	1,040,952	669,818	65.68
3.	Kigoma	1,184,180	734,478	63.37
4.	Tanga	1,473,596	807,786	61.35
5.	Kagera	1,952,667	1,139,074	59.28
6.	Rukwa	1,061,531	621,694	59.03
7.	Kilimanjaro	1,236,813	762,596	58.96
8.	Coast	889,146	527,029	58.42
9.	Ruvuma	985,830	534,419	56.67
10.	Arusha	1,292,973	788,203	56.28
11.	Mbeya	1,803,624	952,018	56.04
12.	Iringa	1,388,637	780,552	55.93
13.	Morogoro	1,270,393	635,923	51.73
14.	Shinyanga	2,670,414	1,323,403	49.30
15.	Mwanza	2,414,603	1,178,373	**47.01**
16.	Manyara	1,040,455	467,837	45.76
17.	Mara	1,191,782	509,851	**44.35**
18.	Lindi	673,737	260,762	37.66
19.	Singida	975,404	369,188	37.17
20.	Tabora	1,529,100	420,510	26.94
Total		27,460,476	14,553,853	**53.47**

Source: National Rural Water Supply and Sanitation Programme Draft Volume 1 Main Report September 2004

N.B.: In the above-mentioned report, the average service ratio for each region was calculated based on average ratios in each district. Therefore, the coverage ratio shown in the table above does not imply "service population / regional administrative population".

b. Water Supply Condition in Study Area

The water supply situation in the Mwanza and Mara regions shall be classified into the following types of use:

- Use of traditional ponds, streams, springs, traditional wells, shallow wells operated with well-buckets.
- Use of shallow and deep wells with hand pumps.
- Direct use of Lake Victoria water.
- Purchasing water from vendors who take it from Lake Victoria or deep wells.
- Use of piped schemes with water sources from Lake Victoria, deep wells, reservoirs and springs.
- Use of protected or unprotected springs.
- Use of rainwater.

Rural residents use water without any treatment in the above-mentioned types of water supply, except for some of the schemes that apply chlorination treatment. This creates serious sanitary problems for humans, especially in Lake Victoria, where the water has been polluted by effluent and there is a possibility that it will worsen in the future. Moreover, local residents have to fetch water from long distances for securing water in the ways above.

In the 928 villages that the Tanzanian government requested to be studied, about 25% of the total population uses shallow or deep wells with hand pumps.

Water supply coverage to access to clean and safe water in each district of the Mwanza and Mara regions is shown in the Table 3.3-2.

Table 3.3-2: Water Supply Coverage (source: NRWSSP Final, Jan. 2006)

Mwanza		Mara	
District	coverage(%)	District	coverage(%)
Misungwi	37	Bunda	55
Sengerema	57	Musoma (R)	24
Kwimba	52	Tarime	49
Magu	62	Serengeti	53
Geita	51		
Ukerewe	42		
Ilemela	43		

The water utilizations of Lake Victoria relating to water supply circumstances are classified into the following three patterns.

- Direct pumping of lake water: Rural residents living near Lake Victoria use 20-liter cans and other containers to draw water out of the lake, and carry it back to their homes several times a day. Also, rural residents customarily wash their bodies, dishes, and clothes at the lakeside.
- Water vendors' intake: Water vendors make a living by drawing water out of the lake, transporting and selling it to rural residents. Their water charges are more expensive than that of water from shallow wells with hand-pumps or piped schemes. In general, their prevailing rate is about Tsh50 per 20-liter can.
- Water source for the piped schemes: Of the 57 existing piped schemes studied this time, 34 piped schemes use lake water as water sources. When checking the piped schemes with defined facility specifications, their capacities are 50 to 60m3/hour on average. However, the facilities have deteriorated with age, so it is highly possible that the actual flow is substantially below the capacities.

3.3.2 Rural Water Supply System

a. Piped Scheme for Water Supply

a.1 Outline of the Existing Piped Scheme

A study covering the current status of 57 out of 110 requested piped schemes, on the associated current status was carried out in two regions comprising 10 districts. The criteria for selecting the piped schemes are as follows:

- Particular existing piped schemes, which cover at least one village out of the requested 928 villages.
- In the service villages, existing piped schemes that cover at least one village classified in the rural area.
- Existing piped schemes that are not included in on-going or proposed projects.
- In the villages where the population is supplied water by using shallow and deep wells

is less than 50% of the administrative population, piped schemes that should cover at least one village.

- The existing piped schemes skipped by recent mid-large scale rehabilitation projects

Most of the existing piped schemes in the 10 districts of the two regions focus on the use of water for household and live stock purposes. Existing piped schemes only for household usage are very few. The largest number of villages in a water supply service area is 17 (in the Mwamashimba scheme in the Kwimba district of the Mwanza region).

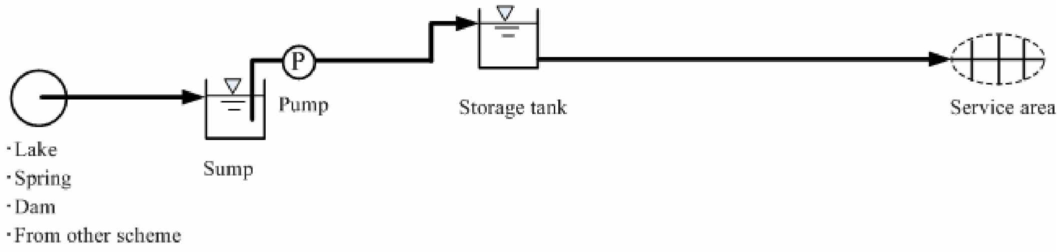
Water source conditions have a very noticeable effect on pipe length in the piped schemes. In the case of piped schemes where lake water is the water source, the maximum straight-line distance from the water intake point to the farthest community is about 35km (average 9km). However, when the water in a scheme comes from a borehole, the maximum distance from the source is about 25km (Average distance: 5km).

Figures 7.④ in the Data Book shows 1:200,000 scale maps of the arrangement and water supply service areas and locations of the main facilities of the 57 piped schemes that are the object of the survey. The water supply service areas were conceptualized based on topography and the locations of main facilities and communities. The main facilities are divided into water intake facilities, pump facilities (intake pumps and booster pumps), and service reservoirs (including break pressure tanks. The location data were obtained using GPS.

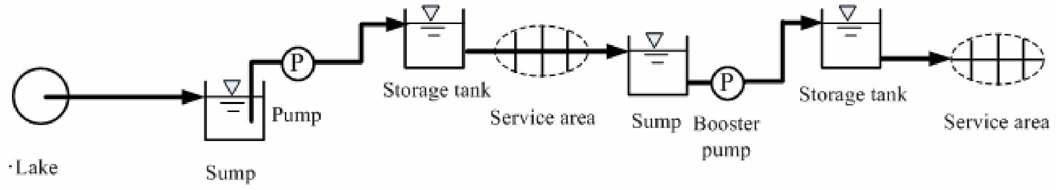
a.2 Types of Existing Piped Schemes

The typical facilities of the existing piped schemes are composed of water sources, intake facilities, pump facilities, transmission pipes, service reservoirs and distribution pipes. Seven facility types classified from A to G based on the form of intake and transmission are shown in Figure 3.1-1. In addition, the number of piped schemes classified by types of facilities is denoted in Table 3.3-3. As per Table 3.3-3, Type “C” is the most abundant type and accounts for about 60% of the 57 piped schemes. This type is a relatively simple structured facility which can provide water without any treatment (Chlorination only for some of the piped schemes) from the water source to the service area through a reservoir that stores raw water directly drawn from the water source. The second most abundant type is type “A”, where raw water is first stored in a receiving chamber, then conveyed to a service reservoir. It is similar to type “C”. Simple structure facilities like types “A” and “C” account for 79% of the 57 piped schemes.

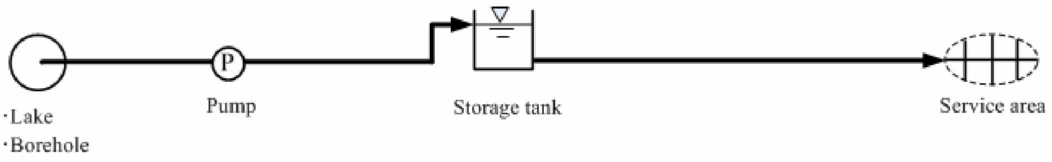
1. Type A : 11 Schemes



2. Type B : 2 Schemes



3. Type C : 34 Schemes



4. Type D : 6 Schemes

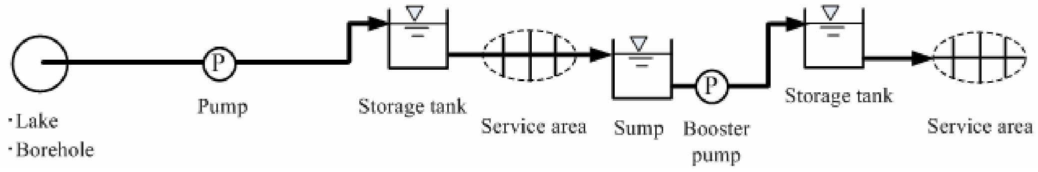
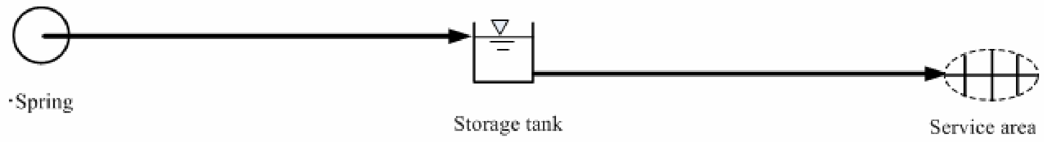
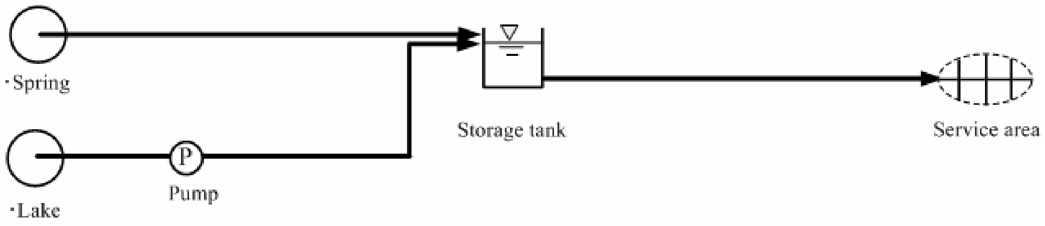


Figure 3.3-1: Facility Types of the Existing Piped Schemes (1/2)

5. Type E : 2 Schemes



6. Type F : 1 Scheme



7. Type G : 1 Scheme

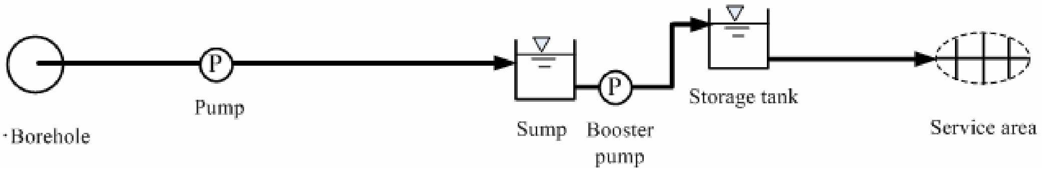


Figure 3.3-1: Facility Types of the Existing Piped Schemes (2/2)

Table 3.3-3: Classification of Water Supply System

Types	Total		Functioning		Partially functioning		Not functioning	
	Nos.	% of type composition	Nos.	% of types	Nos.	% of types	Nos.	% of types
A:	11	19.2	1	10.0	1	8.3	9	24.3
B:	2	3.5	0	0.0	2	16.7	0	2.7
C:	34	59.6	7	70.0	3	25.0	24	64.9
D:	6	10.5	1	10.0	3	25.0	2	5.4
E:	2	3.5	0	10.0	1	8.3	1	2.7
F:	1	1.8	0	0.0	1	8.3	0	0.0
G:	1	1.8	0	0.0	1	8.3	0	0.0
Total	57	100.0	9	15.8	12	21.1	36	63.2

b. Current Status of the Existing Piped Scheme

b.1 Overview

As a result of the study on 57 existing piped schemes, the overview of the current status on the existing facilities is summarized as follows (see Table 3.3-4.)

- Water source: About 60% of the 57 piped schemes use Lake Victoria as a water source, about 28% use boreholes, and the rest rely on other sources such as dams and springs.
- Functional status of the facilities: About 63% of the 57 piped schemes are not functional (see Table 3.3-3).
- Year of completion: Construction of about 68% of the existing piped schemes was completed in the 1970s, and around 22% were built in the 1960s or before. In other words, about 90% were constructed in the 1970s or before.

About 70% of the target piped schemes (57 out of 110 piped schemes) were constructed in the 1970s and their functional capacity has deteriorated remarkably. In addition, inappropriate operation and insufficient maintenance have worsened the functional status of the facilities. They are no longer sufficient for the increasing population. From this point of view, it is assumed that only about 10% of the total design population (Design population: about 350,000 assumed, because data on design population for some of the piped schemes are missing) served by these 57 piped schemes take water from functional and operational piped schemes. Assuming that all of the 57 existing piped schemes are operating under optimum conditions, about 50% of the about 710,000 people living in villages served by existing piped schemes would benefit (This percentage is based on existing design population/administrative population of component villages).

Table 3.3-4: Summary of the Existing Piped Schemes

District	Submitted in pre-study	Final requested schemes	Target schemes	Types of sources					Status of function			Year of completion			
				Lake	Wells	Springs	Dams	Others	Functional[1]	Partially functional	Not functional	Before 1969	1970s	1980s	Since 1990
Nyamagana & Ilemela[2]	6	6	-	-	-	-	-	-	-	-	-	-	-	-	-
Missungi	9	10	5	3	2	0	0	0	2	0	3	3	2	0	0
Kwimba	8	12	6	0	6	0	0	0	0	1	5	3	3	0	0
Sengerema	10	10	7	6	0	0	1	0	3	0	4	3	4	0	0
Magu	12	11	7	5	0	0	0	2	1	2	4	1	5	1	0
Geita	6	7	4	3	1	0	0	0	0	0	4	0	3	1	0
Ukerewe	8	9	8	7	0	1	0	0	0	2	6	1	7	0	0
Sub total	**59**	**65**	**37**	**24**	**9**	**1**	**1**	**2**	**6**	**5**	**26**	**11**	**24**	**2**	**0**
				64.9 %	**24.3 %**	**2.7 %**	**2.7 %**	**5.4 %**	**16.2 %**	**13.5 %**	**70.3 %**	**29.7 %**	**64.9 %**	**5.4 %**	**0.0 %**
Bunda	5	5	4	4	0	0	0	0	2	1	1	0	4	0	0
Musoma (R)	11	11	5	3	2	0	0	0	0	2	3	1	2	2	0
Tarime	19	19	9	3	5	1	0	0	1	2	6	1	8	0	0
Serengeti	9	10	2	0	1	1	0	0	0	2	0	0	1	0	1
Sub total	**44**	**45**	**20**	**10**	**8**	**2**	**0**	**0**	**3**	**7**	**10**	**2**	**15**	**2**	**1**
				50.0 %	**40.0 %**	**10.0 %**	**0.0 %**	**0.0 %**	**15.0 %**	**35.0 %**	**50.0 %**	**10.0 %**	**75.0 %**	**10.0 %**	**5.0 %**
Total	**103**	**110**	**57**	**34**	**17**	**3**	**1**	**2**	**9**	**12**	**36**	**13**	**39**	**4**	**1**
				59.6 %	**29.8 %**	**5.3 %**	**1.8 %**	**3.5 %**	**15.8 %**	**21.1 %**	**63.2 %**	**22.8 %**	**68.4 %**	**7.0 %**	**1.8 %**

1 Two schemes that have not been working because of lack of fuel are included.

2 It was excluded because of classification for urban based on the Tanzania government statistics.

b.2 Pump Facilities

Centrifugal surface pumps are the typical intake pumps used at water sources such as Lakes and booster pumps. For boreholes, borehole line shaft pumps (Mono pump manufacture) are more common than submersible pumps. The pump engines are mostly diesel type. This is because there are no commercial power supply facilities of TANESCO (Tanzania Electric Supply Company) in about 85% of the villages where the 57 piped schemes exist. However, installation of submersible pumps is increasing for improving facilities recently.

Moreover, since flow meters have not been installed in all the piped schemes, actual flow provided by pumping is not clear.

b.3 Pipes for Intake, Transmission and Distribution

Ductile cast iron (DI), galvanized (GS), poly-vinyl (PVC) polyethylene pipes (PP), etc. have been used in the study area. For small size pipes mainly laid in the study area, GS has been commonly used. The total length of the pipes at the 57 piped schemes is about 856km (Mwanza region: about 605km, Mara region: about 251km).

b.4 Service Reservoirs and Break Pressure Tanks

Service reservoirs and break pressure tanks are mainly made of stone masonry, concrete, concrete block and steel structures. The Major structure of service reservoirs is stone masonry which is cheaper and easier to procure materials than other materials.

b.5 Service Connection Facilities

There is a lack of documents comprising drawings and specifications of the exiting facilities because of inadequate management in the Regional Water Engineering office (RWE office) and the District Water Engineering office (DWE office). Therefore, service connection information is not accurate. However, according to the information compiled in the DWE offices, service connections are categorized into three types such as house connections, connections for public or private institutions, and public tap connections. The three types of connections are often combined in the same piped scheme. Namely, there are piped schemes of Level 2 and 3 in the study area.

b.6 Efficiency of Water Supply Facility

In order to verify the efficiency of the water supply facilities and cost effectiveness by the water sources (Lake Victoria and boreholes), the various existing piped schemes were remodeled into one simple drawing of a piped scheme as shown in Figure 3.3-2. Characteristics of the remodeled piped schemes are listed in Table 3.3-5.

The piped schemes with boreholes as a water source are more efficient at transporting water through pipes (annual amount of water distributed per meter of pipe length) than the scheme with Lake Victoria. The efficiency of the pipe used is one index that indicates the efficiency of the water supply system and varies according to the density of villages and topographical factors. For reference, the average efficiency of pipes used in a small-scale water supply system that covers a population of less than 10,000 in Japan, is about 13m3/m.

In addition, in terms of the initial cost of construction per capita, the piped schemes with boreholes are 50% cheaper than with Lake Victoria and their cost effectiveness is higher.

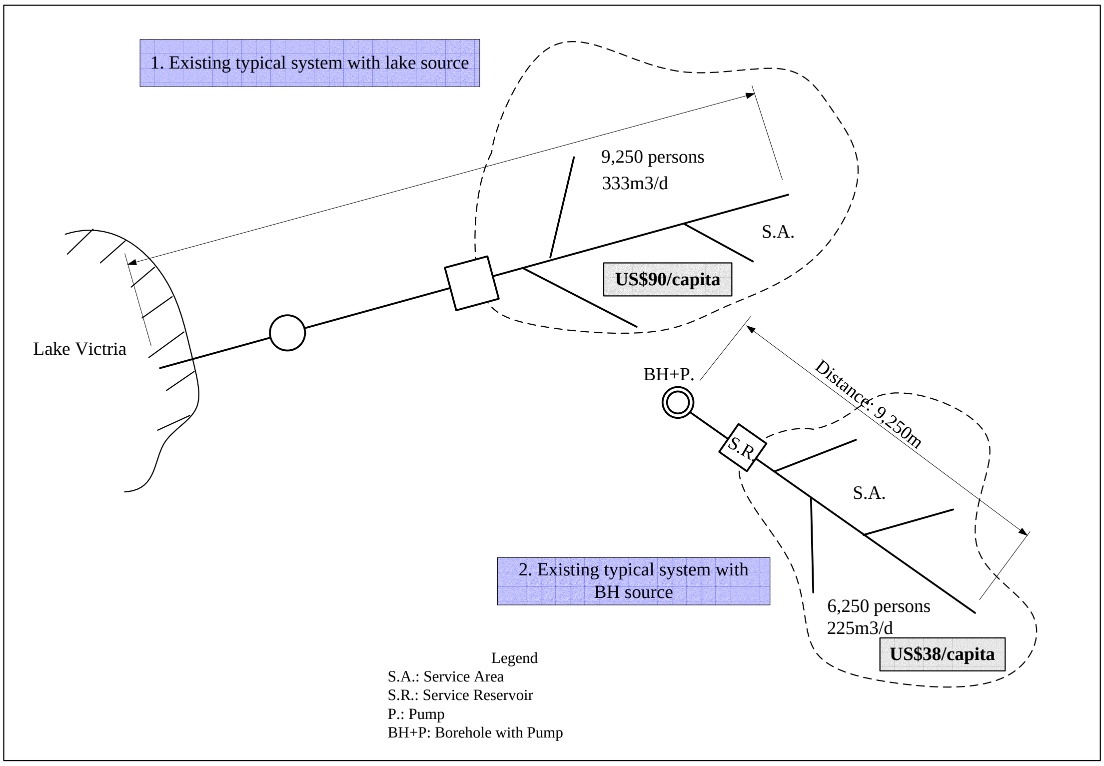


Figure 3.3-2: Modeled System of Existing Piped Water Supply Scheme

Table 3.3-5: Characteristics of Existing Piped Schemes

Items	Remodeled system in Mwanza		Remodeled system in Mara		Remodeled system for both of regions	
Water source	Lake Victoria	Borehole	Lake Victoria	Borehole	Lake Victoria	Borehole
Service population	7,000	9,000	11,500	3,500	9,250	6,250
Pipe length (m)	20,200	12,500	17,200	6,000	18,700	9,250
Design capacity (m3/day)	252	324	414	126	333	225
Efficiency of pipe used (m3/m)	4.6	9.5	8.8	7.7	**6.5**	**8.9**
Capita per pipe used (capita/100m)	35	72	67	58	**49**	**68**
Initial cost per capita (US$/capita)	99	36	80	40	**90**	**38**

The process for remodeling existing piped schemes is as follows. Data and information gathered on existing piped schemes from the District Water Engineer office, etc are used for revising the trial calculation remodeling.

① In the existing piped schemes (*) that have clear facility specifications in the Mwanza and Mara region, the average pipe length by intake, transmission and number of distribution pipes per piped scheme were calculated, as was the total length of all pipes such as intake, transmission and distribution pipes.

② The total length of ① was divided by the design population of the existing piped schemes (*) to derive the service population per 1m of pipe.

③ The service population is assumed to be "①/②".

④ Basic conditions for the remodeled facilities are based on the Tanzania design manual.

The main conditions are as follows.

- Unit water demand: 25 l/capita/ day
- Rate of uncounted water: 20%
- Daily peak factor: 1.2
- Hourly peak factor: 2.0
- Coefficient of velocity: 120

c. Problems with the Existing Piped Schemes

There are many piped schemes that were completed 30-40 years ago that have had mechanical troubles and/or are deteriorating. However, some of the piped schemes have not been repaired for a long time and their operations have been suspended. The status of various facility items and the main causes of trouble are shown in Table 3.3-6 and overview and current status of problems in each existing piped scheme is shown in Table 3.3-7 by type of facility such as water source, intake, transmission, and distribution facilities. In addition, the problems listed in Table 3.3-6 are summarized by type of facility in Table 3.3-8. Table 3.3-8 shows that troubles at intake facilities including pump units account for about 38% of all problems involving the 57 piped schemes. That is followed by troubles with distribution facilities including service reservoirs, which account for about 32%. Troubles with only the pump facilities such as intake and booster pumps accounted for about 29% of all the problems with the 57 piped schemes. This is because of inappropriate operation of the machinery. There are almost no stand-by pumps available, so when the main pumps experience trouble, water pumping can be suspended.

Table 3.3-6: Current Facility Problems and their Main Causes

No.	Problems	Main causes
C-1	• Clogging and damage to foot valves at intake points	• Clogging of waste, deterioration from aging
	• Damage to chambers receiving raw water	• Deterioration from aging
	• Collapse of the water source structure	• Design error
C-2	• Decrease of water level.	• Natural fluctuation of water level by roughly 10-year cycle (source: hydrology information)
C-3	• Lack of capacity for the water source	• Natural fluctuation of water level by year
C-4	• Disconnection	• Deterioration from aging, exposure of pipes
	• Damage or deterioration of pipes	• Work activity of other enterprises, exposure of PVC
C-5	• Incomplete construction, installation, etc	• Lack of finance
C-6	• Use rising pipes for distribution as well	• Cost reduction
C-7	• Insufficient water pressure	• Lack of pump capacity • Location of reservoirs
C-8	• Lack of pump capacity	• Inappropriate mobilization of the pump

		• Increasing demand • Design error
C-9	• Damage, breaking, wearing out of pump units	• Deterioration from aging
C-10	• Theft of pump units	• Lack of security
C-11	• Deterioration such as cracks on the tank structure	• Deterioration from aging
	• Leakage	• Cracks
C-12	• Lack of tank capacity or insufficient tanks	• Increasing demand
C-13	• Financial problems with fuel or power	• Lack of operation and maintenance funding

Table 3.3-7: Status of the Existing Piped Schemes (1/5)

No.	ID No.	Name of scheme	Present population (2004)		% of Service pop.	Water source		Type of system	No. of Service Connections (as of 2004)			Status of facility function							Power source	General condition of facilitily	Year of completion	Year of suspension	Years of operation
												Water source	Intake facilities		Rising & booster pump facilities		Distribution facilities						1960s 1970s 1980s 1990s 2000s
			Each village	Total		Types	Nos. of sources		House or yard	Institution	Stand Post (Inc. Kiosk)		Pipe	Pump Unit	Pipe	Booster pump unit	Storage tank	Pipe					0 5 9 0 5 9 0 5 9 0 5 9 0 5
Mwanza Region																							
Missungwi District																							
1	MwPM-1	Usagara	2,403	2,403	25.0	B	1	**C**	19	0	4			C-9	C-4		C-11	C-4		N.F.	1961		▨
2	MwPM-2	Mbarika	2,816	2,816	-	L		**C**	20	2	12						C-11			F.	1971		□
3	MwPM-3	Kasololo / Igongwa	4,463 3,948 3,538 2,136 4,257 2,142	20,484	-	L		**C**	0	3	26		C-4				C-11	C-4	C-13	F.	1976		□
4	MwPM-4	Ukiriguru	3,346 1,969 2,929 3,474	11,718	34.1	L		**A**	180	0	20		C-4	C-9			C-11			N.F.	1961	2004	▨
5	MwPM-5	Misasi	3,324	3,324	-	B	1	**C**	19	1	1			C-9			C-11			N.F.	1968	2004	▨
Sengerema District																							
6	MwPS-1	Nyamazugo / Sengerema	17,235 4,894 9,407 5,250 2,788 3,676 2,929 2,304 6,060	54,543	33.0	L		**C**	1530	37	0		C-4				C-11			F.	1975		□
7	MwPS-2	Katunguru	5,559 2,733 4,416	12,708	43.3	L		**C**	5	3	26						C-11			F.	1962		□
8	MwPS-3	Lumeya / Kalebezo	3,809 5,506 11,225	20,540	22.4	L		**D**	7	4	24		C-4				C-11			F.	1973		
9	MwPS-4	Sima	5,338	5,338	14.1	D		**A**	0	2	8	C-3		C-9	C-4					N.F.	1967	1987	▨
10	MwPS-5	Luchili	6,264 5,477 3,561	15,302	22.9	L		**C**	0	2	21	C-2			C-6			C-4		N.F.	1973	2000	▨
11	MwPS-6	Busisi	3,358	3,358	443.8	L		**C**	0	1	6		C-4	C-9	C-4 C-5		C-11	C-4		N.F.	1975	1987	▨
12	MwPS-7	Lugasa	7,901	7,901	8.2	L		**C**	8	1	3		C-4	C-9			C-12			N.F.	1968	1978	▨
Kwimba District																							
13	MwPK-1	Ngudu	11,317 675 332 490 3,429	16,243	40.6	B	6	**G**	240	7	4	C-3		C-5 C-9		C-9	C-11			P.F.	1955		□
14	MwPK-2	Mantare	895 3,364	4,259	37.6	B	1	**C**	0	0	4			C-8 C-9	C-4		C-12			N.F.	1977	2004	▨
15	MwPK-3	Ilula	2,932 3,399 2,505	8,836	8.1	B	1	**C**	2	4	3			C-9	C-4		C-11			N.F.	1967	1998	▨
16	MwPK-4	Kadashi	4,436 3,659 2,413 3,555 1,686	15,749	-	B	1	**C**	1	0	5			C-9	C-4			C-4		N.F.	1964	2004	▨

Table 3.3-7: Status of the Existing Piped Schemes (2/5)

No.	ID No.	Name of scheme	Present population (2004)		% of Service pop.	Water source		Type of system	No. of Service Connections (as of 2004)			Status of facility function							Power source	General condition of facilitily	Year of completion	Year of suspension
						Types	Nos. of sources		House or yard	Institution	Stand Post (Inc. Kiosk)	Water source	Intake facilities		Rising & booster pump facilities		Distribution facilities					
			Each village	Total									Pipe	Pump Unit	Pipe	Booster pump unit	Storage tank	Pipe				
17	MwPK-5	Mwamashimba	3,147 3,167 2,075 3,117 3,932 2,512 2,350 1,963 5,492 4,601 2,166 1,923 2,001 2,243 2,842 1,788 2,832	48,151	85.1	B	6	**D**	0	0	50	C-3		C-9	C-4	C-9	C-11	C-5		N.F.	1975	2001
18	MwPK-6	Ilumba	2,213	2,213	-	B	1	**C**	0	0	2	C-3		C-9	C-4		C-11			N.F.	1974	1996
Magu District																						
19	MwPMa-1	Kabila-Ndagalu	4,954 3,348	8,302	37.9	O	1	**E**	15	5	10	C-3			C-5		C-11			N.F.	1974	1985
20	MwPMa-2	Magu	2,189 3,521 742 762 2,922 3,406	13,542	44.3	L		**A**	914	47	38				C-6					P.F.	1984	
21	MwPMa-3	Kalemela/Mkula	5,470 5,927 2,359 1,756 1,082 5,273 2,395 2,800 2,949	30,011	15.0	L		**B**	31	14	26		C-4		C-4			C-4		P.F.	1973	
22	MwPMa-4	Kisesa	4,104 2,362 1,963	8,429	3.8	O	1	**A**	65	5	25					C-9	C-12			N.F.	1975	2005
23	MwPMa-5	Ilumya	2,755 3,041 2,898	8,694	13.8	L		**A**	12	4	8			C-10	C-4			C-4		N.F.	1971	1988
24	MwPMa-6	Nassa	2,526 5,455 3,339 2,853	14,173	5.6	L		**C**	15	4	8		C-4	C-9						N.F.	1975	2003
25	MwPMa-7	Kiloleli	2,755 2,709	5,464	5.5	L		**A**	21	4	4								C-13	F.	1963	

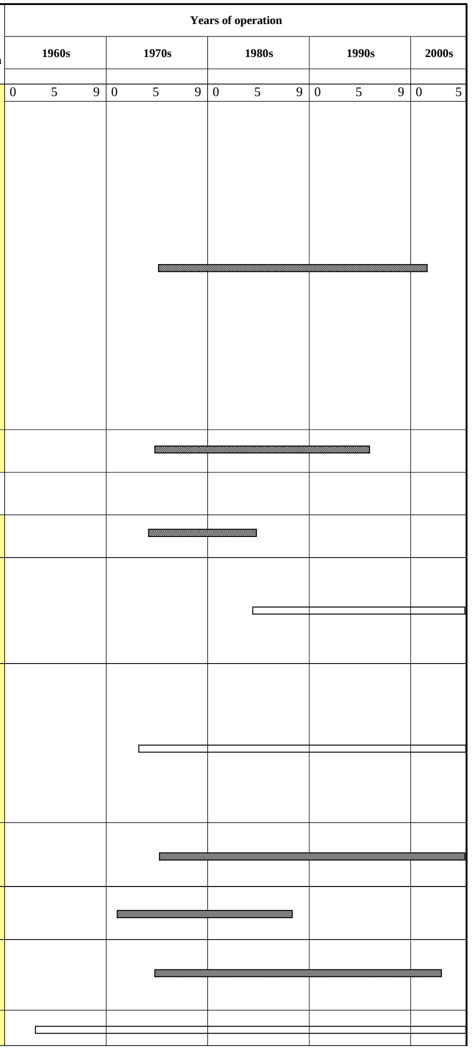


Table 3.3-7: Status of the Existing Piped Schemes (3/5)

No.	ID No.	Name of scheme	Present population (2004)		% of Service pop.	Water source		Type of system	No. of Service Connections (as of 2004)			Status of facility function							Power source	General condition of facilitily	Year of completion	Year of suspension	Years of operation				
						Types	Nos. of sources		House or yard	Institution	Stand Post (Inc. Kiosk)	Water source	Intake facilities		Rising & booster pump facilities		Distribution facilities						1960s	1970s	1980s	1990s	2000s
			Each village	Total									Pipe	Pump Unit	Pipe	Booster pump unit	Storage tank	Pipe					0 5 9	0 5 9	0 5 9	0 5 9	0 5
Geita District																											
26	MwPG-1	Karumwa / Msalala	2,709 675 4,647 2,218 1,331 2,175 2,717 2,551 5,361 2,709	27,093	67.5	L		**D**	10	8	25	C-2	C-4	C-9	C-4	C-10	C-11			N.F.	1973	2000		▨	▨	▨	▨
27	MwPG-2	Nzera	6,852	6,852	13.1	L		**C**	0	2	4		C-4	C-9	C-4		C-11			N.F.	1978	1988		▨	▨		
28	MwPG-3	Nyang'wale	3,320 2,199	5,519	47.5	B	1	**C**	0	4	6			C-9			C-11			N.F.	1980	2004				▨	▨
29	MwPG-4	Nyakagomba	3,630 4,732 3,990 4,285 1,384 3,630 2,162 5,231	29,044	63.2	L		**A**	0	3	6		C-4	C-8						N.F.	1973	1973		▨			
Ukerewe District																											
30	MwPU-1	Gallu	3,994	3,994	60.8	L		**C**	0	0	17			C-9			C-11			N.F.	1971	1985		▨	▨		
31	MwPU-2	Muriti	2,405 2,394	4,799	142.8	L		**C**	0	0	15		C-4	C-9	C-4					N.F.	1976	1986		▨	▨		
32	MwPU-3	Kazilankanda	2,671 2,985 3,082 3,706 2,736 2,057 3,975 2,560 4,419 3,208	31,399	85.3	L		**A**	0	9	51	C-2	C-4				C-11 C-12			N.F.	1977	2005		▨	▨	▨	▨
33	MwPU-4	Murutunguru	4,737	4,737	172.4	L S	1	**F**	0	0	9	C-2	C-4	C-9			C-11			P.F.	1972			□	□	□	□
34	MwPU-5	Nansio	6,412 5,927 528 3,706 4,558	21,131	12.5	L		**C**	141	20	104	C-2	C-4		C-6		C-11			P.F.	1974						
35	MwPU-6	Kagunguli / Bukindo	1,444 5,987	7,431	73.6	L		**A**	0	3	10			C-9			C-11			N.F.	1968	2002	▨	▨	▨	▨	▨
36	MwPU-7	Bukonyo	1,557	1,557	80.7	L		**C**	0	0	3		C-4	C-9 C-10						N.F.	1973	1982		▨	▨		
37	MwPU-8	Irugwa	3,072 2,870	5,942	61.7	L		**A**	0	0	17		C-4	C-9	C-4				C-13	N.F.	1978	1985		▨	▨		

Table 3.3-7: Status of the Existing Piped Schemes (4/5)

No.	ID No.	Name of scheme	Present population (2004)		% of Service pop.	Water source		Type of system	No. of Service Connections (as of 2004)			Status of facility function							Power source	General condition of facilitily	Year of completion	Year of suspension	Years of operation				
			Each village	Total		Types	Nos. of sources		House or yard	Institution	Stand Post (Inc. Kiosk)	Water source	Intake facilities		Rising & booster pump facilities		Distribution facilities						1960s	1970s	1980s	1990s	2000s
													Pipe	Pump Unit	Pipe	Booster pump unit	Storage tank	Pipe					0 5 9	0 5 9	0 5 9	0 5 9	0 5
Mara Region																											
Bunda District																											
38	MPB-1	Bunda	26,482 4,587 2,737 1,726 2,092 7,984 3,012 1,659 2,144	52,423	57.2	L		**D**	422	26	80		C-4	C-9		C-9	C-11			P.F.	1973						
39	MPB-2	Kasahunga	3,416 2,139 930	6,485	18.5	L		**C**	0	4	20		C-4		C-4		C-11 C-12			F.	1975						
40	MPB-3	Kibara	6,339 3,718	10,057	6.0	L		**C**	13	2	25		C-4				C-11 C-12			F.	1973						
41	MPB-4	Iramba	1,797 3,518 1,452 1,584 2,948	11,299	67.3	L		**C**	4	5	37		C-4	C-8 C-9 C-10			C-11			N.F.	1978	1980					
Musoma (R) District																											
42	MPMr-1	Masurura	3,237	3,237	103.2	B	2	**C**	3	4	8			C-10	C-4		C-11	C-4		N.F.	1982	2005					
43	MPMr-2	Itaro	5,692	5,692	155.1	L		**C**	2	0	9	C-2	C-4	C-9	C-4		C-11			N.F.	1975	2004					
44	MPMr-3	Murangi	4,097	4,097	101.3	L		**C**	0	3	3							C-7		P.F.	1962						
45	MPMr-4	Kyankoma	3,884	3,884	15.4	B	1	**C**	0	2	0			C-10	C-4		C-11			N.F.	1988	1988					
46	MPMr-5	Mugango / Butiama (TR)	3,674 1,877 2,106 4,429 4,927 5,568 3,816 3,074 4,266 3,008	36,745	43.5	L		**D**	237	8	1			C-8	C-4		C-11	C-7		P.F.	1975						
Tarime District																											
47	MPT-1	Komuge (TR. No.2)	2,111 1,362 3,405 3,265 3,093 3,338	16,574	-	L		**D**	62	5	65					C-9	C-11	C-4		P.F.	1977						
48	MPT-2	Shirati (TR. No.1)	4,363 1,686 2,704 3,373 2,704 1,773	16,603	-	L		**B**	75	7	50		C-4	C-8 C-9	C-4	C-9	C-11	C-4		P.F.	1979						
49	MPT-3	Marasibora	2,064 2,419	4,483	83.8	B	2	**C**	4	5	19			C-10			C-11			N.F.	1978	1996					
50	MPT-4	Ochuna	1,289	1,289	99.6	B	1	**C**	0	1	8			C-10	C-4					N.F.	1968	1994					

Table 3.3-7: Status of the Existing Piped Schemes (5/5)

No.	ID No.	Name of scheme	Present population (2004)		% of Service pop.	Water source		Type of system	No. of Service Connections (as of 2004)			Status of facility function							Power source	General condition of facilitily	Year of completion	Year of suspension	Years of operation				
			Each village	Total		Types	Nos. of sources		House or yard	Institution	Stand Post (Inc. Kiosk)	Water source	Intake facilities		Rising & booster pump facilities		Distribution facilities						1960s	1970s	1980s	1990s	2000s
													Pipe	Pump Unit	Pipe	Booster pump unit	Storage tank	Pipe					0 5 9	0 5 9	0 5 9	0 5 9	0 5
51	MPT-5	Nyarwana	3,790	3,790	-	B	1	**C**	0	1	5			C-10	C-4		C-11			N.F.	1976	1980					
52	MPT-6	Changuge	4,335	4,335	100.4	S	1	**A**	3	3	10			C-10			C-11			N.F.	1979	1984					
53	MPT-7	Nyamagaro	4,596 4,596	9,192	43.5	B	1	**C**	0	2	5			C-9 C-10			C-11			N.F.	1971	2005					
54	MPT-8	Kyangasaga	4,396	4,396	-	L		**C**	0	0	5	C-2		C-10	C-4		C-11			N.F.	1972	1985					
55	MPT-9	Nyanduga	2,523	2,523	182.3	B	1	**C**	0	2	17				C-4			C-4		F.	1979						
Serengeti District																											
56	MPS-1	Mugumu	12,549	12,549	-	B	9	**C**	185	23	13	C-3		C-9 C-10	C-4		C-11			P.F.	1974						
57	MPS-2	Musati Gravity Scheme	2,409	2,409	307.2	S	2	**E**	0	2	11	C-1 C-3					C-11			P.F.	1992						

Note:
1. Types L - Lake, B - Boreholes, S - Shallow wells, R - River, SP - Spring, D -Dam, O - Others
2. Villges in bold type are shown in the village list.
3. F.- Functioning, P.F.- Partially functioning, N.F.- Not functioning
4. Underlined symbols in "Status of facility function" column denote main causes of suspension.
5. Auumed population in hatching.

Table 3.3-8: Summary of Current Status (Problems) of Facilities

Facility condition	Function of facilities							Operation	Total
	Water sources	Intake facilities		Rising & booster pump facilities		Distribution facilities		Fuel or power	
		Pipes	Pump Units	Pipes	Booster pump units	Service reservoir	Pipes		
C-1	1								1
C-2	7								7
C-3	7								7
C-4		23		25			11		59
C-5			1	2			1		4
C-6				3					3
C-7							2		2
C-8			5						5
C-9			28		6				34
C-10			12		1				13
C-11						39			39
C-12						6			6
C-13								3	3
Total	15	23	46	30	7	45	14	3	183
%	8.2	12.6	25.1	16.4	3.8	24.6	7.7	1.6	100
	8.2	37.7		20.2		32.3		1.6	100

The number of existing piped schemes and the functions of the facilities are listed by the year of completion in Table 3.3-9. As per the Table, most of the existing piped schemes were completed in the 1970s, and make up about 68% of the 57 piped schemes. Most of the existing piped schemes completed in the 1970s have been suspended. About 90% of the suspended piped schemes are facilities that were completed in the 1970s, the 1960s or before 1960.

Also, the main causes for the suspension of the facilities are at pump facilities which make up 78%, and especially suspended pump facilities, which are concentrated in piped schemes completed in 1970s. The main causes for the suspension of the facilities by the year of completion are shown in Table 3.3-10.

On the other hand, concrete protecting taps and taps are remarkably damaged in some service connections. Especially, many service connection taps are missing due to theft etc. in piped schemes that are not functional and this is very serious situation.

Table 3.3-9: Status of Suspension on Facility Function

Total	1960s or before	1970s	1980s	1990s	2000s	Total
The number of the all schemes	13	39	4	1	0	57
%	22.8	68.4	7.0	1.8	0.0	100.0
Total	1960s or before	1970s	1980s	1990s	2000s	Total
The number of the suspended schemes	9	24	3	0	0	36
%	25.0	66.7	8.3	0.0	0.0	100.0

Table 3.3-10: Numbers of Suspended Facilities and their Causes

The facilities which caused suspension	Water sources	Pipes	Pump Units	Others※	Total
1960s or before	0	0	9	0	**9**
1970s	5	1	17	1	**24**
1980s	0	1	2	0	**3**
1990s	0	0	0	0	**0**
2000s	0	0	0	0	**0**
Total	**5**	**2**	**28**	**1**	**36**
%	**13.9**	**5.6**	**77.8**	**2.7**	**100.0**

※Financial problem with fuel or power supply

d. Current Rehabilitation of Exiting Piped Schemes

Some of the pump units have been replaced in 19 of the 57 piped schemes so far. Replacement of some pump units began in 1982 and replacement of other pump units began in 1994. This is to restore the functionality of the facilities that have been suffering remarkable deterioration, theft, etc.

Also, some of the pipes were replaced in 19 other piped schemes (some replacement projects overlap one another). In the piped schemes where the pipes were replaced, about 25% of the total length was replaced. This is equivalent to about 9% of the total pipe length (about 850km) of the 57 piped schemes being replaced.

Thus, these rehabilitation works are only useful to provide limited water temporary, because other huge deteriorated and damaged facilities are remained.

Chapter 4

Geophysical Prospecting

4 Geophysical Prospecting

4.1 Purpose and Method

4.1.1 Purpose of Study

The geology in the Region of Mwanza and Mara has a broad distribution of various types of granite. The geology of the bedrock that forms the mountain chiefly consists of granite and the areas in which no bedrock is exposed probably have a distribution of weathered granite layers. The flat landform areas mostly have a distribution of lake and marsh sediment. Besides the geology mentioned above, the northern part of Mara has a distribution of sedimentary rocks.

The resistivity of granite is generally high, whereas that of sedimentary rocks are low. However, the rocks of the same lithofacies may have different resistivity depending on the percentage of moisture content or the degree of weathering and alteration in their strata. Electrical prospecting is to analyze the conditions of groundwater and the geological structures by researching the resistivity of the rocks and the geology in the ground through the use of the diversity of electrical characteristics of rocks, or the phenomena occurred by that fact.

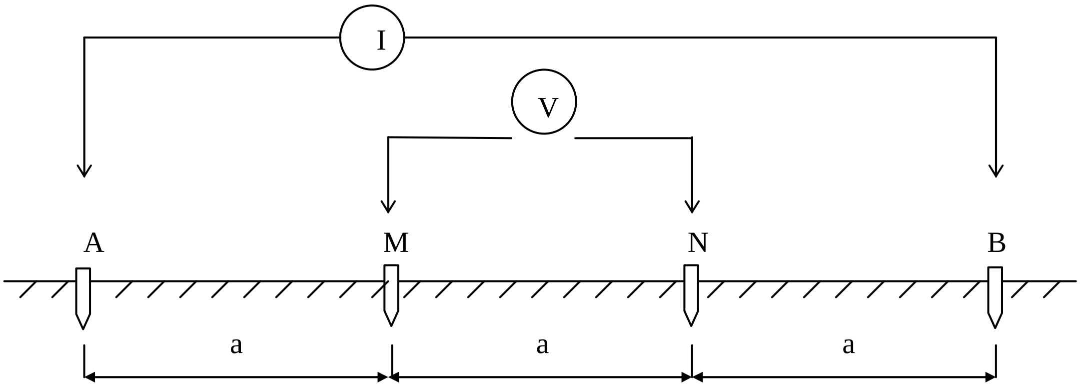
4.1.2 Principle

An artificial current is run through electrodes into the ground to measure the distribution of the potential field. The result then provides the basis for analyzing resistivity structure below the ground. In this survey we used the vertical and horizontal profiling methods.

a. Horizontal Electric Profiling Method

The Horizontal Electric Profiling is to identify apparent resistivity anomalies (fractured zones of rock in the foundation rock and/or points that differ from the surrounding geological structure). Wenner’s formula is used for the horizontal profiling. Maintaining an electrode interval shown in Figure 4.1-1, Wenner’s formula is used to measure apparent resistivity by moving the electrode profile along a measuring line while maintaining a constant electrode interval. In the survey, electrode spacing was 30m, 60m, and 80m. The survey profile was perpendicular to the lineaments, and the survey point spacing was 10m.

Entering the measurement data in the field book, and plotting it as the apparent resistivity curve (apparent resistivity (ρ_a)—electrode interval (a) on logarithmic graph paper, we identified the abnormal points in the plotted graphs and selected them as the measuring points for the Vertical Electric Sounding.

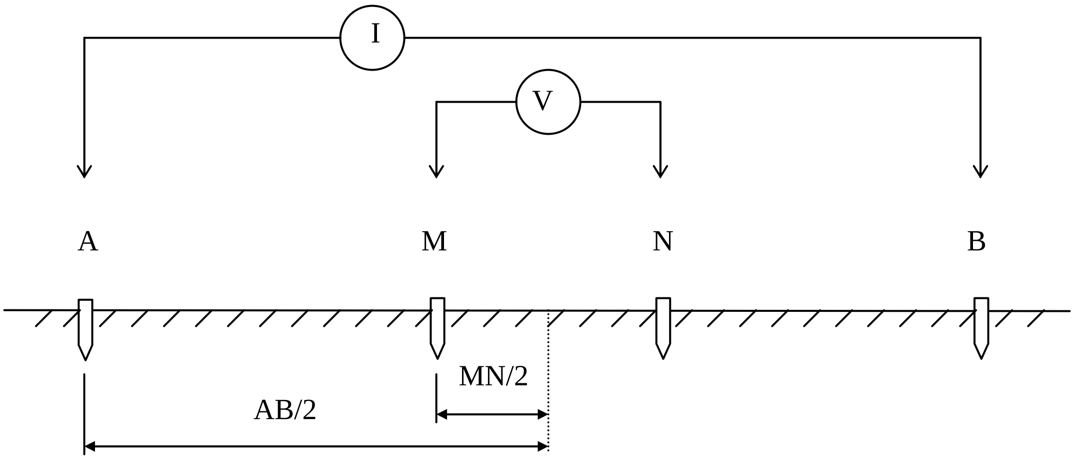


$\rho_a=\pi/4\times((AB^2-MN^2)/MN)\times(V/I)$、 ρ_a= apparent resistivity (ohm-m)
I: current between of A and B (Ampere), V: potential between of M and N (Voltage)
AB: current electrodes, MN: potential electrodes

Figure 4.1-1: Wenner Electrode Configurations

b. Vertical Electric Sounding Method

Vertical Electric Sounding is a method to provide a layered structure. Schlumberger electrode configurations were applied to estimate layered resistivity structure (Figure 4.1-2).



$\rho_a=\pi/4\times((AB^2-MN^2)/MN)\times(V/I)$、 ρ_a= apparent resistivity (ohm-m)
AB: current electrodes, MN: potential electrodes

Figure 4.1-2: Schlumberger Electrode Configurations

The center of the symmetrically-arranged electrode configuration is fixed in place, while the current, electrical potential and polarity intervals are varied to measure the apparent resistivity (ρ_a). The ρ_a-a curve derived there from is used to obtain the thicknesses of the layers and their resistivity. In other words, current is energized through outer electrodes A and B that are installed on the measurement profile, while electrodes M and N on the inside are used to measure differences in electrical potential. The equipment used for this measurement is the same as that for horizontal electrical profiling. The measurement data are recorded in a log book and plotted on the ρ_a — an apparent resistivity curve on double-logarithm graph paper (VES curve; Vertical Electric Prospecting curve).

Schlumberger combinations of electrode-interval are shown in Table 4.1-1.

Table 4.1-1: Schlumberger Electrode Spacing

Unit: meter

(AB/2)	1	2	4	6	8	10	15	20
(MN/2)	0.2	0.2	0.2	0.2/1	0.2/1	1	1	1
(AB/2)	25	30	35	40	45	50	60	70
(MN/2)	1/5	1/5	5	5	5	5/10	5/10	10
(AB/2)	80	90	100	120	140	170	200	250
(MN/2)	10	10	10/20	10/20	20	20	20/50	20/50

c. Measurement Instrument

SARIS (Scintrex Automated Resistivity Imaging System) made by SCINTREX, Canada was used for this survey. The appearance of this electrical prospecting instrument and its specifications are as shown in Photo 4.1-1 and Table 4.1-2.

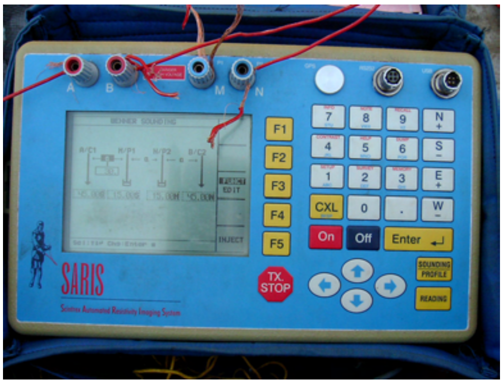


Photo 4.1-1: Electric Prospecting Instruments (Saris)

Table 4.1-2: Specifications of Electric Prospecting Instrument

Instrument	Specifications
SARIS	Output current: 0.1～500mA

d. Others

We had no measurement plans to use magnetometers this time. Although there was no magnetic survey plans this time, experimental magnetic prospecting was applied in parts of the areas. The instrument used for these measurements was a portable proton magnetic prospecting instrument, GSM-8 made by GEM Systems, Canada (see Photo 4.1-2 and Table 4.1-3). The magnetic measurement values are affected by regional heterogeneous near survey points, and its observed magnetic anomalies may provide information of the underground structures and the rock condition.

Photo 4.1-2: Magnetic Prospecting Instruments (GSM-8)

Table 4.1-3: Specification of Magnetic Prospecting Instrument

Instrument	Specification
GSM-8	Measuring range: 22～90kgammas

The magnetic measurement was conducted along profiles crosses with the lineament perpendicular and the magnetic. The measuring area range is from 22 to 90kgammas. The measurement values displayed on screen was recorded on the measurement field notes, and the values were used to extract magnetic anomalies. The magnetic sensor was set at 2 meters above ground, and the measurement interval was 5m of measurement intervals.

4.1.3 Field measurement

a. Measuring Method

In baserock and sedimentary rock areas, the vertical and horizontal profiling methods are used in the following combinations.

- Baserock areas: a combination of horizontal and vertical methods

The number of the villages covered by baserock distribution area is 32. Points indicating abnormal values are identified by the horizontal method. Then they are subjected to the vertical method to clarify the depth of estimated resistivity values and fissures that contain groundwater.

- Sedimentary rock areas: vertical method

The number of villages covered by sedimentary rock distribution area is 18. The vertical method is used to obtain resistivity values in layers that are considered to be rich in groundwater-containing pores.

b. Measurement Situations

Our pre-survey preparation extracted the fractured fault zones and the lineaments that probably contain groundwater according to the interpretation of the aerial photos. The traverse lines for the horizontal prospecting were set in the directions that cross with the lineaments extracted at right angles. The Additional traverse lines were also set in the valley bottoms and the lowlands with hydro-geological characteristics that have developed no lineaments. The Surveys by only vertical prospecting focused on the measurements of the vicinities of the lineaments.

The measurements went smoothly with no weather troubles. However, the topsoil was very dry in the dry season and indicated high ground resistance. This hardly allowed the electrical current to pass through the ground. Therefore some of the current electrodes were relocated, additional current electrodes were fixed, and the topsoil was watered to lower their ground resistance in the dry areas before the measurements.

In measurements that used 1mA or less of conducting current, measurement values had no repeatability. Thus, measurement values when 1mA or higher current conducted were adopted. Most of the data obtained were in good condition.

The latitudes and the longitudes of the measurement points were identified by GPS. A site map was prepared, some photos of the measurement points were taken, and some wooden rods were set as landmarks for the measurement points.

Besides the electrical prospecting, horizontal prospecting with magnetic prospecting instruments was conducted in several villages. However, no definite magnetic anomalies were detected. This posed questions—such as: whether the measurement directions were crossed with the lineaments at right angles, whether the magnetic sensors were fixed in the directions that cross with the lineaments at right angles, whether there actually were lineaments or not, or whether the lineaments were large enough to react to the magnetic sensors. The causes still remain unknown.

4.1.4 Data Analysis Method

A “Resix-P” was used to analysis the data.

In order to determine underground resistivity structure from a measurement result, an analysis technique called Occam’s inversion and a layered earth inversion were used. The resistivity model was used to conduct analyses by considering the groundwater level from existing wells, the analytical results from neighboring points, topography, geology, and so on.

a. Occams‘s Inversion

In actual analysis, or the first step of actual analysis, we utilized Occam's inversion (=Smooth inversion).

Occam’s inversion is a method that automatically sets layer thicknesses to logarithmically increase in a depth direction and analyzes only a resistivity value of each layer by inversion. Furthermore, a restricting condition that resistivity of each layer varies moderately is set.

The program used in the study can provide layers with a maximum of 15 layers, and calculations can be started with a semi-infinite medium structure. For this reason, appropriate initial values as those used in normal inversion do not have to be provided. Because the layer thickness is fixed in advance, this technique cannot investigate and calculate resistivity boundary depths accurately. Nevertheless, this technique can estimate analysis results without providing initial values and is capable of producing the same results independent of analysis personnel (see Figure 4.1-3).

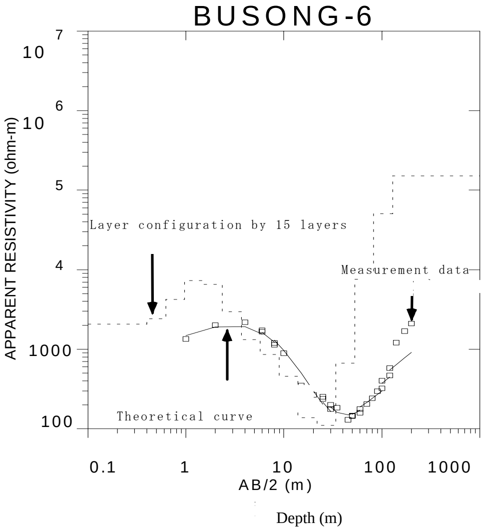


Figure 4.1-3: Occam's Inversion

b. Layered Earth

Layered earth structure inversion provides the number of layers, resistivity value of each layer and values of each layer as initial values and analyzes a horizontal multilayer structure that is most suitable to measurement results based on these initial values (see Figure 4.1-4 Layered earth inversion).

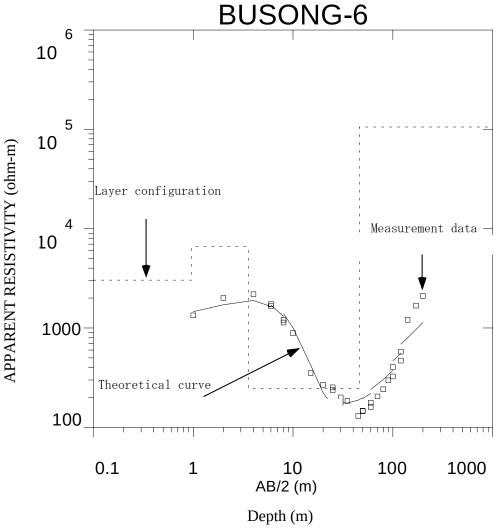


Figure 4.1-4: Layered Earth Inversion

4.2 Selection of Measurement Points

4.2.1 Quantity of Electrical Prospecting

The target survey area covers 50 villages in 10 districts in the Region of Mwanza and Mara. Table 4.2-1 shows the survey quantity of the electrical prospecting. For details, please refer to List of Geophysical Prospecting in the Data Book

Table 4.2-1: Electric Prospecting Quantity

Region	District	Village	Total number	
			Vertical electrical sounding (m)	Vertical electrical sounding
MWANZA	MISUNGWI	5	1,200	21
	SENGEREMA	7	1,800	27
	KWIMBA	7	1,200	24
	MAGU	6	1,200	23
	GEITA	5	900	20
	UKEREWE	2	900	12
MARA	BUNDA	4	300	18
	MUSOMA	4	600	18
	TARIME	8	1,700	33
	SERENGETI	2	1,000	12
Total	10	50	10,800	208

4.2.2 Pre-Exploration of Target Villages

In the presence of the RWE office, our counterpart, we visited the DWE offices in each district to provide a general explanation about the project. Then we confirmed the locations of the villages for the electrical prospecting and checked the road conditions to the villages. In addition, the engineers from the DWE offices accompanied us to visit the Office of the Village Executive Officer in the target villages. They helped us to explain to the village mayor, VEO (Village Executive Officer), and/or WEO (Water Executive Officer) about the project. At the same time, we confirmed the locations of the existing wells, had interviews with the people concerned about the water supply conditions and checked for the current status of other donors regarding the water supply, and asked the rural residents to participate in setting the traverse lines for the electrical prospecting and the actual measurements.

4.2.3 Selection of Measurement Points

The 929 villages that applied for the electrical prospecting at the beginning were narrowed down to 428 villages meeting certain criteria, and 50 villages out of the 428 were selected conclusively. For the test-drilling, one village was selected from each district, which amounted to 10 villages in total. Since the result of the electrical prospecting in Kitongosima Village in Magu district showed a low possibility of containing groundwater in that area, Igekemaja Village was investigated instead. Table 4.2-2 indicates the criteria for the selection of each test-drilling village, and the numbers and the drilling depths selected from the results of the electrical prospecting.

Table 4.2-2: Criteria for Selection of Each Test-Drilling Village

District	Village	Criteria for selection	Ves No. Drilling Depth
MISUNGWI	Busongo	Fracture confirm of Basement rock, confirmation of existing BH (depth45m,waterlevel 21m,lineament)	Ves6 50-70m
SENGEREMA	Busekeseke	Fracture confirm of Basement rock, confirmation of existing BH（depth85m,waterlevel9m,lineament）	Ves4 70m
KWIMBA	Nyamatala	Fracture confirm of Sedimentary rock, lineament	Ves7 50-60m
MAGU	Kitongosima	Fracture check of Basement rock	Low-potential
MAGU	Igekemaja	Confirmation of Basement rock (No lineament area)	Ves1 60-80m
GEITA	Ikina	Fracture confirm of Sedimentary rock(NE-SW lineament)	Ves5 80m
UKEREWE	Buhima	Fracture confirm of Basement rock, (N-S lineament)	Ves7 50-60m
BUNDA	Mcharo	Fracture confirm of Basement rock, (yield 320l/day,lineament)	Ves5 90-100m
MUSOMA	Saragana	Fracture confirm of Sedimentary rock,(depth300ft, lineament of NE-SW and N-S)	Ves6 70-130m
TARIME	Raranya	Fracture confirm of Basement rock, (lineament of NE-SW and NW-SE)	Ves12 100m
SERENGETI	Kebancha	Fracture confirm of Basement rock, (lineament of NE-SW)	Ves2 100-120m
Average			70-90m

4.3 Survey Results and Analysis Results

4.3.1 Survey and Analysis Results

Electric Prospecting Data and Location Map of the Electric Prospections in the Data Book show the measurement results of electrical prospecting. Field Survey Photographs in the Data

Book, covers working photos of electrical prospecting.

Results of the Electric Prospections and Vertical Electric Sounding and Analysis Result Graph in the Data Book show the analysis results. The results of the electrical prospecting analysis, being included at the end of this document, cover the geological and geographical sections of measurement points, geological map sheet names, UTM coordinates, VES curve types, resistivity structure, existing well conditions, etc. In addition, the results also refer to the possibility of occurrences of groundwater at the measurement points.

Regarding villages that had test drillings, we used the results of layer structure analysis to make a resistivity section and a plan view. For drilling points in these villages, we selected measurement points that indicated low resistivity. We also set a drilling depth by adding several tens of meters to the lower side depth of the low resistivity layer. It seems that low resistivity layers are chiefly made of weathered granite layers or sediments of earth and sand while the high resistivity beds beneath these beds consist of basement rock. As described in Subsection 4.2.3, drilling depths for villages are 70m to 90m on the average.

4.3.2 Correlation between Apparent Resistivity and Geology

Apparent resistivity (ρ a) values of sedimentary rocks obtained are rather low by the range of some 100 to 1,100ohm-m in basement rock areas, and by the range of 60 to 960 ohm-m in sedimentary rock areas (Table 4.3-1, Range of Apparent Resistivity). In general, the resistivity values of sand beds, gravel beds, and sandstone beds of sedimentary rocks are within the range of several to hundreds of ohm meters. Resistivity values of granites and other abyssal rocks tend to indicate 1,000 ohm-m or more (source: Society of Exploration Geophysicists of Japan, Resistivity such as Rock and Groundwater, 1989). In other words, tens of ohm-m of resistivity in this area seems to indicate weathered beds of gravel, mud, and granites, while over hundreds of ohm-m of resistivity seem to indicate granites.

Table 4.3-1: Range of Apparent Resistivity

Geology	Apparent Resistivity (ohm-m)	
	Minimum	Maximum
Basement rock area	103	1,086
Sedimentary rock area	60	964
Average	87	1,043

a. VES Curves

VES curves are classified into three types. Type A is the VES curve whose apparent resistivity values indicate "high to low to high”or "high to low to high to low to high”beneath the ground surface (concave type); type B is the VES curve whose apparent resistivity values are“low to high”from the ground surface (⊿ type); type C is the VES curve whose apparent resistivity values lowers deep underground (convex type).

Type A accounts for some 80% of the VES curves, and type B, 20％ (Table 4.3-2). Type A indicates occurrences of groundwater. In general, the depth of a low resistivity zone beneath the ground surface is too shallow to have groundwater. Thus, the possibility of groundwater occurrence seems to be moderate or less.

Table 4.3-2: Resistivity Structure and Type of Vertical Electrical Sounding

Layers	Measurement point	VES type		
		A(concave)	B(◿)	C(convex)
2layers	15	—	15	—
3layers	111	88	23	—
4layers	54	50	3	1
5layers	22	22	—	—
6layers	6	6	—	—
Total	208	166	41	1

b. Resistivity Structure

Resistivity structure consists of 2 to 6 layers. In general, 3 to 4 layers account for some 80% of the structure (Table 4.3-2). Of this, 3 to 4 layers that are likely to have groundwater (type A) account for 66% (138).

4.4 Technical Transfer to C/P

Water supply facilities for villages are implemented by the hydrogeology controller office (RWE), an agency of the Ministry of Water and Livestock Development (MOWLD). The counterpart for geophysical prospecting is Mr. Sumbuka Stanslaus Buluba (DED Principal Water Technician) for the Mwanza Region, and Mr. Dimoso Mmba (LVBO Senior Water Technician) for the Mara Region. The counterparts belong to the Hydrogeology Unit (for synonym, Ground Water Assessment and Exploration). They have an experience of having used a geophysical prospecting instrument (ABEM TERRAMETER SAS 300B), provided from Health Sanitation and Water (IDA) in 1985, to determine drilling points for wells.

We requested support and cooperation from the hydrogeology control offices so that improvement in the skills (including the background, purpose, and result of the survey operation) of counterparts through on-the-job training (OJT) in the course of this survey can be achieved. Such support and cooperation was also needed to implement a survey with a given accuracy.

The following table lists the contents of the groundwater surveys and technical transfers of regional hydrogeology controller offices.

Table 4.4-1: Training Contents of Geophysical Exploration Technology Transfer

Date	Location	Numbers	Content
26 July	Mwanza, RWE office	4	Practical Training
29 July	Mwanza, RWE office	8	Lecture, Practical Training
1st Aug.	Mara, RWE office	6	Inspection, Analysis
2nd Aug.	Mara, RWE office	4	Practical Training
4 Aug.	Mwanza, RWE office	6	Analysis

4.4.1 Transfer of Technology to the Mwanza Regional Hydrogeology Controller Office

a. Activities of the Hydrogeology Unit

The Hydrogeology Unit of the Mwanza Regional Hydrogeology Controller Office has 7 members (one hydrogeologist, three trained hydrogeology technicians and three on-job-training technicians). This groundwater survey used an electrical prospecting instrument (ABEM TERRAMETER SAS300B). In addition, a BOOSTER was provided. However, the instrument was not used after failure. Accordingly, the current to be conducted in the earth ranged 0.2 to 20mA (Table 4.4-2), thus measurement in the dry ground surface was difficult. In addition, the rechargeable battery was unused because of contact trouble during measurement and the elapse of the effective period (the battery failed and was discarded). The power supply consisted of 10 items of dry cell batteries. However, since the quality of cell batteries sold in Tanzania is poor, we always carried replacements during measurement.

The groundwater development project, being implemented by Mwanza RWE, is carried out by Kinango Secondary School and the Kahama village. The project adopted electrical prospecting to select well drilling points. The drilling depth is determined with the analysis of the standard curve (manual).

The photo on the left shows a set of electrical prospecting instruments; the main unit can be seen at the lower center of the instruments; the upper center refers to a BOOSTER. The wooden box on the lower side of the main unit in the photo on the right indicates a hand-made battery box which incorporates 10 items of dry cell batteries.

Photo 4.4-2: Electric Prospecting Instruments of Mwanza RWE

Photo 4.4-1: Electric Prospecting Instruments and Battery

Table 4.4-2: Specs of Electric Prospecting Instrument of Mwanza RWE

INSTRUMENT NAME	SPEC
MAIN: ABEM TERRAMETER SAS 300B BOOSTER: SAS 2000	OUTPUT CURRENT: 0.2～20mA, 50～500mA(BOOSTER)

b. Content for Technical Transfer Training

A series of photo of the practical training of technical transfer is presented in the Data Book.

We held outdoor practical training with electrical prospecting instruments, owned by the Mwanza Regional Hydrogeology Controller Office, on July 26th, 2005 on the premises of the office. Trainees included counterparts of the hydrogeology controller offices and members of the Hydrogeology Unit.

On the morning of July 29th, we held an indoor lecture and an outdoor practical training of workers at the hydrogeology controller offices. The manuals of electrical prospecting used at the lecture is attached in Appendix 1. On the afternoon of July 29th, we held practical training at the Kinango Secondary School implemented by Mwanza RWE.

Furthermore, we used measurement data obtained at Kinango Secondary School on August 4th, 2005 to make analysis with Personal computer (PC) software programs and the standard curve. Analysis with the standard curve focused on the shallow zone because the deep zone was difficult to analyze. PC analysis can target deep zones and the analysis is more precise than with the standard curve. When their analytical results are compared with each other, their analytical results for shallow zones were relatively similar.

The members of the Hydrogeology Unit experienced a series of PC analysis for the first time. The unit members made fast PC analysis of deep zones under the ground’s surface. The unit requested us to transfer a set of PCs and analysis software programs to the Regional Hydrogeology Controller Office.

4.4.2 Transfer of Technology to Mara Regional Hydrogeology Controller Office

a. Activities of the Hydrogeology Unit

The Hydrogeology Unit of the Mara Regional Hydrogeology Controller Office consists of six members (one hydrogeologist, three trained hydrogeology technicians, and two technicians). The electrical prospecting instruments include the ABEM TERRAMETER SAS300B that the Mwanza Region and HESAWA provided. However, the failed BOOSTER was discarded. At present, Mara RWE is engaging in the groundwater development projects at Ikizu High School, Ikizu Secondary School (Bunda District), and Rwamkoma National Service Camp.

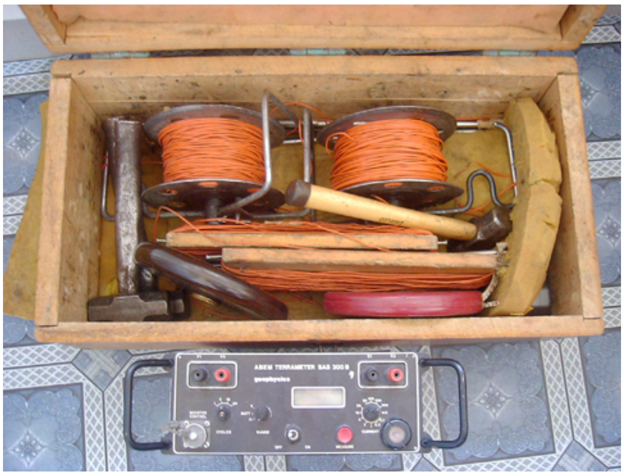


Photo 4.4-3: Electric Prospecting Instruments of Mara RWE

b. Contents of Technical Transfer Training

On August 1st, we visited Ikizu High school and Ikizu Secondary School in which the RWE was conducting surveys for groundwater development. These schools were selected for water supply projects because the number of students was increasing year by year, and water pumping volumes of the existing wells could not afford the amount of water needed (intake time restricted). Thus, additional wells were definitely needed. The drilling point that RWE selected for a well in electrical prospecting was located at a point barely 50 meters distance from the existing well in the valley bottom. In particular, because these schools had faced a shortage of water volume, the existing well and the new well were likely to interfere with each other when groundwater was pumped up from the aquifer (lowering of water level). We think that the members of Hydrogeology Unit of the RWE need to have continuing basic studies of hydrogeology.

On the afternoon of August 1st, we provided a lecture in prospecting methods for ten unit members, and demonstrated PC analysis. Photo 4.4-4 and Table 4.4-3 show the result of the analysis. The upper side on the photo shows the result of the analysis with the standard curve, while the lower side of the photo shows the drawing of layer structure which resulted from the analysis with analysis software programs. If looking at the VES curve, analysis in four-layer structures is considered appropriate. The result of the standard curve at ① indicates a two-layer structure. However, when analysis software was used, the analysis resulted in a four-layer structure. Moreover, although the result of analysis with the standard curve at ② was even in a two-layer structure, analysis with analysis software resulted in a four-layer structure. When these results are compared with each other, they are similar up to the two-layer structure.

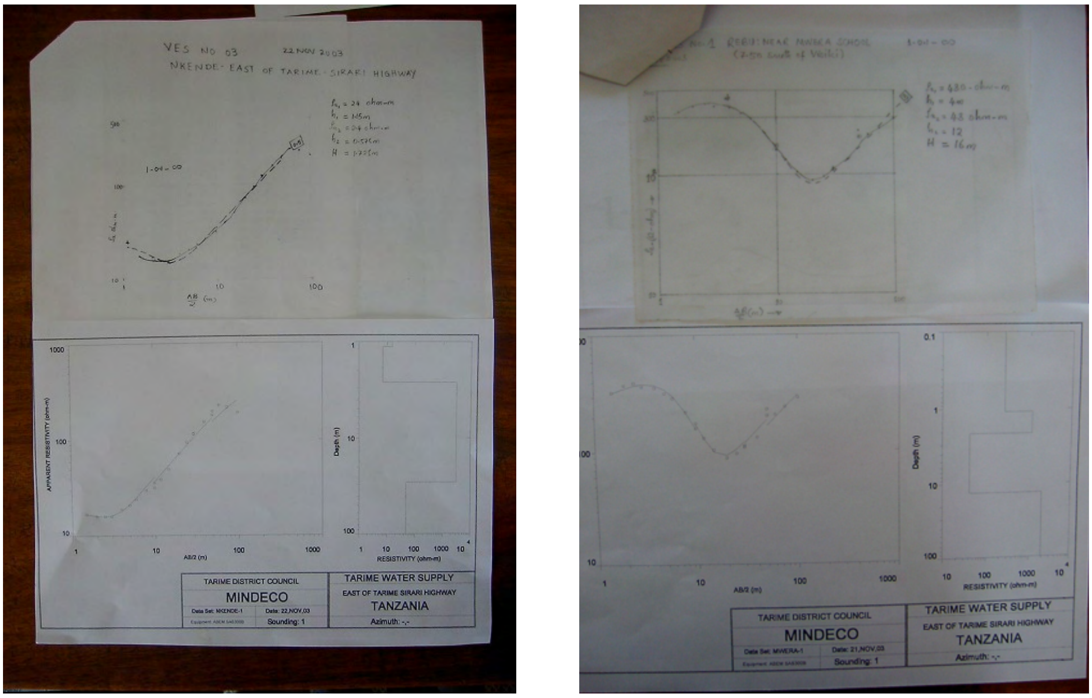


Photo 4.4-4: Comparison of Standard Curve and Analysis Software Interpretations

(Left: ①, Right: ②)

Table 4.4-3: Comparison of Standard Curve and Analysis Software Interpretations

Survey area	Analysis	Parameter	1layer	2layer	3layer	4layer
① Tarime Sirari Highway	Standard curve	Resistivity(Ohm-m	24	2.4	—	—
		Thickness(m)	1.2	0.6	—	—
		Depth(m)	1.2	1.8	—	—
	Analysis software	Resistivity(Ohm-m	15	7.0	2990	48
		Thickness(m)	1.1	1.5	26	—
		Depth(m)	1.1	2.6	29	—
② Mwera High School	Standard curve	Resistivity(Ohm-m	430		48	—
		Thickness(m)	4		12	—
		Depth(m)	4		16	—
	Analysis software	Resistivity(Ohm-m	260	1120	41	1960
		Thickness(m)	1.1	1.0	11	—
		Depth(m)	1.1	2.1	13	—

On August 2^{nd}, we checked the conditions of electrical prospecting instruments kept by the Mara Regional Hydrogeology Controller Office, and held outdoor practical training within the premises of the office. Like the Hydrogeology Unit of Mwanza, no operation problems of measurement were observed.

Districts in Mara Regional had 100m-class drillings. So members of the Hydrogeology Unit were of the opinion that the resistivity structure in the deep zone should be defined with the use of PC analysis software programs.

4.4.3 Technical Transfer in the Future

Members of the Hydrogeology Unit know basic theory on the electrical prospecting method and have rich experiences on surveys. However, in many cases, field measurement obtained data in mechanical measurement. Thus, there is lack of experience of examining the quality of individual data obtained. Furthermore, geological drawings, hydrogeological drawings, and aerial photos needed for the surveys are not held by the unit. In general, lowland and valley bottom were selected for measurement points and highland was avoided. Since measurement with the horizontal electrical prospecting method is unknown, the vertical electrical prospecting method alone is applied to measurement.

We checked past drilling data obtained through electrical prospecting. Some of the drilling data indicated a low possibility of groundwater (unsuccessful wells), while other drillings were canceled after small ranges of area were surveyed. The problems of selecting a measurement point were also discussed. Furthermore, although analysis is made with the standard curves, differences in analysts' aligning the standard curves tend to result in different interpretations of the result. This is because members of the Hydrogeology Unit seem to have no unified analysis and interpretation.

The contents for technical transfer in the future should include study of the basics of hydrogeology, how to interpret maps/geological drawings, photo analysis, measurement (measurement with different methods in geography/geology), and training of analysis with the standard curve and PCs. Technical transfer in view of long prospects is definitely needed in order to improve the skills of water supply engineers.

4.5 Supplemental Survey

4.5.1 Summary of the Survey

In the 2^{nd} on site survey conducted in the 2^{nd} year of the project, electrical prospecting was conducted at test wells in 3 villages in order to better understand geological conditions. The on site work was performed from February 23 to March 14, 2006.

The electrical prospecting involved measurements taken by the JICA study team using a Syscal-R2 electrical prospecting instrument (BRGM Co., France: see Photo 4.5-1 and Table 4.5-1) that they had brought from Japan. The measurements were taken with the assistance of local residents, and hydrogeologists, one from each of the regions RWSD (Rural Water Supply Division).

The electrical prospecting consisted of both horizontal electric profiling and vertical electric sounding, with the horizontal electric profiling using the Wenner method and the vertical electric sounding using the Schlumberger method. Analysis was made using the “RESIX-P” software (Interpex Ltd., USA). The following table lists some information about the 3 surveys.

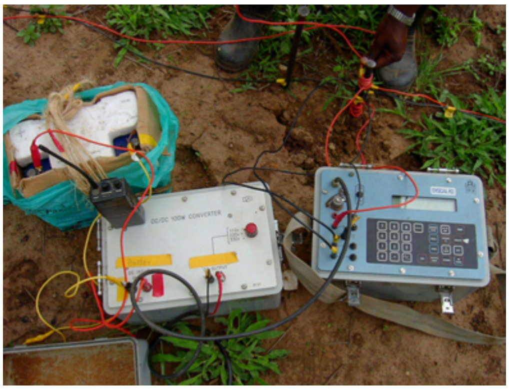


Photo 4.5-1: Electric Prospecting Instruments (Syscal-R2)

Table 4.5-1: Specifications of Electric Prospecting Instrument

Instrument	Specifications
SYSCAL-R2	Output current: 0.1～1,500mA
100w DC-DC converter	Input:10～30VDC Output:110V,220V,330V

Table 4.5-2: Information about the 3 Surveys

Survey date	Region	District	Village	Horizontal electric profiling	Vertical electrical sounding
Feb 23～ Feb 27	MWANZA	KWIMBA	Hungumalwa	2,060m (7 lines)	22
Mar 2 ～ Mar 7	MARA	MUSOMA	Saragana	1,830m (8 lines)	21
Mar 10～ Mar 14	MWANZA	SENGEREMA	Buswelu	1,090m (6 lines)	19

4.5.2 Survey and Analysis

Electric prospecting data diagrams showing measuring points, resistivity depth distribution, profile section of apparent resistivity in the horizontal electric profiling and tables and figures showing analytical results, were compiled into a Data Book.

a. Hungumalwa Village

The measurement site was located on the western slope of Hg'wanzabalimi Hill, 3km west of the center of Hungumalwa Village. At the western toe of the slope, a linear topographic formation where water collects easily, known as a "water pot", was discovered. This "water pot" has a N-S orientation along a line that connects existing wells and scattered water springs, and may be parallel to a lineament that is thought to exist on the eastern side of the hill, with which it may have some sort of geostructural correlation. In the electrical prospecting, a measuring line for the linear horizontal electric profiling was set up perpendicular to the "water pot's" orientation. Points with abnormal values were identified from the measurement data, and subjected to vertical electric sounding.

The apparent resistivity values, which were roughly in the 20～700ohm-m range, were highest around Hg'wanzabalimi Hill, and decreased as the distance from the hill increased. Measurements in the horizontal electric profiling were taken at electrode interval depths (=a) of 40m and 80m. Generally speaking, the apparent resistivity was low (50ohm-m or less) at the shallower depth (a=40m) and high (50～100ohm-m or above) at the deeper depth (a=80). However, point L5-140 on measuring line 5 showed the opposite trend, with the shallower depth (a=40m) having a higher value than the deeper depth (a=80m). The same type of result was obtained at point L5-140 in the vertical electric sounding, and a concave section of the apparent resistivity was found near electrode interval AB/2=90m, suggesting the presence of a fissure in the baserock. The same types of results were also obtained at points L2-10, L3-50, and L5-200. Geologically speaking, a low resistivity of less than 10 ohm-m or so suggests sedimentary rock layers of sands, gravels, sandstone, etc., while higher resistivity values of several hundred ohm-m suggest granites and similar rocks.

The data obtained from the vertical electric sounding were analyzed and the results were compiled into a depth distribution map of the resistivity. This distribution map uses contour lines to show the depth transition from low resistivity to high resistivity. At the western toe of Hg'wanzabalimi Hill, there is a belt of low resistivity 20m or more below the surface, extending in a N-S direction; this col structure is especially prominent at point L5-140. The area of this belt of resistivity layers roughly coincides with the N-S oriented "water pot" and is believed to contain sandy layers, gravel layers, sandstone, etc., and fissures may be developing, indicating a high possibility of the existence of groundwater. Therefore, it was decided to drill at point L5-140 on measuring line 5, down to a maximum depth of 100m.

b. Saragana Village

The measuring point was on the eastern side of Saragana Hill, a little more than 200m SW of last year's Test Drilling point JT8 (point Ves6 in the vertical probe). In the vertical electric sounding results for point Ves6, the apparent resistivity fell sharply near electrode interval AB/2=60m; below that depth there was an area of lost circulation where water was being pumped at a rate of 50 liters/min. In the present survey, ground points with the same apparent resistivity curve as Ves6 will be identified.

The measured apparent resistivity ranged from about 20～500ohm-m, and was highest near Saragana Hill. Fluctuations in the apparent resistivity were found at measuring lines 1, 7 and 8 near the JT8 side, which may indicate the existence of fissures in the baserock, and points having a different geology to that of the surrounding area. However, in measuring lines distant from JT8, there was no fluctuation in apparent resistivity.

The results of the vertical electric sounding showed that near areas on measuring lines 1, 7, and 8 near Saragana Hill, a low apparent resistivity existed until an electrode interval of about AB/2=50m. Apparent resistivity curves that were particularly similar to that of point Ves6 of the vertical electric sounding were found at point L1-50 of measuring line 1; points L7-60 and L7-90 of measuring line 7; and point L8-70 of measuring line 8. At an electrode interval of AB/2=60～90m, there was a sudden drop in the apparent resistivity. At other points, there was low apparent resistivity near an electrode interval of AB/2=20m, but below that the values dramatically increased.

In the depth distribution map of resistivity, a layer of high resistivity appears in shallow sections as the distance from JT8 increases. On the other hand, there exists a low resistivity layer starting at a depth of 30m on measuring lines 1, 7, and 8 near JT8; low values are particularly striking at depths of 70m and below at point L7-60 on measuring line 7, and point L8-70 on measuring line 8. The depth of this low resistivity is believed to extend in direction toward JT8.

The geological column map of JT8 shows a weathered layer down to about 10m below the surface; below that, weathered layers intermingle with layers where fissures have developed, and a quartz vein has been confirmed at a depth of around 80m. It is believed the shallow areas near measuring lines 1, 7 and 8, having apparent resistivity curves resembling that of point Ves6, have a weathered layer and/or a gravel belt in the baserock. Point L8-70 on measuring line 8 was selected as a drilling point because its apparent resistivity curve most approximated that of point Ves6; it was decided to drill down to a maximum depth of 100m.

c. Buswelu Village

The measuring site was in a gently sloping area about 2km east of the center of Buswelu Village. To the south is a zone of wet paddy fields. In this area in 1977, SIDA drilled 5 wells, 4 of which were successful and the other, unsuccessful. The unsuccessful site was on the western side of the measuring site, where a steel pipe was being drilled down into the ground. The measuring point map shows the locations of these wells.

The measured apparent resistivity ranged from about 50～1,000ohm-m. The horizontal electric profiling was conducted on measuring line 5. Measurements were also attempted at a permanent (year-round) spring. For the analysis, vertical electric soundings were taken at existing wells (the respective points where the successful wells and the unsuccessful well were drilled) and compared with the values derived at the measuring site.

The apparent resistivity curves at the existing wells showed sharp drops at 2 electrode interval ranges: near AB/2=40～60m, and near AB/2=80～100m. On the apparent resistivity curve obtained of the measuring site, the points which most closely resembled the apparent resistivity curves of the existing wells were L1-200 on measuring line 1; L2-160 and L2-210 on measuring line 2; L3-180 and L3-200 on measuring line 3; and L4-60 on measuring line 4.

In the resistivity distribution map compiled based on these analytical results, there are deep low- resistivity layers near the end points of measuring lines 1, 2 and 3. Outcrops of pegmatite, which can be seen in these areas of low- resistivity, continue on to the vicinity of either point L4-110 of measuring line 4, or point L5-100 of measuring line 5. There is a high possibility that fissures exist in the granitic baserock of the low-resistivity layers distributed deep below the surface, and it appears that rainwater may pass deep down through these fissures to the water table.

It is interesting to note that measurements taken at water springs start showing high-resistivity near an electrode interval of AB/2=30m, suggesting that the spring sources are relatively shallow. It was decided to drill at point L2-210 on measuring line 2, where there was a deep distribution of low resistivity. As there are two candidate target areas for groundwater near a depth of 60m, and near a depth of 120m below the surface it was decided to drill down to a maximum depth of 120m.

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